TAKE COMPLETE CONTROL OF YOUR MUSIC with the
MCS-1 MIDI CONTROLLED SAMPLER

Once again, Powertran and ERMM combine to bring you
versatility and top quality from a product out of the
realm of fantasy and within the reach of the active
musician.

The MCS-1 will take any sound, store it and play it back
from a keyboard (either MIDI or Wavetable). Pitch bend or
vibrato can be added and infinite sustain is possible
thanks to a sophisticated, looping system.

All the usual delay line features (Vibrate, Phasing,
Flanging, ADT, Echo) are available with delays of up to 32
seconds. A special interface enables sampled sounds to be
stored digitally on a happy disc via a BBC microcomputer.

The MCS-1 gives you many of the effects created by top
professional units such as the Fairlight or Emulator, but the
MCS-1 doesn't come with a 5-figure price tag. And, if you're
prepared to invest your time, it's almost cheap!

Specification
Memory Size: Variable from 3 bytes to 64K bytes.
Storage time at 32 KHz sampling rate: 2 seconds.
Storage time at 8 KHz sampling rate: 16 seconds.
Longest replay time (no special effects): 32 seconds.
Converters, ADC & DAC: 8 bit companding, Dynamic
range: 76 dB.
Audio Bandwidth: Variable from 12 KHz to 3000 Hz.
Internal 4 pole tracking filters for anti-aliasing and
recovery.
Programmable wide range sinusoid sweep generator.
MIDI control range: 5 octaves.
+1 Vocoder control range: 2 octaves with optional
transpose of further 5 octaves.

Digital Delay Line

Introducing the Powertran Delay Line, brought digital quality
effects to thousands of musicians. Now available in
kit form at only £179.00 + VAT.

£499 + VAT IN KIT FORM
£699 + VAT READY BUILT

Professional quality MIDI-controlled sampling unit

Write or phone now to place an order.
Powertran Cybernetics Limited,
Portway Industrial Estate,
Andover, Hants, SP10 3PE
Telephone: 0264 64455

POWERTRAN cybernetics ltd
PORTWAY INDUSTRIAL ESTATE, ANDOVER, HANTS SP10 3PE
CONSTRUCTIONAL PROJECTS

CAR COMPUTER—Part 1 by S. H. Cousins BSc PhD and P. D. Wilson BEng
Ignorance is an expensive bliss where motoring is concerned
RING MODULATOR by John M. H. Becker
Part Two: Music Modulation—The effects
NICAD CHARGER by M. Tooley BA and D. Whitfield MA MSc CEng MIEE
Fully automatic charger with 24 charge rate options
AUDIO NOISE GENERATOR by Tom Gaskell BA(Hons) CEng MIEE
Produces "white" and "pink" noise for testing audio systems
NEPTUNE AND MENTOR ROBOTS by Richard Becker and Tim Orr
Part Four: The electro-mechanics and control electronics for Mentor

GENERAL FEATURES

SEQUENTIAL LOGIC TECHNIQUES by M. Tooley BA and D. Whitfield MA MSc CEng MIEE
Part Three: Latches, registers and counters
VERNON TRENT AT LARGE
SEMICONDUCTOR CIRCUITS by Tom Gaskell BA(Hons) CEng MIEE
Digital Noise Source (MM5837N)

NEWS AND COMMENT

EDITORIAL
NEWS AND MARKET PLACE
Including Countdown and Points Arising
INDUSTRY NOTEBOOK by Nexus
News and views on the electronics industry
SPACEWATCH by Dr. Patrick Moore O.B.E.
Glorious Past—Bright Future; The Sun; Think Tank; The Sky This Month
PRINTED CIRCUIT BOARD SERVICE
A new service for readers
SPECIAL OFFER—PE QUASAR STEREO CASSETTE KIT
INDEX FOR VOLUME 20
Complete index for PE 1984

BUYER'S GUIDE

SOLDERING INSTRUMENTS
We look at a wide range of soldering equipment

OUR JANUARY 1985 ISSUE WILL BE ON SALE FRIDAY, DECEMBER 7th, 1984
(for details of contents see page 50)
Above items. Be satisfied before you buy.

EPSON RX80 F/T Printer
EPSON RX80 Printer

MANY MORE PRINTERS, MONITORS, INTERFACES, APPLICATIONS like

81" or 91" Fan fold paper (1000 sheets)

TEX EPROM ERASER. Erases up to 32 ICs in

C106D
84/600V
2A/400V

0491
0481
0447
N5401

VERO WIRING PEN and Spool
50407
40402

Bimboard 1
'DIP' Board

1 3W
420 276p
125 96p
110 56p

SIL Socket plus spare tip

32K UPGRADE

50V to
62

Soldering Irons
SOLDER WIRING PEN and Spool Wire (Spool 7sp)

7 Segment Displays
PLD's

FERRIC CHLORIDE

100% x pro plus tip

DIAGRAM BLOCKS

Copper strip
5x5

DIAL ENCHY RESIST
Pen plus spare tip 100p

DIP SWITCHES
(SPI7: 4 way 85p, 8 way 85p; 8 way up to 100p; 10 way 320p)

AMPHENOL CONNECTORS

IDC
IC600

EDGE CONNECTORS

Sockets

32K UPGRADE

Gold flashed contacts

FEMALE RECEPTACLE Jumpers Leads 36"

MOUNTING BUSHES 32 way 25p 375p

150W Widerate

550p

185p

Puzzle, Say Me, Think, Jack, Yell, Stamp, Stamp

Library Plastic Storage Cases

Holds ten 5;" Diskettes .......... £2

DISC ALBUMS

Attractively finished in beige leatherette-Ploterote cases contain-ly store up to 20 discs. Each disc can be easily seen through the clear vinyl window.

ONLY £4.25

5;" Disc Drive

HEAD CLEANING KIT £14

SPECTRUM CENTRONICS/RS232 PRINTER INTERFACE

It was the first!

It is still the best!

Centronics and Bi-DIRECTIONAL RS-232 with full hand-shaking.

OASIS LIST and PRINT

Split-Speed Operation for RS-232. (Use it to communicate with the BBC MICRO or OTHER PERIPHERALS).

Interface 1, Interface 2 & Microdrive compatible.

Configuration program creates customized M/C driver to suit your

Hi-Res screen dumps in 2 sizes on

EPSON, SEIKOSHA, STAR, SHARP, TELEPERF, TALLY, NEC, RITEKMAN, KAGA, TANDM, STANDARD FEATURES Not an afterthought.

Complieable with TASSWORD TWO and most professional programs.
Cirkit stock all the components, accessories and tools and the kits you're looking for.

Designed and selected to offer the best possible standards at the best possible price.

Cirkit's always well stocked.

As soon as new products are available, Cirkit has them.

When it comes to kits, Cirkit's got the lot. At the price you want to pay.

Just send for our catalogue or visit one of our three outlets at:

200 North Service Road, Brentwood, Essex. CM14 4SG;
53 Burrfields Road, Portsmouth, Hampshire. PO3 5EB; Park Lane, Broxbourne, Hertfordshire. EN10 7NQ.

Please add 15% VAT to all advertised prices and 60p post and packing.
Minimum order value £5 please.
We reserve the right to vary prices in accordance with market fluctuation.

To: Cirkit Holdings PLC, Park Lane, Broxbourne, Hertfordshire. EN10 7NQ.
I enclose 85p. Please send me your latest catalogue and 3 x 1.1 discount vouchers!
If you have any enquiries please telephone us on Hoddesdon (0992) 444111.

Name ____________________________ Telephone ____________________________
Address ____________________________ ____________________________
Area of Special Interest ____________________________

Cirkit

Bigger Stock, Better Service.

Cirkit Kits

CIRKIT ELECTRONICS TOOL KIT
Contains: 15W Soldering Iron 2 spare bits, heat shunt, solder, pliers, cutters, and screwdriver 40-00007 15.56
AUDIO FUNCTION GENERATOR
Versatile waveform generator with sine, triangular and square wave outputs.
On board mains PSU 41-01302 27.00
STEREO 40W AMPLIFIER
Single board 40W per channel stereo amplifier 41-01301 38.00
STEREO VU METER
5 LED per channel stereo VU meter for use with stereo amplifiers 41-01401 11.50
5W AUDIO AMP
A very compact audio output stage for use in a wide range of equipment 41-01406 4.60
UNIVERSAL AMP
A universal audio pre-amp with a gain of 10 41-01604 6.45
MORO REVERBERATION UNIT
Single channel, spring line reverb unit to add echo effects to tape recording etc. 41-01602 10.00
TONE GENERATOR AND DETECTOR
Very low distortion tone generator and signal detector for circuit fault finding
10MHz DFM 41-01603 10.45
8 Digit LED digital frequency meter and period measurement 41-01500 54.10
50MHz PRESCALER
Extend the range of the 10MHz DFM to 50MHz 41-01501 8.55
1-5MHz PRE AMP
Low frequency pre-amp and waveform shaper for the 10MHz DFM 41-01502 5.13
1-30V 1mA-2A PSU
Adjustable 1-30V power supply with pre-setable current limit from 1mA-2A 41-01600 37.46

5-12V 1A PSU
Adjustable PSU from 5-12V with current protection, 1 amp max output 41-01504 6.45
1-30V 1.5A PSU
1-30 volt adjustable PSU with protected output up to 1.5 Amps 41-01402 10.45
3 DIGIT LED DVM
DVM to read up to 99.9 volts or configured as an ammeter to read up to 0.99 amps 41-01403 17.00

INFRARED LINK
Single channel IR Link with relay output 41-01300 9.60
TEMPERATURE SENSOR
Thermistor based temperature sensor with relay output 41-01303 6.20
LOCOMOTIVE SOUND GENERATOR
Realistic steam sound and whistle for model railways 41-01304 9.20
1A MP DIMMER
Control lamps and drill speed 41-01305 5.70
WATER LEVEL ALARM
Alarm to indicate high water level or flooding 41-01601 2.70
3 NOTE CHIME
Doorbell chime with adjustable tones 41-01503 7.00
2W PRE AMP
Miniature low-noise MOSFET pre-amp for the 2m amateur band 41-01307 3.91
2W CONVERTER
Low noise 144MHz-28MHz amateur band converter 41-01306 17.35
2M POWER AMP
2W - 10dB gain - power amplifier for the 2m band. Automatic TX switch over, RX pre-amp, robust construction 41-01404 32.87
70cm PRE AMP
Low noise, miniature pre-amp for the 70cm amateur band 41-01506 4.78
70cm CONVERTER
70cm to 144MHz low noise converter featuring pre-aligned helical filters, schottky diode mixer and low noise transistors 41-01405 21.50
70cm PA
10W Power amp to boost the output of handheld and portable 70cm transceivers 41-01505 33.82
CRYSTAL CALIBRATOR
Crystal reference calibrator for alignment of receivers, outputs at 4.2, 1MHz, 100, 50 AND 10kHz 41-00601 4.32
CB NOISE SQUELCH
Improves to mute performance of the majority of CB rigs 41-01405 5.40
CENTRONICS INTERFACE
Connect your personal computer to the outside world via the Centronics printer output 41-01406 22.50

To: Cirkit Holdings PLC, Park Lane, Broxbourne, Hertfordshire. EN10 7NQ.
Nicad Batteries & Chargers
High quality nickel cadmium rechargeable batteries. Equivalent in size with popular Dry Cell sizes e.g. HP7 (AA), HP11 (C), and HP2 (D). Minimum life 600 (300 PP3 size) full charge/discharge cycles. Batteries must be charged from a constant current source only. All batteries are supplied only with a residual charge and should be charged before used.

DATA & PRICES

<table>
<thead>
<tr>
<th>Type</th>
<th>V(nom)</th>
<th>Capacity</th>
<th>Stock No.</th>
<th>Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>1.2V</td>
<td>500mA</td>
<td>01-12004</td>
<td>0.80</td>
</tr>
<tr>
<td>C</td>
<td>1.2V</td>
<td>900mA</td>
<td>01-12024</td>
<td>2.35</td>
</tr>
<tr>
<td>D</td>
<td>1.2V</td>
<td>1200mA</td>
<td>01-12044</td>
<td>2.00</td>
</tr>
<tr>
<td>PP3</td>
<td>8.4V</td>
<td>110mA</td>
<td>01-84054</td>
<td>3.70</td>
</tr>
</tbody>
</table>

CH/4/50
To recharge up to 4 AA size NiCads. Size; 112 x 71 x 37mm 01-00409 4.95

CH/12
To charge PP3 type NiCads. Size; 70 x 50 x 32mm 01-00159 4.30

CH/8/3X
Will recharge AA, C, D and PP3 size cells with automatic voltage selection. Will recharge following combinations: 4x0, 4x3AA, 4xC, 2xPP3, 2x0 + 2x3C, 2x0 + 2xAA, 2x2 + 1xPP3, 2x0 + 2xAA, 2xC + 1xPP3, 2x0 + 1xPP3. Charge rate: 11mA for PP3, 45mA for AA size, 120mA for C and D size, for 16 hrs. Power: 240V 50Hz. Output Voltage: 2.9V for AA, C and D size, 11.0V for PP3 size. Weight: 0.475kg. Size: 195 x 105 x 55mm. 01-02204 9.45

HT320
High quality, high specification meter at a reasonable price. In addition to the usual ranges, facilities are provided for measuring transistor parameters such as Ic eoe and Ic e. Meter movement fully protected against overloads. 3-colour mirrored scale in robust case. Supplied complete with comprehensive instructions, test leads, transistor test leads and batteries (2 x HP-7, 1 x PP3).

DC Volts: 0.1V, 0.5V, 2.5V, 10V, 50V, 250V, 1kV (10k/1V). AC Volts: 10V, 50V, 250V, 1kV (18k/1V). DC current: 50µA, 2.5mA, 25mA, 250mA. Resistance: 2k, 20k, 2M, 20M, AF Output: -10dB to +22dB for 10VAC (0dB/0.775V, 600Ω). Leakage (Ic eoe) 5µA, 15mA, 150mA. Hfe: 0-1000 (LC/Tb). Weight: 410gms. 56-30201 14.00

Linear ICs

<table>
<thead>
<tr>
<th>Stock No.</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>LF351</td>
<td>0.49</td>
</tr>
<tr>
<td>LF353</td>
<td>0.43</td>
</tr>
<tr>
<td>LM380N</td>
<td>0.90</td>
</tr>
<tr>
<td>LM381</td>
<td>0.90</td>
</tr>
<tr>
<td>NE554</td>
<td>0.21</td>
</tr>
<tr>
<td>NE555N</td>
<td>0.42</td>
</tr>
<tr>
<td>u747ICN</td>
<td>0.42</td>
</tr>
<tr>
<td>TDA1062</td>
<td>1.95</td>
</tr>
<tr>
<td>TDA1062</td>
<td>1.95</td>
</tr>
<tr>
<td>HA1388</td>
<td>0.27</td>
</tr>
<tr>
<td>MC1496P</td>
<td>0.25</td>
</tr>
<tr>
<td>TDA2002</td>
<td>0.25</td>
</tr>
<tr>
<td>ULN2228</td>
<td>1.25</td>
</tr>
<tr>
<td>CA3089</td>
<td>1.00</td>
</tr>
<tr>
<td>CA310E</td>
<td>0.84</td>
</tr>
<tr>
<td>CA3140E</td>
<td>0.46</td>
</tr>
<tr>
<td>MC3359</td>
<td>2.95</td>
</tr>
<tr>
<td>LM3900</td>
<td>0.00</td>
</tr>
<tr>
<td>LM3930N</td>
<td>0.68</td>
</tr>
<tr>
<td>KB4412</td>
<td>0.00</td>
</tr>
<tr>
<td>IC7555S</td>
<td>0.95</td>
</tr>
<tr>
<td>HA11225</td>
<td>0.00</td>
</tr>
<tr>
<td>HA12017</td>
<td>0.00</td>
</tr>
<tr>
<td>MC14412</td>
<td>0.00</td>
</tr>
</tbody>
</table>

RF Generator LSG17
A stable wide-range generator for the hobbyist, service technician, schools, colleges, etc.
Frequency range: A/10kHz-300kHz, B/300kHz to 1MHz (Harmonics 96-450MHz) C/1MHz-3.5MHz, D/0kHz-11MHz, E/10MHz-35MHz, F/32MHz-150MHz. Accuracy: ±1.5%. Output greater than 100mV (no load). Ext. xtal osc for 1 to 15MHz crystal. Power required: AC110, 115 or 230V 3VA. Size & weight: 190(H) x 238(W) x 130(D)mm, 2.5kg approx. 56-90017 115.00

Selected Lines

<table>
<thead>
<tr>
<th>Stock No.</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>P027210</td>
<td>0.55</td>
</tr>
<tr>
<td>100MA1</td>
<td>0.52</td>
</tr>
<tr>
<td>100MAA</td>
<td>0.49</td>
</tr>
<tr>
<td>P217</td>
<td>2.90</td>
</tr>
<tr>
<td>CM161</td>
<td>0.25</td>
</tr>
<tr>
<td>BBC to Centronics Connect Cable</td>
<td>0.25</td>
</tr>
<tr>
<td>CH1 Computer Cassette Tape</td>
<td>0.25</td>
</tr>
<tr>
<td>CH2 Computer Cassette Tape</td>
<td>0.25</td>
</tr>
<tr>
<td>CH3 Computer Cassette Tape</td>
<td>0.25</td>
</tr>
<tr>
<td>CH4 Computer Cassette Tape</td>
<td>0.25</td>
</tr>
<tr>
<td>CH5 Computer Cassette Tape</td>
<td>0.25</td>
</tr>
</tbody>
</table>

Books

<table>
<thead>
<tr>
<th>Title</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beginners Guide to Amateur Radio</td>
<td>0.25</td>
</tr>
<tr>
<td>Beginners Guide to Electronics</td>
<td>0.25</td>
</tr>
<tr>
<td>Active Filter Cookbook</td>
<td>0.25</td>
</tr>
<tr>
<td>CMOS Cookbook</td>
<td>0.25</td>
</tr>
<tr>
<td>TTL Cookbook</td>
<td>0.25</td>
</tr>
<tr>
<td>Design of Active Filters</td>
<td>0.25</td>
</tr>
<tr>
<td>Design of Op-amp Circuits with experiments</td>
<td>0.25</td>
</tr>
<tr>
<td>Effectively Using the Oscilloscope</td>
<td>0.25</td>
</tr>
<tr>
<td>The SK Spectrum</td>
<td>0.25</td>
</tr>
<tr>
<td>Practical Design of Digital Circuits</td>
<td>0.25</td>
</tr>
<tr>
<td>Electronic Projects for Home Security</td>
<td>0.25</td>
</tr>
<tr>
<td>Electronic Telephone Projects</td>
<td>0.25</td>
</tr>
<tr>
<td>55 Timer Applications Sourcebook</td>
<td>0.25</td>
</tr>
<tr>
<td>Television Engineers Pocket Book</td>
<td>0.25</td>
</tr>
<tr>
<td>7th Ed</td>
<td>0.25</td>
</tr>
<tr>
<td>99 Practical Electronic Projects</td>
<td>0.25</td>
</tr>
<tr>
<td>More Electronic Projects in the Home</td>
<td>0.25</td>
</tr>
<tr>
<td>The Radio Amateur Question and Answer Reference Manual</td>
<td>0.25</td>
</tr>
<tr>
<td>Basic Programming on the BBC Microcomputer</td>
<td>0.25</td>
</tr>
<tr>
<td>Using Microprocessors and Microcomputers: The 6800 Family</td>
<td>0.25</td>
</tr>
<tr>
<td>8085 Microcomputer Design Projects</td>
<td>0.25</td>
</tr>
<tr>
<td>Z80 Microcomputer BNC Coax Relays</td>
<td>0.25</td>
</tr>
<tr>
<td>A Design Handbook</td>
<td>0.25</td>
</tr>
</tbody>
</table>

Practical Design of Digital Circuits

8000: Principles and Programming | 0.25 |
4005A Cookbook | 0.25 |
Handbook of Electronic Tables | 0.25 |
Formulas | 0.25 |
Polar Circuits: Ready Reference | 0.25 |
Semiconductor Data Book | 0.25 |
11th Edition | 0.25 |
TOP QUALITY ... TOP SERVICE ... BOTTOM PRICES!

For FREE CATALOGUE send 9 x 6" SAE — includes full list of stock range all at very competitive prices. Cash with order (except account customers). Access or Barclaycard telephone orders welcome. Add 85p per q to VAT at all UK orders. Overseas customers add £2.50 p&p Europe, £6.00 elsewhere. Giro No. 529314002. Goods by return subject to availability. Shop open 9am — 5pm (Mon-Fri) 10am — 4pm Sat. ALL PRICES EXCLUDE VAT

MICROPROCESSOR TIMER KIT

Designed to control 4 outputs independently — switching on and off at preset times over a 7-day cycle. LED display of time and day, easily programmed via 20-way keyboard. Ideal for central heating (central Booking to suit switching times for weekends). Battery back-up circuit includes box. 18 time settings.

CT6000K £39.00
XK114. Relay kit for CT6000 includes PCB, connections and one relay. WR accept up to 4 relays. 3A-240V 50/60 f contains £3.90
701 115 Additional Relays £1.65

ELECTRONIC LOCK KIT

With hundreds of uses indoors, garages, car and motor device, electronic equipment. etc. Only the correct easily change door code will open it. It requires a 5.165V DC supply. Output 750mA. Fits into standard electrical wall box. Code change exceptional function. XK101 £11.90

Electrical Lock Mechanism for use with existing door locks and the above kit. Requires relay 112 AC/DC (01 1705) £14.99

HOME LIGHTING KITS

These kits are designed to replace a standard wall switch to control up to 300w of lighting.

TDR300K Remote Controlled Light Timer £14.99
MK6 Transmitter for above £4.50
TD300K Touch Dimmer £7.75
TS300K Touch Switch £7.75
TDR5 2-way extension for above kits £2.50
LD300K Rotary controlled Light Dimmer £3.95

DISCO LIGHTING KITS

DILO1000K — This value-for-money 4-way chaser features 4 directional sequences simultaneously. £39 per channel. £15.99
DILO1000K — A lower cost multi-directional version of the above. Zero switching to reduce interference. £8.99
DILO1000K — Battery operated using audible tones (DILO13) £17.40
DILO1000K — An 8-channel sound to light kit features variable volume switching, automatic level control and built-in mono phone jack. 1x 15w speaker £12.95

OTHER KITS

CT6000K Clock/Timer £14.99
CT1000K Clock/Timer & Box £17.40
MKO15 LED Battern & Box £16.50
MK7 Thermostat £6.40
MK5 Solid State Relay £6.40
MK12 Temperature Switch £5.60
MK5 Temperature Switch £5.60
MK10 Infra Red Transmitter £6.40
MK8 Infra Red Receiver £10.50

These kits are all described in the Microprocessor Timer section.

For further details send S.A.E.

ELECTRONICS

11-13 Boston Road
London W7 3SJ

ORDERS ENQUIRIES
01-567 8910 01-579 9794
01-579 2842 TECHNICAL AFTER 3pm

TOP QUALITY ... TOP SERVICE ... BOTTOM PRICES!

For FREE CATALOGUE send 9 x 6" SAE — includes full list of stock range all at very competitive prices. Cash with order (except account customers). Access or Barclaycard telephone orders welcome. Add 85p per q to VAT at all UK orders. Overseas customers add £2.50 p&p Europe, £6.00 elsewhere. Giro No. 529314002. Goods by return subject to availability. Shop open 9am — 5pm (Mon-Fri) 10am — 4pm Sat. ALL PRICES EXCLUDE VAT

MICROPROCESSOR TIMER KIT

Designed to control 4 outputs independently — switching on and off at preset times over a 7-day cycle. LED display of time and day, easily programmed via 20-way keyboard. Ideal for central heating (central Booking to suit switching times for weekends). Battery back-up circuit includes box. 18 time settings.

CT6000K £39.00
XK114. Relay kit for CT6000 includes PCB, connections and one relay. WR accept up to 4 relays. 3A-240V 50/60 f contains £3.90
701 115 Additional Relays £1.65

ELECTRONIC LOCK KIT

With hundreds of uses indoors, garages, car and motor device, electronic equipment. etc. Only the correct easily change door code will open it. It requires a 5.165V DC supply. Output 750mA. Fits into standard electrical wall box. Code change exceptional function. XK101 £11.90

Electrical Lock Mechanism for use with existing door locks and the above kit. Requires relay 112 AC/DC (01 1705) £14.99

HOME LIGHTING KITS

These kits are designed to replace a standard wall switch to control up to 300w of lighting.

TDR300K Remote Controlled Light Timer £14.99
MK6 Transmitter for above £4.50
TD300K Touch Dimmer £7.75
TS300K Touch Switch £7.75
TDR5 2-way extension for above kits £2.50
LD300K Rotary controlled Light Dimmer £3.95

DISCO LIGHTING KITS

DILO1000K — This value-for-money 4-way chaser features 4 directional sequences simultaneously. £39 per channel. £15.99
DILO1000K — A lower cost multi-directional version of the above. Zero switching to reduce interference. £8.99
DILO1000K — Battery operated using audible tones (DILO13) £17.40
DILO1000K — An 8-channel sound to light kit features variable volume switching, automatic level control and built-in mono phone jack. 1x 15w speaker £12.95

OTHER KITS

CT6000K Clock/Timer £14.99
CT1000K Clock/Timer & Box £17.40
MKO15 LED Battern & Box £16.50
MK7 Thermostat £6.40
MK5 Solid State Relay £6.40
MK12 Temperature Switch £5.60
MK5 Temperature Switch £5.60
MK10 Infra Red Transmitter £6.40
MK8 Infra Red Receiver £10.50

These kits are all described in the Microprocessor Timer section.

For further details send S.A.E.

ELECTRONICS

11-13 Boston Road
London W7 3SJ

ORDERS ENQUIRIES
01-567 8910 01-579 9794
01-579 2842 TECHNICAL AFTER 3pm
IN CAR ELECTRONICS

Electronics in motor cars has provided PE with many interesting features and projects over the years. Back in 1965 we were publishing car alarms, instruments and parking lights as projects. Interestingly one news item at that time reported the first car to car phone call across the Atlantic. The call was made on July 5 1965 from a car in London using a Radiophone made by Pye to a taxi cab in Montreal also using Pye equipment. This event followed the official opening of the London Radiophone service which covered an area of about 30 miles around London.

Electronics has moved on in the last twenty years and of course so have our projects. In December 81 we published our first car computer which broke new ground in its mode of operation. Car Computer of 1981 but provides all the basic information without the need to fix a fuel sensor and is consequently an inexpensive item to build. We believe this design again breaks new ground in its mode of operation.

BUYER'S GUIDES

Buyer's guides, as regular readers may have noticed, are becoming quite a part of PE. It seems that the information we provide is of great value to hobbyists and those involved in the electronics industry and education. We have now covered quite a wide field with our guides and are planning further subjects for next year.

Soldering equipment is well covered in this issue and, while we make no claim that the guide is complete, it will give readers a good basis on which to build a list of required equipment. No doubt many readers will find new companies and products which they were not aware of before. If you make an enquiry about any product we describe (especially those detailed in our buyer's guides) would you please mention PE as the source of the original information. This applies equally to educational establishments and industry or training departments etc., as such feedback to the suppliers assists us to give good coverage in future guides.

INDEX

As usual this issue of PE carries the index for the year. If you find an article you would like to read our back numbers department may be able to assist—see below. Alternatively a local library, particularly a technical one or one attached to a school or college etc., might carry copies.

In extreme cases we can supply a photostat of the article from the editorial office but we do have to charge 75p for each article or part of a series.

Editor Mike Kenward
Secretary Pauline Mitchell
Assistant Editors
Dave Barrington (Production)
David Shortland (Technical)
Technical Editor
Mike Abbott
Projects Editor
David Brunskill

Technical Sub-Editors
Richard Barron
Brian Butler
Art Editor Jack Pountney
Assistant Art Editor
Keith Woodruff
Senior Tech. Illustrator
John Picking
Tech. Illustrator
Isabelle Greenaway

Advertisement Manager David Tillett 01-261 6876
Secretary Christine Pocknell 01-261 6676
Advertisement Sales Executive Richard Willett 01-261 6619
Classified Supervisor Barbara Blake 01-261 5897
Ad. Make-up/Copy Brian Lamb 01-261 6601

Technical and editorial queries and letters (see note below) to:
Practical Electronics Editorial, Westover House, West Quay Road, Poole, Dorset BH15 1JG

Phone: Editorial Poole 671191
We regret that lengthy technical enquiries cannot be answered over the telephone.

Queries and letters concerning advertisements to:
Practical Electronics Advertisements, King's Reach Tower, Stamford Street, London SE1 9LS
Telex: 915748 MAGDIV.G

Letters and Queries

We are unable to offer any advice on the use or purchase of commercial equipment or the incorporation or modification of designs published in PE. All letters requiring a reply should be accompanied by a stamped, self addressed envelope, or addressed envelope and international reply coupons, and each letter should relate to one published project only.

Components and p.c.b.s are usually available from advertisers; where we anticipate difficulties a source will be suggested.

Back Numbers and Binders

Copies of most of our recent issues are available from: Post Sales Department (Practical Electronics), IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 0PF, at £1 each including Inland/Overseas p.p. Please state month and year of issue required.

Binders for PE are available from the same address as back numbers at £5.50 each to UK or overseas addresses, including postage, packing and VAT where appropriate. State year and volume required.

Subscriptions

Copies of Practical Electronics are available by post, inland for £13, overseas for £14 per 12 issues, from: Practical Electronics, Subscription Department, IPC Magazines Ltd, Room 2816, King's Reach Tower, Stamford Street, London SE1 9LS. Cheques, postal orders and international money orders should be made payable to IPC Magazines Limited. Payment for subscriptions can also be made using a credit card.
**Mains' utilities Monitoring System**

A new remote-monitoring system, designed for load-management of electricity, gas and water supplies, is presently undergoing trials in London and Milton Keynes. The Thorn/EMI system *Mainsborne Telecontrol* uses the electricity mains to carry bi-directional coded data between the central control and the consumer combining far more cost-effective tariff structures with remote meter reading.

The purpose of the trials is to establish the long term levels of reliability of the unique spread spectrum bi-directional signalling system over the low voltage mains, a system adopted to overcome excessive noise problems. A spread spectrum signal essentially provides a continuous frequency over the band and is highly resistant to narrow band interference. It is also capable of signalling through a high noise level environment such as the mains and additionally provides high security.

The customer is provided with a microprocessor controlled home unit and communications module. These carry out a number of tasks including accumulating signal pulses from electricity, gas and water meters; tariff switching; calculating actual and estimated costs incurred by the consumer; operating 80 amp and 25 amp contactors for space and water heating control and also for detecting any tampering with the meters. The communications module contains a clock/calendar synchronised to that of the central controller which is housed in the local C.E.G.B. transformer chamber. Non-volatile RAM storage of 1K byte permits a one day store of incremental meter readings for each utility.

The central controller can communicate via the mains with up to 1,024 addresses. There is 500K bytes of non-volatile bubble memory capable of storing three days of 48 half-hourly meter readings from all three utilities as well as storing data retransmission upstream to Load Management Control or downstream to home units.

The customer display (pictured) has a 10 digit, alphanumeric, vacuum fluorescent display with 19 touch sensitive keys. A series of control and data display functions are available to the customer such as display of meter reading including multi-tariff metering; display of units consumed and cost so far since last bill; display of estimated cost of next bill; display of water and space heating on/off times; when not in use for any other reason the display shows the time.

Two other communication systems are presently being tested in the UK for remote-monitoring and load management: one uses an idle line facility on the standard telephone network, the other uses radio signals transmitted in the 200kHz band by the BBC.

**TOP WOMEN?**

Women in London will have the opportunity to train for top engineering jobs in new technology thanks to £350,000 in grants from the Greater London Enterprise Board, the Greater London Training Board and the European Commission.

The grants are in recognition of the work being done by the GLEB-sponsored London New Technology Network (LNTN) based in Camden and will finance training courses for women to be supervisors and trainers in micro-electronic engineering.

**Enter MSX**

The long awaited MSX computer range is finally finding its way into the UK shops. MSX is a standard system adopted by 15 multinational electronics companies, mainly based in Japan. The standard is based on the Z80 processor, a TI video display chip and a General Instruments sound generator chip; all MSX machines and their peripherals are totally compatible. It is undoubtedly the hope of the conglomerate that their standard will eventually dominate the home-computer market.

Mitsubishi, Toshiba, Sony, Sanyo, JVC, Hitachi and Canon recently held a joint launch for their machines which all cost around the same—between £279 and £300. The software has been written by the American company Microsoft, it is a version of Basic. Around 75 general interest software packages are currently available. All the machines have a similar appearance and each possesses 64K bytes of user RAM with a separate 16K bytes of video RAM; the basic is stored in a 32K byte ROM.

Peripherals available will include 3J in floppy discs, printers, data cassette recorders, joysticks, touchpads, tracker balls and communications adaptors. Mitsubishi are the only company to launch two machines, the cheaper version (pictured) is a 32K byte model ML F48 costing £249.
**WATFORD’S MODEM 84**

The Watford Modem 84 is a direct connect unit for use with BBC micros; it is a fully British Telecom approved device and is probably the cheapest way to connect to Prestel. The unit is supplied with or without a software ROM.

Having a full duplex capability the system can send and receive data at the same time. Only 1K byte of memory is used by the system for preparing mailboxes and system operation. User passwords can be optionally programmed into the ROM giving automatic log-on whilst still allowing you to change the personal passwords from the keyboard. The system has many special features. Modem 84 costs £97 including the software ROM. The two can be bought separately, Modem 84 alone £74, software alone £23. All prices include VAT and P & P.

For further details and full specification contact: Watford Electronics, 33/35 Cardiff Road, Watford, Herts, WD1 8ED. (0923 40588).

**Computer look alikes**

Systema has introduced a mini desk calculator together with an LCD clock both styled like modern computer terminals.

The DC2 computer-calculator has a full working keyboard with memory, percentage and square root functions. Its eight digit display is fitted into the VDU cabinet. Overall measurements are 80 x 75 x 47mm.

The time and date are displayed alternately on the VDU of the CC1 computer-clock and its time keeping is accurate to within two seconds a day. Overall measurements are 52 x 45 x 41mm.

Both items are fitted with long life batteries. Prices are £6.95 for the DC2 computer-calculator and £3.68 for the CC1 computer-clock, inc VAT and P & P. From Systema (UK) Ltd., 72/74 South Street, Reading, Berks. RG1 4LG. (0734 586429).

**Briefly...**

Constructors please note: as part of a 'moving sale' the Midwich Computer Co. Ltd. is featuring many BBC products and compatible peripherals at low prices. Examples include a 100K, 40 track disc drive for £99.95, and the Uchida daisy wheel printer for £237.65. Prices exc VAT. All offers are while stocks last. New address: Gilray Road, Diss, Norfolk IP22 3EU. (0379 4131).

The Mitsubishi Electric Corporation has developed a method of access control that recognises personnel by their palm prints. Employees' palms are photographed and entered into a Charge Coupled Device (CCD) camera recognition system. Access to restricted areas is gained as the prospective entrant keys in a personal code and simultaneously presses his palm on a recognition plate; a positive palm print check coupled with the correct code number permits entry.

**POINTS ARISING...**

**PARALLEL/SERIAL CONVERTER**

September '84

The +ve connection of C2 should be connected to +5V and not to TR2 as printed. See page 18. Fig. 3 (circuit diagram).


Your Computer Xmas Fair Dec 30-Jan. 2 '85. Olympia. K2


British Toy & Hobby Fair Jan. 18–Feb. 2 '85. Olympia. D6

**Countdown...**

Please check dates before setting out, as we cannot guarantee the accuracy of the information presented below. Note: some exhibitions may be trade only. If you are organising any electrical/electronics, radio or scientific event, big or small, we shall be glad to include it here. Address details to Mike Abbott.

Leisuretronics Cancelled (see report, far left.)

Compec Nov. 13–16. Earl's Court. K2

P.C.B. Manufacture & UV Box Construction (meeting) Nov. 17. Electronic Organ Constructors Society. Y4


Business & Data Processing Nov. 20–24. Kelvin Hall, Glasgow. M

Northern Computer Fair Nov. 22–24. Belle Vue, Manchester. K2

Northern Energy Manager Nov. 27–28. Lancashire County Cricket Club, Old Trafford, Manchester. W3

Transducer Tempcon Nov. 27–29. Harrogate Exhibition Centre, Yorkshire. T

D4 Network 0280 815226

D6 † 01-701 7127

E † 01-228 4107

E5 † 01-231 1481

E6 † 01-888 4466

K2 † 01-888 4466

M † 01-486 1951

L † 01-486 8383

O † 01-486 8383

T † 01-228 4107

T1 † 0822 4671

W3 MCM † 01-231 1481

Y4 † 0202 423863
HOW MUCH DOES IT REALLY COST TO USE YOUR CAR?

LONDON, Geneva, Frankfurt, Paris... hardly a motor show goes by without a major car manufacturer introducing a new top-of-the-range car fitted with either a trip computer or a digital m.p.g. readout integrated into the instrument panel. Now here is an opportunity to bring your car right up to date with one of the new generation of car computers. These devises are designed primarily to add interest to your motoring, but they can save you money as well.

There is plenty of money to be saved. The average motorist drives 9000 miles each year, which given a typical 30m.p.g. means consuming 300 gallons per annum, costing £540 at £1.80 a gallon. Next year petrol is likely to go above £2 a gallon if only to keep pace with inflation and the weak pound. But this is only half the story because, as a rule of thumb, for every pound spent on petrol another pound is spent in total on oil, tyres, maintenance costs and car depreciation due to additional miles on the clock.

The Outrider car computer has been developed after the first wave of car computer novelties, and we are able to build on their experience. We have concentrated on achieving a high standard of design so that the Outrider will be simple and safe to use whilst driving, easy to fit to the car and easy to refit if you change cars. But most important of all we have developed a high quality digital m.p.g. readout which is stable under continuous driving conditions such as on a motorway, yet is also responsive to acceleration and responsive too, when easing off the accelerator pedal. It is not necessary to fit sensors to the accelerator incidentally!

When the car is stationary other features of the computer can be accessed. For example, the computer will predict the gallons of fuel required for a trip and the trip cost before you travel. To do this simply enter onto the computer the distance you expect to travel and view the appropriate functions. Precise how data is entered is dealt with later, but it is worth noting at this stage that, as a safety measure, cars can only be entered into the computer when the car is stationary.

One important computer feature is the calculation of long term average m.p.g. which provides the information you require to decide whether the car needs servicing.

CAR SHARING
Displaying the trip cost can be an incentive for car sharing. Not only do you become fully aware of the cost of car travel, which may encourage you to share, but so do your passengers!

The Outrider automatically displays the cost of the trip (petrol cost plus a mileage charge) when you switch off the ignition. This is shown for ten seconds before the computer switches off the display.

BUSINESS TRAVEL
Many of us have to record our mileage in order to reclaim expenses from our employers. The trip distance key is invaluable for this as we can easily underestimate the true length of trips when claiming expenses. Self-employed people and company managers may also benefit from knowing the cost of car operation for particular business trips.

CAR OPERATING COSTS
So how should we evaluate the cost of travelling by car, and at what value should the mileage charge within the computer be set? To work out the cost of operating your car fill in Balance Sheet 1.

The most obvious cost of motoring is fuel cost and if the mileage charge is set to zero then just the fuel cost of a trip will be displayed by the COST key.
However, each time you drive you incur additional costs. When you have estimated these and set the mileage charge to cover these costs then the trip cost displayed by the COST key will be the sum of the fuel cost and the extra costs that you incur having driven the distance of your trip. If you had stayed at home this is the total amount that you would have saved. If you use the trip cost prediction facility you would have an estimate of the trip cost that you could directly compare to the rail fare or a telephone call. Setting the mileage charge to cover these additional costs is the most useful setting for household owned cars.

Business users, the self employed and car sharers may however want to add the fixed car costs into the figure, not just those additional costs which are incurred at the time of driving.

MAIN BOARD

The heart of the circuit is a Motorola 6803 single chip microcomputer. This chip contains the processor, 128 bytes of RAM, a programmable timer and 13 input/output lines. The program for the microcomputer resides in a 2K byte EPROM. A 74LS373 is used to latch the low order address lines from the 8 bit multiplexed address/data bus. Timing information is derived from the 3.579545 MHz crystal. This part is commonly available as it is used in colour t.v. sets.

KEYBOARD AND DISPLAY

Each of the four I.e.d. digits and the function indicator I.e.d.s are controlled by a transistor driven from one of five output lines of the 6803. Rapid scanning of the digits synchronising with the data to switch segments on or off, which is held in the 74LS374 latch, gives the impression of all digits being on simultaneously but with great economy in wiring and components.

The 7-segment I.e.d.s were selected for both their appearance and their high brightness. The latter is particularly important for car instruments which must be readable in all light conditions.

The five digit lines are also used to scan the five input keys, which have a common line of input to the processor. The processor detects a key press when this line goes high.

The Outrider contains calibration and trip information which must not be lost when the ignition is switched off. 64 bytes of the 6803 memory can be retained even when the processor is turned off, through the Vcc standby pin. This pin is connected directly to the 5V regulator which is in turn connected directly to the 12V car battery. The power to the rest of the circuit is switched by a transistor which is turned on either by the ignition line or an output line from the 6803. This enables the 6803 to hold the power on to enter a defined power down sequence and to display trip cost information for a 10 second period after ignition is turned off.

TRANSUDER

This is a high inductance coil mounted as close as possible to the rotating magnet found in all conventional speedometers. Normally it is sufficient to place the coil tight up against the back of the speedometer case and mounted at right angles to the axis of the drive cable. Exceptionally it is necessary to drill through the speedometer case to locate the transducer internally.

Each time a pole of the speedometer magnet passes the sensor coil a voltage is induced which is then converted to a digital signal by a Schmitt trigger on the main circuit board. A twisted pair connects the sensor coil to the main board to remove any electrical noise problems coming from the car's ignition circuit.

A computer model eliminates the need for a fuel flow meter

The keys display these functions

<table>
<thead>
<tr>
<th>Keys</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIST</td>
<td>Distance travelled on trip</td>
</tr>
<tr>
<td>FUEL</td>
<td>Fuel used on trip</td>
</tr>
<tr>
<td>MPG</td>
<td>Instantaneous m.p.g. (above 20m.p.h.)</td>
</tr>
<tr>
<td>COST</td>
<td>Trip average m.p.g. (below 20m.p.h.)</td>
</tr>
<tr>
<td>SET</td>
<td>Display brightness</td>
</tr>
</tbody>
</table>

Fig. 1.1. Block diagram
Fig. 1.2. Circuit diagram. The Outrider will work with almost any make of vehicle, including diesel and fuel injected.
HOW THE COMPUTER WORKS

The overall configuration of the computer is shown in Fig. 1.2. Distance travelled is detected by a sensor coil located behind the speedometer. Fuel consumption information is fed into the computer via the computer keyboard. This is done by entering into the computer's electronic notebook the amount, in pounds and pence, spent when fuel is purchased. The computer then displays the price of a gallon of petrol the previous time it was bought to check that this is still the current price. The amount spent on fuel purchase is then divided by the price of a gallon of petrol to give the volume of petrol purchased. The volume of fuel purchased is not displayed but is retained in the computer and ultimately divided by the total distance travelled when the user requests a calculation of long term average m.p.g. This calculation is best made when the tank is completely filled and gives a highly accurate result. Long term average m.p.g. may be displayed at any time by pressing the MPG key when the computer is in calibration mode.

The distance sensor controls the dynamic behaviour of the computer outputs in conjunction with the crystal oscillator which provides a time source. Together the distance and time inputs are used to determine distance travelled, cold starts, vehicle speed, vehicle acceleration and vehicle braking. These factors are used in the computer model to determine instantaneous m.p.g. using the long term average m.p.g. to calibrate the model itself. Readers will recognise this kinetic method of calculating instantaneous m.p.g. as being very similar to the approach taken in the standard EEC driving cycle for new cars. Here m.p.g.s are given according to the speed at which they are driven (56m.p.h. and 75m.p.h.) and for an urban driving cycle involving acceleration and braking.

There are advantages to this kinetic method of determining instantaneous m.p.g. Flow meters in the fuel line can be inaccurate or expensive and there is always a slight additional risk of a petrol leak if a meter is introduced into the fuel line. Fuel flows reflect the characteristics of the carburettor float chamber as well as driver behaviour and the combination can be confusing to the driver particularly during continuous, e.g. motorway driving. By contrast the kinetic method can give a high quality signal to the driver.

Trip m.p.g. is the average of the instantaneous values over the period since the trip data were reset to zero. Fuel consumed on trip and trip cost are also calculated from the trip average m.p.g. figure. In the latter case the cost of fuel used and distance times the mileage charge are also used to determine the total trip cost. Users determine an appropriate charge per mile to reflect an average of all non-petrol costs or those costs less the truly fixed costs (tax, insurance, etc.).

Provided that the power supply to the computer is maintained, all trip and calibration data are retained when the computer display is off and the car is not in use.

THE M.P.G. READOUT

There has been considerable debate about whether a digital or analogue readout is best for car instrumentation in general and for the m.p.g. display in particular. Our display (Fig. 1.2) is something of a hybrid using three of the 7-segment I.e.d.s to display digital m.p.g. while the fourth I.e.d. is effectively an analogue display summarising how the car is being driven. This horizontal bar can be usefully positioned at the edge of the driver's vision when the driver is at the wheel and looking straight ahead.

DATA ENTRY

Always begin data entry by pressing the SET key (for two seconds until SET is displayed and the light above the SET key flashes slowly). Next choose the function key that you wish to tell the computer about, e.g. COST. Now any number between 00-00 and 99.99 can be entered as follows. Each of the four left-hand keys rolls a separate digit on the display. "Roll-up" your desired number (the price of a gallon of petrol, say 1.75 in this case) then press the SET key to finish.

This is the sequence keys you will press to enter data

SET FUNCTION NUMBER SET

(2 secs)

Remember the car must be stationary and the SET key pressed for two seconds.

Data entries are as follows for each function key:

<table>
<thead>
<tr>
<th>Function Key</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SET DIST 0000</td>
<td>Resets all trip data to zero, e.g. fuel used on trip, distance travelled on trip and cost of trip</td>
</tr>
<tr>
<td>SET DIST NUMBER SET</td>
<td>Predicts the fuel required and cost of trip a NUMBER miles long</td>
</tr>
<tr>
<td>SET FUEL NUMBER SET</td>
<td>Enter the amount spent on fuel each time you buy petrol. The NUMBER is the total cost of fuel which you have just purchased. The computer also needs to know the cost per gallon of the fuel and to help here the computer automatically goes over to the cost function and displays the cost per gallon last used. Change if necessary. Press SET to return to normal computer operation.</td>
</tr>
<tr>
<td>SET MPG tF00</td>
<td>Calculates your average m.p.g. over the last 6 to 10 gallons*. tF stands for &quot;tank Fraction&quot;. Enter here the position of the needle on your petrol gauge. If it is reading half full enter tF50; if it is a quarter full enter tF-25 etc. To make a completely accurate result fill the tank and enter fuel purchases in the usual way (above) then the tF-99 should be entered. After pressing SET, average m.p.g. will be displayed. Press SET to return to normal computer operation.</td>
</tr>
<tr>
<td>SET COST NUMBER SET</td>
<td>Enter here the cost of a gallon (equal to the volume of your petrol tank, see calibration section.</td>
</tr>
</tbody>
</table>

The Outrider car computer is available from: Mark Space Enterprises, 11 Church Green Rd., Bletchley, Milton Keynes MK3 6BJ. The complete kit costs £59.95 inclusive of carriage and VAT. A kit comprising those parts not generally available, i.e. case, label, 5 x front panel switches, p.c.b.s, 4 x 7-seg. displays, coil, programmed ROM is available for £29.95—most useful for the constructor with a well endowed spares box!

When ordering, please specify the make and model of the vehicle if known.

NEXT MONTH: Construction, installation and setting up.
The demonstration model is now under construction on a hill at Lifracombe, Devon, and should be operational by the end of the year. It has a three-bladed rotor 25m in diameter and will generate up to 250kW. The project is financially aided by the EEC and by the Department of Trade and Industry. Naturally, the control system is electronic and one of the more interesting features is that microprocessor technology is employed for remote control over a telephone link from WEG's offices in Greenford, Middlesex, together with feedback of operating data for analysis.

The windmills of the 80s and 90s will help conserve oil resources but that is not the main sales message. The real truth behind WEG's optimistic sales forecast is that by clever engineering wind energy is now price-competitive with conventional diesel generated electricity in small communities.

**Turnabout**

Conventional wisdom has it that the requirements of national defence and, in particular, a fighting war, is the forcing ground for truly innovative developments. The most notable example is radar which made enormous progress during World War 2 and didn't come into civil use on any scale until after the conflict.

An offshoot of radar was microwave technology which, again, only surfaced for civil communications use after the war. Today, we still hear stories that defence R & D operates on the very frontiers of knowledge and with large budgets, especially in the United States, there is still an element of truth in such assertions.

But curiously, the most revolutionary innovations of all time, the integrated circuit and later the microprocessor, had their origins in the civil market and were adopted only with some reluctance by the military.

The first simple i.c.s were the brain-children of the Texas Instruments and Bob Noyes of Fairchild Semiconductor in 1958 and 1959. Acceptance by the industry was painfully slow until ten years later Intel was formed (in 1968) as a specialist i.c. company with its first product a 64-bit solid state memory.

In 1968 a Japanese company, Busicom, asked Intel to help produce a set of i.c.s for a projected range of high performance calculators. Busicom's ideas were very good but in the opinion of Intel's project engineer, Dr Marcian E. Hoff Jr, they could be made more cost-effective by adopting a systems approach using a general purpose central processor and using peripheral memory chips to achieve the calculator functions.

Hoff had previously worked on the PDP-8 computer at Digital Equipment and was systems-trained. He also foresaw many applications other than calculators where a CPU could be of value. This was the beginning of the MPU as we know it today and what brought Intel to its present impressive status in the industry.

Hoff's i.c. went out of business in November 1971 with the 4004 CPU chip followed by the 8008, the first of the 8-bit chips and a succession of more powerful devices. By 1975 the new innovation was gaining ground with Intel and its competitors shipping 1 million chips.

Five years later the annual shipments had topped 50 million. Ironically, Busicom who had started the bandwagon rolling went out of business. Note, too, that cross-fertilisation of TI and Fairchild's original work plus Digital Equipment system experience plus market demand (Busicom) combined with Intel's own expertise to generate something entirely new.

The military are not entirely to blame for tardiness in adopting the new technology. They were apprehensive over reliability in view of earlier experience with transistors which were sensitive to breakdown through power line surges and spikes. Additionally there were storage and other military specifications to be met. Many of today's operational devices for the military depend on Mil Spec qualification in both production and testing but in non-operational or sheltered environments good commercial quality is good enough.

We see this also in certain items of equipment. Naval electronic warfare equipment for the military depends on operational quality and it has to be good because in nearly all cases, to search for alternative sources of revenue.

University R & D is a case in point. It has been traditional for research departments to take out patents and enjoy the benefits of royalties but there are now signs that our academics are becoming far more business-minded. They are actually forming separate companies to sell their services. Thus we see Safford's Industrial Centre. Unisheff Ventures owned by Sheffield University and Unived Technology set up by Edinburgh University.

There are others and the trend is likely to continue. As private companies they can raise their own funds in the commercial market and even conceivably go beyond R & D and consultancy work through to manufacture and marketing, either independently or in joint ventures with existing companies.

How refreshing to see people rising to a challenge instead of indulging in perpetual self-pity.
Folding LCD Multimeter With Auto-Range

£64.95

- Automatic Range Setting
- Automatic Polarity Reverse
- Automatic Power-Off When The Case Is Shut!
- Extra Large Non-Glare Display
- "Beep" Indicator For Quick Continuity Testing

It's the DVM that thinks! YOU select the function and IT selects the proper range automatically. Features extra large 11/16" non-glare display with adjustable viewing angle, a built-in compartment for its test leads, "beep" indicator for quick continuity testing, range-hold switch to override autoranging, diode/semiconductor junction check function and zero-ohms adjust for super-accurate low resistance measurements. DC volts to 1000. AC volts to 500. Up to 10 amps AC and DC. Resistance to 2 megohms. Open: 107/8 x 55/8 x 11/2". Requires two "AA" batteries. 22-193

Snaps Shut When Not In Use!

Compact 25-Range, 20,000 Ohms/Volt Folding Multimeter

£19.95

- 90-120-150-180° Hold-Position Hinge
- Fuse and Surge-Absorber Protection

"Big meter" features include fuse and surge-absorber protection, 4" three-colour mirrored meter with automatic shunt protection (when shut) 20,000 ohms per volt DC sensitivity. DC Volts: 0 to 1200, 7 ranges. AC Volts: 0 to 1200, 5 ranges. DC Current: 0-60 mA, 3-30-300 mA, 4 ranges. Resistance: 0-2-200k-2 megohms (centre scale 24). dB: -20 to +63 dB, 5 ranges. Accuracy: ±3% DC, ±4% AC. Measures Open: 71/4 x 45/16 x 11/2". Requires "AA" battery. 22-211

Folds Up For Travel!

Take A Look At Tandy, Today!

Visit your local store or dealer and see this and many more sale bargains. We service what we sell - over 2,700 exclusive lines!

See Yellow Pages For Address Of Store Nearest You

OVER 9,000 STORES & DEALERSHIPS WORLDWIDE

Prior to this advertisement, all quoted regular prices have been charged during the last six months at the Tandy Store, Tameway Tower, Bridge Street, Walsall, West Midlands. WS1 1LA.

Known As Radio Shack In The U.S.A.

Prices may vary at Dealers

Offers subject to availability
We have already made some use of a simple data latch configured around the four D-type bistable stages of a 7475. Data latches are ideal for the temporary storage of data and several enhanced devices have appeared. One such device, the 74175, is a quad edge-triggered bistable which can be used both as a conventional parallel type latch having separate data input and output lines from each bistable, and as a serial type shift register where data is fed from one bistable stage to the next.

The 74175 is housed in a 16-pin D.I.L. package, the pin connections of which are shown in Fig. 3.1. The internal logic of the device is shown in Fig. 3.2. A common clock input is applied to each of the bistable stages and data present on the D inputs is transferred to the Q outputs on the positive-going edge of the clock pulse. It should be noted that clock triggering occurs at a particular voltage level present at the clock input and is not directly related to the transition time of the positive-going pulse. A common master reset input is also provided which, when taken low, asynchronously clears all of the Q outputs.

**74175 4-BIT PARALLEL DATA LATCH**

We shall start our investigation of the 74175 by showing how it can be used as a 4-bit parallel data latch in the arrangement shown in Fig. 3.3. The four incoming data lines are connected to the four D inputs whilst the four output lines are derived from the four Q outputs. The latch enable signal is applied to the clock input whereas the clear signal is applied to the master reset pin.

The 74175 should be inserted into socket C of the Logic Tutor ensuring, as usual, that pin 1 aligns with C1. The following connections should be made:

- C1 to logic 1 (active low clear)
- C2 to D1 (D1 shows state of Q0)
- C4 to S1 (data input, D0)
- C5 to S2 (data input, D1)
- C7 to D2 (D2 shows state of Q1)
- C8 to OV (common)
- C9 to clock (latch enable)
- C10 to D3 (D3 shows state of Q2)
- C12 to S3 (data input, D2)
- C13 to S4 (data input, D3)
- C15 to D4 (D4 shows state of Q3)
- C16 to +5V (supply)

Adjust S1 to S4 to produce logic 0 on all input lines. Check the state of the output lines (Q0 to Q3) by examining the state of D1 to D4 and verify that these all go to logic 0 (and stay at logic 0) after the first rising clock edge. Now wait until the clock goes low and depress S4 so that logic 1 appears on this input. The corresponding output (indicated by D4) should remain at logic 0 until the clock next goes high, at which point the output should change to logic 1.

Readers should experiment with various combinations of data input obtained by appropriate adjustment of S1 to S4. It should be noted that, in all cases, data is only latched on a positive going clock edge (i.e. as the clock i.e.d. becomes illuminated). Furthermore, after the clock transition has occurred, the 74175 ignores any further changes on its data inputs until the next rising clock edge arrives. In practice, this means that input data MUST remain stable for the duration of the rising latch enable input signal since this is the only time at which the input data is valid.
The clear input may now be tested by first loading data into the latch, disconnecting the link from C1 to +5V (the input pin of the 74175 remains at logic 1 during this process) and then connecting the link from C1 to logic 0. All four outputs should then immediately go to logic 0 and no further data will be latched until the clear input is returned to logic 1 (or left to float high again).

**A SIMPLE LOGIC ANALYSER**

Here is an example of the use of the data latch. One of the primary functions of a logic analyser is that of "capturing" transient data present in a microprocessor based system and "freezing" it so that it can be displayed and examined at leisure.

The point at which data is captured is defined by a "trigger event". This usually takes the form of a particular set of logic states present on the control bus. When this pre-set bit pattern occurs, data is latched into the memory of the logic analyser, decoded and displayed in binary or hexadecimal form.

A very simple form of logic analyser is shown in Fig. 3.4. Two 4-bit data latches are used to capture the lower nibble (present on data lines D0 to D3) and the upper nibble (present on data lines D4 to D7). The clock and clear lines of all eight bistable stages are common; the clock being driven from the trigger event decoding logic (which is arranged to produce a 0 to 1 transition when the trigger event occurs) whilst the clear line is connected to a push-button 'reset' switch.

Whilst this simple arrangement is only capable of capturing a single byte (i.e. the eight data bits present on the bus) at a time, most logic analysers provide a memory of 1K bytes (or more) and, in addition, will offer the facility to capture data both before and after the pre-determined trigger event.

**SHIFT REGISTERS**

Shift registers essentially provide a form of serial memory (as opposed to the parallel form of data latch which we looked at last month) in which data can be synchronously clocked from one stage to the next. In a simple shift register made from D-type bistables this means that the Q output of the first stage must be taken to the D input of the next stage, and so on. A register of this type is shown in Fig. 3.5 and is known as a serial-input/serial-output (SISO) shift register.

Instead of using D-type bistable elements in the SISO shift register we could, of course, use J-K bistables. The equivalent of Fig. 3.5 using J-K bistables is shown in Fig. 3.6. Both of these arrangements use four cascaded bistable elements, thus four clock pulses will be needed in order to shift data right through the shift register.

At this point it is probably worthwhile making a clear distinction between the SISO shift register and the simple binary counter. In the former case, the clock line is common to every bistable element whereas, in the latter, the Q output from the first stage feeds the clock input of the next stage, and so on.

On its own, the SISO type of shift register is only capable of providing a delay equivalent to the length of the shift register in clock pulses. Hence an 8-stage SISO shift register will, for example, impose a delay of eight clock pulses between serial data entering the register and that leaving it.

Other types of shift register do, however, have a seemingly endless variety of applications arguably the most important of which involves the conversion of serial data to parallel data and vice versa. In such cases the basic SISO register arrangement must be modified so that parallel data access (input and/or output) is possible. One
obvious possibility is that of making each Q output of the SISO shift register available. Such an arrangement is shown in the serial-input/parallel-output (SIPO) register of Fig. 3.7. Here serial data is synchronously clocked into the register and, after the requisite number of clock pulses (four in this particular case), the register is completely loaded and the data is then available in parallel form from the four Q outputs.

Another possibility is that of parallel loading the data into a shift register using the PRESET and PRECLEAR inputs of the bistable elements. Data may then be shifted out in serial form. Such an arrangement is known as a parallel-input/serial-output (PISO) shift register, a simplified form of which is shown in Fig. 3.8. The data on the parallel inputs should not, of course, be allowed to affect the state of the bistable elements during the shifting process and hence the PISO shift register must have additional logic to control the parallel loading of data. Most, if not all, PISO shift registers also provide a serial data input and thus can be also used for serial-to-parallel data conversion.

A further refinement is that of providing both parallel data input and parallel data output from the shift register. Such an arrangement is shown in Fig. 3.9 and is known as a parallel-input/parallel-output (PIPO) shift register. This arrangement, which is sometimes also referred to as a “universal shift register”, is very similar to that of the PISO, the only difference being the addition of data output lines derived from the Q outputs of each bistable stage.

We shall begin our practical investigation of shift registers showing how a simple SIPO arrangement can be built using the four D-type bistables of a 74175 quad data latch. The 74175 was introduced last month and hence we will not repeat the pin-out or internal logic schematic of the device.

**SIPO SHIF REGISTER USING THE 74175**

The circuit diagram of a simple SIPO shift register based on the 74175 is shown in Fig. 3.10. It should be noted that the clock input (pin-9) is common to each D-type bistable. The active-low clear input is taken to logic 1 and the serial data input (derived from push button S1) is taken to the D input of the first bistable stage. The four I.e.d. indicators of the Logic Tutor are used to monitor the state of the Q outputs. With the 74175 in socket C (and with pin-1 aligned with C1), make the following connections on the Logic Tutor:

- C1 to logic 1 (active low clear)
- C2 to D1
- C3 to D2
- C4 to D3
- C5 to D4

**Fig. 3.7. A 4-bit SIPO shift register using D-type bistables**

**Fig. 3.8. A 4-bit PISO shift register using D-type bistables**

**Fig. 3.9. A 4-bit PIPO shift register using D-type bistables**

**Fig. 3.10. A SIPO shift register based on a 74175 quad data latch**
The subsequent movement of the logic 1 in Fig. 3.11 should be observed as it shifts right. After the fourth clock cycle, S1 should then be released and the register will empty as the logic 1's are successively replaced with logic 0's. After observing this process for one or two further periods of four clock cycles, readers should be reasonably familiar with the operation of this simple form of 4-bit SIPO shift register.

It should be noted that the outputs of the 74175 shift register can be simultaneously set to logic 0 by taking the active-low clear input to logic 0. Readers may wish to confirm that this is so.

To convert the arrangement used in Fig. 3.10 to that in Fig. 3.12 it is only necessary to disconnect the link from C4 to S1 and reconnect C4 to C14. When power is applied the register will successively fill with 1's and then 0's, taking eight clock cycles for the complete sequence.

THE 74195

The 74195 is a versatile 4-bit parallel access PIPO shift register. The device is useful in a wide variety of shifting, counting and storage applications. The 74195 is particularly suited to high speed serial-to-parallel and parallel-to-serial data conversion. The device is housed in a 16-pin d.i.l. package, the pin connections of which are shown in Fig. 3.14. The internal logic of the device is shown in Fig. 3.15. The 74195 has two distinct modes of operation: shift right and parallel load. These modes are selected by means of a SHIFT/LOAD input. In the shift mode the SHIFT/LOAD control input is taken to logic 1 and serial data enters the first bistable via the J and K inputs when the SHIFT/LOAD input is at logic 1. Data is then shifted through the register one bit (in the direction Q0 to Q3).
Fig. 3.14. Pin connections for the 74195

Fig. 3.15. Internal logic of the 74195

Fig. 3.16. Parallel 4-bit PIPO shift register using the 74195

$\Rightarrow Q_1 \Rightarrow Q_2 \Rightarrow Q_3$ following each low-to-high clock transition.

In the parallel load mode the SHIFT/LOAD control input is taken to logic 0 and data on the four parallel data inputs ($D_0$ to $D_3$) is transferred to the respective bistable outputs ($Q_0$ to $Q_3$) at the next low-to-high clock transition.

Shift left operation ($Q_3 \Rightarrow Q_2 \Rightarrow Q_1 \Rightarrow Q_0$) can also be achieved by tying the $Q_0$ outputs to the $D_{n-1}$ inputs (i.e. $Q_3$ to $D_2$, $Q_2$ to $D_1$, $Q_1$ to $D_0$) and holding the SHIFT/LOAD control input at logic 0.

It should be noted that all parallel and serial data transfers are synchronous and occur after each positive clock edge is received. Furthermore, by virtue of the edge triggered characteristic, there is no restriction on the activity on the $J$, $K$, $D$ and SHIFT/LOAD inputs other than that associated with set-up and release.

The 74195 also has an active low clear input which sets all $Q$ outputs low independent of any other input condition. It should be noted that, since the clear and clock inputs are internally gated, to avoid false clocking a low-to-high transition on the clear input should only be permitted during the period for which the clock is low.

The 74195 should be inserted into socket B of the Logic Tutor ensuring, as usual, that pin-1 aligns with B1. The following connections should then be made:

- B1 to S3 (active low clear)
- B2 to B3 (serial data input)
- B3 to S1 (parallel data input $D_0$)
- B4 to logic 1 (parallel data input $D_1$)
- B5 to logic 0 (parallel data input $D_2$)
- B6 to logic 1 (parallel data input $D_3$)
- B7 to logic 0 (common)
- B8 to OV (shift/load control)
- B9 to S4 (clock input)
- B10 to clock (D4 shows state of $Q_3$)
- B12 to D4 (D3 shows state of $Q_2$)
- B13 to D3 (D2 shows state of $Q_1$)
- B14 to D2 (D1 shows state of $Q_0$)
- B15 to D1 (supply)
- B16 to +5V (A total of 15 links)
The Logic Tutor arrangement conforms to the circuit shown in Fig. 3.16. The shift register should be tested by first adjusting S3 to produce a logic 0 input on the clear line. All i.e.d. indicators should immediately become extinguished as all the Q outputs go low. Note also that S1 and S4 have no effect whilst the clear line is held low. Now adjust S4 to produce a logic 1 on the SHIFT/LOAD input and then operate S3 to generate a logic 1 on the clear line. The register will now commence loading from the serial input but, since S1 is producing logic 0, there will be no change in any of the Q outputs and the i.e.d. indicators will remain extinguished.

Now wait for the clock to go low (D9 extinguished) and depress S1. This places a logic 1 on the serial input. Notice how, as the clock next goes high, this logic 1 is transferred into the first stage of the shift register and D1 becomes illuminated as the first bistable changes state and Q0 goes high. Now release S1 and notice how a logic 0 loads into the first stage on the next rising clock edge, and so on. This arrangement conforms to the circuit diagram shown in Fig. 3.17. Serial data can be fed into the register by means of S1 and cleared by means of S3 (a logic 0 being required to clear the register). Now wait for the clock to go low and then press S1 to generate a logic 1. D4 will become illuminated when the next rising clock edge occurs and data will then be subsequently transferred from Q3 to Q2 (D4 to D3) on the next rising clock edge, and so on. To clear the register S3 should be adjusted for logic 0 and all Q outputs will then go low regardless of the state of the clock.

**SHIFT LEFT OPERATION**

In order to obtain shift left operation, the 74195 should be left in socket B and the links re-arranged as follows:—

| B1 to S3 | (active low clear) |
| B2 to B3 |
| B3 to logic 1 |
| B4 to B14 |
| B5 to B13 |
| B6 to B12 |
| B7 to S1 | (serial data input) |
| B8 to OV | (common) |
| B9 to logic 0 |
| B10 to clock | (clock input) |
| B12 to D4 | (D4 shows state of Q3) |
| B13 to D3 | (D3 shows state of Q2) |
| B14 to D2 | (D2 shows state of Q1) |
| B15 to D1 | (D1 shows state of Q0) |
| B16 to +5V | (supply) |

(A total of 15 links)

This arrangement conforms to the circuit diagram shown in Fig. 3.17. Serial data can be fed into the register by means of S1 and cleared by means of S3 (a logic 0 being required to clear the register). Now wait for the clock to go low and then press S1 to generate a logic 1. D4 will become illuminated when the next rising clock edge occurs and data will then be subsequently transferred from Q3 to Q2 (D4 to D3) on the next rising clock edge, and so on. To clear the register S3 should be adjusted for logic 0 and all Q outputs will then go low regardless of the state of the clock.

**NEXT MONTH: Pseudo random numbers and universal shift registers**
RING MODULATOR

JOHN M.H. BECKER
PART 2

At this point it is worthwhile looking at some oscillograms of simple waveform combinations, produced with the unit described in Part 1. Table 1 shows a schematic representation of the control settings used.

<table>
<thead>
<tr>
<th>Fig</th>
<th>S7</th>
<th>S4</th>
<th>S6</th>
<th>S5</th>
<th>S3</th>
<th>S2</th>
<th>VRI</th>
<th>VR5</th>
<th>VR4</th>
<th>VR6</th>
<th>S1</th>
</tr>
</thead>
<tbody>
<tr>
<td>3a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3b</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3c</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5b</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5c</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5d</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6b</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6c</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6d</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6e</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6f</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6g</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6h</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6i</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6j</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6k</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6l</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7b</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7c</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7d</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Switch settings

WAVEFORM OSCILLOGRAMS

In Fig. 3, a triangle wave of 3kHz is being used as the carrier signal going to one input, though its actual waveshape is irrelevant at this moment. This is being modulated by a second waveform, on the other input, at a much lower frequency of about 150Hz. The two frequencies shown are widely diverse for illustrative convenience but a similar principle applies to other spacings. The modulating waveform is shown in the upper trace, and the composite output in the lower, with the higher frequency inside the 'bubble' envelope. It will be immediately apparent that the unit in the mode selected has doubled the frequency of the sinusoidal and triangle modulators to 300Hz. Although the ramp modulator appears not to be doubled, close examination of the oscillogram reveals that each diamond 'bubble' is in fact two, with a very fast change at the centre, coinciding with the ramp trailing edge. The effect of modulating by square wave is not shown as the edges are too fast to produce a readily visible effect, though it can just be discerned audibly. What is not apparent in the oscillogram is that the carrier within the 'bubble' now consists of 3kHz—300Hz = 2700Hz, and 3kHz + 300Hz = 3300Hz and on the oscilloscope the carrier in the alternate 'bubbles' is seen to be phase shifted by 180°, with a slight vibrato on its edges. Although the full harmonic content of the product signal is not seen in the oscillograms, the differentials can be heard clearly through an amplifier. Using two signal generators with one supplying a fixed frequency, the other is slowly swept across the audio spectrum. When the sweep frequency is rising but below the fixed one, two notes are heard at the output, one rising, the other falling. Close to frequency equality the lower note becomes progressively deeper until at the balance point the low frequency is totally cancelled and only a doubling of the fundamental is heard. As the sweep progresses upwards so two frequencies are again heard, but each rising, one more slowly than the other. The very low frequency heard near the balance point is clearly shown in Fig. 4. The high frequency within the shape is at twice the original. This then is the sum of the two, and the difference. The frequency doubling can also be verified without a scope by taking both the final signal and one of the originals into a mixer and alternating the pan control between both, whereupon the output differential is heard. The same can be repeated when a low frequency note modulates a high frequency one. If the high frequency is out of audio range, the low frequency modulator will be heard to be one octave lower than the bass content of the output.

FREQUENCY DOUBLING

Fig. 5 shows the effect of deliberately feeding the same signal in to both the modulating and carrier inputs. From these photographs it will be clear that frequency doubling occurs with each of the four different, original waveforms, but also that the output does not have the shape of the original. In the photographs of the ramp and squarewaves, both original waveforms have been intentionally slightly distorted so that the very fast intermediate peaks are more clearly seen. In all cases the frequency doubled peaks are more clearly seen. In all cases the frequency doubled peaks are more clearly seen.
spikier shape, even for the sine wave. Indeed in other frequency doubling methods known to the author, a similar degree of sharpening is experienced. Any frequency doubled signal is thus bound to be a harsher note one octave higher, especially so with the ramp, and from an audio position, frequency doubling of a square wave will only produce objectionable clicks as the mark-space ratio is so wide. Doubling still takes on a harsher sound when introducing a time delay, which produces a phase shift, to one of two identical signals. (Interesting sounds are produced though, if the complete ring modulator is preceded or followed by echo, or reverb units). The doubling effectiveness is also subject to the complexity of the original signal. For simple monotonic frequencies, the effect is quite usable. However, if used when the signal is complex, like trying to double the pitch of a chord or of multiple instruments, the effect is cacophony. Speech too takes on extremely odd noises if octave raising in a ring modulator is attempted. For true frequency doubling with waveform retention, much more complex equipment is needed.

![Fig. 3a. Sine-wave modulator](image)

![Fig. 3b. Triangle modulator](image)

![Fig. 3c. Rising-ramp modulator](image)

**Fig. 3 (above). Triangle wave 3kHz, used as the carrier. The upper trace is the modulating waveform and the lower, the composite output**

![Fig. 4 (above). High frequency modulator, with modulating carrier at almost same frequency showing effective slow-beat frequency](image)

![Fig. 5a. Sine-wave](image)

![Fig. 5b. Triangle-wave](image)

![Fig. 5c. Rising-ramp-wave](image)

![Fig. 5d. Square-wave](image)

**Fig. 5 (right). Effects of using the same signal in both modulating and carrier inputs**

**TRACKED RING MODULATING**

Another option available is to use the inputs with two accurately controlled waveforms of different frequencies. The most usual source of these is two oscillators of a synthesizer, with the frequencies tracking identically, and exactly spaced so that the correct harmonic relationship is the same throughout the range. The complex chording structure is then simpler to achieve. Referring back to the frequency example earlier, 'G' at 396Hz is 1.5 times the frequency of 'C' at 264Hz. Similar relationships between two original signals will produce other equivalent composites, though not necessarily of a concordant nature.

**FIXED CARRIER**

It is not necessary for the carrier frequency to be shifting in sympathy with the modulator and in many cases it is better to keep the carrier static for the production of some weird and interesting effects. When using a low frequency simple waveform with a higher frequency source such as speech or music, tremolo can be given to the music, and speech can be made to sound robot-like. In creating Dalek voices, one of the essentials is to modulate the voice at a low frequency, though other factors are involved in the production of the authentic Dalek sound. Tremolo and vibrato modulation are both effects that when used with discretion can greatly enhance the interest of many sounds.

For music the speed of modulation is at its most satisfying if the rate is in the region of 6-5Hz. In an analysis some years ago of the modulation given by violin players and opera singers, there was remarkable consistency between all of them, modulating their pitch within about 1 cycle of 6-5Hz. The author is involved in many types of effects units and finds that when testing rhythmic sources the most satisfying, and eventually the most hypnotic rates, are those within this same range. It is an interesting speculation that there might be a correlation between this frequency and the brain wave frequencies associated with Alpha and Theta rhythms. Theta rhythms are those with a frequency of about 4Hz to 7Hz, and which appear to be connected with mood. Alpha rhythms occur between 8Hz and 12Hz and occur most often in relaxed meditation. It is possibly no coincidence that the most satisfying tremolo and vibrato rates lie between the two.

Proper vibrato cannot be readily produced by a ring modulator as it involves true frequency shifting without additional tone generation, but tremolo with a trace of vibrato is easily obtained through low frequency amplitude modulation around 6-5Hz. Voice modulation for Dalek-type production lies in the range of about 15Hz to 30Hz. At frequencies lower than this the modulation tends to be lost amongst the consonant peaks of speech as the vowels are usually much shorter than in singing. As the modulation rate increases between 400Hz and 1kHz so a metallic quality is acquired by the voice, becoming more pronounced but less intelligible.
as the carrier goes beyond 1kHz. If music is modulated with a fixed carrier in the higher frequency ranges extremely uncanny effects are produced. This is particularly true of carriers between 3kHz and 6kHz, when music can take on an almost nightmarish quality. When working on the prototype, the author found that 10 or 15 minutes of this upper frequency modulation was all that was tolerable at one time. Using low frequency ramps and squarewaves to modulate complex higher frequency sounds usually results in objectionable clicks. However, these clicks can be made use of if the carrier is a single high frequency or white noise source. With the former ‘pinging’ sounds can be produced and with the white noise, a variety of steam engine effects can be created. Using a white noise generator in conjunction with an external pulse source can also produce sounds akin to gun shots.

Fig. 6 shows the effect of VR5 in the d.c. control mode at three settings when a high frequency intermodulates with a low frequency. As will be seen some quite distinctive waveform shapes appear, all of which have their own unique effect upon the final output quality. When bypassing the ALC control a 180° phase change occurs and the ramp waveform changes to the opposite slope introducing a fifth set of variations. Full modulation in the d.c. mode is intentionally inhibited as the increased level required would inherently raise the carrier breakthrough level. Full carrier modulation is of course provided when S4 is in the a.c. mode. When switching between both modes, the nature of the circuitry produces a cross-fade effect between them. This is due to the relative d.c. levels applied to C21 changing, at a rate determined by the biasing resistors and provides a smooth changeover. A similar effect is produced when S7 is switched in and out. Fig. 7 shows the effect of using the same signal as both modulator and carrier in the d.c. mode. Frequency doubling still occurs but with a changed amplitude relationship.

Fig. 6. Various effects in the d.c. control mode with a high frequency intermodulating with a low frequency

Fig. 6a. Sine-wave
Fig. 6b. Triangle-wave
Fig. 6c. Rising ramp-wave
Fig. 6d. Square-wave
Fig. 6e. Sine-wave
Fig. 6f. Triangle-wave
Fig. 6g. Falling ramp-wave
Fig. 6h. Square-wave
Fig. 6i. Sine-wave
Fig. 6j. Triangle-wave
Fig. 6k. Rising ramp-wave
Fig. 6l. Square-wave

Fig. 7. Effects of using the same signal for modulator and carrier in the d.c. mode

Fig. 7a. Sine-wave
Fig. 7b. Triangle-wave
Fig. 7c. Rising ramp-wave
ASSEMBLY

The p.c.b. layout is shown in Fig. 8 and the wiring diagram in Fig. 10. It is easiest to assemble the printed circuit board in order of component size, leaving the insertion of i.c.s into their sockets until last. The short wire links on the p.c.b. can be shaped from resistor offcut leads. It also helps with subsequent checking if the components are mounted with their identities readily visible. Diodes, electrolytic capacitors and i.c.s must only be inserted the correct way round as shown. At the very least the circuit will not work properly if this is ignored, at worst components could suffer extinction.

Wiring to the controls must be tackled neatly and methodically to avoid the unit looking like a pig's nest! Make the connections between the panel components first, then wire up to the p.c.b., keeping all wires coming round the edges of the p.c.b.—coming over it makes it messy. They should be reasonably short, but long enough to enable the p.c.b. to be turned over for track side examination. Try to get it right first time as the box space is tight and it is tricky to manoeuvre the p.c.b. between the various panel parts. Tick off components and wires as they are connected minimises errors, as does closely studying solder joints with a magnifying glass. These should look round and shiny, covering all round the solder pad on the p.c.b. If they look dull, crazed or daylight can be seen through them, then they are not good joints. Neither is one that has the solder spread across adjacent tracks. The author sometimes sees home assembled projects returned for servicing, and in practically all cases the only reason for malfunction is that improper attention has been given to soldering. It is very rare for modern components to be the cause of any misbehaviour.

SETTING UP

Alignment of the three presets is quite straightforward and no specialised equipment is needed. First, VR1 min, VR2 and 3 fully right, VR4 midway, VR5 min, VR6 max, VR7 halfway, S1 position 1 (sinewave), S2 position 1 (internal VCO), S3 up (gate off), S4 off (d.c. coupled), S5 up (slow VCO), S6 up (ALC bypass), S7 up (R-mod override). If a signal generator is not available it is preferable to use a pre-recorded speech or music track from a cassette recorder or similar during testing. Plug this in to the high input jack socket, and the output jack socket into the main amplifier. Check that the cassette signal reaches the amplifier, if necessary increasing VR1.
to a suitable level without distortion. Switch on S7 and a similar output level should remain. Switch on S4 to a.c. mode whereupon the sound should diminish. Slowly adjust VR3 around its midway point until the minimum level is heard. Bringing up VR5 to maximum, a slow modulation of the sound should be heard. Varying VR4 the modulation rate will change. Switching on S5 the rate will increase dramatically, and the quality of the audio output change with it. Remove audio source from the input leaving only the carrier signal. Switch S1 through its four settings and note that changes in carrier quality are evident. The carrier level will also change with the settings of S1. With S6 switched on to ALC mode the variations will be less pronounced and on an amplifier VU meter, the levels will appear practically the same. Maximise VR5 and carefully adjust VR2 around its midway point until carrier breakthrough is as low as possible. Again apply audio source from cassette. Switching on S7, carrier modulation will cease leaving only the original sound. Now align VR7 adjusting it around its midway point until minimum waveform distortion is heard at higher amplitudes. If no difference is noticeable, leave midway and ignore, though the correct setting will be obvious on an oscilloscope if a triangle waveform from a signal generator is used. Finally again remove the cassette, switch off S7, set VR5 max, VR4 and S5 set for maximum frequency. Increase amplifier volume until carrier breakthrough is audible. Switching on S3 the noise gate should come into operation and close down the output, eliminating all but the very smallest trace of crosstalk within IC4. Experiment with all the controls and switches with various types of speech and music inputs until familiar with the operation of the unit. If making minute adjustments to VR2 and VR3 allow the unit to be switched on first for a few minutes in case of a slight temperature sensitivity, although this was not apparent in the author's model.

The basic functions of a ring modulator have been covered in the introduction. The use of the unit is otherwise subject only to the imagination of the user. It will soon become familiar knowledge which settings are best for which type of input, whether for trains or tremolo, musical effects, or for modifying speech for robot and Dalek type vocalisations.
TERMS OF BUSINESS

- All prices exclude V.A.T. and carriage. Please add carriage to order total before adding V.A.T.
- Carriage charges extra on all orders as follows:
  - UK: £0.75
  - Books/Data/Software: £2.00
  - Printers, Monitors, Disc drives, etc: £4.50
- Strictly cash with order or credit card (Access or VISA) only.
- Any query or complaint regarding an order should be made in writing within 7 days of receipt of the order. No telephone queries will be entertained.
- Goods incorrectly ordered cannot be accepted for replacement without our prior agreement. Due to high processing costs a minimum of 15% handling charge may be levied on any returns or cancelled orders.
- We will issue a full immediate refund, if requested, for out of stock items.
- All items carry full manufacturers warranty.
- A V.A.T. receipt will be supplied with all orders.
- Prices quoted are correct at the time of going to press but we reserve the right to effect changes without prior notice.
SOLDERING is one area of electronics where many constructors seem to give little thought to either the equipment they use or the methods they adopt. This often causes damage to components and p.c.b. tracks and can result in many unnecessary hours of fault finding once the project has been assembled. These problems can be easily overcome by using a suitable soldering iron and following the few simple rules set out below.

The basic requirement of a soldered joint is to provide an electrically conductive path with a secondary consideration being the mechanical strength of the joint.

Before soldering it is essential that the surfaces to be soldered are clean and free from any dirt or grease. If solder is to be applied to any heat-sensitive components then a suitably sized heat-shunt should be used. These are normally in the form of specially designed tweezers, although many people prefer to use a small pair of pliers.

The most important part of the soldering iron is the 'tip' or 'bit'. This is the part of the iron which stores the heat ready for passing onto the joint. The size of the bit and the power rating of the iron will determine the amount of heat that is supplied by the iron to the work and also the rate at which the work can be carried out.

When choosing a soldering iron for your particular needs you must take into account all the applications for which it will be used. Soldering irons come in a variety of wattages, bit sizes and operating voltages. Some irons come as part of a soldering station and include a holder, sponge tray and a temperature adjustment to set the operating temperature of the bit.

In this buyer's guide we have tried to show the wide range of soldering irons currently available and have also included some of the soldering aids that can be used.

The prices shown include VAT but not post and packing except where stated.

**PLEASE NOTE**

We would like to point out that readers buying from the guide are not protected by the Mail Order Protection Scheme unless the company concerned have advertised the product in a display advertisement in this issue.

The guide is designed as an aid to the purchaser and makes no recommendations.
The Oryx M3 iron is rated at 17 watts and has a normal operating temperature of 380 degrees centigrade. It is supplied complete with a replaceable push-on tip and storage hook. The M3 is available in 12V, 110V and 210/240V versions with the 12V model fitted with a cigar-lighter plug for car repair work. Priced at £6.85 it is available from Greenwood Electronics, Portman Road, Reading, Berks 0734 595844.

The Litesold EC50 has an electronic temperature control which can be easily adjusted via an aperture in the handle. The temperature can be adjusted between 280 and 400 degrees centigrade. The bits are iron coated copper for long life and are retained by circlips to prevent sticking. The 50 watt iron is priced at £28.00 and is available from Light Soldering Developments Limited, Spencer Place, 97/99 Gloucester Road, Croydon 01-689 0574.

The LC18 from Litesold is a high efficiency iron suitable for general electronic assembly and servicing work. It can be either mains or low voltage powered and takes a wide range of bits. The LA12 is similar to the LC18 but is rated at 12 watts and is mainly intended for smaller work. The LA12 is priced at £7.25 and the LC18 is priced at £7.31. Light Soldering Developments Ltd, 01-689 0574.

The Weller WM12D weighs just 7 ounces and is the smallest iron in their range. It is rated at 12 watts and develops a tip temperature of 425 degrees centigrade. There is a choice of three tips which can be easily interchanged. The WM12D which is priced at £6.58 is also available in kit form together with two spare tips, a pair of tweezers and a supply of resin cored solder. Cooper Tools Limited, Sedling Road Wear, Washington, Tyne & Wear 091 416 6062.

The new portable butane powered soldering iron from Oryx is only slightly bigger than a felt-tip pen. There is no flame during use, the chemical energy of the gas is converted into heat by means of a catalytic converter in the bit. The iron delivers the equivalent of 60 watts with the tip temperature being variable between 250 and 450 degrees centigrade. The iron will run for 60 minutes on its gas supply. The Oryx Portasol is available from Greenwood Electronics and is priced at £17.25. 0734 595844.

The totally self-contained Oryx HSR1 requires no external air or vacuum supply lines. It consists of five units: the TC84 temperature controlled iron, the SR84 vacuum solder removing iron, the p.s.u. and two magnetic base safety stands for the irons. The TC84 is fitted with a fume extractor which can be switched from the TC84 to the SR84 as required. The workstation is priced at £570.00. Greenwood Electronics 0734 595844.
SOLDERING INSTRUMENT BUYER'S GUIDE

The Litesoild ETC-4/FXc soldering station has a built in fume extractor (see inset), and fully variable electronic temperature control with digital readout. The 40 watt iron uses a thermocouple sensor, is “spike” and “r.f.i.” free, and also free of static and leakage. Price £299 + p&p from Light Soldering Developments Ltd., Spencer Place, 97/99 Gloucester Rd., Croydon, Surrey CRO 2DN. 01-689 0574.

The TCSU-D is a 60-watt soldering station with an electronic temperature control range of ambient to 495 deg. C. The iron itself works on 24V stepped down from mains to safety and isolation. Price £80-81 from Antex (Electronics) Ltd., Mayflower House, Plymouth, Devon. 0752 667377.

P.c.b. Track Repair Kit includes master frames with tracks, fingers, pads, elbows and flatpack pads, eyelets and funnelets plus the setting tools. Includes epoxy, flux, cleaner, spatulas, abrasive sticks, tweezers, clamps and knives. An economy version is also available. Price, standard £145-90. Economy £72. OK Industries UK Ltd., Dutton Lane, Eastleigh, Hants SO5 4AA. 01-619841.

SA-6 desoldering iron is a powerful lightweight tool combining heating and suction. The suction chamber is easily removed for cleaning. Available. 115 or 230V. Price £19-19 from OK Industries.

Adcole 101 electronic controlled soldering iron is production orientated. Features r.f.i. free temperature control, zero leakage, open circuit free and quick recovery, decade adjusting, variable temp. dial with cut out, and protection. Price £75-60. (63 carryage) from Adcole Products Ltd., Adcole House, Gauden Rd., London SW4 6LY. 01-622 0291.

SA-8 series industrial grade soldering irons, available in 371 deg. C (SA-8-15) and 427 deg. C (SA-8-20), heat-up in two minutes using ceramic elements. They may be used with static-sensitive components without earthing. Tips are corrosion resistant. Available in 115 and 230V versions. Price £21:80, from OK Industries.
The Weller SI-25 25 watt iron, along with the Weller SI-15, SI-40 and WH1/2 hobby kits are claimed to be the only soldering related products on the market entitled to display the BEAB seal of approval for safety. Price £7.80 from Cooper Tools Ltd., Sedling Rd., Wear, Washington, Tyne & Wear NE38 9BZ. 091 416 6062.

**Litesold SK18 Soldering Kit** includes the LC18 18 watt iron along with a selection of bits, 18 s.w.g. fluxed solder, tweezers, three other aids and desolder braid. All in p.v.c. wallet. Price £15.24 from Light Soldering Developments.

Oryx ISO-TIP series irons are cordless (rechargeable) for complete mains isolation. The iron automatically recharges itself when placed in its base, and has a built in spotlight. The 50 watt iron can solder 100 joints between charges. Tip temperature is 370°C. Also takes a drill attachment. Price £41 from Greenwood Electronics, Portman Road, Reading, Berks RG3 1NE. 0734 995644.

**Solon-Electrex DS400 Station** supplied with TC24 Iron (50 watt) is thermostatically controlled from 150–400 deg. C (1% precision) with digital readout. The iron takes the 'Duratyp' range of bits. Price £138.69 from GEC-Henley, Gravesend, Kent DA11 9DA. 0474 644666.

**Solon-Electrex 325** is a 25 watt mains 'instant' heat soldering iron of maximum temperature 380 deg. C. It uses C25 tip or TP30. Price £10.79 from GEC-Henley.

**Adamin Model 15** miniature iron is available in 240V or 12V (12 watts). One of the smallest irons in the world and takes a range of bits from 1.2mm. Price (iron) £5.97, (spring stand) £5.11 from Light Soldering Developments Ltd., Spencer Place, 97/99 Gloucester Road, Croydon.

---

Practical Electronics December 1984
GLORIOUS PAST—BRIGHT FUTURE

A rather sad note has been struck. The Carnegie Institute of Washington, which operates the observatory on Mount Wilson in California, has announced that during 1985 the great 100-inch Hooker reflector there will be "mothballed," and support for the two famous solar tower telescopes, the 150-foot and the 60-foot, will be gradually withdrawn. The other large instrument, the 60-inch reflector, will remain in service, but, as one commentator has said, the decision "sounds the death-knell" for Mount Wilson as a leading astronomical institution.

The trouble is due to the continued spread of the city of Los Angeles, which has become not only larger, but also brighter and more polluted. From the city, the summit of Mount Wilson can be clearly seen, and from the top of the mountain the sky is not nearly so dark as it was in 1917, when the 100-inch reflector came into operation. This means that many branches of research can no longer be carried out there.

The 100-inch has a glorious history. When it was completed, it was not only the world's largest telescope, but it was in a class of its own, and it remained so until 1948, when it was surpassed by the Palomar 200-inch.

Using the Mount Wilson reflector in the 1920s, Edwin Hubble proved that the objects then called "spiral nebulae" were in fact independent galaxies, far beyond the limits of our own Milky Way system. Hubble achieved this by studying the behaviour of certain variable stars inside the spirals. These variables, known as Cepheids, "give away" their real luminosities—and hence their distances—by the way in which they brighten and fade. In Hubble's day, only the 100-inch was powerful enough to be used in studying them.

The telescope itself is as good today as it ever was, but by modern standards it is old-fashioned, and there is no thought of moving it to a better site. So its story may be coming to a close, even though it is still capable of carrying out really valuable research. At any rate, its place in history is assured, and mercifully there has been no suggestion as yet that it will be dismantled, so that hope remains.

Two major telescopes are being planned elsewhere: one in Hiroshima in Japan, and the other to be set up at the observatory on La Palma, in the Canary Islands, where the I.N.T. or Isaac Newton Telescope is now in full operation. (While I was there, a few months ago, we used the I.N.T. to obtain a colour video picture of the Ring Nebula in Lyra—the first time that this had been achieved for an object beyond the Solar System.) The projected new telescope is a 100-inch reflector, and will be a joint venture by Norway, Sweden, Denmark and Finland. The optics will be made at Turku in Finland.

Halley's Comet is now under regular observation, and continues to brighten slowly as it draws in toward the Sun, but it will not come within the range of average-sized telescopes until the middle of next year. Unfortunately, this is a poor return, and the comet will be not nearly so conspicuous as it was in 1910 or in 1835, though with luck it will be easily visible with the naked eye towards the end of 1985.

THE SUN

On 22-23 November there will be a total eclipse of the Sun. The path of totality begins in the Molucca Islands and then crosses New Guinea, passing north of New Zealand and ending in the South Pacific. The maximum length of totality is exactly two minutes.

The partial phase will be seen from the Philippines, parts of Australia and New Zealand, and also from part of Antarctica, but of course the eclipse will be invisible from Europe, as it occurs during European night.

The next total eclipse to be seen from anywhere in Britain will be that of 11 August 1999, when the track of totality will cross Cornwall.

Despite Skylab and other space-stations, total solar eclipses are still of tremendous importance, because it is only when the Sun is completely covered by the Moon that ground-based observers can see the corona in its full glory. At this month's eclipse the corona will be of the "minimum" type, because the Sun is now approaching the lowest point of its 11-year cycle of activity. There have already been several spotless periods this year, when the solar disc has been entirely blank.

The solar cycle is not perfectly regular, and the usually quoted figure of 11 years between successive maxima is only an average. Moreover, it may well be that we know less about the Sun than we used to believe. Even the cycle may not be permanent; there is excellent evidence that between 1645 and 1715 there were almost no sunspots at all—a period now generally known as the Maunder Minimum, since attention was first drawn to it by the British astronomer E. W. Maunder (and, independently, by Spörer in Germany).

SPACE MINE

Very important studies are being carried out from what is undoubtedly one of the strangest observatories in the world: It is situated a mile below ground, at Homestake Mine in South Dakota. This is the country of the gunslingers; little more than a century ago it was the home of colourful characters such as Calamity Jane, Wild Bill Hickok and "Doc" Holiday.

It is also a gold-mining area. Today the gunslingers have gone, but the gold is still there, and Homestake Mine is the largest in the whole of the United States. The solar observatory has been set up in a special chamber, or rather pair of chambers, hollowed-out specially for the purpose.

The Sun is radiating by nuclear transformations taking place near its core. Basically, hydrogen nuclei are combining to form nuclei of helium, with release of energy and loss of mass. (The mass-loss amounts to 4,000,000 tons per second, though by solar standards this is not very much, and there is no reason to suppose that the Sun will change dramatically first-discovered of the minor planets or asteroids, comes to opposition on November 10. It is in Taurus, near the stars Xi and Omicron Tauri, but its magnitude is only 6.9, so that it is too faint to be seen with the naked eye. Binoculars will show it, though of course it looks exactly like a star. Its diameter is rather over 620 miles, and it is much the most massive member of the asteroid swarm.

Plans for asteroid probes are now being made, and should be put into practice by the mid-1990s, but it seems likely that the first target will be not Ceres, but Vesta—the brightest member of the group—which is smaller than Ceres, but considerably closer in to the Sun.

THE SKY THIS MONTH

This is not a particularly good month from the viewpoint of planetary enthusiasts. Mercury, Venus, Mars and Jupiter are all technically evening objects, but Mercury is well south of the celestial equator, and badly placed from Britain, even when at its greatest eastern elongation on 25 November.

Mars and Jupiter are also in the southern hemisphere of the sky, and set not long after the Sun; moreover Mars is now so far away that its magnitude has faded to 0.8, about the same as that of Aldebaran, and even large telescopes will show little upon its disc. Saturn is in conjunction with the Sun on November 11, and is therefore out of view altogether.

It may be worth noting that Ceres, the largest and

SPACEWATCH

BY D. PATRICK MOORE O.B.E.
for at least 5,000 million years in the future.) Theorists also calculate that there should be the emission of neutrinos, which are particles with no electrical charge and virtually no mass—so that they are extremely hard to detect, since they can pass through the Sun and also through the Earth without being checked.

The only way to catch them is by making them interact with atoms of chlorine. If a neutrino hits a chlorine atom, the result will be an atom of Argon-37, which is radioactive and is therefore comparatively easy to track down.

THINK TANK

In Homestake Mine, Dr. Ray Davies and his colleagues have set up a large tank containing 100,000 gallons of perchloroethylene, which contains a great deal of chlorine and is nothing more nor less than cleaning fluid! The procedure is to leave the tank for a period of around eight weeks, and then carry out tests to see how many atoms of Argon-37 have been produced.

Since there will not be more than about a dozen of them, and the whole tank contains about a thousand million million atoms of various kinds, the tests are far from straightforward. But for the radioactive qualities of Argon-37, there would be no hope at all.

Why "go underground"? The answer is simple. Cosmic rays from space will affect the chlorine in exactly the same way as neutrinos. But cosmic rays cannot penetrate a mile of solid rock—at least, not easily; a few can get through, but these can be allowed for. This is why Homestake is so suitable for this particular experiment.

The solar observatory has now been in action ever since the 1960s, and the results have been startling. Apparently the Sun is sending out only about a quarter as many neutrinos as in theory it ought to do. Unless there is something wrong with the experiment, which seems unlikely, or else there is a defect in our theories—or even the possibility that at the present epoch the Sun is behaving abnormally.

Neutrino emission is very sensitive to temperature. It has been calculated that the temperature at the core of the Sun is about 15,500,000 degrees Centigrade. If we reduce this by a million degrees, the neutrino results fall neatly into place, but such a fall in calculated temperature would raise other theoretical problems. Is it possible that neutrinos are more complicated than we think, so that they could break up or become modified during their 93,000,000 mile journey from the Sun to the Earth?

As yet we do not know. The Homestake results seem reliable enough, and are confirmed by a similar experiment being carried out in the Soviet Union. So we must do some re-thinking, and it is not surprising that solar physicists are placing great importance on the behaviour of a tank of cleaning fluid deep in a South Dakota gold-mine.

PRACTICAL ELECTRONICS
PRINTED CIRCUIT BOARD SERVICE

Printed circuit boards for certain PE constructional projects are now available from the PE PCB Service, see list. They are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £1 per board for overseas airmail. Remittances should be sent to: PE PCB Service, Practical Electronics Editorial Offices, Westover House, West Quay Road, Poole, Dorset BH15 1JG. Cheques should be crossed and made payable to IPC Magazines Ltd.

Please note that when ordering it is important to give project order code and the quantity. Please print name and address in Block Caps. Do not send any other correspondence with your order.

Readers are advised to check with prices appearing in the current issue before ordering.

NOTE: Please allow 28 days for delivery. We can only supply boards listed here or in the November issue.

<table>
<thead>
<tr>
<th>PROJECT TITLE</th>
<th>Order Code</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horologium</td>
<td>109-01</td>
<td>£3.16</td>
</tr>
<tr>
<td>Analogogue Frequency Meter</td>
<td>109-02</td>
<td>£3.11</td>
</tr>
<tr>
<td>Ignition System</td>
<td>109-03</td>
<td>£2.97</td>
</tr>
<tr>
<td>Med. Resolution Equaliser (UK 101)</td>
<td>204-01</td>
<td>£1.73</td>
</tr>
<tr>
<td>Automatic Photograph</td>
<td>208-01</td>
<td>£1.94</td>
</tr>
<tr>
<td>Home Alarm</td>
<td>208-02</td>
<td>£3.21</td>
</tr>
<tr>
<td>Waveform Digitiser</td>
<td>209-01</td>
<td>£8.24</td>
</tr>
<tr>
<td>Radio Booster</td>
<td>302-02</td>
<td>£1.80</td>
</tr>
<tr>
<td>Into the Real World</td>
<td>303-01</td>
<td>£3.99</td>
</tr>
<tr>
<td>Accessory PSU</td>
<td>303-02</td>
<td>£1.38</td>
</tr>
<tr>
<td>Digital Frequency Meter</td>
<td>303-03</td>
<td>£3.69</td>
</tr>
<tr>
<td>Phaser</td>
<td>304-01</td>
<td>£3.41</td>
</tr>
<tr>
<td>Program Conditioner</td>
<td>306-01</td>
<td>£2.30</td>
</tr>
<tr>
<td>Guitar Active Tone Control</td>
<td>309-01</td>
<td>£2.27</td>
</tr>
<tr>
<td>Ground Communication System</td>
<td>309-02</td>
<td>£2.13</td>
</tr>
<tr>
<td>Expanding the Vic 20</td>
<td>309-03</td>
<td>£2.31</td>
</tr>
<tr>
<td>Spectrum Autosave</td>
<td>403-01</td>
<td>£1.83</td>
</tr>
<tr>
<td>Microstepper</td>
<td>404-01</td>
<td>£1.74</td>
</tr>
<tr>
<td>Sustain Unit</td>
<td>405-02</td>
<td>£2.82</td>
</tr>
<tr>
<td>Audio Signal Generator</td>
<td>405-03</td>
<td>£4.28</td>
</tr>
<tr>
<td>Cross Hatch Generator</td>
<td>406-01</td>
<td>£3.52</td>
</tr>
<tr>
<td>Comm. 64 RS232C Interface</td>
<td>408-01</td>
<td>£3.02</td>
</tr>
<tr>
<td>Field Measurement</td>
<td>408-02</td>
<td>£3.19</td>
</tr>
<tr>
<td>Digital Dice</td>
<td>408-03</td>
<td>£2.76</td>
</tr>
<tr>
<td>Simple Logic Analyser</td>
<td>408-04</td>
<td>£4.23</td>
</tr>
<tr>
<td>Alarm System</td>
<td>408-05</td>
<td>£2.93</td>
</tr>
<tr>
<td>Oscilloscope Calibrator</td>
<td>408-06</td>
<td>£4.24</td>
</tr>
<tr>
<td>Comm. 64 RS232C Interface</td>
<td>408-07</td>
<td>£3.14</td>
</tr>
<tr>
<td>Parallel to Serial Converter</td>
<td>409-01</td>
<td>£2.92</td>
</tr>
<tr>
<td>Through the Mains Controller</td>
<td>409-02</td>
<td>£2.88</td>
</tr>
<tr>
<td>Logic Probe</td>
<td>410-01</td>
<td>£1.90</td>
</tr>
<tr>
<td>Computer DFM Adaptor</td>
<td>411-01</td>
<td>£2.76</td>
</tr>
<tr>
<td>NiCad Charger</td>
<td>412-01</td>
<td>£2.40</td>
</tr>
</tbody>
</table>
Unlike their lead acid counterparts, nickel cadmium cells require a constant current rather than a constant voltage charging source. Furthermore, comparable sintered and mass plate cells have different charge rate requirements and this must also be taken into account.

The maximum indefinite charge rate for a sintered cell is usually taken as C/8, i.e. for a 1Ah battery the maximum indefinite charging current is 125mA. Cells may, however, be charged at higher rates provided care is taken to avoid overcharging which can permanently damage the cells. The maximum charge rate for a sintered cell is usually assumed to be 10C but, before attempting to 'fast-charge' a nickel cadmium cell of any variety, it is essential to ensure that the cell is initially fully discharged. Using the same 1Ah battery, for example, a 2C charge would be achieved by charging at 2A for 30 minutes.

The relationship between charge period and charge rate for nickel cadmium cells is illustrated in Fig. 1. To ensure a long cell life and a maximum number of charge/discharge cycles, charge rates in excess of C should be avoided if at all possible. Mass plate cells cannot, by virtue of their construction, be charged at the high rates associated with sintered cells. The maximum charge rate for such cells is usually C/10 for 14 hours whilst the maximum indefinite charging current is often no more than C/100. Hence, for a 110mAh PP3 battery, the recommended charging current is 1mA for a period of 14 hours. Furthermore, if this type of battery is to be left on-charge indefinitely, the charging current should not be allowed to exceed 1.1mA. Table 1 shows the recommended charge rate for a number of popular nickel cadmium batteries.

<table>
<thead>
<tr>
<th>Battery type</th>
<th>Max. indefinite charging current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAA</td>
<td>20</td>
</tr>
<tr>
<td>AA</td>
<td>66</td>
</tr>
<tr>
<td>C</td>
<td>250</td>
</tr>
<tr>
<td>D</td>
<td>500</td>
</tr>
<tr>
<td>PP3</td>
<td>1.1</td>
</tr>
<tr>
<td>PP9</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 1. Maximum indefinite charge rates for various nickel cadmium batteries

We shall now describe a simple automatic charger which provides a total of 24 different charge rate options.
COLLECTOR CURRENT $I_c$ (mA)

COLLECTOR-EMITTER VOLTAGE $V_{CE}$ (V)

**Fig. 2.** Typical output characteristics for a transistor connected in common emitter mode

Another simple constant current charging source is shown in Fig. 4. Here a conventional monolithic three-terminal regulator is connected in what, at first sight, may appear to be a strange arrangement. The normal regulator output is, in fact, developed across $R_s$ and since this voltage remains substantially constant, the current flowing through it will also be constant. The output current is given by:

$$I_o = \frac{5}{R_s} \times I$$

where $I \approx 5$mA

The value of $R_s$ can be varied so that different charge rates can be catered for, as shown in Table 2.

With the two previous circuits, the charge rates may be easily selected by changing just one component. In practice, different charge rates can be obtained either by switching resistors or by incorporating a variable resistor into the circuit. There is, however, one problem; it is all too easy to connect the charger to a battery, switch 'on', and then forget it! Whilst this may be of little consequence when charge rates of C/10 are concerned, serious damage may be done if a fast charge rate is selected and thus, ideally, a charger should incorporate a facility which will discontinue the charge after a pre-determined time interval has elapsed. Hence, if separate controls for charging current and charging time are provided, a wide variety of charge rates can be accommodated to suit almost any type of cell which may be encountered. Furthermore, the user can rest assured that no harm will be done if the unit is left connected for an indefinite period!

**AN AUTOMATIC CHARGER**

The complete circuit of the automatic charger is shown in Fig. 5. A conventional mains transformer, T1, and bridge rectifier, REC1, provides an unregulated supply rail of approximately 17V. A programmable timer, IC1, is used to provide accurate monostable timing periods which are derived from a timebase and eight-stage binary counter. The two fundamental timing components are $C_2$ and $R_2$ and only the last four divider outputs are employed. A miniature normally-open push-button switch, S4, is used to initialise the timing sequence whilst a similar switch, S3, is used to re-set the timer, aborting the current timing period and discontinuing the charge.

The time period is selected by a rotary switch, S1, and the voltage at this point goes low for the duration of the timing period removing the bias from TR1 and switching the transistor 'off'. In this condition, $R_5$, $D_1$ and $D_2$ supply bias for the constant current source, TR2. At the end of the monostable period the base voltage of TR1 rises and TR1 conducts. In this condition, $D_1$ no longer achieves its Zener voltage and no base current is supplied to TR2. The output current, which is selected by means of rotary switch S2, thus falls to zero and remains in this state until another charging period is initialised by the user.

**CONSTRUCTION**

The majority of the components for the automatic charger are mounted on a single sided p.c.b. measuring approximately $53 \times 104$mm, the design of which is shown in Fig. 6. The corresponding component layout is shown in Fig. 7. The recommended sequence for mounting components is: terminal pins, d.i.l. socket, resistors, diodes, transistor, bridge rectifier, and capacitors.

The underside of the completed p.c.b. should be carefully checked for solder bridges and dry joints whilst the component side should be examined paying particular attention to the placement and orientation of the polarised components. The remainder of the components, excluding the mains transformer, fuseholder, and mains connector, are all mounted on the aluminium front panel. The wiring of the front panel should follow the layout given in Fig. 8 and connec-
## COMPONENTS...

### Resistors
- R1: 47k
- R2: 2M2
- R3: 100
- R4: 10k
- R5: 1k
- R6: 56
- R7: 202
- R8, R9: 506 (2 off)
- R10: 10
- R11: 15
- R12: 1
- R13: 22k
- R14: 1k
- R6 to R12 are 1W 10% carbon
- R1 to R5 and R13 and R14 are 1/2W 5% carbon

### Capacitors
- C1: 1000µF 16V p.c. electrolytic
- C2: 220µF 16V p.c. electrolytic
- C3: 100n polyester

### Semiconductors
- D1: B2Y88 C4V7 Zener
- D2: Green 0-2in I.e.d.
- D3, D4: IN4148 (2 off)
- D5: Red 0-2in I.e.d.
- TR1: BC108
- TR2: TIP32A
- IC1: 2240
- REC1: Green 0.2in I.e.d.

### Miscellaneous
- T1: 6VA mains transformer with 2 x 6V or 1 x 12V secondary winding rated at 500mA
- 16-pin d.i.l. socket TO220 heatsink (see text)
- S1: 3P 4W rotary switch (1 pole only used)
- S2: 2P 6W rotary switch (1 pole only used)
- S3: normally-open miniature push-button switch
- S4: normally-open miniature push-button switch
- S5: DPST mains switch
- PCB: Plastic case (West Hyde)
- Push-on knobs (2 off) Terminal pins (20 off)

---

**INITIAL TESTS**

When all wiring is complete, a final check should be made before inserting IC1 into the d.i.l. socket (taking care to observe the correct orientation). The mains supply should then be connected and the charger switched 'on'. The red I.e.d., D5, should immediately become illuminated whilst the green I.e.d., D2, should remain extinguished. At this point it is worth checking the positive supply rail voltage which appears at pin 16 of IC1. This should be 17V ±1 V. If this is not the case, connections to the mains switch, fuse, and transformer should be carefully checked.

The charge period switch, S1, should then be switched to give the shortest time (3-5 hours) whilst the charge current switch, S2, should be switched to the lowest current setting (12.5mA). S4 should now be momentarily pressed at which point the green I.e.d., D2, should become illuminated. Now momentarily depress S3 to reset the charger. As S3 is released, D2 should become extinguished. This set/reset procedure should be repeated a few times until the user is familiar with its operation. If no charge is apparent, readers

---

![Fig. 5. Complete circuit diagram of the automatic charger](media/image.png)
Fig. 6. P.c.b. design

Fig. 7. P.c.b. component layout

Fig. 8. Front panel wiring
All voltages measured with a 20kohm/V multimeter

**Table 3. Test voltages**

<table>
<thead>
<tr>
<th>Test point</th>
<th>Voltage</th>
<th>Reset</th>
<th>Set</th>
</tr>
</thead>
<tbody>
<tr>
<td>IC1 pin-16</td>
<td>17.0</td>
<td>17.0</td>
<td>17.0</td>
</tr>
<tr>
<td>TR1</td>
<td>14.0</td>
<td>1.0</td>
<td>8.8</td>
</tr>
<tr>
<td>TR2</td>
<td>0</td>
<td>16.6</td>
<td>16.7</td>
</tr>
<tr>
<td>Output (Sk2)</td>
<td>17.0</td>
<td>16.0</td>
<td>16.0</td>
</tr>
</tbody>
</table>

should refer to the test voltages provided in Table 3. If the supply voltage is correct but neither I.e.d. is illuminated, it is worth checking the polarity of D2 and D5.

Having confirmed that the set/reset switching is functional, the next stage is to check the charge time. Since it would be somewhat tedious to wait for even the shortest charge period (approx. 3.5 hours) it is more expedient to employ one of the unused shorter time periods available from the programmable timer, IC1. The shortest of these is available at pin 1 and readers should refer to the test circuit of Fig. 9a. The time period for a 'high' output should be measured using the following procedure:

1. Connect the test circuit using either a voltmeter or digital timer. The voltmeter should be switched to the 20V, 25V or 30V range whilst the timer should be adjusted to 'start' on a positive edge and 'stop' on a negative edge.

2. Depress S4. The voltage at pin-1 should be 'low' for several minutes and then it will go 'high'. At this point timing should commence (using a stopwatch or the digital timer).

3. After approximately 13 minutes the voltage should go 'low' again. At this point timing should stop. The time period at pin-1 is 1/16 of the nominal 3.5 hour period. However, due to component tolerances (particularly that associated with C2), the time period will seldom be exact. Where a precise time interval is desired, R2 may be replaced with a 2M2 pre-set resistor in series with a 1M fixed resistor, as shown in Fig. 10. The pre-set resistor is then adjusted for a pin-1 high output time of approximately 790 seconds.

Finally, the charge current should be checked. This is accomplished using a typical battery pack consisting of four series connected AA cells and measuring the current delivered with the charger set. The required circuit arrangement is shown in Fig. 9b. The charge current on each range of S2 should be measured and this should be within approximately 10% of that marked. If this is not the case, minor ad-

**Table 4. Recommended charge rates for the automatic charger**

<table>
<thead>
<tr>
<th>Charge Time (hours)</th>
<th>3.5</th>
<th>7</th>
<th>14</th>
<th>28</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.5</td>
<td>30</td>
<td>60</td>
<td>90</td>
<td>180</td>
</tr>
<tr>
<td>33</td>
<td>80</td>
<td>160</td>
<td>320</td>
<td>640</td>
</tr>
<tr>
<td>45</td>
<td>110</td>
<td>220</td>
<td>440</td>
<td>880</td>
</tr>
<tr>
<td>66</td>
<td>160</td>
<td>320</td>
<td>640</td>
<td>1280</td>
</tr>
<tr>
<td>100</td>
<td>250</td>
<td>500</td>
<td>1000</td>
<td>2000</td>
</tr>
<tr>
<td>250</td>
<td>612</td>
<td>1200</td>
<td>2400</td>
<td>4800</td>
</tr>
</tbody>
</table>

(Note: Battery capacity is shown in mAh)

*Finally, care should be taken to ensure correct polarity of cells connected to the charger. Failure to observe this precaution may result in damage to both the cells themselves and to the charger!*
Heathkit - IT'S A PLEASURE TO BUILD

Bring the enjoyment back into your hobby with a kit from Heathkit. The beautifully illustrated documentation and step-by-step instructions make building a Heathkit a relaxing, absorbing pleasure! Choose from their huge range of fascinating kits and self-instruction electronics and computing courses.

The Heathkit range includes the ultimate in amateur radio kits, computerised weather stations, a highly sophisticated robot, a 16-bit computer kit and a range of home (or classroom) learning courses. These state-of-the-art courses have easy-to-understand texts and illustrations, divided into sections so that you can progress at your own pace, whilst the hands-on experiments ensure long-term retention of the material covered.

All Heathkit products available in the UK from:

Maplin Electronic Supplies Ltd.
P.O. Box 3, Rayleigh, Essex, SS6 8LR.
Tel: (0702) 552911.
(For shop addresses see back covers.)

You'll be proud to say, "I built it myself!"

STEEL DISHED WASHER
OUTER INSULATION
SECONDARY WINDING
INSULATION
PRIMARY WINDING
END CAPS

TOROIDALS

The toroidal transformer is now accepted as the standard in industry, overtaking the obsolete laminated type. Industry has been quick to recognise the advantages toroidals offer in size, weight, lower radiated field and, thank to I.L.P., PRICE.

Our large standard range is complemented by our SPECIAL DESIGN section which can offer a prototype service within 14 DAYS together with a short lead time on quantity orders which can be programmed to your requirements with no price penalty.

VIA
PRICE: £9.50

 SERIES SECONDARY RMS

<table>
<thead>
<tr>
<th>Core No.</th>
<th>Core Diameter</th>
<th>Core Height</th>
<th>RMS Secondary Winding</th>
<th>Core Kit Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>0100</td>
<td>6 x 6</td>
<td>3.6 x 1.0</td>
<td>90 x 40mm</td>
<td>3.030</td>
</tr>
<tr>
<td>0101</td>
<td>6 x 6</td>
<td>3.6 x 1.0</td>
<td>90 x 40mm</td>
<td>3.028</td>
</tr>
<tr>
<td>0102</td>
<td>6 x 6</td>
<td>3.6 x 1.0</td>
<td>90 x 40mm</td>
<td>3.018</td>
</tr>
<tr>
<td>0103</td>
<td>6 x 6</td>
<td>3.6 x 1.0</td>
<td>90 x 40mm</td>
<td>3.017</td>
</tr>
<tr>
<td>0104</td>
<td>6 x 6</td>
<td>3.6 x 1.0</td>
<td>90 x 40mm</td>
<td>3.016</td>
</tr>
<tr>
<td>0105</td>
<td>6 x 6</td>
<td>3.6 x 1.0</td>
<td>90 x 40mm</td>
<td>3.015</td>
</tr>
<tr>
<td>0106</td>
<td>6 x 6</td>
<td>3.6 x 1.0</td>
<td>90 x 40mm</td>
<td>3.014</td>
</tr>
<tr>
<td>0107</td>
<td>6 x 6</td>
<td>3.6 x 1.0</td>
<td>90 x 40mm</td>
<td>3.013</td>
</tr>
</tbody>
</table>

Why a Toroid?
- Smaller size & weight to meet modern 'slimline' requirements.
- Low electrically induced noise demanded by compact equipment.
- High efficiency enabling conservative rating whilst maintaining size advantages.
- Lower operating temperature.

Why ILP?
- Ex-stock delivery for small quantities.
- Gold service available. 21 days manufacture for urgent deliveries.
- 5 year no quibble guarantee.
- Realistic delivery for volume orders.
- No price penalty for call off orders.

POST: ILP Electronics Ltd., Dept. 2
Graham Bell House, Roper Close,
Canterbury, Kent. CT2 7EP
Tel: (0227) 54778 Telex: 965780

Mail Order - Please make your crossed cheques or postal orders payable to ILP Electronics Ltd.
Trade - We will open your credit account immediately upon receipt of your first order.

POST: ILP Electronics Ltd., Dept. 2
Graham Bell House, Roper Close,
Canterbury, Kent. CT2 7EP
Tel: (0227) 54778 Telex: 965780

Prices including P&P and VAT

<table>
<thead>
<tr>
<th>VA Size</th>
<th>VA Type</th>
<th>VA Size</th>
<th>VA Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>0-10</td>
<td>0-10</td>
<td>0-10</td>
</tr>
<tr>
<td>10-20</td>
<td>10-20</td>
<td>10-20</td>
<td>10-20</td>
</tr>
<tr>
<td>20-30</td>
<td>20-30</td>
<td>20-30</td>
<td>20-30</td>
</tr>
<tr>
<td>30-40</td>
<td>30-40</td>
<td>30-40</td>
<td>30-40</td>
</tr>
<tr>
<td>40-50</td>
<td>40-50</td>
<td>40-50</td>
<td>40-50</td>
</tr>
<tr>
<td>50-60</td>
<td>50-60</td>
<td>50-60</td>
<td>50-60</td>
</tr>
<tr>
<td>60-70</td>
<td>60-70</td>
<td>60-70</td>
<td>60-70</td>
</tr>
<tr>
<td>70-80</td>
<td>70-80</td>
<td>70-80</td>
<td>70-80</td>
</tr>
<tr>
<td>80-90</td>
<td>80-90</td>
<td>80-90</td>
<td>80-90</td>
</tr>
<tr>
<td>90-100</td>
<td>90-100</td>
<td>90-100</td>
<td>90-100</td>
</tr>
<tr>
<td>100-110</td>
<td>100-110</td>
<td>100-110</td>
<td>100-110</td>
</tr>
<tr>
<td>110-120</td>
<td>110-120</td>
<td>110-120</td>
<td>110-120</td>
</tr>
<tr>
<td>120-130</td>
<td>120-130</td>
<td>120-130</td>
<td>120-130</td>
</tr>
<tr>
<td>130-140</td>
<td>130-140</td>
<td>130-140</td>
<td>130-140</td>
</tr>
<tr>
<td>140-150</td>
<td>140-150</td>
<td>140-150</td>
<td>140-150</td>
</tr>
<tr>
<td>150-160</td>
<td>150-160</td>
<td>150-160</td>
<td>150-160</td>
</tr>
<tr>
<td>160-170</td>
<td>160-170</td>
<td>160-170</td>
<td>160-170</td>
</tr>
<tr>
<td>170-180</td>
<td>170-180</td>
<td>170-180</td>
<td>170-180</td>
</tr>
<tr>
<td>180-190</td>
<td>180-190</td>
<td>180-190</td>
<td>180-190</td>
</tr>
<tr>
<td>190-200</td>
<td>190-200</td>
<td>190-200</td>
<td>190-200</td>
</tr>
<tr>
<td>200-210</td>
<td>200-210</td>
<td>200-210</td>
<td>200-210</td>
</tr>
<tr>
<td>210-220</td>
<td>210-220</td>
<td>210-220</td>
<td>210-220</td>
</tr>
<tr>
<td>240-250</td>
<td>240-250</td>
<td>240-250</td>
<td>240-250</td>
</tr>
<tr>
<td>260-270</td>
<td>260-270</td>
<td>260-270</td>
<td>260-270</td>
</tr>
<tr>
<td>270-280</td>
<td>270-280</td>
<td>270-280</td>
<td>270-280</td>
</tr>
<tr>
<td>280-290</td>
<td>280-290</td>
<td>280-290</td>
<td>280-290</td>
</tr>
<tr>
<td>290-300</td>
<td>290-300</td>
<td>290-300</td>
<td>290-300</td>
</tr>
</tbody>
</table>

For 10VA primary insert "0" in place of "X" in type number.
For 220VA primary (Europe) insert "2" in place of "X" in type number.

IMPORTANT: Regulation - All voltages quoted are FULL LOAD.
Please add regulation figure to secondary voltage to obtain no load voltage.
**HERE'S A QUESTION:** just how many companies in the components business, do you think, started out as a display of valves in the side window of a butcher's shop? I know of only one. That's the firm of A. F. Bulgin—a household name in the industry for more than half a century.

The founder was one Arthur Bulgin whose father was a respected purveyor of high-quality meats to the gentry (this was the grand title, or something similar, that graced his letterheads). And although he was probably disappointed that his son showed no inclination to follow the tradition of victualing the well-to-do, he gave the lad every encouragement in a venture which was, on the face of it, somewhat dicey. So the side window was donated willingly, if I, suspect, with not a little trepidation. What the squire and other distinguished beef-champers thought about it is not recorded.

Arthur justified his father's confidence when he set up a business proper in April 1923. This was at a time when the British Broadcasting Company had just launched the first public radio service in the UK and the future was rich in golden opportunity.

"**The first product . . . was a light-emitting escutcheon**"

Long before he went in for manufacturing, Arthur traded as a distributor—he was totally dedicated to this method of marketing. His family claims—and who shall blame them—that he was one of the first to operate in this now firmly established branch of the component sector.

The first product to come out of Bulgin's modest stable was described as a light-emitting escutcheon. Or, to put it more simply, a signal window. It was set in the cabinet of a radio receiver and a quick gander through it told you if your valves were alive and well. A comforting glow meant you were in business. An inky blackness spelt trouble.

By 1948—and we're having to skip a bit of history here—Bulgin had become a limited company employing 250 people and turning out what the Americans call panel hardware: switches, connectors, fuses, fuse-holders, signal lamps, clips and so on. And in spite of a considerable broadening of the range over the years, such "nuts and bolts" remain the firm's bread and butter.

Arthur's four brothers emulated their father's farsighted support of his meat-shy son and one-by-one they came into the business, leading it on to bigger and better things and consolidating the high reputation it continues to enjoy.

Today the family tide runs even more strongly. Ronnie Bulgin, son of the founder, is chairman and MD of what has become a group rather than a single company. His cousin Robert is his deputy. Ronnie's son Richard (25) bowler-hatted his way through the Stock Exchange for three years before joining the fold in 1980 and is now involved in selling and marketing with a new Bulgin venture—of which more anon. Robert's son Clifford (23) is equally active on the production side. And I'm told there is a reserve stock of other little Bulgins—too young yet to get in on the family act—watching out for their cues.

I met Ronnie and Robert the other day. Ronnie is shrewd and softly-spoken. Robert is a burly, jovial extrovert. That's understandable. Before joining the firm he was in advertising for a spell. It's the group's good fortune that he eventually decided to mend his ways. Between them, the cousins house a lot of ability and a treasury of enthusiasm.

"Let's tell you about our exciting new operation," said Ronnie. "Some months ago we consolidated Ambit International, Solent Component Supplies, Broxlea and Proexy Distribution—which represent Bulgin's distribution and custom manufacturing activities—into a single company called Cirkit. It's the first stage of a major development programme.

"Cirkit, far from taking a 'me too' stance in the distributor ranks by stockling all and sundry, is going for the specialist route. It is building an inventory of essential popular components from the top manufacturers with an emphasis on exclusivity. Among the lines for which it is sole stockist are Alp's (the world's largest manufacturer of electro-mechanical devices) and Toko (taps in wound components). Additionally, we're appointed distributors in the South of England for Cooper Tools/Weller, brand leaders in soldering and desoldering equipment. And we're not stopping there. We plan to secure other important franchises, with the accent on high-volume components and high technology, in such key areas as telecoms, defence, control and computers."

Cirkit is also stepping up its operations in the home-use and hobbyist market, through both mail order and across-the-counter outlets. New kits coming on to the market include, in the 'expert' category, a 20W, 144MHz linear power amplifier for boosting the output of hand-held and transportable transceivers, but also, in the 'enthusiast' bracket, a universal audio function generator with on-board mains PSU.

The aspiring 'student' class is not forgotten either. Kits in this area range from a universal temperature sensor which can be used as a frost warning, deep freeze alarm, greenhouse temperature alarm, etc., to a locomotive sound generator with whistle—a boon and a blessing for the rabid thwarted railwayman who has turned his attic into a miniature Clapham Junction.

While Ronnie and Robert Bulgin keep a watchful eye on Cirkit as non-executive members of the board, they have mustered a whole new team to steer the company on its adventures. Spearheading the team is Chief Executive Christopher Sawyer, a born leader who has achieved a particularly successful track record with such giants as BMW, Smedleys and the Ross Group. Alongside him is Financial Director, Ronald McKellar CA, who like Sawyer is in his late 30's and has an equally impressive business background.

Chairman of Cirkit is Alistair McDonald, who brings not only a wealth of experience in top-level financial-type appointments, but also, I suggest, an odour of sanctity. He spent many years with the Church Commissioners, juggling, as investment secretary, with assets in excess of £1,000 million. Another stalwart is ex-sailor Ken Hollingsworth. He came into electronic component distribution in 1963 and has become rich in the knowledge of the game. Then there's Jonathan Burchell, who is master-minding the introduction of Cirkit's new range of kits. Richard Bulgin (Consumer Sales) and Chris Bursky (Marketing Services) represent the third generation of the founding family.

"We have tried," said Ronnie Bulgin, "to bring a real breath of fresh air into the business of electronic component distribution. This is typified by the appointment of Alistair McDonald, who, in spite of coming into this sector for the first time, is generating enormous enthusiasm."

"When you think about it, this kind of consolidation of several distribution companies into one is plain commercial common sense. Promoting each of them individually, with their own advertising and catalogues, as well as premises, is not only hideously expensive, but inefficient."

There's one point the Bulgins underline in bold capitals: In spite of its expansion in the distribution area, it remains firmly in the business of making, with a main factory at Barking (Essex) and a satellite at Broxbourne (Herts). In fact, in the current year the ratio will be 40 per cent distribution to 60 per cent production, turning out components for internationally-known customers with products ranging, as Robert Bulgin said, from toasters to telecoms, robots to oil rigs.

With an eye, no doubt, on future manpower needs, Cirkit has put £100,000 into an electronics award scheme for young people at schools and colleges. They must make and design an electronic device with a viable application in everyday life—for business or leisure. Any design taken up will attract royalties and, what's more, the company will help with patenting.

Arthur Bulgin would, I'm sure, be delighted to see what that valve display, cliche-blow-in-the-lamb-chops, has led to in the space of one man's lifetime. But would he, like me, have some doubts about that name Cirkit? It's certainly ingenious. But, because I've that sort of mind, I can't for the life of me resist adding 'and see'.

And I'm sure we shall.
In April 1982 PE, in conjunction with RT-VC, published the **PE Quasar Stereo Cassette Deck** design. The design provides some outstanding features, including variable recording bias and a gate noise reduction system. As a result of this successful design we are now pleased to be able to offer kits to PE readers at this exclusive price. The kits, including a wrap round simulated wood finish case, will be accompanied with a reprint of the PE articles which fully describe the unit and its construction.

The offer is for a limited period only and a coupon should be sent to the address shown. The specification of the made-up unit is given below:

**SPECIFICATION**

- Case size 285 x 260 x 90mm approx.
- Mechanism with automatic stop and tape counter with reset button.
- Tape Speed: 4.76cm/sec. (1.8 in/sec.).
- Wow & Flutter: Typically 0.1%.
- Drive Motor: 12V d.c. with electrical governor.
- Play Torque: 40–75g/cm (DYNAMIC).
- Rewind & Fast Forward Torque: 60–140g/cm (STATIC).
- Rewind & Forward Time: Less than 100 sec. for C60 tapes.
- Bias/Erase Oscillator: Externally variable, frequency 90–100kHz.
- Output: (Adjustable) Up to 1 volt r.m.s.
- Mic. Sensitivity: 1mV @ 47k.
- DIN Sensitivity: 30mV @ 47k.
- Frequency Response: 30Hz–12.5kHz (–3dB).
- Signal to Noise Ratio.
  - Noise reduction OFF: –50dB
  - Noise reduction H.F.: –50dB
  - Noise reduction FLAT: –70dB
- Cross Talk: Typically –50dB.

To: RT-VC, 21B High St., Acton, London W3 6NG

Please send me  

<table>
<thead>
<tr>
<th>Kit/s</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>One deck kit costs £29.95 plus £2.75 p&amp;p (£32.70)</td>
<td></td>
</tr>
</tbody>
</table>

I enclose PO/Cheque No ................................ Value  

Name ..................................................

Address ..................................................  

Please allow 28 days for delivery

OFFER CLOSES FRIDAY DECEMBER 14 1984

Name ..................................................

Address ..................................................

Access 'phone orders 01-992 8430

To: RT-VC, 21B High Street, Acton, London W3 6NG
GENERATING NOISE

We've already considered the fact that noise is a random type of signal. It contains no steady frequency components at all which are discernible; in fact, a perfect broadband noise signal can be considered to simultaneously contain all possible frequencies from d.c. up to infinity, the net result of which is a wave pattern in which no repetitive waveforms or tones can be distinguished. This is the type of signal produced by natural phenomena within all normal semiconductor materials, albeit at an extremely low level. In very high gain amplifiers this noise is amplified along with the signal, resulting in unwanted background 'his'.

One technique for generating noise uses exactly this effect, and is shown in Fig. 2. TR1 is connected as a reverse biased diode with its collector open circuit. The tiny noise current generated by this is amplified, first by TR2 then by the op-amp IC1. This technique is simple, and usually works fairly well, although different types of transistor used for TR1 can give different types of noise, i.e. noise signals with different amplitudes at different parts of the spectrum; a lack of low frequency components in the noise, an excess of mid-band components, or similar. A more consistent performance can be obtained by using a special noise generating Zener diode, such as the Z5.1, with a suitable high gain amplifier configuration, although these tend to be quite expensive. There can also be problems with mains hum and interference, or instability, caused by the very high gains of the circuitry involved, so care must be taken with the design and construction of this type of system.

A DIGITAL NOISE SOURCE

An alternative way of generating noise uses an 'artificial', rather than an amplified natural effect, and this is the basis for the i.c. featured this month, the MM5837N from National Semiconductor. It's a digital technique using a clocked shift register with multiple feedback paths. Fig. 3 shows the block diagram of the i.c. An internal high frequency clock oscillator is used to continuously clock a 17 bit shift register. The shift register acts as a 17 bit 'first

**Table 1. Pinout and specification**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Notes</th>
<th>Minimum Value</th>
<th>Typically</th>
<th>Maximum Value</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vss supply voltage</td>
<td>With respect to +ve supply pin, Vgs (pin 4). (absolute maxima)</td>
<td>Vss = -25 V</td>
<td>Vss = -14 V</td>
<td>Vss + 0.3 V</td>
<td>V</td>
</tr>
<tr>
<td>Vgg supply voltage</td>
<td></td>
<td>Vss = -33 V</td>
<td>Vss = -27 V</td>
<td>Vss + 0.3 V</td>
<td>V</td>
</tr>
<tr>
<td>+ve supply Vss for normal operation</td>
<td>Vgs and Vgg connected to OV</td>
<td>+8.9</td>
<td>+14</td>
<td>+25</td>
<td>V</td>
</tr>
<tr>
<td>Temperature range</td>
<td></td>
<td>0 °C</td>
<td>+70 °C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For all following specs, Vss = 0V, Vdd = -14V, Vgg = -27V

Quiescent current, Vss (pin 1) | No output load | 3 mA | 8 mA |

Quiescent current, Vgg (pin 2) | | 7 mA |

Half power point | 2.4 kHz | 56 kHz |

Cycle time | 1.1 s | 2.4 s |

Output voltages: | (pin 3 loaded with 20k to Vss and 20k to Vdd) | | |
LOGIC 1 | Vss = -1.5 V | Vss = Vss | V |
LOGIC 0 | Vdd = Vss, i.e. = -14V | Vdd = Vdd | V |
LOGIC 0 | | Vdd + 1.5 V | V |
LOGIC 0 | | Vdd + 3.5 V | V |

* = data not available from manufacturer—this was measured on prototype circuit.
perfectly random; it does have a pattern which
continuously
whatever pattern of logic 1's and 0's is present
register is connected back to its data input,
that they were pushed in. If the output of the
one; they emerge at the other end, one by one,
coloured balls into a length of tubing one by
cycles later. In this respect, the action of the
emerge at the data output pin exactly 17 clock
tions of output bits in multiple feedback paths
spectrum becomes somewhat irregular,
the voltage drops to around this figure, the
murers. who don't give a lower limit figure. As
plications circuit, not by the
specification, Fig.
In
oscillator
is derived
as between 24 and 56kHz, inferring that the
frequency limit of the output noise spectrum. The
are needed. This is a high frequency oscillator,
and it totally defines the maximum high fre-
quency limit of the output noise spectrum. The
'half power' (i.e. the -3dB) point is specified
as between 24 and 56kHz, inferring that the
clock frequency must be around 100kHz or
more.

NOISE COLOUR
The spectral content of a noise signal is
referred to as its colour. There are actually
many colours of noise: red, blue, etc., but the
two types most commonly used are white and
pink.

White noise is characterised by having
equal energy per constant bandwidth in the
spectrum. For example, the energy content in
the region between 1kHz and 2kHz will be the
same as that between 2kHz and 3kHz,
because in each case the bandwidth is 1kHz.
The energy content will rise by 3dB per oct-
ave, however, with an octave being defined as
a doubling of frequency, so the energy con-
tained in the region 2kHz to 4kHz will be 3dB
higher than that in the region 1kHz to 2kHz.
The converse is true for pink noise, which has
an equal energy level per octave, i.e. a 3dB
loss in amplitude per constant bandwidth. For
example, the energy content in the region
2kHz to 4kHz will be 3dB LOWER than that
in the region 1kHz to 2kHz. Put very simply,
white noise is a very hissy sound with high fre-
quency content, whereas pink noise is a duller
'wooshing' low frequency content sound.

For audio use, especially in the setting up of
graphic equalisers and sound systems, the use
of pink noise is widespread. Graphic
equalisers are usually calibrated in octaves,
with each control cutting or boosting the
audio signal in a narrow octave wide, or even
one third of an octave wide band. Using pink
noise ensures that the mean signal amplitude
will be the same in each band of the equaliser,
allowing the spectral response of the system to
be tailored precisely.

CONVERTING WHITE NOISE TO PINK
The MM5837N produces only white noise,
so to obtain a pink noise signal we must in-
clude filtering to roll off the amplitude at the
rate of 3dB per octave. Unfortunately, even a
simple resistor/capacitor network has a 6dB

could be used, but the arrangement employed
by the MM5837N is quite satisfactory for
most applications.

OUTPUTS FROM THE I.C.
The i.c. is fabricated using PMOS
technology, hence the unusual approach of
calling the positive supply $V_{pp}$ and the
negative supply $V_{dd}$. A third, optional supply
$V_{ee}$ can be biased somewhat more negatively
than $V_{dd}$ if required, which will slightly im-
prove the output drive voltage available from the
MOSFET output buffer stage connected
to pin 3. The manufacturer's specifications are
based on using the i.c. in a positive earth
arrangement, with 0V connected to pin 4,
and 27V connected to pin 5. This would cause considerable
headaches in most potential applications, so it
is quite acceptable to simply connect pin 4 to
the positive supply rail (±8-9 to ±25V) and
connect both pins 1 and 2 to 0V. This will give
an acceptable output voltage swing for most
purposes. Note that the lower voltage limit
given in the specification, Fig. 1, is derived
from experimentation on the prototype ap-
plications circuits, not by the i.e.
manufacturers, who don't give a lower limit figure. As
the voltage drops to around this figure, the
noise spectrum becomes somewhat irregular,
and below this voltage fixed frequency tones
start to become discernible within the noise.

The clock oscillator is completely self-
contained, so no external timing components

in first out' storage device. Any data bit pre-
tant at its input when the clock is pulsed will
emerge at the data output pin exactly 17 clock
cycles later. In this respect, the action of the
shift register can be likened to pushing
coloured balls into a length of tubing one by
one; they emerge at the other end, one by one,
a fixed time later, in exactly the same order
that they were pushed in. If the output of the
register is connected back to its data input,
whatever pattern of logic 1's and 0's is present
within the register at that time will be 'rotated'
continuously round the register without changing.

If we look at other points within the shift
register, such as the 14th bit rather than the
output (the 17th bit), we see the state that the
input was at 14 clock cycles earlier, rather than
17 cycles earlier as would be the case
when looking at the output. If the 14th and
17th bits are combined together with some
logic gating, such as an exclusive-OR gate, we
can feed a rather oddly derived signal back to
the data input of the shift register. The
mathematics of the resultant effect are very
complex, but the practical end result is an
almost purely random digital signal, known as
a 'pseudo-random' signal. In fact, it's not
perfectly random; it does have a pattern which
repeats, but only every 1-1 to 2-4 seconds,
which only affects very low frequency applica-
tions of the noise source. Various different
lengths of shift register, and various combina-
tions of output bits in multiple feedback paths

![Fig. 2. Analogue noise generator](image1)

![Fig. 3. Block diagram](image2)

![Fig. 4. Simple pink noise generator](image3)

Practical Electronics  December 1984  47
per octave slope, and most active filters are designed for 12, 18, or more dB's per octave. The easy solution is to cascade several resistor/capacitor networks together, each set to different turnover frequencies in such a way that they combine to produce an overall slope of only 3dB per octave. National Semiconductor's recommended network to do this for the MM5837N is shown in Fig. 4. Note that the output of this circuit has a fairly small amplitude for the actual noise signal (only about 1V peak-to-peak) but this rides on a d.c. level of just over half the supply rail voltage, and as a result will normally need a series decoupling capacitor prior to feeding into any other circuitry.

APPLICATIONS
The i.c. can be used either as a purely digital noise source, or with suitable filtering or amplification as an analogue noise source. Consider using the i.c. output to feed into a CMOS serial in/parallel out register's data input, then clock that register with a regular slow clock pulse. The output from the register will be a pseudo-random digital number. If fed into a digital to analogue converter, this would produce a regularly changing random analogue voltage, ideal for use in experimental sound or music synthesis. Other potential uses for a noise generator have already been discussed, but perhaps the most obvious is the basis for this month's applications project. The MM5837N can be obtained from Alpha Electronics, 66 Wilbury Way, Hitchin, Herts, SG4 0TT.

AUDIO NOISE GENERATOR

The circuit diagram for a useful audio noise generator is shown in Fig. 5. It can produce either white or pink noise, and has a variable level control to adjust output amplitude. The output is electronically balanced, making it ideal for feeding into balanced inputs to audio equipment, although it can equally well be used with unbalanced systems.

One of the attractions of the MM5837N is that it is very compact, replacing several larger i.c.s with an 8-pin d.i.l. package. The circuit, and its Veroboard layout, have been designed to take advantage of the small size of the device, and the result is a very small assembly, ideal for building into a hand-held case. R1, R4, R5, R6, R7, R8, C2, C3, C4, and C5 form the passive network which derives pink noise from the i.c. output. The more difficult to obtain values in Fig. 4 have been replaced by different quantities of other values of component to make it easier to build with full accuracy. The pink noise is amplified up to a reasonably high level by IC2a, then fed to the selector switch S1. The white noise feed to S1 comes from the output of IC1, decoupled by C1, attenuated and biased to 0V by R3, and with a high frequency roll-off provided by R2 and C7 to help reduce high frequency components in the waveform caused by the sharp edges of the digital output of IC1.

IC2d buffers the output of the level control VR1, and feeds into the two halves of the balanced output, IC2b and IC2c. These are connected to give EXACTLY the same gain, one with signal inversion, and the other without. The two outputs are thus symmetrical, i.e. mirror images, about 0 volts. This

![Fig. 5. The Audio Noise Generator](image-url)
OS C4 can be made up of two capacitors in parallel.

Fig. 6. Veroboard layout

can directly drive into balanced inputs of audio equipment, while for conventional unbalanced systems, either output, positive or negative, can be used, with the common 0V or ground connected as the return. C16 and C17 roll off the response of the amplifiers at high frequencies to keep them stable, and R18 helps to match the response of IC2c as closely as possible to that of IC2b. Ideally, the values of R16 and R17 should be within 0.1% of each other, although the actual value itself is not as critical. Practically, 1% is adequate for most systems, and even 5% resistors can be used if non-critical uses are anticipated.

BIAS POINT

Components R9, R10, and C6 provide a half-rail bias point for the op-amps, C12 and C13 decouple the supply, C14 and C15 decouple the outputs to block d.c. from the op-amps, and R19 and R20 bias the outputs to 0V. The output impedance is very low indeed, so if a 600 ohm output impedance is required, then a pair of 300 ohm resistors, again matched to within 0.1% or 1% of each other, should be added in series with the +ve and -ve outputs. The relative amplitudes of pink and white noise can be adjusted by varying the gain of IC2a (change R12 or R13) or the attenuation of the white noise source (change R3), although care must be taken to avoid clipping of the waveform, which could be checked for on an oscilloscope. Many quad op-amp packages could be used for IC2, but some do not work well on low supply voltages in the voltage follower mode. The MC3403P does work well under these conditions, although if supplies of 18V or more (or +/-9V) are used the TL074 offers better high frequency performance, and is to be preferred.

The noise generator can be used for testing noise rejection or reduction systems, for setting up graphic equalisers or room equalisers, or even for generating special effects. Its compactness is largely due to the diminutive MM5837N, and shows a typical use for this digital noise source i.e.

**MASTER**

**Electronics - Microprocessors - Now!**

The PRACTICAL Way!

- Electronics — Microprocessors — Computer Technology is the career and hobby of the future. We can train you at home in a simple, practical and interesting way.
- Recognise and handle all current electronic components and 'chips'.
- Carry out full programme of experimental work on electronic & computer circuits including modern digital technology.
- Build an oscilloscope and master circuit diagrams.

New Job? New Career? New Hobby?

Please send your brochure without any obligation to:- I am interested in:

| NAME | ADDRESS | | |-- | |
| BLOCK CAPS PLEASE |

British National Radio & Electronics School Reading, Berks. RG1 1BR

British National Radio & Electronics School Reading, Berks. RG1 1BR

SEND THIS COUPON NOW.

BN R E S. PE12

ELECTRONICS

MICROPROCESSORS

RADIO AMATEUR LICENCE

CITY & GUILDS EXAMS

Other Subjects

OR TELEPHONE US 0734 51515 OR TELEX 22758 (24 HR SERVICE)

British National Radio & Electronics School Reading, Berks. RG1 1BR
This effects unit is ideal for either the performing musician or for enhancing pre-recorded cassettes and records. The Chorus effect improves the acoustic depth whilst the Flanger is similar to reverberation and phasing only with greater resonance. 

LASERS AND HOLOGRAMS

You probably benefit from the use of Holograms and LASERs every day. Now you can find out what they are, how they work and what they are used for. 

RADAR ALARM

Part two of the Radar Security Alarm (Part 1 was in the October '84 issue) will include a new transmitter design and give full construction and setting-up details of the complete system. Make sure your home is protected.
## ELECTROVALUE

### Your SPECIALIST SUPPLIERS for SWITCHES

Out of a very wide range of types, we show some of the more popularly demanded ones. The full range currently stocked will be found in our latest free 48 page A-Z illustrated products price list. Please mention this journal when contacting Electrovalue.

**MINIATURE TOGGLES, 7000**
- Series: 206V/2A, 120V/1A
- Single, double, three and four pole configurations inc. Centre Off/On and biassed.
- CK WAVECHANGE with adjustable stops: 1 P/12 way, 2 P/6 W, 3 P/4 W, 4 P/3 W, 5 P/2 W.

**Switch Kits**
- RA Shaft Assemblies up to 6 wafer.
- DP Mains switch, Screws, Spacers.

**CAPACITORS**
- Ceramic 0.01F for £1.00.
- Full range of Mica Types available.

**SWITCHES MIN. TOGGLE**
- 1 pole, 2 way: £0.62
- 2 pole, 2 way: £0.73
- 3 pole, 2 way: £1.10
- 4 pole, 2 way: £1.30
- 2 pole, 3 way: £0.97

**SWITCHES SLIDE MIN.**
- 1 pole, 2 way: £0.10
- 2 pole, 2 way: £0.15

### Back Panel
- Fuse Holder: £0.10
- 5 pin DIN Sockets: £0.05
- 3 pin DIN Sockets: £0.03
- Push button Micro Switches: £0.50

### Panel Mounting Pots
- 25K, 25K dual log: £0.20
- 100K, 100K: £0.30
- 47K single linear: £0.15

### Tantalum Capacitors
- Dry type: B axial values between 2.2 MFD & 47 MFD, £0.99 the lot P&P 5p.
- Min. 4 pcs, one value: £0.15 each P&P 15p.

### Cermet Trimmers
- All values: £0.60 each. P&P 15p.

### Trimmer Capacitors
- Min. 5 pcs: £0.10 each. P&P 15p.

### Digital Clock Module
- Needs only single power supply: £7.00 P&P 50p.

### Full Range of Mounting Bezels:
- 47K dual log: £0.20
- 47K single linear: £0.15

## Hi-Fi SYSTEMS - Sennheiser (all reviewed)
- Tuners: LW/MW/FM: £25.00
- 30 Watt Amplifier: £29.00
- 20 Watt Amplifier: £42.00
- High Velocity Headphones: £11.00

## Hi-Fi SPEAKERS
- Minimax II: £59.90
- BB 1132: £39.90 (3 way)
- DB 1206: £49.90 (3 way)

### Sub Woofer Special "Practical Electronics" Design
- £69.00
- Kit as above: £40.90

### LCD Dot Matrix Panels:
- 1 x 16
- 1 x 40
- 2 x 16
- 2 x 4
- 2 x 24

### COMPUTER PRODUCTS
- Graphite/Colour Graphics
- CPU/lnput boards
- Printers/Bar Code Readers
- Monitors: send for full data and prices

### ALL PRICES INCLUDE VAT
- Goods normally despatched within 7 days

---

### ELBAR SALE

All products new with money back guarantees

### In Car Equipment:
- 7 Stage Graphic Equaliser: £19.50
- Door Speakers (per pair): £9.50
- Wedge Speaker (per pair): £4.10

### Professional Audio ( Literature available on request)
- 100 Watt Compression Drivers: £65.00
- 100 Watt Tweeters: £50.00
- 12" x 60 Watt Bass Units: £28.00
- HD 30 Watt Tweeters: £7.00
- 15" x 100 Watt Bass Units: £78.00

### Components:
- Opto Electronics
  - Red LEDs: £0.10
  - Green LEDs: £0.25
  - Orange LEDs: £0.25
- Panel Mounting Pots
  - 7 Segment Displays
    - LED 0.3": £0.90
    - LED 0.6": £1.40
    - LED 1": £2.00
- 7+7 Driver Decoder: £0.50
- Panel Meters
  - Centre zeros 100uA: £1.60
  - Level Meter 100uA: £1.50
  - VU Meter 100uA: £1.50
- Capacitors
  - ceramic .01F: £0.50
  - Full range of Mica Types available
- Switches Min. Toggle
  - 1 pole, 2 way: £0.62
  - 2 pole, 2 way: £0.73
  - 3 pole, 2 way: £1.10
  - 4 pole, 2 way: £1.30
  - 2 pole, 3 way: £0.97
- Switches Slide Min.
  - 1 pole, 2 way: £0.10
  - 2 pole, 2 way: £0.15

### Hi-Fi Systems - Sennheiser (all reviewed)
- Tuners: LW/MW/FM: £25.00
- 30 Watt Amplifier: £29.00
- 20 Watt Amplifier: £42.00
- High Velocity Headphones: £11.00

### Hi-Fi Speakers
- Minimax II: £59.90
- BB 1132: £39.90 (3 way)
- DB 1206: £49.90 (3 way)

### Sub Woofer Special "Practical Electronics" Design
- £69.00
- Kit as above: £40.90

### LCD Dot Matrix Panels:
- 1 x 16
- 1 x 40
- 2 x 16
- 2 x 4
- 2 x 24

### COMPUTER PRODUCTS
- Graphite/Colour Graphics
- CPU/lnput boards
- Printers/Bar Code Readers
- Monitors: send for full data and prices

### ALL PRICES INCLUDE VAT
- Goods normally despatched within 7 days

---

### ELECTROVALUE LTD

**Unit 4, Airport Trading Estate, Biggin Hill, Westerham, Kent TN16 3BW**

**Tel**: Biggn Hill 71011-15

**Telex**: 957353

**Name**: Practical Electronics

---

### SPARKRITE

KITS FROM £7

...TO £60

**Sparkrite**

Buy Sparkrite Brand Leading Auto Electronics in self-assembly kit form – And save pounds!!

- Electronic Ignition systems – contact triggered and contactless
- Electronic Car Security Systems – including a new ultrasonic unit
- Car Drive Computer – with 12 functions

**SEND FOR FREE LITERATURE PACK – TODAY!**

& SOPHISTICATED KITS TO CHOOSE FROM.

---

**Address**: Sparkrite (A Division of Stadium Ltd.), Queensway, Enfield, EN3 4SD

**Telephone**: 01-804 4343

**Name**: 

**Address**: 

---

**Unit 4, Airport Trading Estate, Biggin Hill, Westerham, Kent TN16 3BW**

**Tel**: Biggin Hill 71011-15

**Telex**: 957353

**December 1984**

---

**ELECTROVALUE LTD**

**Access & Barclaycard Welcome**

---

**Telephone**: (0794) 33803, Telex 264475

**North 680 Burnage Lane, Manchester (061) 422 4846**

**EV Computing Shop, 700 Burnage Lane, Manchester (061) 421 4860**

---

**BRITAIN'S No. 1 QUALITY COMPONENT SUPPLIERS**

**SEND FOR LATEST 44 PAGE A-Z LIST FREE**

**ATTRACTION DISCOUNTS-FREE POSTAGE-GOOD SERVICE & DELIVERY**

---

**Sparkrite (A Division of Stadium Ltd.), Queensway, Enfield, EN3 4SD**

**Telephone**: 01-804 4343

---

**NAME**

**ADDRESS**
This series is concerned in part four with the control electronics and mechanical construction of the MENTOR robot. Like the NEPTUNE series, MENTOR interfaces directly to any one of three popular home computers and provides the facility for control either from the keyboard, or by making use of the "learning arm".

**PRINCIPLES OF OPERATION**

MENTOR is a 6-axis servo controlled electric robot (Fig. 4.1). Whilst the NEPTUNES are designed for industrial use, MENTOR is primarily intended for educational purposes but as can be seen from the specification (Table 1) it too has the repeatability for many commercial applications, where the load is light. Each of the axes is powered by a small d.c. servo motor with integral gearbox with a large reduction ratio.

Axis 0 is the centre column which rotates in a nylon bearing in the top plate of the base of the robot and is powered by the motor through an additional pair of gears (Fig. 4.2). The radial position of the column is sensed by a conductive polymer potentiometer fitted to the underside of it. The column is hollow to enable the cables to pass down it to the computer interface board.

Axis 1 is the lower section of the arm which rotates about an axle fitted to the centre column (Fig. 4.3). Again a pair of gears is used to transfer torque from the motor to the axle and a potentiometer provides the feedback information. The axle is hollow for the cables to pass through it.

Axis 2, the fore arm is driven in the same manner as axis 1. A large piece of steel at the back end of the lower arm section counterbalances the weight of this section of the arm making the robot's position stable when there is no power applied to it;

---

**Table 1. MENTOR SPECIFICATION**

<table>
<thead>
<tr>
<th>Axis</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>AXIS 0 (centre column)</td>
<td>Angular movement 210°. Axle centre 170mm above top of base.</td>
</tr>
<tr>
<td>AXIS 1 (shoulder)</td>
<td>Angular movement 180°. Arm length between axle centres 165mm.</td>
</tr>
<tr>
<td>AXIS 2 (elbow)</td>
<td>Angular movement 230°. Arm length between axle centres 150mm.</td>
</tr>
<tr>
<td>AXIS 3* (left wrist axle)</td>
<td>Angular movement 320°.</td>
</tr>
<tr>
<td>AXIS 4* (right wrist axle)</td>
<td>Angular movement 320°.</td>
</tr>
<tr>
<td>WRIST PITCH</td>
<td>Angular movement 140°.</td>
</tr>
<tr>
<td>WRIST ROTATION</td>
<td>Jaw opening 30mm. Jaw pressure 10 newton. Distance from end of jaws and axis 3 and 4 axes 105mm.</td>
</tr>
<tr>
<td>AXIS 5 (gripper)</td>
<td>Jaw opening 30mm. Jaw pressure 10 newton.</td>
</tr>
<tr>
<td>REPEATABILITY</td>
<td>2mm.</td>
</tr>
<tr>
<td>LIFTING CAPACITY</td>
<td>300gm.</td>
</tr>
<tr>
<td>REACH (from axis 1 axle centre)</td>
<td>420mm.</td>
</tr>
<tr>
<td>BASE DIMENSIONS</td>
<td>Overall width 320mm. Overall depth 270mm. Overall height 189mm.</td>
</tr>
</tbody>
</table>

---

**PART FOUR**

**CONTROL SYSTEM**

All axes servo controlled with servoing performed by the control electronics. Position defined by 8 data bits giving angular resolution of 0.4%.

**COMPUTER INTERFACE**

Parallel. Robot addressed as if part of computer memory. Connects to expansion port (1MHz bus on BBC).

**SOFTWARE**

Accepts commands in BASIC or machine code.

**SOFTWARE PROVIDED**

Extensive package of BASIC programs including direct control from computer keyboard, control by simulator, sequence storing, replay, sequence editing, sequence storage on disc or tape, multi-speed control and graphical illustration of robot dynamics.

*AXIS 3, 4 movements are combined to provide wrist pitch and wrist rotation.*
therefore the drive motor does not have to be continuously on to keep the arm in position. There are also counterbalance weights on the fore arm to balance out the wrist motors.

Axes 3 and 4 are the wrist drive motors. The movements are combined to provide wrist elevation and wrist rotation by means of a set of bevel gears. When axes 3 and 4 advance together the
wrist rises. When the axes move in equal and opposite directions
the elevation remains constant but the wrist rotates, as shown in
Figs. 4.4 and 4.5.

Axis 5 is the gripper which is also servo controlled. To keep
down the weight at the front end of the fore arm the drive motor
for this is fitted to the lower arm with the power applied to the
jaws via a flexible cable consisting of a nylon-coated multi-
strand steel wire inside a spiral wound PVC-coated conduit. This
is similar to the brake cable of a bicycle. Torsion springs open
the jaws when tension is released on the cable. Being servo con-
trolled it is possible to program different degrees of jaw closure.
If the programmed position is for a gap between the jaws of less
than the size of the object to be handled then the grip will depend
on how much further the servo system is trying to move the
jaws.

THE MENTOR CONTROL SYSTEM

The MENTOR, like the NEPTUNE, can be connected to one
of three popular computers, the Commodore VIC20, the Sin-
clair ZX Spectrum and the BBC. When the computer sends the
robot new data it responds by moving to a position where the
feedback information from the potentiometers exactly matches
the information from a DAC (digital-to-analog converter) con-
trolled by the computer. This process is called servoing. Each of
the 6 axes of movement can be defined with 8-bit (1 part in 256
or 0.4%) resolution.

ROBOT CONTROL

To move each of the axes the computer sends (WRITEs) 6
bytes of data to the robot, one to each axis. The servoing is per-
trolled by the computer. This process is called servoing. Each of
the information from a DAC (digital-to-analog converter) con-
verted to 6 position control voltages. The analog elec-
tronics on the interface board then compares these voltages with
the feedback voltages. The difference between these two voltages
is delivered to high power operational amplifiers which drive the
motors in the direction which reduces the difference to zero. This
is the servoing process.

FEEDBACK

The computer is not involved in the servoing, it is merely
generating data and relying on the robot to follow the instruc-
tions correctly. However the computer can perform a READ of
any or all of the 6 feedback voltages and can thus be aware of all
the movements of the arm. This process can be used to delay
sending the next set of co-ordinates until the previous set of co-
ordinates have been reached or for varying the speed of the
robot during playback of a sequence. It is also easy to produce a
graphical display of the movements and observe the effect of
varying loads and of alterations to the components determining
the characteristics of the servo system.

The computer can also READ the position of the simulator,
which is a small hand operated model of the robot which can be
plugged into the learn axis input CN400. The computer READS
the position of the simulator and then WRITES this data into
the robot. The arm follows the real-time motion of the simulator.
The movements are stored in the memory of the computer and
can be transferred to tape or disc for later use.

COMPUTER INTERFACES

All three computers make available various signals for exter-
nal use. See Fig. 4.6. These include the data bus D0 to D7, some
of the lower address lines, READ and WRITE signals, the
system clock and on the VIC20 and BBC a memory block
decode. The BBC and VIC20 both use the 6502 microprocessor,
so have relatively similar decoding electronics. The Spectrum
uses a Z80. This together with some unusual practices in the
Spectrum design makes interfacing somewhat different.

All the data and address lines are hard wired together so if
two computers were simultaneously connected a bus clash
would occur. However there is no reason why two or more
robots should not be daisy-chained together either to perform
the same task or completely different tasks if a different address
is used. For example, using a BBC Computer one robot could be
addressed with the link-selected “FRED” decode (FC00–FCFF)
whilst the other is addressed with the link-selected “JIM” decode
(FF00–FEFF). All three interfaces generate a VALID WRITE
signal. The Spectrum WRITES to the block 0000–1FFF which
is where the ROM resides and as ROMs are not normally writ-
ten to no conflict occurs. The other computers WRITE to non-
existent areas of RAM. IC302 is a multiplexer which selects
which interface will generate the READ and WRITE signals.
The Spectrum interface generates two READ signals (ZXRD63
and ZXRD95). These are not passed through the multiplexer
but are used later on in the electronics to perform direct
READs.
Fig. 4.6. Interface electronics
DACs (1C105, 108, 110, 113, 115, 118). All the data passes in the latches is converted into position control voltages by the axis. The other axes are then written to similarly. The data held goes high the data is written into the latch corresponding to that axis. When the VALID WRITE signal is generated and the LSBs of the address bus are instruction cycle, the data is set up on the data bus, a VALID address lines. A typical WRITE is as follows. In one computer address decodes from IC102, which is driven by the lowest three address lines. See Fig. 4.7. Six latches are used to store this data (IC104, 107, 109, 112, 114, 117). These are individually clocked with the direction from A to B (READ mode). When the D1R signal is high, data passes in the other direction from A to B (WRITE mode). The data in the latches is converted into position control voltages by the DACs (IC105, 108, 110, 113, 115, 118). All the data passes through IC100 which is a 74LS245 bus transceiver. When the DIRECTION signal is low, data passes from B to A (WRITE mode). When the DIR signal is high, data passes in the other direction from A to B (READ mode).

**READING**

There are two ADCs in the system, IC400 and 402 as shown in Fig. 4.8. These are 8-bit devices with integral 8-way analog multiplexers and integral 3-bit address latches. IC400 is used to look at the feedback voltages VF1 to VF5 and the other looks at the learn axis (simulator) signals VL0 to VL5. The input voltages to the analog multiplexer must not exceed the ADC

---

**Fig. 4.7. The electronics concerned with a “Write” operation**
supply rails. To prevent this from occurring diode and transistor clamps are used wherever higher voltages could possibly arise.

A READ is performed as follows. The axis channel is selected by writing a 3-bit code (BD8,1,2, and BD4,5,6) into the ADCs. The ALE (Address Latch Enable) signal latches these codes into the ADC internal registers. These codes select the multiplexer position. A start conversion signal is then generated. The ADC takes about 100 microseconds to perform the conversion. A test can be made for the end of conversion (EOC). By generating the EOC signal both EOCs can be tested as both ADCs convert at the same time. A high indicates end of conversion (see IC101). When the conversion is complete then one or both of the ADCs can be READ. The ADCs have tri-state outputs which are enabled by the OEF and OEL signals (active high). The READ is then performed by generating a VALID READ signal and an address code to select one of the two ADCs. This enables the tri-state output of the selected ADC and also generates a DIR signal which sends data out from the interface board onto the computer's data bus. The computer can then READ the axis data.

NEXT MONTH: MENTOR construction

Fig. 4.8. Analog-to-digital conversion for a 'Read' operation
TWO FABULOUS OFFERS FROM
ALCON

The incredible ‘MINI 20’

28 ranges
20kΩ/V d.c. & 4kΩ/V a.c.
(With protective fuse)

Accuracy: 2% d.c. and resistance,
3% a.c.

28 ranges: d.c. V 100mV, 3V, 10V,
30V, 100V, 300V, 600V, d.c. I
150μA, 600μA, 6mA, 60mA, 1.0μA,
15V, 50V, 150V, 500V, 1500V, a.c.
130mA, 300mA, 3.0A. Ohms: 0-
2kΩ, 0-2MΩ from -10 to +62 in
6 ranges.

Dimensions: 105 x 130 x 40mm.

The 28 ranges cover all likely
requirements. Operation is straight-
forward, just turn the selection
switch to the required range.

This special offer is a wonderful
opportunity to acquire an essen-
tial piece of test gear with a saving
of nearly £10.00.

THE IDEAL INSTRUMENT
FOR THE CONSTRUCTOR

(please with carrying case, leads and instructions)

ONLY £21.60

‘SUPER 20’
A SUPER PROTECTED UNIVERSAL MULTIMETER

★ 20KΩ/V
AC AND DC
★ 39 RANGES
★ INDESTRUCTIBLE
( on all ranges but 10A )

Accuracy: d.c. ranges and Ω 2% a.c. 3% (of f.s.d.)
39 ranges: d.c. V 100mV, 1V, 3V, 10V, 30V, 100V,
30V, 100V, d.c. I 50μA, 100μA, 300μA, 1.0μA, 3mA, 10mA, 30mA,
100mA, 1A, 10A.

a.c. V 10V, 30V, 100V, 300V, 1000V;
a.c. I 1mA, 10mA, 30mA, 100mA, 1.0A, 10A.
Ω 0-5kΩ, 0-50kΩ, 0-500kΩ, 5MΩ, 50MΩ.

db from -10 to +61 in 5 ranges.

Dimensions: 105 x 130 x 40mm.

These special offers is a wonderful
opportunity to acquire an essen-
tial piece of test gear with a saving of nearly £20.00.

(please with carrying case,
leads and instructions)

ONLY £33.50

PRICES
Our prices include VAT and postage and goods are normally
dispatched by return.

For details of these and the many other instruments in the Alcon range,
including multimeters, components measuring, automotive and elec-
tronic instruments, please write or telephone:

ALCON
Instruments Ltd.
19 MULBERRY WALK - LONDON SW3 6DZ - TEL: 01-352 1897 - TELEX: 918967
<table>
<thead>
<tr>
<th>Project Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alarm, Anti-Theft</td>
<td>Mar 24</td>
</tr>
<tr>
<td>Alarm, Baby</td>
<td>May 43</td>
</tr>
<tr>
<td>Alarm, Low Water Level</td>
<td>Aug 58</td>
</tr>
<tr>
<td>Alarm, Radar Security</td>
<td>Oct 30</td>
</tr>
<tr>
<td>Alarm System by G. E. Lumley</td>
<td>July 48, Aug 60</td>
</tr>
<tr>
<td>Analysers, Simple Logic</td>
<td>July 14, Aug 50</td>
</tr>
<tr>
<td>Anti-Theft Alarm by M. Tooley BA and D. Whitfield MA MSc CEng MIEE</td>
<td>Apr 23</td>
</tr>
<tr>
<td>Audio Noise Generator by Tom Gaskell BA(Hons) CEng MIEE</td>
<td>Dec 48</td>
</tr>
<tr>
<td>Audio Signal Generator by Stephen Ibbs</td>
<td>May 30</td>
</tr>
<tr>
<td>Autosave, Spectrum</td>
<td>Mar 14</td>
</tr>
<tr>
<td>Baby Alarm by Tom Gaskell BA(Hons)</td>
<td>May 43</td>
</tr>
<tr>
<td>Calibrator, Oscilloscope</td>
<td>July 56</td>
</tr>
<tr>
<td>Camera Trigger, Ultrasonic</td>
<td>Jan 28</td>
</tr>
<tr>
<td>Car Computer by S. H. Cousins and P. D. Wilson</td>
<td>Dec 10</td>
</tr>
<tr>
<td>Car Interior Light Delay Switch by N. J. Chaffey</td>
<td>Apr 36</td>
</tr>
<tr>
<td>Clock Timer by T. J. Johnson</td>
<td>Feb 24</td>
</tr>
<tr>
<td>Combination Lock by Tom Gaskell BA(Hons) CEng MIEE</td>
<td>Nov 26</td>
</tr>
<tr>
<td>Commodore 64 RS232C Interface by R. A. Penfold</td>
<td>Aug 12</td>
</tr>
<tr>
<td>Computer, Car</td>
<td>Dec 10</td>
</tr>
<tr>
<td>Computer DFM Adaptor by R. A. Penfold</td>
<td>Nov 49</td>
</tr>
<tr>
<td>Computer Terminal by Ray Stuart</td>
<td>Feb 16, Mar 28</td>
</tr>
<tr>
<td>Continuity Checker by Chris Lare</td>
<td>June 52</td>
</tr>
<tr>
<td>Controller, Temperature</td>
<td>Feb 50</td>
</tr>
<tr>
<td>Controller, Through-the-Mains</td>
<td>Sept 40</td>
</tr>
<tr>
<td>Converter, Parallel to Serial</td>
<td>Sept 17</td>
</tr>
<tr>
<td>Cross Hatch Generator by R. A. Penfold</td>
<td>June 48</td>
</tr>
<tr>
<td>DFM Adaptor, Computer</td>
<td>Nov 49</td>
</tr>
<tr>
<td>Digital Dice by P. Leah</td>
<td>Aug 30</td>
</tr>
<tr>
<td>Dissolve, Slide</td>
<td>July 30</td>
</tr>
<tr>
<td>Duplicator, EPROM</td>
<td>July 20</td>
</tr>
<tr>
<td>Echo &amp; Reverb, Mono/Stereo</td>
<td>Sept 10</td>
</tr>
<tr>
<td>EPROM Duplicator by Prof. K. Padmanabhan PhD MIEE and S. Ananthi</td>
<td>July 20</td>
</tr>
<tr>
<td>Expanding the VIC 20 by Sam Withey</td>
<td>Jan 36, Mar 36, April 46, May 36</td>
</tr>
<tr>
<td>f-Stop Enlarger Timer by Tom Gaskell BA(Hons) AMIEE</td>
<td>July 28</td>
</tr>
<tr>
<td>Field Measurements by T. P. Manning</td>
<td>July 22</td>
</tr>
<tr>
<td>Filter Shift Phaser by John H. Becker</td>
<td>Oct 10</td>
</tr>
<tr>
<td>Frequency Oscillator, Spot</td>
<td>June 60</td>
</tr>
<tr>
<td>Generator, Audio Signal</td>
<td>May 30</td>
</tr>
<tr>
<td>Generator, Cross Hatch</td>
<td>June 48</td>
</tr>
<tr>
<td>Generator, Heads &amp; Tails</td>
<td>Apr 42</td>
</tr>
<tr>
<td>Generator, Logic Signal</td>
<td>May 23</td>
</tr>
<tr>
<td>Heads and Tails Generator by M. Tooley BA and D. Whitfield MA MSc CEng MIEE</td>
<td>Apr 42</td>
</tr>
<tr>
<td>Hyperchaser by P. Newbury</td>
<td>June 24</td>
</tr>
<tr>
<td>Interface, Commodore 64 RS232C</td>
<td>Aug 12</td>
</tr>
<tr>
<td>Light Delay Switch, Car Interior</td>
<td>Apr 36</td>
</tr>
<tr>
<td>Lock, Combination</td>
<td>Nov 26</td>
</tr>
<tr>
<td>Lock, Opto</td>
<td>Oct 56</td>
</tr>
<tr>
<td>Logic Probe, Pulse Direction</td>
<td>Oct 52</td>
</tr>
<tr>
<td>Logic Signal Generator by M. Tooley BA and D. Whitfield MA MSc CEng MIEE</td>
<td>May 23</td>
</tr>
<tr>
<td>Low Water Level Alarm by Tom Gaskell BA(Hons) AMIEE</td>
<td>Aug 58</td>
</tr>
<tr>
<td>Mastermind Timer by J. D. Parkinson BSSc</td>
<td>Aug 18</td>
</tr>
<tr>
<td>Measurements, Field</td>
<td>Aug 22</td>
</tr>
<tr>
<td>Meter, Plant Watering</td>
<td>Apr 39</td>
</tr>
<tr>
<td>Microstepper by L. G. Parkin BA</td>
<td>Apr 18</td>
</tr>
<tr>
<td>Modulator, Ring</td>
<td>Nov 10, Dec 23</td>
</tr>
<tr>
<td>Mono/Stereo Echo &amp; Reverb by John M. H. Becker</td>
<td>Sept 10</td>
</tr>
<tr>
<td>Opto-Lock by Tom Gaskell BA(Hons) CEng MIEE</td>
<td>Oct 56</td>
</tr>
<tr>
<td>Oscilloscope Calibrator by M. Tooley BA and D. Whitfield MA MSc CEng MIEE</td>
<td>July 56</td>
</tr>
<tr>
<td>Parallel to Serial Converter by R. A. Penfold</td>
<td>Sept 17</td>
</tr>
<tr>
<td>Phaser, Filter Shift</td>
<td>Oct 10</td>
</tr>
<tr>
<td>Plant Watering Meter by Tom Gaskell BA(Hons)</td>
<td>Apr 39</td>
</tr>
<tr>
<td>PSU, Simple</td>
<td>May 60</td>
</tr>
<tr>
<td>Pulse Direction Logic Probe by S. A. Withey</td>
<td>Oct 52</td>
</tr>
<tr>
<td>Radar Security Alarm</td>
<td>Oct 30</td>
</tr>
<tr>
<td>Regulator, Voltage and Current</td>
<td>Sept 45</td>
</tr>
<tr>
<td>Ring Modulator by John H. Becker</td>
<td>Nov 10, Dec 23</td>
</tr>
<tr>
<td>Robots, Neptune</td>
<td>Sept 32, Oct 28, Nov 28, Dec 52</td>
</tr>
<tr>
<td>Simple Logic Analyser by Chris Atkins</td>
<td>Jul 14, Aug 50</td>
</tr>
<tr>
<td>Simple PSU by Stephen Ibbs</td>
<td>May 60</td>
</tr>
<tr>
<td>Simple Speech by P. Creighton</td>
<td>Jan 55</td>
</tr>
<tr>
<td>Slide Dissolve by Peter F. Wells</td>
<td>July 30</td>
</tr>
<tr>
<td>Spectrum Autosave by R. A. Penfold</td>
<td>Mar 14</td>
</tr>
<tr>
<td>Spot Frequency Oscillator by Tom Gaskell BA(Hons) AMIEE</td>
<td>June 60</td>
</tr>
<tr>
<td>Stardesk by Peter Newbury</td>
<td>Jan 16, Feb 32</td>
</tr>
<tr>
<td>Sub Woofer by Cliff Hardcastle</td>
<td>July 24</td>
</tr>
<tr>
<td>Sustain Unit by R. A. Penfold</td>
<td>May 26</td>
</tr>
<tr>
<td>System, Alarm</td>
<td>July 48, Aug 60</td>
</tr>
<tr>
<td>Temperature Controller by T. J. Johnson</td>
<td>Feb 50</td>
</tr>
<tr>
<td>Terminal, Computer</td>
<td>Feb 16, Mar 28</td>
</tr>
<tr>
<td>Through-the-Mains Controller by R. A. Penfold</td>
<td>Sept 40</td>
</tr>
<tr>
<td>Timer, Clock</td>
<td>Feb 24</td>
</tr>
<tr>
<td>Timer, f-Stop Enlarger</td>
<td>July 28</td>
</tr>
<tr>
<td>Timer, Mastermind</td>
<td>Aug 18</td>
</tr>
<tr>
<td>Ultrasonic Camera Trigger by R. A. Penfold</td>
<td>Jan 26</td>
</tr>
<tr>
<td>Unit, Sustain</td>
<td>May 28</td>
</tr>
<tr>
<td>VIC 20, Expanding the</td>
<td>Jan 36, Mar 36, Apr 46, May 36</td>
</tr>
<tr>
<td>Voltage and Current Regulator by Tom Gaskell BA(Hons) CEng MIEE</td>
<td>Sept 34</td>
</tr>
<tr>
<td>woofer, Sub</td>
<td>July 24</td>
</tr>
</tbody>
</table>
GENERAL FEATURES

Compact Disc by Chris Kelly ........................................... Jan 30
Disc Drives Explained by M. Tooley BA and D. Whitfield MA MSc CEng MIEE .... Sept 22, Oct 20, Nov 40
Fibre Optics by D. Stewart ........................................... July 42
Hands on the QL by Dr. A.A. Berk ................................... July 34
INGENUITY UNLIMITED ................................................. April 25, 31, 41, May 63, June 34, Aug 44, Oct 58
A Simple VCO by A. Flind ........................................... Aug 48
Audible Reversing Alarm by J. McPherson ......................... June 34
Audio to Logic Interface by P. Thompson ......................... Aug 48
Automatic Bilge Pump by G.W. Co/es ................................ Oct 58
Flood Alarm by Dr. C.J.D. Catto ...................................... Aug 44
Foolproof Switch Bank by G. Durant ................................ April 41
Infra-Red Shop Doorbell by A.R.W. Hall .......................... Aug 46
Internal Resistance Meter by R.P. Dudley ......................... Aug 47
Intruder Alarm by P.E. Mackrell .................................... May 63
Joystick for Dragon 32/64 by T.M. Gooding ....................... Aug 45
Low Cost Keyless Lock by S.A. Brown ................................ Aug 49
Low Power Voltage Regulator by A. Flind ......................... Aug 45
Micropower Regulator by B. Hunter ................................ Oct 58
Monostable Frequency Divider by P. Thompson .................. April 25
Power Supply Fast Shut Off by G.V. Whitney ...................... Aug 46
Scalectrix Motor Control by A. Cook ............................... June 34
Venetian Blind Intruder Alarm by G.E. Lumsley ................. Aug 49
Voltage Controlled Amplitude by A. Flind ......................... Aug 44
35 i.e.d. Tacho by I. Benton ........................................... April 31
INMOS by Tom Ivall ..................................................... March 50
Introduction to Digital Electronics by M. Tooley BA and D. Whitfield MA MSc CEng MIEE .... Jan 46, Feb 60, March 54, Apr 62, May 52, June 38
Micro Bus ................................................................. Feb 67, March 61, April 35, May 58, June 56, Aug 26, Sept 57, Oct 29
Microprofessor Review by M. Tooley BA .......................... April 58
Monitors for Home Computers by M. Tooley BA and D. Whitfield MA MSc CEng MIEE .... Feb 44, March 47
Multimeters—Buyer’s Guide .......................................... May 14
Nickel Cadmium Batteries by M. Tooley BA and D. Whitfield MA MSc CEng MIEE .... Nov 17, Dec 38
Radio Astronomy by Frank W. Hyde ............................... Aug 35
SEMI DUC T OR COUR C I T S by Tom Gaskell BA(Hons) CEng MIEE ..... Jan 60, Feb 28, March 18, April 38, May 42, June 58, July 26, Aug 57, Sept 52, Oct 54, Nov 24, Dec 46
Stereo Signal Processor (TDA 3810) ................................ Jan 60
LED Bargraph Drivers (UB ... B Series) ................................Feb 28
Tachometers (LM 2917N-8 and LM 2917N) ......................... July 26
Fluid Detector (LM 1830N) ........................................... Aug 57
Voltage and Current Regulator (L 200C) .......................... Sept 52
Encoder/Decoder (MM 53200N) ........................................ Oct 54
Pushbutton Locks (LS 7228 and LS 7229) ......................... Nov 24
Digital Noise Source (MM5837N) ................................. Dec 46
Sequential Logic Techniques by M. Tooley BA and D. Whitfield MA MSc CEng MIEE .... Oct 16, Nov 53.
Soldering Instrument—Buyer’s Guide ................................ Dec 15
Spot Pricing by T.W. Berrie ............................................. June 35
Technology Update: SO SMD’s ....................................... May 48
Test Instruments—Buyer’s Guide ..................................... June 14
Transputer by R.W. Coles ............................................ April 26
Vernon Trent at Large ............................................... Jan 34, Feb 56, March 23, April 32, May 35, June 47, July 41, Aug 54, Sept 56, Oct 51, Dec 44

NEWS AND COMMENT

BOOK REVIEWS ......................................................... Aug 67
EDITORIAL ......... Jan 13, Feb 13, March 11, April 15, May 11, June 11, July 9, Aug 7, Sept 7, Oct 7, Nov 7, Dec 7
INDUSTRY NOTEBOOK by Nexus ................................. Jan 24, Feb 22, March 17, April 54, May 45, June 23, July 33, Aug 29, Sept 31, Oct 36, Nov 23, Dec 28
LEADING EDGE by Barry Fox ........................................ Aug 43, Sept 46

NEWS AND MARKET PLACE ...... Jan 14, Feb 14, March 12, April 16, May 12, June 12, July 10, Aug 8, Sept 8, Oct 8, Nov 8, Dec 8
PATENTS REVIEW ............. Feb 43, April 44, May 47, July 38
PRINTED CIRCUIT BOARD SERVICE ............ Nov 37, Dec 37
READOUT ......................................................... Jan 62, March 34, 62, Oct 46
SPACEWATCH by Frank W. Hyde ......................... Jan 45, Feb 59, March 35, April 57, June 33
SPACEWATCH by Dr. Patrick Moore OBE ............. Aug 40, Sept 49, Oct 49, Nov 38, Dec 38
STRICTLY INSTRUMENTAL by K. Lenton-Smith ....... Aug 66

SPECIAL SUPPLEMENTS

Micro-File by Ray Coles
Filesheet 13 ZB .................................................... Jan
Filesheet 14 8073 .................................................. March
Filesheet 15 NSC800 ................................................ May
Filesheet 16 NS16032 ............................................... June
Filesheet 17 Z800 .................................................. July
Robotics by Tom Ivall ............................................. Nov
PRACTICAL INTERFACE CIRCUITS FOR MICROS
by G. Loveday
Price: £8.50

RADIO AND TELEVISION SERVICING 1983-84
MODELS
by R.A. Warnwright
Price: £5.04

UNIVERSAL TROUBLESHOOTING ELECTRONICS
by Texas Instruments
Price: £5.45

ESSENTIAL ELECTRONICS AN A TO Z GUIDE
by G. Loveday
Price: £5.07

OPERATIONAL AMPLIFIER EXPERIMENTAL Manual
by G. Clayson
Price: £7.30

TELEVISION PRINCIPLES & PRACTICE
by G.R. Williams & Monochrome
by J.S. ZARACH
Price: £7.60

SERVICING DIGITAL CIRCUITS IN TV RECEIVERS
by R. Fisher
Price: £14.60

VLSI TECHNOLOGY
by S.B.
Price: £10.95

ENGINEERING APPROACH TO DIGITAL DESIGN
by W.F. Fletcher
Price: £17.50

DIGITAL SYSTEMS & TECHNIQUES
by D.C. Green
Price: £6.75

PRACTICAL INTERFACE CIRCUITS FOR MICROS
by G. Loveday
Price: £8.50

RADIO AND TELEVISION SERVICING 1983-84
MODELS
by R.A. Warnwright
Price: £5.04

UNIVERSAL TROUBLESHOOTING ELECTRONICS
by Texas Instruments
Price: £5.45

ESSENTIAL ELECTRONICS AN A TO Z GUIDE
by G. Loveday
Price: £5.07

OPERATIONAL AMPLIFIER EXPERIMENTAL Manual
by G. Clayson
Price: £7.30

TELEVISION PRINCIPLES & PRACTICE
by G.R. Williams & Monochrome
by J.S. ZARACH
Price: £7.60

SERVICING DIGITAL CIRCUITS IN TV RECEIVERS
by R. Fisher
Price: £14.60

VLSI TECHNOLOGY
by S.B.
Price: £10.95

ENGINEERING APPROACH TO DIGITAL DESIGN
by W.F. Fletcher
Price: £17.50

DIGITAL SYSTEMS & TECHNIQUES
by D.C. Green
Price: £6.75

PRICES INCLUDE POSTAGE & PACKING a

THE MODERN BOOK CO.
BRITAIN'S LARGEST STOCKIST
of British and American Technical Books

19-21 PRAED STREET
LONDON W2 1NP

Phone 01-402 9176
Closed Saturday 1 p.m.

Please allow 14 days for reply or delivery.

PRACTICAL INTERFACE CIRCUITS FOR MICROS
by G. Loveday
Price: £8.50

RADIO AND TELEVISION SERVICING 1983-84
MODELS
by R.A. Warnwright
Price: £5.04

UNIVERSAL TROUBLESHOOTING ELECTRONICS
by Texas Instruments
Price: £5.45

ESSENTIAL ELECTRONICS AN A TO Z GUIDE
by G. Loveday
Price: £5.07

OPERATIONAL AMPLIFIER EXPERIMENTAL Manual
by G. Clayson
Price: £7.30

TELEVISION PRINCIPLES & PRACTICE
by G.R. Williams & Monochrome
by J.S. ZARACH
Price: £7.60

SERVICING DIGITAL CIRCUITS IN TV RECEIVERS
by R. Fisher
Price: £14.60

VLSI TECHNOLOGY
by S.B.
Price: £10.95

ENGINEERING APPROACH TO DIGITAL DESIGN
by W.F. Fletcher
Price: £17.50

DIGITAL SYSTEMS & TECHNIQUES
by D.C. Green
Price: £6.75

PRICES INCLUDE POSTAGE & PACKING a

THE MODERN BOOK CO.
BRITAIN'S LARGEST STOCKIST
of British and American Technical Books

19-21 PRAED STREET
LONDON W2 1NP

Phone 01-402 9176
Closed Saturday 1 p.m.

Please allow 14 days for reply or delivery.

ADVANCED TELECOMMUNICATIONS

Careers with extensive experience at Cheltenham
Join the Government Communications Headquarters, one of the world's foremost centres
for R & D and production in voice/data communications ranging from HF to satellite
– and their security. Some of GCHQ's facilities are unique and there is substantial emphasis on creative
solutions to develop complex telecommunications problems using state-of-the-art techniques
including computer/microprocessor applications. Current opportunities are for:

Telecommunication Technical Officers

- Two levels of advancement offer two salary scales: £62-82 & £84-100

Minimum qualifications are TEC/SCOTEC in Electronics/Telecommunications or a similar discipline
and C or G Part II Telecommunications Technicians Certificate or Part I plus Maths B, Technology B
and either Radio Line Transmission B or Computers B or equivalent:

ONC in Electronics, Electronics or Telecommunications Engineering or a CIE Part I

Application forms may be available.

For further information and your application form, please telephone:
Cheltenham (0242) 239123 or write to:

GCHQ
Recruitment Office, Government Communications Headquarters,
Oakley, Priory Road, Cheltenham,
Gloucestershire, GL52 5AJ.

1984/5 CATALOGUE

This single volume catalogues all

1984/5 CATALOGUE

This single volume catalogues all

OP2010 110 x 80 x 20mm, this too has cut outs for range switches and terminal, with a smart aluminium cover with rings etc. Battery removable by removal cover on back. 75p.

OP20100 Same size as above, but this was for use as a digital thermistor, so there's only a single 9mm O.D. hole in the front panel. 75p.

FIBRE OPTICS

Scoop purchase of single and twin cable. For use with 9V light or red core. Cost 1mm dia, overall 1.2mm dia, Single £1.90, Twin £3.00. 10m spool. £7.90.

MINIATURE RELAYS

PCB mounting. £55.00 to £11.00 per 100.

NICAD CHARGER PANEL

12V £113mm PCB with one massive 24 cell £37 x 120mm flatpack and another smaller £32 x 35mm O.D. rated 3.6v 600mA. The price of these Nicad units now is over £20. Also on the panel is a mains input changer transformer with two separate secondary windings wired by bridge rectifiers, smoothing capacitors and a relay to the output board. The panel will weigh 3kg. All this for just £59.00

AM TUNER PANEL

Z816 For use with mono amp set above. Next panel is £11.00. Only £1.10. For £12.00.

NI-CAD CHARGERS SCOOOP

Every Ready model CH4, this charger will take up to 4 AA or D cells plus 2 PP3 if required Smart two

ever

CLUTCH, thus enabling turning of the vehicle, and a

WAY RELAYS

MINIATURE RELAYS

PCB mounting. £55.00 to £11.00 per 100.

NICAD CHARGER PANEL

12V £113mm PCB with one massive 24 cell £37 x 120mm flatpack and another smaller £32 x 35mm O.D. rated 3.6v 600mA. The price of these Nicad units now is over £20. Also on the panel is a mains input changer transformer with two separate secondary windings wired by bridge rectifiers, smoothing capacitors and a relay to the output board. The panel will weigh 3kg. All this for just £59.00

AM TUNER PANEL

Z816 For use with mono amp set above. Next panel is £11.00. Only £1.10. For £12.00.

NI-CAD CHARGERS SCOOOP

Every Ready model CH4, this charger will take up to 4 AA or D cells plus 2 PP3 if required Smart two

Copyright © 2023 Corel Corporation. All Rights Reserved.
When replying to Classified Advertisements please ensure:
(A) That you have clearly stated your requirements.
(B) That you have enclosed the right remittance.
(C) That your name and address is written in block capitals, and
(D) That your letter is correctly addressed to the advertiser.
This will assist advertisers in processing and despatching orders with the minimum of delay.

RECEIVERS AND COMPONENTS
ROUNDETON WROXHAM. Electronic components specialising in receivers for 33 years. FORRESTERS (NATIONAL RADIO SUPPLIES), Late Holdenhurst Road Now at 36, Ashley Road, Boscombe. Tel: 302204. Closed Weds.

FIFTY 74 SERIES on panel £2.20. Assorted components £5.00/£6.50 lbs or 10 lbs post paid. J. W. BLANSHARD. 2 SUPPLIES, Late Holdenhurst Road. Now at Rastos.

RESISTOR PACKS FOR ALL PROJECTS
1 watt carbon film resistors 5% 1 ohm to 10M £1.20 series. Packs of 10 each value (1690 resistors) £10.00. Your choice of quantities/your choice of E12 Series. Packs of 10 each value (6000 resistors) £30.00.

BARGAIN BUMPER BOX OF BITS
Contains: working calculator, working watch module, various IC's, transistors, display tubes, PCBs, diodes batteries, gears, switches etc., etc. All useful items. Would cost much, much more if bought separately. ONLY £15 (inc. VAT and P&P).

SEND CHEQUE/P.O. TO:
Barbara Page, Spares Dept., Decimo Ltd
4-18 Chobham St., Luton LU1 3BS

ORDER FORM PLEASE WRITE IN BLOCK CAPITALS

Please insert the advertisement below in the next available issue of Practical Electronics for insertions. I enclose Cheque/P.O. for £

(Cheques and Postal Orders should be crossed Lloyds Bank Ltd. and made payable to Practical Electronics)

NAME
ADDRESS

ORDER FORM PLEASE WRITE IN BLOCK CAPITALS

Please insert the advertisement below in the next available issue of Practical Electronics for insertions. I enclose Cheque/P.O. for £

(Cheques and Postal Orders should be crossed Lloyds Bank Ltd. and made payable to Practical Electronics)

NAME
ADDRESS

ORDER FORM PLEASE WRITE IN BLOCK CAPITALS

Please insert the advertisement below in the next available issue of Practical Electronics for insertions. I enclose Cheque/P.O. for £

(Cheques and Postal Orders should be crossed Lloyds Bank Ltd. and made payable to Practical Electronics)

NAME
ADDRESS

ORDER FORM PLEASE WRITE IN BLOCK CAPITALS

Please insert the advertisement below in the next available issue of Practical Electronics for insertions. I enclose Cheque/P.O. for £

(Cheques and Postal Orders should be crossed Lloyds Bank Ltd. and made payable to Practical Electronics)

NAME
ADDRESS

ORDER FORM PLEASE WRITE IN BLOCK CAPITALS

Please insert the advertisement below in the next available issue of Practical Electronics for insertions. I enclose Cheque/P.O. for £

(Cheques and Postal Orders should be crossed Lloyds Bank Ltd. and made payable to Practical Electronics)

NAME
ADDRESS

ORDER FORM PLEASE WRITE IN BLOCK CAPITALS

Please insert the advertisement below in the next available issue of Practical Electronics for insertions. I enclose Cheque/P.O. for £

(Cheques and Postal Orders should be crossed Lloyds Bank Ltd. and made payable to Practical Electronics)

NAME
ADDRESS

ORDER FORM PLEASE WRITE IN BLOCK CAPITALS

Please insert the advertisement below in the next available issue of Practical Electronics for insertions. I enclose Cheque/P.O. for £

(Cheques and Postal Orders should be crossed Lloyds Bank Ltd. and made payable to Practical Electronics)

NAME
ADDRESS

ORDER FORM PLEASE WRITE IN BLOCK CAPITALS

Please insert the advertisement below in the next available issue of Practical Electronics for insertions. I enclose Cheque/P.O. for £

(Cheques and Postal Orders should be crossed Lloyds Bank Ltd. and made payable to Practical Electronics)

NAME
ADDRESS

ORDER FORM PLEASE WRITE IN BLOCK CAPITALS

Please insert the advertisement below in the next available issue of Practical Electronics for insertions. I enclose Cheque/P.O. for £

(Cheques and Postal Orders should be crossed Lloyds Bank Ltd. and made payable to Practical Electronics)

NAME
ADDRESS

ORDER FORM PLEASE WRITE IN BLOCK CAPITALS

Please insert the advertisement below in the next available issue of Practical Electronics for insertions. I enclose Cheque/P.O. for £

(Cheques and Postal Orders should be crossed Lloyds Bank Ltd. and made payable to Practical Electronics)

NAME
ADDRESS

ORDER FORM PLEASE WRITE IN BLOCK CAPITALS

Please insert the advertisement below in the next available issue of Practical Electronics for insertions. I enclose Cheque/P.O. for £

(Cheques and Postal Orders should be crossed Lloyds Bank Ltd. and made payable to Practical Electronics)

NAME
ADDRESS

ORDER FORM PLEASE WRITE IN BLOCK CAPITALS

Please insert the advertisement below in the next available issue of Practical Electronics for insertions. I enclose Cheque/P.O. for £

(Cheques and Postal Orders should be crossed Lloyds Bank Ltd. and made payable to Practical Electronics)

NAME
ADDRESS

ORDER FORM PLEASE WRITE IN BLOCK CAPITALS

Please insert the advertisement below in the next available issue of Practical Electronics for insertions. I enclose Cheque/P.O. for £

(Cheques and Postal Orders should be crossed Lloyds Bank Ltd. and made payable to Practical Electronics)

NAME
ADDRESS

ORDER FORM PLEASE WRITE IN BLOCK CAPITALS

Please insert the advertisement below in the next available issue of Practical Electronics for insertions. I enclose Cheque/P.O. for £

(Cheques and Postal Orders should be crossed Lloyds Bank Ltd. and made payable to Practical Electronics)

NAME
ADDRESS

ORDER FORM PLEASE WRITE IN BLOCK CAPITALS

Please insert the advertisement below in the next available issue of Practical Electronics for insertions. I enclose Cheque/P.O. for £

(Cheques and Postal Orders should be crossed Lloyds Bank Ltd. and made payable to Practical Electronics)

NAME
ADDRESS

ORDER FORM PLEASE WRITE IN BLOCK CAPITALS

Please insert the advertisement below in the next available issue of Practical Electronics for insertions. I enclose Cheque/P.O. for £

(Cheques and Postal Orders should be crossed Lloyds Bank Ltd. and made payable to Practical Electronics)

NAME
ADDRESS

ORDER FORM PLEASE WRITE IN BLOCK CAPITALS

Please insert the advertisement below in the next available issue of Practical Electronics for insertions. I enclose Cheque/P.O. for £

(Cheques and Postal Orders should be crossed Lloyds Bank Ltd. and made payable to Practical Electronics)

NAME
ADDRESS

ORDER FORM PLEASE WRITE IN BLOCK CAPITALS

Please insert the advertisement below in the next available issue of Practical Electronics for insertions. I enclose Cheque/P.O. for £

(Cheques and Postal Orders should be crossed Lloyds Bank Ltd. and made payable to Practical Electronics)

NAME
ADDRESS

ORDER FORM PLEASE WRITE IN BLOCK CAPITALS

Please insert the advertisement below in the next available issue of Practical Electronics for insertions. I enclose Cheque/P.O. for £

(Cheques and Postal Orders should be crossed Lloyds Bank Ltd. and made payable to Practical Electronics)

NAME
ADDRESS

ORDER FORM PLEASE WRITE IN BLOCK CAPITALS

Please insert the advertisement below in the next available issue of Practical Electronics for insertions. I enclose Cheque/P.O. for £

(Cheques and Postal Orders should be crossed Lloyds Bank Ltd. and made payable to Practical Electronics)

NAME
ADDRESS

ORDER FORM PLEASE WRITE IN BLOCK CAPITALS

Please insert the advertisement below in the next available issue of Practical Electronics for insertions. I enclose Cheque/P.O. for £

(Cheques and Postal Orders should be crossed Lloyds Bank Ltd. and made payable to Practical Electronics)

NAME
ADDRESS

ORDER FORM PLEASE WRITE IN BLOCK CAPITALS

Please insert the advertisement below in the next available issue of Practical Electronics for insertions. I enclose Cheque/P.O. for £

(Cheques and Postal Orders should be crossed Lloyds Bank Ltd. and made payable to Practical Electronics)

NAME
ADDRESS

ORDER FORM PLEASE WRITE IN BLOCK CAPITALS

Please insert the advertisement below in the next available issue of Practical Electronics for insertions. I enclose Cheque/P.O. for £

(Cheques and Postal Orders should be crossed Lloyds Bank Ltd. and made payable to Practical Electronics)
To advertise in this space

Ring MANDI
01-261 5846
The FULLY programmable digital synthesiser that you can AFFORD!

THE NEW CLEF COMPUTER MUSIC SYSTEM is so user programmable that you need a BBC Micro to run it! 32 harmonically programmable oscillators. 5 octave touch sensitive keyboard, up to 4 OSC/ENVs per voice. Real time sequencing. Massive potential for future software. Complete system (without BBC Micro) £675. Built. Phone or write for details. Modular systems also available.

P.E. HYPERCHASER

**CHANNEL PSEUDO INTELLIGENT LIGHT UNIT**
- 16 Programmes
- Manual Flash Buttons
- Manual/ Auto Programmes
- Stripe Outputs
- Individual Dimming
- Sound To Light

Not just a light unit but a sophisticated & comprehensive effects unit containing a full kit of parts including P.C.B., face, case, etc. Reprint of article on request.

PRICE INCLUDING P&P £84.95

BENNASHAM RECORDING LTD
327 Whitehorse Road, Croydon, Surrey CR0 2HS
Shop Hours: Mon - Sat, 10 to 5
Please allow 14 days for delivery.
Determine your destiny with dice and dexterity with the NEW FANTASY ADVENTURE GAME "THE TOWER OF TERROR" IN NEW PROTEUS £6.50 No. 1 A Complete Fantasy Adventure Game Magazine COMPLETE GAME ON SALE NOW
The amazing Maplin Catalogue is here again! The new edition is packed with hundreds and hundreds of new electronic components to bring you right up to date with all the latest developments. As all home constructors agree (and a good many professionals too) the Maplin Catalogue is the one essential piece of equipment they really need. And now with all our prices on the page the Maplin Catalogue is better value than ever.

On Sale From 10th November 1984.

Pick up a copy as soon as it's published at any branch of W.H. Smith or in one of our shops. The price is still just £1.35, or £1.75 by post from our Rayleigh address (quote CA02C).

Post this coupon now for your copy of the 1985 catalogue. Price £1.35 + 40p post and packing. If you live outside the U.K. send £2.40 or 11 International Reply Coupons. I enclose £1.75.

Name

Address

P.E 12/84