AUGUST 1993

# EVERYDAY WITH PRACTICAL ELECTRONICS

INCORPORATING ELECTRONICS MONTHLY

FULLY S.O.R. £1.80


## FREE INSIDE! 48 page GREENWELD Summer Sale Catalogue

## EXPERIMENTAL ELECTRONIC PIPE DESCALER

Hard Water? Build this experimental descaler for under £20.

## TRI-STATE THERMOMETER

Keep an eye on your engine temperature

## AUDIO AMPLIFIER DESIGN ENGINEERING OR ALCHEMY? PART 1

John Linsley Hood investigates

## BIKE ODOMETER

How far have you pedaled?

9 770262 361034 08

THE No. 1 INDEPENDENT MAGAZINE for ELECTRONICS, TECHNOLOGY and COMPUTER PROJECTS

VOL. 22 No. 8 AUGUST 1993

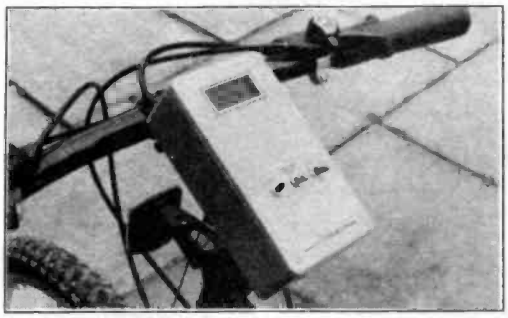
# EVERYDAY WITH PRACTICAL ELECTRONICS

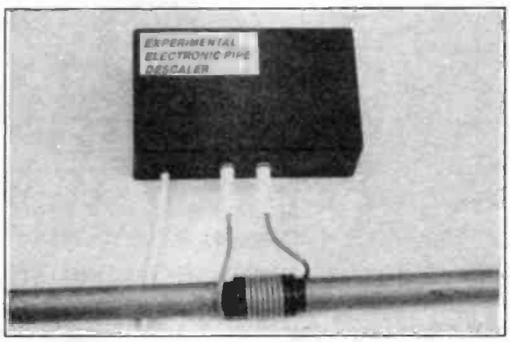
INCORPORATING ELECTRONICS MONTHLY

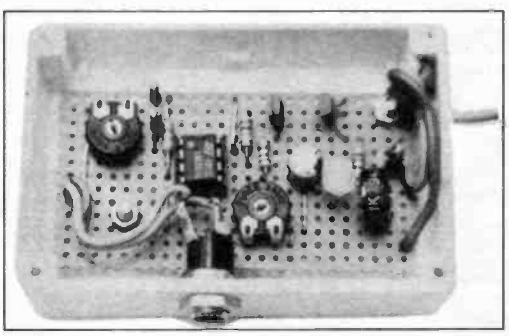
**The No. 1 Independent Magazine for Electronics, Technology and Computer Projects**

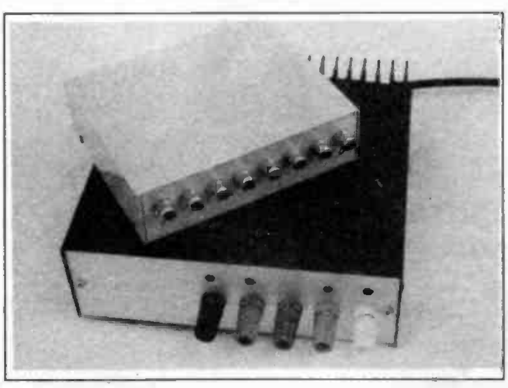
ISSN 0262 3617

PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .







## *Projects*



## *Series*



## *Features*





***Our September '93 Issue will be published on Friday, 6 August 1993. See page 555 for details.***

# NEXT MONTH

## SOUND ACTIVATED CAMERA TRIGGER

*Most cameras have a self-timer facility which enables photographs to be taken about five to ten seconds after the release button has been activated. This facility is included primarily to enable the photographer to take self portraits. In many instances a simple self-timer facility is quite adequate, but the delay sometimes proves to be too short. In particular, it is often inadequate when the photographer has to position him or herself in a group of people. The delay can also be too short if the photographer wishes to pose with a prop, such as "the one that did not get away", or some sort of cup or trophy.*

*With this unit the general idea is to get into position and then shout to activate the trigger. After a brief delay to allow the operator to compose him or herself, the camera is then automatically triggered.*

## CHARGE-15

### Quarter-hour charging for AA batteries

*Charge-15 is a mains-operated unit designed to charge a set of the popular "AA" type (HP7 size) nickel-cadmium cells in about 15 minutes – hence the name. This time compares with 15 hours for commercial* standard charging *units and between two and five hours for the* fast charge *variety. It will thus be found useful whenever batteries are likely to let you down suddenly or where it is essential to have ready access to a fully-charged set.*

*Ultra-fast charging is not thought to be particularly good for batteries and it is possible that they may suffer from some shortening of life. However, in tests on the prototype unit, cells were repeatedly charged and discharged over 50 cycles and were found to be still in perfectly good condition at the end with no significant loss of capacity. Since a nickel-cadmium cell costs little more than the throw-away alkaline variety these days (about £1 compared with 70p) any shortening of life is thought to be of little consequence even taking into account the much lower energy content (one fifth approximately) of rechargeable cells compared with alkaline ones.*

## LIGHT WORK

### A handy aid for checking trailer or caravan lights

*Light Work provides a convenient way of testing the operation of rear lights on a caravan or trailer. It will thus be found useful for any reader who owns a caravan, boat or motorcycle trailer, horse box, etc. With this unit you can check the rear lights from the drivers seat without assistance, trailing wires or mirrors etc. It's all done with electronics!*

**EVERYDAY WITH PRACTICAL ELECTRONICS**

**SEPTEMBER ISSUE ON SALE FRIDAY, AUGUST 6th**

# MAILTECH

## ELECTRONIC COMPONENTS

**PROJECT BOXES** A range of high quality boxes moulded in black high impact ABS, easily drilled or punched to produce a professional looking end product

| TYPE | W | L | H | PRICE |
|---|---|---|---|---|
| T2 | 75 | 56 | 25 | £0.77 |
| T4 | 111 | 57 | 22 | £0.92 |
| MB1 | 79 | 61 | 40 | £1.35 |
| MB2 | 100 | 76 | 41 | £1.47 |
| MB3 | 118 | 98 | 45 | £1.71 |
| MB4 | 216 | 130 | 85 | £5.19 |
| MB5 | 150 | 100 | 60 | £2.35 |
| MB6 | 220 | 150 | 64 | £3.95 |
| MB 7 | 177 | 120 | 83 | £3.42 |
| MB8 | 150 | 80 | 50 | £2.22 |

All sizes are in millimetres

**SPECIAL OFFER – PROJECT BOX**
As above boxes
50 x 70 x 25mm
60p each 10 for £5.00
**KEY SWITCH**
3 Position keyswitch £2.35

**CRYSTAL OSCILLATORS**

| | |
|---|---|
| 4.0 mhz | ALL |
| 7.5 mhz | £1.50 each |
| 12.0 mhz | OR |
| 18.432 mhz | 4 FOR |
| 33.33 mhz | £5.00 |

**MICRO SWITCH** roller arm operation spdt 40p each

**MINIATURE TOGGLE SWITCHES**

| | | | |
|---|---|---|---|
| spdt | 60p each | spdt 3 position c/off | 70p each |
| dpdt | 70p each | dpdt 3 position c/off | 80p each |
| spdt biased | 60p each | spdt 3 position c/off biased both ways | 70p each |
| | | dpdt 3 position c/off biased one way | 80p each |

**MINIATURE TOGGLE SWITCH** pcb mounting 3pdt — 50p each 10 for £4.00
**MINIATURE PUSH TO MAKE SWITCH** — 50p each
**DIL RELAYS** 5 volt dp/changeover — 60p 10 for £5.00
12 volt dp/changeover — 80p 10 for £6.00
**RELAY** 10 amp contacts sp/changeover 12 volt coil — £1.20 each
**CAR HORN RELAY** In metal can with fixing lug, s/pole on 10 amp contacts — £1.00 each 6 for £5.00
**20 AMP RELAY** dp on 12 volt coil — £1.50 each 4 for £5.00
**REED RELAY** 12 volt — 50p each 10 for £4.00
**240 VOLT AC RELAY.** 3-pole c/o 10 amp contacts — £1.50 each 4 for £5.00

**DIL SKTS**

| | | |
|---|---|---|
| 8 pin | 10 for | £0.60 |
| 14 pin | 10 for | £0.90 |
| 16 pin | 10 for | £1.00 |
| 18 pin | 10 for | £1.00 |
| 20 pin | 8 for | £1.00 |
| 24 pin | 8 for | £1.00 |
| 28 pin | 6 for | £1.00 |
| 40 pin | 5 for | £1.00 |

**'D' CONNECTORS**

| | plug | socket | cover |
|---|---|---|---|
| 9 pin | 30p | 30p | 35p |
| 15 pin | 40p | 40p | 35p |
| 25 pin | 50p | 50p | 40p |

**ALL COMPONENTS FULL SPECIFICATION DEVICES**

**SEMICONDUCTORS – TRANSISTORS – ICS – DIODES – REGULATORS – ETC**

VOLTAGE REGS
7812/7805/7912/7905 — all 35p each, any 4 for £1.20
AD592An Temperature Sensor i.c. mounted on 1.5m screened lead omplete with data and application notes — £1.50 each
LM3914/LM3915 Bargraph ics — £2.95 each
78512 12V +VE 2amp regulator — 50p each
78505 5V +VE 2amp regulator — 50p each
**MICRO IC'S** –Z80A CPU £1.20; Z80A PIO £1.50; Z80B SIO-1 £4.00

**OPTO DEVICES – LEDS – ETC**

5mm rnd red/yellow/green/amber — 10p each 12 for £1.00 any mix
5mm rnd high brightness red/green — 20p each 6 for £1.00 any mix
5mm rnd flashing — red 60p each, yellow/green 70p each
5mm rnd bi-colour — 35p each, tri-colour 45p each
LED mounted in chrome bezel red, yellow or green — 30p each, 4 for £1
LED mounted in a black bezel red only — 25p each, 5 for £1.00
PLASTIC BEZEL for 5mm rnd leds — 10 for 40p
High brightness bi-colour l.e.d., rectangular, red/green, two leads — 40p each

**RESET TIMER PCB**

Gives a timed relay closure following a momentary input. Requires 12V d.c. supply SP c/o relay output LED indication. 19 different time intervals from 25sec to 35min 20sec. £5.98 each.

**ALARM CONTROL UNIT**

Single zone alarm control unit built into a domestic light switch box. Ideal for home, caravan, boat, garage, shed etc.
Facilities: – Normally closed loop for pir sensors, door/window contacts etc.
Normally open loop for pressure mats.
24-hour loop for personal attack button
Visual indication that the system is operational.
Automatic entry/exit delay.
Automatic system reset.
Alarm output cmos logic level.

**SIREN**
12 volt dc for external use 115db — £8.95
**BELL BOX**
A plastic bell box cover supplied with backplate. Red/yellow/white — £8.99 each

PRICE COMPLETE WITH FULL INSTRUCTIONS — £8.95
BELL/SIREN INTERFACE BOARD COMPLETE — £3.95

**PASSIVE INFRA-RED ALARM SENSORS**

**SUB-MINIATURE PASSIVE INFRA-RED SENSOR ONLY £5.95**
Brand new passive infra-red sensor, measures only 33mmW x 24mmH x 29mmD. Logic level output. Full data and application notes supplied.

**EX INSTALLATION SENSORS** tested working.
Type 1. Measures 180 x 112 x 70mm with walk test led, relay output and tamper protection. 12 volt dc supply required — £8.50 each
Type 2. As above but a smaller unit 123 x 62 x 50mm — £11.75 each
Type 3. Ceiling mounting passive, infra red sensor 360° detection, 12V d.c. supply relay output, tamper circuit and pulse count option. Data supplied. — £15.70 each

**DOOR/WINDOW CONTACTS**
Surface or flush mounting, white — £1.10 each
**JUNCTION BOX**
white 6 way — 60p

*Please note: There may be variations in the size of the above passive infra red sensors depending on stock at the time of ordering. But the unit will certainly be within the stated sizes.*

**DUAL TECH SENSOR** Microwave and passive infra-red combined. Separate led indication for each function. Measures 120 x 75 x 50mm. 12 volt d.c. supply, Relay output. Tamper protection. — £29.95 each

**BREADBOARDS – CAPACITORS – SOLAR CELLS – HEATSHRINK – ETC**

**SOLAR CELL** 2 volt 150mA max, size 60 x 100mm — £1.35 each 5 for £6
**BNC SOCKETS** 50 ohm single hole fixing — 50p each 10 for £4.00

**MERCURY TILT SWITCH**
Standard on/off £1.00 each
4 Contact (Directional) £1.50 each
**PIEZO VIBRATION SENSOR**
with data sheet £1.00 each

**BREADBOARD**
173 X 65mm 840TP £5.25 each
**TEXTOOL ZIF SOCKET**
28 pin zero insertion socket £5.95 each

**6 VOLT NI-CAD PACK** 5AA NI-CADS, fast charge type — £3.95
**CAPACITOR** 10,000 mfd 25 volt with fixing clip — 60p each
**EPROMS 27C256 – 30 27C512 – 25.** Once programmed but never used eprom. Mounted on a plastic carrier, can easily be removed from the carrier or used with a low insertion force socket.
**27C256** £1.00 each 6 for £5.00 — **27C512** £1.20 each 5 for £5.00
Suitable low insertion force socket 28 pin — 40p each 3 for £1.00
**MULTITURN PRESETS** 20mm RECT, 500R, 1K, 5K, 10K, 20K, 50K, 100K 1MO. — 40p each, 3 for £1.00
**CAR CIGAR LIGHTER ADAPTER (DUAL SIZE)**
mounted on two metres of cable — £2.00 each
**100db PIEZO SOUNDER**
2KHz note, 3-12V d.c. 40Ma, 45mm dia. x 26mm — £1.76 each
**VIBRATION SENSITIVE ALARM BOARD WITH PIEZO SOUNDER**
Originally a bike alarm. There is a short delay after activation then the piezo sounder operates for a preset period. — £3.76 each
or the above alarm board with custom designed case, fixing clip and keyswitch — £9.95
**INFRA-RED BREAK BEAM** Transmitter and receiver p.c.b. with 2 lens assemblies. 12V d.c. supply. These are ex-installation units and are not guaranteed to be working. — £4.96 pair
**RECHARGEABLE BATTERIES** — £7.64 each

| | | | |
|---|---|---|---|
| AA (HP7) 600 mAH | £1.02 each | C (HP11) 1200 mAH | £2.29 each |
| D (HP2) 1200 mAH | £2.40 each | PP3 8.4V 100 mAH | £4.77 each |

**FLOURESCENT LIGHT INVERTOR.** Drives an 8 watt tube directly from 6V d.c. Data supplied — £4.50 each

## £1.00 BARGAIN PACKS

**SUB-MINIATURE TOGGLE SWITCHES**
P.C.B. Mounting

BO1 S.P. on 4 for £1.00
BO2 D.P. on 3 for £1.00
BO3 3 x D.P. 3 pos. centre off
BOO4 **DIL SWITCHES** 4-way S.P. on 3 for £1.00
BOO5 **DIL SWITCHES** 8-way S.P. on 2 for £1.00
BOO6 **DIL SWITCHES** 12-way 90° sp on 2 for £1.00
BOO7 **12 x PP3 BATTERY SNAPS**
BOO8 **1 x CAPACITOR 1 FARAD 5.5 VOLT** 20mm dia. x 7mm high
BOO9 **INSTRUMENT KNOBS (0.25" SHAFT)** High quality grey plastic knob, collet fixing 15mm dia, 5 for £1.00
BO10 as above but 29mm dia, 3 for £1.00
BO11 **4 x MAGNETIC EARPIECE** 8 ohm with 3.5mm plug
BO12 **4 x 28-WAY TURNED PIN DIL SOCKET**
BO13 **15 x 12 VOLT WIRE-ENDED LAMPS**
BO14 **8 x 2 PIN DIN PLUGS** screw terminal connection
BO15 **2 x LIGHT DEPENDENT RESISTOR** Less than 200 ohms in daylight, greater than 10 megohms in darkness
BO16 **1 x KEYPAD** 20-key in 5 x 4 matrix bubble type switch contacts
BO17 **2 x PIEZO BUZZERS** approx 3 to 20 volt d.c.
BO18 **5 x 78M12 VOLTAGE REGULATORS** positive 12V 500mA
BO19 **4 x TL082CP** bi-fet op-amps
BO20 **20 x ASSORTED LEDS** full spec. various shapes and sizes
BO21 **3 x INFRA-RED DIODE TX/RX PAIRS** made by Honeywell(no info)
BO22 **4 x CONSTANT CURRENT LED** 5mm round, red 2-18V d.c. or a.c. nominal 14mA
BO23 **50 x IN4148** diode
BO24 **2 x INFRA-RED TRANSISTOR FPT5133**
BO25 **5 x DIACS**
BO26 **3 BDX33C** 10 amp 100V npn transistor
BO27 **12 x 2N3702** Transistor
BO28 **12 x 2N3904** Transistor
BO29 **12 x BC337** Transistor
BO30 **4 x LM317T** Variable regulator mounted on a small heatsink
BO31 **2 x MAN6610** 2 digit 0.6" 7 segment display Com anode, amber
BO32 **3 x PHONO TO PHONO LEAD** 63cm long
BO33 **15 x RECTANGULAR RED LEDs** 6 x 6 x 2mm stackable
BO34 **1 x PHOTO SENSITIVE SCR** mounted on a PCB, data sheet supplied
BO35 **4 x IEC Panel Mounting Mains Plug** Snap fix
BO36 **5 x ASSORTED PIEZO TRANSDUCERS**
BO37 **5 LENGTHS OF HEATSHRINK SLEEVING** 8mm dia. 400mm long
BO38 **25 x CERAMIC DISC CAPACITORS** 0.1 mfd 63V
BO39 **15 x MONOLITHIC CERAMIC CAPACITORS** 0.1 mfd 63V, in a dil package
BO40 **25 x ASSORTED ELECTROLYTIC CAPACITORS** PCB mounting useful values
BO41 **25 ASSORTED PRE-SET RESISTORS**
BO42 **6 x 3·5mm LINE JACK SOCKETS** (mono)
BO43 **6 x 3·5mm JACK PLUG** (mono)
BO44 **8 x 3·5mm CHASSIS SOCKET** (mono)
BO45 **2 x TRIACS** 800 volt 8 amp
BO46 **12 x BC213L** Transistor
BO47 **12 x MIN SLIDE SWITCH** dpdt
BO48 **15 x MIN CERMET TRIMMER POTS** (good range of values)
BO49 **1 x PCB WITH TWO LARGE LEDS** 15mm square, one red and one green
BO50 **1 x 12V DC RELAY** 4-pole c/o with plug in base
BO51 **4 x LM324** quad op-amps
BO52 **4 x 555** Timer
BO53 **5 x 741** op-amp
BO54 **25 x IN4001** diode
BO55 **20 x IN4007** diode
BO56 **1 x SLOTTED OPTO**
BO57 **1 x DAC08** Digital to analogue convertor with data
BO58 **4 x OPTO ISOLATOR**

**Please use order code when ordering the bargain packs.**

**Please make cheques and postal orders payable to Mailtech.**

All prices include VAT.
Please add 75p postage to all orders.

*At the moment it is not possible to have a full telephone answering service. But we will have the phone definitely manned on Tuesdays, Wednesdays and Thursdays between 10am and 5pm.*

**Dept EE, Mailtech**
**PO Box 16 Ludlow**
**Shropshire SY8 4NA**
**Tel: 058 474475**

# ESR ELECTRONIC COMPONENTS

Station Road, Cullercoats,
Tyne & Wear NE30 4PQ
Tel. 091 251 4363 Fax. 091 252 2296

## 74LS Series

| | |
|---|---|
| 74LS00 | £0.14 |
| 74LS01 | £0.14 |
| 74LS02 | £0.14 |
| 74LS03 | £0.14 |
| 74LS04 | £0.14 |
| 74LS05 | £0.14 |
| 74LS08 | £0.14 |
| 74LS09 | £0.14 |
| 74LS10 | £0.14 |
| 74LS107 | £0.23 |
| 74LS109 | £0.21 |
| 74LS11 | £0.17 |
| 74LS112 | £0.21 |
| 74LS113 | £0.21 |
| 74LS114 | £0.21 |
| 74LS12 | £0.14 |
| 74LS122 | £0.31 |
| 74LS123 | £0.31 |
| 74LS125 | £0.21 |
| 74LS126 | £0.21 |
| 74LS13 | £0.14 |
| 74LS132 | £0.21 |
| 74LS133 | £0.18 |
| 74LS136 | £0.16 |
| 74LS138 | £0.24 |
| 74LS139 | £0.25 |
| 74LS14 | £0.18 |
| 74LS145 | £0.56 |
| 74LS147 | £1.26 |
| 74LS148 | £0.70 |
| 74LS15 | £0.14 |
| 74LS151 | £0.25 |
| 74LS153 | £0.25 |
| 74LS154 | £0.70 |
| 74LS155 | £0.25 |
| 74LS156 | £0.25 |
| 74LS157 | £0.25 |
| 74LS158 | £0.25 |
| 74LS160 | £0.32 |
| 74LS161 | £0.32 |
| 74LS162 | £0.32 |
| 74LS163 | £0.32 |
| 74LS164 | £0.26 |
| 74LS165 | £0.48 |
| 74LS170 | £0.30 |
| 74LS173 | £0.24 |
| 74LS174 | £0.24 |
| 74LS175 | £0.24 |
| 74LS190 | £0.25 |
| 74LS191 | £0.24 |
| 74LS192 | £0.24 |
| 74LS193 | £0.24 |
| 74LS195 | £0.24 |
| 74LS196 | £0.24 |
| 74LS197 | £0.24 |
| 74LS20 | £0.16 |
| 74LS21 | £0.14 |
| 74LS22 | £0.14 |
| 74LS221 | £0.36 |
| 74LS240 | £0.32 |
| 74LS241 | £0.32 |
| 74LS242 | £0.32 |
| 74LS243 | £0.32 |
| 74LS244 | £0.32 |
| 74LS245 | £0.33 |
| 74LS247 | £0.32 |
| 74LS251 | £0.24 |
| 74LS257 | £0.24 |
| 74LS258 | £0.24 |
| 74LS26 | £0.14 |
| 74LS266 | £0.14 |
| 74LS27 | £0.14 |
| 74LS273 | £0.32 |
| 74LS279 | £0.25 |
| 74LS30 | £0.14 |
| 74LS32 | £0.14 |
| 74LS365 | £0.21 |
| 74LS367 | £0.21 |
| 74LS368 | £0.21 |
| 74LS37 | £0.14 |
| 74LS373 | £0.32 |
| 74LS374 | £0.32 |
| 74LS375 | £0.34 |
| 74LS377 | £0.32 |
| 74LS378 | £0.62 |
| 74LS38 | £0.14 |
| 74LS390 | £0.25 |
| 74LS393 | £0.24 |
| 74LS395 | £0.26 |
| 74LS399 | £0.62 |
| 74LS40 | £0.14 |
| 74LS42 | £0.25 |
| 74LS47 | £0.42 |
| 74LS51 | £0.14 |
| 74LS670 | £0.69 |
| 74LS73 | £0.17 |
| 74LS74 | £0.19 |
| 74LS75 | £0.19 |
| 74LS76 | £0.25 |
| 74LS83 | £0.31 |
| 74LS85 | £0.35 |
| 74LS86 | £0.20 |
| 74LS90 | £0.23 |
| 74LS92 | £0.35 |
| 74LS93 | £0.25 |

## 4000 Series

| | |
|---|---|
| 4000 | £0.17 |
| 4001 | £0.17 |
| 4002 | £0.17 |
| 4006 | £0.32 |
| 4007 | £0.17 |
| 4008 | £0.31 |
| 4009 | £0.19 |
| 4010 | £0.23 |
| 4011 | £0.16 |
| 4012 | £0.16 |
| 4013 | £0.17 |
| 4014 | £0.30 |
| 4015 | £0.31 |
| 4016 | £0.18 |
| 4017 | £0.27 |
| 4018 | £0.27 |
| 4019 | £0.19 |
| 4020 | £0.31 |
| 4021 | £0.31 |
| 4022 | £0.32 |
| 4023 | £0.16 |
| 4024 | £0.21 |
| 4025 | £0.15 |
| 4026 | £0.59 |
| 4027 | £0.18 |
| 4028 | £0.22 |
| 4029 | £0.27 |
| 4030 | £0.17 |
| 4031 | £0.70 |
| 4033 | £0.56 |
| 4034 | £1.24 |
| 4035 | £0.31 |
| 4040 | £0.31 |
| 4041 | £0.31 |
| 4042 | £0.22 |
| 4043 | £0.28 |
| 4044 | £0.35 |
| 4046 | £0.31 |
| 4047 | £0.25 |
| 4048 | £0.31 |
| 4049 | £0.20 |
| 4050 | £0.20 |
| 4051 | £0.25 |
| 4052 | £0.25 |
| 4053 | £0.25 |
| 4054 | £0.56 |
| 4055 | £0.34 |
| 4060 | £0.31 |
| 4063 | £0.29 |
| 4066 | £0.18 |
| 4067 | £1.91 |
| 4068 | £0.16 |
| 4069 | £0.20 |
| 4070 | £0.17 |
| 4071 | £0.20 |
| 4072 | £0.17 |
| 4073 | £0.17 |
| 4075 | £0.17 |
| 4076 | £0.30 |
| 4077 | £0.17 |
| 4081 | £0.14 |
| 4082 | £0.17 |
| 4085 | £0.28 |
| 4086 | £0.26 |
| 4089 | £0.55 |
| 4093 | £0.18 |
| 4094 | £0.31 |
| 4095 | £0.56 |
| 4097 | £1.20 |
| 4098 | £0.31 |
| 4099 | £0.38 |
| 4502 | £0.38 |
| 4503 | £0.31 |
| 4508 | £0.90 |
| 4510 | £0.26 |
| 4511 | £0.32 |
| 4512 | £0.32 |
| 4514 | £0.73 |
| 4515 | £0.98 |
| 4516 | £0.31 |
| 4518 | £0.27 |
| 4520 | £0.26 |
| 4521 | £0.62 |
| 4526 | £0.40 |
| 4527 | £0.39 |
| 4528 | £0.40 |
| 4529 | £0.44 |
| 4532 | £0.32 |
| 4534 | £2.24 |
| 4536 | £1.00 |
| 4538 | £0.37 |
| 4541 | £0.33 |
| 4543 | £0.46 |
| 4555 | £0.34 |
| 4556 | £0.34 |
| 4560 | £1.18 |
| 4566 | £1.96 |
| 4572 | £0.25 |
| 4584 | £0.24 |
| 4585 | £0.32 |
| 4724 | £0.70 |
| 40106 | £0.31 |
| 40109 | £0.50 |
| 40163 | £0.46 |
| 40174 | £0.34 |
| 40175 | £0.36 |
| 40193 | £0.60 |

## TRANSISTORS

| | | | | | |
|---|---|---|---|---|---|
| 2N1613 | £0.31 | BC186 | £0.33 | BD534 | £0.47 |
| 2N1711 | £0.26 | BC204C | £0.72 | BD535 | £0.48 |
| 2N1893 | £0.29 | BC206B | £0.72 | BD536 | £0.65 |
| 2N2218A | £0.28 | BC207C | £0.72 | BD646 | £0.52 |
| 2N2219A | £0.25 | BC208 | £0.72 | BD648 | £0.52 |
| 2N2222A | £0.16 | BC209A | £0.72 | BD650 | £0.53 |
| 2N2646 | £0.80 | BC212 | £0.08 | BD707 | £0.42 |
| 2N2904A | £0.25 | BC212L | £0.08 | BD807 | £0.80 |
| 2N2905A | £0.23 | BC212LB | £0.08 | BDX32 | £1.78 |
| 2N2907 | £0.20 | BC213 | £0.08 | BDX33C | £0.46 |
| 2N2926 | £0.16 | BC213LC | £0.08 | BDX34C | £0.50 |
| 2N3053 | £0.27 | BC214 | £0.08 | BDX53C | £0.47 |
| 2N3054 | £0.90 | BC214L | £0.08 | BDX54C | £0.50 |
| 2N3055 | £0.62 | BC237B | £0.09 | BF180 | £0.31 |
| 2N3440 | £0.50 | BC238C | £0.09 | BF182 | £0.31 |
| 2N3702 | £0.09 | BC239C | £0.10 | BF185 | £0.31 |
| 2N3703 | £0.10 | BC251 | £0.13 | BF194 | £0.19 |
| 2N3704 | £0.10 | BC252 | £0.13 | BF195 | £0.19 |
| 2N3705 | £0.10 | BC261B | £0.24 | BF244 | £0.35 |
| 2N3706 | £0.10 | BC262B | £0.24 | BF257 | £0.33 |
| 2N3771 | £1.44 | BC267B | £0.30 | BF259 | £0.33 |
| 2N3772 | £1.51 | BC307 | £0.10 | BF337 | £0.36 |
| 2N3773 | £1.79 | BC308 | £0.10 | BF355 | £0.38 |
| 2N3819 | £0.40 | BC327 | £0.10 | BF423 | £0.13 |
| 2N3820 | £0.58 | BC328 | £0.10 | BF451 | £0.19 |
| 2N3904 | £0.10 | BC337 | £0.10 | BF459 | £0.29 |
| 2N3905 | £0.10 | BC338 | £0.10 | BF469 | £0.36 |
| 2N3906 | £0.10 | BC414C | £0.13 | BFX29 | £0.29 |
| 2N4036 | £0.31 | BC441 | £0.40 | BFX84 | £0.31 |
| 2N5296 | £0.57 | BC461 | £0.40 | BFX85 | £0.31 |
| 2N5321 | £0.57 | BC463 | £0.29 | BFY50 | £0.29 |
| 2N6107 | £0.60 | BC478 | £0.32 | BFY51 | £0.26 |
| AC126 | £0.30 | BC479 | £0.32 | BFY52 | £0.28 |
| AC127 | £0.30 | BC490 | £0.24 | BS107 | £0.21 |
| AC128 | £0.28 | BC516 | £0.22 | BS170 | £0.21 |
| AC187 | £0.45 | BC517 | £0.20 | BSW66 | £1.35 |
| AC188 | £0.37 | BC527 | £0.20 | BU126 | £1.70 |
| ACY17 | £3.84 | BC528 | £0.20 | BU205 | £1.82 |
| AD149 | £1.67 | BC537 | £0.20 | BU208A | £1.73 |
| AD161 | £0.92 | BC546C | £0.08 | BU326A | £1.80 |
| AD162 | £0.92 | BC547C | £0.09 | BU500 | £2.32 |
| BC107 | £0.14 | BC548C | £0.08 | BU508A | £1.76 |
| BC107B | £0.15 | BC549C | £0.10 | BU526 | £2.24 |
| BC108 | £0.13 | BC550C | £0.08 | BU806 | £1.36 |
| BC108A | £0.14 | BC556A | £0.08 | BUX84 | £0.77 |
| BC108C | £0.16 | BC557C | £0.08 | IRF540 | £1.60 |
| BC109 | £0.14 | BC558C | £0.08 | IRF740 | £1.63 |
| BC109C | £0.15 | BC559C | £0.08 | MJ11015 | £2.11 |
| BC114 | £0.41 | BC560B | £0.09 | MJ11016 | £2.11 |
| BC115 | £0.41 | BC637 | £0.21 | MJ2501 | £1.60 |
| BC116 | £0.41 | BC638 | £0.21 | MJ3001 | £1.52 |
| BC118 | £0.41 | BC639 | £0.21 | MJE340 | £0.40 |
| BC132 | £0.36 | BC640 | £0.21 | MJE350 | £0.42 |
| BC134 | £0.36 | BCY70 | £0.21 | MPSA13 | £0.12 |
| BC135 | £0.36 | BCY71 | £0.20 | MPSA42 | £0.17 |
| BC140 | £0.25 | BCY72 | £0.20 | MRF475 | £6.21 |
| BC141 | £0.27 | BD135 | £0.20 | TIP121 | £0.35 |
| BC142 | £0.31 | BD136 | £0.21 | TIP122 | £0.37 |
| BC143 | £0.34 | BD137 | £0.22 | TIP125 | £0.37 |
| BC149 | £0.12 | BD138 | £0.22 | TIP127 | £0.37 |
| BC154 | £0.36 | BD139 | £0.23 | TIP132 | £0.46 |
| BC157 | £0.12 | BD140 | £0.24 | TIP137 | £0.46 |
| BC159 | £0.12 | BD150C | £0.82 | TIP142 | £1.06 |
| BC160 | £0.28 | BD165 | £0.42 | TIP147 | £1.12 |
| BC170 | £0.16 | BD166 | £0.35 | TIP2955 | £0.63 |
| BC170B | £0.16 | BD187 | £0.39 | TIP29C | £0.31 |
| BC171 | £0.11 | BD201 | £0.40 | TIP3055 | £0.63 |
| BC171B | £0.16 | BD202 | £0.40 | TIP30C | £0.31 |
| BC172 | £0.13 | BD203 | £0.40 | TIP31C | £0.32 |
| BC172B | £0.13 | BD204 | £0.40 | TIP32C | £0.38 |
| BC177 | £0.18 | BD222 | £0.40 | TIP33C | £0.72 |
| BC178 | £0.18 | BD225 | £0.42 | TIP41A | £0.36 |
| BC179 | £0.17 | BD232 | £0.38 | TIP42C | £0.38 |
| BC182 | £0.08 | BD237 | £0.32 | TIP47 | £0.48 |
| BC182L | £0.08 | BD238 | £0.32 | TIP48 | £0.62 |
| BC182LB | £0.08 | BD240B | £0.37 | TIP50 | £0.53 |
| BC183 | £0.08 | BD243B | £0.50 | VN10KM | £0.44 |
| BC183L | £0.08 | BD244A | £0.53 | VN66AF | £1.50 |
| BC183LB | £0.08 | BD246 | £1.06 | ZTX300 | £0.16 |
| BC184 | £0.08 | BD441 | £0.41 | ZTX500 | £0.16 |
| BC184L | £0.08 | BD442 | £0.41 | | |

## LINEAR ICs

| | |
|---|---|
| CA311E | £0.28 |
| CA324 | £0.23 |
| CA555 | £0.22 |
| CA741CE | £0.18 |
| CA747CE | £0.39 |
| CA3046 | £0.37 |
| CA3080 | £0.72 |
| CA3130 | £0.98 |
| CA3130E | £0.98 |
| CA3140 | £0.56 |
| CA3240 | £1.22 |
| ICL7621 | £1.70 |
| ICM7555 | £0.43 |
| ICM7556 | £0.96 |
| LM301A | £0.25 |
| LM348N | £0.31 |
| LF351N | £0.36 |
| LF353 | £0.41 |
| LM358N | £0.27 |
| LM377 | £2.57 |
| LM380N | £1.12 |
| LM381 | £2.70 |
| LM386 | £0.48 |
| LM387 | £1.60 |
| LM392N | £0.79 |
| LM393N | £0.28 |
| LM748CN | £0.31 |
| LM1458 | £0.26 |
| LM3900 | £0.72 |
| LM3914 | £2.70 |
| LM3915 | £2.70 |
| MC3340 | £1.60 |
| MC4558 | £0.36 |
| NE531 | £1.56 |
| NE556N | £0.36 |
| NE567N | £0.36 |
| NE5532 | £0.80 |
| NE5534 | £0.66 |
| TBA120S | £0.77 |
| TBA810S | £0.68 |
| TBA820M | £0.39 |
| TDA2030 | £1.35 |
| TL061 | £0.35 |
| TL062 | £0.42 |
| TL064 | £0.46 |
| TL071CP | £0.32 |
| TL072CP | £0.34 |
| TL074CN | £0.48 |
| TL081 | £0.33 |
| TL082CP | £0.34 |
| TL084CN | £0.46 |
| UA733 | £0.64 |
| ULN2004 | £0.48 |
| ZN414Z | £1.04 |
| ZN425E | £4.68 |
| ZN426E | £2.61 |
| ZN427E | £8.82 |
| ZN428E | £6.12 |
| ZN435E | £5.31 |
| ZN448E | £7.92 |

## EPROMS & RAMS

| | |
|---|---|
| 2716 | £4.46 |
| 2732 | £4.84 |
| 27128-20 | £3.69 |
| 2764-25 | £3.00 |
| 27C64-25 | £2.80 |
| 21728-20 | £3.15 |
| 27C128-20 | £3.31 |
| 27256-20 | £3.15 |
| 27C256-20 | £3.55 |
| 27C512 | £3.69 |
| 27C010 | £4.97 |
| 6116-10 | £1.53 |
| 6264-10 | £3.06 |
| 62256-10 | £5.35 |
| 4164-15 | £1.78 |
| 41256-10 | £2.80 |
| 511000-8 | £5.61 |
| 514256-8 | £5.61 |

## TRIACS

| | |
|---|---|
| Z0105DA | £0.42 |
| TIC206D | £0.65 |
| TIC226D | £0.73 |
| BTA08-600B | £0.84 |
| TIC236D | £0.96 |
| DIAC | £0.20 |

## THYRISTORS

| | |
|---|---|
| PO102AA | £0.30 |
| TIC106D | £0.40 |
| TIC116D | £0.66 |
| TIC126D | £0.77 |

## VOLTAGE REGULATORS

| | |
|---|---|
| 78L05 | £0.24 |
| 78L12 | £0.24 |
| 78L15 | £0.24 |
| 79L05 | £0.28 |
| 79L12 | £0.28 |
| 79L15 | £0.28 |
| 7805 | £0.28 |
| 7812 | £0.28 |
| 7815 | £0.28 |
| 7905 | £0.38 |
| 7912 | £0.38 |
| 7915 | £0.38 |
| LM317T | £0.44 |
| LM723 | £0.29 |
| L200CV | £1.16 |
| LM323K | £2.70 |
| LM338K | £6.62 |

## HARDWARE

| | |
|---|---|
| T2 Box 75 x 56 x 25mm | £0.82 |
| T3 Box 75 x 51 x 25mm | £0.82 |
| T4 Box 111 x 57 x 22mm | £0.98 |
| MB1 Box 79 x 61 x 40mm | £1.44 |
| MB2 Box 100 x 76 x 41mm | £1.56 |
| MB3 Box 118 x 98 x 45mm | £1.82 |
| MB5 Box 150 x 100 x 60mm | £2.50 |

## DIL SOCKETS

| | |
|---|---|
| 8 Pin | £0.07 |
| 14 Pin | £0.11 |
| 16 Pin | £0.15 |
| 18 Pin | £0.15 |
| 20 Pin | £0.16 |
| 24 Pin | £0.19 |
| 28 Pin | £0.22 |
| 40 Pin | £0.25 |

## ELECTROLYTIC RADIAL CAPACITORS

| uF | 16V | 25V | 63V | 100V | 450V |
|---|---|---|---|---|---|
| 0.47 | – | – | £0.05 | £0.07 | – |
| 1.0 | – | – | £0.05 | £0.06 | £0.15 |
| 2.2 | – | – | £0.05 | £0.06 | £0.18 |
| 4.7 | – | – | £0.05 | £0.08 | £0.30 |
| 10 | £0.05 | £0.05 | £0.06 | £0.08 | £0.48 |
| 22 | £0.05 | £0.05 | £0.09 | – | – |
| 47 | £0.06 | £0.06 | £0.11 | – | – |
| 100 | £0.06 | £0.09 | £0.11 | – | – |
| 220 | £0.09 | £0.12 | £0.31 | – | – |
| 470 | £0.15 | £0.19 | £0.57 | – | – |
| 1000 | £0.22 | £0.29 | – | – | – |
| 2200 | £0.37 | £0.57 | – | – | – |
| 4700 | – | £1.11 | – | – | – |

## ELECTROLYTIC AXIAL CAPACITORS

| uF | 16V | 25V | 63V | 100V | 450V |
|---|---|---|---|---|---|
| 0.47 | – | – | – | £0.15 | – |
| 1.0 | – | – | £0.10 | £0.10 | £0.19 |
| 2.2 | – | – | £0.10 | £0.10 | £0.22 |
| 4.7 | – | £0.09 | £0.10 | £0.10 | £0.34 |
| 10 | – | £0.12 | £0.10 | £0.12 | £0.48 |
| 22 | – | £0.09 | £0.13 | £0.17 | £1.06 |
| 47 | £0.10 | £0.11 | £0.16 | £0.20 | £1.33 |
| 100 | £0.10 | £0.13 | £0.21 | – | £2.46 |
| 220 | £0.13 | £0.18 | £0.42 | – | – |
| 470 | £0.21 | £0.24 | £0.69 | – | – |
| 1000 | £0.33 | £0.40 | £1.05 | – | – |
| 2200 | £0.52 | £0.64 | – | – | – |
| 4700 | £0.90 | – | – | – | – |

## ENAMELLED COPPER WIRE

All 2oz Reels

| | |
|---|---|
| 14 SWG | £0.63 |
| 16 SWG | £0.67 |
| 18 SWG | £0.67 |
| 20 SWG | £0.72 |
| 22 SWG | £0.76 |
| 24 SWG | £0.80 |
| 26 SWG | £0.89 |
| 28 SWG | £0.91 |
| 30 SWG | £0.93 |
| 32 SWG | £0.93 |
| 34 SWG | £0.99 |
| 36 SWG | £1.04 |
| 38 SWG | £1.10 |
| 40 SWG | £1.22 |

## OPTO DEVICES

| | |
|---|---|
| 5mm Red LED | £0.09 |
| 5mm Green LED | £0.10 |
| 5mm Yellow LED | £0.10 |
| 5mm Orange LED | £0.10 |
| 3mm Red LED | £0.08 |
| 3mm Green LED | £0.12 |
| 3mm Yellow LED | £0.13 |
| 3mm Orange LED | £0.13 |
| 5mm Flashing Red | £0.50 |
| 5mm Flashing Green | £0.54 |
| 5mm Bi Colour | £0.36 |
| 5mm Tri Colour | £0.48 |
| 5mm Plastic Bezel | £0.04 |
| 3mm Plastic Bezel | £0.05 |
| 0.3" 7 Segment Display Red | |
| common anode | £1.14 |
| common cathode | £1.14 |

## SOLDERING IRONS

| | |
|---|---|
| Antex Soldering irons | |
| M 12 Watt | £7.75 |
| C 15Watt | £7.78 |
| G 18Watt | £7.96 |
| CS 17Watt | £7.88 |
| XS 25Watt | £7.96 |
| ST4 STAND | £2.85 |
| 35Watt Gas Iron | £11.58 |
| Desolder Pump | £3.00 |
| Antistatic Pump | £4.30 |
| 22SWG 0.5Kg Solder | £7.40 |
| 18SWG 0.5Kg Solder | £6.60 |
| 1mm 3 yds Solder | £0.62 |
| Desolder Braid | £0.87 |

## RF CONNECTORS

| | |
|---|---|
| BNC Solder Plug 50R | £0.93 |
| BNC Solder Plug 75R | £0.96 |
| BNC Crimp Plug 50R | £0.68 |
| BNC Crimp Plug 75R | £0.68 |
| BNC Solder Skt | £1.08 |
| BNC Chassis Skt | £0.80 |
| PL259 5.2mm | £0.68 |
| PL259 11mm | £0.62 |
| RND UHF socket | £0.68 |
| SQR UHF socket | £0.45 |
| F Plug RG58 | £0.30 |
| F Plug RG6 | £0.27 |
| N Plug RG8 | £1.60 |
| N Socket RG8 | £1.40 |
| BNC Crimp Pliers | £15.50 |

## PCB EQUIPMENT

| | |
|---|---|
| UV EXPOSURE UNIT | £67.38 |
| PLASTIC DEVELOPING TRAY | £1.35 |
| PHOTO RESIST AEROSOL SPRAY (100ml) | £3.90 |
| FERRIC CHLORIDE CRYSTALS (0.5Kg) | £2.45 |
| TIN PLATING POWDER (90g) | £10.80 |
| ETCH RESIST PEN | £0.72 |
| PCB POLISHING BLOCK | £1.84 |

### STRIPBOARD 0·1 PITCH

| | |
|---|---|
| 64mm x 25mm | £0.27 |
| 64mm x 95mm | £0.90 |
| 64mm x 431mm | £3.22 |
| 95mm x 127mm | £1.50 |
| 95mm x 95mm | £1.10 |
| 95mm x 431mm | £4.80 |
| 100mm x 160mm | £1.60 |
| 119mm x 454mm | £6.20 |

### BREADBOARD

| | |
|---|---|
| 81mm x 60mm | £3.06 |
| 175mm x 42mm | £3.74 |
| 175mm x 67mm | £5.56 |
| 203mm x 75mm includes mounting plate & posts | £7.36 |

### COPPER BOARD (G. Fibre)

| | |
|---|---|
| 100mm x 160mm | £0.90 |
| 110mm x 220mm | £1.24 |

### PHOTO RESIST BOARD (G. Fibre)

| | |
|---|---|
| 3" x 4" | £0.86 |
| 4" x 6" | £1.62 |
| 4" x 8" | £2.09 |
| 6" x 6" | £2.41 |

### PHOTO RESIST BOARD (Paper)

| | |
|---|---|
| 3" x 4" | £0.67 |
| 4" x 6" | £1.24 |
| 4" x 8" | £1.58 |
| 8" x 10" | £4.63 |

## CAPACITORS

Ceramic Mini Disc 100 & 63V
1.0pF to 100nF
1pF-1nF £0.06, 1n2-2n7 £0.07,
3n3-4n7 £ 0.12,
10n & 12n £0.07
Polystyrene 160V 5% 47pF to 10nF
47p-2n2 £0.09, 2n7-10n £0.12

## SWITCHES

3amp 250v 6.4mm φ mounting

| | |
|---|---|
| SPST Toggle | £0.58 |
| SPDT Toggle | £0.60 |
| SPDT CO Tog | £0.64 |
| DPDT Toggle | £0.68 |
| DPDT CO Toggle | £0.76 |
| DPDT CO Toggle (biased) | £1.20 |
| DPDT CO Toggle (biased 1 way) | £1.20 |
| DPDT mini slide | £0.15 |
| Rotary Wafer 1P-12W, 2P-6W, 3P-4W, 4P-3W | £0.78 |
| Key Switch SPST | £2.70 |
| Push to make | £0.25 |
| Push to break | £0.28 |
| Latching Push Sqr | £0.63 |
| PCB Tact 6 x 6mm | £0.25 |

## D CONNECTORS

| | Plug | Socket |
|---|---|---|
| 9 Pin | £0.29 | £0.30 |
| 15 Pin | £0.39 | £0.39 |
| 15 Pin H.D. | £0.81 | £0.90 |
| 23 Pin | £0.40 | £0.49 |
| 25 Pin | £0.48 | £0.50 |
| 9 Way plastic cover | | £0.30 |
| 15 Way plastic cover | | £0.33 |
| 23 Way plastic cover | | £0.36 |
| 25 Way plastic cover | | £0.36 |

## BRIDGE RECTIFIERS

| | |
|---|---|
| W005 1.5A 50V | £0.19 |
| WO2 1.5A 200V | £0.20 |
| BR32 3A 200V | £0.36 |
| BR62 6A 200V | £0.64 |
| 1004 10A 400V | £1.39 |

## RESISTORS

| | |
|---|---|
| 0.25W 5% CF E12 Series | £0.60/100 |
| 0.5W 5% CF E12 Series | £0.95/100 |
| 0.25W 1% MF E24 Series | £1.72/100 |
| POTS Log or Lin 470R – 1MO 25mm dia 0.25in shaft | £0.42 |
| PRESETS Enclosed Horz or Vert 100R – 1MO 0.15W | £0.15 |
| PRESETS Skeleton Horz or Vert 100R – 1MO 0.1W | £0.11 |

★ PLEASE STATE VALUE REQUIRED ★

## COMPUTER ACCESSORIES

| | |
|---|---|
| Parallel Printer Lead 2m | £6.90 |
| RS232 Lead (all pins) Male – Male | £3.60 |
| RS232 Lead (all pins) Female – Male | £3.60 |
| Centronics 36 Way Lead Male – Male | £4.78 |
| **Gender Changers** | |
| 9 Way D Mini Female to Female | £1.81 |
| 9 Way D Mini Male to Male | £1.98 |
| 25 Way D Mini Female to Female | £2.23 |
| 25 Way D Mini Male to Male | £2.23 |
| 9 Way D Female to Female | £2.33 |
| 9 Way D Male to Male | £2.33 |
| 25 Way D Female to Female | £2.71 |
| 25 Way D Male to Male | £2.71 |
| **Adaptors** | |
| 9 Way Male to 25 Way Female | £2.33 |
| 25 Way Male to 9 Way Female | £2.33 |
| 25 Way D Male to 36 Way Centronic | £3.56 |
| 25 Way Null Modem Female – Female | £3.02 |
| 25 Way Null Modem Male to Female | £3.02 |
| 25 Way Null Modem Male to Male | £3.02 |
| RS232 Surge Protector Male - Female | £6.12 |
| RS232 Jumper Box Male to Female | £3.02 |
| RS232 Tester (7 LEDs) Male – Female | £6.59 |
| **Data Switch Boxes** | |
| Serial Switch box – 2 Way A/B | £9.20 |
| Serial Switch box – 3 Way A/B/C | £13.16 |
| Serial Switch box – 4 Way A/B/C/D | £15.15 |
| Serial Switch box – Cross over | £19.69 |
| Parallel box – 2 Way A/B | £11.84 |
| Parallel box – 3 Way A/B/C/ | £17.11 |
| Parallel box – 4 Way A/B/C/D | £18.43 |
| Parallel box – Cross over | £20.42 |

## DIODES

| | |
|---|---|
| Zener Diodes 2V7-33V | |
| BZY88400Mw | £0.08 |
| BZX85 1.3W | £0.14 |
| 1N4001 | £0.06 |
| 1N4002 | £0.07 |
| 1N4003 | £0.07 |
| 1N4004 | £0.07 |
| 1N4005 | £0.07 |
| 1N4006 | £0.08 |
| 1N4007 | £0.08 |
| 1N5400 | £0.09 |
| 1N5401 | £0.09 |
| 1N5402 | £0.09 |
| 1N5404 | £0.11 |
| 1N5406 | £0.11 |
| 1N5407 | £0.14 |
| 1N5408 | £0.15 |
| 1N914 | £0.06 |
| 1N916 | £0.06 |
| 1N4148 | £0.05 |
| BY133 | £0.13 |
| OA47 | £0.28 |
| OA90 | £0.07 |
| OA91 | £0.10 |
| OA202 | £0.27 |
| BA157 | £0.10 |
| BA158 | £0.10 |
| BA159 | £0.10 |
| 1N4149 | £0.06 |
| OA200 | £0.10 |

## ORDERING INFORMATION

All prices exclude VAT.
Please add £1.25 carriage to all orders and VAT (17.5%).
No minimum order charge.
Free Computer listing with all orders over £5.00.
Please send payment with your order.
PO/Cheques made payable to
**ESR Electronic Components**
Access & Visa cards accepted
Offical orders from schools & colleges welcome.

**CALL IN – OPEN: MON-FRI 8.30-5.00 SAT 10.00-5.00**

# EVERYDAY WITH PRACTICAL ELECTRONICS

INCORPORATING ELECTRONICS MONTHLY

**VOL. 22 No. 8** **AUGUST '93**



**Editorial Offices:**
EVERYDAY with PRACTICAL ELECTRONICS EDITORIAL,
6 CHURCH STREET, WIMBORNE,
DORSET BH21 1JH
Phone: Wimborne (0202) 881749
Fax: (0202) 841692. DX: Wimborne 45314.
See notes on **Readers' Enquiries** below – we regret that lengthy technical enquiries cannot be answered over the telephone.

**Advertisement Offices:**
EVERYDAY with PRACTICAL ELECTRONICS
ADVERTISEMENTS,
HOLLAND WOOD HOUSE, CHURCH LANE,
GREAT HOLLAND, ESSEX CO13 0JS.
Phone/Fax: (0255) 850596


## GOLDEN EARED

When you get to the end of John Linsley Hood's *Audio Amplifier Design – Engineering or Alchemy* series, you will find the following paragraph. "Much of what is claimed by the 'golden eared' fraternity, does exist – but is much, much smaller than they think – and when it exists, and it sometimes doesn't, there are good reasons why."

I feel it is one of those statements that will be well quoted over the coming years. The series leads up to this conclusion and explains it "stage by stage", looking first at tests, both listening and engineering, and going on to see how components, even wire, can affect the results. Few designers are as open minded or enlightened as John and his examples and conclusions are interesting and stimulating. The series will make you think and hopefully understand the various views proffered within the hi-fi fraternity.

We are sure that not everyone will agree with everything he says and your letters on the subject are welcome, we must however ask that you keep them as short as possible. We hope to provide a couple of John's amplifier designs to round off the series.

## DESCALER

Everytime you look around at the moment the subject of the effects of magnetism on fluids and gases is causing controversy. We have seen various articles and tests on magnets used for car fuel enhancement and even on beer to reduce the requirements of cleaning pipes in Public Houses. We are sure there is more to come on this subject.

We will certainly be interested to hear of readers' experiences with our *Experimental Electronic Pipe Descaler* and hopefully such information will lead to a better general understanding of the subject by Joe Public. Once again your letters are welcome.

While the action of magnetism on water seems to be well accepted, claims for other magnetic devices aimed at fuel saving are certainly not yet proven, or at least not yet generally accepted as being proven. Anyone want to try a Descaler on their car fuel line or boiler gas pipe?

Mike Kenward

### SUBSCRIPTIONS

Annual subscriptions for delivery direct to any address in the UK: £20. Overseas: £26 (£43.50 airmail). Cheques or bank drafts **(in £ sterling only)** payable to Everyday with Practical Electronics and sent to EPE Subscriptions Dept., 6 Church Street, Wimborne, Dorset BH21 1JH. Tel: 0202 881749. **Subscriptions start with the next available issue.** We accept Access (MasterCard) or Visa payments, minimum credit card order £5.


### BACK ISSUES

Certain back issues of EVERYDAY ELECTRONICS, PRACTICAL ELECTRONICS and EVERYDAY with PRACTICAL ELECTRONICS (from Nov '92 onwards) are available price £2.00 (£2.50 overseas surface mail) inclusive of postage and packing per copy – **£ sterling only please**, Visa and Access (MasterCard) accepted, minimum credit card order £5. Enquiries with remittance, made payable to Everyday with Practical Electronics, should be sent to Post Sales Department, Everyday with Practical Electronics, 6 Church Street, Wimborne, Dorset BH21 1JH Tel: 0202 881749. In the event of non-availability one article can be photostatted for the same price. *Normally sent within seven days but please allow 28 days for delivery.* **We have sold out of Jan, Feb, Mar, Apr, May, June, Oct, & Dec 88, Mar, May & Nov 89, Mar 90, April, Aug & Sept 91 Everyday Electronics, and can only supply back issues from Jan 92 to Oct 92 (excluding Mar 92) of Practical Electronics. Dec 92, Jan 93 and Feb 93 Everyday with Practical Electronics are also unavailable.**

### BINDERS

New style binders to hold one volume (12 issues) are now available from the above address for £4.95 plus £3.50 post and packing (for overseas readers the postage is £6.00 to everywhere except Australia and Papua New Guinea which cost £10.50). *Normally sent within seven days but please allow 28 days for delivery.*

**Payment in £ sterling only please.**
**Visa and Access (MasterCard) accepted, minimum credit card order £5. Send card number and card expiry date with your name and address etc.**


**Editor:** MIKE KENWARD
**Secretary:** PAM BROWN
**Deputy Editor:** DAVID BARRINGTON
**Business Manager:** DAVID J. LEAVER
**Subscriptions:** MARILYN GOLDBERG
**Editorial:** Wimborne (0202) 881749
**Advertisement Manager:**
PETER J. MEW, Frinton (0255) 850596
**Advertisement Copy Controller:**
DEREK NEW, Wimborne (0202) 882299


### READERS' ENQUIRIES

We are unable to offer any advice on the use, purchase, repair or modification of commercial equipment or the incorporation or modification of designs published in the magazine. We regret that we cannot provide data or answer queries on articles or projects that are more than five years old. Letters requiring a personal reply must be accompanied by a **stamped self-addressed envelope** or a **self addressed envelope and international reply coupons.**

All reasonable precautions are taken to ensure that the advice and data given to readers is reliable. We cannot however guarantee it and we cannot accept legal responsibility for it.

### COMPONENT SUPPLIES

**We do not supply electronic components or kits** for building the projects featured, these can be supplied by advertisers.

We advise readers to check that all parts are still available before commencing any project in a back-dated issue.

We regret that **we cannot provide data or answer queries on projects that are more than five years old.**

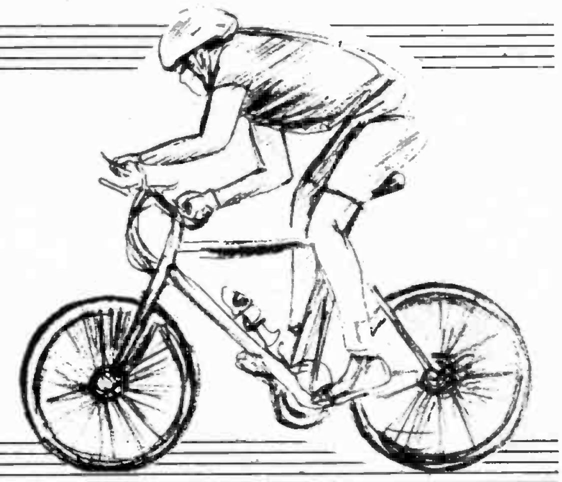
### ADVERTISEMENTS

Although the proprietors and staff of EVERYDAY with PRACTICAL ELECTRONICS take reasonable precautions to protect the interests of readers by ensuring as far as practicable that advertisements are *bona fide*, the magazine and its Publishers cannot give any undertakings in respect of statements or claims made by advertisers, whether these advertisements are printed as part of the magazine, or are in the form of inserts.

The Publishers regret that under no circumstances will the magazine accept liability for non-receipt of goods ordered, or for late delivery, or for faults in manufacture. Legal remedies are available in respect of some of these circumstances, and readers who have complaints should first address them to the advertiser.

### TRANSMITTERS/BUGS/TELEPHONE EQUIPMENT

We would like to advise readers that certain items of radio transmitting and telephone equipment which may be advertised in our pages cannot be legally used in the UK. Readers should check the law before using any transmitting or telephone equipment as a fine, confiscation of equipment and/or imprisonment can result from illegal use. The laws vary from country to country; overseas readers should check local laws.



# BIKE ODOMETER

STEVE KNIGHT

*Pedal power takes on a new meaning with this digital readout distance recorder.*

CYCLING is good for us all, so they say, and so a year or so ago the author abandoned his car and bought himself a two-wheeled machine with which he took to the leafy lanes whenever the sun was in the sky and strong winds were in another part of the country. All very nice and refreshing, too, but liking to know how far I had gone on each excursion so that my progress (or lack of it) could be quantified, I felt the need for some kind of distance measurer, or "odometer" as they call it in the trade.

Simple mechanical counters affixed to the front fork of the bike and tapped around by a projection attached to one of the spokes were common some years ago and perhaps still are. However, the making of an electronic system was enough of a challenge to get me started in that direction.

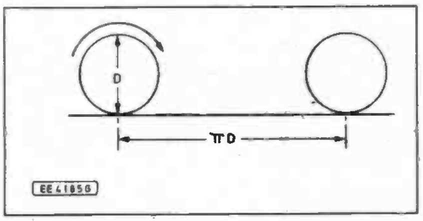



*Fig. 1. For each revolution of the wheel the distance travelled is π times the diameter.*

There is available a fully computerised odometer from "bike" shops which gives us not only distance but average speed, elapsed time, maximum speed and clock time; no doubt this will be used by entrants for the *Olympics* and the *Milk Race*, but something a little more basic (with component availability) will suit the rest of us.

## BASIC PRINCIPLES

Basically any distance measuring system must depend upon counting the number of revolutions a wheel, of known circumference, makes during a particular journey, and interpreting this number in terms of the total distance travelled. For a wheel of diameter D as shown in Fig. 1, the distance travelled per revolution is $\pi D$, hence the number of revolutions per mile (or km) is easily found by dividing the mile (or the km) by the distance $\pi D$, both in the appropriate units.

Knowing by some means how many revolutions have been made over the journey, the total distance can then be determined. To keep things uncomplicated we will work in miles, but anyone who wishes to work in metric may do so by following the same approach to the problem and making the necessary adjustments to the dividing circuitry in the general design.

There are three basic questions to ask before beginning an odometer design; what kind of display should be used; what kind of accuracy is required to make the building of the unit worth the while, and what maximum mileage needs to be recorded?

Well, answering the last question first. Not being an entrant for the *Milk Race* and being completely satisfied with a leisurely ride of perhaps twenty to thirty miles with a country pub somewhere about the halfway mark, I plumped for a maximum readout of 100 miles (161km), in steps of 0·1 mile.

So returning to the first question, what kind of display do we want, this can now be a three-digit l.e.d. system reading up to 99·9 miles. And the accuracy? Well, as we shall see later on, the basic accuracy *at* the 0·1 mile points can be less than one per cent; however, the *readable* accuracy must lie within the 0·1 mile minimum step.

For instance, at the end of a ride, if the display indicates, say, 23·4 miles, the actual distance may be anything from 23·4 miles to 23·49 miles; you may have only just passed the 23·4 mark or you may be just short of the 23·5 mark. But an "error" of 176 yards (0·1 mile) is not a lot to worry about on a journey of several miles and the added complication of another decimal place to read to an accuracy of 0·01 mile is hardly justified. So down to a practical design.

## BASIC CALCULATIONS

The cycle to be fitted with the odometer had 24in. diameter wheels, which are common enough, and the overall diameter with the tyres, measured from hub to ground with the machine upright was 26.2in. Working from this figure, the wheel circumference is $26{\cdot}2\pi$ or 82.3in. In travelling 0·1 mile, or 6336in., therefore, the wheel will rotate 6336/82.3 = 77 times. What we want, then, is a circuit system based on the block diagram of Fig. 2.

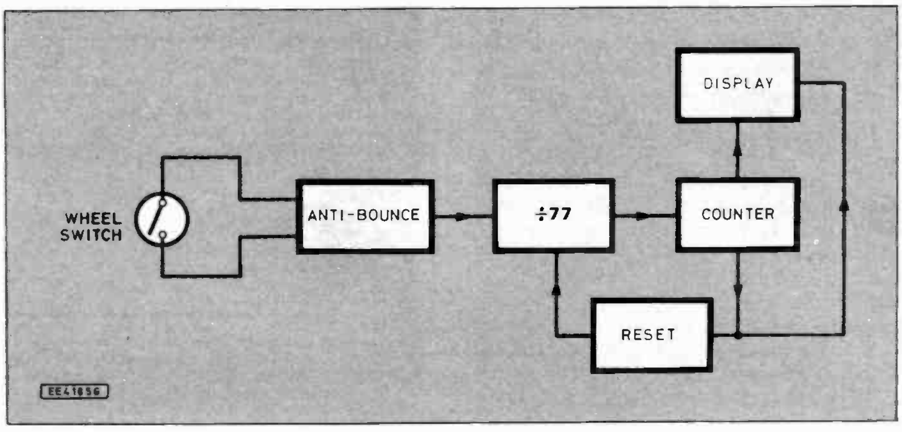
Some sort of wheel operated switch sends a pulse for each rotation of the wheel, via an anti-bounce circuit, to a system that will divide the input by 77, so that an output pulse is obtained for every 77 input pulses. Hence an output pulse is received for each 0·1 mile travelled. By counting these pulses and showing the result on a conventional display, the mileage covered will be indicated in steps of 0·1 mile up to the maximum of 99·9 miles.

Slight variations in tyre size will, of course, affect things somewhat, but even for changes in the overall wheel diameter of up to 0·5in., the error will be quite small and of little significance on the accuracy of the readout.

## CIRCUIT DESCRIPTION

Division by 77 is not quite so straightforward as division by, say, five or 10. There

*Fig. 2. The block diagram for the Cycle Odometer designed for nominal 26in. wheels.*



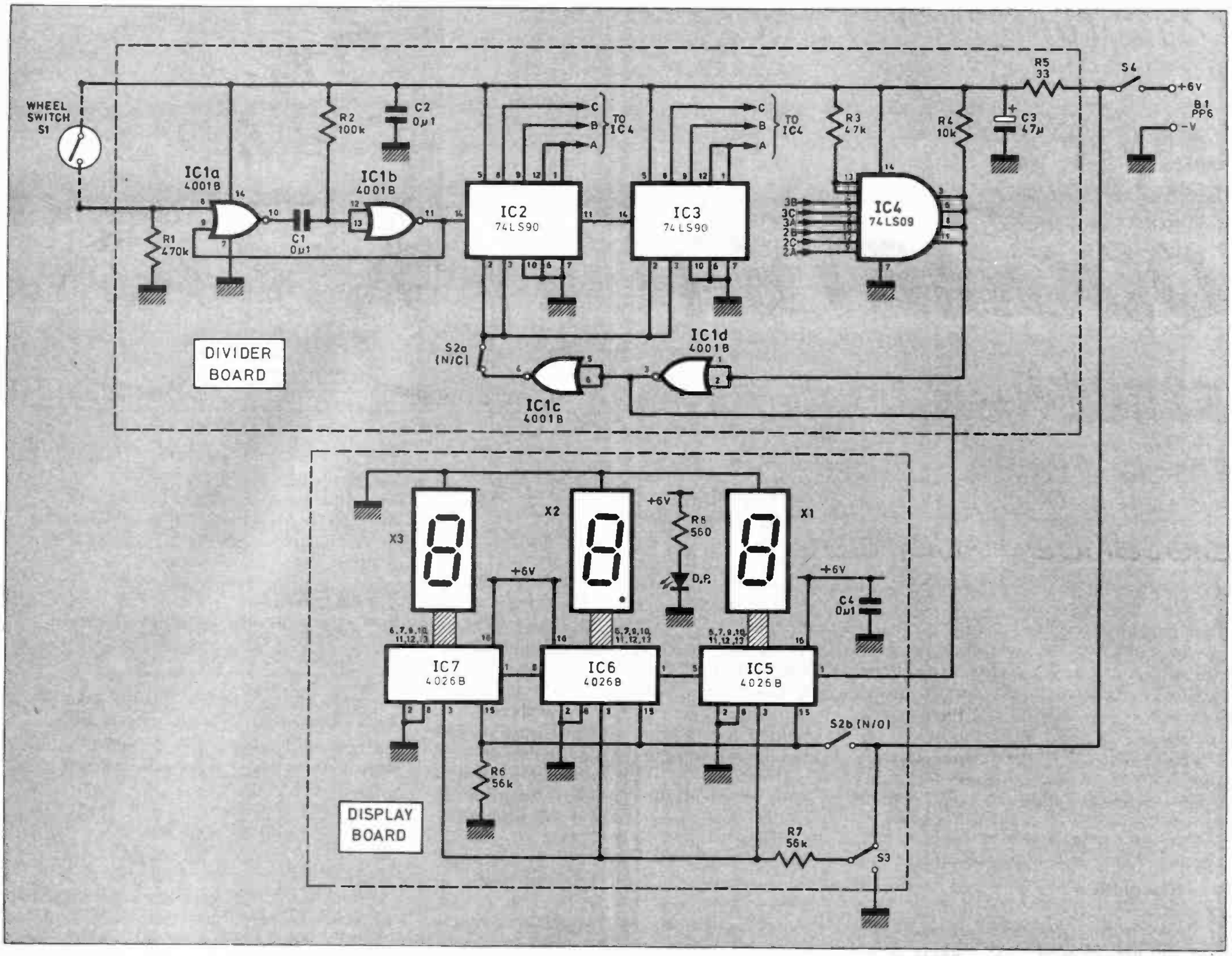



*Fig. 3. Full circuit diagram for the Bike Odometer. The circuit is built in two stages – Divider board and Display board.*

are a number of ways of achieving the division but the one used employs a couple of 74LS90 decade counter i.c.s followed by a 74LS09 quad 2-input AND gate i.c., with open-collector outputs.

It is possible to use the reset-to-nine facilities on the 74LS90 to divide by 7, but it is easier in this circuit to use the AND gate method. A 4001B quad-input NOR chip additionally serves as a debouncing circuit for the wheel generated pulses and as a resetting and isolating buffer for the dividing circuits.

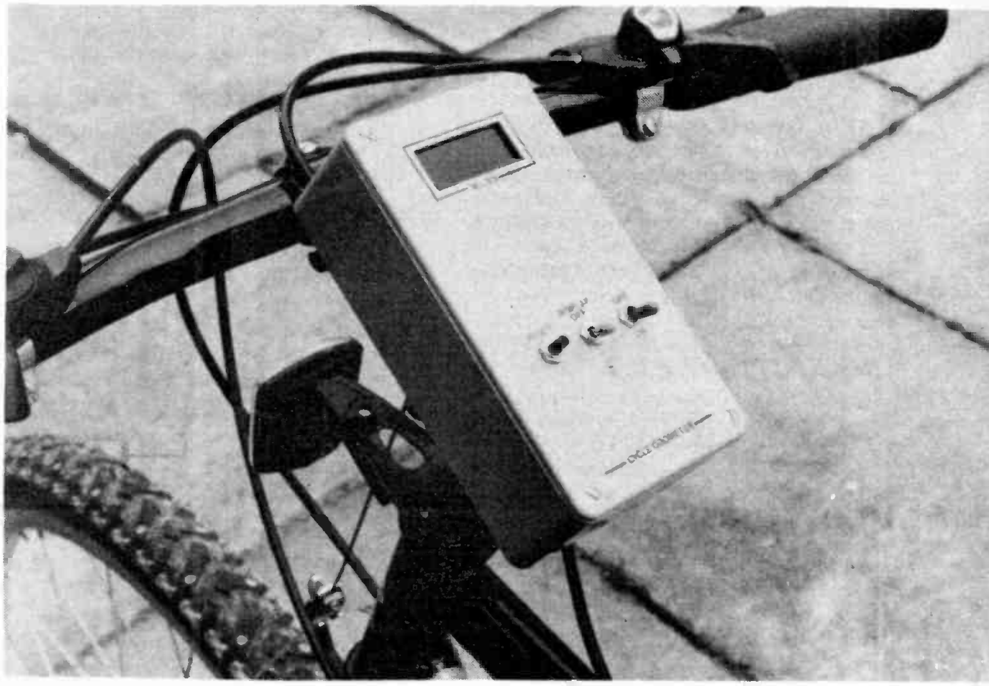
The complete circuit diagram for the Bike Odometer is shown in Fig. 3. This includes both the divider and the l.e.d. display systems. The assembly is on two small p.c.b.s (printed circuit boards), measuring 82mm by 55mm and 82mm by 45mm respectively. These are indicated by the broken outlines on the diagram; the upper being the divider system, debouncer and reset facilities, and the lower the display and the display counter and driver i.c.s.

## DIVIDER CIRCUIT

The wheel operated switch S1 (of which more later) closes once per wheel revolution; the resulting pulse passes through the conventional debouncer, IC1a, IC1b, to the input pin (14) of the first of the dividers, IC2. The first counter IC2 divides by 10 in the usual manner and on the tenth pulse input passes an output, from pin 11, to the input pin of IC3. This in turn is connected as a divide-by-10, so although in a normal situation this would enable a count up to 99 to be achieved, the output this time cannot exceed 77 before resetting to zero.

This is easily explained by looking at the circuit again. We have only a two-digit number to deal with and it is convenient to express this as two groups of binary, that is, as 0111 0111.

When the count of 77 is reached, therefore, the *A*, *B*, and *C* binary coded outputs of *both* dividers are all high. When these highs are applied to the inputs of the AND gate IC4, the output of this gate will also



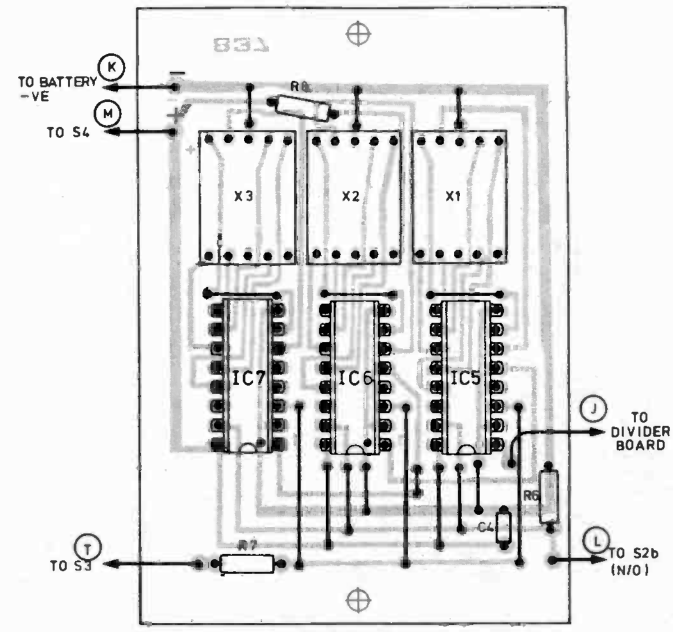




*Fig. 5. Display printed circuit board component layout and full size copper foil (opposite) master pattern.*

go high, hence a single pulse output is obtained for each group of 77 input pulses (or wheel revolutions) from the wheel switch.

The AND gate used is a 74LS09 (IC4) which as mentioned above comprises four 2-input AND gates with open-collector outputs. This last requirement is necessary as the four outputs can then be connected together with a single load resistor, R4, giving us an 8-input, single-output gate.

We need only six of these inputs for our present purpose, the remaining pair simply being held permanently high by returning them to the positive line by way of resistor R3. An output is then obtained only when all eight inputs are simultaneously high.

The output pulse is then passed to the counter display board by way of a buffering inverter IC1d and also to the reset pins of IC2 and IC3 via a further inverter, IC1c, and the manual reset switch S2a which is normally closed (N/C). Opening this switch momentarily will reset the dividers to zero and is normally used only at the start of a journey.

## DISPLAY BOARD

The display board houses the three 7-segment l.e.d. displays together with the associated counter-divider chips, IC5 to IC7. The CD4026B counters not only do the necessary counting of the input pulses from the AND gate but also include an output decoder which converts the binary information about the count into the form necessary to drive the l.e.d. displays directly.

The pin-out information is shown in Fig. 4. The circuit is therefore very economical in components and runs satisfactorily from a 6V supply.

The display must be zeroed at the start of a journey and this is accomplished by a momentary closing of the reset switch S2b which is ganged to S2a, the reset for the 7490 dividers. For economy of the battery supply, the display itself can be turned off if necessary by the Display Enable switch S3 during the journey or part of a journey.

All the time the readout is switched off, the count continues and the distance travelled will be fully logged and restored when reactivating the display l.e.d. segments. The decimal point on the centre digit is permanently activated via resistor R8 and can be used, when the display itself is off, as an indicator that the circuit is switched on.

Total current consumption averages 140mA with the display enabled and 40mA with the display off.

## CONSTRUCTION

A home built electronic system cannot compete for size with the small mechanical or computerized devices mentioned earlier, but the ABS plastic box used for this project does fit neatly on the crossbar of the bike and is sufficiently waterproof to resist anything but a tropical downpour. Those who wish may, of course, use a diecast box of similar dimensions.

A smaller box can be used if the battery is separated from it and carried, say, in a

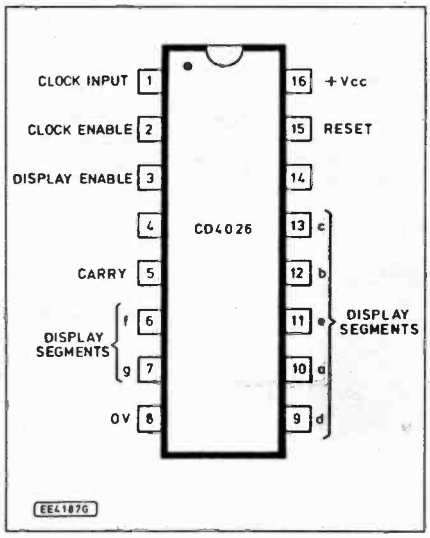



*Fig. 4. Pin-out details for the CD4026 counter/driver i.c.*

rear pannier. In fact, the whole box can be carried in a pannier but access to it can then only be made at the end of a trip or a stop-off at a pub!

So these constructional notes will cover only the existing boxed assembly as used on my own machine; any enthusiastic constructor can of course feel free to do his own thing with the basic circuit and make the disposition of things and the attachment to the bike to suit his or her particular liking. This kind of project can be quite open-ended.

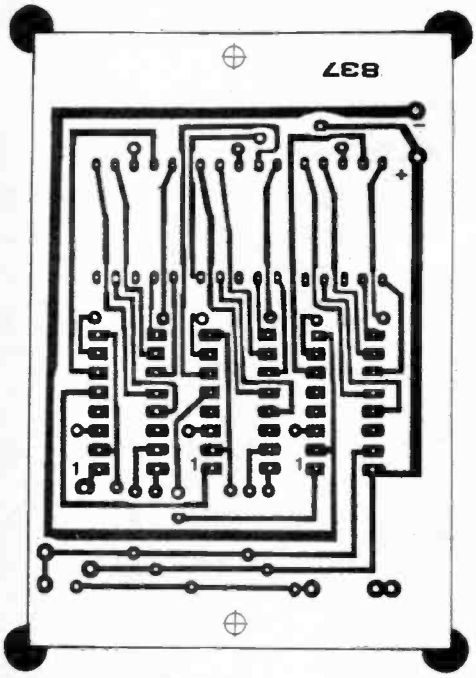
The Divider and Display printed circuit boards topside component layouts and underside full size copper foil master patterns are shown in Fig. 5. and Fig. 6. These boards are available from the *EPE PCB Service*, codes EPE 836 (Divider) and EPE 837 (Display). If you make your own, some care is needed particularly with the display board to avoid shorting between the copper foil paths.

The Display board layout suits the specified 7-segment displays which have 0·56in. high digits with overall dimensions 0·7in. by 0·5in. Alternative displays will need adjustment to the board pin spacings, but see Shop Talk.

Assemble the boards carefully; there are quite a number of links, particularly on the display board. Notice particularly that there is a link which goes *under* IC2, insert this link *before* mounting the i.c. or its holder.

Next mount the resistors and capacitors. If you decide to use holders for the i.c.s, make these low profile types and when fitting the displays, space these about 2mm from the board surface so that their upper faces are slightly higher than the tops of the i.c.s.

There is only one board interconnection to be made later, that from the "commoned" 3, 5 and 6 pins of IC1c and IC1d to the input (pin 1) of IC5. All other leads go to the various switches mounted on the lid of the box. Use solder pins for the battery connection points and flying leads for the other outgoing wires, leaving these about 6 inches (150mm) for the time being.



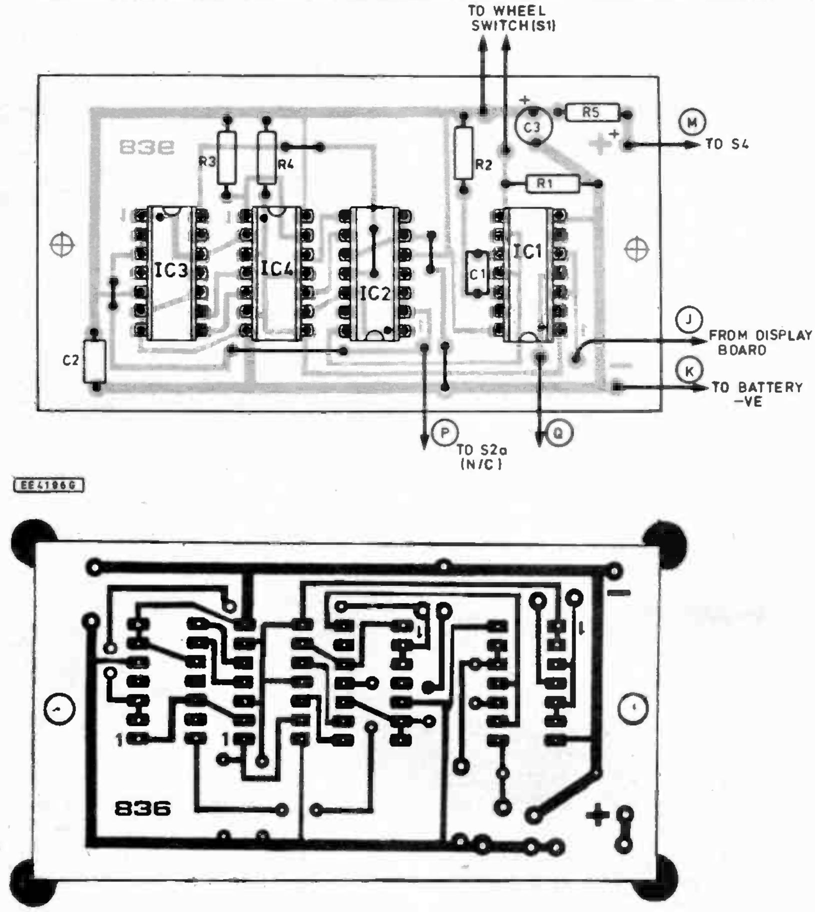




Fig. 6. Divider printed circuit board component layout and full size copper foil master pattern.

## COMPONENTS

**Resistors**

R1 470k
R2 100k
R3 47k
R4 10k
R5 33
R6, R7 56k (2 off)
R8 560
All 0·25W 5% carbon film

See SHOP TALK Page

**Capacitors**

C1, C2, C4 0µ1 min. polyester (3 off)
C3 4µ7 tantalum bead, 25V

**Semiconductors**

IC1 4001B quad 2-input NOR gate
IC2, IC3 74LS90 decade counter (2 off)
IC4 74LS09 quad 2-input AND gate
IC5, IC6, IC7 4026BE 7-segment display counter/driver (3 off)
X1 to X3 7-segment 0·56in., common-cathode, display type HDSP-5303 (3 off).

**Miscellaneous**

S1 Min. microswitch, with roller-lever actuator.
S2 Pushbutton switch with N/C and N/O contacts
S3, S4 Miniature, s.p.c.o. toggle (2 off)

Printed circuit boards available from the *EPE PCB Service*, codes EPE 836 (Divider) and EPE 837 (Display); ABS case, 150mm x 80mm x 50mm (or see text); 16-pin d.i.l. holders, low profile (3 off); 14-pin d.i.l. holders (4 off); 15mm 6BA clear spacers (4 off); small piece of 18s.w.g. aluminium sheet; 1mm sockets and plugs (2 off); PP6 battery, or similar; Terry clips (2 off); 45mm to 50mm long 6BA screws or studding (2 off); flexible wire; piece of thin red perspex or display filter material approx 30 by 60mm.

*Approx cost guidance only* **£20**

## BOX MOUNTING

The two boards, when completed, are mounted one above the other as shown in Fig. 7, using 45mm. 6BA screws or studding with plain spacers and the fixing holes provided on the boards. Care must be taken to ensure that the spacers, if metal types are used, do not touch the copper foil.

With the board interconnection made, this assembly is mounted in the ABS case; two Terry clips of appropriate size are then bolted under the box, using the fixing points of the board screws, so that the box can be clipped to the crossbar or to some other part of the bike.

The two leads to the wheel switch are brought out by way of two one millimetre type miniature sockets at the side of the box. The holes for these should be drilled before the boards are fitted.

It is now necessary to prepare the lid of the box. The switch and display positions are indicated in Fig. 8. The exact position for the display cut-out cannot be given as there will be small variations in the board positions from one project to another.

However, having mounted the boards in the box, there should be no problem in marking out the correct position of the cut-out and taking it out with an ordinary fret saw. Obtain a piece of display filter material (or a *thin* piece of red Perspex, which is cheaper) and glue it behind the cut-out, taking care not to get the glue on the viewing area.

Now mount the three switches in the positions shown in the back panel view of Fig. 9. With the lid now positioned close to the box, wire up the switches to the board leads, leaving these just slack enough to

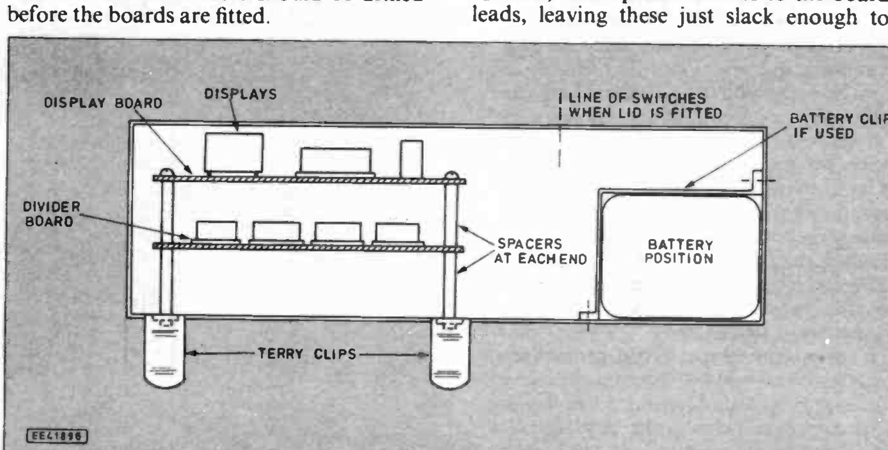



Fig. 7. See-through view of the board and battery mounting in the case. The face of the displays should be about 1mm below the top of the case.

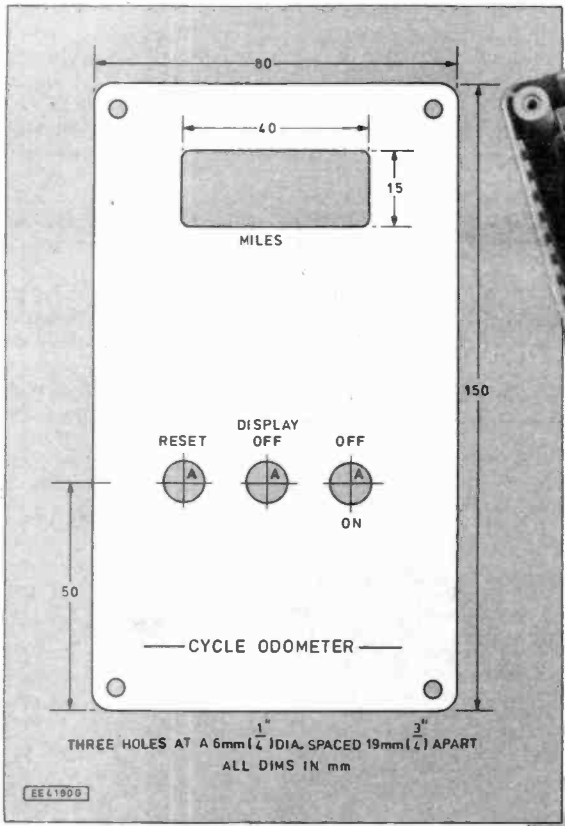
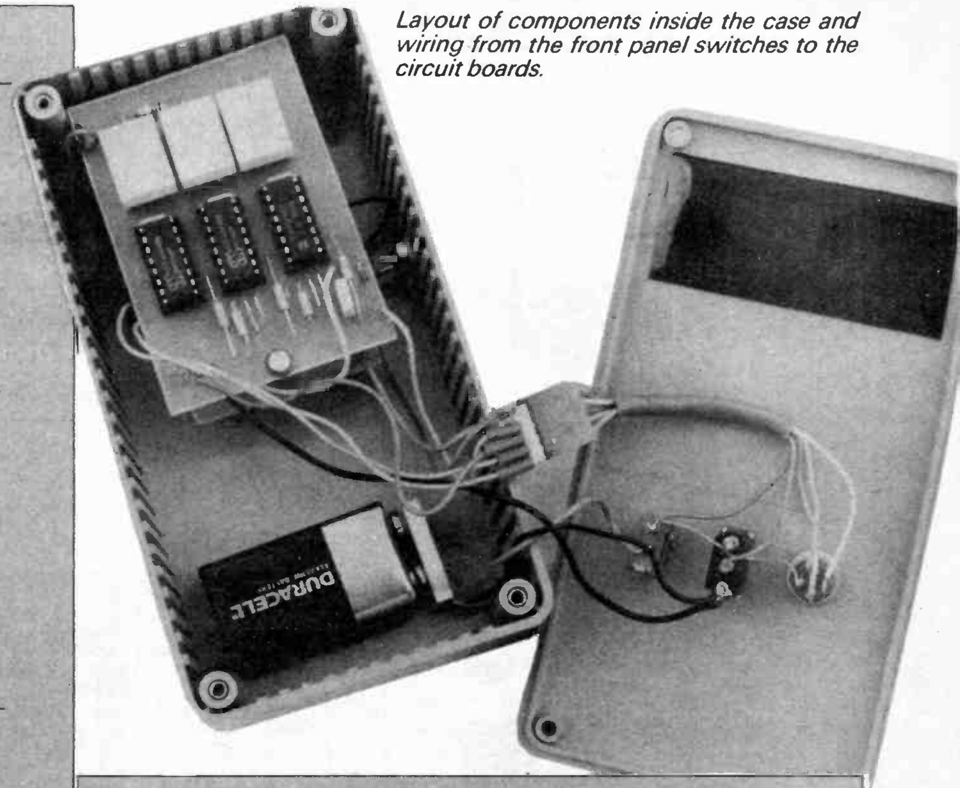



Fig. 8. Cut-out, drilling and legends for the front panel.



Layout of components inside the case and wiring from the front panel switches to the circuit boards.

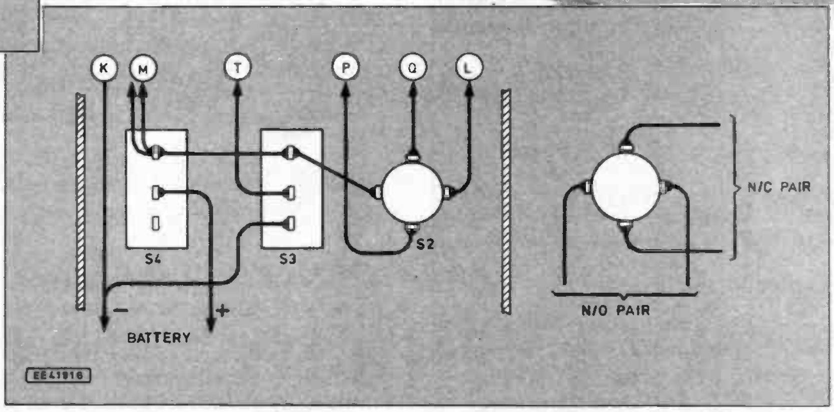



Fig. 9. Wiring to the switches on the rear of the front panel. The letters refer to locations on the two p.c.b.s.

enable the lid to be turned over and screwed to the box once the wiring is complete.

Be especially careful in the wiring to the two switches (S1a and S1b) which are in a single push-button switch unit. There are four tags on this switch, opposite pairs of which go to one normally-open (N/O) switch and one normally-closed (N/C) switch. Which is which is easily checked with a continuity tester, and they must be wired in accordance with the circuit diagram or resetting will be impossible. Don't forget to wire the side terminals which will later connect the wheel switch.

The 6V battery, if it is to be mounted in the box, can be a PP6 type or 4 x AA cells in a suitable holder. This fits into the lower end of the box and can be held by a simple metal clip or by a couple of adhesive pads.

## TESTING

The Odometer can be *bench* tested by connecting the wheel switch (a roller-lever type microswitch) to the side terminals. Switch the unit on; the display and the single decimal point should light up, and by pressing the Reset button, the reading should show 00·0. Check, using the Display Off switch, that the display can be blanked but that the decimal point remains on to act as a reminder that the unit is still "live".

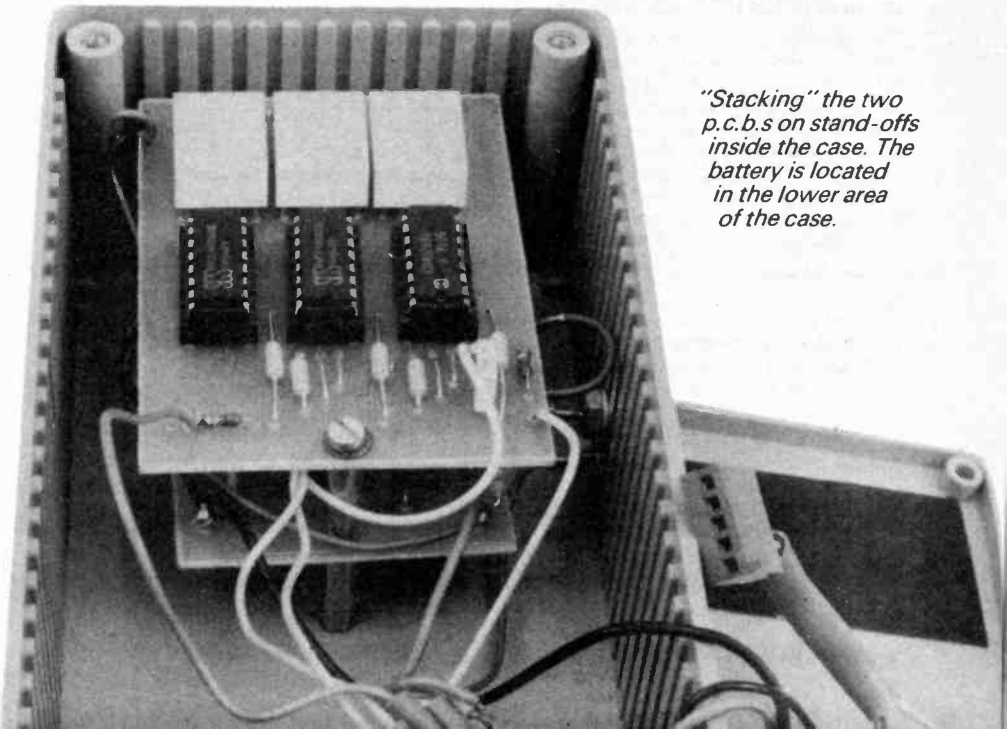
Return the display and now operate the microswitch by hand, counting the number of contacts made. On reaching 77, the display should indicate 00·1, representing one-tenth of a mile.

Carrying on in this way, the next total of 77 operations should bring up a reading of 00·2 and so on. There is no need to carry this tedious procedure too far; if the changes take place up to, say, 00·3, it is most likely that there is no fault on the unit.

To check things quickly, of course, the input can be derived from a pulse generator giving an output of about 5V at a frequency of some 10Hz to 50Hz, and this will check the display reading right through to 99.9. But it is *still essential* to make sure (by the hand-operated switch method) that the display moves up for each group of 77 input pulses.

## OTHER WHEEL SIZES

If you are making your own board, it is not too difficult to make small changes to the Divider section so that other wheel sizes can be accommodated in the design.



"Stacking" the two p.c.b.s on stand-offs inside the case. The battery is located in the lower area of the case.

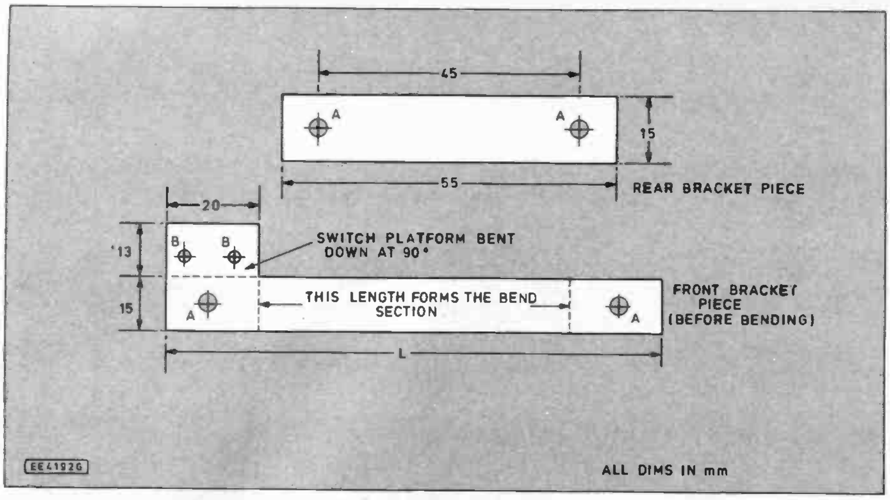



*Fig. 10. The two bracket pieces made from 18s.w.g. aluminium. The bend position can be judged from Fig. 11. Length L to suit size of fork but approx. total length before bending is 80mm. Four holes at "A" are matched after bending front bracket piece (4BA). Two holes at "B" drilled to suit microswitch.*

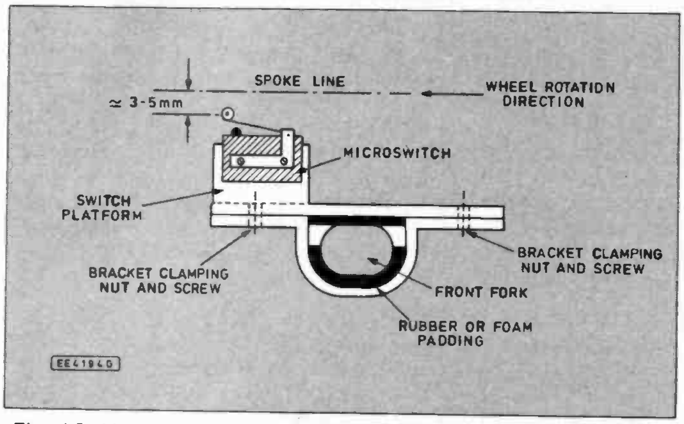
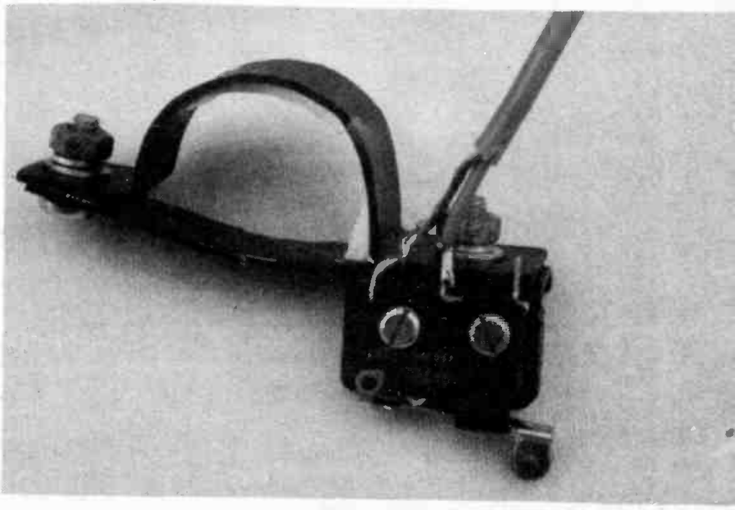



*Fig. 12. How the completed bracket and microswitch are fitted to the front fork. The roller should clear the nearer spokes by the amount indicated.*



*The wheel microswitch mounted on the completed fork bracket.*

This involves alternative arrangements to the inputs of the AND gate, IC4, hence the necessity of modifying the board.

Suppose we have a 21-inch wheel, then the circumference will be $21\pi$ or 66-inches and the number of revolutions made in 6336-inches (0·1 mile) is 96. We can write this as 1001 0110 in binary groups, hence we need to connect the A and D outputs of IC2 (which are high on 9) to two of the AND gate inputs; and the B and C outputs of IC3 (which are high on 6) to two other IC4 inputs.

The actual inputs are not important. The remaining inputs to IC4 are all held high by way of resistor R3 as in the circuit diagram. Note that the D output (most significant digit) of the counter i.c.s is pin 11. In a similar way, other wheel sizes can be accommodated.

It is also possible to "fine tune" the display readout on the 26-inch wheel circuit by such adjustments to IC4 inputs as outlined above. If, for example, you find on a test ride over a known mileage (possibly checked by a car drive) is over or under the correct figure by, say, more or less than 0·2 mile and you would like to be closer, then the count of wheel revolutions can be altered slightly to compensate for the error.

Instead of counting to 77, a count of perhaps 76 or 78 will make the necessary adjustment. To do this, use the same method as already described for different wheel sizes. The equivalent group binary for 76, for example, will be 0111 0110; the count by IC2 will be unaffected but the ABC outputs of IC3 will be 011 which means that only the BC outputs will go to inputs on IC4 while the then unused input which otherwise accepted the A output is strapped to the positive line via R3.

## WHEEL SWITCH

This is that part of the project where individual ideas can prosper. We need a device that will give us an output pulse for each wheel revolution. The two most obvious systems that come to mind are a magnetically operated reed switch (a non-contacting method) and a microswitch operated by some kind of stud on the wheel (a contacing system).

I did get a reed switch to work successfully but the setting and the consequent assembly was critical and, I felt, not really capable of being described in a manner that would be repeatable for every situation or style of machine. This does not mean that any constructor has to abandon this method; once again there is scope for the enthusiast to dabble for himself.

A possible objection to the mechanically operated switch is that it makes a clicking sound as the wheel rotates. With the method used here, the sound output is negligible as the contact is very light and any frictional effect on the rotation of the wheel is infinitesimal.

The use of a roller-lever microswitch helps in this way; avoid cheap devices which have a primitive form of hinge for the lever and which results in a floppy free movement of the lever. This can lead to problems when cycling at speed (but nothing dangerous!) as rebounds of the lever could strike the spokes and lead to false counting and a wrecked microswitch.

A two-piece bracket has to be made to position the switch properly, but this is easy to fabricate and fit and can be formed from a piece of 18s.w.g. aluminium. In the diagrams illustrating this bracket the fixing hole positions are approximate and must be adjusted as necesary to suit your own machine, but large variations are very unlikely to be needed.

The two pieces needed to fabricate the wheel switch bracket are shown in Fig. 10, these being cut out neatly from the aluminium sheet and any burrs or rough edges smoothed off with a fine file. Now the switch actuator is most conveniently fitted to the wheel reflector, so the right position for mounting the bracket on the fork is in line with the reflector as the wheel rotates. Fig. 11 illustrates this point.

So, using a piece of wood or tube similar in size and shape to the wheel fork at the correct position (I used the left-hand front fork) shape the front bracket piece around it to conform finally to the configuration shown in Fig. 12. Line the inside of the loop and the mid-part of the back bracket piece with rubber or foam protective padding (as indicated); this takes care of any slight inaccuracies or slackness and prevents damage to the paintwork. It was found that draught excluder strip, sticky on one side, was ideal.

The bracket is secured to the fork by two 4BA screws with nuts and spring washers; try the fitting out before fitting the microswitch and ensure that it will clamp on to the fork very firmly with no tendency to slide or rotate. The rear piece of aluminium will bow *slightly* as the nuts are tightened

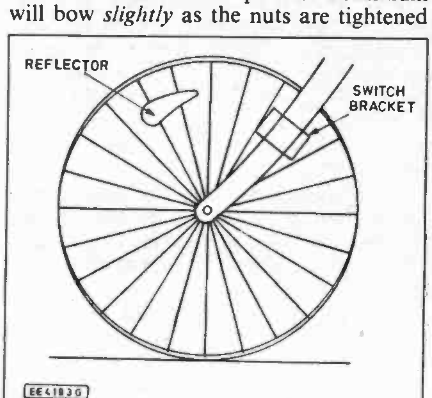



*Fig. 11. The switch bracket should be positional on the same radius as the reflector.*

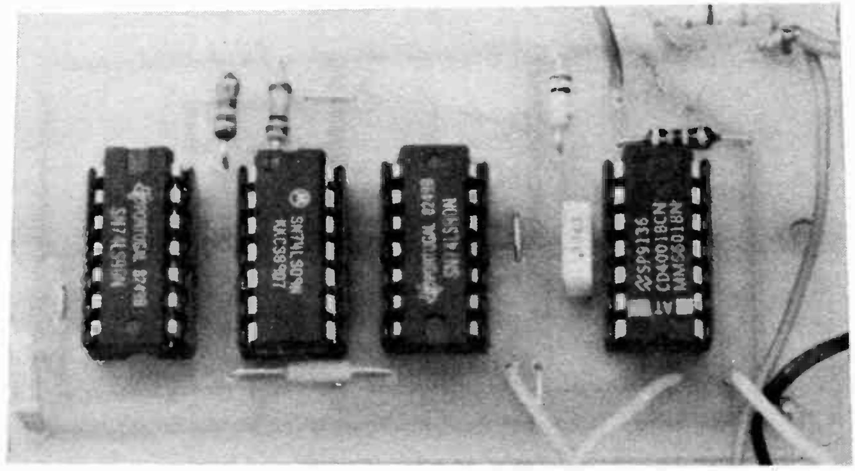
but this helps the tightness of the assembly.

Any *severe* bowing will indicate that your front bracket piece needs readjusting to match the shape of the fork better. Aim for a good job, poor and inaccurate work must be avoided.

Now fit the microswitch to the platform in such a position that the roller, when it is in its normal "rest" position, clears the nearer spokes as the wheel is rotated by some 3mm to 5mm.

## ON STRIKE

All that remains now is to provide some kind of "striker" mechanism which will close the microswitch momentarily on each rotation of the wheel. This is where the wheel reflector comes in; by fitting a shaped piece of material on to the reflector, a ready made support is available, so avoiding any other form of fixing the striker to the spokes.



*Layout of components on the completed Divider board. Do not forget the link under IC2.*

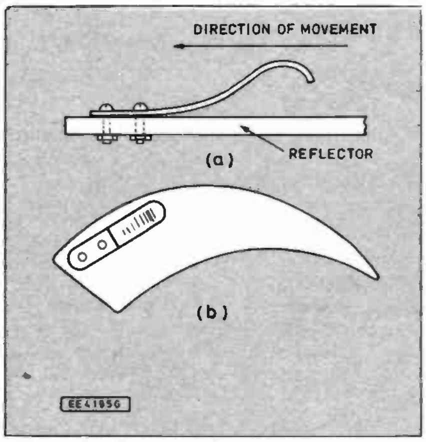



*Fig. 13. General configuration of the "striker peg" and its attachment to the wheel reflector.*

A springy striker is best and a piece of 30s.w.g. brass did the job admirably and has so far survived for several hundred miles of travel. A piece of spring steel, salavaged from an old electric bell, and some 26s.w.g. aluminium have been tried and these have worked successfully as well. There is nothing too critical about either the material used or its thickness (within reason, that is) for this application.

The general shape needed for the striker and its mode of fixing is shown in Fig. 13a. Two fixing holes are necessary, and the final degree of bending is best done after assembly.

The reflector is drilled through 6BA and the striker screwed to it as shown in Fig. 13b). Make sure that the striker is in line with the microswitch lever as it passes and not at some oblique angle.

The bend of the striker is finally adjusted in situ; arrange the contact with the roller of the microswitch so that only the *minimum* movement of the lever occurs to close the switch contacts as the striker passes by. This need be no more than 2mm to 3mm; the lever *must not* be forced down to make contact with the body of the switch or both the striker and the lever will soon be distorted.

Having finalised the fitting, two leads are then soldered to the normally-open contact tags on the microswitch and taped to the frame as they are brought up to the side terminals on the main box. Happy cycling! □

# Innovations

**A roundup of the latest Everyday News from the world of electronics**

# SORTING OUT TRAFFIC JAMS

## TRAFFICMASTER TO THE RESCUE

*By Hazel Cavendish*

A British firm has scored an important world first with "Trafficmaster", a novel electronically-based in-car traffic information service, extended nationwide in Spring this year after a triumpahnt two-year pilot scheme which proved itself on the M25 – an area suitably chosen for its monumental traffic snarl-ups at peak times. General Logistics is the UK company behind this innovative system which is designed to help drivers avoid time-wasting traffic jams and escape dangers ahead.

The Trafficmaster unit is a specially-designed, purpose-built portable radio receiver with a clear, easy-to-read screen showing a map of the motorways covered, which fits neatly into a subscriber's car or lorry. A simple group of control buttons enables details to be viewed in close-up and there is a supporting narrative which can be reviewed as required. It provides an information system which tells the motorway user accurately, quickly and simply when the road is clear and when it is congested, showing the extent of the congestion and the average speed of the traffic.

With this information available the driver can schedule journeys when the roads are at their least crowded, can choose alternative routes when likely delays are shown up on his screen, and know the extent of the delay if there is no option but to sit it out.

*IR sensors being fitted to a motorway bridge.*

*Trafficmaster display inside a vehicle.*

## SPEED MONITORS

The key to the system is the installation of traffic speed monitors on 450 motorway bridges and gantries across the country's motorway system at a cost of £3 million over the last two years. These high-tech sensors are mounted in groups, for each direction, on motorway bridges and gantries, or on lamp-posts and signposts in more urban situations. Unlike Gatso speed-check cameras used by the police, these all-weather infra-red devices sense the vehicles passing underneath and measure their speed, although it is emphasised they cannot identify individual vehicles.

In order to give comprehensive coverage, the sites are on average only two miles apart. Each bridge site has its own microprocessor which calculates a three-minute rolling average speed of traffic, providing an accurate measurement of speed of flow as well as measuring the number of vehicles passing along the motorway.

Every bridge site is programmed to send information to the Control Centre in Luton when the average speed drops below a preset threshold of 30 m.p.h., the speed at which it is estimated congestion and delay build up on a busy road. Police, motoring organisations, road repair contractors and local government supply the information for the accompanying narrative which indicates speed, direction and extent of congestion, and will also give a reason for the problem occurring – "red Mini overturned at final roundabout before entering Norwich" – giving a driver the opportunity to re-route their journey.

## DISPLAY

When motorway information is transmitted from the sensor via the Control Centre to the Trafficmaster the problem is displayed on the map as a flashing square. In this square an arrow indicates the direction of the hold-up and a number which is the average speed in miles per hour of the traffic at that point. This information is updated every three minutes. The speeds shown in the squares start at 25 m.p.h. and range down in units of 5 m.p.h. to zero. The user should soon become adept at assessing the delay a particular hazard may imply; the length of the tailback can be assessed by the number of squares flashing.

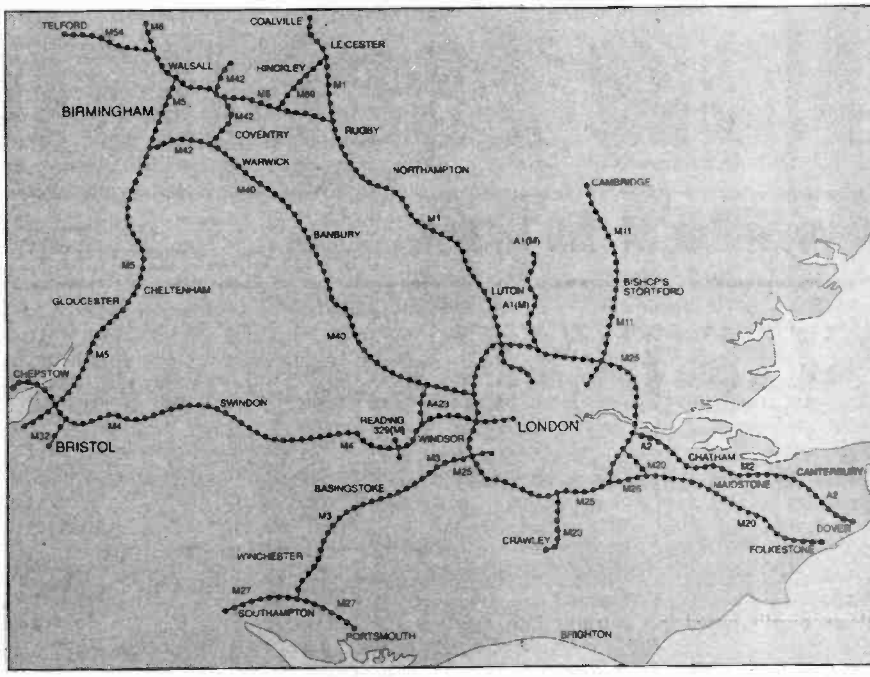
As an optional extra, Trafficmaster can double as a message pager, storing messages that can be read at a convenient time. On the large screen complete messages can be seen at a glance, making reading simple. As the Trafficmaster is portable – each unit being located in a specially-installed holster from which it can be removed for security – paging messages can be received in the office, at meetings or in restaurants and can be automatically transferred from a cellular phone to the screen.

A supplementary service covering the London area inside the M25 provides a comprehensive view of closures and serious incidents, showing the location of major accidents on the screen with supporting information in a separate "memory" which can be recalled on demand.

## U.S. BELTWAY

Already used by a quarter o the FT-SE 100 index companies in Britain – the list reads like an inventory of Britain's top comapnies ranging from Grand Met and ICI to Virgin Atlantic and Marks and Spencer – Trafficmaster's technology and expertise has been seized upon by the Americans for their equivalent of our M25 – The Washington DC "Beltway" – which will try out the scheme in September this year following a significant deal with Westinghouse Electric Corporation of Baltimore. This gives the American company exclusive use of General Logistics' technology on a 15-year licence.

Trafficmaster is poised to benefit from a worldwide expansion into driver information systems as public authorities use their road allocation funds more effectively. These systems are known as Road Traffic Informatics (RTI) and Intelligent Vehicle Highway Systems (IVHS). A recent report estimated that the UK RTI market will be worth £5 billion by the year 2010, and the Clinton administration has funded IVHS with $925 million over the next four years. General Logistics would seem to be in on a winning ticket.



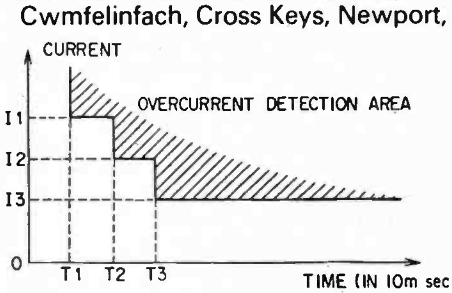

*The present Trafficmaster network.*

In his capaicty as Seretary of State for Transport, John MacGregor praised Trafficmaster as a remarkable private sector initiative, saying "Trafficmaster is a major breakthrough in driver information systems which many other countries are watching closely. It is an important aid to business efficiency, and helps to reduce costs and stress."

In the UK General Logistics has this year extended the M25 trial scheme to cover more than 1,000 miles of motorway in the south and midlands, including the M27 between Portsmouth and Southampton, and is planning a substantial development in Scotland over the next two years. It is also involved in RTI projects in Europe, the Middle East and the Far East.

# THE THINGS PEOPLE PATENT!

**The following abstracts are taken from recent UK patent applications in the general electrical/electronics area. British Patent Specifications can be ordered from the Patent Office, Sales Branch, Unit 6, Nine Mile Point, Cwmfelinfach, Cross Keys, Newport, Gwent, NP1 7HZ.**




## Detecting overcurrent

In UK patent 2257314 Kabushiki Kaisha Toyoda Jidoshokki Seisakusho describe a means of detecting with high accuracy a current which may adversely affect an electric circuit if continued for an extended time. The apparatus periodically samples an output of a current sensor connected to the circuit and includes a memory, storing data of current values, (I1 to I3) regarded as representing overcurrents, in consideration of their respective durations, T1 to T3.

The current values are stored in pairs with time values of the durations. The sampled value is compared sequentially with the current values stored in the memory while duration of the sampled value is compared with the time value paired with that current value in order to determine whether or not an overcurrent has occured. The circuit may be used to drive the motor of a battery-powered fork lift truck.

## Motor control system

In UK patent 2258094 Racal Health & Safety Ltd. describe a control system for an electric motor driving a fluid moving device, such as the air fan in a powered respirator. The system senses the speed of the motor by the back e.m.f. which it produces and senses the running current of the motor by the voltage drop across a fixed series resistor.

From these parameters, the prevailing rate of flow from the fan can be calculated in a microprocessor and compared with a specified value. The resultant error signal is used to modulate the widths of power pulses suplied from a drive to the motor so that the fan is controlled to produce a substantially constant rate of flow, in spite of variations of flow resistance caused by progressive blockage of associated filters.

## COVER PIC

**Acknowledgement:** we appologise for forgetting to credit David Lee of Barton-on-Humber with last month's excellent front cover photograph of the **Micro Lab**.

## TOOL-UP

A recent price reduction makes a good value 15 Piece Students Tool Kit from Maplin a real bargain. The kit includes a 25W soldering iron with two interchangeable bits (flat and pointed), a detachable hook and small fold-up stand, desoldering tool, a supply of solder and a pot of flux.

For working on p.c.b.s and delicate equipment, a "helping hands", "scraper" and a wire wrap tool are included. To help in assembly and repair of projects, two crosspoint screwdrivers, two standard screwdrivers, a pair of pliers, a pair of wire cutters and a pair of tweezers are also supplied.

All the tools are housed in a smart, tough carrying case with preformed sockets to hold them in place during transit. The cost of this kit is now £14.95 including VAT, it is available from Maplin shops and by mail order Tel. 0702 554161.

# New Technology Update

*Ian Poole reports on developments in battery technology.*

INCREASING demands are being placed on battery technology nowadays. People who use batteries want new types which pack more power into a smaller space whilst being cheaper and environmentally friendly.

It is this last point which is becoming increasingly important. Virtually all batteries in use at the moment include chemicals which can be hazardous in one way or another. Even the standard zinc-carbon battery contains an acidic electrolyte which can be quite corrosive as anyone who has had them leak into a radio will know. They also contain manganese dioxide which is toxic.

## NiCad

NiCad cells seem to be the answer to many problems. They can be recharged time after time thereby reducing the amount of chemicals which are needed. However even these cells do not last for ever. It is quoted that they can have up to 1000 charge/discharge cycles, but in reality their life is somewhat less.

They are seldom used under ideal conditions: they may be overcharged, totally discharged, or used in a battery where it is possible for one or more cells to become reverse charged. All of these factors will lead to a reduction in the life of the cell by a considerable degree. There are very few applications where a cell will reach its maximum expected life.

Environmentally NiCad cells are much worse than standard cells. They contain potassium hydroxide which is corrosive. Worse than this is the cadmium they contain. Such are the fears about the disposal of these cells that some countries are considering a ban on their use. A number states in the USA are actively considering this, and the European Community is legislating to control their disposal.

Whilst NiCad cells are one of the worse environmental offenders other types of battery in everyday use also cause problems. The lead acid battery used in every car uses a corrosive electrolyte as owners of older cars can testify from the rust around the battery. In addition to this the lead is also a significant hazard.

Lithium cells are not particularly good either because they use some strong oxidising agents. In fact many of today's batteries give cause for concern in one way or another.

## Green

The green lobby is growing rapidly but there is also an increasing reliance on batteries for everything from cam-corders and personal stereos to professional test equipment. These factors mean that there is a great need for new, safe batteries.

This presents a magnificent opportunity for any company which can develop a suitable battery to fill the need. As a result a number of organisations are investing large amounts of money into this field.

## NMH

Already there are a number of new batteries which are being developed. Some years ago rechargeable lithium cells appeared on the horizon as the solution to the problem, but despite all the coverage in the technical media they have not reached the market.

Now another type of cell called the Nickel Metal Hydride or NMH cell has appeared and it is already being used in some applications. The cell has several advantages, but as the NiCad has been in use over 20 years and has been well refined, there is still a way to go before the NMH cell can perform as well in all respects.

Fortunately the NMH cell is very similar to a NiCad in its performance. This means that given enough development it could actually replace the NiCad in the near future, it has the advantage of being far more environmentally friendly. In addition to this it is much lighter and has a higher storage capacity. As an example a typical NiCad type AA cell has a capacity of around 0·5Ah whereas the new NMH cell can store just over 1Ah.

The output voltage is very similar to that of a NiCad. The open circuit voltage is between 1·3V and 1·4V falling to just over 1·2V under moderate loads. In fact the output voltage is only about 0·05 volts higher than a NiCad. The cell also maintains its output voltage well through the discharge cycle, falling rapidly once it becomes discharged as shown in Fig. 1. The main difference between the two cells is the additional charge which the NMH cell can hold.

The charge profiles are also very similar. One feature which is very useful for NiCad chargers is an increase in the cell voltage once full charge is reached. This is often used by so called intelligent chargers to detect when a cell is fully charged. A similar effect is also exhibited by the NMH cell, but it is less marked (Fig. 2).

## Drawbacks

Whilst these new cells may seem ideal in many respects there are a number of drawbacks and problems which still need to be solved. The first is that NMH cells surprisingly have small traces of cadmium in them at the moment. This should not remain the case for much longer because manufacturers have stated that this will be removed shortly, enabling these cells to be disposed of without any major environmental concerns.

A more serious long term problem is their cost. Currently they are about two and a half times the price of an equivalent NiCad. However when the increased capacity and cell life-time is considered the cost seems more reasonable.

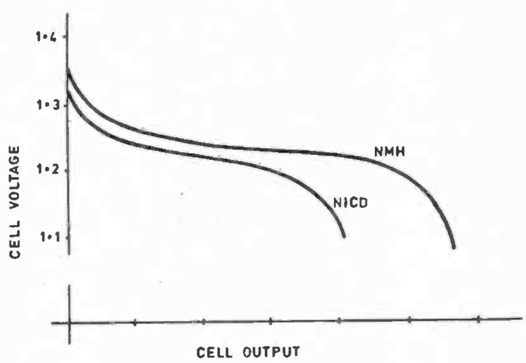
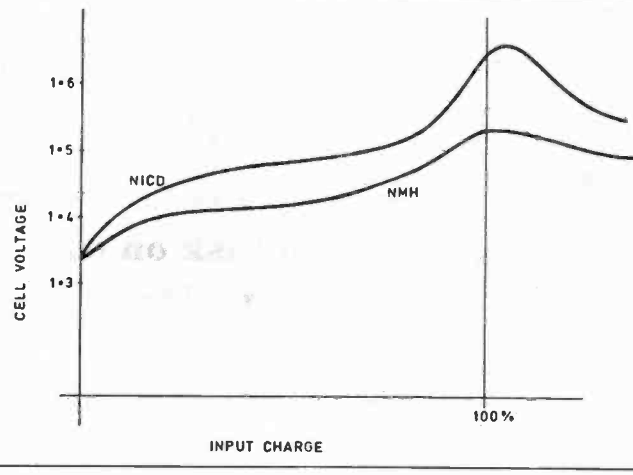



*Fig. 1. Discharge profiles of NMH and NiCad cells.*

*Fig. 2 (right). Charge profiles of NMH and NiCad cells.*



One area which is receiving the most development is that associated with loss of charge over a period of time when the cell is not in use. Currently NMH cells discharge at about twice the rate of NiCads which in turn is much higher than that for ordinary non-rechargables. Fortunately development is beginning to bear fruit and it is expected that it will be possible to reduce self-discharge rates to acceptable levels within the foreseeable future.

Charging of these new cells also creates a problem. Whilst standard NiCad rechargers can almost always be used, great care has to be taken not to overcharge them. If this is done then the capacity of the cells is greatly reduced.

As a result of the dangers of overcharging, these cells are not available as separate items. Instead they are built into manufactured equipments which contain intelligent chargers to prevent overcharging. Currently the main users are lap-top computers and mobile phones. In both of these applications weight and capacity are of great importance. On both of these counts the new NMH cells win over NiCads.

Whether NMH cells become as widely used as the standard NiCad cells depends to a large extent on other battery developments. At the moment a number of industrial battery manufacturers are making them or developing their own versions. However as yet there are none available separately on the domestic market.

Like any cell, whether rechargeable or primary, the new NMH cell has two electrodes, one positive, one negative, and between them there is an electrolyte.

From the name of the cell it can be deduced that one electrode (the positive one) is made from nickel compounds. In fact it is very similar to that used in a NiCad. The electrolyte is also very similar, being an alkaline solution.

The main difference occurs in the area of the negative electrode. Instead of using cadmium the new cells use a new alloy which can store hydrogen. The reason for this is that towards the end of the charge cycle, oxygen and hydrogen are given off. To overcome this problem a secondary electrode is added to absorb the oxygen, whilst the hydride in the primary electrode is able to store the hydrogen. In this way the cell can be sealed, only having a vent for emergencies.

# TRI-STATE THERMOMETER

T.R. de VAUX-BALBIRNIE

## Don't get all steamed up! Stay cool – build this overheating alert for your car.

GONE are the days when car dashboards sported an array of chrome-bezelled instruments to monitor the engine's state of health. Along with the fuel gauge, there was often an ammeter, oil pressure gauge, water temperature gauge and possibly a voltmeter.

There may have been others indicating inlet manifold vacuum, oil temperature and so on. Car manufacturers tell us that today's motorist does not want or need such instruments and many drivers would not understand the readings anyway.

### ILLUMINATING

Pointer-type instruments were always something of a problem since the driver's eyes had to be taken off the road to see and interpret the readings properly. Also, traditional instruments do not positively signal attention – for example, a slowly decreasing engine oil pressure reading would probably be missed. A further point is that these instruments were not very effective at night.

In most cars warning lights are now provided. These remain normally *off* unless there is a fault. Thus, a red light comes on when the battery is not charging, another if the engine overheats and so on. There may be other lights to indicate worn brake pads, etc.

Lights have the advantage of attracting attention much more readily than a meter and are also more effective at night. However, unlike instruments, most warning lights have only two states – *on* and *off*.

In the case of a water temperature warning light, the operating point often appears to be set on the high side (so that it usually remains off to avoid alarming the driver). Unfortunately, instead of providing a timely warning, the light comes on when it is obvious – in the form of boiling noises and steam seen issuing from beneath the bonnet – that overheating has already taken place.

It may not be possible to stop the car there and then yet driving even a short distance may have serious and expensive consequences – indeed, damage may already have been caused. If the cylinder head is made of light alloy – very common in today's cars – even moderate overheating can cause distortion which, in turn, can lead to loss of compression and water entering the cylinders past the cylinder head gasket.

The cost of dismantling, possibly having the cylinder head machined true, cleaning and re-assembling can be very high. If the warning had been given earlier – that is, at a slightly lower temperature, the car could have been driven gently off the road and the cause investigated. This may turn out to be simply due to an inexpensive radiator hose having burst but the problem could be compounded into a costly repair.

### COLOURFUL VIEW

This project is a type of thermometer but instead of a pointer-on-scale meter, it uses a special tri-colour l.e.d. for the display. This lights up *green* for "cool", *yellow* to signify "normal" operating temperature and *red* to warn of "overheating". The only part on view is the l.e.d. in a small plastic box so the appearance of the project is very small and neat.

The operating temperatures are freely adjustable at the setting-up stage. In the prototype unit, yellow may be made to show at any temperature between 35°C and 70°C and red from 70°C onwards. The red l.e.d. will normally be set to operate just a few degrees above normal engine operating temperature.

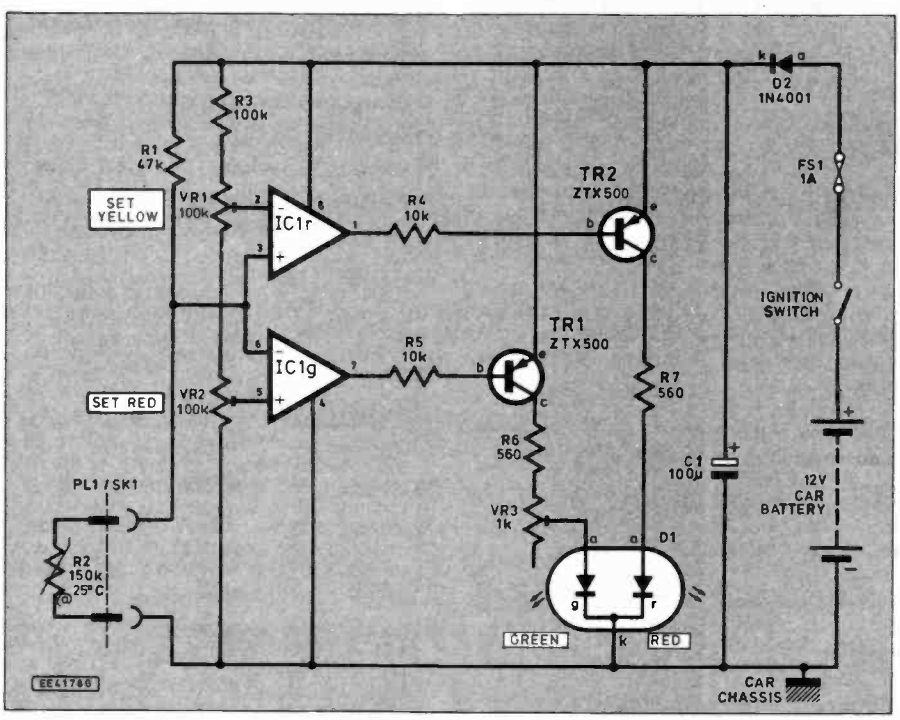
The Tri-State Thermometer draws current from the 12V car supply and is only active while the ignition is switched on. Current consumption is about 10mA which may be regarded as negligible.

### CIRCUIT DESCRIPTION

The full circuit diagram for the Tri-State Thermometer is shown in Fig. 1. Before going on to explain how it works, it will be helpful to understand the operation of the tri-colour l.e.d., D1. This device contains two separate l.e.d.'s – one red and one green – connected with common cathode (k) in a milky white package.

When the l.e.d.'s are used individually, they emit red or green light in the usual way but if they are operated *together*, the impression given to the eye is that of *yellow* light. This is because red and green are

*Fig. 1. Complete circuit diagram for the Tri-State Thermometer.*

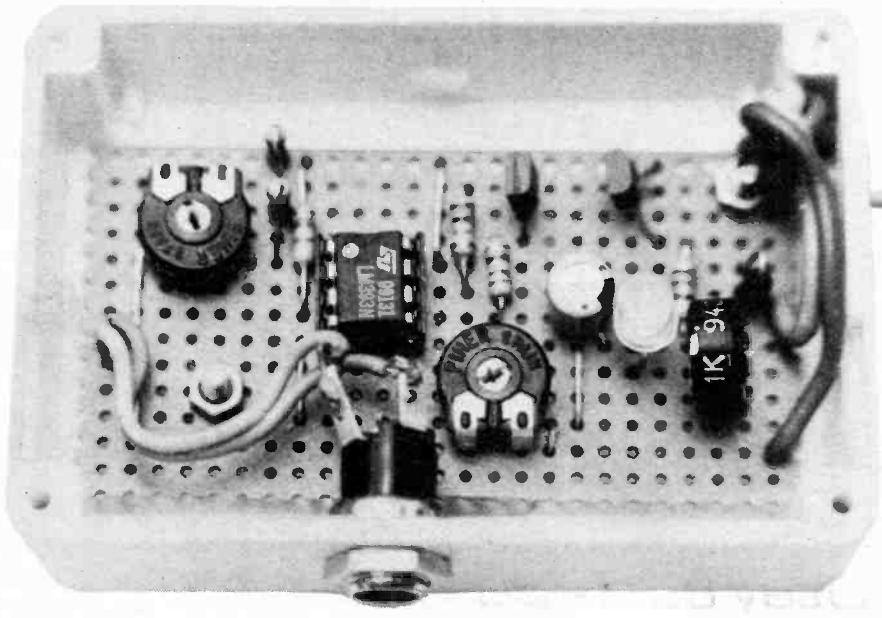


*primary* colours and these add to give a *secondary* colour – in this case, yellow.

In the following description, D1g refers to the *green* l.e.d. and D1r, the *red* one. Referring to Fig. 1, the temperature is detected by thermistor, R2, which is placed in thermal contact with a suitable part of the engine which becomes hot in operation (details for this are given later).

The thermistor has a *negative temperature coefficient* – that is, as its temperature increases, its resistance falls. The way in which it does this is shown graphically in Fig. 2 and it will be noted that the response is non-linear, that is, it does not provide equal changes in resistance for equal changes in temperature.

Thermistor R2, in conjunction with fixed value resistor, R1 form a potential divider connected across the nominal 12V supply. Thus, as the temperature of R2 rises, the voltage across it falls and this is applied to IC1 pins 3 and 6. It is this changing voltage which operates the rest of the circuit.



Layout of components inside the small plastic case.

## IN COMPARISON

Integrated circuit, IC1, contains two identical voltage comparators (a comparator is a form of operation amplifier). These are referred to in the text as the *red* and *green* sections (IC1r and IC1g respectively) according to which l.e.d. the output is responsible for.

Each comparator has two inputs; an inverting (−) and a non-inverting (+) one (pins 2 and 3 respectively for IC1r, and pins 6 and 5 respectively for IC1g). It also has an output (pin 1 for the red and pin 7 for the green). The voltages applied to the two pairs of inputs are *compared* – hence the name of the device – *comparator*.

If the voltage applied to an inverting input exceeds that at the corresponding non-inverting one, the respective output will be *low*. In fact, the situation is slightly complicated because the output of this particular device is in the form of *an open collector transistor* which becomes *low* when the device is actuated.

This fact demanded certain considerations in design. With either comparator output low, the transistor for which it is responsible, TR1 or TR2, will switch on and light the appropriate l.e.d., D1r or D1g. This is because the transistors are of the *pnp* type and operate when the base is *low* compared with the emitter which is maintained at supply positive voltage. Resistors R4 and R5 limit the base current.

## HOW IT WORKS

Suppose thermistor, R2, is at a low temperature (the car has only just had its engine started and has not warmed up yet). The voltage applied to pin 3 will be fairly high (approaching supply positive voltage). Presets VR1 and VR2 form potential dividers whose sliding contacts apply certain voltages to pins 2 and 5 respectively according to their adjustment.

With a cold thermistor and with VR2 correctly adjusted, the voltage applied to pin 6 will exceed that at pin 5 so IC1g output, pin 7, will be low. Transistor TR1 hence D1g will therefore operate. Fixed resistor, R6, in conjunction with preset potentiometer, VR3, limit the operating current.

Meanwhile, with VR1 correctly adjusted the voltage applied to pin 3 (the same as that at pin 6) will exceed that at pin 2 so transistor TR2 and hence D1r will remain off. With D1g on and D1r off, the display is *green*.

As the temperature sensed by R2 rises, the voltage applied to pin 3 falls below that at pin 2. IC1r pin 1 therefore becomes low so TR2 and D1r switch on, with resistor R7 limiting the operating current. Since the voltage applied to pin 6 still exceeds that at pin 5, D1g remains on and with both l.e.d.'s operating, the display is *yellow*.

Now, suppose the engine temperature rises still further. The voltage at pin 3 remains below that at pin 2 so D1r is still on. However, the voltage at pin 6 falls below that at pin 5 so D1g switches off. With D1r only on, the display is *red*. Correct adjustment to presets VR1 (SET YELLOW) and VR2 (SET RED) cause the transitions to occur at the chosen temperatures.

Changes in supply voltage have virtually no effect on the operating temperatures. This is because IC1 is comparing *pairs of voltages* applied to its inverting and non-inverting inputs. Since these are all derived from the same supply they will all rise and fall with supply variations in like manner. Thus, the operating conditions remain unchanged.

With the arrangement of presets VR1 and VR2 as shown, the green l.e.d. goes off

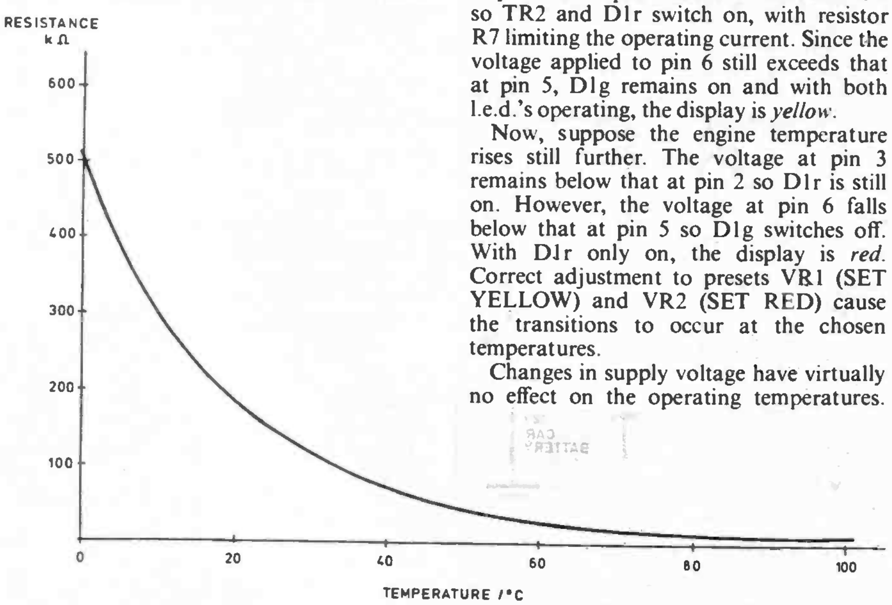



*Fig. 2. Response of the thermistor resistance to change in temperature.*

## COMPONENTS

**Resistors**

| | |
|---|---|
| R1 | 47k |
| R2 | miniature bead thermistor, nominal resistance at 25°C 150k |
| R3 | 100k |
| R4, R5 | 10k (2 off) |
| R6, R7 | 560 (2 off) |

All 0·25W carbon, except R2

See SHOP TALK Page

**Capacitors**

| | |
|---|---|
| C1 | 100µ radial elect., 16V |

**Potentiometers**

| | |
|---|---|
| VR1,VR2 | 100k sub-min preset, horizontal (2 off) |
| VR3 | 1k sub-min preset, vertical |

**Semiconductors**

| | |
|---|---|
| D1 | 5mm tri-colour common cathode l.e.d. |
| D2 | 1N4001 50V 1A rect. diode |
| TR1, TR2 | ZTX500 *pnp* silicon (2 off) |
| IC1 | LM393 dual comparator |

**Miscellaneous**

| | |
|---|---|
| PL1/SK1 | 2·1mm power-type plug and matching socket or 2·5mm mono jack plug and socket – see text |
| FS1 | In-line car-type fuseholder and 1A fuse to fit |

Stripboard 0·1in. matrix, size 13 strips x 25 holes; 8-pin d.i.l. socket; plastic box, size 75mm x 50mm x 25mm; potting box size 28mm x 18mm x 14mm; 3A auto-type wire; light-duty stranded wire; car-type connectors; rubber grommets as required; fibreglass insulation; quick-setting epoxy resin adhesive; solder; etc.

*Approx cost guidance only* **£9**

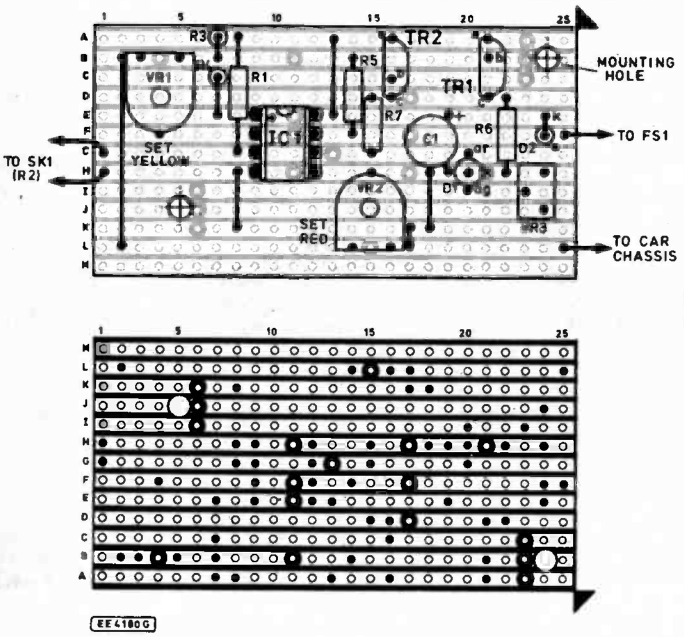



*Fig. 3. Stripboard component layout and details of breaks required in the underside copper tracks. Note that there is NO break between pins 3 and 6 of IC1.*

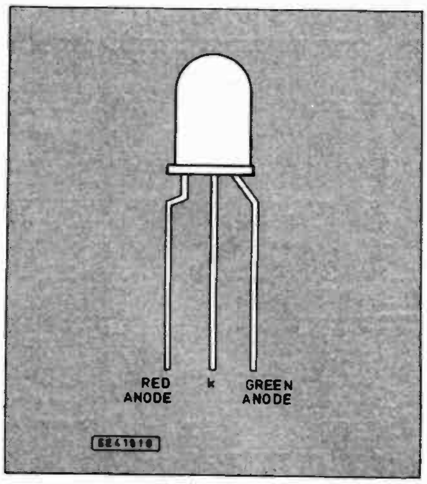



*Fig. 4. Pin connection details for the tri-colour l.e.d.*

after the red one has come on – that is, on rising temperature the sequence will always be *green, yellow* and *red.* Preset VR3 allows for some adjustment to D1g operating current and this will be used to provide the best yellow colour at the end of construction. It seemed in tests that the green l.e.d. always appeared brighter than the red one so VR3 allows the current through D1g to be reduced so allowing the brightness levels to be balanced.

Diode D2, in conjunction with capacitor, C1, smooth the supply obtained from the car charging system. D2 also prevents damage if the supply is connected with the wrong polarity. Fuse FS1 provides protection in the event of faulty connections or a short-circuit.

A plug and socket arrangement, PL1/SK1 is used to connect the remote thermistor sensor to the main unit. In the prototype a 2·1mm power-type connector was used but it would be possible to use a 2·5mm mono jack plug and socket or any other similar connector.

## CONSTRUCTION

Construction of the Tri-State Thermometer is based on a circuit board made from a piece of 0·1in. matrix stripboard, size 13 strips x 25 holes (see Fig. 3). Cut the material to size, drill the two mounting holes and make all track breaks as indicated. Note the *intact* copper strip between IC1 pins 3 and 6.

Follow with the topside inter-strip link wires and finally add the soldered on-board components including the i.c. socket. Do not insert the i.c. at this stage, however.

Take care to observe the polarities of the electrolytic capacitor C1, and diodes D1, D2. Note that the tri-colour l.e.d. D1 has its two outer leads bent in different shapes to denote the red and green anodes. The common cathode (k) is the centre lead – see Fig. 4.

The l.e.d. should be soldered in position so that it stands with its tip 20mm approximately above the circuit board. This should ensure that the end will protrude through a hole which will be drilled in the lid of the box later. It would be possible to mount the l.e.d.. remotely if desired so that the box containing the circuit panel could be placed out of sight and the l.e.d. mounted alone on a small bracket.

Solder 5cm pieces of light-duty stranded wire to strips *G* and *H* on the left-hand side of the circuit panel. Solder a 20cm piece of light-duty *red* stranded wire to copper strip *F* and a similar piece of *black* wire to strip *L* on the right-hand side.

Solder one section of fuseholder, FS1, to the free end of the red wire. Make a careful check for errors particularly to ensure that all cut racks are *completely* broken and that there are no solder "bridges" formed between adjacent copper strips.

## CASE DETAILS

Drill the circuit board mounting holes in the base of the box and the hole in the side for the two supply wires leading through from the circuit board. Drill the hole for the thermistor connecting socket SK1 (see photograph).

Mount the circuit panel temporarily and measure the position of the l.e.d. carefully. Drill a hole in the lid, having the same diameter as the l.e.d., to correspond with it.

An alternative method is to put a dot of ink on the top of the l.e.d. using a felt-tip pen. Immediately place the lid on top aligned with the correct position. The ink will mark the box at the point to be drilled.

Check that the l.e.d. will protrude through the hole when the lid is in position. Careful bending of the l.e.d. leads is permissible to provide small adjustments.

Only the *tip* of the l.e.d. should show through the case. If it protrudes through the hole too far, the separate glow of the green and red l.e.d.'s will be seen when the device is viewed at an angle and this will spoil the effect.

Measure the positions of presets VR1 and VR2. Drill two small holes in the lid to correspond with these positions so that these presets may be adjusted using a small screwdriver when the lid of the box is in place.

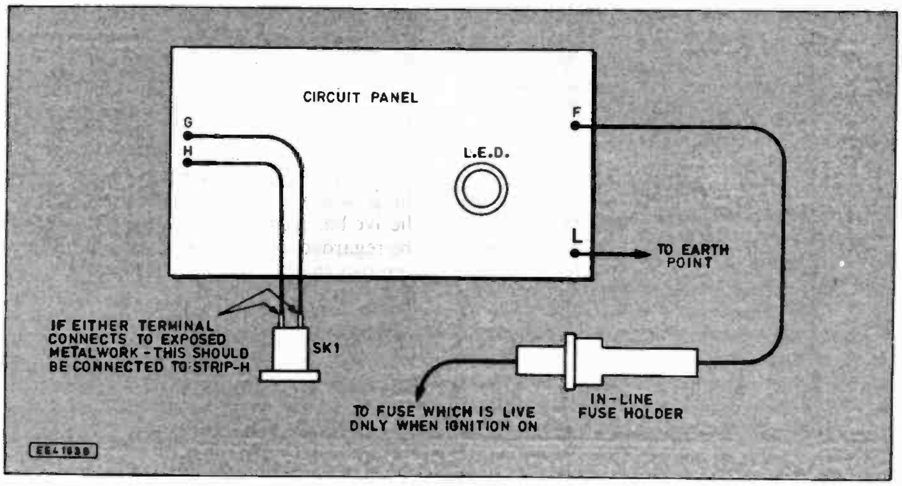
Mount the circuit panel on piece of thin cardboard to provide some padding. Attach the thermistor connecting socket and wire it up. The terminal connected to any exposed metal should be wired to supply negative – i.e. to strip *H* on the circuit panel (see Fig. 5).

Make sure all connections remain clear of VR2 and other components. Tie a knot in the supply wires to provide some strain relief and pass them through the hole in the box drilled for the purpose leaving a little slack.

Adjust all three presets to approximately mid-track position. Finally, insert the i.c. into its socket observing the orientation.

Use a short piece of light-duty twin wire to make a temporary connecting lead for the thermistor. Fit one end with the plug

*Fig. 5. Interwiring from the circuit board. The "earth" wire is taken to a metal chassis point.*



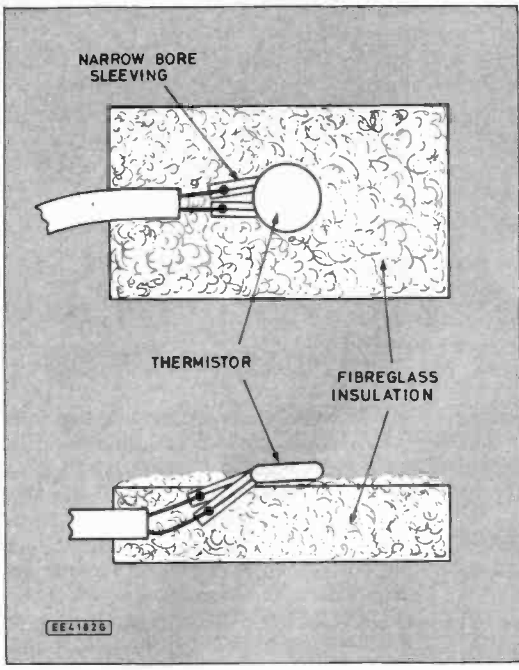
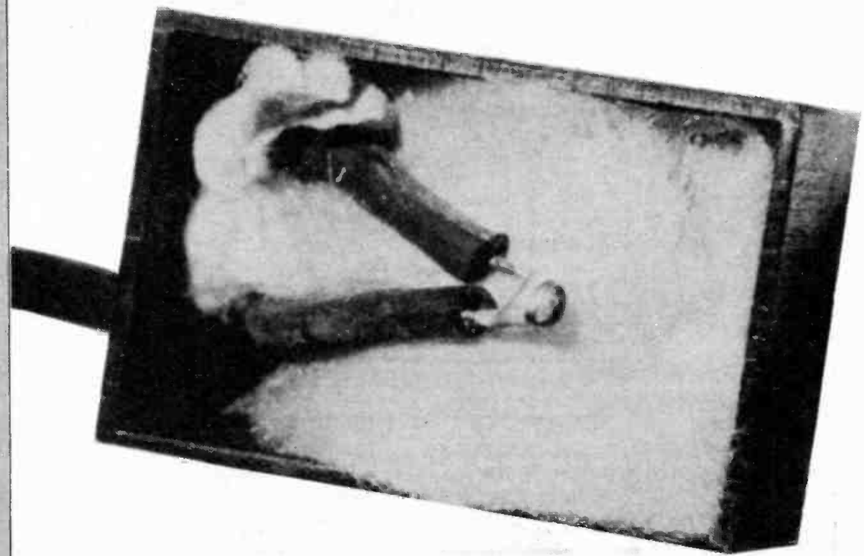


*Fig. 6. Suggested method of housing the thermistor inside a small "potting" box.*


*The thermistor housed in a potting box on a bed of fibreglass insulation.*

and twist the other ends on to the thermistor wires. Take care since the thermistor is a delicate component and the wire ends are easily broken off.

## TESTING

Initial testing and setting-up are made using a 9V battery instead of the car supply. If a thermometer which reads up to 100°C is available, this may help but is not essential. Testing on the bench is convenient since any small problems which may have arisen are more easily corrected.

Connect the battery with the positive terminal to the red wire and the negative to the black one. The l.e.d. should glow *green* although a little less brightly than it will be when connected to the car's 12V system.

Warm the thermistor R2 by dipping it in hot water. The l.e.d. should go to the yellow stage (with preset VR1 at mid-track position this should occur at 50°C approximately) and eventually show red towards boiling point.

This is only a basic test – there is no point in trying to set the operating temperatures this way since water conducts electricity well enough to disturb the operating points. In any case, the exact temperatures can only be set with the thermistor under true working conditions.

Instead of using hot water for testing purposes, it would be possible to use a hair dryer instead. With the l.e.d. showing yellow, adjust preset VR3 to provide the best colour and replace the lid of the box.

If all is well, attention may be given to the thermistor housing. The thermistor cannot be simply attached to the engine block in its present form because the wire ends would soon break off.

Also, cool air circulating around the engine would lower the temperature of the thermistor and alter the operating points. This would lead to unpredictable results with the transitions depending on the air temperature, the speed of the car and so on.

It is therefore necessary to provide mechanical protection and also some insulation. This was achieved in the prototype using the arrangement shown in Fig. 6.

Obtain a piece of light-duty *stranded* twin wire sufficiently long to reach from the unit to the thermistor position. In the prototype, 4-core burglar alarm wire was used with two of the wires cut off short.

The small plastic box used for the thermistor housing is a *potting box* (see components list). This needs a small hole drilled in the side to accommodate the connecting wire.

One end of the connecting lead is passed through to the inside. The thermistor is then soldered to the free ends with the connections insulated with narrow-bore sleeving or (better) heat-shrinkable sleeving. Some strain relief is needed for the wire inside the box – a piece of thin string tied tightly around it is adequate.

The box is now stuffed with fibreglass – such as a little roof or pipe insulation. The thermistor is left on this bed of fibreglass with the top level or slightly higher than the open end of the box (see photograph).

A suitable site on the engine block now needs to be found which becomes hot in operation. This must be clear of *all mechanical parts* and be easily accessible. The thermistor unit *must not* be placed on or near the exhaust system. The local garage will probably help in advising on a suitable place if necessary.

The area is carefully cleaned of all oil and dirt and then roughened using emery paper. The engine should then be run until the attachment site is warm so that the adhesive will set quickly.

Quick-setting epoxy resin adhesive is applied to the face of the thermistor (this is important to provide good thermal contact between the thermistor and the engine block) and around the rim of the box. Take care to avoid putting adhesive on to the fibreglass. The box is then pressed firmly in position and supported until the adhesive has hardened. The attachment must be regarded as permanent – any attempt to remove the box will probably destroy the thermistor.

## INSTALLATION

***Before installing the unit, you must disconnect the car battery.***

Installation is simply a matter of connecting the thermistor wire to the unit inside the car and making the power supply connections. Choose a suitable site for the unit. With care, the position may be chosen so that only the lower part of the box with the l.e.d. shows.

Pass the thermistor connecting wire to the unit position inside the car. It saves time to use an existing hole and grommet by pushing the new wire through alongside the existing ones but if a new one needs to be drilled make sure a rubber grommet is used to avoid damage.

Leave a little slack in the connecting wire to allow for engine vibration. Cut off any excess wire and solder the plug PL1 to the end (polarity unimportant).

Using a piece of red auto-type wire of 3A rating minimum, connect one end to the output side of a fuse which is live only when the ignition is switched on. Use a proper connector here – *do not rely on twisted connections.* Often a "piggy-back" converter may be used to add a wire to an existing terminal.

Cut the wire to the correct length and connect the remaining half of the in-line fuseholder – see Fig. 5. Assemble this with a 1A fuse inside.

Connect the black wire to an "earth" chassis point. If no existing earth point can be found drill a small hole in a metal part and use an eyelet secured with a self-tapping screw. Support the unit temporarily using a piece of string or an elastic band.

## ADJUSTMENT

Re-connect the car battery then switch on the ignition. The l.e.d. should show *green*.

Run the car until the engine is warm – rather less than normal operating temperature – and adjust preset VR1 (SET YELLOW) using a small screwdriver through the hole in the lid so that the l.e.d. just shows *yellow*. Run the car until the engine is at normal operating temperature and adjust VR2 (SET RED) so that the l.e.d. *just* fails to show red under all normal driving conditions. Note that with both VR1 and VR2, clockwise rotation increases the operating temperature.

If the red l.e.d. tends to come on when driving uphill or when waiting in a traffic queue with the engine running, further small adjustments may be made to prevent this from happening. It only remains to attach the unit permanently in position using a small bracket. □

# FOX REPORT

## by Barry Fox

### INTERFERING INTERFERENCE

In the good old days, anyone suffering radio or TV interference went to the local Post Office to fill in a form for a free check. After the split and privatisation of British Telecom, responsibility shifted to the Radiocommunications Agency, in Waterloo. If someone knows for sure where interference is coming from, the RCA will act free. If the RCA has to track down interference the fee payable is a still-reasonable £31.

The RCA has recently announced that it now has a Central Enquiry number for sufferers to ring (071 215 2150). This made me check back on the previous situation. I checked both the telephone directory and BT's Phone Disc CD-ROM. Neither listed either the RCA or Radiocommunicatons Agency.

I now learn that this was not a mistake. Although the RCA and its enquiry number will now be listed, the Agency has for all these years not been entered under its own name. To find the number a member of the public has needed to know that the RCA is an Executive Agency of the DTI, and then phone the DTI's main enquiry number, 071 215 5000.

Perhaps everyone did know this. Or just perhaps this little oversight had the happy effect of shielding the RCA from a lot of interfering phone calls from people suffering interference.

### MS-DOS PATENT BATTLE

Microsoft announced Version 6 of the MS-DOS operating system on 30 March. The launch went ahead despite the fact that Microsoft is being sued for infringement of patents on the data compression system, called DoubleSpace, which Microsoft bought in from Vertisoft and modified to bundle with DOS 6.

Stac Electronics, the owner of the patents and vendor of third party compression system Stacker, has been only too happy to talk about the legal case. Although Microsoft has refused to comment on the case, I read, and reported, a message circulated on electronic bulletin boards by a consultant employed by Microsoft which told how the company is trying to break Stac's patents. Although I normally get all Microsoft's press releases and invites, by some mysterious quirk of the mail I got no invite to the launch "party" for DOS 6.

IBM chose Microsoft, in the early eighties, to provide the operating system for its then-new range of personal computers. Apple's stubborn refusal to licence its much more friendly Lisa and Mac operating systems guaranteed the PC's success and made Microsoft's founder Bill Gates the richest man in America. Despite the user-hostility of DOS, over 100 million IBM and IBM-compatible PCs already use it and Microsoft ships more than 20 million units a year. Microsoft earns around $3 billion a year and employs 12,000 people in 27 countries. But Microsoft knows the market will shrink in the future, because existing owners of PCs will not upgrade their operating system, unless there is a real incentive to do so.

Microsoft believes the best incentive to buy a new version of DOS, is to build in data compression. There are already several third party data compression sytems available, with Stac's Stacker one of the most popular. Stac has grown from a company with 25 employees and a revenue of less than $1 million in 1989 to a company with over 200 employees and revenue of $150 million. Stacker takes advantage of the fact that all computer files contain redundant information, for instance repeated use of the same characters, which need not be fully coded.

### STACKER STALL?

Stac claims that in late 1991 Microsoft's founder, Chairman and Chief Exective Officer, Bill Gates, saw Stacker winning computer industry awards, and asked Stac's President Gary Clow, about including Stacker technology in MS-DOS. During six months of negotiation Microsoft showed Stac a spreadsheet analysis, which predicted that if MS-DOS 6 incorporated data compression, Stac's sales of Stacker would stall. This view is shared by the computer industry.

In the February 1993 issue of *Personal Computer World*, a review of Stacker predicted that MS-DOS with compression would make the "market for utilities like Stacker.... disappear", and suggested to anyone thinking of buying a data compression system that "waiting for MS-DOS 6 may be no bad thing".

Stac says that Microsoft has refused to pay Stac "reasonable compensation" for using Stacker technology in DOS 6, with negotiations between the two companies breaking down, re-starting and failing several times during 1992. In the second half of the year Microsoft released a Beta test version of MS-DOS 6 for software developers to check for problems or "bugs".

Stac checked this and claims that although Microsoft's DoubleSpace may vary slightly from Stacker, it still infringes its two master patents, US patents 4 701 745 and 5 016 009. The first was filed by John Waterworth of Ferranti of the UK, but is now owned by Stac. Microsoft has retained a consultant who describes it as the "king pin" of a tree of patents on compression, but says he is "completely convinced of the patent's triviality" and that it is "ludicrous" that the patent was ever granted.

The consultant warns that the stakes are high. If a company as large as Microsoft wins, then the whole tree of patents will fall; if Microsoft loses, then it is unlikely the patent will be challenged again and will thus be massively strengthened.

Microsoft's difficulty is that it must now prove that what appears trivial now, was trivial when John Waterworth filed his application in March 1985. The patent claims the basic idea of searching data for sequences of bytes which are identical to sequences already processed, and then storing only code which identifies the location of previously stored identical sequences.

"This is a fundamental and obvious technique in data compression and it is ludicrous that it should be anywhere but in the public domain", claims Microsoft's consultant who has been posting notices on electronic bulletin boards for computer engineers and enthusaists all round the world to read. "If you know of any prior art . . . please contact me" pleads Microsoft's aid.

### WILFUL

Microsoft's informal line now is that only 10% of DoubleSpace derives from Vertisoft's original work, and 90% comes from Microsoft's ongoing development; and DoubleSpace, like all compression systems, builds on the same common foundation that Stac is claiming to monopolise. Stac hopes to convince the court in Los Angeles that because Microsoft asked for a licence under its patents, Microsoft's infringement is "wilful". Everything now hangs on the legal validity of Stac's patents.

Stac is now promising a new version of Stacker to be available within 30-60 days from the release of DOS 6. This, says Stac, will hook onto DOS and integrate itself into Microsoft's operating system, by replacing whatever DoubleSpace system comes with DOS 6. The 30-60 day delay was needed because until the official launch of DOS 6, no-one could be sure exactly what DoubleSpace would look like.

# Teach-In '93

**with Alan Winstanley**
**Keith Dye B.Eng(Tech)AMIEE and**
**Geoff MacDonald B.Sc(Hons) AMIEE**

## Part 10

***Teach-In '93 continues a tradition of offering an interesting and thorough tutorial series aimed specifically at the novice or complete beginner in electronics. The series is designed to support those undertaking either GCSE Electronics or GCE Advanced Levels.***

LAST month we introduced lots of new terms that are used in the world of microprocessors and their operating programs. We'll now focus on programming and try to avoid too many new terms. We will not be able to delve into complex programming techniques, but hope to provide an interesting overview to commonly used programming techniques. Don't worry if you find it difficult to grasp the idea of programming on your first reading. If you have built the *Micro Lab* have a go at entering programs – you can't damage anything by pressing the keys!

## INTRODUCTION TO PROGRAMMING

**Machine Code** is the basic language understood by the Microprocessor (or machine). It is made up of *byte instructions* followed by *data* or *address locations.* This is the form that a program is stored in a computer's memory, and will be used to enter instructions into the *Micro Lab*. Unfortunately, it is not easy to understand code written in this way as it just appears as a stream on hexadecimal numbers. Higher level languages are easier to use and understand because they use English to describe the program operations. See the separate section on *High Level Languages.*

An improvement on machine code is an **Assembler Language** program. Assembler language is the preferred method of entering microprocessor code because it uses the three-character mnemonics from the *instruction set.* As the mnemonic represents the function of the instruction, it helps you to understand a program that has been written by someone else (or yourself if you have an average memory!).

All microprocessors have an instruction set with a set of mnemonics. The instruction sets are different for each manufacturer's devices, although there are families of devices that use similar types of code. Instructions written in "assembler" cannot run on the microprocessor in that form and must be converted into machine code. This is achieved either by hand, or with a program that converts the assembler into the machine code of the target microprocessor. Most desk top computers (e.g. the BBC and IBM machines) come with software that allows a program written in assembler to be converted to machine code.

An example of the program listing from our 6502 assembler is shown in Fig. 10.1. This shows the result after the assembler has been converted into machine code. Assemblers come with some other useful features that allow a programmer to choose where the converted code will be placed in the microprocessor's memory map. In this example the code has been placed at 8080h.

## Fig. 10.1 Description of 6502 Program Listings

All the programs written in 6502 assembler language are shown in this format. This is the output of the assembler translation software that produces the 6502 machine code. All the programs can be run on the Micro Lab, but must be entered in machine code. To do this enter the MODify command and type in the memory location – say $0200 – then press enter. The program is then entered as A9 00 85 90 A9 02 etc.

```
8080   A900  D_DEMO0:  LDA   #$00   ;Set up start address of table
8082   8590            STA   $90
8084   A902            LDA   #$02
```

| Memory Address | Op-Codes (Machine Code) | Labels | Mnemonic (Assembler Language) | Operands | Comments |
|---|---|---|---|---|---|

**Numbers**

In computer programs we need to know how to distinguish between decimal and hexadecimal numbers. We will always place an *(H)* or *h* after hexadecimal numbers to distinguish them from decimal numbers. Unfortunately, the output from the 6502 assembler uses a different convention to indicate Hexadecimal numbers. A $ is placed in front of hexadecimal numbers as:

Hex number    $200

**Memory Address**

The memory address is the location of the program in the microprocessor memory map. On the Micro Lab address locations from $8000 to $FFFF are contained in the EPROM. You cannot alter these memory locations.

**Op-Codes**

The op-codes are the machine code instructions that the 6502microprocessor follows. In the first line the op-code for the LDA (Load Accumulator) instruction is A9. The value to be loaded into the accumulator follows the op-code – in this case decimal 00.

**Labels**

Labels are names given by the writer of the program to identify particular points in the program. The assembler language can recognise the names as locations to branch to within the program. In this example D_DEMO0 is at address $8080. An instruction to jump or branch to D_DEMO0 will load the program counter with 8080 and the program will run from this address.

**Assembler Language**

The instructions entered by the programmer are these assembler language descriptions of the program. The mnemonic is a three character abbreviation of the instruction command name. The operand is the data or address that the instruction applies to. In the second line the accumulator is stored at address 0090. (This is a zero page instruction and only two bytes are needed to describe the memory location.)

**Comments**

The comments are an optional description that the programmer can enter. They are used to describe the instruction or process operation. Good programmers use extensive comments to aid others to understand their programs.

# Fig. 10.2 - 6502 Instructions

**BCC – Branch on Carry Clear** NV-BDIZC
--------

Tests the carry flag for 0. If clear, the program will branch forward or backwards by the number of bytes specified. If set, the next program instruction is executed. Displacement range from +127 to -128 from the next instruction after BCC.

| Address Mode | Op-Code | Example | |
|---|---|---|---|
| Relative | 90 | 90 20 | BCC PC+20h |

**BEQ – Branch on Z = 1** NV-BDIZC
--------

Tests the zero flag for 1. If set, the program will branch forward or backwards by the number of bytes specified. If clear, the next program instruction is executed. Displacement range from +127 to -128 from the next instruction after BCC.

| Address Mode | Op-Code | Example | |
|---|---|---|---|
| Relative | F0 | F0 20 | BEQ PC+20h |

**BNE – Branch on Not Equal to Zero** NV-BDIZC
--------

Tests the Z flag for 0. If clear, the program will branch forward or backwards by the number of bytes specified. If set, the next program instruction is executed. Displacement range from +127 to −128 from the next instruction after BCC.

| Address Mode | Op-Code | Example | |
|---|---|---|---|
| Relative | D0 | D0 20 | BNE PC+20h |

**BRK – Break** NV-BDIZC
---1----

A software interrupt of the program. The PCL is set to the value stored at FFFE and the PCH is set to the value stored at FFFF. The B flag in the status register is set, and the status register is saved on the stack.

| Address Mode | Op-Code | Example | |
|---|---|---|---|
| Implied | 00 | 00 | BRK |

**CPY – Compare to Y Register** NV-BDIZC
x-----xx

Compares the contents of the specified memory or immediate data from the Y register. If the result is zero Z is set. If bit 7 = 1 (positive) then N is set to 1. If the register equals or is greater than the data (negative) the C flag is set. The memory and accumulator contents are unchanged.

| Address Mode | Op-Code | Example | |
|---|---|---|---|
| Immediate | C0 | C0 20 | CPY #20h |
| Absolute | CC | CC 34 12 | CPY 1234h |
| Zero Page | C4 | C4 20 | CPY 20h |

**DEX – Decrement X Register** NV-BDIZC
x-----x-

Decrements 1 from the X register.

| Address Mode | Op-Code | Example | |
|---|---|---|---|
| Implied | CA | CA | DEX |

**INY – Increment Y Register** NV-BDIZC
x-----x-

Adds 1 to the contents of the Y register.

| Address Mode | Op-Code | Example | |
|---|---|---|---|
| Implied | C8 | C8 | INY |

**JMP – Jump to Address** NV-BDIZC
--------

Loads the program counter with the address specified. The program will jump to the new address.

| Address Mode | Op-Code | Example | |
|---|---|---|---|
| Absolute | 4C | 4C 34 12 | JMP 1234h |
| Indirect | 6C | 6C 34 12 | JMP (1234h) |

**JSR – Jump to Subroutine** NV-BDIZC
--------

Stores the program counter + 2 onto the stack, and loads a new address into the program counter. The program jumps to that address. An RTS is used to return to address stored in the stack.

| Address Mode | Op-Code | Example | |
|---|---|---|---|
| Absolute | 20 | 20 34 12 | JSR 1234h |

**LDA – Load the Accumulator** NV-BDIZC
x-----x-

Loads the data into the accumulator.

| Address Mode | Op-Code | Example | |
|---|---|---|---|
| Immediate | A9 | A9 20 | LDA #20h |
| Absolute | AD | AD 34 12 | LDA 1234h |
| Zero Page | A5 | A5 20 | LDA 20h |
| (Indirect,X) | A1 | A1 20 | LDA (20h,X) |
| (Indirect),Y | B1 | B1 20 | LDA (20h),Y |
| Zero Page,X | B5 | B5 20 | LDA 20h,X |
| Absolute,X | BD | BD 34 12 | LDA 1234h,X |
| Absolute,Y | B9 | B9 34 12 | LDA 1234h,Y |

**LDX – Load the X Register** NV-BDIZC
x-----x-

Loads the data into the X register

| Address Mode | Op-Code | Example | |
|---|---|---|---|
| Immediate | A2 | A2 20 | LDX #20h |
| Absolute | AE | AE 34 12 | LDX 1234h |
| Zero Page | A6 | A6 20 | LDX 20h |
| Absolute,Y | BE | BE 34 12 | LDX 1234h,Y |
| Zero Page,Y | B6 | B6 20 | LDY 20h,Y |

**LDY- Load the Y Register** NV-BDIZC
x-----x-

Loads the data into the Y register

| Address Mode | Op-Code | Example | |
|---|---|---|---|
| Immediate | A0 | A0 20 | LDY #20h |
| Absolute | AC | AC 34 12 | LDY 1234h |
| Zero Page | A4 | A4 20 | LDY 20h |
| Zero Page,X | B4 | B4 20 | LDY 20h,X |
| Absolute,X | BC | BC 34 12 | LDY 1234h,X |

**LSR-Logical Shift Right** NV-BDIZC
x-----xx

Shifts the contents of the memory or accumulator 1 bit to the right, and saves the result. Bit 7 is set to 0. Bit 0 is stored in the C flag.

| Address Mode | Op-Code | Example | |
|---|---|---|---|
| Absolute | 4E | 4E 34 12 | LSR 1234h |
| Zero Page | 46 | 46 20 | LSR 20h |
| Accumulator | 4A | 4A | LSR A |
| Zero Page,X | 56 | 20 | LSR 20h,X |
| Absolute,X | 5E | 5E 34 12 | LSR 1234h,X |

**PHA – Push Accumulator onto Stack** NV-BDIZC
--------

Copies the contents of the accumulator onto the stack and decrements the stack pointer.

| Address Mode | Op-Code | Example | |
|---|---|---|---|
| Implied | 48 | 48 | PHA |

**PLA – Pull Accumlator from Stack** NV-BDIZC
x-----x-

Loads the top byte from the stack into the accumulator and increments the stack pointer.

| Address Mode | Op-Code | Example | |
|---|---|---|---|
| Implied | 68 | 68 | PLA |

**STA – Store Accumulator in Memory** NV-BDIZC
--------

Copies the accumulator to the specified memory location.

| Address Mode | Op-Code | Example | |
|---|---|---|---|
| Absolute | 8D | 8D 34 12 | STA 1234h |
| Zero Page | 85 | 85 20 | STA 20h |
| (Indirect,X) | 81 | 81 20 | STA (20h,X) |
| (Indirect),Y | 91 | 91 20 | STA (20h),Y |
| Zero Page,X | 95 | 95 20 | STA 20h,X |
| Absolute,X | 9D | 9D 34 12 | STA 1234h,X |
| Absolute,Y | 99 | 99 34 12 | STA 1234h,Y |

## Instruction Sets

Every microprocessor is designed to follow a set of instructions. Unfortunately every manufacturer uses a different set of instructions for their products. This means that a program written for one type of processor will not run on another without some alterations. As more powerful processors are developed, some manufacturers have tried to provide an upward compatibility for existing programs. In the case of Intel's 86*xxx* series of microprocessors used in IBM compatible personal computers, programs written for the early microprocessors will run on the latest devices. The process does not work in reverse, as later devices usually have additional features built in and programs written to use these will have commands that the early devices cannot understand.

As we have used the 6502 microprocessor for the *Micro Lab* we have to use its instruction set. Some of the instructions we use this month are shown in Fig. 10.2. The instructions are all given in the same format and we have given examples of how the commands are used.

All the instructions have a one byte code which is the command that the microprocessor understands. This is called the *Operation Code*, or more usually the *Op-Code*. A sequence of op-codes make a program that a microprocessor will follow – it can only operate on one op-code at a time.

As one byte is used for the Op-Code there are theoretically 256 different instructions that could be used. The 6502 only uses 150 instructions – codes that are not valid instructions are ignored.

There are only 56 basic instructions for the 6502, but some of these have different ways of being used within programs. Each basic instruction type is given a three letter "name" or mnemonic that helps you to remember the instruction. For example the instruction Branch on Carry Clear is called BCC. If you look at the instruction set you can see that this instruction has only one mode of use. Some of the instructions have eight modes of operation, and we will look at some of these different modes.

## Addressing Modes

A computer program will usually spend most of its time reading and writing data to and from memory. There are a number of ways in which the program may need to do this. For example, you may need to set a register to a particular value. This is called *immediate addressing*, as the register is immediately loaded with the value specified. If you have a program that needs to repeat a section of the program a set number of times you will first have to store the repeat value in a register. As the computer completes this section of the program it will subtract one from the register. If the register is not zero the program will jump to the start of that section again. We will look at these techniques again later.

There are several other ways in which you may want to load and store data to and from registers and memory depending on what you want your program to do. Each different way of accessing the memory is called an *addressing mode*. The addressing modes available depend upon the micro processor being used, although they all provide the same basic facilities. Each addressing mode of the 6502 is described below. As with most things, some addressing modes are more useful than others and will therefore be used more often. An example is given with each mode. The examples given are of usable programs and may contain several addressing modes.

If you have successfully constructed the Micro Lab, have a go now at entering the programs. The *Micro Lab* User Manual contains comprehensive details of how to enter your own code and see it operate. Remember, you cannot damage the *Micro Lab* if you press the wrong keys, just try again! If you have a 6502 based computer ( like the BBC B and Acorn Master series) you could try to enter the code in assembler or machine code. (Note: the programs may not run as the memory map will be different on these machines.)

A table of Hexadecimal and Decimal numbers and their ASCII equivalents is given in opposite. Use this to help you understand some of the numbers being entered in the programs.

**Immediate Addressing**

Loads a register (not a memory location) with an immediate value.

```
0200 A9 20     LDA   #20h      ;Load accumulator with 20h
```

The example loads the accumulator immediately with the value 20h.

**Implied Addressing**

This term is used for instructions which do not have an addressing mode specified. For example pushing the contents of the accumulator onto the stack:

```
0200 48        PHA             ;Save accumulator
```

# ASCII TABLE

| HEX | DEC | ASCII | HEX | DEC | ASCII |
|---|---|---|---|---|---|
| 00 | 0 | NUL | 40 | 64 | @ |
| 01 | 1 | SCH | 41 | 65 | A |
| 02 | 2 | STX | 42 | 66 | B |
| 03 | 3 | ETX | 43 | 67 | C |
| 04 | 4 | EOT | 44 | 68 | D |
| 05 | 5 | ENQ | 45 | 69 | E |
| 06 | 6 | ACK | 46 | 70 | F |
| 07 | 7 | BEL | 47 | 71 | G |
| 08 | 8 | BS | 48 | 72 | H |
| 09 | 9 | HT | 49 | 73 | I |
| 0A | 10 | LF | 4A | 74 | J |
| 0B | 11 | VT | 4B | 75 | K |
| 0C | 12 | FF | 4C | 76 | L |
| 0D | 13 | CR | 4D | 77 | M |
| 0E | 14 | SO | 4E | 78 | N |
| 0F | 15 | SI | 4F | 79 | O |
| 10 | 16 | DLE | 50 | 80 | P |
| 11 | 17 | DC1 | 51 | 81 | Q |
| 12 | 18 | DC2 | 52 | 82 | R |
| 13 | 19 | DC3 | 53 | 83 | S |
| 14 | 20 | DC4 | 54 | 84 | T |
| 15 | 21 | NAK | 55 | 85 | U |
| 16 | 22 | SYN | 56 | 86 | V |
| 17 | 23 | ETB | 57 | 87 | W |
| 18 | 24 | CAN | 58 | 88 | X |
| 19 | 25 | EM | 59 | 89 | Y |
| 1A | 26 | SUB | 5A | 90 | Z |
| 1B | 27 | ESC | 5B | 91 | [ |
| 1C | 29 | FS | 5C | 92 | \ |
| 1D | 29 | GS | 5D | 93 | ] |
| 1E | 30 | RS | 5E | 94 | ^ |
| 1F | 31 | US | 5F | 95 | _ |
| 20 | 32 | SPACE | 60 | 96 | ` |
| 21 | 33 | ! | 61 | 97 | a |
| 22 | 34 | " | 62 | 98 | b |
| 23 | 35 | # | 63 | 99 | c |
| 24 | 36 | $ | 64 | 100 | d |
| 25 | 37 | % | 65 | 101 | e |
| 26 | 38 | & | 66 | 102 | f |
| 27 | 39 | ' | 67 | 103 | g |
| 28 | 40 | ( | 68 | 104 | h |
| 28 | 41 | ) | 69 | 105 | i |
| 2A | 42 | * | 6A | 106 | j |
| 2B | 43 | + | 6B | 107 | k |
| 2C | 44 | , | 6C | 108 | l |
| 2D | 45 | - | 6D | 109 | m |
| 2E | 46 | . | 6E | 110 | n |
| 2F | 47 | / | 6F | 111 | o |
| 30 | 48 | 0 | 70 | 112 | p |
| 31 | 49 | 1 | 71 | 113 | q |
| 32 | 50 | 2 | 72 | 114 | r |
| 33 | 51 | 3 | 73 | 115 | s |
| 34 | 52 | 4 | 74 | 116 | t |
| 35 | 53 | 5 | 75 | 117 | u |
| 36 | 54 | 6 | 76 | 118 | v |
| 37 | 55 | 7 | 77 | 119 | w |
| 38 | 56 | 8 | 78 | 120 | x |
| 39 | 57 | 9 | 79 | 121 | y |
| 3A | 58 | : | 7A | 122 | z |
| 3B | 59 | ; | 7B | 123 | { |
| 3C | 60 | < | 7C | 124 | \| |
| 3D | 61 | = | 7D | 125 | } |
| 3E | 62 | > | 7E | 126 | ~ |
| 3F | 63 | ? | 7F | 127 | DEL |

**Absolute Addressing**

This is used to access a particular memory location to either load a register with the location's value or store the register value in the memory location. This may be used to access *peripherals* such as the keyboard, display, l.e.d.s etc. or using memory for storage of program *variables* (for example the number of ships the player has left in a game of space invaders, today's date, etc.).

```
0200 A9 AA     LDA  #AAh    ;Load accumulator with AAh
0202 8D 00 80  STA  8000h   ;Store accumulator in LEDs
```

This loads the accumulator with AAh (10101010 in binary) and stores it at the memory location used by the l.e.d.s. This has the effect of turning on every other l.e.d. Try this out on the *Micro Lab* and see the l.e.d.s light up.

**Offset Addressing**

Offset addressing is only used by the 6502 *branch* instructions. These instructions change the program counter if a particular condition is true or false (e.g. if the last arithmetic result was zero). If the condition is met, the program counter is added to the parameter. Note that when the instruction is read from memory, the program counter is pointing to the first byte of the next instruction. This means that an offset of zero will have no effect. An offset of three will branch forwards, skipping three bytes. An offset of -2 (or FEh) will branch to the start of the branch instruction – looping continuously if the condition is met.

```
0200 A9 00     LDA  #00h    ;Load acc. with zero
0202 F0 03     BEQ  0207h   ;Jump to 0207h if ZF is set
0204 4C 00 03  JMP  0300h   ;Jump to 0300h
0207 00        BRK          ;Stop program
```

The above example will always jump to address 0207h then stop.

```
0200 A0 10     LDY  #16     ;Load IY with 16
0202 88        DEY          ;Subtract one from IY
0203 D0 FD     BNE  0202h   ;Jump to 0202h if not zero
0204 00        BRK          ;Stop program
```

The above example will loop for sixteen (10h) times then stop.

**Zero Page Addressing**

Zero page addressing is a subset of absolute addressing. The address specified is only eight bits wide. The upper eight bits of the address are set to zero (hence the name). Therefore, only addresses between 0000h and 00FFh may be accessed with this addressing mode. The advantage of using zero page addressing is that the instruction uses less memory (a considerable advantage a few years ago when memory was very expensive, but not so today). Using less memory means that the processor can read the instruction from the program faster.

```
0200 A5 90     LDA  90h     ;Load accumulator with the
                            ;contents of address 0090h
```

**Absolute Indexed Addressing**

This is a more complex addressing mode than those previously described, but it is probably one of the most often used. A *base address* is specified, along with an index register (either IX or IY). The value held by the index register is added to the base address and the resulting address is the one used by the instruction.

The following example stores 12h in address 0410h using absolute indexed addressing. This may seem pointless, as the same result can be obtained using simple absolute addressing, however a better use of this addressing mode will be described later when we talk about *program loops*. This addressing mode is denoted by a ",X" or ",Y" after the base address.

```
0200 A9 12     LDA  #12h     ;Load accumulator with 12h
0202 A0 10     LDY  #10h     ;Load IY with 10h
0204 99 00 04  STA  0400h,Y  ;Store acc. at 0410h
```

**Zero Page Indexed**

Again, this is a subset of the absolute indexed addressing mode. The base address specified must be in the range 00h to FFh and the upper eight bits of the resultant address are always 00h. This means that, for example, if the base address is F0h and the IX register is 20h, the address accessed will be 0010h, *not 0110h*.

```
0200 A2 20     LDX  #20h    ;Load IX with 20h
0202 XX F0     LDA  F0h,X   ;Load acc. with contents
                            ;of address 0010h
```

**Indirect Addressing**

This one's a bit more complicated! The processor looks at the contents memory at the address specified and then at the contents of the one after it. The two values read are then used as the resultant address. This is best shown by an example. Indirect addressing is shown by placing the address in brackets.

```
If
    Address 0400h holds the value 00h
    Address 0401h holds the value 05h
Then the instruction
0200 6C 00 04 JMP  (0400h)
Will make the program jump to address 0500h
```

**Indexed Indirect Addressing**

Indexed Indirect Addressing simply adds the value of the IX register to the address which is to be looked at to get the resultant address! This is shown by inserting a ",X" after the address.

```
If
    Address 0096h holds the value 00h
    Address 0097h holds the value 05h
    Address 0500h holds the value 34h
Then the instructions
0200 A2 06     LDX  #06h
0202 XX 90     LDA  (90h,X)
Will load the accumulator with the value 34h (held at
address 0500h).
```

**Indirect Indexed Addressing**

This mode looks at contents of the two bytes specified (as with indexed addressing) and then adds the value of the IY register. This addressing mode is shown by placing a ",Y" after the close bracket.

```
If
    Address 0090h holds the value 00h
    Address 0091h holds the value 05h
    Address 0504h holds the value 56h
Then the instructions
0200 A0 04     LDY  #04h
0202 XX 90     LDA  (90h),Y
Will load the accumulator with the value 56h.
```

The last three addressing modes may seem a bit complicated at first, but you'll soon get the hang of it! They may also seem a bit pointless, but they do have their uses, especially when you are using *text strings, look-up* tables or large areas of memory (greater than 256 bytes). Again, we will go into this in more detail later. Don't worry if it seems a bit incomprehensible at the moment. We hope that the *Micro Lab* will help you to clarify things.

## REGISTERS

In order to run a program, the microprocessor needs to keep track of such things as where the next program instruction can be found, or the result of the last arithmetic operation, etc. These values are stored in *registers*. There are two types of register – *user registers* may be used by the user's program to store values, pass information, etc. *Specific registers* are used to control the way in which the processor operates or are set by the processor to inform the user program of various events.

The 6502 has six registers, five of which are eight bits wide. (See last months Fig. 9.10 – CPU Internal Architecture.) So, binary numbers between 00000000 and 11111111 may be stored in them. In decimal, the range is 0 to 255. The exception to this is the *program counter* register. This register is sixteen bits wide (as the address bus is sixteen bits wide) and, thus, may store decimal values between 0 and 65535.

There are three specific registers, the *program counter (PC)*, the *processor status word (PSW)* and the *stack pointer (SP)*.

The program counter holds the memory address of the next instruction that the processor is to execute. As each byte of the instruction is read from memory, the value in the PC is incremented by one. The user may set the PC to a specific value when required. This has the effect of making the program *branch* or *jump* to a new address.

Unlike the other registers, processor status word is not used as an eight bit number. Instead is a collection of single bit *flags* which indicate various states within the processor. For example, the N flag is set to a 1 if the result of the last arithmetic operation was negative (less than zero) – one way in which this could happen is if a register containing zero was *decremented* by one.

The stack pointer holds the lower eight bits of the next free stack address. The upper eight bit of the stack address are always 00000001 (i.e., the stack is stored in *page one* of the memory

## MACHINE CODE AND HIGH LEVEL LANGUAGES

Computer languages come in all shapes and sizes. Most of you will be aware of languages such as BASIC, Pascal and C, which are examples of *high level languages*. Conversely, machine code is known as a *low level language*. A high level language uses complex language to describe the program. This makes the program easier to understand as it reads like a description of the operations to be performed. A low level language uses terse instructions made from the basic computer commands. These are often difficult to follow and understand as they have no easy flow of language, and the instructions are not easily remembered.

A computer can not directly run programs written in a high level language, they must first be translated into machine code. This can happen in one of two ways - *interpreting* and *compiling*. To illustrate the difference, consider a piece of text written in French which a person who only understands English wishes to read. An interpreter may be hired to read the text to the person every time he or she wishes to read it, or a translator may be hired to rewrite it in English.

Although the second option has an initial time overhead whilst the translator rewrites the text, the text may then be read quickly by the English speaking person and, indeed, any other English speaking person without the need for a translator. This is equivalent to *compiling* a program, the first option is equivalent to *interpreting* it. Compiled programs run faster than interpreted ones but there is a time penalty each time the program is compiled which can slow down program development. Additionally, interpreted programs need the interpreter present on every computer in which they are to run. With modern computers, the time taken to compile a program is quite small and, so, there are very few interpreted programming languages around today.

There are several advantages to writing programs in a high level language instead of machine code:

Program development is much easier and quicker

It is easier for other people to understand your programs

A program may be made to run on a system with a different processor by passing it through a compiler for that processor (similar to using a different translator to rewrite the French text in German). A machine code program will need to be completely rewritten for the new processor.

However, programs written directly in machine code will run *much* faster than their compiled counterpart and the final code will also be much smaller. Computer games tend to be written mainly in machine code for these reasons, as they are very demanding on the microprocessor as they are continually calculating new positions and updating the display whereas a word processor, for example, spends most of its time waiting for the user to press a key.

The choice of high level language or machine code depends upon the application. You should remember, however, that it is always possible to mix the two.

space). The stack is used to temporarily store numbers and addresses. When a number is *pushed* onto the stack, the number is stored at this address and the address is decremented by one. For example, if SP = FFh and the value 05h was pushed onto the stack, then address 01FFh would hold the value 05h and the SP would be FEh. When a number is *pulled* from thestack, the opposite occurs – i.e., SP is incremented by one and the contents of the stack address are read. This type of stack is known as a *last in, first out (LIFO) stack*. This means that the last item pushed onto the stack will be the first item pulled from it. This is similar to placing dinner plates in a pile. You only place a new plate on the top of the pile and may only remove the top plate in the pile.

The three remaining registers are the user registers. These are named the *accumulator (A)*, the *X index register (IX)* and the *Y index register (IY)*. These registers may be used in any way by the user's program, the only restriction being that the 6502 uses **only** the accumulator for the arithmetic and logic functions.

For example, when adding two numbers together, the first number must be stored or *loaded* into the accumulator and the second must then be added to it. The result is then placed back in the accumulator.

## COMPARISONS AND LOOPS

A useful computer program will often need to skip sections of code or jump to particular sections depending upon one or more *conditions*. As an example, to set memory locations between 0400h and 044Fh to zero, you could use a program like this:

```
0200 A9 00     LDA  #00h      ;Load acc. with zero
0202 8D 00 04  STA  0400h     ;Set address 0400h to zero
0205 8D 01 04  STA  0401h     ;Set address 0401h to zero
                 . . .
02F2 8D 4F 04  STA  044Fh     ;Set address 044Fh to zero
02F5 00        BRK            ;Stop program execution
```

And so on, until every memory location is set to zero. But, obviously, you wouldn't want to do it this way! Instead, you would write a program which would repeat the code to store the accumulator at a particular memory location the required number of times:

```
0200 A9 00     LDA  #00h      ;Load acc. with zero
0202 A2 00     LDX  #00h      ;Load IX with zero
0204 8E 00 04  STA  0400h,X   ;Set loc. 0400h + IX to zero
0207 E8        INX            ;Add 1 to IX
0208 E0 50     CPX  #50h      ;IX = 50h?
020A D0 F8     BNE  0204h     ;No – Jump to 0204h
020C 00        BRK            ;Stop program execution
```

Note the use of indexed addressing to store the accumulator in memory and offset addressing to branch back in the program.

The comparison is performed by the CPX instruction. This instruction compares the IX register with the immediate value of 50h. If the two are equal, then the *zero flag* in the PSW is set, otherwise it is cleared. The BNE instruction looks at the zero flag and jumps to the specified address if it is clear (i.e. IX is not equal to 50h). The opposite of this is the BEQ instruction which jumps if the zero flag is set.

Branch instructions on the 6502 always use an offset addressing mode. This addressing mode restricts you to branching forwards by a maximum of 127 bytes and backwards by a maximum of 128 bytes. There will be occasions when this range is not adequate. So, it is normal to test for the opposite condition to skip over an absolute jump to the address required. As an example, the following program looks at the DIPswitches on the *Micro Lab* and jumps to address 0500 if they are all on.

```
0200 AD 10 80  LDA  8010      ;Get switch settings
0203 C9 FF     CMP  #FFh      ;Switches all on?
0205 D0 03     BNE  020Ah     ;No – skip over the jump
0207 4C 00 05  JMP  0500h     ;Yes – jump to 0500h
020A 00        BRK            ;Stop program
```

## LOOK-UP TABLES

Look-up tables are used at some point by most programs – for writing text, reading keyboards, determining the number of days in a month, etc. In 6502 machine code, a look-up table is normally accessed using absolute indexed addressing.

To demonstrate this, we will first show you how to determine the number of days in a month then how to write a text string to the l.c.d.

**Determining the Number of Days in a Month**

A table of twelve numbers is generated. The first number being the number of days in January and the last being the number of days in December (we will ignore leap years).

In decimal, this table is:

**31, 28, 31, 30, 31, 30, 31, 31, 30, 31, 30, 31**

Converting this into hexadecimal, we get:

**1F, 1C, 1F, 1E, 1F, 1E, 1F, 1F, 1E, 1F, 1E, 1F**

This table must be stored in memory at a known start location, say 0300h.

If the IX register is loaded with the number of the month we wish to look at (from 0 to 11), a single instruction may be used to load the accumulator with the number of days in that month. You may use the REGS command on the *Micro Lab* to set the IX register before running the program.

```
0200 BD 00 03  LDA  0300h,X   ;Get no. of days in month
0203 00        BRK            ;Stop program
```

When the program has been run, the l.c.d. on the *Micro Lab* shows the register values, the IX register will contain the number of the month and the accumulator will contain the number of days in this month.

There are two ways to change the program to number the months from 1 to 12:

The first is to set the base address of the table to one less than the real start of the table:

```
0200 BD FF 02 LDA  02FF,X   ;Get no. of days in month
0203 00       BRK           ;Stop program
```

The second is to subtract one from the IX register before looking at the table:

```
0200 CA       DEX           ;Subtract one from IX
0201 BD 00 03 LDA  0300h,X  ;Get no. of days in month
0204 00       BRK           ;Stop program
```

**Writing Text to an LCD**

To write text to an l.c.d. (or, indeed, any type of display) you need to make a table containing the ASCII values of the characters which you wish to write. (See the table in Fig. 10.10 for a list of ASCII characters.) The l.c.d. on the *Micro Lab* will not display all of the ASCII codes, as some are only used in controlling computer terminals. Try some of them out – you can't damage the l.c.d. by giving it characters it cannot display.

An index register is set to zero so that the first character from the table may be read. This character is then sent to the l.c.d. The index register is then incremented by one to point to the next character. This character is also sent to the l.c.d. This is repeated as many times as necessary. For text with a known size, you can compare the index register with the number of characters which you are to display in order to end the cycle, however it is normal to place a byte which does not represent a display character (say 00h) at the end of the text table:

```
0200 A2 00    LDX  #00h     ;Point to start of table
0202 BD 00 03 LDA  0300h,X  ;Get next character
0205 F0 07    BEQ  020Eh    ;If Char. = 00h, end loop.
0207 20 06 00 JSR  0006h    ;No – Send char. to l.c.d.
020A E8       INX           ;Point to next char.
020B 4C 02 02 JMP  0202h    ;Loop back
020E 4C 0E 02 JMP  020Eh    ;Loop forever

0300 48 65 6C               ;Text table for "Hello"
0303 6C 6F 00               ;With a 00h at the end.
```

Note that unlike previous examples, there is not a BRK instruction at the end of the program. This is because a BRK instruction returns the user to the *Micro Lab monitor* program, which displays the CPU registers on the l.c.d., overwriting the previous display. The **JMP 020Eh** instruction simply loops back to itself so that the only way to stop it is to reset the processor or press **STOP** on the *Micro Lab* keyboard.

This program can only display text beginning at a particular area of memory (0300h). Next month, we will show you how to write a *subroutine* which can be called by your programs to display text from anywhere in the computer's memory, using indirect indexed addressing.

## MICRO LAB INPUT AND OUTPUT CIRCUITS

That's enough programming technique for this month! Lets take a look at some *Micro Lab* **Input and Output** (I/O) circuits to see how data can be transferred to and from a computer system.

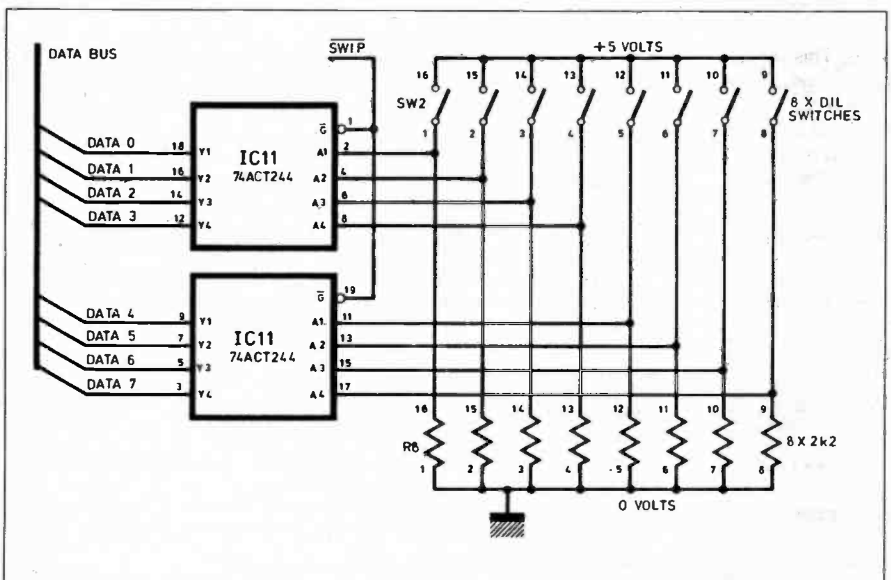



*Fig. 10.3. Input switches*

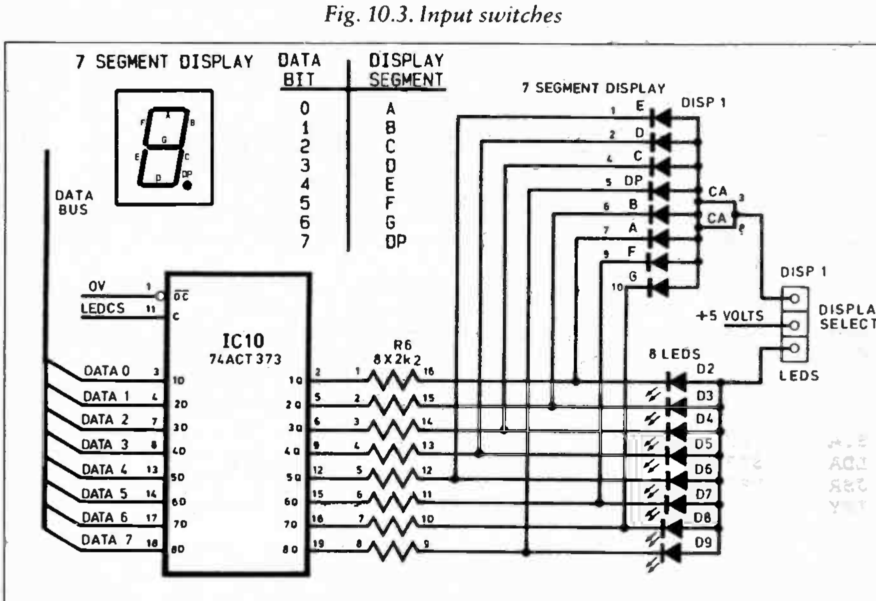



*Fig. 10.4. Output LEDs*

**Switch Input Circuit**

The switch input circuit is shown in Fig. 10.3. This allows the microprocessor to "read" the state of the eight input switches. The eight inputs are pulled to ground via eight 2k2 resistors. When the switches are closed the voltage across the resistors rises to five volts. IC11 is an octal tri-state line receiver whose outputs (O/Ps) are connected to the computer's data bus. The switch data can only pass through the tri-state receiver when the enable input on pin 1 and pin 19 is taken low. This is driven by the address decoding circuits and synchronised to allow the switch data to be placed on the data bus when no other data is present.

The $\overline{SWIP}$ enable signal is activated when the CPU reads from addresses 8010h. This "read" instruction allows the CPU to load the contents of the data bus into the accumulator, and the only data on the bus will be the switch settings.

**L.E.D. Output Circuit**

The LED output (O/P) circuit of the *Micro Lab* is shown in Fig. 10.4. In this case the CPU writes data to IC10 – an octal tri-state latch. The data is loaded into the latch when the LEDCS control line goes low. Again this is synchronised by the decoding circuit to only allow data intended for the l.e.d.s to be latched.

The eight outputs drive the high efficiency l.e.d.s via eight 2k2 current limiting resistors. The outputs are connected to both 8 separate l.e.d.s and a 7 segment display. A link is used to apply five volts to the required display.

The LEDCS signal is activated when the CPU writes to address 8000h.

**Keyboard Input Circuit**

The keyboard I/P circuit for the *Micro Lab* is shown in Fig. 10.5. This circuit uses a dedicated keyboard scanning i.c. (IC4) to constantly check the keypad for a key press. When a key is pressed IC4 generates an interrupt signal from its IRQ output. This goes to the CPU's Non Maskable Interrupt ($\overline{NMI}$). When the $\overline{NMI}$ goes low the CPU enters an interrupt program to read IC4 and determine which key has been pressed.

The keys are arranged in a matrix of rows and columns. Pressing any key links a row to

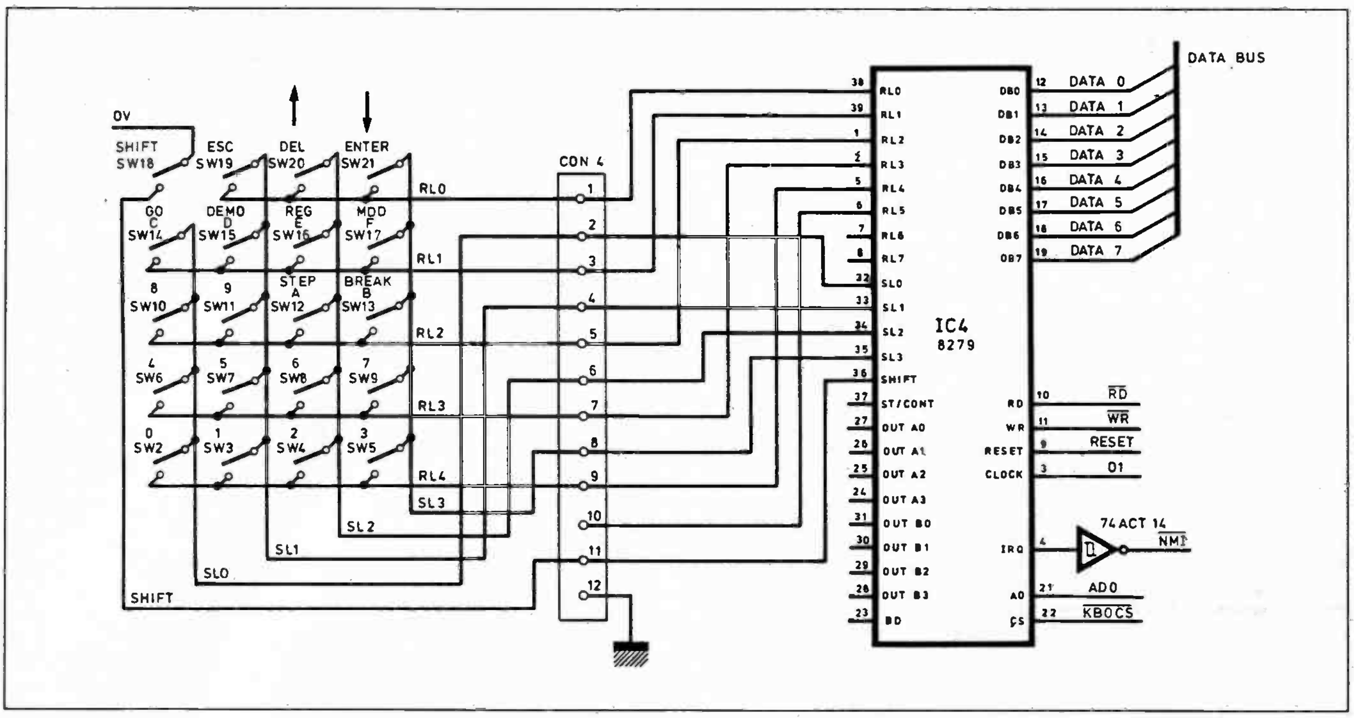



*Fig. 10.5. Keyboard input.*

a column and this is decoded in IC4 into a binary value. This is read from IC4 via the data bus when decoder O/P (KBDCS) goes low. Again the decoder circuit ensures that only the data from IC4 will be on the data bus during this read operation. The keyboard registers are located at 8060h and 8061h. IC4 can also drive l.e.d.s and has a separate write (WR) line to allow data to be written to the display registers. We do not use this feature on the *Micro Lab*.

## INTERFACING MICROPROCESSORS TO THE "REAL WORLD"

We are now at the stage where we can apply some of the topics discussed. This month, we will cover simple input and output (I/O) devices – switches and l.e.d.s. The programs used are already contained within the *Micro Lab* monitor. Three topics are covered which drive simple l.e.d.s and 7-Segment displays and read multiple switch inputs. These use the I/O circuits previously described.

**Demonstration 0:**

This program shows you how to illuminate eight LEDs in a pre-defined sequence. The use of look up tables, indirect indexed addressing, comparisons and branching is demonstrated. Fig. 10.6 gives the program listing.

On the *Micro Lab*, the LEDs are mapped to address 8000h. Writing a number to this address will change the pattern displayed. Each number will produce a different pattern. Some examples are given below:

**Fig. 10.6. Demonstration 0**

```
8080          ;***************************************************************************
8080          ;***                                                                      ***
8080          ;*** Everyday Electronics Micro-Lab                                       ***
8080          ;***                                                                      ***
8080          ;***    Name:             Demonstration 0                                 ***
8080          ;***    Version:          1.0                                             ***
8080          ;***    Author:           Geoff MacDonald                                 ***
8080          ;***    Date:             13/01/1993                                      ***
8080          ;***    Last Update:                                                      ***
8080          ;***                                                                      ***
8080          ;***************************************************************************
8080
8080                          ;Read a sequence beginning at address $0200, of length
8080                          ;stored at $0300 and send the sequence to the LEDs, with
8080                          ;a delay stored in $0301 (in 1/100 sec) between each output.
8080
8080  A900    D_DEMO0:        LDA    #$00          ;Set up start address of table
8082  8590                    STA    $90
8084  A902                    LDA    #$02
8086  8591                    STA    $91
8088  A000    DEMO0A:         LDY    #$00          ;Get byte to send to LEDs
808A  A55D    DEMO0B:         LDA    KBSIZE        ;Key pressed?
808C  D014                    BNE    DEMO0C        ;Yes - terminate demonstration
808E  CC0003                  CPY    $0300         ;End of table?
8091  F0F5                    BEQ    DEMO0A        ;Yes - restart sequence
8093  B190                    LDA    ($90),Y
8095  8D0080                  STA    LED           ;Set up LEDs
8098  AD0103                  LDA    $0301         ;Delay for specified time
809B  201800                  JSR    DELAY
809E  C8                      INY                  ;Point to next value
809F  4C8A80                  JMP    DEMO0B
80A2  202100  DEMO0C:         JSR    KBCLR         ;Clear keyboard buffer
80A5  A9FF                    LDA    #$FF          ;Switch LEDs off
80A7  8D0080                  STA    LED
80AA  00                      BRK
```

| Number Written | Pattern Displayed |
|---|---|
| 00h | * * * * * * * * |
| 01h | * * * * * * * . |
| FEh | . . . . . . . * |
| FDh | . . . . . . * . |
| FBh | . . . . . * . . |
| F7h | . . . . * . . . |
| 55h | * . * . * . * . |
| AAh | . * . * . * . * |

where "·" = LED off
"*" = LED on

Writing a sequence of numbers to the LEDs, pausing between each, will produce a changing pattern. The following sequence will produce a single dot moving from left to right:

7Fh, BFh, DFh, EFh, F7h, FBh, FDh, FEh

- Referring to listing 1, the first four lines of the program store the address of the look up table in locations 90h and 91h.
- The table will be read using an **LDA (90h),Y** instruction. So, the next line sets the IY register to zero so that the first value in the table will be read.
- The program then checks to see if a key has been pressed. If one has, then it jumps to the end of the program, where the key is read, then l.e.d.s are turned off and the program stops (the BRK instruction).

## Fig. 10.7. Demonstration 1

```
80AB          ;**********************************************************************
80AB          ;***                                                                 ***
80AB          ;*** Everyday Electronics Micro-Lab                                  ***
80AB          ;***                                                                 ***
80AB          ;***     Name:           Demonstration 1                             ***
80AB          ;***     Version:        1.0                                         ***
80AB          ;***     Author:         Geoff MacDonald                             ***
80AB          ;***     Date:           13/01/1993                                  ***
80AB          ;***     Last Update:                                                ***
80AB          ;***                                                                 ***
80AB          ;**********************************************************************
80AB
80AB                         ;Read a sequence beginning at address $0200, of length
80AB                         ;stored at $0300 and send the sequence to the 7 segment LED
80AB                         ;waiting for a key press between each output.
80AB
80AB  A900    D_DEMO1:       LDA    #$00         ;Set up start address of table
80AD  8590                   STA    $90
80AF  A902                   LDA    #$02
80B1  8591                   STA    $91
80B3  A000                   LDY    #$00         ;Get byte to send to LEDs
80B5  CC0003  DEMO1A:        CPY    $0300        ;End of table?
80B8  F00C                   BEQ    DEMO1B       ;Yes - terminate
80BA  B190                   LDA    ($90),Y
80BC  8D0080                 STA    LED        ;Set up segment LEDs
80BF  201B00                 JSR    KBWAIT       ;Wait for key to be pressed
80C2  C8                     INY                 ;Point to next value
80C3  4CB580                 JMP    DEMO1A
80C6  A9FF    DEMO1B:        LDA    #$FF         ;Clear 7-segment LED
80C8  8D0080                 STA    LED
80CB  00                     BRK
```

## Fig. 10.8. Demonstration 2

```
80CC          ;**********************************************************************
80CC          ;***                                                                 ***
80CC          ;*** Everyday Electronics Micro-Lab                                  ***
80CC          ;***                                                                 ***
80CC          ;***     Name:           Demonstration 2                             ***
80CC          ;***     Version:        1.0                                         ***
80CC          ;***     Author:         Geoff MacDonald                             ***
80CC          ;***     Date:           13/01/1993                                  ***
80CC          ;***     Last Update:                                                ***
80CC          ;***                                                                 ***
80CC          ;**********************************************************************
80CC
80CC                         ;This demonstration reads the settings on the DIP-switches
80CC                         ;and displays the states on the LCD
80CC
80CC  A200    D_DEMO2:       LDX    #0           ;Position cursor at left side
80CE  A001                   LDY    #1           ;of bottom row
80D0  A900                   LDA    #0           ;Turn cursor off
80D2  200900                 JSR    CURSOR
80D5  AD1080                 LDA    DIPSW        ;Read the DIP switch states
80D8  A208                   LDX    #8           ;Set up number of switches
80DA  4A      DEMO2A:        LSR    A            ;Get state of single switch
80DB  48                     PHA
80DC  9004                   BCC    DEMO2B
80DE  A94F                   LDA    #$4F         ;Switch is on - display "O"
80E0  D002                   BNE    DEMO2C
80E2  A92D    DEMO2B:        LDA    #$2D         ;Switch is off - display "-"
80E4  200600  DEMO2C:        JSR    OPCHAR
80E7  68                     PLA
80E8  CA                     DEX                 ;Decrement number of swiches left
80E9  D0EF                   BNE    DEMO2A       ;Repeat if not finished
80EB  A90A                   LDA    #10          ;Delay for 1/10 sec.
80ED  201800                 JSR    DELAY
80F0  A55D                   LDA    KBSIZE       ;Key pressed?
80F2  F0D8                   BEQ    D_DEMO2      ;No - start again
80F4  202100                 JSR    KBCLR        ;Empty keyboard buffer
80F7  00                     BRK
```

- If no key has been pressed, then the IY register is compared with address 0300h. This address holds the number of values in the table. If the IY register equals this value, the program jumps back to the line where it is loaded with zero.
- Next, the accumulator is loaded with the IYth number in the table. This is then copied to the l.e.d. address.
- The program then pauses by calling the monitor's DELAY routine.
- Finally, the IY register is incremented by one and the program jumps back to the line which checks for a key press,

Before running the demonstration, you should use the *Modify* command to store the desired sequence beginning at address 0200h. Next, the length of the sequence should be stored at address 0300h and the delay between changes (in 0.01 seconds) should be stored at address 0301h. Then enter *Demo 0* and the l.e.d.s will show the entered sequence.

There is no danger of accidentally damaging these demo programs stored in the EPROM. This is a read only device, and cannot be changed by the user. If you get into a muddle just press the reset button to start again!

## DEMONSTRATION 1

Segment displays, as used in digital clocks, etc. are made from seven l.e.d.s arranged in an "8" and another l.e.d. forming a decimal point to the right. These l.e.d.s may be driven in the same way as normal l.e.d.s as shown earlier. The *Micro Lab* seven-segment l.e.d.s are addressed at 8000h (a link is used to select between the normal l.e.d.s and the seven-segment display). Fig. 10.4 shows which bit of the data bus controls which segment. You should note that setting a bit to 1 will turn the corresponding segment off.

Demonstration program 1 is similar to demonstration program 0, except that it waits for you to press a key after copying a value from the look up table to the l.e.d.s and it stops when the end of the table has been reached. Fig. 10.7 gives the program listing.

Before running this program, you should set up the look up table starting at address 0200h, storing the length of the table in 0300h, to output the numbers 0 through to 9 (address 0300h should be set to 0Ah in this case).

To get you started, the number "0" is displayed with binary 00111111 (or 3Fh) and "1" is displayed with binary 00000110 (or 06h).

## DEMONSTRATION 2

In order to be useful, a computer system must have some form of input. On the *Micro Lab*, there are four basic input devices – the keyboard, the DIP switches, the analogue input and the 6522 VIA. The simplest of these to use are the DIP switches, which are mapped directly into memory at address 8010h. Fig. 10.8 gives the program listing.

To read the switches, all you need to do is load a register with the contents of address 8010h (e.g. with *LDA 8010h*).

The following program simply reads the switches and copies the result to the l.e.d.s:

```
0200 AD 10 80   LDA   8010      ;Get switch value
0203 8D 00 80   STA   8000h     ;Store in l.e.d.s
0206 4C 00 02   JMP   0200      ;Repeat forever
```

Demonstration program 2 is similar to this, except that the switch settings are displayed on the l.c.d. (a "-" means that the switch is off, and a "O" means that the switch is on). Monitor routines are called to write to the display. Unlike the simple program shown above, to display the switch settings on the l.c.d., each switch setting must be displayed separately. There are two ways to do this. One way is to AND the switch reading with 01h (to read the left most switch) and compare the result with zero. Next, you would AND the switch settings with 02h and compare with zero again. You would copy this for all eight switches.

This method is most useful when you are only interested in the value of one particular switch at a time (if you were writing a game and the switches were push buttons – left, right and fire – then you would use this method to test each switch in turn), however, it is not really suited to this particular task. A neater way is to load the switch settings into the accumulator then use the LSR instruction to shift the lowest order bit into the carry then test the carry flag (using BCC or BCS) to read the state of the left most switch and display it on the l.c.d. This is repeated eight times in a loop, once for each switch. The resulting program is much smaller and does not contain large amounts of repeated code.

**Next month:** We take a look at data logging, analogue measurement and controls, and digital-to-analogue conversion. We demonstrate further routines to help you grasp further principals of microprocessor systems.

# EXPERIMENTAL ELECTRONIC PIPE DESCALER

ANDY FLIND

*A mains powered "black box" to make your calcium less sticky and, in time, your water flow more freely.*

Do you suffer from furry pipes? Clogged conduits? Calcified kettles? Quite a few readers do, it seems. The problem, of course, is due to "hard" water containing calcium, which tends to precipitate onto the surfaces of pipes, kettles, etc, forming the familiar "scale". In addition it can cause scum and lack of lather, resulting in the need for extra detergent and other problems.

Not so long ago the only cure was a large and expensive chemical filter, but recently several new claimed solutions have appeared. Some of these are electronic, mains-powered "black boxes" supplying a signal to a coil of wire placed around the incoming water pipe. Since these are usually expensive, EPE has received enquiries from readers concerning the possibility of constructing one for a more modest outlay.

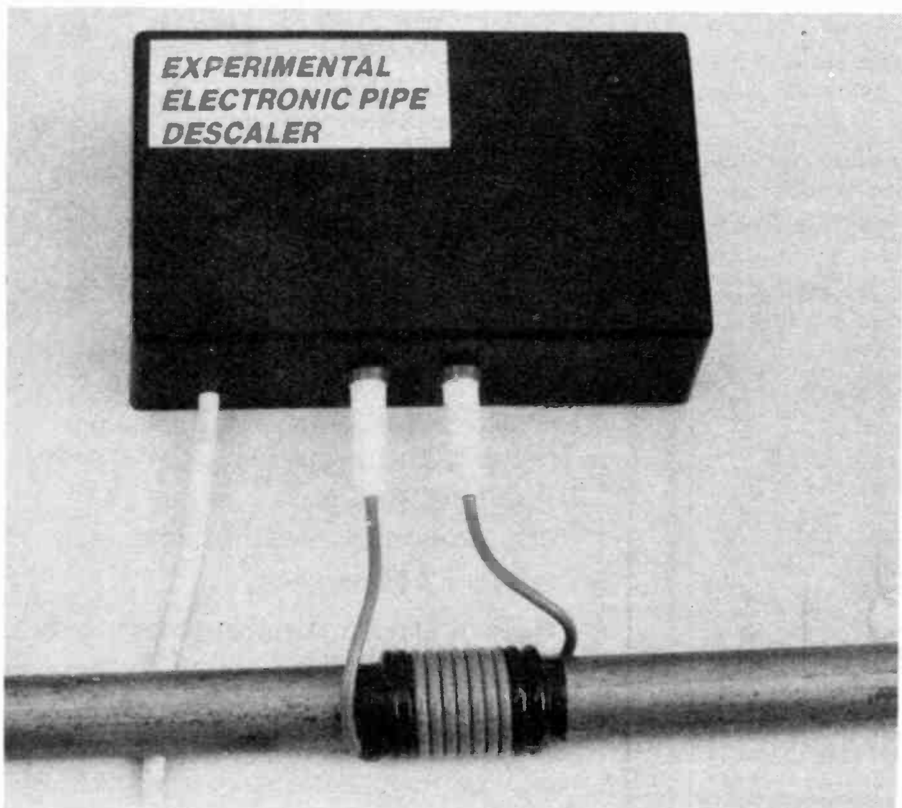
## RESEARCH

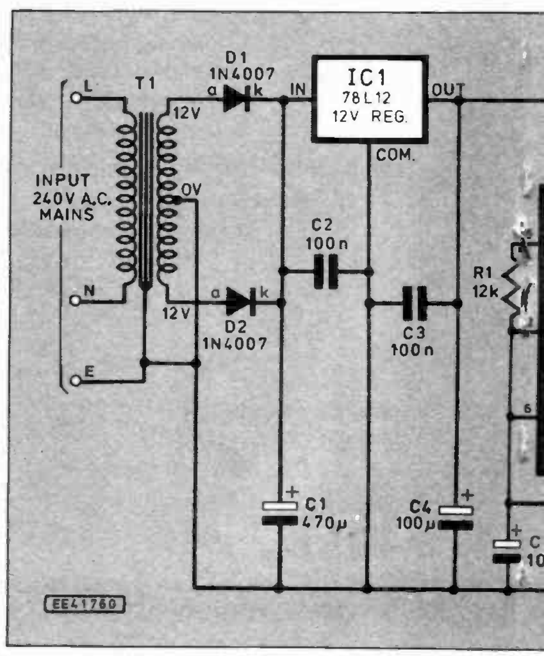
Following "extensive research" the design presented here was arrived at. At the time of writing no definitive results have been obtained as to whether it actually works, but as it is cheap and simple to construct it was decided to publish forthwith for interested readers to try for themselves.

Commercial units produce a square wave output, with frequency swinging between 1400Hz and 2000Hz at a rate of about five Hertz. The output power is surprisingly low.

The wire used for winding around the pipe tends to be thick, around 2·5mm, so it could be assumed that the current would be several amps. However, the output is a twelve-volt peak-to-peak source from a resistance of 10k, so operating into the virtual short-circuit of the short wire coil this gives an average current of just 0·6mA!

It's hard to see how this tiny current produces significant effects of any kind, but suppliers of commercial units state that it most certainly does. The output, by the way, is purely a.c., there is no d.c. component at all. This suggests a blocking capacitor in the output circuit.



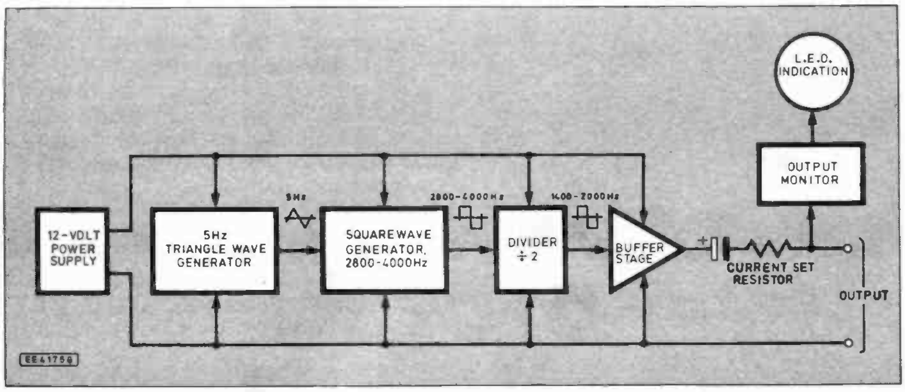



*Fig. 1. Block diagram of the Experimental Electronic Pipe Descaler.*

## ACTION

The claimed action is to render dissolved calcium in the water less "sticky". In other words it's still present, but has less tendency to precipitate out and stick to the surfaces it comes into contact with.

The effect of current passing through a coil of wire around a water pipe is twofold. It produces electrostatic and magnetic fields, both alternating at the frequency of the current.

A metal pipe of any kind would block an electrostatic field. This leaves the magnetic one, which would be significant at this low frequency, although still very small given the tiny current used. However, a lot of older houses (the author's included) have iron supply pipes, which would also attenuate the magnetic field to some extent. It might be worth a mention in passing that other descaling devices on sale consist of a powerful permanent magnet designed for fitting around the water pipe.

## CIRCUIT

The aim of this project therefore, is to produce a signal varying at 5Hz between 1400Hz and 2000Hz, initially at 0·6mA, though provision is made for experimenting with increased current. The design has an output buffer stage capable of higher output, controlled by the value of one resistor.

A simple block diagram, Fig.1, shows the complete arrangement. Power from a small mains transformer is regulated to twelve volts. A 5Hz triangle-wave generator controls the squarewave generator. Since the output mark-space ratio of this is uneven and variable with frequency, it is produced at double the required rate and then halved by a divider, resulting in a perfectly even output signal.

A buffer stage provides output power, a capacitor blocks the d.c. voltage and a resistor sets the current supplied to the coil around the pipe. A monitor circuit confirms that the oscillator is working and that output connections are intact.

The circuit diagram of Fig. 2 shows how these functions are achieved in practice. Power is supplied by the mains transformer T1 and maintained at a constant twelve volts by regulator IC1. IC2 is an ICM7556, a dual low-power version of the popular 555 timer. Both are used as astable oscillators, although in slightly different ways.

The first has the output, pin 5, connected through R1 to input pins-2 and 6, with R1 and C5 setting the output frequency to about 5Hz. The signal across capacitor C5 is approximately triangular with an amplitude of 4V peak-to-peak, and this is applied directly to pin 11, the control input of the second timer. This uses the conventional astable timer circuit.

## COMPONENTS

**Resistors** — See SHOP TALK Page

| | |
|---|---|
| R1 | 12k |
| R2 | 22k |
| R3 | 47k |
| R4, R5 | 10k (2 off) |
| R6, R7, R9 | 100k (3 off) |
| R8 | 8k2 (see text) |
| R10 | 470k |
| R11 | 1k |

All 0·6W 1% metal film

**Capactiors**

| | |
|---|---|
| C1 | 470µ axial elect. 25V |
| C2, C3, C8, C9, C10 | 100n polyester layer (5 off) |
| C4, C7 | 100µ axial elect. 25V |
| C5 | 10µ axial elect. 25V |
| C6 | 4n7 close tolerance polystyrene, 1% type |
| C11 | 10n polyester layer |
| C12 | 470p min. disc ceramic |

**Semiconductors**

| | |
|---|---|
| D1, D2 | 1N4007 diode (2 off) |
| D3, D4, D5 | 1N4148 diode (3 off) |
| D6 | green l.e.d. |
| TR1, TR3 | BC184L *npn* silicon transistor (2 off) |
| TR2 | BC214L *pnp* silicon transitor |
| IC1 | 78L12 12-volt positive regulator |
| IC2 | ICM7556 CMOS 555 dual timer |
| IC3 | 4024B CMOS divider |

**Miscellaneous**

| | |
|---|---|
| T1 | 12-0-12 volt 100mA sec., mains transformer |

4mm plugs and sockets; case, ABS plastic box 158mm x 95mm x 54mm; p.c.b. available from the *EPE PCB Service*, order code 839; 2-core mains lead; wire for coil – see text; strain relief bush for mains cable.

*Approx cost guidance only* **£18**

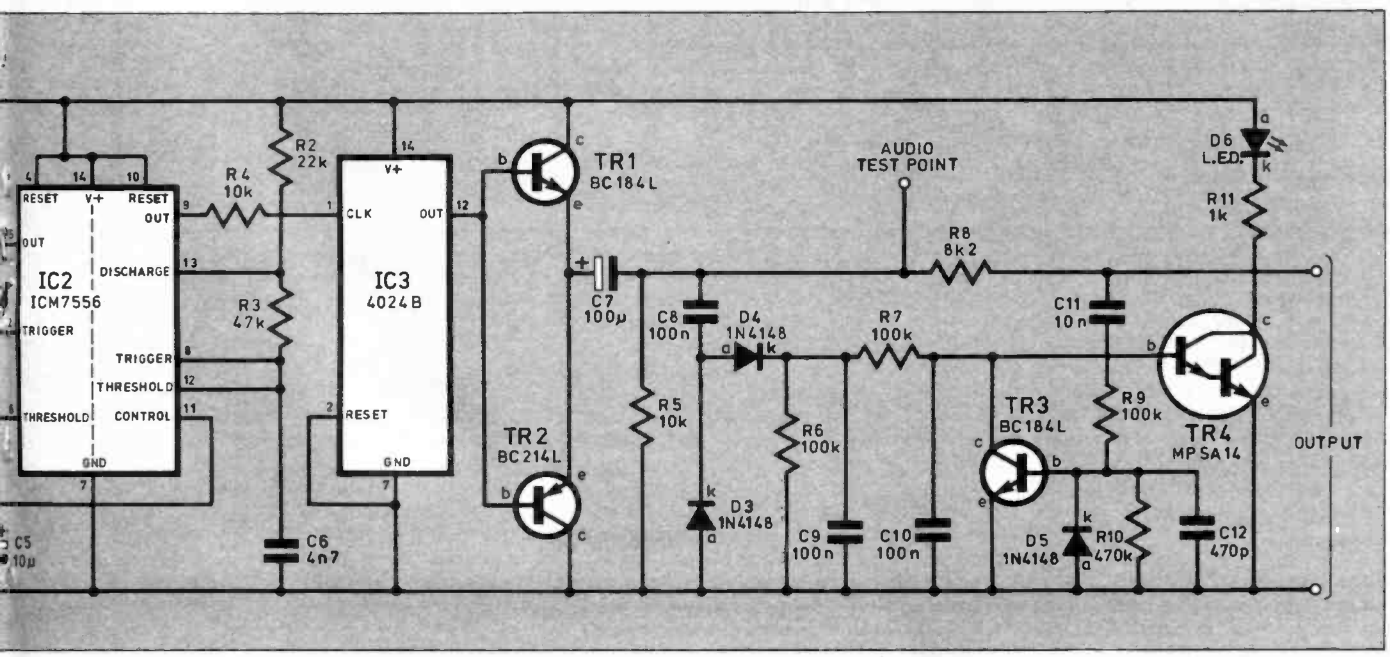
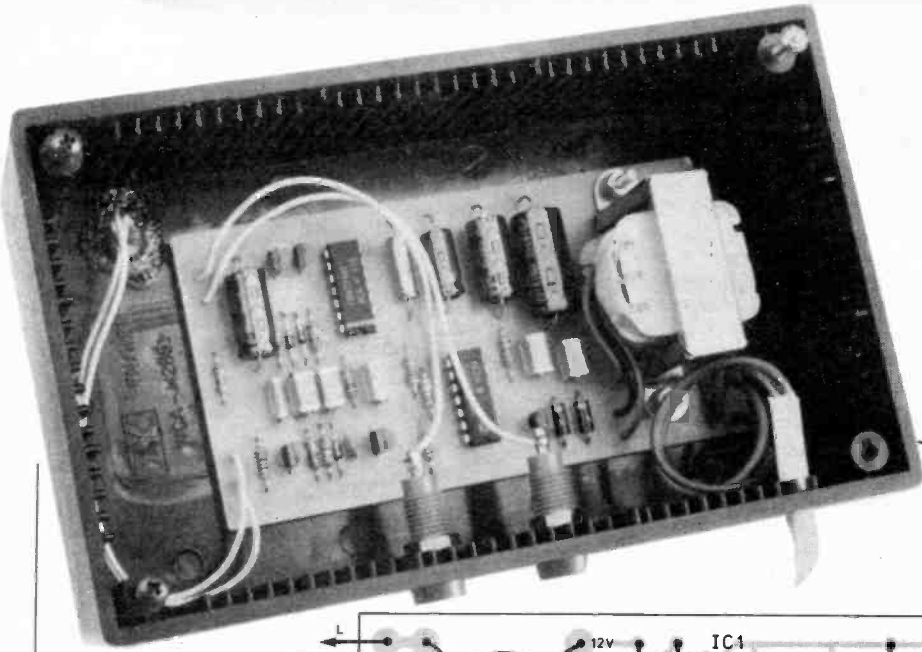



*Fig. 2. Complete circuit diagramof the Experimental Electronic Pipe Descaler.*



C11 will cause TR3 to conduct on alternate half-cycles. This discharges C10 and there is insufficient time between half-cycles for R7 to charge this capacitor and turn on TR4 again. This means that the output signal must be present and connections to the coil around the pipe must be sound for the indicator to be lit.

A "Darlington" transistor was chosen for TR4 for two reasons. The very high gain ensures adequate drive for the l.e.d. from a small base current, and double the base-emitter voltage of a normal transistor is needed before it will conduct. These two factors permit practical resistor and capacitor values to be used in this part of the circuit.

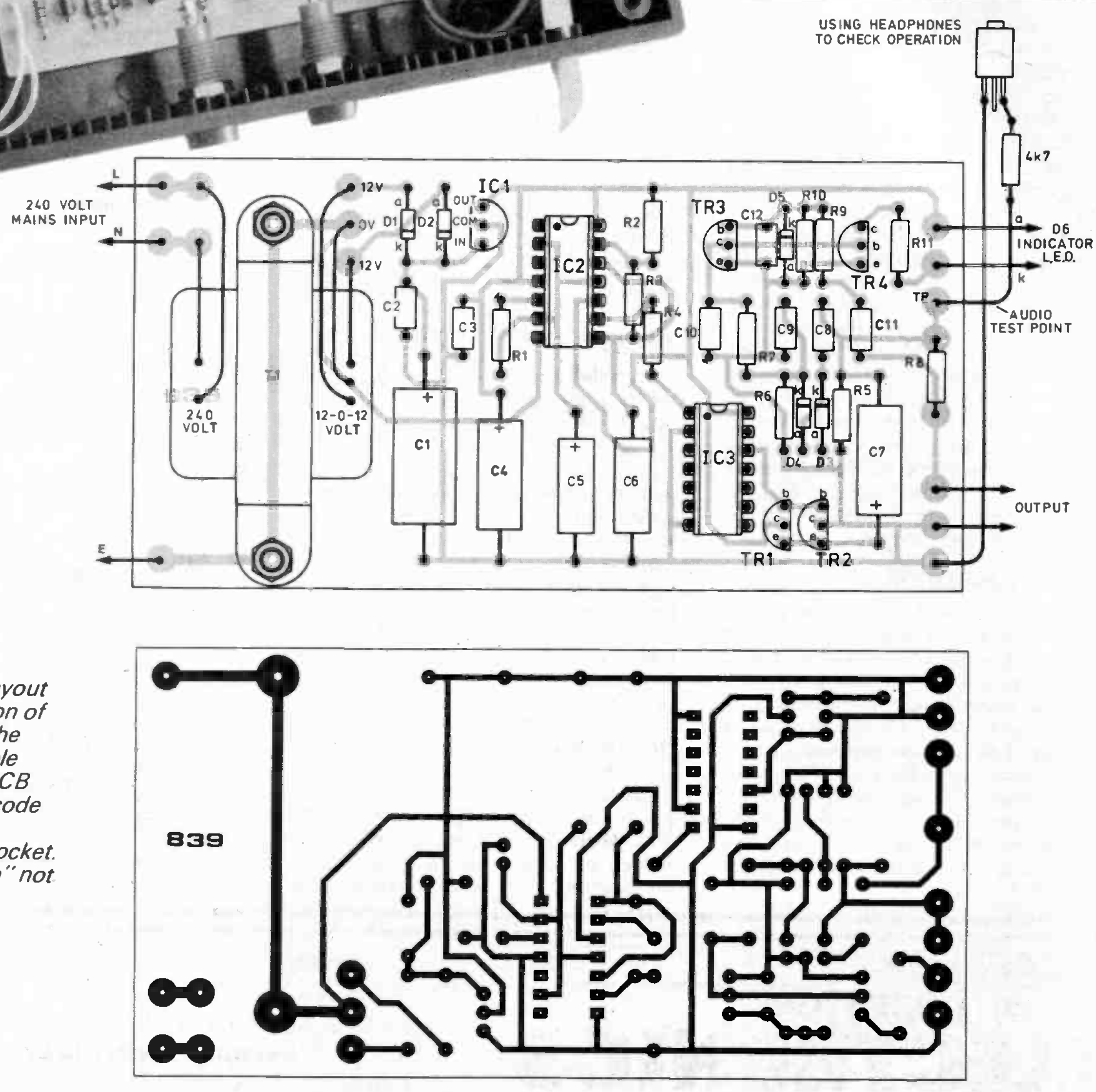



*Fig. 3. P.C.B. layout and construction of the Descaler. The p.c.b. is available from the EPE PCB Service, order code 839.*
*Headphone socket. Note "common" not used, placing headphones in series.*

With the values of R2, R3 and C6 used the output, from pin 9, varies between about 2600Hz and 4000Hz. Capacitor C6 is a close-tolerance (one per cent) type to ensure adequate accuracy of these frequencies. As the control voltage affects only half of the output waveform the mark-space ratio varies quite a bit, but passing the signal through divider IC3 results in a final output of 1300Hz to 2000Hz with a perfectly even ratio.

## OUTPUT

The buffer transistors TR1 and TR2, provide additional output drive capability. Whilst not really necessary for 0·6mA, it was felt that constructors might wish to experiment with higher currents so this stage can provide over 50mA if desired. C7 blocks d.c. voltage from the output, leaving a pure a.c. signal. Again, the value of 100μ is excessive for the small current, but provides for use of a much higher one.

The output current is set by R8. The value of 8k2 in this design compensates for the small voltage drop across TR1 and TR2. Reducing the value of this resistor increases the output.

The remainder of the circuit provides monitoring to ensure that the unit is working. The a.c. output signal charges C9 through the rectifier circuit D3 and D4. As long as the output is present and the coil connections are sound, d.c. current from C9 passes through R7 to TR4, causing this to conduct and illuminate the l.e.d. D6.

If the output connections become faulty, the resulting increase in voltage applied to

Although this monitoring is fairly complex, it was considered necessary as it will normally be the only indication that the unit is actually working. Astute readers will realise that there is still one item not covered, namely operation of the 5Hz oscillator. It's unlikely that this will fail, but the simple addition of a resistor and stereo socket shown in Fig.4 will allow an occasional check with a pair of headphones, as the output has a very distinctive sound.

## CONSTRUCTION

All the components of this project are mounted on the circuit board so construction should be straightforward, though step-by-step checking is recommended. All component positions are shown in Fig. 3.

Transformer T1 is secured to the board with two screws. This, with diodes D1 and D2 and capacitor C1 can be fitted first, then powered up and the voltage across C1 checked. Note that 240 volt mains is present on the p.c.b. tracks connecting to the transformer primary, this of course is a hazardous voltage and appropriate precautions should be taken. If this part of the board is suitably insulated, perhaps with a couple of layers of tape, danger should be practically eliminated.

The voltage across C1 should be about 17V, the "peak value" from the transformer. Following this, IC1 and capacitors C2 to C4 can be fitted, the unit powered again and presence of the regulated 12 volt supply across C4 checked.

This design represents a departure from the author's usual recommendation of the use of d.i.l. sockets for the i.c.'s. As it may have to operate for long periods in adverse conditions (where is your rising mains water pipe situated?) and may be encapsulated in resin, it was felt that the possible contact problems arising from the use of sockets would be best avoided. Therefore, IC2 and IC3 are soldered directly into the board.

As these are both CMOS types, and the ICM7556 in particular can be a bit static sensitive, appropriate handling measures are advised. The main precaution is earthing of the constructor. If an anti-static wrist strap is available it should be used. If not, earthing of the constructor is recommended, perhaps by a wire around the wrist with a couple of 1M resistors in series for safety.

## CHECKING

Integrated circuit IC2 and associated components should be fitted first, and with the circuit powered the voltage at pins 5 and 9 can be checked. Pin 5 should display an average level of about 6V, and with an analogue meter the 5Hz flicker will be observable. Pin 9 will be between 5 and 6 volts. Following this R4 and IC3 can be added. If this operates correctly the d.c. voltage at pin 12, as read with a meter, should be exactly half the supply voltage as it is switching between the supply rails for equal periods of time.

Finally the remaining components can be installed, and the l.e.d. connected for testing. When the unit is powered this should not light until the output is shorted to simulate healthy connections to an output circuit. Once it is lit, it could be useful to ensure that it also goes out if pin 1 of IC3 is shorted to negative rail, simulating oscillator failure.

The output can also be tested with headphones and a suitable resistor between the test point and negative; 4k7 should be a suitable value for most headphones, if connected in series.

## CASE

The assembled board can be fitted into a case of the constructor's choice. The prototype used an inexpensive plastic box, with the l.e.d. mounted at the front and two 4mm sockets for output on the side. If it is to be used in a hostile environment, such as an area subject to damp, it might be advisable to "pot" it in resin for protection. In fact this is a good way to secure it in the case, the unit being propped in the centre of the case which is then filled with resin.

Some constructors may wish to use a watertight case and these are now available at realistic prices.

## INSTALLATION

To install the descaler, first the incoming water supply pipe, or the pipe supplying an item to be protected, should be located. The unit should be mounted close to this pipe, no more than a metre or so from it, with a suitable coil wound on the pipe for connection to the unit. This consists of eleven turns of thick multi-strand insulated wire, close-wound, with ends secured by tape or cable-ties and terminated with 4mm plugs to fit the descaler.

Suitable wire can be obtained by stripping the cores from some heavy-duty mains flex or from car electrical suppliers. The coil should be on a straight length of pipe, at least 50mm from any fittings or fixings etc. The tails to the descaler should be short, not be more than a metre in length.

There may be installations where the unit has to be fitted in a bathroom or similar area where use of mains electricity is forbidden or hazardous. In such cases, the best approach is to encapsulate the circuit in the case with a mains lead long enough to be routed right out of the room before connection. The cable routing should obviously be chosen to protect it from possible damage.

In all cases the unit should be connected to the mains supply via a suitable 2A fuse either in a 13A mains plug or a switched mains flex outlet.

## IN USE

If the unit works as intended, scale build-up should stop immediately and existing scale should eventually start to dissolve. There is a possibility of apparent increased water hardness at first, as existing scale re-dissolves back into the water, but this should clear after a few weeks of use.

Remember that the calcium is still there and will be seen in the kettle or on taps when the water has dried, it simply will not stick so much and therefore not build up.

As stated earlier, this project is experimental in nature. Unlike commercial versions it's cheap, so it will cost little to test on plumbing systems plagued by hard water. It might be worth trying more than one, with additional units fitted to supply pipes to hot water cylinders, dishwashers etc. Although the output power is very low, it may be increased by altering the value of resistor R8. Constructors are welcome, indeed encouraged, to try this.

The minimum suggested value of R8 is 100 ohms, which will give an output current of 56mA, although with 47 ohms it will push out over 100mA. At this level over half a watt will be dissipated in the resistor, so a suitable wattage rating will be needed.

## FEEDBACK

The experience of users of this project, and comments on it's performance etc, are welcomed by the author as from them it may be possible to ascertain it's effectiveness and whether any improvements might be worthwhile.

Details such as the material and diameter of pipe it was used on, location e.g. rising main, input to hot water cylinder etc, and the output current used, together with results obtained and how long they took to appear, should help to build up a picture of the effectiveness of electronic descaling. □

# Audio Amplifier Design, Engineering or Alchemy?

JOHN LINSLEY HOOD PART 1

## Can you trust performance tests?

THERE are two fundamental, but mutually contradictory beliefs in the field of audio, and these can be summarised as:

1. "All competently designed audio amplifiers, used within their ratings, will sound the same," and:

2. "All things in an audio system are important – so that even the nature of the wiring which is used to interconnect the pieces will alter the sound of the system."

By and large the first of these beliefs is that held by professional audio engineers and designers, and the second by the readers and a majority of the editorial staff and contributors to "Hi-Fi" magazines, who I will call the "subjectivists", simply as a convenient group label.

Both of these groups are willing to demonstrate the validity of their points of view – the "engineers" by carefully arranged group listening trials, using "double blind" tests, (those in which neither the listening panel nor the person doing the switching actually knows which amplifier they are listening to at the time) – and the "subjectivists" by "one to one" demonstrations in the comfort of their own homes, on a "now, just listen to this" basis.

### SANDWICHED

As an audio amplifier designer, I find myself uncomfortably sandwiched between these two opposing views. Obviously, the possession of test instruments, and some measure of faith in the results they give, is just as essential a requirement for any serious design work as a good understanding of the nature of the technology and its theoretical basis, if only because it is in the nature of mankind to make occasional mistakes, and instruments are helpful in drawing attention to these errors.

On the other hand, it is impossible to predict with absolute confidence just how audible some of the residual performance shortcomings of the hardware – and there always are some, in even the best of designs – will prove to be.

Our understanding of what the human ear is prepared to accept as "accurate" is getting better, but we're not there yet, and I note, with regret, that one still comes across engineers who will flatly deny the existence of technical faults in a system, even when these are so glaring that their own ears object to the nature of the sound they are hearing.

### HEAD IN THE SAND

As a relatively recent example of this "head in the sand" approach, I have a book on digital audio systems, written in the mid. '80s, soon after the introduction of the compact disc, in which the author says "of course, digital sound sounds entirely different from analogue, because it is so much more 'accurate'. However, in time we will get used to this different and superior sound quality, and accept it for what it is."

In reality, the big difference, at that time, between, for example, the sound of an LP (analogue) and a CD (digital) replay was due to the unwanted presence of large h.f. phase errors, which ruined transient response, and the pre- and post-transient "ringing" caused by the primitive "brick-wall" (steep-cut anti-imaging) filters on the output of the CD players. Because of these problems, some of the early machines really did sound different from analogue systems: they were harsh and strident, and not at all pleasant to live with.

Fortunately, some of the engineers working in this field were prepared to accept that the deficiencies in the sound produced by these early CD systems were real, and were due to measurable technical faults, and they worked to improve things.

So now, with a multiple "over-sampling" type of CD player, which can give good replay phase linearity, and a decent transient response, due to relatively gentle h.f. filter slope characteristics, the only significant audible difference between a CD and an LP of the same music, when the LP is replayed in synchronism on a good turntable (so that the listener can switch over directly from one to the other), will be the greater freedom from "rumble", "clicks" and surface noise on the CD. However, this certainly wasn't the case ten years ago.

### PERFECTION?

The history of audio is full of instances when new ideas were introduced, but which didn't work as well as they should, and, because the errors in the design were not apparent in the test results, or were noted but not thought to be particularly important, their designers or manufacturers claimed that perfection had been attained.

Since the more perceptive of the listeners, and you might not need to be very perceptive at that, were very aware that things were wrong, the mistaken claims of the engineers tended to undermine the validity of the very measurements they quoted, and this, sadly, is now the climate of popular opinion in which we audio engineers must work. I say "sadly" because it is essential to make measurements, and the idea that test results are of no value to anybody undermines the whole basis of technical progress.

However, one needs to measure the right things. For example, the one measurement that Joe Public will trust, when he goes into the showroom of his local "hi-fi" discount warehouse, is the quoted "Total Harmonic Distortion" (THD) figure, and this, unless you know the specific conditions of the test, really is pretty meaningless. I will explain, later.

### SUBJECTIVISTS

Taking the side of the "subjectivists" for a moment, one of the first areas of conflict was about the influence of loudspeaker connecting leads. The hi-fi devotees noted, and tested out for themselves, and supported, the claim that different kinds of loudspeaker connecting wires "sounded different". "Rubbish" retorted the engineers, "provided that the loudspeaker lead resistance is less than a tenth of an ohm, or thereabouts, it can't possibly have any effect with an eight ohm loudspeaker unit".

Indeed, so it shouldn't. But, if you have a pair of adequately low resistance leads and you decide that one of them doesn't need to be as long as the other, and so you chop off a length of it, you will find that you have now altered the apparent position of the centre of the stereo image, and this is evident as the new position required from the amplifier balance control.

Of course, part of this effect is due to the fact that "transient" type signals are very important to the human ear, particularly in assessing the position of the sound source, and most modern loudspeaker units have a very low input impedance to transient type input signals. This just means that we had measured our "eight ohm" loudspeaker impedance in the wrong way. Indeed with an impedance vs. frequency curve that usually looks like a Sherpa's eye view of the Himalayas, it seems a pretty meaningless measurement anyway.

### THE PSYCHOLOGY OF TINKERING

I have a close friend with a professional interest in human psychology, and he assures me that it is well known that most

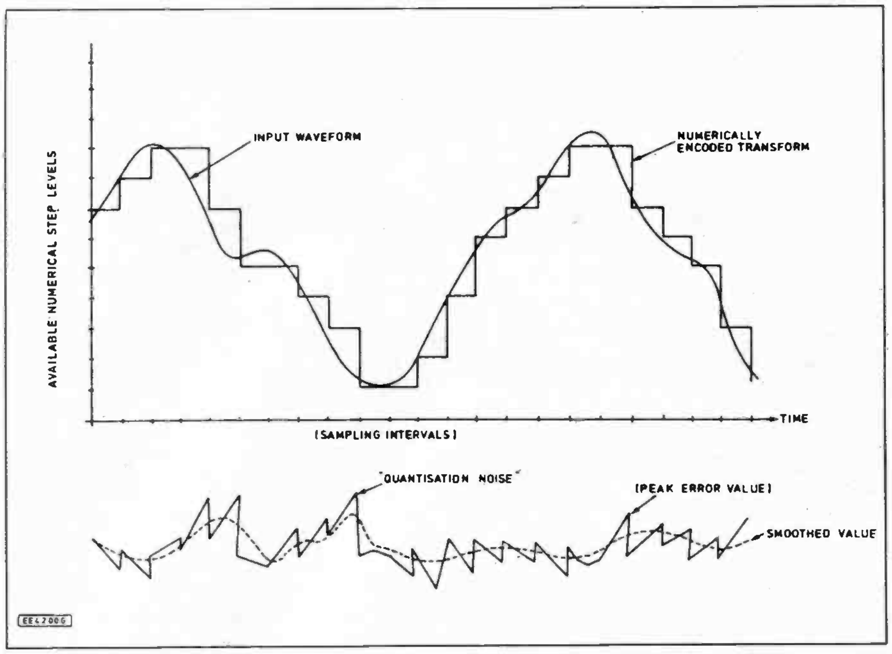



*Fig. 1. The origins of "Quantisation Noise" in a digitally encoded signal.*

people get great satisfaction from adding their own contributions to any system, and will, because of this, be predisposed to believe that if they make a mod. to their audio system, it will sound better as a result of any changes they have made.

Of course, most hi-fi users will hesitate to take snips or soldering iron within the entrails of their expensive kit, so most of the changes they will be inclined to try will be restricted to various "bolt on" external bits and pieces, to go on their input, loudspeaker or mains power leads, and the difficulty here is the fugitive nature of the acoustic memory, in the interval between one trial and the next.

It is helpful if one has a balanced pair of stereo channels, so one can try one's new gizmo just in one channel, so the two can be given a simultaneous trial, but even this begs the question of what one means by "better".

## WHICH WAY IS "UP"?

Some years ago, a highly respected audio systems reviewer set up, as an experiment, an arrangement by which he could introduce controlled amounts of harmonic distortion into his normal listening system, and invited his various visitors and sundry local friends to listen to some music, and indicate which "amplifier" they preferred.

The results he obtained indicated that most of his ad hoc listening panel actually liked the effect produced by the addition of relatively small amounts, say 0·5 per cent, of second harmonic distortion – they said it sounded "richer" – and it so happens to be the kind of distortion that one finds in most traditional valve amplifier systems, which are so much liked for their "rich" sound quality.

The problem, therefore, with basing ones judgment solely on listening tests, is that one's ear can often tell you what it likes best, but not always what is actually better from a technical point of view. Since 0·5 per cent of second harmonic distortion may lead – depending on the conditions of the test and the nature of the system – to one per cent or more of "intermodulation distortion" (which is the kind of distortion which muddles up the sound), the author of these tests might have got a different answer if he had asked which of his "amplifiers" sounded "clearer".

The fact that people like to fiddle with their gear, and will often "hear" improvements in sound as a result of using some gadget or other has, I suspect, made a few small fortunes for the inventors of various magic boxes.

## ARE ANY OF THE DIFFERENCES REAL?

It is very easy for the "engineers" – including me – to dismiss the claims of the "subjectivists" that there really are audibly significant effects, in the face of the invariably negative results given by carefully arranged "double blind" listening tests. These negative results have been obtained even when the listening panel was deliberately chosen to include "subjectivists" who had publicly declared their belief that there were big differences between the very amplifers which were being tested, and they could hear these differences without the slightest difficulty.

Is there any plausible explanation for this? I think there is, and that it is based on the length of the tests and on familiarity.

Another friend of mine is a professional recording engineer, of perfectionist inclinations, and he was concerned at the time that he was about to adopt a digital recording system to supplement, and eventually replace, his tried and trusted 15in./sec. analogue tape recorder, that the results from his new digital system might be audibly less good. I was lucky to be one of those he asked to sit, individually, in judgment on this contest, for which the same musical performance had been recorded simultaneously on both analogue and digital recorders, to either of which I could listen, at the flick of a switch, when they were replayed simultaneously in synchronism.

Given a sufficiently long duration sample of each system I was correct in my identification every time, but with 5 to 10 second samples I really could not tell the one from the other. And the reason why? Because, given time, I could hear the differences between the types of background noise characteristics of the two systems. Digital audio encoding and decoding processes lead to the kind of noise called "quantisation noise", shown in Fig. 1, due to the inability of the "staircase" waveform to follow the smooth curve of the input signal.

(What I have shown in the diagram would correspond, approximately, to an audio signal at about 2kHz sampled at 44·1kHz, using a "4-bit" encoding resolution. A thing to be noted in relation to this is that this sampling error will decrease if the sampling interval is reduced or if there are a greater number of permissible quantisation levels – with the example chosen the error "noise" could be as much as 10 per cent of the signal, though this would be reduced by subsequent filtering.)

In digital audio, this kind of noise always accompanies the signal, but it stops when the signal stops. In analogue systems the noise is there all the time. And this was the difference I listened for.

## ALL OF A DITHER

Of course, in the early '80's, the modern technique of adding "dither" (a synthesized, amplitude limited, random noise voltage), to the replay signal was not common practice. If it had been used in my friends relatively early digital set-up I really wouldn't have been able to identify them.

However, "dither" is not simply added to baffle attempts to tell digital from analogue, it really does improve the ability of the digital decoding process to resolve fine detail, and reduce the "granularity" (staircase characteristic) of the replay signal, particularly if the sampling frequency is increased. For optimum results, the added dither voltage should be between a half and a third of the size of the decoding voltage step.

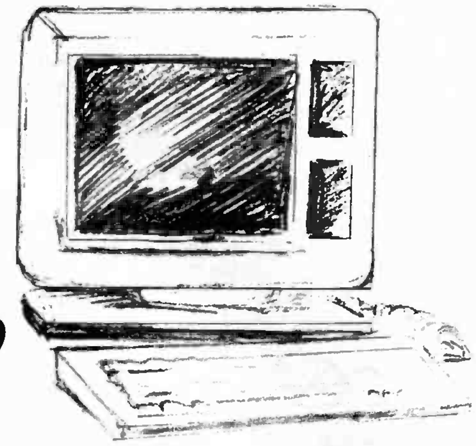
The other point about even carefully arranged statistical tests is that small differences in sound quality may become more noticeable if one lives with a system for a little while, and this is an aspect which cannot be included in the inevitably brief "listening panel" trials.

## DO COMPONENTS MATTER?

Apart from the claimed importance of connecting leads, the other main plank of the "subjectivists" platform is the difference in sound quality caused by the choice of component type or construction used in the circuitry. Once again, I find myself sandwiched between the "yes there is" and "no there isn't" schools of thought.

Some of the effects are indeed real, and there are good reasons why they should be, and I propose to have a look at these in the next article.

# AMSTRAD PCW 8-CHANNEL A/D CONVERTER



JASON SHARPE

- Eight buffered analogue inputs
- Built in Sample/Hold Function
- Fast 2·5μS conversion time (0·4 MSPS)

THE WORLD we live in is continuous, for example, seconds can be divided into tenths of seconds, hundredths of seconds, etc. to infinity. But the world of the digital computer is discrete, its shortest time period determined by the clock rate.

Our world is also analogue, for example, it can be very bright, bright, dim, dark etc. In the computer's world it would be either dark or not dark.

## A-to-D CONVERTER

The A/D converter enables a digital computer to take discrete samples of the continuous world. The Amstrad PCW 8-Channel ADC circuit is based on the popular AD7828 (IC2), an 8-channel ADC i.c., which contains an 8-channel analogue multiplexer, a sample and hold function, a half flash analogue-to-digital converter, and I/O control logic.

## QUICK AS A FLASH

The 7828 uses a half-flash technique to digitise the input signal. A 2-bit flash A/D converter is shown in Fig. 1. The analog input is compared simultaneously with $2^n - 1$ (where $n$ is the number of bits) equally spaced voltage reference voltages.

The comparitor outputs are fed into a $2^n$ bit priority encoder, which outputs the digital value. This is the fastest method of A/D conversion, using this method speeds of 300 million samples per second (MSPS) can be achieved.

The main problem with the Flash ADC is its price (e.g. an 8-bit, 20 MSPS flash ADC costs approx. £70, 150 MSPS costs approx. £125) this is because of the large number of comparators required ($2^{\text{No. Bits}} - 1$). Half-flash conversion is the second fastest conversion technique, it provides near flash speed with a much lower cost, thanks to a neat trick.

The block diagram for an eight-bit half-flash convertor is shown in Fig. 2. The input signal is fed into an n/2 bit flash converter, which digitises the most significant part of the voltage, this data is then fed into an n/2 bit DAC.

The DAC output is subtracted from the input voltage and the resulting voltage is digitised by another n/2 bit flash converter, which provides the least significant part of the output. Using this method speeds of up to 20MSPS can be achieved. An eight-bit flash converter would need 255 comparators, but with this method only 30 comparators are required.

## CIRCUIT DESCRIPTION

The circuit diagram for the 8-channel A/D Converter is shown in Fig. 3. The circuit for the buffer i.c.s, IC3 to IC10, is repeated for each stage.

Address decoding is performed by IC1 (74HC688), a high speed CMOS 8-bit comparator. When each P-input is in the same state as the corresponding Q-input, pin 19

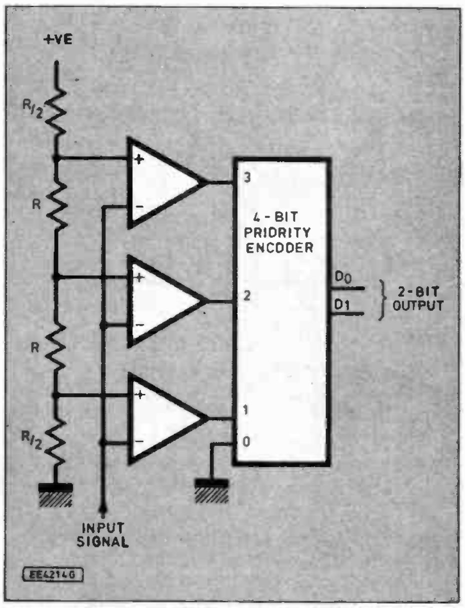



Fig. 1. Two-bit flash converter.

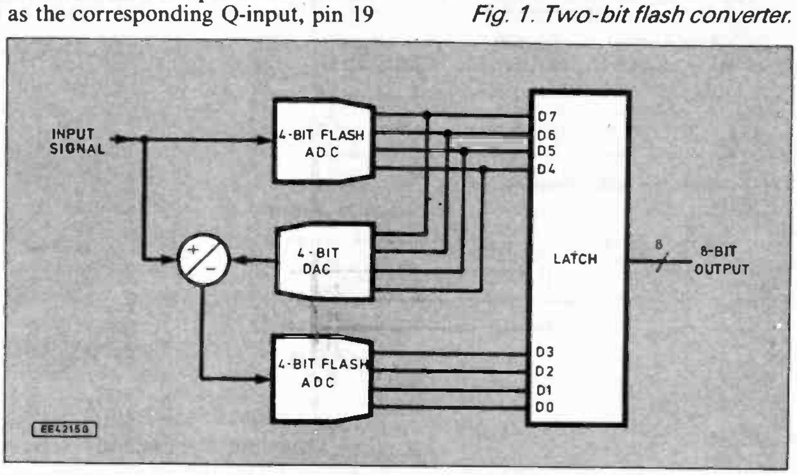



Fig. 2. Block diagram for 8-bit half flash ADC.

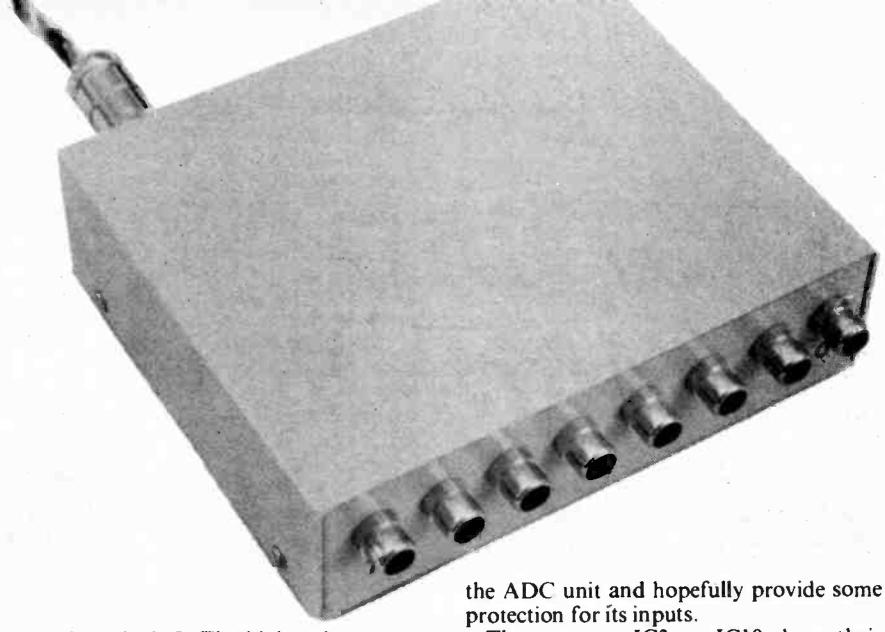
($\overline{P=Q}$) goes low enabling IC2. When NOT IOReQuest goes low and the low byte of the address bus (A0→A7) contain an address in the range 176 to 183 (Inclusive) the ADC i.c. is enabled.

As the ADC unit runs from a separate supply, the PCW's 5V line is also fed into IC1 to make sure the unit is disabled when the PCW is turned off. The PCWs pull up resistors R4 to R7 are used to bring the TTL level outputs upto CMOS levels ($\overline{IORQ}$ and A7 are tied high inside the PCW).

The AD7828, IC2, is set to mode 1. In this mode a conversion is started by reading from a port in the range 176 to 183 (B0 to B7 Hex), the channel on which the conversion is performed is determined by the address on lines A0, A1, A2.

Reading from port 176 starts a conversion on Channel 0, through to port 183 which starts a conversion on Channel 7. To get the results of the conversion just read from one of the eight ports, this will also start a conversion on the selected channel.

It was mentioned above that the 7828 has a track/hold function, this is basically achieved by charging 31 internal 1pF capacitors. These capacitors, plus about 14pF of stray capacitance must be charged to the input voltage through the resistance of the input multiplexer (approx. 5kΩ) in

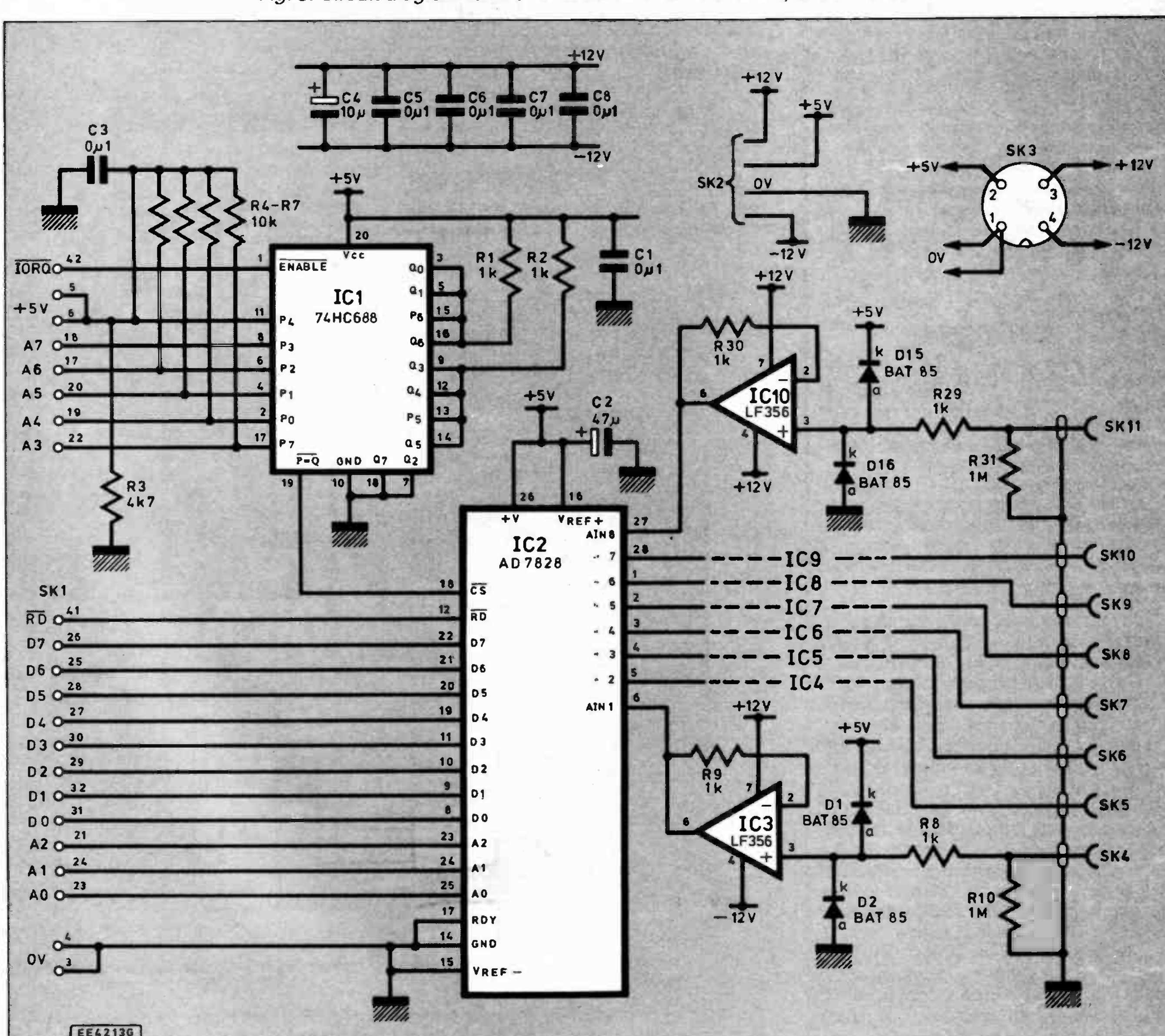


approximately 1µS. The higher the source resistance the longer it takes for the input capacitance to charge.

To make sure the capacitance is charged in time, unity gain buffers IC3 to IC10, with low output impedances, were added to the inputs of IC2. The use of these buffers also increases the input impedance of the ADC unit and hopefully provide some protection for its inputs.

The op.amps IC3 to IC10 draw their power from a ± 12V supply to allow a full output voltage swing of 0V to 5V. The output of the op-amps are capable of going within a few volts of the supply, so if say 7V was placed on an input the output would swing to 7V destroying the input of IC2!

*Fig. 3. Circuit diagram for the Amstrad PCW 8-Channel A/D Converter*



To provide some protection, diodes D1 to D16 were added to prevent the input of the buffers from going outside the 0V to 5V range. Schottky diodes are used as these have a low forward voltage drop and fast "reaction time." *These diodes only provide limited protection, and care should still be taken to keep the input voltage in the 0V to 5V range.*.

The op-amps chosen for the buffers have low input offset voltages, so they require no trimming.

## CONSTRUCTION

The 8-channel A/D Convertor is constructed on a double-sided printed circuit board (p.c.b.). The board component layout, top and underside full size copper foil master patterns are shown in Fig. 4. This board is available from the *EPE PCB Service*, code EPE838.

Track pins are used to connect tracks from one side of the p.c.b. to the other. These should be inserted into the holes (without components) marked ● on the component overlay. Push them in from the top of the p.c.b. and solder them, then turn the board over and solder them to the other side of the board – see Fig. 5a. After you have finished this check the tracks are actually connected with a multimeter.

Insert and solder the remaining components in height order, flattest up to tallest. The leads marked ⊙ on the component overlay should be soldered to the *top* layer as well as the *bottom* – see Fig. 5b. Be careful not to over heat the diodes, also when bending the leads make sure you do not damage the glass cases.

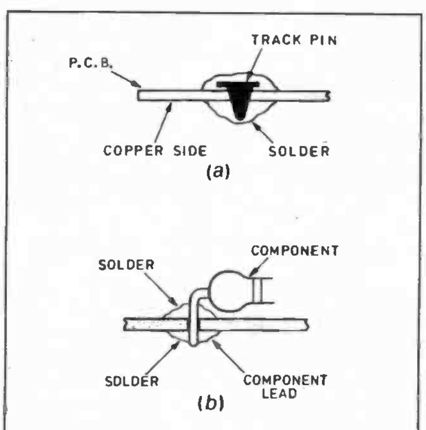
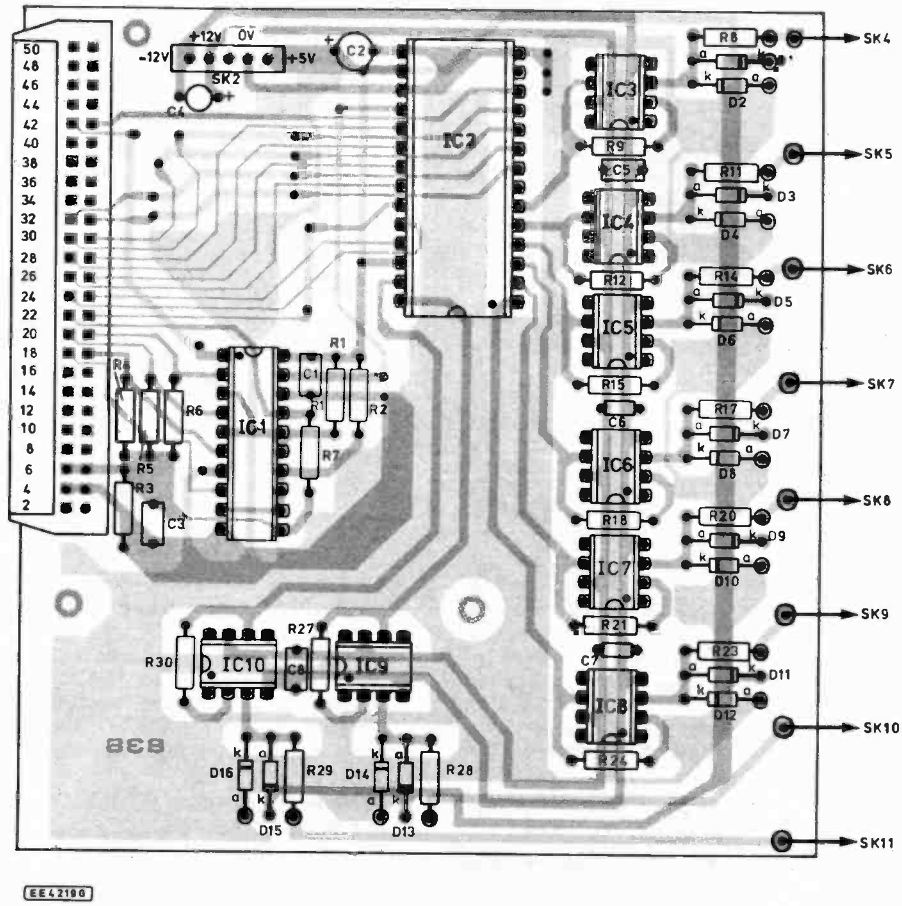



*Fig. 5 (a) Connecting one side of p.c.b. to the other with "track pins". (b) soldering component to both sides of board.*

Power is connected to the board using a "Minicon" connector. Strip about 5mm of insulation from the end of the wire, and tin it. The wire can then be crimped to the metal connector, this can be carried out using a pair of thin nose pliers. Then push the assembly into the plastic housing until the locking pin clicks into place, as shown in Fig. 6.

The one megohm (R10 to R31) between the inputs and "ground" are soldered between the input phono sockets SK4 to SK11 and their solder tags. One end of the lead is used to connect the p.c.b. input to the phono socket. One of the solder tags should also be connected to the 0V input.

Case construction is shown in Fig. 7. Make the hole for the 50-way connector quite high so that some "grommet strip" can be used to cover the sharp edges and prevent damage to the ribbon cable.




● = *Track solder pin.* ⊙ = *Solder to top and bottom tracks.*

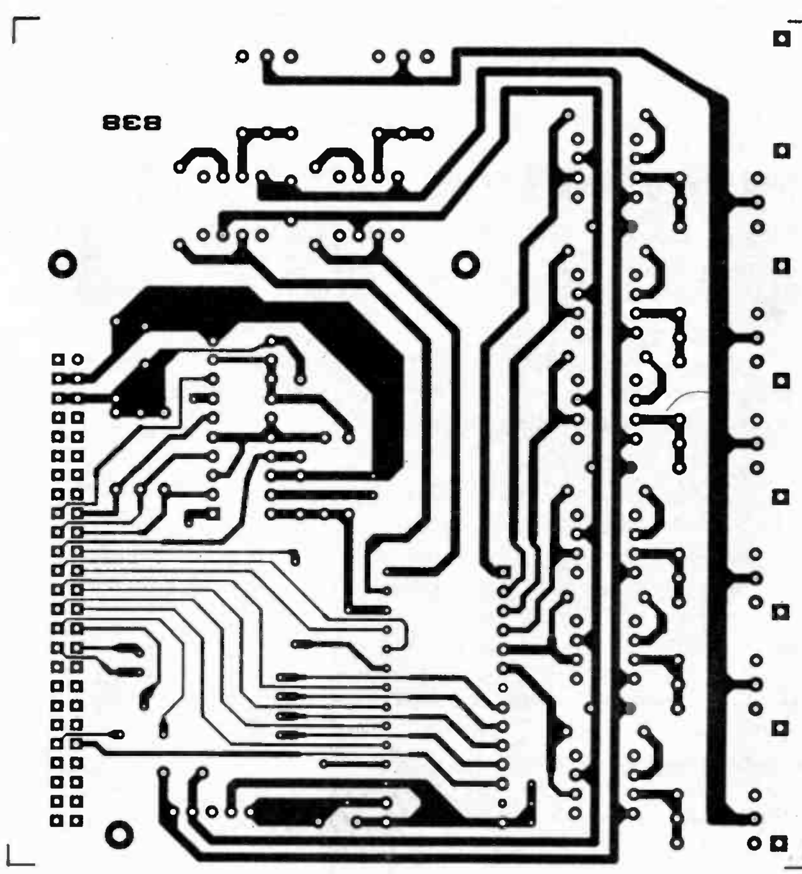
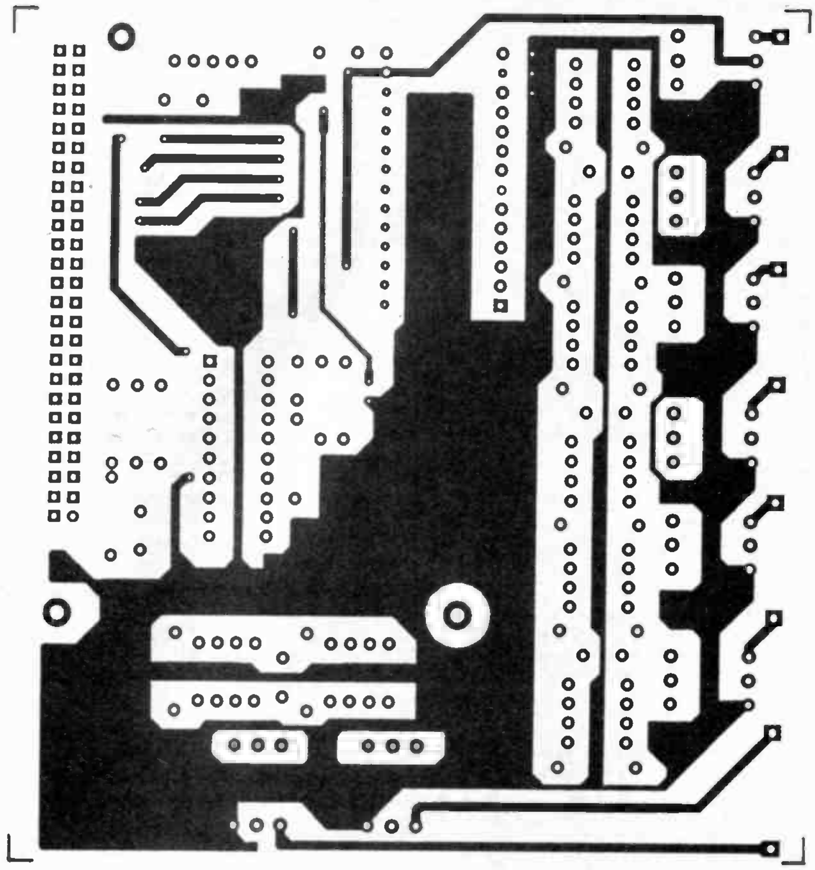



*Fig 4. (top) Printed Circuit board component layout, (top right) full size component side copper foil pattern, (above) full size underside copper foil master pattern.*



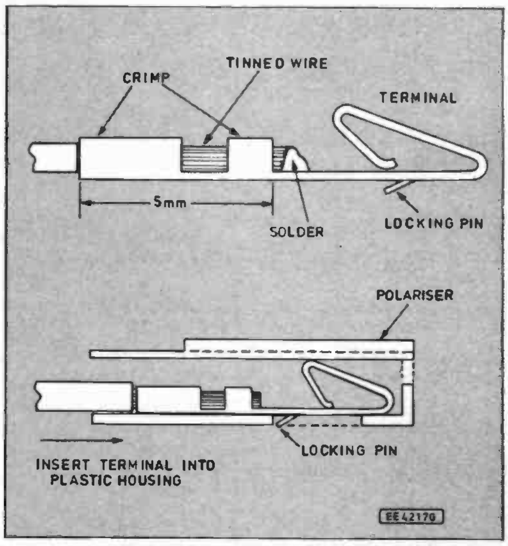


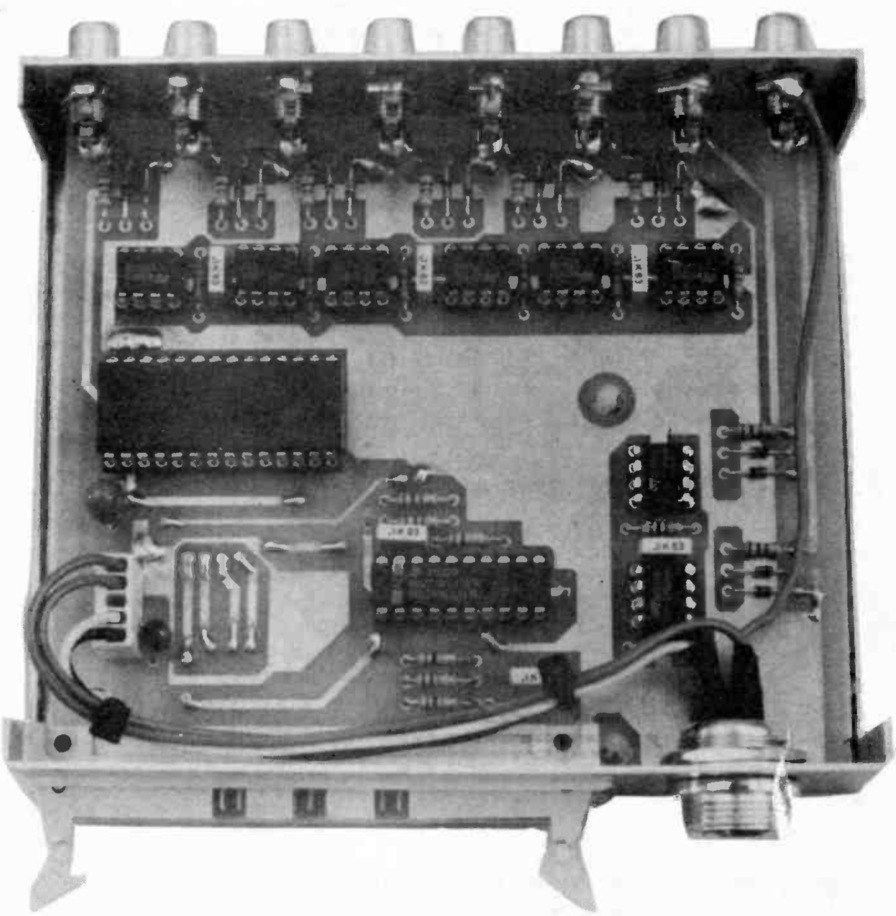

*Fig. 6. Assembly of the "Minicon" connector.*

The unit should be connected to the PCW using ribbon cable terminated at one end with a 50-way IDC connector, and at the other with a 50-way IDC edge connector (check when assembling the lead that pin one of the edge connector is connected to pin one of the IDC socket).

The cable should be kept as short as possible (less than 50cm). If longer, ringing and cross-talk may become a problem.

## TESTING

Check all joints and connections and make sure there are no shorts caused by



## COMPONENTS

**Resistors**

| | |
|---|---|
| R1, R2, R8, R9, R11, R12, R14, R15, R17, R18, R20, R21, R23, R24, R26, R27, R29, R30 | 1k (18 off) |
| R3 | 47k |
| R4 to R7 | 10k (4 off) |
| R10, R13, R16, R19, R22, R25, R28, R31 | 1M (8 off) |

All 0·25W
5% carbon film

See SHOP TALK Page

**Capacitors**

| | |
|---|---|
| C1, C3, C5, C6, C7, C8 | 0µ1 polyester (6 off) |
| C2 | 47µ tantalum bead, 16V |
| C4 | 10µ tantalum bead, 35V |

**Semiconductors**

| | |
|---|---|
| D1 to D16 | BAT85 Schottky diode (16 off) |
| IC1 | 74HC688 CMOS 8-bit comparator |
| IC2 | AD7828 High speed 8-bit 8-channel analogue-to-digital converter |
| IC3 to IC10 | LF356N f.e.t.-input wideband op.amp (8 off) |

**Miscellaneous**

| | |
|---|---|
| SK4 to SK11 | Phono or BNC socket (8 off) |

Aluminium case, size approx. 125mm x 105mm x 35mm; double-sided printed circuit board available from *EPE PCB Service*, code 838; Minicon connector; 50-way IDC socket and R/A plug; 50-way IDC edge connector; 50-way ribbon cable; 4-pin locking chassis plug and line socket; 8-pin low-profile d.i.l. socket (8 off); 10-pin low-profile d.i.l. socket; 28-pin low-profile d.i.l. socket; interconnecting wire; plastic self-adhesive p.c.b. stand-off pillars (3 off); stick-on rubber feet (4 off); plastic edging; solder etc.

*Approx cost guidance only* **£56**

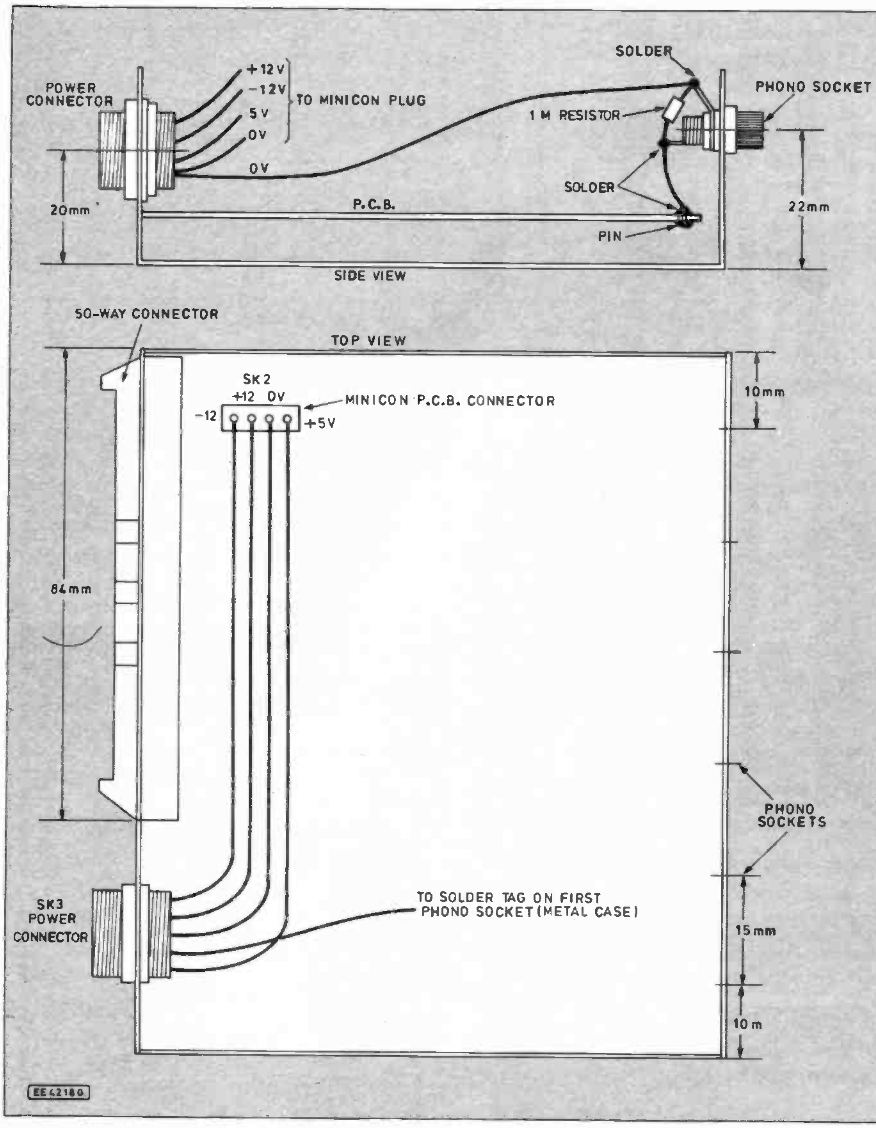



*Fig. 7. Interwiring, installation and case drilling details.*

excess solder. Before inserting the i.c.s or connecting to the PCW, connect the power supply and check the voltages at the Mincon connector are correct (with a circuit containing a £20 i.c. this is worth doing!).

If all is okay insert the i.c.s. The 7828 and 74HC688 are both CMOS and so should be handled carefully (wearing an anti-static wrist-strap is recommended).

Connect the unit to the PCW and the power supply. First switch on the external supply, then switch on the computer and "boot up" as normal. If the computer will not boot up or does anything abnormal turn off the PCW then the power supply, unplug the unit and check all joints, orientation of the i.c.s etc.

To test the inputs connect a 10 kilohm or 20 kilohm potentiometer (multi-turn are best as they give better resolution per turn) between the 0V and +5V outputs of the power supply and the wiper to Channel 0 of the ADC to form a variable voltage source. Enter the test program, Program 1, and then run it.

Enter 0 when the prompt "Which Channel" appears. A list of values will scroll up the screen, which should vary between 0 and 255 as the potentiometer is turned. If the values don't change check you are using the correct channel. The other 7 channels can also be tested in this way.

**Program 1: Test Program**

```
10 Input "Which Channel (0 to 7):",
        channel
20 REM **Read last result, and start next
        conversion, then repeat**
30 PRINT INP(176+channel) :GOTO 30
```

## TAKE CARE

Phono connectors were used for the input sockets SK4 to SK11 as they are widely available and are quite low cost compared to most other screened connectors. Care should be taken when connecting things to the ADC using phono plugs as the centre conductor mates before the screen (this is not really a very good design). Unless the ADC and the source it is being connected to have a common ground this could cause damage to the ADC unit.

The best ways around these possible problems are:

a) To connect the phono socket first and then connect the source (with another type of connector).
b) Use a common earth for the units (only connect the screen to the ground at one end).
c) Make all the connections before the power is switched on.

## PROGRAMMING

This unit is very simple to use. The main thing you must remember is that the value read from the port is the result of the *last* conversion.

The conversion program, Program 2, is an example of the above, it prints the values of Channels 7 and 0 repeatedly on the screen. First (line 20) the old value is cleared from the ADC and discarded, this also starts a conversion on Channel 7 (port 183).

The result of this conversion is printed at line 40, which also starts a conversion on channel 0 (port 176). The result of this conversion is pinted at line 60, which also starts a conversion on channel 7. The program then loops round to line 40.

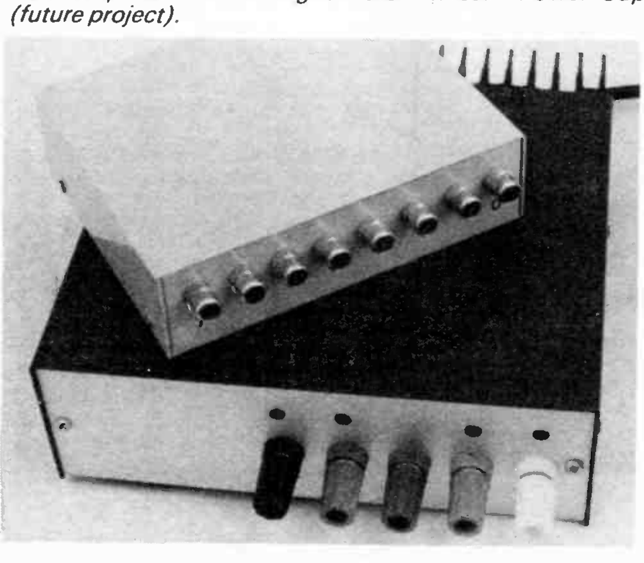
**Program 2**

```
10 REM **Start conversion on channel 7 (discard value read from
        port)**
20 Discard% = INP(183)
30 REM **Start conversion on channel 0 and print result of last
        conversion**
40 PRINT "Value of Channel 7 <";INP(176);
50 REM **Start conversion on channel 7 and print result of last
        conversion**
60 PRINT "> Value of Channel 0 <";INP(183)">"
70 GOTO 40 :REM Repeat
```

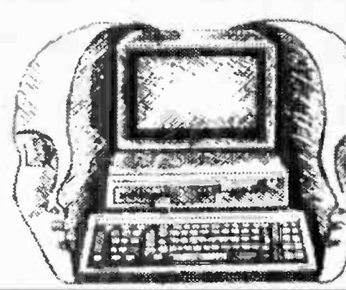
There are many uses for this compact analogue-to-digital converter unit. In Part Two, next month, more programming details and some possible applications will be given when we set out and give information on "Using The ADC Unit". For example, how to use the ADC for monitoring/data logging – with simple sensors, its use for sampling signals at higher sampling rates and some elementary signal processing will be outlined.

Also, a future article will present a "Linear" Power Supply designed especially for the A/D Converter. However, the outputs of +12V at 1A; +5V at 1·5A; −12V and −5V at 0·5A make it ideal for many general purpose uses and an invaluable acquisition for the "test gear" collection. □

*The completed unit sitting on the "Linear" Power Supply (future project).*



# INTERFACE



## Robert Penfold

As most readers who own PCs will probably be aware, upgrades to MS/DOS version 6.0 have recently become available. This version of DOS has a number of new features, but the most interesting of these is undoubtedly the "DoubleSpace" program. This is a disk compression program which can be used with any disks, but is primarily intended to be a means of effectively doubling the size of a hard disk drive.

Although some reports in the computer press seemed to suggest that this program had been withdrawn from MS/DOS 6.0 due to legal reasons, it is definitely included in the package. It is the utility program that can convert disks compressed using "Superstore" to "DoubleSpace" format that has been withdrawn. Apparently this conversion program is available separately from Microsoft for a small fee.

### Crash Drive

Hard disk compression programs have rather poor reputations, and many users seem to run into trouble when using them. On the other hand, other users seem to experience no real difficulties at all.

I tried a hard disk compression program about a year ago, but was far from impressed. When the hard disk became more than half full, and the program started to provide extra disk capacity, the system would seriously crash. In fact it was difficult to regain control of the computer again, and this was only possible by reformatting the disk and restoring all the files from the backup disks.

Another problem is that the way in which most of these programs operate is something less than convenient. The usual arrangement is for drive C: to contain the usual start-up files, plus a huge file generated by the compression program. This huge file takes up practically all of drive C:'s capacity.

A notional drive D: is generated, and this has a capacity of around double the hard disk's actual capacity. It is here that the programs and data are stored. Of course, the huge file on drive C: and the notional drive D: are one and the same.

The problem with this arrangement is that moving the programs and other files from drive C: to drive D: can cause malfunctions, with files not being where programs expect them to be. It is a system that works best if it is used from the start, rather than being applied to a hard disk which is already loaded with your programs and data.

A program such as "DoubleSpace", which is part of the operating system, has a big advantage over an add-on program. The fact that the disk has been subjected to compression can be completely hidden from the user, with drive C: seeming to increase in capacity after the compression program has been run. The programs and other files remain on drive C:.

The only peculiarity of the "DoubleSpace" program is that it generates a drive H:, which has a capacity of about eight megabytes. No compression is used on this drive, and it's main purpose seems to be as temporary storage space for Windows. It can also be used for other files that must not be subjected to any compression.

### Installation

I obtained the 3·5 inch version of the MS/DOS 6.0 upgrade, which is supplied on three high density disks. If necessary, a set of 720k disks can be obtained by sending off the appropriate card to Microsoft.

Installation is easy since a setup program is provided. Unless a custom installation is required, it is basically just a matter of pressing the right key when requested, and changing disks at the appropriate times.

Like the MS/DOS 5.0 upgrade, some existing files can be automatically loaded onto an "uninstall" disk. This makes it possible to return to the old version of DOS if required.

The "DoubleSpace" program is loaded into the DOS directory, but it is not run during the installation process. If hard disk compression is required, "DoubleSpace" must be run once the installation procedure has been completed.

It is very straightforward to use, and for most users it is just a matter of accepting the defaults. The compression process takes a while, and it took just over an hour to compress my 105 megabyte hard disk drive which was almost full. This includes the time taken for the program to defragment the disk.

Like most programs of this type, "DoubleSpace" provides what in most cases is something less than a two-to-one compression of the data on the disk. However, it still provides a very worthwhile increase in effective disk capacity. With a 105 megabyte hard disk drive I gain about 70 megabytes on drive C:, plus the eight megabytes or so of decompressed space on drive H:.

The amount of space gained by compression depends very much on the contents of the disk. Compression programs mostly use more than one compression technique.

The most popular forms of compression rely on a certain amount of repetition in each file. A long string of binary 1s or 0s might be present, and it will then be possible to save disk space by coding these as X number of 1s or 0s.

This process can be taken a stage further, with repeated binary patterns being coded in much the same way. The longer the binary patterns, and the more often they are repeated, the greater the space saving that can be achieved. After compression, many programs repeat the processing on a second pass in an attempt to produce further space saving.

Compression techniques mostly work quite well with program files, but give much more variable results with data files. Bit maps generally offer excellent scope for quite high degrees of compression, while ASCII and similar files generally lend themselves to moderate amounts of compression.

However, many programs apply one or more compression techniques to saved data, it is probably this factor that results in programs like "DoubleSpace" tending to fall short of their design aim of two-to-one compression. I achieved a compression ratio of about 1·8 to 1, which seems to be fairly typical of these programs.

As anyone who used PC shareware in the early 1980s will remember all too well, not all compression programs manage to decompress files with 100 per cent accuracy. Many of the early efforts crashed half way through the decompression process, or produced errors in the decompressed files.

There was a lot of shareware in circulation which did not run due to decompression errors. Fortunately, modern disk compression programs seem to be totally reliable, and I have certainly not experienced any problems when using "DoubleSpace".

### Half Time

There is a potential problem with disk compression programs that work "on-the-fly", and this is that they can seriously slow down disk accesses. Every time something is written to disk, or read back from the disk, it must be processed by the compression/decompression program. This process is "transparent" to the user, but it goes on in the background every time the hard disk is accessed, and it takes time.

In practice the problem is less severe than one might think. It has to be borne in mind that hard disks tend to be quite slow by the standards of the rest of the computer. Processing the data takes extra time, but having less data to read and write saves time.

Using disk compression can speed up disk accesses, or slow them down. It all depends on the access time, etc. of the disk, and the speed the data processing is carried out.

In my experience of these programs they do not seem to have much effect one way or the other.

Using a 33MHz 80386 based computer and an IDE drive with a quoted 14mS access time, loading large programs is definitely somewhat slower using the "DoubleSpace" program.

Loading large data files into programs seems to give a less significant difference. Overall, any slowing down of the computer would not seem to be of great significance.

MS/DOS 6.0 has several other new features, including a program which helps to free more RAM, an anti-virus utility, a defragmenter program, an undelete utility, and improved backup programs. Incidentally, the "DoubleSpace" program can be used to compress data on floppy disks, and it is not restricted to use on hard disks.

The MS/DOS 6.0 is available from most PC software retailers, and it currently has a recommended retail price of £49 plus VAT. It is worth shopping around though, since it can be obtained for about this price, inclusive of VAT.

Either way, it represents very good value for money. Note that this is an upgrade program which can only be installed on a computer which is running an earlier version of DOS, or Microsoft's OS/2 operating system.

## Joystick Port

From time to time I receive letters concerning the PC joystick ports. Some readers wish to use this as a mouse port. As explained in a previous *Interface* article, this is not a practical proposition because the joystick port is incompatible with all the normal types of mice. Most of the others wish to use this port for interface temperature probes, light sensors, or other analogue devices.

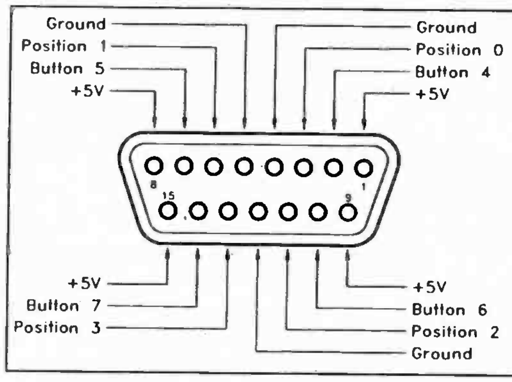



*Fig. 1. Pin functions of the joystick port.*

This seems to be a more realistic proposition, since the PC joystick port is an analogue type. In this respect it is quite like the BBC computer's analogue port. Unfortunately, it seems to work in a rather different fashion to the BBC computer's analogue port. The latter utilizes a four-channel 12-bit analogue-to-digital converter which is easily interfaced to various analogue devices.

The PC joystick port does not use a proper analogue-to-digital converter. It seems to work on the basis of using the resistance of each joystick potentiometer in a timer circuit.

Presumably a software counter operates until the end of the each timing pulse. The higher the joystick resistance, the longer the pulse duration, and the higher the count. A resistance of around zero to 140k or so seems to be required.

The standard connector for the joystick port is a 15-way D-type socket. The pin functions for this port are shown in Fig.1.

The two potentiometers for joystick 1 connect from +5V to the "Position 1" and "Position 2" terminals. Presumably the potentiometers in a second joystick connect from +5V to the "Position 2" and "Position 3" terminals.

It might be possible to use these four inputs with some types of sensors, but the sensors would have to provide varying resistances, and not varying voltages. Also, the linearity of these inputs does not seem to be particularly good. The joystick port can only be used for very basic analogue sensing applications, but it is potentially useful.

There are two firebutton inputs for each joystick. These inputs are "Button 4" to "Button 7", and in normal use they are connected to the earth rail via the firebutton switches. These seem to be four conventional TTL digital inputs which could be used for other purposes.

The interfacing possibilities of the PC games port will be covered in more detail next month.

# Those Amazing Barcodes

ALAN WINSTANLEY

*The product "identity card" that's scanned by lasers and interpreted by computers.*

MANY advances in terms of technological applications, speed of operation, capacity, power and size have been made within the last decade. For example, the computer age is well and truly upon us, as immensely powerful personal computers can now be found in the home, in the office, and even in the briefcase.

## DEVELOPMENTS

Facsimile ("fax") machines, which were exclusively sported by the wealthiest of companies six or seven years ago, have tumbled in price, even finding their way into domestic homes as they can now be bought in the high street for as little as £229. A fax machine can even be purchased which is not much larger than an ordinary telephone.

Miniaturisation continues unabated as the manufacturers now proffer pocket-sized colour televisions, talking language translators no bigger than a calculator, electronic diaries and address books, palm-sized video cameras and hi-fi equipment which is a fraction of the size of its predecessors.

One of our more amazing electronic developments is now taken very much for granted. They pop up all around us in everyday life. Checking out at the supermarket, buying a magazine at a newsagent, selecting a programme to be taped by our video recorder, those striped symbols are now familiar to us all.

*Barcodes* seem very innocuous. They adorn almost every product you can buy in every store and supermarket. There are thousands of millions of them in circulation, each bearing a computerised code which has revolutionised the way we do our shopping.

## CHECK THIS OUT

Queuing up at that supermarket "scanning" check-out (electronics still hasn't solved the problem of those interminable delays at the cash register!), you will now hear the monotones of a computerised cash register which "reads" the barcodes of the produce as the check-out assistant passes it over a **laser scanner.** Each electronic beep is a confirmation that the laser has "seen" the barcode – whether it's on a bag of crisps, a tin of soup or lengths of timber.

In the surface of each check-out counter you may see a small window, probably less than twelve inches square. Look carefully at the window and you may often observe the laser light itself, in the form of a red pin-prick of light. Adjacent you may see both a small red and a green indicator lamp. The green lamp briefly flashes, accompanied by a beep, to confirm that the goods have been scanned correctly by the barcode reader. A price and product description then flashes up on an alphanumeric display nearby. The red indicator lamp occasionally warns the operator to repeat the scanning process.

The laser scanner is quite capable of reading the barcode forwards or backwards, as they scan over the barcode with a matrix of low-power light beams which can be directed by mirrors mounted internally under the window. Thus, the way in which the operator presents the goods to the scanner is not critical, because the multi-directional beams are bound to register the barcode no matter which way the product is presented. The check-out assistant merely passes the goods over the scanner in a casual manner which belies the complexities of the light-directional mechanism and the electronic deciphering system being used behind the scenes.

How does a check-out scanner actually "read" this barcode? When the item is passed over the scanner window, a precise laser light beam is directed by a series of lenses and mirrors over the merchandise and so over the barcode. This beam of laser light – which, unlike those fictional ones which James Bond encountered in the movies, is completely harmless – is actually absorbed by the dark bars of the barcode, but reflected back by the lighter sections.

The image which bounces off the barcode is directed back into an electronic detector which decodes the reflection, see Fig. 1. Thus, the check-out computer obtains the product's *digital code* by deciphering the barcode from the series of light pulses which are received by the detector and decoding system.

## MEMORIES ARE MADE OF THIS

The barcode is in effect a unique "I.D. card" for that particular line of merchandise. The cash register system then reads through its database, looking for a code number which matches the number it has just deciphered from the barcode, see Fig. 2. The system's memory then instantly flashes back to the cash register with a product description, and, more importantly to the housewife, the price to be charged. In addition, the computer now knows that a particular product has just been purchased, and so it also updates its stock records accordingly.

In an instant, the cash register has been updated with a product description, and the product name is printed onto the till receipt along with its price. The customer now has a clear record of the purchase, instead of an unhelpful roll of paper indicating nothing but a string of prices.

Even more amazingly, the senior staff back at the head office – which could be

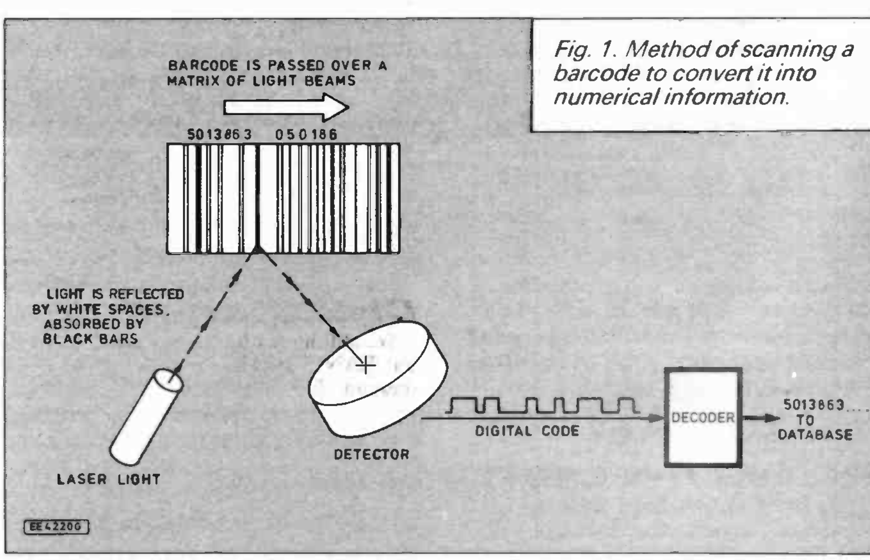
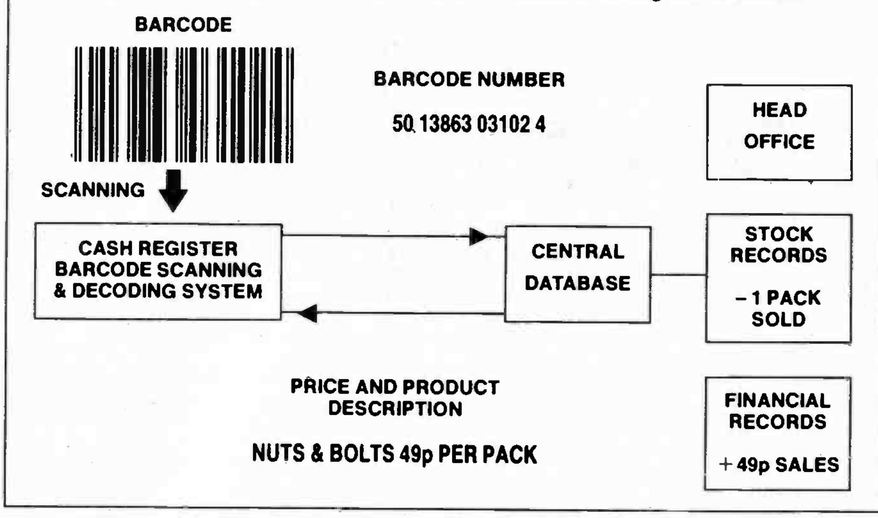



*Fig. 1. Method of scanning a barcode to convert it into numerical information.*

*Fig. 2. Block diagram of a stock control system utilizing barcode data*




anywhere in the country – can also be connected into the system by a network of computer links, and by using their own computer terminal they are able to watch the sales figures of their merchandise clocking up.

Computers analyse product sales by the hour, or offer summaries based on the number of units sold this week if wanted. They can also forecast whether it will be possible to meet any forthcoming demand for a product.

## STOCK

Buyers whose responsibility it is to source and replenish stocks, can obtain virtually instantaneous information on sales so that their suppliers can be instructed to deliver replacement stocks. Slow-moving lines are also highlighted to be considered for deletion. Indeed a retailer's entire operation centres around the movement of stocks. Over-stocking means that cash is tied up needlessly in stocks when it could be better utilised in other aspects of their business – so the raw data provided by those barcodes is actually critical for efficient stock control and market planning.

If the products concerned are of a less manageable nature, such as certain lines found in d.i.y. superstores then it's obviously impossible to pass the cumbersome goods over the scanner window – unless you relish heaving lengths of timber onto the counter! As you may have experienced yourselves at a check-out, in these cases the operator is armed with an electronic "gun" which is "fired" at the barcode label attached to the goods.

A precision light-beam scans over the barcode and then the decoded data is transmitted instantly into the store's computer system, which responds with the product description and value. The useful range of the "gun" can be many centimetres, which enables the cashier to "shoot" the barcode label affixed to the goods in the customer's shopping trolley.

An alternative system is for the check-out operator to hold a book with the barcodes of various bulky items (e.g. bags of potting compost) all printed inside. Whenever a customer buys one of these items, the operator simply scans the appropriate barcode from the book.

## SEEING THE LIGHT

Have you ever wondered what the barcode actually means? There are some two dozen or more different types of barcode in common use, but the system which the consumer will mostly see in retail stores is known as the "EAN" system, short for European Article Number. This is generally based on a thirteen-digit code number – the EAN13 format – which is unique to that product. A different system is used for magazine sales.

5 013863 031024

*Fig. 3. A typical EAN13 barcode.*

A typical EAN13 barcode is shown in Fig. 3. The thirteen digits of the code can be divided into four groups. Firstly, two digits placed at the beginning of the code indicate the country of origin of the barcode. You will see "50" at the start of all codes originating in the United Kingdom.

Each manufacturer who subscribes to the barcode number system is allocated a unique five-digit code number by the Article Number Association. This number represents their company and cannot be used by any other. That of my own firm is 13863. The code belonging to Halfords Ltd., for example, is 15025. These five numerals follow the country of origin code. So the first half of the code number may be 5013863 or 5015025, for instance.

The supplier or manufacturer is free to allocate another five digit code entirely of their own choice to the product. The code will take into account the packaging of the product: the maker of a particular chocolate bar may offer several sizes, perhaps packed in units of half a dozen bars, as well as individually. Whilst one barcode may appear on the individual bar's wrapper, a different one will appear on the outer wrapping of the six-pack.

## CHECK DIGIT

We still have one digit to account for in our EAN13 system – the numeral right at the end. This **check digit** is included as a built-in test which tells the barcode scanner that it has read the rest of the code correctly. A simple algorithm is utilised in order to validate that the barcode is sound. The panel on the right shows how the algorithm works for the EAN13 system. By ignoring the last (check) digit of the EAN13 code, work backwards through the code number, right to left, adding up *every other* numeral in the code. Multiply the total by *three*.

Go back to the end of the code, and work through the barcode again, adding to your total each digit which you omitted in your initial calculation, and make a grand total. Now simply determine the *next whole multiple of ten* up from your grand total, and calculate the *difference* between your grand total and this multiple of ten.

Your result will be a single numeral which is the check digit. This is appended at the end of the twelve digits to make thirteen in all. It is an in-built check which confirms that the scanner has read the barcode correctly. Have a look at any thirteen-digit barcode and work out the final check digit for yourself.

The EAN13 digital sequence which results is encoded into a precise pattern of stripes, which are reproduced on the packaging to fine tolerances. The width of the bars is precisely controlled, but also has to take into account the fact that printing ink might spread or "bleed" during the printing process – so barcodes might be deliberately printed very slightly narrower than required (using a bar width reduction factor, measured in microns), because they will expand somewhat when the wet ink spreads.

### Key to Barcode Numbers

***Example Barcode Number (EAN-13 format)***

| 50 | 13863 | 03102 | 4 |
|---|---|---|---|
| **UK** | **COMPANY I.D.** | **PRODUCT CODE** | **CHECK DIGIT** |

**"PRODUCT IDENTITY CARD"**

The barcode number is unique to that line of merchandise and represents the "I.D. card" for that product. The numerical information contains the country of origin of the barcode *(not the product)*, company *(not necessarily the manufacturer)* and product codes and a "check digit".

***How the check digit is calculated:***
A modulo-10 algorithm is used to calculate the final check digit. It can be proved as follows. Starting at the end of the product code (before the "check digit"), go back from right to left and add up every other numeral.

$$2+1+0+6+3+0=\mathbf{12}$$

Multiply your answer by 3:

$$3 \times 12=\mathbf{36}$$

Now go back and add up the numbers which you missed first time:

$$0+3+3+8+1+5=\mathbf{20}$$

Add your result to the answer from the first calculation:

$$20+36=\mathbf{56}$$

Find the next whole multiple of 10 up from this answer (= **60**).

The difference between your final answer and the multiple is the check digit:

$$60-56=\mathbf{4}.$$

## COME ON DOWN...

It will not have gone unnoticed that no *price* has so far been mentioned in the barcode itself. In fact, the price of the goods is not denoted by the barcode as such. Whilst a product designer will allow for the EAN13 code to be shown on the packaging, it is left to the *retailer* to allocate a price on their computer's database. The retailer can change the retail prices (e.g. reduce them in a sale) by altering the computer records of that product code number. *Otherwise the barcode contains no price information at all – it's simply a product identifier.*

Sometimes you might observe a shorter code, one which contains not thirteen but just eight digits – this is not surprisingly called the EAN8 format. You might see it on small items which are not physically big enough to carry a large EAN13 barcode – a packet of "Polo" mints, for instance. Because the eight digit system cannot accommodate a great number of individual manufacturers and products (the system would soon be filled to capacity), the EAN8 format is only employed by a select few manufacturers who have been lucky enough to be allocated an abbreviated code number.

Barcodes often appear on the edges of shelves of supermarkets, too. A portable computer scanner will be used by a store assistant to read each product designation. Then the assistant will count the stock which is adjacent to the shelf barcode, and type this figure into the portable computer.

The machine may transmit the barcode and stock check figures back to the office computer by remote control, which will then update its "actual" stock level information for that product code. In other systems, the terminal may be plugged into a computer inlet once the stock count has been completed by the operator, thereby transferring the entire stock check into the central computer.

## PROBLEMS

Of course, no system is entirely infallible. It is still possible for sophisticated barcode scanners to become a bit confused. Whilst the barcodes themselves are printed to very exact standards – the width of each line and the gap between them is absolutely critical, and has to take the weaknesses of the printing process into account – scanners may sometimes have difficulty reading a shiny object such as a bag of frozen peas.

Alternatively, the barcode may have been damaged or soiled in the store. In these instances, the operator is then able to manually enter the digital product code as printed underneath the barcode: the computer can then "look up" the price and description as normal. That's why there is always a "human recognisable" numerical code underneath the otherwise incomprehensible barcode.

## BAH! CODES

Whilst the technology of barcodes has been highly refined over the past few years, problems with the machinery itself, though thankfully rare, can give rise to nightmarish headaches for system users. It was reported that shortly after a new supermarket opened its doors for the first time, the computer system unfortunately "crashed". The system was soon crippled through a fault or "bug" in the scanning equipment.

Because the store used a barcode scanning system, their check-out cashiers were unable to ascertain the prices of the customers' purchases: of course, the goods did not bear any price labels! Instead, paralysed by the loss of their computer, the staff were instructed to ask the customers to make a reasonable offer for each item – perhaps the management considered it was worth making a loss if necessary rather than alienate its new patrons!

Apart from retailing, barcodes also crop up in other applications. Recently, the writer was invited to an exhibition of leisure products, and was sent a lapel badge beforehand. This badge, apart from bearing my name, also included a barcode. At the entrance to the exhibition, the barcode on the badge was quickly scanned by a receptionist holding a "wand" scanner like a large pen. This informed the organiser's central computer that I had attended the exhibition.

From the barcode the computer could also determine my company name and address, not to mention my position, and the organisers will then write to me next year with another invitation to the show knowing that I visited their last one.

Additionally, when I called on to an exhibitor's stand, each exhibitor, instead of accepting a business card would scan the barcode on the badge: after the show, they could then decode the information and follow up with a visit or a written quotation to my business address.

## SELF PARKING

A Japanese car manufacturer is reported to have designed and built a prototype car which will automatically park itself in the garage: it looks for barcodes fixed to various locations on the garage walls, in order that it can find its "bearings" and correct its position accordingly!

It was recently announced that pension and allowance books will include a barcode, unique to the book-holder, in an attempt to foil any attempts to fraudulently claim an allowance by using another person's book. Each Post Office will probably become equipped with a barcode wand unit so that they can scan the identifying barcode. A false claim will become immediately apparent if the allowance book has been reported as stolen, and a "stop" can be applied instantly by the authorities.

In industry as well as warehousing, barcode information systems are being increasingly used to help central computers to monitor the throughput of stocks or products. By automatically reading a special-format barcode which has been allocated to, say, a motor car during assembly, the progress of the product can be controlled as each unit is logged into and out of various processes.

## AUTOMATIC

One large retailer I visited holds some £30 million of stocks stored in Europe's largest automatic warehouse which is integrated into a highly efficient stock control system, but it still depends on barcode systems to monitor the throughput of stock. Merchandise which is destined for a particular store is loaded into plastic mini-skips, each box having a unique barcode label on the side. Infra-red detectors read the barcode as the box travels automatically through the warehousing system on an assortment of conveyors and robotic transporters.

Gradually the box is filled with a variety of products all destined for one particular store. An impressive, fully automatic sorting process then eventually diverts these boxes to a suitable loading bay, ready for despatch by lorry. The automated warehouse system sorts the boxes into *reverse order*: The system is aware of the route which the vehicle will take when it travels around the country, so that the first box to be loaded onto the vehicle will always be the last one off!

A new hand-held l.c.d. game – the Barcode Battler (reviewed last month) – actually utilises barcodes in order to allocate a number of points to a player. Barcodes are "swiped" into the games unit like a credit card at a checkout. The barcode is then transformed into points and the game commences. This has led to a craze in Japan where merchandise is bought simply to snip off and scan the barcode into the machine!

Next time you visit a supermarket, spare a thought for those often overlooked, incongruous barcodes: the electronic industry's little miracles which hold the key to the entire merchandising system. □

### Magazine Barcoding System

Magazines are regularly barcoded in order to speed the pricing-up process at check-outs. A barcode on the front cover is scanned by a hand-held pen-like "wand" which reads the barcode into the decoding system. This generates a digital code which can be referred to a computer "look-up" table as usual.

Magazines and serial journals use the ISSN system – the International Standard Serial Numbering system, where every barcode number begins with the digits 977. Then seven digits are used to indicate the ISSN reference number for that journal; two spare digits follow, which can contain the price if needed and a check digit appears at the end. Finally two extra digits can indicate the issue number i.e. 08 for the August issue.

In addition to helping at the check-out the barcode on a magazine is also used for sale or return (S.O.R.) processing. Unsold magazines being returned to the wholesaler are scanned and the "sales" level for each issue stored on the wholesalers' and distributor's computer systems are corrected and credits given by the distributor.

08

9 770262 361034

### More Information

Any party considering becoming involved with the barcoding of merchandise for the first time might find the following useful:

The **Article Numbering Association** controls the issue of company codes, and every supplier using a barcode on packages needs to subscribe with this body.

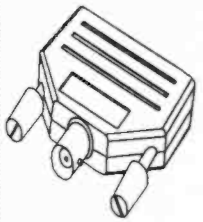
Article Numbering Association (UK) Ltd., 11 Kingsway, London WC2B 6AR
Tel. 071 240 3056, Fax. 071 240 8149

# Low cost data acquisition for IBM PCs & compatibles...

A unique range of low cost data acquisition products for IBM PCs and compatibles. Installed in seconds they simply plug directly into either the serial or parallel port. They are completely self contained, require no external power supply and take up no expansion slots.

Each device comes with an easy to use software package (PicoScope, PicoLog or both). C, Pascal, and Basic drivers are supplied for those who want to develop their own software, as is a manual giving full details of the hardware and software. All software supplied on 3.5" disk.

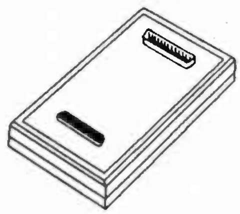
## ADC-10



- Up to 24kHz sampling rate from a 386/33MHz machine
- 0-5V Input range
- BNC input connector allows use of standard scope probes
- 30V overload protection
- Parallel port connection
- Includes PicoScope software

**Single Channel 8 bit ADC** **£49**

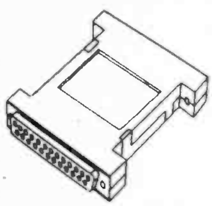
## ADC-16



- Software selectable single ended or differential inputs
- Resolution programmable between 8 and 16 bits + sign
- ±2.5V input range
- 5V reference output
- Connects to serial port
- Includes PicoLog software

**8 Channel 16 bit + sign ADC** **£99**

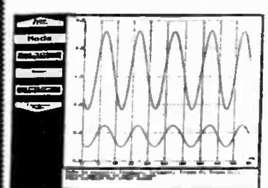
## ADC-11



- 15K samples per second
- 0-2.5V Input range
- Digital output
- D25 input connector
- 30V overload protection
- Parallel port connection
- Includes both PicoScope and PicoLog software

**11 Channel 10 bit ADC** **£75**

## PicoScope

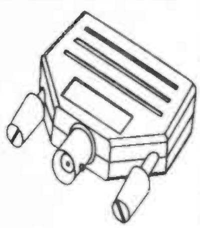


**Scope, voltmeter, spectrum analyser**

'Virtual instrument' software package for the ADC-10, ADC-11 and ADC-12.

Storage oscilloscope with trigger and timebase. Traces can be printed and saved. Multiple meters on screen. Real time spectrum analysis.

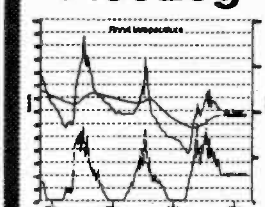
## ADC-12



- Up to 18kHz sampling rate
- 0-5V Input range
- BNC input connector allows use of standard scope probes
- 30V overload protection
- Parallel port connection
- Includes both PicoScope and PicoLog software

**Single Channel 12 bit ADC** **£85**

## PicoLog



**Advanced data logging software**

Collect samples from 1 per ms to one per day. Scale samples linearly, by equation or by table look-up. Graphical (against time or XY) and text reports can be displayed, printed or exported.

Picolog is also available for the ADC-10: call for details.

| Typical application | ADC-10 | ADC-11 | ADC-12 | ADC-16 |
|---|---|---|---|---|
| Oscilloscope | ● | ● | ● | |
| Voltmeter | ● | ● | ● | ● |
| Spectrum analyser | ● | ● | ● | |
| Audio sampling | ● | | ● | |
| Chart recorder emulation | | ● | | ● |
| Temperature measurement | ● | ● | | ● |
| Pressure measurement | ● | ● | ● | ● |
| Chromatography | | | | ● |
| Automotive monitoring | | ● | | ● |
| Medical research | | ● | ● | ● |
| Education | ● | ● | ● | ● |

### PICO BENEFITS

- 30 day no quibble money back policy
- Full 1 year guarantee
- 1 year's free software upgrades
- Free technical support
- Free user newsletter
- Same day dispatch

PICO TECHNOLOGY

VISA

Pico Technology Ltd. Broadway House, 149-151 St Neots Road, Hardwick, Cambridge. CB3 7QJ.

**TEL: 0954-211716 FAX: 0954-211880**

Phone or FAX for sales, ordering information, data sheets, technical support. All prices exclusive of VAT.

# DOWN TO EARTH

George Hylton

## CONDUCTANCE

EVERYBODY is familiar with the idea of resistance in an electrical circuit. We feel happy with "resistance" in an electrical circuit because we are so accustomed to hearing it in everyday, non-technical situations.

This is not true of the technical relatives of resistance: impedance, reactance, conductance, admittance. They bear some resemblance to familiar words but have no obvious meanings. Let's have a look at one of them: *Conductance.*

## EARLY DAYS

At one time, there were no volts, ohms, and amperes, only something vague, called "electricity". Electrical researchers were struggling to discover whether the sort of electricity you made by rubbing amber with a dry cloth was the same as the sort that you got from one of Volta's new-fangled piles. In present-day words, they were trying to find out whether static (frictional) electricity and current electricity were two aspects of the same thing or two different things.

Georg Simon Ohm was a pioneer researcher in this field. His now classic paper was called (in German) "The Galvanic Chain". We would now say "The Electric Circuit".

## CONDUCTANCE

Ohm was trying to get answers to the question: do some things conduct electrical currents better than others? Note that it was the ability to conduct that Ohm set out to research, not the ability to resist conduction. Resistance hadn't been thought of!

He showed, to his own satisfaction (though for a long time to nobody else's) that "ability to conduct" is a measurable quantity, expressible in precise terms (known to us as Ohm's Law). If the ability of a circuit to conduct is called its conductance, what determines the amount of current that flows?

## OHM'S LAW AS HE SAW IT

Ohm saw the current as something governed by the number of cells in his battery and the circuit's ability to conduct. A battery provides an electromotive force ($E$) and the ability to conduct can be called the conductance.

The intensity ($I$) of the current is then given by the product of these two quantities. Current = electromotive force times conductance.

That may not look like the Ohm's Law you know and love. That says: Current = Voltage divided by Resistance: $I=E/R$ (or $V/R$ if you call the electromotive force the voltage.

If two things are each equal to a third thing then they must also be equal to one another. In the present case we have two things each equal to the current. It follows that one of them (conductance) must be equal to the other. But what *is* the other? Not $R$, but 1 divided by $R$. Conductance is just a 1/R.

For convenience, to avoid having to write 1/R every time, electrical engineers usually give it an alternative symbol, $G$. So $I=E.G$. Conductance is a sort of mirror image of resistance.

When Ohm started his work nobody really knew whether one conductor was different from another in any electrically important way. The first electrical circuits were just batteries or cells whose terminals were connected together via a length of wire. They were virtually short-circuits.

What limited the current wasn't so much the resistance of the wire as the internal resistance of the battery, which was usually very much larger. It was only as a result of Ohm's painstaking research that the idea of resistance was born.

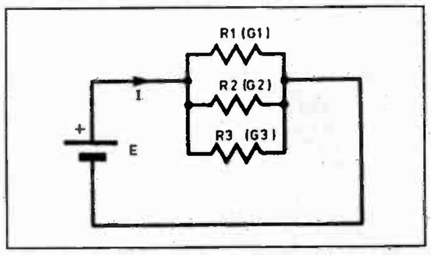



*Fig. 1. Simple electrical circuit.*

## PARALLEL CONNECTION

A circuit like Fig. 1 is easier to understand if the elements are thought of as conductances rather than resistances. Common sense tells you that the more parallel paths there are the more current flows.

In other words the conductances add. The total conductance is G1+G2+G3. Writing 1/R for G, the total conductance is 1/R1+1/R2+1/R3.

Before the computer age these 1/Rs were mathematically a bit awkward. Pocket calculators have now made things easy, and you can work out a conductance by entering the resistance then using the reciprocal (1/X) key.

What is the conductance of a circuit with 29 ohms, 97 ohms and 133 ohms all in parallel? My calculator says 0·00523...

Inverting this (1/X) gives 19·11, which is the equivalent resistance in ohms. (Since conductance is the inverse of resistance, then by inverting again you get back to resistance.)

## UNITS

Conductance, as we've seen, is a measure of a circuit's ability to pass current when a voltage is applied. The more volts, the more amps. This leads straight to one unit of conductance, amperes-per-volt. A resistance of 1 ohm, when connected to 2 volts, allows 2A to flow. The corresponding conductance is one amperes-per-volt.

This is a bit clumsy. Back in the Victorian age, William Thompson (Lord Kelvin) made a rather whimsical suggestion. By then, the unit of resistance had been named: the Ohm. Since conductance is the inverse of resistance, said Kelvin, let's just invert the word Ohm and call the unit of conductance the mho. The mho = one ampere-per-volt.

The matter might have rested there. But scientists decided that they must honour another electrical pioneer, Siemens (pronounced ZEEMENS). So they changed the mho to the Siemens. The result is that, depending mainly on the age of the books you use, you'll find conductance expressed in three ways: amperes-per-volt, mhos, or Siemens. Small wonder that people find it confusing!

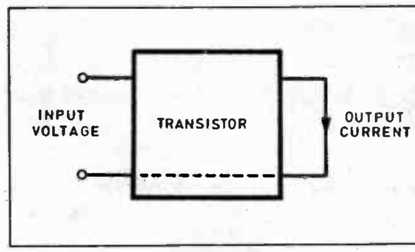



*Fig. 2. "Black Box" transistor.*

## MUTUAL CONDUCTANCE

You are most likely to encounter conductance in transistor data. A transistor of any kind can be regarded as a "black box" with input and output terminals (Fig. 2). When a voltage is applied to the input terminals a corresponding amount of current flows (from the battery) through the output terminals.

Voltage causing current flow is what conductance is all about. So conductance is happening in the transistor.

Applying one volt to the input of a silicon power transistor might cause a collector current of 3A to flow. So the conductance here is three amperes-per-volt, or 3mhos, or, nowadays, three Siemens.

However, there's something odd about this conductance. The 3A does not come directly from the 1V at the input. All the 1V does is drive a relatively small base current. This base current then makes the collector current flow.

Processes which link input and output in this way are often labelled with the word "transfer conductance". In the example just given the transfer conductance is 3S.)

You may find that the transistor data adds the word "forward" and quote the "forward transfer conductance" as 3S. "Forward" just means that we are talking about the normal use of the transistor with an input to the base (or gate, if it's a f.e.t.) and output at the collector (or drain). Transfer conductance is often telescoped to make "transconductance".

Some transistor data call the forward transfer conductance the mutual conductance. This is an old term used to describe the same effect in radio valves.

A Siemens is rather a large conductance, and for convenience it can be divided in the usual way, into a thousand milliSiemens (mS) or a million microSiemens (μS). In the case of *pnp* or *npn* transistors (but not f.e.t.s) there is a useful way of estimating the transconductance.

If the emitter current is 1mA the transconductance is about 40mS. For other emitter currents the transconductance rises or falls in proportion. So for an emitter current of 100μA (0·1mA) the transconductance is about 4mS.

The accuracy of the estimate diminishes as the emitter current becomes much larger or smaller than its typical value for the transistor in question. For power transistors, the estimated value is often higher than the real value. The transconductance is more or less independent of the current amplification factor.

This quick estimate enables you to work out the voltage gain of a one-transistor amplifier. The gain is: transconductance in mS times load in kilohms. So an *npn* transistor with a load of 2k and an emitter current of 1mA has a voltage gain of 80.

In multistage amplifiers the d.c. collector load is shunted by the input impedance of the next stage. This reduces the voltage gain.

# Techniques

## ACTUALLY DOING IT!

### by Robert Penfold

THIS is a piece of advice which has been given in *Everyday With Practical Electronics* many times before, but is one which seems to be more important now than in the past. "Make sure that you can obtain *all* the components for a project before you start buying any of the parts."

Be especially careful if you are building an old design. If a project requires anything that is at all out of the ordinary, it is not a bad idea to obtain the unusual components first, and to progress to the mundane components only when the awkward ones have been obtained.

Difficulties in obtaining components seem to have increased significantly over the last year or so, with a number of components having suddenly disappeared from the market. I have certainly noticed a recent increase in the number of readers letters concerning problems with obtaining components. Some of the problem components are ones which went off the market quite recently, while others have not been available for years but still bring in a steady flow of letters.

## Has Beens

I find it surprising that components which have been available for as long as I can remember can suddenly disappear from the market. It seems to be a fact of modern commercial life that unless something can be manufactured and sold in vast quantities, it is often not worthwhile producing it.

This has led to the demise of several components that seemed to be selling quite well. Unfortunately, the specialist nature of many of these "ex" components means that there is no possibility of using substitute components. In a few cases there are suitable alternatives available, for the time being anyway.

The number of readers' letters received concerning problems with defunct components suggest that it would be well worthwhile mentioning some of the components which are now causing problems. Hopefully, this will deter some constructors from starting projects that can never be finished, and will help others to find alternative components where suitable substitutes are still available.

## Springline Units

As far as I am aware, the last of the springline units were sold last year and they are no longer in production. It seems unlikely that they will become available again unless some surplus units appear.

A reverberation unit based on a c.c.d. device would seem to be the only alternative. This requires a completely different type of circuit though (a c.c.d. reverberation project appeared in the June 1992 issue of *Everyday Electronics*).

## Dual Gate MOSFETS

Popular dual gate MOSFETs of the past such as the MEM616, 40673, 3N140, and 3N141 now seem to be obsolete. Some of the more recent surface-mount types could be used in place of "wired" devices without too much difficulty, but many of these now also seem to be unobtainable. Dual gate MOSFETs appear on the surplus market from time to time, but are often at quite high prices.

The MFE201 from ***Cirkit*** is new stock, quite cheap, and is pin for pin compatible with the 40673, etc. Electrically it is not an exact equivalent to any of the devices mentioned above, but in practice it seems to work well as a substitute for any of them. Apart from surplus devices, it is quite possibly the only dual gate MOSFET currently available to amateur users.

## Bucket Brigades

The Mullard TDA1022 and TDA1097 c.c.d. delay line ("bucket brigade") chips used to be very popular, but despite this the manufacture of both chips was ceased. Readers sometimes enquire about the possibility of using the Hitachi MN30** series of chips in place of the TDA10** devices.

Due to physical and electrical differences there no easy way of achieving such a substitution. However, surplus Mullard "bucket brigade" devices are often available from ***Cricklewood Electronics***, who are able to supply many semiconductor devices which have been out of production for some time.

A number of other integrated circuits have gone out of production in recent years. Due to their specialist nature there is little chance of finding a proper substitute for any of these components. Searching for a surplus device is the only course of action which is likely to end in success.

## BC650

The BC650 is a very high gain, very low noise, *npn* silicon transistor which was very popular about ten to fifteen years ago. Unfortunately, it has been out of production for some time now, and it is unlikely that any BC650s are still available.

As far as I can gather, no true equivalent to this device is currently available. However, using a BC549 seems to give only a marginal reduction in performance in most applications.

A number of transistors that were quite popular in the 1970s now seem to be unobtainable or in short supply. It is worth bearing in mind that for most low power, low frequency applications, a BC549 *(npn)* or BC559 *(pnp)* transistor will provide satisfactory results. More careful substitution is needed if high frequencies, high currents, or high voltages are likely to be involved.

## Denco Coils

The famous Denco Coils have been out of production and unavailable for many years. It is possible to use Toko ready-made coils or home wound coils in place of many Denco coils, and this was covered in a previous *Actually Doing It* article.

However, it is now probably best to seek out modern designs which use readily available components, rather than try to resurrect old designs based on Denco components.

## TIL209/TIL220

When l.e.d.s first appeared they were mainly sold under type numbers, like most other semiconductors. These days they are normally sold as l.e.d.s of certain sizes, shapes, colours, and efficiencies.

The TIL209 and TIL220 are "bog standard" red l.e.d.s having diameters of 3mm and 5mm respectively. Any modern low cost red l.e.d.s of the correct diameters should be suitable replacements for these devices.

## In Stock

I think that it is worth pointing out, yet again, that many readers still complain of difficulties in obtaining components that are readily available. In some cases the problem is simply due to a minor misunderstanding which is easily cleared up. In other cases a source of supply is provided in either the article or the *Shop Talk* feature which is included in every issue of this magazine. Studying the article concerned and the relevant section of the *Shop Talk* feature could save a lot of wasted time and effort!

Many component buying problems seem to be the result of readers not being equipped with a few of the larger component catalogues. With the vast range of components that are currently available, a few large mail order catalogues have to be regarded as an essential part of the hobby. Many of these catalogues are worth the money for the general data and information that they contain. – Not forgetting the ones given *Free* with this magazine from time to time – *Ed.*

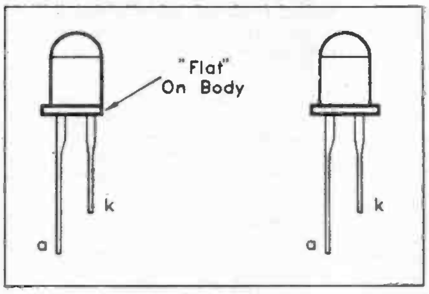



*Fig. 1. The polarity of l.e.d.s is normally indicated by a "flat" on the body, and (or) a shorter cathode ("k") lead.*

## LED Polarity

Determining the correct polarity of l.e.d.s is a subject which crops up from time to time. In the past, most l.e.d.s have had the polarity indicated by a "flat" on the body of the component next to the cathode ("k") terminal. Additionally, the cathode leadout wire is usually shorter than the anode leadout.

Wiring diagrams in magazines and books often indicate the polarity of l.e.d.s by showing the flat on the cathode side of the body. However, many real l.e.d.s now seem to lack the flat on the body, but many still have the shorter cathode leadout wire (Fig.1).

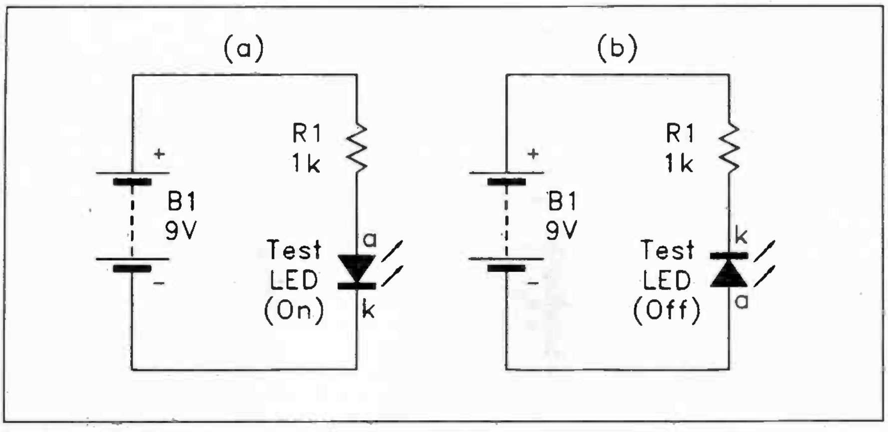



*Fig. 2. A simple method of testing l.e.d. polarity.*

In fact all the l.e.d.s I have bought in the last year or two have lacked the flat. Looking on the bright side, one advantage is that these l.e.d.s fit into some types of panel holder much more reliably than those which have the flat.

Rather unhelpfully, some l.e.d.s seem to lack both the flat and the shorter cathode leadout wire! It is only fair to point out that a few l.e.d.s having the anode lead as the shorter one have been produced. Consequently, it is not 100 per cent safe to assume that the shorter lead is the cathode terminal.

The only certain way of determining the polarity of a l.e.d. is to connect it into a simple test circuit. I generally use the circuit of Fig.2 which can be quickly breadboarded, or put together with the aid of a couple of crocodile clip leads. The l.e.d. lights up if it has the polarity shown in Fig.2(a), or remains off if it has the polarity shown in Fig.2(b).

An *analogue* multimeter set to a low ohms range (about 500Ω mid-scale) can also be used to check the polarity of l.e.d.s. When the l.e.d. lights up, its cathode is connected to the positive test prod. When it fails to switch on, the cathode is connected to the negative test prod.

A digital multimeter can also be used, but if it has high and low test voltage settings it must be set to the "low" position. Modern digital multimeters seem to use low test currents, so even using the lowest resistance range the l.e.d. might not light up very brightly. Note that with a digital multimeter the cathode is connected to the negative test prod when the l.e.d. lights up, and to the positive test prod when the l.e.d. fails to switch on.

I give all newly received l.e.d.s a quick check of this type to ensure that they are working properly, and that the polarity is as I think it is. Where the leadouts are the same length it is a good idea to determine the polarity of the l.e.d., and then trim the cathode leadout slightly so that the polarity is obvious when it is time to connect the device into a circuit.

If a l.e.d. should be connected into circuit the wrong way round, it is highly unlikely that it will sustain any damage. Consequently, if a project has only one or two l.e.d.s, the correct method of connection can, if necessary, be found by trial and error. With projects that contain numerous l.e.d.s this is not a practical proposition, and it is then essential to determine the polarity of the l.e.d.s before starting to wire them into circuit.

# READOUT

## MINI DILEMMA

Dear Ed.,

Examining notes on your *Micro Lab* project, I have noticed a frequent refference to another project i.e. *Mini Lab* described in Feb. '92 issue, however there is no circuit diagram hence it's difficult to understand its usefullness in connection with *Micro Lab* (the 5V/1A supply can be provided by any other means).

However the 34 way ribbon cable used between both units makes me think that there are some other uses of *Mini Lab* not so obvious without the above mentioned circuit diagram.

Could you perhaps kindly advise.

*E. du Puget*
Oadby

*Thank you for your letter concerning the Teach-In* Mini *and* Micro Labs. *We hope we can clarify the position for you.*

*The Teach-In tutorial series lasts for twelve months and is designed to support those undertaking GCSE and GCE "A" Level Electronics studies. Additionally we have tried to frame the material such that it would have broad appeal to regular readers too. In order to demonstrate the basic principles of micro-electronics, we designed a special tutorial unit – the Teach-In* Mini Lab.

*This is a large printed circuit board roughly the size of a page of EPE Magazine. It is modular in nature, where one section of the p.c.b. is assembled every month to form a handy piece of test equipment relevent to that month's material.*

*The immensely popular* Mini Lab *has without a doubt captured the imagination of the beginner in electronics and is* the *ideal learning centre, to be used in conjunction with the experiments carefully detailed in our* Teach-In *series. A photo of the* Mini Lab *appears in the Magenta advertisement, who incidentally retail a full kit of parts for both Labs.*

*Because the* Mini Lab *consists of many sections, each connected to a versatile power supply, it's not possible to reproduce the individual circuit of the* Mini Lab *as such, but it should still be possible to obtain the relevant back-numbers starting with Part 1 back in November 1992.*

(Unfortunately we have sold out of Dec. '92, Jan and Feb '93 issues but we can provide photostats of the relevent parts for the same price as back numbers – see page 565 for ordering details. Ed.).

*After completion, the* Mini Lab *forms a great test bed for demonstrating and testing electronic circuits, especially as it incorporates a breadboard, simple voltmeter, fixed and variable power supply, signal generator, logic probe, audio amplifier and radio tuner amongst other useful items – everything you need for project development!*

*In order to demonstrate the function of the microprocessor, a separate* Micro Lab *has been designed for more advanced readers. We soon saw though that the* Micro Lab *would not only demonstrate m.p.u.'s but could also act as a stand-alone unit which could be programmed to function as a dedicated m.p.u. controller.*

*Hence, the* Micro Lab *can be powered either from a* Mini lab *(which incorporates a 5V and 12V supply) where the supply voltage is fed through the ribbon cable; alternatively, experienced readers who are seeking a dedicated* stand-alone *flexible microprocessor controller for a particular task, would not need the* Mini Lab *(which includes many features that may not be relevant in many microprocessor applications) and so we included a separate 5V terminal also.*

*However, the* Mini *and* Micro *lab systems can* combine together *via the ribbon cable to form an extremely versatile microprocessor demonstration and applications unit. If you are interested in actually* learning about *and* demonstrating *microprocessors then the idea is to use the* Micro Lab *in conjunction with the* Mini Lab.

*The reason you might need* both *Labs is that the* Mini Lab *includes several input/output peripheral devices (e.g. the breadboard, potentiometers, switches etc.) as well as useful modules like the Audio Amplifier, and these will be hooked up via the ribbon cable to the Micro lab for use in certain demonstrations. Most of the microprocessor input/output information is accessible via the 34 way ribbon cable, apart from seperate D/A and A/D signals which are carried through the 4-way screw terminal block. The l.c.d. display shows alphanumeric data too.*

*To summarise, our* Teach-In *series can help you as follows:–*

- *If you are a beginner in electronics (apologies if you aren't), consider the* Mini Lab *only, in order to gain a basic foundation. The* Micro Lab *is not really suitable for assembly by beginners.*
- *If you have a little experience of microprocessors and would like to see how they operate, you will need both the* Mini *and* Micro Labs *if you are to benefit from the series fully.*
- *If you are already familiar with microprocessors (especially the 6502) and would like a versatile 8-bit m.p.u. controller, build the* Micro Lab *on its own, in which case you will need a separate 5V power supply.*

*Please note, the* Micro Lab *is a finely-detailed p.c.b. and it is necessary to be able to use a fine-tipped soldering iron skilfully. Other than that, expect the* Micro Lab *to work first time if it is soldered neatly – our own models did!*

*We hope this will help and encourage you to join all our regular readers around the world who enjoy following* Teach-In.

Best wishes for your success.

Alan Winstanley and Keith Dye
*- Teach-In '93 Team*
*Micro Lab Software Author:*
Geoff MacDonald

# Home Base

*Jottings of an electronics hobbyist – Terry Pinnell*

## To Catch a Mouse

"We've definitely got mice," said my friend Annie. "They're getting into the pantry somehow. But even if I could bring myself to do it, there's no way the kids will let me use poison or a mousetrap."

It was a Sunday lunchtime and we were sitting at a table in the sun outside the local pub.

"Maybe I could make you an electronic mousetrap," I said, looking up from my newspaper, always alert for a chance to slip into my Eccentric Inventor role.

Oblivious to the tolerant smiles exchanged between the others around the table, my mind was already on the grand design as I reached for my pint. Making a device which would allow overnight capture and morning release would not really be all that complex, but I thought I might stretch it out to a few days if I worked at it.

Although it went against the grain, I did even fleetingly consider an idea that wouldn't actually need any electronics. Suitably lured onto the top of a box, the unsuspecting mouse would step onto a piece of tissue paper or cloth covering a hole, fall through and be unable to climb out. (I probably got the idea as a kid watching Tarzan movies, in which they always seemed to be digging holes in the jungle – to trap man-eating tigers or Tarzan, I don't exactly remember). However, I decided it was most unlikely that a mouse with the minimal survival skills that had got it this far would be stupid enough to fall for (or fall through) such an obvious ambush.

No, it was clear that what I would need was an open box, into which I would lure the unwanted rodent, then trap it. But how to persuade it to venture inside?

## Attraction

Focussing now on an all-electronic design, I first consulted the Sound Effects section of my ageing Circuit References Binder, but this yielded no Rodent Attractors or such-like. The closest was a Fish Caller in a late '70s magazine – a multivibrator in a watertight jar – but I dismissed that as unpromising for my more discriminating mammal target. Anyway, why look further than the traditional piece of cheese?

Needless to say my mousetrap had to be electrically operated – a merely mechanical contrivance was not an option for an electronics hobbyist. Battery operation was another obvious criterion; mains sockets aren't usually sited with mouse catching in mind, and the idea of an extension reel was abandoned quickly.

It was clear that I would need a door of some sort which would close when the mouse was about to start its one course meal, remaining shut until its merciful release by A Kind Human some time later, presumably the following morning. So the first interesting design questions were: what sort of door and how to close it?

A vertical freely-sliding type was the obvious choice, given that it had to close quickly. Our small guest was unlikely to linger over the cheddar, watching with interest as a hinged type slowly closed in conventional manner. I decided to use a piece of thin hardboard suspended at the sides in grooves, so that when suitably released it would fall quickly downwards.

## Sting in the Tail

This prompted some rough calculations as to how long the box should be. I did not want news of successful capture to be marred by hearing that the mouse's nether extremity had been amputated – a sting in the tail as it were. Unsure as to the upper size bounds of the local mouse populace, I was inclined to be generous. After all, I could limit its width to discourage larger nocturnal prowlers like cats or the occasional hedgehog. The box eventually built was about 35cm long.

The next question was how to contrive the door's release. I decided in favour of a small strip of wood glued to its inner side and resting on a sliding rod of some kind. It would have to allow for the trapdoor to be raised again of course, so this 'ledge' was bevelled as shown in Fig. 1.

For withdrawing the rod so that the trapdoor could fall, a solenoid was my first thought. But I knew that the only ones I had were specified as 24V types. So for a while I experimented with a small d.c. motor, winding a length of nylon line around its spindle so that on powering the motor the line would pull in the rod. However, the snag was that the rod needed to be returned to its holding position.

A light spring was not strong enough to pull it back against the motor's resistance, and a stronger spring would have prevented the rod pulling inwards. Anyway, I decided that this approach was basically inelegant and fault-prone, so abandoned it.

I then experimented with one of my surplus solenoids and found that satisfactory operation could be obtained using an 18V supply made from two 9V batteries, despite the 24V specification. This depended on ensuring that friction between the solenoid's rod and the wooden catch was minimised by careful smoothing, and avoiding too heavy a trapdoor.

## Triggering

Then I turned to the method of triggering the solenoid. To minimise current consumption it should only be held in long enough to fully release the trapdoor. This indicated that a monostable would probably be needed. Also, it should only be triggered once; further operation once the door was shut would be redundant and waste power. This indicated using a bistable as well as the monostable.

Triggering should occur when the mouse was fully inside, so that its tail would not be under the falling door. This meant positioning whatever switch was chosen well inside the box and ensuring reliable triggering.

Simplicity and reliability were the main reasons I selected a microswitch as the method of activation. I did briefly consider an interrupted light beam, but widely varying ambient light levels would add complexity and encourage spurious triggering.

## Miceofarads

One other option was a proximity switch, which I considered because it could be made relatively unobtrusive. I had in mind something similar to the circuit I'd built into lamps around the house. When you touch or come very close to the antenna of one of these, a piece of metal or metal foil, it is triggered by capacitive attenuation to ground of an h.f. oscillator (around 100kHz). So a small piece of aluminium cooking foil covered with some cloth could possibly activate the solenoid driver circuit.

However, although I was familiar with the sensitivity of this circuit to human proximity, I was by no means sure how it would perform with a mouse. What is the capacitance of mice anyway? (In *Mice*ofarads of course.)

Anyway, such a high-tech trigger circuit would have needed continuous current, limiting useful battery life. It was better to go for a circuit with negligible standby current.

So as seen in Fig.1 I arranged a microswitch with its lever in such a way that when the mouse was on the hinged base section it would close the contacts.

Perhaps next month I'll cover the simple electronic circuit and describe its exciting inauguration in my friend's pantry.

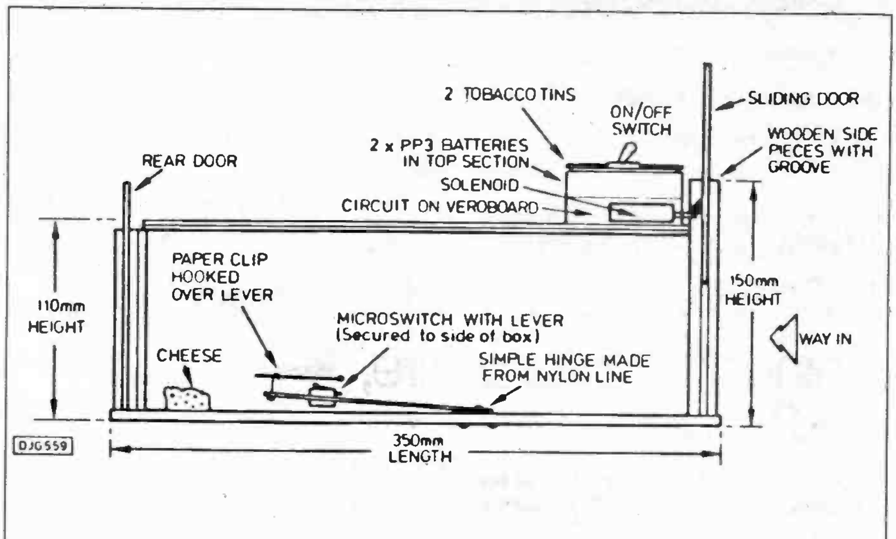
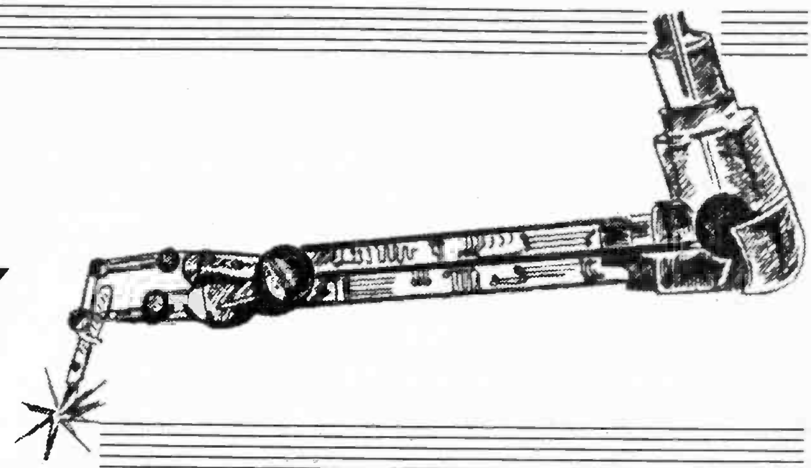



*Fig. 1. Basic construction of the electronic mousetrap.*

Regular Clinic



# CIRCUIT SURGERY


## MIKE TOOLEY B.A.


***Welcome once again to* Circuit Surgery*, our regular clinic devoted to readers' problems. This month we return to the world of digital electronics and some interesting and useful circuits. We begin with a fairly common logic problem...***

## No coincidence?

***D. Salmon*** from Benfleet, Essex, writes:

*"Logic gates like AND and NAND provide an output whenever both inputs are the same, either both 0 or both 1. I need a circuit which will operate an audible alarm when two input signals (both standard TTL levels) are different (i.e., 0 and 1 together or 1 and 0 together). There doesn't seem to be a standard logic gate that provides this function – can you help?"*

Well, Mr Salmon, there *is* a standard TTL logic gate that provides this 'anti-coincidence' funtion. You actually need an exclusive-OR gate, the truth table and ANSI logic symbol of which is shown in Fig. 1. A standard 74LS86 TTL chip provides four exclusive-OR gates and can be used, together with an external transistor along the lines shown in Fig. 2, to provide an audible warning whenever the two logic states differ. The audible transducer can be any piezoelectric sounder.


| A | B | X |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

EE42230

*Fig. 1. Symbol and truth table for an exclusive–OR gate.*

## Simple Pulse Generator

Regular reader, ***Matthew Hume***, is looking for a simple variable duty-cycle pulse generator. Matthew writes:

*"I have used the 555 timer as a source of square wave pulses but I wonder if there is any way in which I can vary the duty cycle over, say a 10:1 range?"*

The 555 must surely be one of the most useful and versatile chips ever invented and, yes, there is a way to vary the duty-cycle using two varable resistors and a couple of diodes, as shown in Fig. 3. VR1 adjusts the "mark" time whilst VR2 sets the "space" time. It is, however, worth noting that the output pulse repetition frequency (p.r.f.) depends on the setting of *both* controls.

The value specified for C1 will produce a p.r.f. of between 1·4kHz (VR1 and VR2 both set to maximum) and 66kHz (VR1 and VR2 both set to minimum). C1 can be scaled up or down to provide different p.r.f.'s alternatively decade values could be selected by means of a simple rotary switch (e.g., 10µ, 1µ, 100n) to produce outputs over the entire range from 14Hz to 66kHz.

It is also worth pointing out that the circuit in Fig. 3 will produce a reasonable square wave output whenever both controls have identical settings (assuming that they both obey a similar law).

## RAM equivalents

Several readers have asked me to provide data on semiconductor memories and,

## COMPONENTS

**Resistors**
R1, R2 1k (2 off)
R3 10
All 0·25W ±5%

**Potentiometers**
VR1, VR2 47k linear carbon (2 off)

**Capacitors**
C1 10n (see text)
C2, C3 100n polyester (2 off)
C4 10µ radial elect. 35V

**Semiconductors**
D1, D2 1N4148 diode (2 off)
IC1 555 timer

**Miscellaneous**
SK1 50 ohm panel mounting BNC socket
S1 S.P.S.T. or s.p.d.t. miniature toggle switch

Battery holder (to accept 9V battery); knobs (two required); 8-pin low-profile d.i.l. socket; small metal or ABS enclosure (approx. 140mm x 80mm x 45mm); small piece of matrix board (approx. 75mm x 60mm); terminal pins (as required).

Approx cost guidance only **£8**

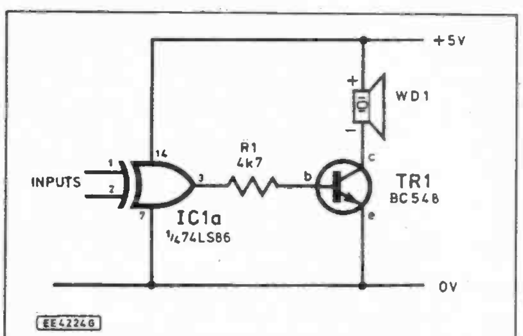
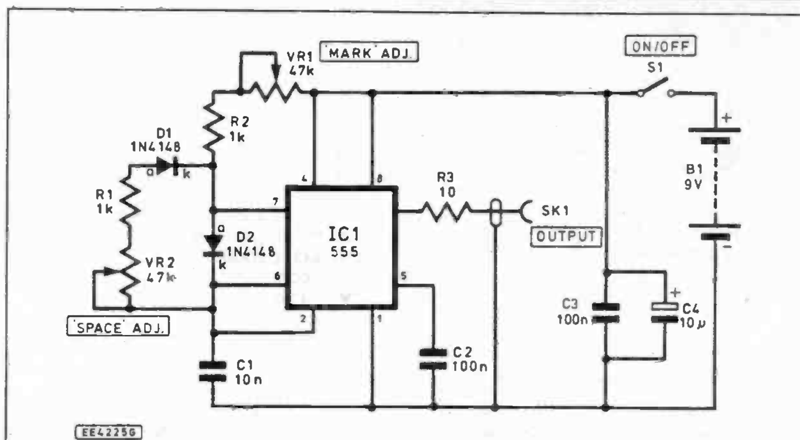



*Fig. 2. Complete anti-coincidence alarm circuit.*

*Fig. 3 (right). Simple pulse generator with individually adjustable "mark" and "space" times.*



in particular, to recommend equivalent devices. It is important to note that RAM devices are supplied with particular access times. Devices with different access times should not be mixed. Furthermore, access times must be selected correctly to match the speed and timing characteristics of the equipment in which the RAM is to be used. In this respect, devices with very fast access times might be just as unsatisfactory as those with very slow access times.

The following data refers to two of the most popular d.i.l. encapsulated RAM types:

| Type | Near equivalents |
|---|---|
| 64K × 1bit | 9064/8264/4164/4264/4564 |
| 256K × 1bit | 4256/6256/41256/37256/50256 |

## Play it again SAM!

Whilst on the subject of RAM, I was interested to see that Texas Instruments (TI) has just announced the first 4Mbit RAM device. This clever chip integrates a 256K x 16 bit dynamic RAM array and a 256 x 16 bit serial access memory (SAM). The chip is supplied in a 64-pin package and volume production should be well under way by the time you read this. Doubtless it won't be too long before we see 8, 16 and 32Mbit devices appearing!

## What's in a name?

***Andrew Pennington*** writes from West Sussex with a query concerning the type numbers of TTL logic devices.

*"I have some integrated circuits marked '74ALS...', '74LS...', '74C...', etc. Can you explain the meaning of the letters and also the significance of the final leter 'N'?"*

Thanks, Andrew for this useful question. To put the record straight, the major 74-TTL sub-families are as follows:

| Device Type | Sub-family |
|---|---|
| AC | Advanced CMOS technology (improved CMOS device) |
| LS | Low-power Schottky (the 'standard') |
| ALS | Advanced low-power Schottky (improved LS device) |
| C | CMOS (CMOS version of the TTL gate) |
| HC | High-speed CMOS technology |
| HCT | High-power CMOS (LS replacement) |
| F | Fast (high-speed TTL replacement) |
| BCT | BiCMOS technology (high-speed, low-power) |
| LVT | Low voltage technology (3.3V supply) |

The letter 'N' simply denotes the dual-in-line version of the device (i.e., the chip is supplied in a standard d.i.l. package). Actually, I have never understood why the 'N' is included in the package marking. After all, isn't the package style obvious?

**Next month:** We describe a versatile power amplifier which can be configured for single-ended and bridge operation. In the meantime, if you have any comments or suggestions for inclusion in *Circuit Surgery*, please drop me a line at: Faculty of Technology, Brooklands College, Heath Road, Weybridge, Surrey, KT13 8TT. Please note that I cannot undertake to reply to individual queries from readers however I will do my best to answer all questions from readers through the medium of this column.

# SHOP TALK

## *with David Barrington*

### Experimental Electronic Pipe Descaler

All components required to build the *Experimental Electronic Pipe Descaler* are standard "off-the-shelf" items and should be available locally. Even the one per cent polystyrene capacitor should be generally available.

If you change the value of resistor R8 to run the unit at a higher output current you are advised to increase the wattage rating for safety. Talking of safety, you must be careful when handling the circuit board as mains voltages are present on the track pads linking up with the mains transformer primary winding leads.

The printed circuit board for the pipe descaler is available from the *EPE PCB Service*, code 839.

### Bike Odometer

A couple of items called for in the *Bike Odometer* will need particular attention when ordering parts for this project. The "two-in-one" pressbutton Reset switch, for instance, was ordered from **Electromail (☎ *0536 204555*)**, code 332-830. Other non-locking types can be used provided the contact sets are identical.

The 0·56in. common cathode displays (type HDSP 5303), used in the prototype, were also ordered from the above company. Most of our regular advertisers will be able to offer suitable devices at very competitive prices.

Seven-segment, 0·5in. high displays can be used without board changes but the body length of these is slightly greater than those of the 0·56in. types, being 19mm instead of 17mm. The width and pin spacings are indentical and there is no reason why 0·5in. displays cannot be used in place of those specified in the parts list.

Some constructors may prefer to use low-current, high-intensity displays; 0·5in. and 0·6in. types are available with compatible pin spacings, for example, the HDSP-E103 in 0·5in. or the HDSP-H103 on 0·56in. but these are of course more expensive than the ordinary types. Most advertisers list comparable types.

Roller-lever microswitches are fairly widely available, avoid devices which have a primitive hinge arrangement for the lever mechanism – check before purchasing. Likewise, the Terry clips will, of course, have to be chosen to suit the dimensions of the particular bike structure.

The two small printed circuit boards (Divider-836 and Display 837) are available as a pair from the *EPE PCB Service*. See page 627.

### Cupboard Guard

For some reason the "micropower" op.amp, type ICL7611, called for in the Cupboard Guard project does not appear in many catalogues. However, it does seem to be appearing on more retailers shelves and is certainly listed by **Cricklewood (☎ *081 452 0161*)**. The ORP12 light dependent resistor is another device which seldom appears on retailers lists, but they can usually offer it, or an equivalent, from their current stocks.

The piezoelectric warning device used in the prototype is the "High Power buzzer" from **Maplin**, code FK84F. Other types may certainly be used in this circuit, but bear in mind that the Darlington transistor collector current should not exceed 300mA. Also, sounders which require external drive circuitry are NOT suitable and this point should be checked when ordering.

Finally, if the "Guard" is used to signal that a young child has tampered with the medicine cabinet, it must not be used in isolation. All the usual "safety code" procedures must be followed at all times.

### Amstrad PCW 8-Channel A/D Converter

The only listings we have come across for the BAT85 Schottky diode used in the *Amstrad PCW 8-Channel A/D Converter* is from **Electromail**, code 300-978. Any readers finding it difficult to source the AD7828 high speed 8-bit analogue-to-digital chip will find it is also listed by the above company under order code 635-482. This CMOS device is not cheap, around the £20 mark, so take special care when handling it.

When ordering the LF356N i.c., make sure you emphasise the letter ***N*** as this designates the d.i.l. package version. Most of the "computer connectors" are standard times now and should be readily available.

The double-sided printed circuit board for the Amstrad A/D Converter is obtainable from the *EPE PCB Service*, code 838.

### Tri-State Thermometer

The miniature bead thermistor used in the *Tri-State Thermometer* is one from the more popular temperature range types and should be generally stocked. The tri-colour, common cathode l.e.d. now appears in most component suppliers catalogues and should also be readily available.

The LM393 dual comparator i.c. may be a little difficult to track down locally, but it is currently on the **Maplin, Cricklewood, Greenweld** and **Cirkit** lists.

The fibreglass insulation wadding will have to be purchased from your local DIY store and the auto connectors and wire will mean a trip to a local garage or motorspares shop.

### Teach-In '93 (Micro Lab)

Those readers who have been following the *Teach-In '93* series and undertaking the "practical experiments" have now reached the micro-processor stage and will, no doubt, have been highly impressed by the quality of the back-up *Micro Lab* project described last month. Although the price tag may, at first, seem high, when compared against a commercial counterpart it stands up very favourably and is excellent value.

There is one small but worthwhile update to the design, the battery life of the SRAM supply can be substantially improved with the following modification: To place the SRAM in minimum power consumption mode the CS pin 20 must be within 0·2 volts of the battery voltage on pin 28. To ensure that this happens an additional pull up resistor of 15k is recommended to be fitted between pin 20 and pin 28 of IC3. This can be soldered onto the back of the printed circuit board, attaching the resistor directly to the pins. Place some insulation onto the resistor leads to ensure they do not touch any other pins of IC3.

Two companies have agreed to produce *complete* kits for the *Micro Lab* and are selling these for £149.95 per kit; which in view of the complexity of the project seems a very reasonable price. The two companies are: **Greenweld Electronic Components, 27D Park Road, Southampton, Hants SO1 3TB** and **Magenta Electronics, 135 hunter Street, Burton-on-Trent, Staffs DE14 2ST**. A ready built, inspected and tested version, with full back-up service, is also being offered by Magenta for the sum of £179.95.

Both the specially-programmed EPROM and PAL device are produced solely by Dytronics and are supplied with the *Micro Lab* p.c.b., from the *EPE PCB Service*. The "Micro Lab User Manual" is also supplied with the board, and contains useful information.

### PLEASE TAKE NOTE

**Barcode Battler** *(July 1993)*

In last month's review on the latest hand-held game entitled Barcode Battler, we gave a Tomy "Customer Careline" phone number.

The Tomy Customer Careline number has changed, and is now ☎ ***0703 872 267***.

# CUPBOARD GUARD

T.R. de VAUX-BALBIRNIE

## Audible protection for cupboards, drawers and filing cabinets.

A LOUD tone a few seconds after a door has been opened is provided by the Cupboard Guard. One possible application for this is to signal that a child has opened a "prohibited" drawer or cupboard. Another use is to provide a warning when a filing cabinet, desk drawer, drinks cupboard, etc. has been opened without permission.

Since the unit is very small, self-contained and battery-operated, it may be moved from place to place as the need arises. In use, Cupboard Guard is simply placed inside the drawer or cupboard to be protected and switched on. Carrying cases and bags may also be monitored providing they are dark inside when closed.

The on-off switch may be key-operated to prevent an unauthorised person from switching off the warning but for low-security everyday applications an ordinary switch may be used as in the prototype unit (see photograph).

### OPERATING TIME

While switched on in standby mode, the current requirement is less than 10µA (6µA approximately in the prototype unit). This may be regarded as negligible and the internal battery will provide many months of service providing the device is not called upon to sound very often.

The delay time (that is, the time elapsing between opening the door and the alarm sounding) is adjustable between limits of two and 20 seconds approximately and this will be set for best effect at the end of construction. This time will be a compromise between being sufficient for legitimate access yet short enough to provide a timely warning.

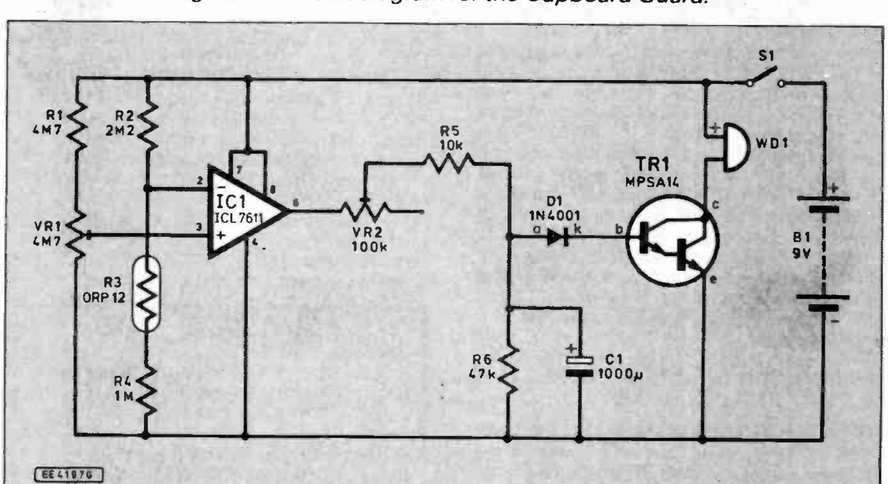
***Important Note:*** *If this circuit is used to signal that a child has opened a medicine cabinet or similar application, it must not be used in isolation. All other safety procedures must be followed and the Cupboard Guard used only as additional "last resort" protection. Also, for any such serious application, the loudness of the sounding device must be checked to ensure that it is sufficient.*

The Guard operates by sensing *light levels*. While a door remains closed there will be little light inside the cupboard. When opened, the light level will rise and it is this change which operates the alarm. In cases where there is no such change – or only a small one – this circuit is unsuitable. Note that fairly dim room lighting is sufficient to trigger the device.

### CIRCUIT DESCRIPTION

The complete circuit diagram for the Cupboard Guard is shown in Fig. 1.

*Fig. 1. Full circuit diagram for the Cupboard Guard.*




The principle component is the micropower op-amp, IC1. This has been specially chosen for its extremely low quiescent current requirement. This is important because the unit draws current all the time it is switched on and so imposes a drain on the battery.

The op-amp IC1 is used in *comparator mode* and operated without feedback. Thus, if the voltage applied to pin 3 (the non-inverting or + input) exceeds that at pin 2 (the inverting or – input), the output at pin 6 will be *high* (positive battery voltage). In other cases it will be *low* – that is, switched off.

The voltage applied to the non-inverting input pin 3 is set to a value which depends on the adjustment of preset potentiometer, VR1. This operates in conjunction with fixed resistor, R1, to provide a voltage lying between 0V and 4·5V approximately.

The voltage applied to the inverting input pin 2 is derived from the potential divider consisting of fixed resistor R2, in the upper section, in conjunction with the light dependent resistor (LDR), R3, and fixed resistor R4 in the lower one. With the light-dependent resistor dimly illuminated, its resistance is very high but when extra light shines on it, as when a cupboard or drawer is opened, its resistance becomes much lower.

The effect of this is that the voltage applied to IC1 pin 2 will be high with the door closed and low with it open. With preset VR1 suitably adjusted and with the cupboard door closed, the voltage at pin 2 will exceed that at pin 3 so the output will be off.

Under *light* conditions (cupboard open), the conditions are reversed and the voltage at pin 3 now exceeds that at pin 2. The op-amp switches on and the output goes high.

Current now flows into the base of Darlington transistor, TR1, through preset potentiometer, VR2 (connected as a variable resistor), fixed resistor R5, and diode, D1. The transistor is thus turned on and collector current flows through the audible warning device, WD1. The purpose of capacitor C1 and fixed resistor R6 will be explained presently.

### SOUND-OFF

The specified audible warning device was loud enough to be heard throughout a medium-sized room. However, as stated previously, the sounder should be chosen according to the application. Using a more powerful one will probably necessitate using a larger box so this must be borne in mind when ordering components. A pulse-tone may be found more effective in attracting attention than a steady-tone type although this was not thought worthwhile in the prototype unit.

The buzzer should be of the piezoelectric type and may draw up to 300mA – this being the maximum collector current allowed for the specified Darlington transistor, TR1. This allows a good choice of devices including some very loud mini-sirens. Note that sounders requiring *external* drive circuitry are unsuitable so this point must be checked before ordering

## HOLD-OFF

To prevent the warning from sounding immediately the door is opened, capacitor C1 and associated components are called into play. When the circuit is triggered and IC1 pin 6 is high, C1 charges through preset VR2 and resistor R5. The voltage across it then rises from zero at a rate determined by its value and the adjustment of VR2.

The base of the Darlington transistor TR1 requires 1·4V to turn on and diode D1 introduces a further voltage drop of 0·7V approximately (i.e. the forward voltage drop). The result is that TR1 is held off until C1 develops 2V approximately across its ends.

With the value of C1 specified and with VR2 set to minimum resistance, the hold-off time is two seconds approximately. At maximum resistance, it is around 20 seconds. Resistor, R6, provides a discharge path for C1 so that the circuit, having operated, will be ready for further use after a minute or two.

The light level at which the unit operates depends on the relative voltages at the two op-amp inputs and not their absolute values. This means, in practice, that the circuit will trigger at the same light intensity whatever the state of the battery. There will come a time, of course, where the battery is unable to operate the buzzer properly – the circuit should be tested frequently and the battery replaced when the buzzer is not as loud as it should be.

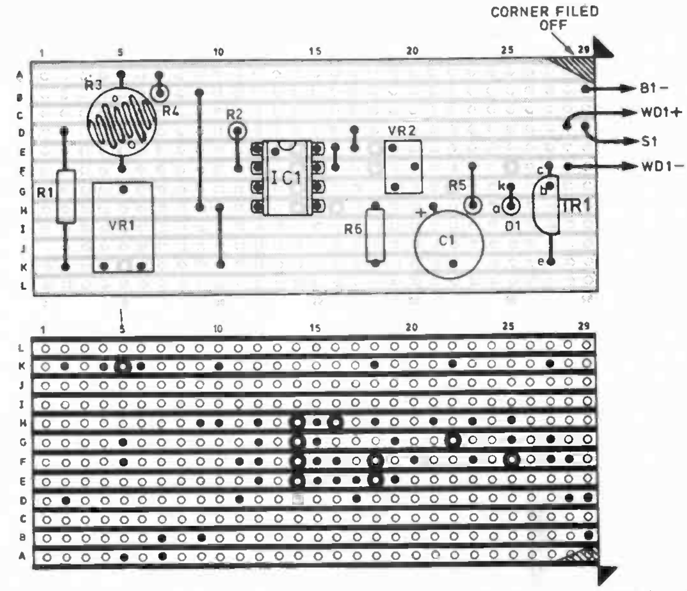


*Fig. 2. Stripboard component layout and details of breaks required in the underside copper tracks.*

## MINIMISING POWER

As mentioned previously, it is essential for the continuous current drain to be kept as low as practicable. It is therefore necessary to reduce the current flowing through the potential dividers consisting of R1 and VR1 on the one hand and R2, R3 and R4 on the other. This is done by keeping all resistor values in this section of the circuit high.

## CONSTRUCTION

Construction of the Cupboard Guard is based on a circuit panel made from a piece of 0·1in. matrix stripboard, size 12 strips x 29 holes. Topside component layout and details of underside track breaks and inter-strip links are shown in Fig. 2.

Begin by cutting the stripboard to size and filing it to fit the slots if using the specified box. Make all track breaks then solder the inter-track link wires in position as indicated. File off one corner, as shown, to allow clearance for connecting wires to pass over the top later.

After a careful check for errors – particularly that breaks in tracks are complete – the on-board components including IC1 socket may be soldered into position. The LDR should be soldered to provide approximately 10mm clearance from the circuit board.

Note that C1, D1 and WD1 are *polarized* components and, as such, must be connected into the circuit the correct way round. Do not insert IC1 into its socket at this stage.

Solder the following wires to the right-hand edge of the circuit panel: the negative battery connector wire to strip *B*, the positive audible warning device wire (red wire)

## COMPONENTS

**Resistors**

| | |
|---|---|
| R1 | 4M7 |
| R2 | 2M2 |
| R3 | ORP12 light dependent resistor (LDR) |
| R4 | 1M |
| R5 | 10k |
| R6 | 47k |

All 0.25W 5% carbon film, except R3.

See SHOP TALK Page

**Potentiometers**

| | |
|---|---|
| VR1 | 4M7 sub-miniature preset, horizontal |
| VR2 | 100k sub-miniature preset, vertical |

**Semiconductors**

| | |
|---|---|
| D1 | 1N4001 50V 1A rect. diode |
| TR1 | MPSA14 *npn* Darlington transistor |
| IC1 | ICL7611 micropower op-amp |

**Capacitor**

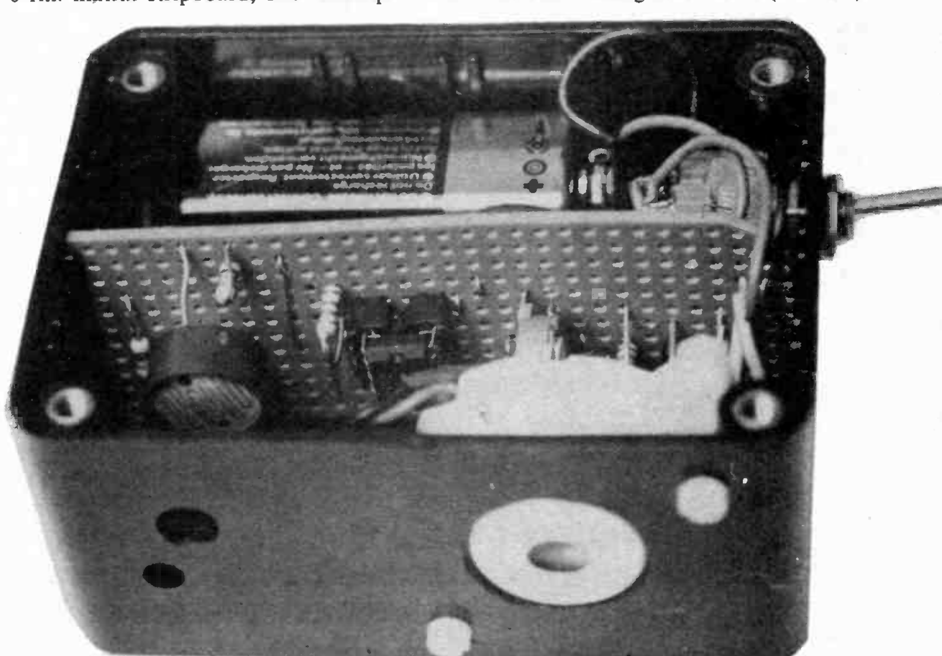
| | |
|---|---|
| C1 | 1000µ radial elect., 16V |

**Miscellaneous**

| | |
|---|---|
| WD1 | Piezoelectric audible warning device. 6V to 9V operation 300mA maximum – see text. |
| B1 | PP3 9V battery and battery connector. |
| S1 | Miniature s.p.s.t. rocker or toggle switch. |

Stripboard 0·1in. matrix size 12 strips x 29 holes; 8-pin d.i.l. socket; plastic box, size 79mm x 61mm x 40mm approximately – see text; small fixings for buzzer; solder; stranded wire, etc.

Approx cost guidance only **£9.50**



and a short piece of stranded connecting wire to strip *D* and the negative audible warning device wire to strip *F*.

Complete construction of the circuit panel by adjusting preset VR1 fully anti-clockwise also VR2 fully clockwise – as viewed from IC1 position – to provide minimum hold-off time. This will simplify the setting-up procedure.

## PREPARING THE BOX

Carefully measure the positions of the LDR and preset VR1 on the circuit panel. Drill holes of 6mm and 4mm diameter respectively in the side of the case to correspond with these positions (see photograph).

Slide the circuit panel into position temporarily to ensure that the holes are in the correct place. Check that VR1 may be adjusted using a small screwdriver through the 4mm hole. Remove the circuit panel again and drill holes for the audible warning device and on-off switch mounting.

Refering to Fig. 3, mount all remaining components and complete the interwiring. Insert IC1 into its socket observing the orientation. Slide the circuit panel into position again and check that the battery cannot cause short-circuits with the copper tracks when in position; if necessary make a cardboard or plastic shield. Secure the battery using an adhesive fixing pad.

Perform a rough check on the system by switching on – the buzzer should sound after a short delay – and rotating preset VR1 sliding contact slowly clockwise. A point should be reached when the sound stops.

If all is well, switch off and return VR1 fully anti-clockwise again. Pass the power supply wires through the space left by the filed-off corner of the circuit panel. Fit the lid before proceeding since this will affect the amount of light reaching the LDR. and hence the optimum setting for VR1.

## SETTING-UP AND TESTING

Commence testing by switching on the unit – the audible warning device should sound in normal room lighting. Cover the LDR hole with a finger and adjust preset VR1 clockwise so that the buzzer stops sounding. Note that the response time for the LDR under these conditions is very slow and it will take several seconds for the buzzer to begin sounding or stop as the case may be.

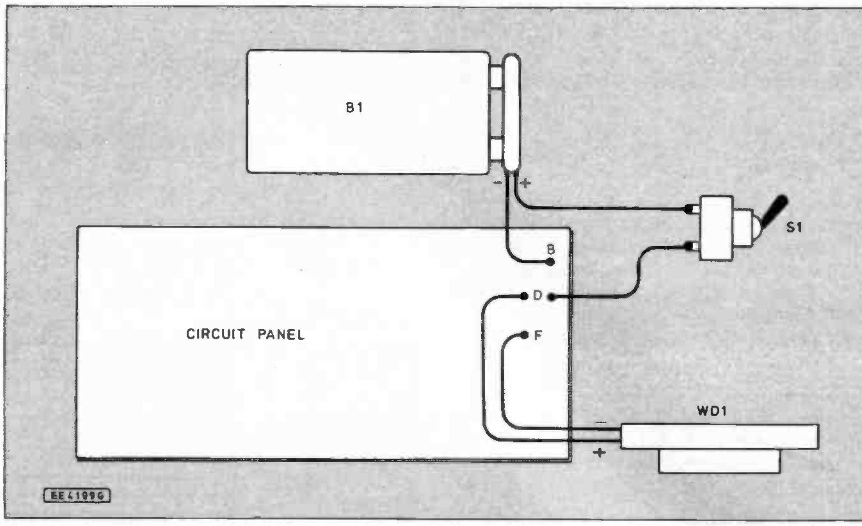
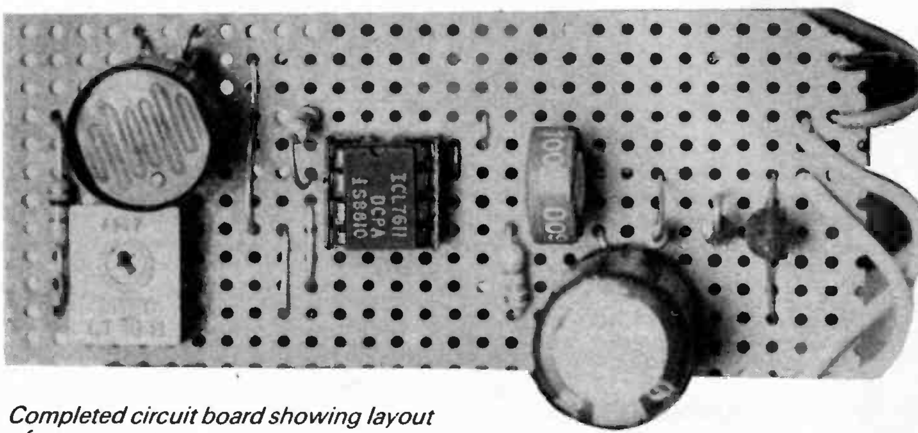



*Fig. 3. Interwiring from circuit board to battery, warning switch and alarm buzzer.*



*Completed circuit board showing layout of components.*

It is quite normal for the buzzer to take a few seconds to reach full volume. It may also change its pitch during this time. Correct adjustment to VR1 is therefore a rather tedious process but it is worth taking time over.

Remove the lid, slide out the circuit panel and adjust VR2 for the required hold-off time – anti-clockwise adjustment (as viewed from the i.c.) increases the timing. If it is adjusted to approximately mid-track position, it should provide a delay of 10 seconds approximately. Note that a minute or two must be allowed between operations for capacitor C1 to discharge otherwise the timing will be too short.

Re-fit the circuit panel and check operation. Over the next few days, further small changes to VR1/VR2 settings may be made for best results.

## ON GUARD

Since the LDR R3 is situated several millimetres below the hole in the box, the response is directional. Normally, the unit will be placed in the drawer or cupboard with the buzzer and LDR facing directly outwards or upwards. However, some experimentation may be needed to find the best position.

Your belongings will always be kept safe with the Cupboard Guard! □

# REPORTING AMATEUR RADIO

## Tony Smith G4FAI

### MORE SPACE EXPERIMENTS

The space shuttle *Columbia* (STS-55), launched on April 26, had five licensed radio amateurs in its crew of seven. Once again SAREX, the Shuttle Amateur Radio Experiment, was a secondary payload with a programme of prearranged contacts with school radio stations during the mission.

SAREX operations included contacts by voice and packet on 2-metres and a second amateur station was installed in the German spacelab module on board. This was designated SAFEX, the Spacelab Amateurfunk-Experiment, and was operated by two German payload specialists who made a number of scheduled contacts with European schools with this equipment.

SAFEX had a 2-metre f.m. downlink and a 70cm f.m. uplink, using a dual band external antenna mounted on the German module, and this gave the SAREX team the opportunity to compare the performance of their window mounted antenna with the German externally mounted antenna. During orbit 61, they transmitted using the window antenna and on orbit 62 they used the external antenna, asking amateurs in the south-eastern United States to participate in the test by taking signal strength readings of the received signal during both orbit passes.

The externally mounted antenna - basically a quarter-wave whip with an airtight feedthrough - proved to be the better of the two, with a significant signal boost compared to the window antenna. Later, when the window antenna failed the shuttle crew moved their packet TNC and Motorola 2-meter hand-held into the German spacelab to continue operations using the external antenna. *(W5YI Report)*.

SWLs may like to note that special QSL cards are available for reception of the SAREX transmissions. Reports on the STS-55 mission should be sent to IBM Amateur Radio Club/1993, PO Box 1328, Boca Raton, FL 33429-1328, USA, marking the envelope STS-55 SWL, enclosing a self-addressed envelope, minimum 10cm x 24cm, and sufficient IRCs to cover return postage.

### REMEMBER THE 1-V-1?

The first electronic project I ever tackled was a single valve 0-V-0 regenerative detector receiver which very quickly hooked me on shortwave radio. I was amazed at what I could hear from around the world on this little set but soon realized it could be improved.

The addition of two extra valves, one as an r.f stage, one as an audio amplifier, made it a 1-V-1 and this set provided me with my sole listening facility for a number of years.

Eventually, and as more funds became available, I moved on to modern, more sophisticated, equipment but I never forgot that exciting sense of involvement which comes from pulling stations in with a set that needs personal operating skill to get the best from it.

Such circuitry is considered vintage today and undoubtedly the performance obtainable at the time cannot compare with that of some of today's remarkable receivers. I have long held the belief, however, that abandoned techniques of the past could benefit from present-day knowledge, techniques and components to produce performance not far short of some of the ultra-sophisticated circuits that have replaced them.

### RADIO BYGONES

An example of this is contained in a recent three-part article in *Radio Bygones* by T.S. Christian. His research into the TRF (tuned radio frequency) techniques of the 1930s and developments of the 1940s, combined with the potential of last-generation frame-grid valves –' plus help from a modern computer – has produced a 1-V-1 design claimed to be at least as useful as a solid-state direct conversion receiver. He claims it provides good a.m. performance for broadcast listening, better strong-signal performance, and gives the operator control over all performance characteristics.

He comments, "The comparative simplicity of the TRF ensured that it remained popular with shortwave enthusiasts after it had been displaced in professional and domestic applications. However, as so often happens, its very simplicity could have contributed to its downfall . . . it may have been neglected rather than developed; skimped rather than elaborated."

In a review of the prototype, Tony Green G0OJJ comments "this radio had a performance I would not have believed possible from a set of such seemingly simple design. Its selectivity is more than adequate for serious CW listening, which its built-in 1kHz note filter brought up to communications receiver quality."

"With a little practice, resolving SSB became easy and careful use of the reaction control allowed many stations way down in the noise to become perfectly readable – allowing me to hear my first Japanese amateur station on 40m which was unreadable on my transceiver . . . a very usable radio with a degree of performance comparable to many communications receivers I have used."

"It is not a 'turn on and tune in' radio but more a 'sit down and fiddle' receiver giving it an appeal which has all but disappeared in recent years . . . it wouldn't impress the key-pad entry radio user, but could be a firm favourite with someone prepared to learn how to use it properly."

The first part of this article was in the February/March 1993 issue of *Radio Bygones*. This bimonthly magazine provides a fascinating mix covering domestic, amateur and professional radio "from yesterday backwards". Available by post only, it costs £17.00 a year, (Eire and overseas £18.00), sample copy £3.00, from G.C. Arnold Partners, 9 Wetherby Close, Broadstone, Dorset BH18 8JB.

### REPEATER LICENSING CHANGES

As from April 1st, licences for amateur repeater stations have been in the hands of individual repeater keepers. Previously, the Radio Society of Great Britain has been the licensee for all amateur repeater stations and there has been a general prohibition on individual amateurs operating a repeater.

The new arrangement lifts that prohibition but the repeater keeper will now be responsible for the correct operation of the repeater, for monitoring its use and taking steps to limit unauthorised transmissions. He/she must also provide effective close-down facilities when interference is caused to the repeater.

Amateur radio repeaters are stations located at advantageous sites throughout the country, intended to extend the range of communications between amateurs operating "mobile" by automatically receiving and re-transmitting their messages.

Unfortunately, they are frequently subject to interference, abuse, and unacceptable operating practices and there has been much debate on the best way to deal with the problem, sometimes culminating in the Radiocommunications Agency stepping in to close-down a repeater for a period of time. The RA is obviously hoping that by devolving the licences they are also devolving the problem.

### SUMMER BROADCAST GUIDE

The International Short Wave League's *Guide to English Language Short Wave Broadcasts to Europe*, covering current summer schedules, is now available. This helpful booklet, published twice a year to reflect broadcasters' seasonal scheduling and other changes, gives details of transmissions receivable round the clock listed by time, frequency and nature of programme. A new feature is the inclusion of details of English language transmissions not intended for, but audible in, Europe.

Extremely useful for both the dedicated and casual short wave listener, it is available from ISWL HQ, 10 Clyde Crescent, Wharton, Winsford, Cheshire CW7 3LA, and represents amazing value at just £1.00, (or two IRCs, or £1 in stamps), post paid.

# DIRECT BOOK SERVICE

The books listed have been selected by Everyday with Practical Electronics editorial staff as being of special interest to everyone involved in electronics and computing. They are supplied by mail order direct to your door. Full ordering details are given on the last book page. For another selection of books see next month's issue.

**EVERYDAY ELECTRONICS DATA BOOK**
**Mike Tooley BA**
**(published by EE in association with PC Publishing)**
This book is an invaluable source of information of everyday relevance in the world of electronics. It contains not only sections which deal with the essential theory of electronic circuits, but also deals with a wide range of practical electronic applications.
It is ideal for the hobbyist, student, technician and engineer. The information is presented in the form of a basic electronic recipe book with numerous examples showing how theory can be put into practice using a range of commonly available "industry standard" components and devices.
A must for everyone involved in electronics!
*256 pages* Order code DATA £8.95

**ELECTRONICS TEACH-IN No. 3 – EXPLORING ELECTRONICS (published by *Everyday Electronics*)**
**Owen Bishop**
Another EE value for money publication aimed at students of electronics. The course is designed to explain the workings of electronic components and circuits by involving the reader in experimenting with them. The book does not contain masses of theory or formulae but straightforward explanations and circuits to build and experiment with.
Exploring Electronics contains more than 25 useful projects, assumes no previous knowledge of electronics and is split into 28 easily digestible sections.
*88 pages (A4 size)* Order code TI3 £2.45

## Special Everyday Electronics Books

**ELECTRONICS TEACH-IN No.4**
**INTRODUCING DIGITAL ELECTRONICS (published by *Everyday Electronics*)**
**Michael J. Cockcroft**
Although this book is primarily a City & Guilds Introductory level course (726/301), approximately 80% of the information forms a very basic introduction to electronics in general, it therefore provides an excellent introductory text for beginners and a course and reference book for GCSE students.
Full details on registering for C&G assessment, details of assessment centres, components required and information on the course in general are given.
The City & Guilds introduction to module 726/301 reads: "A candidate who satisfactorily completes this module will have a competence to identify basic components and digital integrated circuits and connect them together to form simple working circuits and logic units." This provides an excellent introduction to the book.
*112 pages (A4 size)* Order code TI4 £2.95

**ELECTRONIC PROJECTS – BOOK 1**
**Published by *Everyday Electronics* in association with Magenta Electronics.**
Contains twenty of the best projects from previous issues of EE each backed with a kit of components. The projects are: Seashell Sea Synthesiser, EE Treasure Hunter, Mini Strobe, Digital Capacitance Meter, Three Channel Sound to Light, BBC 16K Sideways Ram, Simple Short Wave Radio, Insulation Tester, Stepper Motor interface, Eprom Eraser, 200MHz Digital Frequency Meter, Infra Red Alarm, EE Equaliser Ioniser, Bat Detector, Acoustic Probe, Mains Tester and Fuse Finder, Light Rider – (Lapel Badge, Disco Lights, Chaser Light), Musical Doorbell, Function Generator, Tilt Alarm, 10W Audio Amplifier, EE Buccaneer Induction Balance Metal Detector, BBC Midi Interface, Variable Bench Power Supply, Pet Scarer, Audio Signal Generator.
*128 pages (A4 size)* Order code EP1 £2.45

**ELECTRONICS TEACH-IN No.5 GUIDE TO BUILDING ELECTRONIC PROJECTS**
**Published by EVERYDAY ELECTRONICS**
Due to the demand from students, teachers and hobbyists we have put together a range of articles from past issues of *Everyday Electronics* that will assist those involved with the construction of electronic projects.
The book contains the complete *Project Development for GCSE* series.
**Contents: Features** – First Steps in Project Building; Building with Vero; Project Development for GCSE; Getting your Project Working; Guide to Printed Circuit Boards; Choosing and Using Test Equipment – The Multimeter, The Oscilloscope, P.S.U.s, Logic Probes, Digital Frequency Meters, Signal Generators, etc; **Data** – Circuit Symbols; Component Codes; Resistors; Identifying Components; Capacitors; Actually Doing It – Understanding the Circuit Diagram, Component Codes, Mounting circuit boards and controls, Understanding Capacitors; **Projects** – Lie Detector; Personal Stereo Amplifier; Digital Experimentsr's Unit; Quizmaster; Siren Effects Unit; UV Exposure Unit; Low-cost Capacitance Meter; Personal Radio.
*88 pages (A4 size)* Order code TI5 £2.95

**ELECTRONICS TEACH-IN 88/89 – INTRODUCING MICROPROCESSORS**
**Mike Tooley BA (published by *Everyday Electronics*)**
A complete course that can lead successful readers to the award of a City and Guilds Certificate in Introductory Microprocessors (726/303). The book contains everything you need to know including full details on registering for assessment, etc. Starting with basic terminology, integrated circuits, logic families and numbering systems the text builds in stages, with revision and assessments built in, up to programming, languages, flow charts, etc. The course is ideal for the newcomer to the subject.
*80 pages (A4 size)* Order code TI 88/89 £2.45


## Computers and Computing

**HOW TO CHOOSE A SMALL BUSINESS COMPUTER SYSTEM**
**D. Weale**
This book is for anyone intending to buy an IBM compatible computer system, whether it is their first system or a replacement. There are sections on hardware, application and systems programs and how to actually make your choice as well as sections on the law, ergonomics and a glossary of common terms.
The text contains many useful tips and some warnings (which could save much effort and expense).
*114 pages* Order code BP323 £4.95

**UNDERSTANDING PC SPECIFICATIONS**
**R. A. Penfold**
If you require a microcomputer for business applications, or a high quality home computer, an IBM PC or compatible is often the obvious choice. They are competitively priced, and are backed up by an enormous range of applications programs, hardware add-ons, etc. The main difficulty for the uninitiated is deciding on the specification that will best suit his or her needs. PCs range from simple systems of limited capabilities up to complex systems that can happily run applications that would have been considered beyond the abilities of a microcomputer not so long ago. It would be very easy to choose a PC system that is inadequate to run your applications efficiently, or one which goes beyond your needs and consequently represents poor value for money.
This book explains PC specifications in detail, and the subjects covered include the following: Differences between types of PC (XT, AT, 80386, etc); Maths co-processors; Input devices (keyboards, mice, and digitisers); Memory, including both expanded (EMS) and extended RAM; RAM disks and disk caches; Floppy disk drive formats and compatibility; Hard disk drives (including interleave factors and access times); Display adaptors, including all standard PC types (CGA, Hercules, Super VGA, etc); Contains everything you need to know if you can't tell your EMS from your EGA!
*104 pages* Order code BP282 £3.95

**AN INTRODUCTION TO 68000 ASSEMBLY LANGUAGE**
**R. A. & J. W. Penfold**
Obtain a vast increase in running speed by writing programs for 68000 based micros such as the Commodore Amiga, Atari ST range or Apple Macintosh range etc., in assembly language. It is not as difficult as one might think and this book covers the fundamentals.
*112 pages* Order code BP184 £2.95

**THE ART OF PROGRAMMING THE ZX SPECTRUM**
**M. James, B.Sc., M.B.C.S.**
It is one thing to have learnt how to use all the Spectrum's commands and functions, but a very different one to be able to combine them into programs that do exactly what you want them to. This is just what this book is all about – teaching you the art of effective programming with your Spectrum.
*144 pages* Order code BP119 £2.50

**A CONCISE INTRODUCTION TO MS-DOS**
**N. Xantaris**
This guide is written with the non-expert, busy person in mind and, as such, it has an underlying structure based on "what you need to know first, appears first". Nonetheless, the guide is also designed to be circular, which means that you don't have to start at the beginning and go to the end. The more experienced user can start from any section.
The guide covers versions 3.0, 3.1 and 3.2 of both PC-DOS and MS-DOS as implemented by IBM and other manufacturers of "compatible" microcomputers, including the AMSTRAD PC's. It covers both floppy disc-based systems and hard disc-based systems.
*64 pages* Order code BP232 £2.95

**MAKING MS-DOS WORK FOR YOU**
**N. Kantanis & P. R. M. Oliver**

This book was written with the busy person in mind and, as such, it has an underlying structure based on "what you need to know first, appears first". Nonetheless, the book has also been designed to be circular, which means that you don't have to start at the beginning and go to the end.
The book explains: How to write customised batch files which allow you to display what you want on your screen, and in the form and order you want it, instead of being forced to use the DOS prompt on a blank screen. How to design and set up a fast interactive and professional looking menu system, so that you or anyone else can run utility applications or commercial software packages easily. How the ANSI.SYS display and keyboard commands can be used to position the cursor on any part of the screen, change the intensity of the displayed characters or change their colour. How the Edit screen editor or the Edlin line editor can be used to enter ESCape (ANSI.SYS) commands into simple ASCII files to allow control of both your screen display and your printer. How to control the operation of the two main types of printers in use today, Epson compatible dot matrix and HP compatible laser printers. How to use several useful routines, such as moving and finding files, protecting files from accidental erasure, a simplified backup process, a screen saver, and a disc cataloguing system.
The Debug program and how it can be used to create, see and change the contents of any file, including those of programs written in assembler code. This includes how to find your way around the names and tasks of the CPU registers and the meaning of some simple assembler mnemonics.
*182 pages* Order code BP319 £4.95

**AN INTRODUCTION TO CP/M**
**R. A. Penfold**
In order to run and use programs operating under CP/M it is not essential to have an understanding of the system, but a reasonable knowledge of the subject can certainly be of immense help when minor problems occur, and also in fully exploiting the possible potential of the system. This book tells the story!
*84 pages* Order code BP183 £2.95

# Audio and Music

**ACOUSTIC FEEDBACK – HOW TO AVOID IT**

Feedback is the bane of all public address systems. While feedback cannot be completely eliminated, many things can be done to reduce it to a level at which it is no longer a problem.

Much of the trouble is often the hall itself, not the equipment, but there is a simple and practical way of greatly improving acoustics. Some microphones are prone to feedback while others are not. Certain loudspeaker systems are much better than others, and the way the units are positioned can produce or reduce feedback. All these matters are fully explored as well as electronic aids such as equalizers, frequency-shifters and notch filters.

The special requirements of live group concerts are considered, and also the related problem of instability that is sometimes encountered with large set-ups. We even take a look at some unsuccessful attempts to cure feedback so as to save readers wasted time and effort duplicating them.

Also included is the circuit and layout of an inexpensive but highly successful twin-notch filter, and how to operate it.

*92 pages* Order code BP310 £3.95

**PRACTICAL MIDI HANDBOOK**
**R. A. Penfold**

The Musical Instrument Digital Interface (MIDI) is surrounded by a great deal of misunderstanding, and many of the user manuals that accompany MIDI equipment are quite incomprehensible to the reader.

The Practical MIDI Handbook is aimed primarily at musicians, enthusiasts and technicians who want to exploit the vast capabilities of MIDI, but who have no previous knowledge of electronics or computing. The majority of the book is devoted to an explanation of what MIDI can do and how to exploit it to the full, with practical advice on connecting up a MIDI system and getting it to work, as well as deciphering the technical information in those manuals.

*128 pages* Order code PC101 £6.95

**PREAMPLIFIER AND FILTER CIRCUITS**
**R. A. Penfold**

This book provides circuits and background information for a range of preamplifiers, plus tone controls, filters, mixers, etc. The use of modern low noise operational amplifiers and a specialist high performance audio preamplifier i.c. results in circuits that have excellent performance, but which are still quite simple. All the circuits featured can be built at quite low cost (just a few pounds in most cases).

The preamplifier circuits featured include:– Microphone preamplifiers (low impendance, high impedance, and crystal). Magnetic cartridge pick-up preamplifiers with R.I.A.A equalisation. Crystal/ceramic pick-up preamplifier. Guitar pick-up preamplifier. Tape head preamplifier (for use with compact cassette systems).

Other circuits include:– Audio limiter to prevent overloading of power amplifiers. Passive tone controls. Active tone controls. PA filters (highpass and lowpass). Scratch and rumble filters. Loudness filter. Audio mixers. Volume and balance controls

*92 pages* Order code BP309 £3.95

**AN INTRODUCTION TO LOUDSPEAKERS AND ENCLOSURE DESIGN**
**V. Capel**

This book explores the various features, good points and snags of speaker designs. It examines the whys and wherefores so that the reader can understand the principles involved and so make an informed choice of design, or even design loudspeaker enclosures for him or herself. Crossover units are also explained, the various types, how they work, the distortions they produce and how to avoid them. Finally there is a step-by-step description of the construction of the *Kapellmeister* loudspeaker enclosure.

*148 pages* Temporarily out of print

**COMPUTERS AND MUSIC – AN INTRODUCTION**
**R. A. Penfold**

Computers are playing an increasingly important part in the world of music, and the days when computerised music was strictly for the fanatical few are long gone.

If you are more used to the black and white keys of a synth keyboard than the QWERTY keyboard of a computer, you may be understandably confused by the jargon and terminology bandied about by computer buffs. But fear not, setting up and using a computer-based music making system is not as difficult as you might think.

This book will help you learn the basics of computing, running applications programs, wiring up a MIDI system and using the system to good effect, in fact just about everything you need to know about hardware and the programs, with no previous knowledge of computing needed or assumed. This book will help you to choose the right components for a system to suit your personal needs, and equip you to exploit that system fully.

*174 pages* Order code PC107 £8.95

**ELECTRONIC PROJECTS FOR GUITAR**
**R. A. Penfold**

This book contains a collection of guitar effects and some general purpose effects units, many of which are suitable for beginners to project building. An introductory chapter gives guidance on construction.

Each project has an introduction, an explanation of how it works, a circuit diagram, complete instructions on stripboard layout and assembly, as well as notes on setting up and using the units. Contents include: Guitar tuner; Guitar preamplifier; Guitar headphone amplifier; Soft distortion unit; Compressor; Envelope waa waa; Phaser; Dual tracking effects unit; Noise gate/expander; Treble booster; Dynamic treble booster; Envelope modifier; Tremelo unit; DI box.

*110 pages* Order code PC110 £8.95

**HIGH POWER AUDIO AMPLIFIER CONSTRUCTION**
**R. A. penfold**

Practical constructional details of how to build a number of audio power amplifiers ranging from about 50 to 300/400 watts r.m.s. Includes MOSFET and bipolar transistor designs.

*96 pages* Order code BP277 £3.95

# Theory and Reference

**ELECTRONIC HOBBYISTS HANDBOOK**
**R. A. Penfold**

Provides an inexpensive single source of easily located information that the amateur electronics enthusiast is likely to need for the day-to-day pursuance of this fascinating hobby. Covers common component colour codes. Details the characteristics and pinouts of many popular seimiconductor devices, including various types of logic ICs, operational amplifiers, transistors, FETs, unijunctions, diodes, rectifiers, SCRs, diacs, triacs, regulators and SMDs, etc. Illustrates many useful types of circuits, such as timers and oscillators, audio amplifiers and filters, as well as including a separate section on power supplies. Also contains a multitude of other useful data.

*88 pages* Order code BP233 £4.95

**NEWNES ELECTRONICS POCKET BOOK**
**E. A. Parr**

Newnes Electronics Pocket Book has been in print for over twenty years and has covered the development of electronics from valve to semiconductor technology and from transistors to LSI integrated circuits and microprocessors. To keep up to date with the rapidly changing world of electronics, continuous revision has been necessary. This new Fifth Edition takes account of recent changes and includes material suggested by readers of previous editions. New descriptions of op.amp. applications and the design of digital circuits have been added, along with a totally new chapter on computing, plus other revisions throughout.

*315 pages (hard cover)* Order code NE02 £10.95

**ELECTRONIC MODULES AND SYSTEMS FOR BEGINNERS**
**Owen Bishop**

This book describes over 60 modular electronic circuits – how they work, how to build them, and how to use them. The modules may be wired together to make hundreds of different electronic systems, both analogue and digital. To show the reader how to begin building systems from modules, a selection of over 25 electronic systems are described in detail, covering such widely differing applications as timing, home security, measurement, audio (including a simple radio receiver), games and remote control.

*200 pages* Order code BP266 £3.95

**FROM ATOMS TO AMPERES**
**F. A. Wilson**

Explains in crystal clear terms the absolute fundamentals behind electricity and electronics. Really helps you to discover and understand the subject, perhaps for the first time ever.

Have you ever: Wondered about the true link between electricity and magnetism? Felt you could never understand the work of Einstein, Newton, Boltzmann, Planck and other early scientists? Just accepted that an electron is like a little black ball? Got mixed up with e.m.f. and p.d.? Thought the idea of holes in semiconductors is a bit much?

Then help is at hand with this inexpensive book, in as simple a way as possible and without too much complex mathematics and formulae.

*244 pages* Order code BP254 £3.50

**PRACTICAL DIGITAL ELECTRONICS HANDBOOK**
**Mike Tooley (Published in association with *Everyday Electronics*)**

The vast majority of modern electronic systems rely heavily on the application of digital electronics, and the *Practical Digital Electronics Handbook* aims to provide readers with a practically based introduction to this subject. The book will prove invaluable to anyone involved with the design, manufacture or servicing of digital circultry, as well as to those wishing to update their knowledge of modern digital devices and techniques. Contents: Introduction to integrated circuits; basic logic gates; monostable and bistable devices; timers; microprocessors; memories; input and output devices; interfaces; microprocessor buses. Appendix 1: Data. Appendix 2: Digital test gear projects; tools and text equipment; regulated bench power supply; logic pulser; verstaile pulse generator; digital IC tester; current tracer; audio logic tracer; RS-232C breakout box; versatile digital counter/frequency meter. Appendix 3: The oscilloscope. Appendix 4: Suggested reading. Appendix 5: Further study.

*208 pages* Order code PC100 £6.95

**ELECTRONICS – A "MADE SIMPLE" BOOK**
**G. H. Olsen**

This book provides excellent background reading for our *Introducing Digital Electronics Teach-In* Book and will be of interest to everyone studying electronics. The subject is simply explained and well illustrated and the book assumes only a very basic knowledge of electricity.

*330 pages* Order code NE10 £5.95

# Project Building

**HOW TO GET YOUR ELECTRONIC PROJECTS WORKING**
**R. A. Penfold**

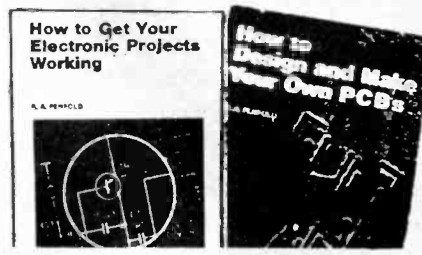
We have all built projects only to find that they did not work correctly, or at all, when first switched on. The aim of this book is to help the reader overcome just these problems by indicating how and where to start looking for many of the common faults that can occur when building up projects.

*96 pages* Order code BP110 £2.95

**HOW TO DESIGN AND MAKE YOUR OWN P.C.B.s**
**R. A. Penfold**

Deals with the simple methods of copying printed circuit board designs from magazines and books and covers all aspects of simple p.c.b. construction including photographic methods and designing your own p.c.b.s.

*80 pages* Order code BP121 £2.50




**A BEGINNERS GUIDE TO MODERN ELECTRONIC COMPONENTS**
**R. A. Penfold**

The purpose of this book is to provide practical information to help the reader sort out the bewildering array of components currently on offer. An advanced knowledge of the theory of electronics is not needed, and this book is not intended to be a course in electronic theory. The main aim is to explain the differences between components of the same basic type (e.g. carbon, carbon film, metal film, and wire-wound resistors) so that the right component for a given application can be selected. A wide range of components are included, with the emphasis firmly on those components that are used a great deal in projects for the home constructor.

*166 pages* Order code BP285 £3.95

**BEGINNER'S GUIDE TO BUILDING ELECTRONIC PROJECTS**
**R. A. Penfold**

Shows the complete beginner how to tackle the practical side of electronics, so that he or she can confidently build the electronic projects that are regularly featured in magazines and books. Also include examples in the form of simple projects.

*112 pages* Order code 227 £1.95

**ELECTRONICS SIMPLIFIED – CRYSTAL SET CONSTRUCTION**
**F. A. Wilson, C.G.I.A., C.Eng., F.I.E.E., F.I.E.R.E., F.B.I.M.**

Especially written for those who wish to participate in the intricacies of electronics more through practical construction than by theoretical study. It is designed for all ages upwards from the day one can read intelligently and handle simple tools.

*80 pages* Order code BP92 £1.75

**GUIDE TO BUILDING ELECTRONIC PROJECTS**
**Published by *Everyday Electronics***

See the first page of books – ELECTRONICS TEACH-IN No.5 – for full details.

**ELECTRONICS PROJECT BOOK**
**Published by *Everyday Electronics* in association with Magenta Electronics.**

See the first page of books for full details.


# Testing and Test Gear

**HOW TO USE OSCILLOSCOPES AND OTHER TEST EQUIPMENT**
**R. A. Penfold**

This book explains the basic function of an oscilloscope, gives a detailed explanation of all the standard controls, and provides advice on buying. A separate chapter deals with using an oscilloscope for fault finding on linear and logic circuits, plenty of example waveforms help to illustrate the control functions and the effects of various fault conditions. The function and use of various other pieces of test equipment are also covered, including signal generators, logic probes, logic pulsers, and crystal calibrators.

*104 pages* Order code BP267 £3.50

# Circuits and Design

**PRACTICAL ELECTRONIC BUILDING BLOCKS – BOOK 2**
**R. A. Penfold**
This books is designed to aid electronic enthusiasts who like to experiment with circuits and produce their own projects, rather than simply following published project designs.
Contains: Amplifiers – low level discrete and op-amp circuits, voltage and buffer amplifiers including d.c. types. Also low-noise audio and voltage controller amplifiers. Filters – high-pass, low-pass, 6, 12, and 24dB per octave types. Miscellaneous – i.c. power amplifiers, mixers, voltage and current regulators, etc.
*112 pages* **Order code BP118** **£1.95**

**PRACTICAL ELECTRONIC FILTERS**
**Owen Bishop**
This book deals with the subject in a non-mathematical way. It reviews the main types of filter, explaining in simple terms how each type works and how it is used.
The book also presents a dozen filter-based projects with applications in and around the home or in the constructor's workshop. These include a number of audio projects such as a rythm sequencer and a multi-voiced electronic organ.
Concluding the book is a practical step-by-step guide to designing simple filters for a wide range of purposes, with circuit diagrams and worked examples.
*192 pages* **Order code BP299** **£4.95**

**ELECTRONIC ALARM CIRCUITS MANUAL**
**R. M. Marston**
One hundred and forty useful alarm circuits, of a variety of types, are shown in this volume. The operating principle of each one is explained in concise but comprehensive terms, and brief construction notes are given where necessary.
Aimed at the practical design engineer, technician and experimenter, as well as the electronics student and amateur.
*124 pages* **Order code NE11** **£13.95**

**ELECTRONIC CIRCUITS FOR THE COMPUTER CONTROL OF MODEL RAILWAYS**
**R. A. Penfold**
The projects consist of various types of interface and controllers, including a high quality pulse type, as well as circuits for train position sensing, signal and electric points control etc.
The use of computers does not have to be restricted to massive layouts. Something as simple as an oval track with a single siding can be given a new dimension by adding computer control and much fun can be had from these relatively simple set ups.
*88 pages* **Order code BP180** **£2.95**

**DIGITAL LOGIC GATES AND FLIP-FLOPS**
**Ian R. Sinclair**
This book, intended for enthusiasts, students and technicians, seeks to establish a firm foundation in digital electronics by treating the topics of gates and flip-flops thoroughly and from the beginning.
Topics such as Boolean algebra and Karnaugh mapping are explained, demonstrated and used extensively, and more attention is paid to the subject of synchronous counters than to the simple but less important ripple counters.
No background other than a basic knowledge of electronics is assumed, and the more theoretical topics are explained from the beginning, as also are many working practices. The book concludes with an explanation of microprocessor techniques as applied to digital logic.
*200 pages* **Order code PC106** **£8.95**

**ELECTRONIC CIRCUITS FOR THE COMPUTER CONTROL OF ROBOTS**
**Robert Penfold**
Robots and robotics offer one of the most interesting areas for the electronics hobbyist to experiment in. Today the mechanical side of robots is not too difficult, as there are robotics kit and a wide range of mechanical components available. The micro controller is not too much of a problem either, since the software need not be terribly complex and many inexpensive home computers are well suited to the task.
The main stumbling block for most would-be robot builders is the electronics to interface the computer to the motors, and the sensors which provide feedback from the robot to the computer. The purpose of this book is to explain and provide some relatively simple electronic circuits which bridge this gap.
*92 pages* **Temporarily out of print**

**ELECTRONIC POWER SUPPLY HANDBOOK**
**Ian R. Sinclair**
This book covers the often neglected topic of electronic power supplies. All types of supplies that are used for electronics purposes are covered in detail, starting with cells and batteries and extending by way of rectified supplies and linear stabilisers to modern switch-mode systems, IC switch-mode regulators, DC-DC converters and inverters.
The devices, their operating principles and typical circuits are all dealt with in detail. The action of rectifiers and the reservoir capacitor is emphasised, and the subject of stabilisation is covered. The book includes some useful formulae for assessing the likely hum level of a conventional rectifier reservoir supply.
*136 pages* **Order code PC108** **£7.95**

**HOW TO USE OP-AMPS**
**E. A. Parr**
This book has been written as a designer's guide covering many operational amplifiers, serving both as a source book of circuits and a reference book for design calculations. The approach has been made as non-mathematical as possible.
*160 pages* **Order code BP88** **£2.95**

**MICRO INTERFACING CIRCUITS – BOOK 1**
**MICRO INTERFACING CIRCUITS – BOOK 2**
**R. A. Penfold**
Both books include practical circuits together with details of the circuit operation and useful background information. Any special constructional points are covered but p.c.b. layouts and other detailed constructional information are not included.
Book 1 is mainly concerned with getting signals in and out of the computer; Book 2 deals primarily with circuits for practical applications.
**BOOK 1** *112 pages* **Order code BP130** **£2.75**
**BOOK 2** *112 pages* **Order code BP131** **£2.75**

**50 SIMPLE LED CIRCUITS**
**R. N. Soar**
Contains 50 interesting and useful circuits and applications, covering many different branches of electronics, using one of the most inexpensive and freely available components – the light-emitting diode (LED). Also includes circuits for the 707 common anode display.
*64 pages* **Order code BP42** **£1.95**
**BOOK 2** 50 more l.e.d. circuits **Order code BP87** **£1.95**

**CIRCUIT SOURCE BOOK 1**
**R. A. Penfold**
Written to help you create and experiment with your own electronic designs by combining and using the various standard "building block" circuits provided. Where applicable, advice on how to alter the circuit parameters is given.
The circuits covered in this book are mainly concerned with analogue signal processing and include: Audio amplifiers (op.amp and bipolar transistors); audio power amplifiers; d.c. amplifiers; highpass, lowpass, bandpass and notch filters; tone controls; voltage controlled amplifiers and filters; triggers and voltage comparators; gates and electronic switching; bargraphs; mixers; phase shifters, current mirrors, hold circuits, etc.
Over 150 circuits are provided, which it is hoped will be useful to all those involved in circuit design and application, be they professionals, students or hobbyists.
*182 pages* **Order code BP321** **£4.95**

# Radio, TV, Satellite

**PROJECTS FOR RADIO AMATEURS AND S.W.L.S.**
**R. A. Penfold**
This book describes a number of electronic circuits, most of which are quite simple, which can be used to enhance the performance of most short wave radio systems.
The circuits covered include:– An aerial tuning unit; A simple active aerial; An add-on b.f.o. for portable sets; A wavetrap for combat signals on spurious responses; An audio notch filter; A parametric equaliser; C.W and S.S.B. audio filters; Simple noise limiters; A speech processor; A volume expander.
Other useful circuits include a crystal oscillator, and RTTY/C.W. tone decoder, and a RTTY serial to parallel converter. A full range of interesting and usefull circuits for short wave enthusiasts.
*92 pages* **Order code BP304** **£3.95**

**AN INTRODUCTION TO AMATEUR RADIO**
**I. D. Poole**
Amateur radio is a unique and fascinating hobby which has attracted thousands of people since it began at the turn of the century.
This book gives the newcomer a comprehensive and easy to understand guide through the subject so that the reader can gain the most from the hobby. It then remains an essential reference volume to be used time and again. Topics covered include the basic aspects of the hobby, such as operating procedures, jargon and setting up a station. Technical topics covered include propagation, receivers, transmitters and aerials etc.
*150 pages* **Order code BP257** **£3.50**

**SIMPLE SHORT WAVE RECEIVER CONSTRUCTION**
**R. A. Penfold**
Short wave radio is a fascinating hobby, but one that seems to be regarded by many as an expensive pastime these days. In fact it is possible to pursue this hobby for a minimal monetary outlay if you are prepared to undertake a bit of d.i.y., and the receivers described in this book can all be built at low cost. All the sets are easy to construct, full wiring diagrams etc. are provided, and they are suitable for complete beginners. The receivers only require simple aerials, and do not need any complex alignment or other difficult setting up procedures.
The topics covered in this book include: The broadcast bands and their characteristics; The amateur bands and their characteristics; The propagation of radio signals; Simple aerials; Making an earth connection; Short wave crystal set; Simple t.r.f. receivers; Single sideband reception; Direct conversion receiver.
Contains everything you need to know in order to get started in this absorbing hobby.
*88 pages* **Order code BP275** **£3.95**

**AN INTRODUCTION TO SATELLITE TELEVISION**
**F. A. Wilson**
As a definitive introduction to the subject this book is presented on two levels. For the absolute beginner or anyone thinking about purchasing or hiring a satellite TV system, the story is told as simply as such a complex one can be in the main text.
For the professional engineer, electronics enthusiast, student or others with technical backgrounds, there are numerous appendices backing up the main text with additional technical and scientific detail formulae, calculations, tables etc. There is also plenty for the DIY enthusiast with practical advice on choosing and installing the most problematic part of the system – the dish antenna.
*104 pages* **Temporarily out of print**

**AN INTRODUCTION TO AMATEUR COMMUNICATIONS SATELLITES**
**A. Pickford**
Communications and broadcast satellites are normally inaccessible to individuals unless they are actively involved in their technicalities by working for organisations such as British Telecom, the various space agencies or military bodies. even those who possess a satellite television receiver system do not participate in the technical aspects of these highly technological systems.
There are a large number of amateur communications satellites in orbit around the world, traversing the globe continuously and they can be tracked and their signals received with relatively inexpensive equipment. This equipment can be connected to a home computer such as the BBC Micro or IBM compatible PCs, for the decoding of received signals.
This book describes several currently available systems, their connection to an appropriate computer and how they can be operated with suitable software.
*102 pages* **Order code BP290** **£3.95**

**AERIAL PROJECTS**
**R. A. Penfold**
The subject of aerials is vast but in this book the author has considered practical aerial designs, including active, loop and ferrite aerials which give good performances and are relatively simple and inexpensive to build. The complex theory and mathematics of aerial design have been avoided.
Also included are constructional details of a number of aerial accessories including a pre-selector, attenuator, filters and tuning unit.
*96 pages* **Order code BP105** **£2.50**

**INTERNATIONAL RADIO STATIONS GUIDE**
**P. Shore**
Provides the casual listener, amateur radio DXer and the professional radio monitor with an essential reference work designed to guide him or her around the ever more complex radio bands. This new edition has been completely revised and rewritten and incorporates much more information which is divided into the following sections:
Listening to Short Wave Radio; Choosing a Short Wave Radio Receiver; How to Use the IRSG; Abbreviations; Country Codes; Worldwide Short Wave Radio Stations; European, Middle Eastern and African Long Wave Radio Stations; European, Near and Middle Eastern and African Medium Wave Radio Stations; Canadian Medium Wave Radio Stations; USA Medium Wave Radio Stations; Broadcasts in English; Programmes for DXers and Short Wave Listeners; UK FM Radio Stations; Time Differences From GMT; Wavelength/Frequency Conversion.
*226 pages* **Order code BP255** **£5.95**

# DIRECT BOOK SERVICE

## ORDERING DETAILS

Please state the title and order code clearly, print your name and address and add the required postage to the total order.

**Add £1** to your total order for postage and packing (overseas readers **add £2** for countries in Europe, or **add £5** for all countries outside Europe, surface mail postage) and send a PO, cheque, international money order, (£ sterling only) made payable to **Direct Book Service** or credit card details (including the card expiry date), Visa or Mastercard (Access) – minimum credit card order is £5 – quoting your name and address, the order code and quantities required to DIRECT BOOK SERVICE, 33 GRAVEL HILL, WIMBORNE, DORSET BH21 1RW (mail order only).

Although books are normally sent within seven days of receipt of your order, please allow a maximum of 28 days for delivery. Overseas readers allow extra time for surface mail post.

*Please check price and availability (see latest issue of Everyday with Practical Electronics) before ordering from old lists.*

**Note – our postage charge is the same for one book or one hundred books!**

**MORE BOOKS NEXT MONTH**

***Direct Book Service is a division of Wimborne Publishing Ltd***

# BABANI BOOKS

We now supply *all* the books published by Bernard Babani (Publishing) Ltd. We have always supplied a selected list of Babani books and you will find many of them described on the previous pages or in next months issue of *Everyday with Practical Electronics* (the books with a BP prefix to the order code are Babani books).

Many readers have asked us to also supply various other Babani books, which have a reputation for value for money. Our customers tell us they appreciate our speedy service and low postage charge and they would like to be able to purchase all the books from us and thus keep the postage charge to an absolute minimum (**£1 for UK p&p no matter how many books you buy**). We are pleased to be able to respond; with the aid of Michael Babani (M.D.) we are now able to meet all your requirements for their books. *If it's Babani and in print we can supply it.* Babani presently list over 180 different technical titles those *not* described in detail on the previous *Direct Book Service* pages or in next months issue are listed below:

| Code | Title | Price |
|---|---|---|
| BP28 | Resistor Selection Handbook | £0.60 |
| BP37 | 50 Projects using Relays, SCRs and TRIACs | £2.95 |
| BP39 | 50 (FET) Field Effect Transistor Projects | £2.95 |
| BP44 | IC 555 Projects | £2.95 |
| BP48 | Electronic Projects for Beginners | £1.95 |
| BP49 | Popular Electronic Projects | £2.50 |
| BP56 | Electronic Security Devices | £2.50 |
| BP58 | 50 Circuits Using 7400 Series IC's | O.O.P. |
| BP63 | Alternating Current Theory (Elements of Electronics – Book 2) | £3.50 |
| BP68 | Choosing and Using Your Hi-Fi | £1.65 |
| BP74 | Electronic Music Projects | £2.95 |
| BP76 | Power Supply Projects | £2.50 |
| BP78 | Practical Computer Experiments | £1.75 |
| BP84 | Digital IC Projects | £1.95 |
| BP86 | An Introduction to BASIC Programming Techniques | £1.95 |
| BP90 | Audio Projects | £2.50 |
| BP94 | Electronic Projects for Cars and Boats | £1.95 |
| BP95 | Model Railway Projects | £2.95 |
| BP97 | IC Projects for Beginners | £1.95 |
| BP99 | Mini-matrix Board Projects | £2.50 |
| BP109 | The Art of Programming the 1K ZX81 | £1.95 |
| BP114 | The Art of Programming the 16K ZX81 | £2.50 |
| BP122 | Audio Amplifier Construction | £2.95 |
| BP125 | 25 Simple Amateur Band Aerials | £1.95 |
| BP126 | BASIC & PASCAL in Parallel | £1.50 |
| BP128 | 20 Programs for the ZX Spectrum & 16K ZX81 | £1.95 |
| BP129 | An Introduction to Programming the ORIC-1 | £1.95 |
| BP132 | 25 Simple SW Broadcast Band Aerials | £1.95 |
| BP133 | An Introduction to Programming the Dragon 32 | £1.95 |
| BP136 | 25 Simple Indoor and Window Aerials | £1.75 |
| BP137 | BASIC & FORTRAN in Parallel | £1.95 |
| BP138 | BASIC & FORTH in Parallel | £1.95 |
| BP143 | An Introduction to Programming the Atari 600/800XL | £1.95 |
| BP144 | Further Practical Electronics Calculations & Formulae | O.O.P. |
| BP145 | 25 Simple Tropical and MW Band Aerials | £1.75 |
| BP148 | Computer Terminology Explained | £1.95 |
| BP149 | A Concise Introduction to the Language of BBC Basic | £1.95 |
| BP153 | An Introduction to Programming the Amstrad CPC 464 & 664 | £2.50 |
| BP154 | An Introduction to MSX BASIC | £2.50 |
| BP156 | An Introduction to QL Machine Code | £2.50 |
| BP157 | How to Write ZX Spectrum & Spectrum + Games Programs | £2.50 |
| BP158 | An Introduction to Programming the Commodore 16 & Plus 4 | £2.50 |
| BP159 | How to Write Amstrad CPC464 Games Programs | £2.50 |
| BF161 | Into the QL Archive | £2.50 |
| BP162 | Counting on QL Abacus | £2.50 |
| BP171 | Easy Add-on Projects for Amstrad CPC 464, 664, 6128 and MSX Computers | £2.95 |
| BP174 | More Advanced Electronic Music Projects | O.O.P. |
| BP175 | How to Write Word Game Programs for the Amstrad CPC 464, 664 and 6128 | £2.95 |
| BP182 | MIDI Projects | £2.95 |
| BP187 | A Practical Reference Guide to Word Processing on the Amstrad PCW8256 and PCW8512 | £5.95 |
| BP190 | More Advanced Electronic Security Projects | £2.95 |
| BP191 | Simple Application of the Amstrad CPCs for Writers | £2.95 |
| BP192 | More Advanced Power Supply Projects | £2.95 |
| BP193 | LOGO for Beginners | £2.95 |
| BP196 | BASIC & LOGO in Parallel | £2.95 |
| BP197 | An Introduction to the Amstrad PC's | £5.95 |
| BP198 | An Introduction to Antenna Theory | £2.95 |
| BP230 | A Concise Introduction to GEM | £2.95 |
| BP243 | BBC BASIC86 on the Amstrad PC's and IBM Compatibles – Book 1: Language | £3.95 |
| BP244 | BBC BASIC86 on the Amstrad PC's and IBM Compatibles – Book 2: Graphics and Disk Files | £3.95 |
| BP245 | Digital Audio Projects | £2.95 |
| BP246 | Musical Applications of the Atari ST's | £5.95 |
| BP247 | More Advanced MIDI Projects | £2.95 |
| BP249 | More Advanced Test Equipment Construction | £3.50 |
| BP250 | Programming in FORTRAN 77 | £4.95 |
| BP251 | Computer Hobbyists Handbook | £5.95 |
| BP258 | Learning to Program in C | £4.95 |
| BP259 | A Concise Introduction to UNIX | £2.95 |
| BP260 | A Concise Introduction to OS/2 | £2.95 |
| BP261 | A Concise Introduction to Lotus 1-2-3 (Revised Edition) | £3.95 |
| BP262 | A Concise Introduction to Wordperfect (Revised Edition) | £3.95 |
| BP263 | A Concise Introduction to dBASE | O.O.P. |
| BP264 | A Concise Advanced User's Guide to MS-DOS | O.O.P. |
| BP269 | An Introduction to Desktop Publishing | O.O.P. |
| BP270 | A Concise Introduction to Symphony | £3.95 |
| BP272 | Interfacing PC's & Compatibles | £3.95 |
| BP273 | Practical Electronic Sensors | £4.95 |
| BP274 | A Concise Introduction to SuperCal5 | £3.95 |
| BP276 | Short Wave Superhat Receiver Construction | £2.95 |
| BP279 | A Concise Introduction to Excel | £3.95 |
| BP280 | Getting the Most From Your PC's Hard Disc | £3.95 |
| BP283 | A Concise Introduction to SmartWare II | £4.95 |
| BP284 | Programming in QuickBASIC | £4.95 |
| BP287 | A Reference Guide to Practical Electronics Terms | £5.95 |
| BP288 | A Concise Introduction to Windows 3.0 | £3.95 |
| BP291 | A Concise Introduction to Ventura | £3.95 |
| BP292 | Public Address Loudspeaker Systems | £3.95 |
| BP293 | An Introduction to Radio Wave Propagation | £3.95 |
| BP294 | A Concise Introduction to Microsoft Works | O.O.P. |
| BP298 | A Concise Introduction to the Mac System & Finder | £3.95 |
| BP302 | A Concise Users Guide to Lotus 1-2-3 Release 3.1 | £3.95 |
| BP303 | Understanding PC Software | £4.95 |
| BP306 | A Concise Introduction to AmiPro 3 | £4.95 |
| BP307 | A Concise Introduction to QuarkXPress | £4.95 |
| BP311 | An Introduction to Scanners and Scanning | £4.95 |
| BP312 | An Introduction to Microwaves | £3.95 |
| BP313 | A Concise Introduction to Sage | £3.95 |
| BP314 | A Concise Introduction to Quattro Pro | £4.95 |
| BP315 | An Introduction to the Electromagnetic Wave | £4.95 |
| BP322 | Circuits Source Book 2 | £4.95 |
| BP324 | The Art of Soldering | £3.95 |
| BP330 | A Concise user's Guide to Lotus 1-2-3 Release 2.4 | £4.95 |

IF NO PRICE IS SHOWN THE BOOK IS OUT OF PRINT (O.O.P.)

**SEE PREVIOUS PAGE FOR FULL ORDERING DETAILS**

# PCB SERVICE

Printed circuit boards for certain EPE constructional projects are available from the PCB Service, see list. These are fabricated in glass fibre, and are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £1 per board for airmail outside of Europe. Remittances should be sent to **The PCB Service, *Everyday with Practical Electronics,* 6 Church Street, Wimborne, Dorset BH21 1JH.** Cheques should be crossed and made payable to *Everyday with Practical Electronics* (**Payment in £ sterling only**).

**NOTE: While 95% of our boards are now held in stock and are dispatched within seven days of receipt of order, please allow a maximum of 28 days for delivery – overseas readers allow extra if ordered by surface mail.**

***Please check price and availability in the latest issue.***

Boards can only be supplied on a payment with order basis.

## SALE! All p.c.b.s on this page reduced to ½ PRICE

***(Just send half the price shown, while stocks last.)***

***PCBS ON OPPOSITE PAGE PRICES AS SHOWN***

| PROJECT TITLE | | Order Code | Cost |
|---|---|---|---|
| Video Guard Alarm | FEB'87 | 556 | £3.80 |
| Fridge Alarm | MAY'87 | 565 | £3.00 |
| Multi-Chan Remote Light Dim | JUNE'88 | | |
| Relay/Decoder | | 601 | £4.86 |
| Power Supply | | 603 | £3.00 |
| Tea Tune Thermostat | AUG'88 | 609 | £3.00 |
| Time Switch | | 614 | £4.84 |
| Suntan Timer | | 610 | £3.07 |
| Car Alarm | | 615 | £3.12 |
| Eprom Eraser | OCT'88 | 620 | £4.07 |
| Doorbell Delay | NOV'88 | 616 | £3.56 |
| Sound-to-Light Interface | MAR'89 | 637 | £6.24 |
| Midi Pedal | | 639 | £7.00 |
| Midi Merge | | 640 | £3.00 |
| Audio Lead Tester | | 641 | £5.77 |

| PROJECT TITLE | | Order Code | Cost |
|---|---|---|---|
| Light Sentinel: Main Board | APR'89 | 632 | £9.20 |
| 4-Channel Auto-Fader Interface | | 642 | £6.80 |
| Electron A/D Interface | MAY'89 | 645 | £4.84 |
| Programmable Pocket Timer | JULY'89 | 648 | £3.82 |
| Electronic Spirit Level | AUG'89 | 649 | £3.85 |
| Distance Recorder | | 651 | £5.23 |
| Power Supplies: Fixed Voltage | SEP'89 | 654 | £4.08 |
| Music on Hold | OCT'89 | 646 | £3.85 |
| Power Supplies – 25V 700mA | | 656 | £4.35 |
| EE Seismograph – Control board only | | 658 | £4.08 |
| Wash Pro | NOV'89 | 643 | £3.83 |
| Logo/lego & Sepctrum Interface | | 664 | £5.60 |
| Biofeedback Signal Generator | JAN'90 | 666 | £4.08 |
| Quick Cap Tester | FEB'90 | 668 | £3.92 |
| Superhet Receiver/Tuner/Amp | MAR'90 | 679/680 | £4.22 |
| Stereo Noise Generator | APR'90 | 681 | £4.24 |
| Digital Experimenter's Unit – Pulse Generator | | 682 | £4.46 |
| Power Supply | | 683 | £3.66 |
| Amstrad Speech Synthesiser | MAY'90 | 68[illegible] | £4.68 |
| 80 Metre Direct Conversion Radio | JUN'90 | 691 | £4.95 |
| Mains Appliance Remote Control | JUL'90 | | |
| Encoder Board A | | 694 | £6.61 |
| Encoder Board B | | 695 | £4.78 |
| The Tester | | 696 | £4.15 |
| Mains Appliance Remote Control Mains ON/OFF Decoder (5 or more 697's ordered *together* £3.25 each) | AUG'90 | 697 | £4.55 |
| Hand Tally: Main Bd and Display Bd | SEP'90 | 699, 700 | £10.95 |
| Alarm Bell Time-Out | | 701 | £4.10 |
| Mains Appliance Remote Control Temperature Controller (p.c.b. only) | | 702 | £5.20 |
| Ghost Waker | OCT'90 | 703 | £4.32 |
| Frequency Meter | | 704 | £5.25 |
| Freq. Meter/Tachometer | NOV'90 | 705 | £3.98 |
| EE Musketeer (TV/Video/Audio) | | 706 | £5.78 |
| Microcontroller Light Sequencer | DEC'90 | 708/709 | £10.90 |
| Versatile Bench Power Supply Unit | | 710 | £4.24 |
| Teach-In '91, Part 1 – L200 Module | | 711 | £3.93 |
| Dual Output Module | | Sorry sold | out |
| LM723 Module | | 713 | £4.21 |

| PROJECT TITLE | Order Code | Cost |
|---|---|---|
| Spatial Power Display JAN'91 | 714 | £5.33 |
| Amstrad PCW Sound Generator | 715 | £5.03 |
| Teach-In '91, Part 2 – G.P. Transistor Amp | 717 | £3.77 |
| Dual Op.Amp Module | 718 | £3.83 |
| Intercom (Teach-In '91 Project 2) | 719 | £4.41 |
| Analogic Test Probe | 720 | £3.24 |
| MARC Phone-In FEB'91 | 721 | £6.87 |
| Teach-In '91 Part 3 – TBA820M Amplifier | 723 | £4.05 |
| High Quality Power Amp | 724 | £4.93 |
| Bench Amplifier (Teach-In '91 Project 3) | 725 | £4.45 |
| Gingernut 80m Receiver | | |
| R.F. section (726), Voltage Regulator (727) | 726/7/8 | £3.06 |
| Audio Amplifier (728) | | per board |
| | all 3 together | £8.16 |
| Pocket Tone Dialler MAR'91 | 729 | £4.36 |
| Simple Basic Alarm | 731 | £4.50 |
| Car Code Lock (pair) | 732a/b | £4.69 |
| Teach-In '91 Part 4 – Sinusoidal Oscillator | 733 | £4.39 |
| 8038 Oscillator | 734 | £4.15 |
| Waveform Generator (Teach-In '91 Project 4) | 735 | £4.72 |
| Humidity Tester APR'91 | 716 | £4.97 |
| Model Train Controller (double-sided) | 736 | £9.75 |
| Electronic Die (Teach-In '91 Project 5) | 737 | £4.93 |
| Teach-In '91 Part 5 – Digital Counter Module | 738 | £4.35 |
| Modular Disco Lighting System MAY'91 | | |
| Switched Power Output Module | 739 | £5.91 |
| Digital LCD Thermostat – Control Board £5 for pair | 740 | £4.05 |
| – Power/Relay Board | 741 | £3.76 |
| Pulse Generator (Teach-In '91 Project 6) | 742 | £4.97 |
| Teach-In '91 Part 6 – Timer Module | 743 | £4.62 |
| Digilogue Car Tachometer JUN'91 | 744 | £5.63 |
| Modular Disco Lights – Simple Chaser | 745 | £5.00 |
| Sweeper Module | 746 | £5.17 |
| Automatic Light Control – PSU Board | 747 | £4.88 |
| Logic Board | 748 | £5.17 |
| Radio Receiver (Teach-In '91 Project 7) | 749 | £4.57 |
| Teach-In '91 Part 7 – R.F. Amplifier Module | 750 | £4.23 |
| Modular Disco Lights – Masterlink JULY'91 | 752 | £6.36 |
| Ultrasonic Proximity Meter | | |
| Display Unit (753) & Sensor Unit (754) | 753/754 | £7.06 |
| Disco Lights (Teach-In '91 Project 8) | | |
| PSU and Pre-amplifier | 755 | £4.54 |
| Low, Mid, High Filter/Triac (set of 3 boards) | 756 | £11.00 |
| Teach-In '91 Part 8 – Solid State Switch Module | 757 | £4.24 |
| Mod. Disco Lights – Pattern Gen AUG'91 | 760 | £6.79 |
| Teach-In '91 Part 8 – Light Sensitive Switch | 761 | £4.74 |
| Opto-Link (Teach-In '91 Project 9) – Transmitter | 762 | £4.85 |
| Receiver | 763 | £4.88 |
| Portable PEsT Scarer | 764 | £3.77 |
| Capacitance Meter SEP'91 | 751 | £5.17 |
| Modular Disco Lights – Dimmer Interface | 765 | £8.17 |
| Mod. Disco Lights OCT'91 | | |
| VU Sound Module (Double-sided) | 767 | £8.68 |
| UV Exposure Unit | 768 | £4.63 |
| PC-Scope Interface – Main Board | 769 | £6.95 |
| Expansion Plug (Double-sided) | 770 | £5.96 |
| Mod. Disco Lights NOV'91 | | |
| Superchaser (Double-sided) | 771 | £6.91 |
| Supersweep (Double-sided) | 772 | £8.26 |
| Bicycle Alarm | 773 | £5.01 |
| Darts Scorer | 774 | £7.90 |
| Knockerbox DEC'91 | 775 | £5.35 |
| Signal Generator – Main Board | 776 | £7.46 |
| PSU | 777 | £4.73 |
| Mind Machine – Main Board | 778 | £7.00 |
| Auto Nightlight | 779 | £5.03 |
| Mind Machine – Programmer Board JAN'92 | 780 | £7.39 |
| Transistor Checker | 781 | £4.63 |
| Stepping Motor Driver/Interface | 782 | £10.39 |
| Micro-Sense Alarm | 783 | £5.42 |
| Telesound FEB'92 | 784 | £4.66 |
| Programmable Timer | 785 | £4.63 |
| Auto Garage Light MAR'92 | 786 | £6.10 |
| Versatile BBC Computer Interface | 787 | £11.59 |
| Economy Seven Timer | 788 | £5.20 |
| Sonic Continuity Tester APR'92 | 789 | £4.79 |
| Telephone Ringer | 790 | £5.46 |
| Experimental Weighing Scale MAY'92 | 792 | £5.17 |
| 12V Drill Charger/PSU (both boards) | 793 | £5.31 |

| PROJECT TITLE | Order Code | Cost |
|---|---|---|
| Digital Servo Interface JUNE'92 | 791 | £4.73 |
| Tie Pulser | 794 | £5.19 |
| CCD Reverb Unit | 795 | £6.39 |
| Switch-Mode Power Supply | 796 | £7.01 |
| UV Exposure Timer JULY'92 | 797 | £5.33 |
| Cricket Game | 798 | £6.77 |
| Quick Prom | 799 | £5.61 |
| Gas Alarm AUG'92 | 800 | £5.47 |
| Dual Metronome | 801 | £6.74 |
| Ultrasonic Tape Measure SEP'92 | 802 | £6.06 |
| Quicktest | 803 | £4.82 |
| Extended Range Capacitance Meter OCT'92 | 804 | £5.63 |
| Traffic Lights System | 806 | £5.04 |
| Mini Lab NOV'92 | MINI LAB | £14.95 |
| EPE Altimet (Altimeter) | 807 | £6.30 |
| Personal Stereo Amplifier | 808 | £6.47 |
| Universal Infra-Red Remote Control DEC'92 | 811T/811R | £6.56 |
| Combination Switch | 812 | £5.68 |
| Christmas Lights Colour Spectrum | 813 | £5.97 |
| TV/UHF Aerial Amp (double-sided) JAN'93 | 814 | £7.23 |
| Continuously Variable Balanced Power Supply | 815 | £5.65 |
| Emergency Lighting Unit | 816 | £6.77 |
| Biomet Pulse Monitor FEB'93 | | |
| Sensor | 817 | £6.30 |
| Display | 818 | £6.30 |
| Biomet Pulse Monitor MAR'93 | | |
| – ADC Interface (double-sided) | 819 | £7.11 |
| Car Electric Window Enhancer | 821 | £5.00 |
| Simplify Atari STFM Interface | 822 | £5.55 |
| Personal Stereo Amp. Add-On | 823 | £3.90 |
| Electronic Fire APR'93 | 820 | £4.84 |
| Mind Machine MKII – Signal Generator | 824 | £5.57 |
| Ventilation Fan Timer | 825 | £4.70 |
| Universal Data Logger | 826 | £5.88 |
| Mind Machine MkII – Magic Lights MAY'93 | 827 | £6.58 |
| Superhet Radio Control Receiver | 828 | £5.93 |
| Guitar Preamp and Distrortion Unit | 829 | £5.46 |
| Linear Clock – Timing Board | 830 | £8.00 |
| Display Board | 831 | £7.00 |
| Universal Alarm Module | 9070 | £3.00 |
| Electronic Snooker Scoreboard JUNE'93 | 832 | £9.17 |
| Mind Machine MkII JULY'93 | | |
| – Computer Interface | 833 | £6.39 |
| Xenon Strobe | 834 | £5.84 |
| Electronic Gong | 835 | £7.50 |
| Micro Lab – p.c.b., EPROM, PAL and booklet | MICRO | £35.00 |
| Bike Odometer (pair of boards) AUG'93 | 836/7 | £7.00 |
| Amstrad PCW A to D Converter (double sided) | 838 | £9.85 |
| Experimental Electronic Pipe Descaler | 839 | £5.50 |

# EPE PRINTED CIRCUIT BOARD SERVICE

**Order Code** **Project** **Quantity** **Price**

..............................................................................................

Name..............................................................................................

Address..............................................................................................

..............................................................................................

BLOCK CAPITALS PLEASE

VISA

I enclose payment of £ ..........(cheque/PO in £ sterling only to **Everyday with Practical Electronics) Access (MasterCard) or Visa No. Minimum order for credit cards £5**

ACCESS

Signature..............................Card Ex. Date..............

Please supply name and address of card-holder if different from the address shown

# VIDEOS ON ELECTRONICS

*Everyday with Practical Electronics* is pleased to announce the availability of a range of videos designed to provide instruction on electronics theory. Each video gives a sound introduction and grounding in a specialised area of the subject. The tapes make learning both easier and more enjoyable than pure textbook or magazine study. They should prove particularly useful in schools, colleges, training departments and electronics clubs as well as to general hobbyists and those following distance learning courses etc.

**VT201 to VT206 is a basic electronics course and is designed to be used as a complete series, if required.**

VT201 54 minutes. Part one; D.C. Circuits. This video is an absolute must for the beginner. Series circuits, parallel circuits, Ohms law, how to use the digital multimeter and much more. **Order Code VT201**

VT202 62 minutes. Part two; A.C. Circuits. This is your next step in understanding the basics of electronics. You will learn about how coils, transformers, capacitors, etc are used in common circuits. **Order Code VT202**

VT203 57 minutes. Part three; Semiconductors. Gives you an exciting look into the world of semiconductors. With basic semiconductor theory. Plus 15 different semiconductor devices explained. **Order Code VT203**

VT204 56 minutes. Part four; Power Supplies. Guides you step by step through different sections of a power supply. **Order Code VT204**

VT205 57 minutes. Part five; Amplifiers. Shows you how amplifiers work as you have never seen them before. Class A, class B, class C, op.amps. etc. **Order Code VT205**

VT206 56 minutes. Part six; Oscillators. Oscillators are found in both linear and digital circuits. Gives a good basic background in oscillator circuits. **Order Code VT206**

By the time you have completed VT206 you have completed the basic electronics course and should have a good understanding of the operation of basic circuit elements.

**NEW NEW NEW**

VT102 84 minutes: Introduction to VCR Repair. Warning, not for the beginner. Through the use of block diagrams this video will take you through the various circuits found in the VHS system. You will follow the signal from the input to the audio/video heads then from the heads back to the output. **Order Code VT102**

VT103 35 minutes: A step-by-step easy to follow procedure for professionally cleaning the tape path and replacing many of the belts in most VHS VCR's. The viewer will also become familiar with the various parts found in the tape path. **Order Code VT103**

**Now for the digital series of six videos. This series is designed to provide a good grounding in computer technology.**

VT301 56 minutes. Digital One begins with the basics as you learn about seven of the most common gates which are used in almost every digital circuit, plus Binary notation. **Order Code VT301**

VT302 55 minutes. Digital Two will further enhance your knowledge of digital basics. You will learn about Octal and Hexadecimal notation groups, flip-flops, counters, etc. **Order Code VT302**

VT303 56 minutes. Digital Three is your next step in obtaining a solid understanding of the basic circuits found in todays digital design. Gets into multiplexers, registers, display devices, etc. **Order Code VT303**

VT304 57 minutes. Digital Four shows you how the computer is able to communicate with the real world. You will learn about digital to analogue and analogue to digital converter circuits. **Order Code VT304**

VT305 56 minutes. Digital Five introduces you to the technology used in many of todays memory devices. You will learn all about ROM devices and then proceed into PROM, EPROM, EEPROM, SRAM, DRAM, and MBM devices. **Order Code VT305**

VT306 56 minutes. Digital Six gives you a thorough understanding in the basics of the central processing unit and the input/output circuits used to make the system work. **Order Code VT306**

By now you should have a good understanding of computer technology and what makes computers work. This series is also invaluable to the computer technician to understand the basics and thus aid troubleshooting.

Each video uses a mixture of animated current flow in circuits plus text, plus cartoon instruction etc., and a very full commentary to get the points across. The tapes are imported by us and originate from VCR Educational Products Co, an American supplier.

(All videos are to the UK PAL standard on VHS tapes)

## ORDERING

To order see our *Direct Book Service* "Ordering Details" – the postage for tapes is the same as for our range of books and you can order tapes and books at the same time and pay only one lot of postage. Each video costs £29.95 inc. VAT. If ordering eight or more together we will give you an extra video FREE, just indicate on your order which extra one you would like.

# NEW STYLE EPE BINDERS

A totally new type of binder is now available to hold and protect twelve issues of *Everyday with Practical Electronics*. This new ring binder uses a special system to allow the issues to be easily removed and reinserted without any damage. A nylon strip slips over each issue and this passes over the four rings, thus holding the magazine in place (see photo).

The new binders are finished in hard wearing royal blue p.v.c. with the magazine logo in gold on the spine. We were hoping to keep the price the same as the previous binders but unfortunately the postage cost has defeated us as they are much heavier than the previous ones. The price is £4.95 plus £3.50 post and packing (for overseas readers the postage is £6.00 to everywhere except Australia and Papua New Guinea which costs £10.50).

Send your payment in £'s sterling to Everyday with Practical Electronics, 6 Church Street, Wimborne, Dorset BH21 1JH. Tel: 0202 881749. Fax: 0202 841692.

We also accept credit card payments Mastercard (Access) or Visa (minimum credit card order £5). Send your card number and card expiry date plus cardholders address (if different to the delivery address).


# EVERYDAY WITH PRACTICAL ELECTRONICS CLASSIFIED

**Everyday with Practical Electronics reaches twice as many UK readers as any other independent monthly hobby electronics magazine, our audited sales figures prove it. We have been the leading independent monthly magazine in this market for the last eight years**

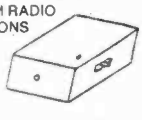
If you want your advertisements to be seen by the largest readership at the most economical price our classified and semi-display pages offer the best value. The prepaid rate for semi-display space is £8 (+VAT) per single column centimetre (minimum 2.5cm). The prepaid rate for classified adverts is 30p (+VAT) per word (minimum 12 words).

All cheques, postal orders, etc., to be made payable to Everyday with Practical Electronics. **VAT must be added.** Advertisements, together with remittance, should be sent to Advertisements, Everyday with Practical Electronics, Holland Wood House, Church Lane, Great Holland, Essex CO13 0JS. Phone/Fax (0255) 850596.

For rates and information on display and classified advertising please contact our Advertisement Manager, Peter Mew as above.

---

**SUPER FM MICROTRANSMITTERS**



HEAR ON ANY FM RADIO
FULL INSTRUCTIONS
BUILT-IN MICROPHONE
LONG RANGE
ENCASED
EASY TO USE

HIGHLY SENSITIVE
READY TO USE
FULLY TUNEABLE 74-115MHz
ON/OFF SWITCH
MATCHBOX SIZE
GUARANTEED

£9.50 Post free. Cheques, PO's. Tel. 0205 362003
Mr. B. Hicks, 24 Brewster Rd., Boston, Lincs PE21 0DY

---

**PC TECHNICAL SHAREWARE**

Would you like to see the best range of low cost technical and scientific public domain & shareware for IBM PC in the UK?
HUGE RANGE includes: – PACKET, FAX, RX/TX control, PCB design, Circuit and ANTENNA analysis, QSO logging. CAD ELECTRONIC & MECH engineering, SCIENTIFIC, MATHS & STATS, MEDICAL, PROGRAMMING, SOURCE CODE, DATA, EDUCATIONAL, WINDOWS, BUSINESS and lots more
Write, phone or fax today for your free 124 page printed catalogue

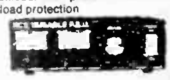
*The Public Domain Software Library*
*Winscombe House, Beacon Road*
*Crowborough, Sussex TN6 1UL*
*Tel 0892 663298, Fax 0892 667473*

ASP Approved Vendor

---

**RCS VARIABLE VOLTAGE D.C. BENCH POWER SUPPLY**

1 to 24 volts up to ½ amp. 1 to 20 volts up to 1 amp. 1 to 16 volts up to 1½ amps d.c. Fully stabilised. Twin panel meters for instant voltage and current readings. Overload protection
Fully variable.
Operates from 240V a.c.
Compact unit.
Size 9 x 5½ x 3in.



**£45** inc. VAT
+ Post and insurance £4

NEW MODEL. Up to 38volts d.c. at 6 amps. 10 amps peak. Fully variable. Twin panel meters. Size 14½ x 11 x 4½in. [illegible] inc VAT. Carr £6.

**RADIO COMPONENT SPECIALISTS**
337 WHITEHORSE ROAD, CROYDON
SURREY, U.K. Tel: 081-684 1665
List. Large SAE. Delivery 7 days. Callers welcome. Closed Wednesday

---

**This 3cm space in Everyday with Practical Electronics Will ONLY cost you £24 + VAT**

---

**VACUUM PUMP DESOLDERER**

Easily made for £10-£30. Revolutionize servicing. Strip i.c.'s from plated thru boards and save £££s. Plans £2.00. Parts available.
Details s.a.e. (UK or IR)
V. Carroll, Castle Lane, Dillonstown, Dunleer, Co. Louth, Ireland.
Tel: 010 353 4151419

---

QUALITY 30W SWITCH MODE POWER SUPPLY
Multi output: –12V at 0.3A, +12V at 1.2A + 5V at 3A
110/240V operation, dimensions, 160 x 100 x 40mm
Prices: Used £5. New £10 plus P&P
Cheques payable to
**CUBE ELECTRONIC SYSTEMS LTD**
26 Park Road, Bingley
West Yorkshire BD16 4JD
Tel 0274 551159. Fax: 0274 551416

---

**SOLAR PANELS**

Special offer 12V nom (20V o/c) 80mA. 12"x6" pre-wired Amorphous Silicon panel £4.50 (5 for £18) plus £1.50 p&p per order. Many other sizes, wind generators and other products. Orders to (Catalogue 2 x 1st class stamps)
**Keysolar Systems, 4 Glanmor Crescent Newport, Gwent NP9 8AX**

---

IT PAYS TO ADVERTISE IN

**EVERYDAY with PRACTICAL ELECTRONICS**

Your advert will reach twice as many UK readers than with any other independent monthly hobby electronics magazine

---

**SURVEILLANCE KITS**

MICRO TRANSMITTER, tuneable 70-115MHz, 500M range, 40mm x 20mm including microphone, 3-12V. Kit £5.95, Assembled £9.95. Order Code KT1.
TELEPHONE TRANSMITTER, 30mm x 10mm, powered from line, transmits both sides of conversation, 500M range, 88-130MHz. Kit £7.95, Assembled £12.95. Order Code KT3.
3 WATT TRANSMITTER, 80-110MHz, 12-15V, adjustable input sensitivity, varicap controlled, several miles range. Kit £15.95, Assembled £25.95. Order Code KT4.
All prices include p&p.
Credit card orders telephone 021 486 3092.
Send 2x1st class stamps for Catalogue. Cheques/P.O.s payable to:
**QUANTEK ELECTRONICS**
Kits Dept. (EPE), 3 Houldey Road, West Heath, Birmingham B31 3HL

---

**THE BRITISH AMATEUR ELECTRONICS CLUB**

exists to help electronics enthusiasts by personal contact and through a quarterly Newsletter.
For membership details, write to the Secretary
**Mr J. S. Hind, 7 Carlyle Road**
**West Bridgford, Nottingham NG2 7NS**
*Space donated by Everyday with Practical Electronics*

---

**Typefit**

**The Typesetting programme for all your Typesetting needs.**
**If you need typesetting for your Adverts, Brochures, etc. Typefit can help you. Please telephone**
**0202 882299**

---

## Miscellaneous

**G.C.S.E. ELECTRONICS KITS** at pocket money prices. S.A.E. for FREE catalogue. SIR-KIT ELECTRONICS, 70 Oxford Road, Clacton CO15 3TE.

**PROTOTYPE PRINTED CIRCUIT BOARDS** one offs and quantities, for details send s.a.e. to B. M. Ansbro, 38 Poynings Drive, Sussex BN3 8GR, or phone Brighton 883871.

**THE HOMEBUILT DYNAMO** (Plans). Reviewed 1989 in PE January and Model Engineer December 15th. Price £42 post paid airmail from Alfred Forbes, PO Box 3919, Auckland, New Zealand. Tel (09) 818-8967.

**ELECTRONIC KITS,** Consultancy & Design: Send £5 Pounds (IN ENGLISH NOTES) With A4 Addressed Envelope; For List & 44 Unusual Circuits: Mr. Lucas P.O. Box 755, Saint Helier, Jersey JE4 8ZZ Channel Islands, UK.

**MOST UNUSUAL ELECTRONIC KITS.** Worldwide Source, Lasers/Metal Detectors/Night Vision/Test EQ; For list, See Advert Mr Lucas P.O. Box 755.

**Z8 MICROCONTROLLERS,** components, boards, kits, and support. Examples Z8681 £4.25, p.c.b. £8. Phone for details 0642 480620.

**PLDs** and **EPROMS** copied or programmed. 25p each +set up and postage. We supply logic devices/convert discrete logic to PLDs. Also PCBs designed. Send for details to PO Box 1561 Bath, or phone 0225-444467 (evenings).

**EPROMs**, secondhand but erased and fully functional. 27C16/27C32 @ £2 and 27C64/27C512 @ £2.25 +£1.50 P&P to Academic Designs Ltd., PO Box 1561 Bath.

**EPE MINI LAB** professionally constructed. Working Order. Power unit included. £99. 0670 367526.

**SOLAR PANELS** 48W £265, 52W £285, many more sizes, with lights, fans, pumps, fridges, portable rechargeable lamps, various solar gifts and a wide range of DIY components. Send £5 for catalogue (£10 overseas). £3 refund with order and quarterly newsletter. Solar Products (Ref EPE), 4 The Mount, Guildford GU2 5HN.

**VALVE AMPLIFIERS,** ex Ministry also spare EF86s, ECC83s, 6BW6s. Projector lenses, motors, and DMMs. SAE for latest list, W. Jarvis, 6 Peggy's Mill Rd., Edinburgh EH4 6JY.

**PHILPS P.M. 3240** 50 MHz dual trace oscilloscope, £180. Phone 0283 69331 for details, private sale.

**WANTED,** Eddystone Receivers, any model in good working order and condition. Contact Lepino, Tel. 0374 128170, Fax. 0372 454381.

**100 WATT AMPLIFIER MODULES,** £8. TO3 Heatsink, built + leads. KIA, 1 Regent Road, Ilkley – SAE.

---

**EVERYDAY WITH PRACTICAL ELECTRONICS**

**SUBSCRIPTION ORDER FORM**

Annual subscription rates (1993):
UK £20.00.
Overseas £26 (surface mail).
£43.50 (airmail)

To: Everyday with Practical Electronics
6 Church Street, Wimborne
Dorset BH21 1JH

Name ........................................
Address ........................................
........................................
M8/93 ........................................

**I enclose payment of £**........................
(cheque/PO in £ sterling only, payable to Everyday with Practical Electronics). Alternatively send Access or Visa number and card expiry date.

Signature ........................................

Please supply name and address of card-holder if different from the subscription address shown above. Subscriptions can only start with the next available issue. For back numbers see the Editorial page.

## COURSES

# ADVERTISERS INDEX




**ADVERTISEMENT MANAGER:**
PETER J. MEW
**ADVERTISEMENT OFFICES:**
EVERYDAY with PRACTICAL ELECTRONICS ADVERTISEMENTS,
HOLLAND WOOD HOUSE, CHURCH LANE,
GREAT HOLLAND, ESSEX CO13 0JS.
Phone/Fax: (0255) 850596


*For Editorial address and phone numbers see page 565.*




Published on approximately the first Friday of each month by Wimborne Publishing Ltd., 6 Church Street, Wimborne, Dorset BH21 1JH. Printed in England by Benham & Co. Ltd, Colchester, Essex. Distributed by Seymour, Windsor House, 1270 London Road, Norbury, London SW16 4DH. Sole Agents for Australia and New Zealand–Gordon & Gotch (Asia) Ltd., South Africa–Central News Agency Ltd. Subscriptions INLAND £20 and OVERSEAS £26 (£43.50 airmail) payable to "Everyday with Practical Electronics" Subs Dept, 6 Church Street, Wimborne, Dorset BH21 1JH. EVERYDAY with PRACTICAL ELECTRONICS is sold subject to the following conditions, namely that it shall not, without the written consent of the Publishers first having been given, be lent, resold, hired out or otherwise disposed of by way of Trade at more than the recommended selling price shown on the cover, and that it shall not be lent, resold, hired out or otherwise disposed of in a mutilated condition or in any unauthorised cover by way of Trade or affixed to or as part of any publication or advertising, literary or pictorial matter whatsoever.