TV Camera

WHAT CB?

4 PAGE PULL-OUT
Guide to Legal Rigs

Build this Executive Toy!
Much more than just kits
quite simply the best way
to make music . . .

The smart contemporary styling of the 'black-boxes' contain the easy-to-build advanced electronics that produce everything from high grade amplification to complex lighting effects. These units are among the finest of their kind available and combine, as do all the Powertran kits, constructional ingenuity with high grade performance capability.

The finest materials and components are used throughout and the easy-to-follow fully illustrated and diagrammed manuals make building as pleasurable as operating.

Each unit can, of course, perform its independent function - but it is compatible with its fellows (same cabinet sizes and the same quality and professional finish) to enable you to assemble an impressive bank of wholly controllable power.

MPA 200 - a 100W amplifier with professional finish and performance at an exceptionally low price. Adaptable inputs mixer accepts a variety of sources. Straightforward construction – an excellent beginners kit.

COMPLETE KIT £49.90 (+ VAT)

CHROMATHEQUE 5000 - 5 channel lighting effect system. Sound to light, strobe to music level, random or sequential effects – each channel handles up to 500W yet minimal wiring is needed with our single-board design.

COMPLETE KIT £49.50 (+ VAT)

ETI VOCODER – 14 channel for maximum versatility and high intelligibility; each channel has independent level control. 2 input amplifiers – for speech/external excitation – each with level control and tone control. The Vocoder is a superb machine capable of infinite variety of operation. Construction with our easy to follow, comprehensive builders' manual – is challenging yet within the scope of most enthusiasts.

COMPLETE KIT £175 (+ VAT)

SP2 200 - 2 channel 100W amplifier. Two of the rugged, reliable and economic amplifiers from the MPA200 are fed by separate power supplies from a common toroidal transformer. Fully finished metalwork, fibreglass PCBs, controls, wire – everything you need to make this powerful unit.

COMPLETE KIT £64.90 (+ VAT)

DJ90 STEREOMIXER – a versatile new mixer with 2 stereo inputs for magnetic cartridges, a stereo auxiliary input and mike input. Auto planning for fast or slow, slider controls, multi-mixing, ducking, interrupt, input modulation – everything ... yet still under £100! (Our console below shows the mixer neatly teamed with a Chromatheque and SP2 200)

COMPLETE KIT £97.50 (+ VAT)
CONSTRUCTIONAL PROJECTS

INDECISION ELIMINATOR by W. C. Dickson
   Every civil servant should have one!
TV CAMERA Part 1 by Philip Gaffney
   Monochrome camera with u.h.f. modulated output
   Increases r.f. output to 4W
PE BANDBOX Part 3 by Alan Boothman B.Sc.
   Construction of system and display boards
DUAL DIGI-DICE by Tom Gaskell B.A.
   Another project incorporated in our Digital Design Techniques series
PE CAR COMPUTER Part 2 by P. MacFarlane
   Fitting of flow and speed sensors
PE ROBOTS Part 3 by Richard Becker and Tim Orr
   Mobile wheel base, motor control, display board and manual control keyboard

GENERAL FEATURES

SEMICONDUCTOR UPDATE by R. W. Coles
   Featuring 1804 WTV008
DIGITAL DESIGN TECHNIQUES Part 6 by Tom Gaskell B.A.
   Numerical Systems
MICROBUS by D. J. D.
   Hardware and software ideas for hobby computers

NEWS AND COMMENT

EDITORIAL
   NEWS & MARKET PLACE
      Including Countdown and Points Arising
INDUSTRY NOTEBOOK by Nexus
   What's happening inside industry
SPACEWATCH by Frank W. Hyde
   Extra-terrestrial activities
SPECIAL OFFER — PCB DRILL
   A quality tool at a bargain price
WHAT CB?
   Pull-out guide to legal rigs
PATENTS REVIEW

OUR FEBRUARY ISSUE WILL BE ON SALE FRIDAY, 8th JANUARY 1982
   (for details of contents see page 31)
Attractive VIDEO MONITOR 9" fully cased. B&W.

EPSON MX SERIES PRINTER: see top right

ETI/WATFORD'S MICRO EXPANSION

VACUUM TUBE DATA - 50v each

UNIVERSAL HEAT SINK

AXTEK Buy with

Soldering

IRONS

COPPER CLAD BOARDS

SOLDERING PENS

ULTRASONIC CRYSTALS

VOLTAGE REGULATORS

SWITCHES

ROCKER SWITCHES

ASTEC UHF

WATFORD'S Ultimate Monitor IC.

A 4K Monitor Chip specially designed to

WATFORD'S Ultimate Monitor IC.

Epson MX Series Printers

New available stock at very competitive prices.

MX80T 10" Tractor Feed, 9x9 matrix, 80 column Speed 80 CPS bi-directional Centronics Interface, Baud rate 110-

MX80FT Has Friction & Tractor Feed also with all the MX80T's facilities £395

MX100 132 Column plus all the facilities of MX80FT2. Value for money. £570
BUY NOW FOR CHRISTMAS
SAME DAY DESPATCH ON ALL EX-STOCK ITEMS
Give yourself something to build during the holiday.

DIGITAL VOLTmeter MODULE
Fully built & tested
- Positive and negative voltages with an FSD of 500mV which is easily extended.
- Requires only single supply - 7 - 12V.
- High overall accuracy ± 0.1% + 1 digit.
- Range bright 0.43" (11mm) LED displays.
- Supplied with full data and applications information.

ULTRASONIC ALARM MODULE
Fully built & tested
- A really effective fully built module which contains both ultrasonic transmitter and receiver, together with the necessary circuitry for providing the appropriate delays and false alarm suppression. Using this module with a suitable 12V power supply and relay unit such as that shown, a really effective though inexpensive intruder alarm may be constructed. The module, which is supplied with a comprehensive data sheet, is fast mounted in a wide range of enclosures. A ready drilled case, together with all the necessary hardware, is available below.

Power Supply & Relay Unit
£3.95 + VAT
Incorporating a stabilised 12V supply and a P.D.C.R. relay with 5A contacts, this unit is designed to operate in conjunction with the above ultrasonic unit. Fully built and tested, its compact size makes it ideal for constructing the smallest of units.

Temperature Measurement
£2.15 + VAT
An easily constructed kit using an I.C. probe providing a linear output of 10mV/°C over the temperature range from -10°C to +100°C. The unit is ideal for use in conjunction with the above DVM module providing an accurate digital thermometer suitable for a wide range of applications.

Power Supply
£4.95 + VAT
This fully built mains power supply provides two stabilised isolated outputs of 9V providing current levels of up to 250mA each. The unit is ideally suited for powering the DVM and the Temperature Measurement module.

In addition to the above a wide range of competitively priced electronic components is stocked. Please telephone your specific requirements.
- V.A.T. must be added on all items.
- Shop hours 9 - 5.30 (Wed. 9 - 1)
- ex-stock delivery on all items.
- Units on demonstration, callers welcome.
- Post and packing charge 50p per order. S.A.E. with all enquiries please.

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- V.A.T. must be added on all items.
- Shop hours 9 - 5.30 (Wed. 9 - 1)
- ex-stock delivery on all items.
- Units on demonstration, callers welcome.
- Post and packing charge 50p per order. S.A.E. with all enquiries please.

Special Offer
for Practical Electronics readers
C90 Cassettes
A major New Product from Videotone
These C90 LH cassettes are manufactured specially for Videotone by a major European manufacturer.

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Please tick the appropriate box for the quantity required:
5 @ 64p ea. + P&P 40p. £3.60
10 @ 50p ea. + P&P 50p. £6.40
25 @ 35p ea. + P&P £1. E14.25
I enclose Cheque/P.O. for:
Deduct amount from Access/B.card No.:
Signed
Name
Address
Post to Videotone, Crofton Park Road, London SE4.

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ALL WITH PRINTED CIRCUIT BOARDS!

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See Lists
128-Note Sequencer SET76 £120.45
16-Note Sequencer SET80 64.63
3-Channel Mixer SET107 £59.55
3-Microphone Mixer SET108 12.99
6-Channel Mixer SET90 96.67
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Audio Effects SET105 £15.12
Choir/Chorus SET100 £120.45
Compressor SET120 £25.05
Digital Reverb SET109 £75.50
Discostrobe SET57 £39.78
Dinamik synthesiser SET119 £10.51
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Formant Synthesiser See Lists £342.71
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Guitar Effects SET42 £16.92
Guitar Multiprocessor SET80 £19.15
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Microphone Pre-amp SET61 £11.32
Noise Limiter SET97 £15.98

NEW LIST NOW READY!
SEND S.A.E. FOR FREE COPY

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Phasing & Vibrato SET70 £36.25
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Rhythm Generators SET103 £75.50
Ring Modulator SET77 £12.82
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Simple Phat Unit SET25 £10.54
Smooth Fuzz SET91 £11.66
Speech Processor SET110 £12.18
Spin-phase Tremolo SET103 £28.98

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Dept. PE21, 22 High Street, Sidcup, Kent, DA14 6EH.
Telephone: 01-302 6104

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Telephone: 01-302 6104

Prices correct at press, E. & D.E., subject to stock.
Delivery frequently by return but please allow 14 days.

Practical Electronics January 1982
DEVELOPMENT

EPROM-PROGRAMMER

ROMULATOR

2716
2732
2532
etc.

1. MONITOR or TV output (625 line UHF). Data contents of memory visible — A WINDOW IN THE CHIP.
2. 28-KEY, 2-LEVEL KEYPAD with HEX ENTRY and EDITING CAPABILITY. (BYTES and BLOCKS of code can be changed, inserted, deleted, shifted around etc.)
3. INPUT and OUTPUT: SERIAL (RS232) and PARALLEL (Centronics) routines provide ready interface with computer or printer.
4. EMULATION of PROGRAM MEMORY in-circuit is performed by plugging SOFTY into the ROM SOCKET. A lead with a 24 pin DIL PLUG is supplied.
5. CASSETTE INTERFACE
6. EPROM-PROGRAMMER: an EPROM may be copied or reprogrammed at the press of a key.
7. PERSONALITY SWITCH selects 2716, 2532, 2732.

SOFTY is used as an EPROM-PROGRAMMER, a production ROM CHECKER and for the DEVELOPMENT and PRODUCTION of PRODUCTS which contain MICRO-PROCESSORS and use EPROM for program storage.

*Price is for a BUILT and TESTED SOFTY (No kits) including POWER SUPPLY, TV LEAD, ROMULATOR LEAD, 90 DAY WARRANTY and 14 day money-back guarantee.

£169.00 + £25.35 (VAT 15%) = £194.35.

DATAMAN DESIGNS,
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Dorchester (0305) 68066 (UK Sales)
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UNBEATABLE VALUE FOR MONEY!

New production capacity at Canterbury has increased our range, decreased our prices, improved our special customer design service. Choose from toroidal transformers in a range of 98 types.

Order using the FREPOST coupon below.

IMPORTANT: Regulation — All voltages quoted are FULL LOAD. Please add regulation figure to secondary voltage to obtain full load voltage.

The benefits of ILP toroidal transformers

ILP toroidal transformers are only half the weight and height of their laminated equivalents, and are available with 110V, 220V or 240V primaries coded as follows:

For 110V primary insert `-0-' in place of `-X-' in type number.
For 220V primary (Europe) insert `-1-' in place of `-X-' in type number.
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How to order Freepost:

Use this coupon, or a separate sheet of paper, to order products or any products from other ILP Electronics advertisements. No stamp is needed if you address to Freepost. Cheques and postal orders must be crossed and payable to ILP Electronics Ltd. C.O.D. orders must be registered. C.O.D. — add £1.00 to total order value. Access and Barclaycards welcome. Such cards must be registered. C.O.D. — add £1.00 to total order value. Access and Barclaycards welcome. All UK orders send post free within 7 days of receipt of order for single and small quantity orders.

ILP Electronics Ltd., Freepost 2, Graham Bell House, Roger Close, Canterbury CT2 7EP, Kent.

Please send me the following:

ILP modules

Total purchase price

Inclosure Cheque: $

Post and Orders

Int. Money Order

Please deduct my Access/ Barclaycard No.

Address

Signature

Post to: ILP Electronics Ltd, Freepost 2, Graham Bell House, Roger Close, Canterbury CT2 7EP, Kent.
Telephone (0227) 54727; Technical (0227) 547223; Telex 956573.

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STAY AHEAD, STAY WITH US

Ant e dition of ILP Electronics Ltd.
Since 1972 Clef Products have consistently produced leading designs in the field of Electronic Musical Instruments, many of which have been published in technical magazines, with musical quality of paramount importance. New techniques have been evolved and the latest musically valid technology has been incorporated into instruments designed for a wide range of technical capability. Back-up TELEPHONE advice to our dealers is available from the Designer of all Kits advertised.

**7½ OCTAVE DOMESTIC MODEL**
**COMPONENT KIT £217**
**COMPLETE KIT £299**

Component Kits include Keyboard, Key-switch hardware, all electronic components and may be purchased in kit form, or complete ready-to-use, with a four octave compass and split keyboard facility.

**ROTOR-CHORUS**
Comprehensive two speed organ rorator-simulator plus a three phase chorus generator on a single 8" x 5" pcb. The kit includes all components for mains operation and a stereo headphone driver pcb. Easily assembled, but is not a complete rorator/amplifier system.

**COMPONENT KIT £91.00**

**KEYBOARDS**
Our Squared Piano Keyboards are designed to provide the discerning musician with a piano feel with physical strength for the high impact players present in the Piano application. Includes electric piano, harpsichord, and clavinova.

**COMPLETE KIT £345**

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**COMPONENT KIT £217**
**COMPLETE KIT £345.70**

Component Kits include Keyboard, Key-switch hardware, and all electronic components plus tone generator. Includes four-octave Driver pcb, and wooden cab. A complete C. M. P. kit series can be supplied for £300.00 inc. post.

**COMPONENT KIT £115.00**

**SIX OCTAVE STAGE MODEL**
**COMPONENT KIT £217**
**COMPLETE KIT £40.25**

Priced to suit the stage area, the musical capability is equal to that of the Domestic Model, but the size is a considerable improvement.

**PRICES INCLUDE VAT, UK CARRIAGE & INSURANCE**

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**SPECIAL OFFER: 2/3" miniature C.C.T.V. cameras £130.00.**

**CLEF PRODUCTS (ELECTRONICS) LTD**

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**THE ELECTRONIC BAND-BOX**
**CURRENTLY IN 'PRACTICAL ELECTRONICS'**

**COMPLETE KIT £289**
**£399 MANFD.**

**PRICES INCLUDE MASTER RHYTHM**

A revoluiion in the field of Computer Music Generation.

**A MUSICIAN/TECHNOLOGY GROUP**
**SINGERS - RECORDING - PRACTICE**
**LIFE PERFORMANCE - COMPOSITION**

THE BAND-BOX provides an Electronic Banging Trio consisting of Drums, Bass, and a Chord Instrument (one of 16 formats /envelope combinations), with the capacity to store over 3,000 User Programmable Chord Changes on more than 120 different Drums. Using advanced Microcontroller technology, a Payback of 30-100 Seconds can be expected at any Key and all chosen Tempo. Complete Music Kit is electronically tuned and starts on any scale. Includes Reversal Chorus and Coda sections in addition to Multiple Score Sequencer. Kits are provided for Volante Pedal and Footswitch plus separate and mixed instrument Outputs. Total size 19" x 11" x 41" incorporating Master Rhythm.

**THE Programmable Drum Machine**

(As Published in conjunction with 'Practical Electronics')

**EIGHT TRACK DRIVE**
**FIFTEEN TRACK INSTRUMENTATION**
**TWELVE INSTRUMENTATION SEQUENCES OR MIXED INSTRUMENTATION**

**PRICE £76.00**
**MANFD. £119.00**

The Clef Master Rhythm is capable of scoring 24 intricate rhythmic patterns, and 30 note sequencer, and 16 note drum patterns, with Drumsticks, Brushes, or Latin Bongos and Caibes.

**FIVE OCTAVE £30.00**
**SIX OCTAVE £57.00**
**SEVEN OCTAVE £85.00**

**FLOPPY DISKS - BOXES OF TEN**

<table>
<thead>
<tr>
<th>System</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5&quot; D.S.S. D.</td>
<td>£325.60</td>
</tr>
<tr>
<td>5.25&quot; D.S.S. D.</td>
<td>£391.59</td>
</tr>
<tr>
<td>3&quot; D.S.S. D.</td>
<td>£37.95</td>
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<tr>
<td>5.25&quot; S.S.S.</td>
<td>£47.15</td>
</tr>
<tr>
<td>3.5&quot; S.S.S.</td>
<td>£64.97</td>
</tr>
</tbody>
</table>

**SPECIAL OFFER:** 2/3" miniature C.C.T.V. cameras £130.00. USE COMPUTER DESKS (NOTE: ONLY PERSONAL CALLERS)

**ALL THE ABOVE PRICES INCLUDE VAT.**

**THE BODY OF ANY SYSTEM**

**Let's face it — you can't produce as crisp an image on a domestic T.V. as you can on a Crofton monitor.**

**TYPICALLY**

- 9" Crofton Monitors
- P4 White £64.97
- P31 Green £79.62

**These Monitor Shugart prices are dependant upon Sterling/Dollar conversion rates.**

**Phone us for up to date prices.**

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**CLEF PRODUCTS (ELECTRONICS) LTD**

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01-922/1053

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**Build a pair of DALESFORD D speakers**

The Dalesford D has enjoyed consistenly good reviews and is acknowledged to be one of the best compact loudspeakers available. It is now offered in kit form at a consideraively saving over the assembled speaker.

Suitable for amplifiers of 20 - 70 watts
Size: 340 x 220 x 265mm. Finish: Walnut/black foam.

Price: £69.95 VAT per pair plus carriage £3.95 inc.

---

**THE electronic BAND-BOX**

**CURRENTLY IN 'PRACTICAL ELECTRONICS'**

**COMPLETE KIT £289**

---

**THE BODY OF ANY SYSTEM**

**Let's face it — you can't produce as crisp an image on a domestic T.V. as you can on a Crofton monitor.**

**TYPICALLY**

- 9" Crofton Monitors
- P4 White £64.97
- P31 Green £79.62

**These Monitor Shugart prices are dependant upon Sterling/Dollar conversion rates.**

**Phone us for up to date prices.**

---

**SHUGART FLOPPY DISK DRIVES**

**No case, No Power Supply**

<table>
<thead>
<tr>
<th>System</th>
<th>Cost</th>
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<tr>
<td>SA 500 5&quot;</td>
<td>£171.40</td>
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<td>SA 450 5&quot;</td>
<td>£171.50</td>
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<tr>
<td>SA 400 5&quot;</td>
<td>£225.80</td>
</tr>
<tr>
<td>SA 400 5&quot;</td>
<td>£325.80</td>
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<tr>
<td>SA 450 5&quot;</td>
<td>£391.59</td>
</tr>
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**FLOPPY DISKS**

**BOXES OF TEN**

<table>
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<th>System</th>
<th>Cost</th>
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<tr>
<td>Single sided 35/40 Track</td>
<td>£26.45</td>
</tr>
<tr>
<td>Double sided 35/40 Track</td>
<td>£37.95</td>
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<tr>
<td>Single sided 77 Track</td>
<td>£41.40</td>
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<td>Double sided 77 Track</td>
<td>£47.15</td>
</tr>
<tr>
<td>Single sided 8&quot;</td>
<td>£40.25</td>
</tr>
</tbody>
</table>

**CALLING ALL ZX-B1 USERS**

- Convert your ZX-B1 to full size
- Your peripherals can be retained
- Ask for more information on internal controls to suit individual taste, thus producing good musical sounds in a library driven unit and 8" x 5" x 25".
You Can't Beat  ILP Bipolar Power Amps for Power and Price

Get maximum power at minimum price, yet still with hi-fi specifications and a wide choice of outputs. ILP Bifetor power amps, now with or without heatsinks are unbeatable for domestic hi-fi — but for disco, guitar amplifiers and PA choose the new range of heavy duty power amps, again with or without heatsinks, with protection against permanent short circuit added safety for the disco or group user. Connection in all cases is simple — via Spins.

Every item has a 5 year no quibble guarantee and includes full connection data. So send your order FREEPOST today!

Load impedance, all models, 4 Ohm — infinitely. Input impedance, all models, 500kOhm. H.F. response, all models 15Hz-50kHz-3db.

Bipolar Standard, with heatsinks

<table>
<thead>
<tr>
<th>Model No.</th>
<th>Output power Watts</th>
<th>Distortion</th>
<th>Supply voltage</th>
<th>Size (mm)</th>
<th>Weight (Kg)</th>
<th>Price inc. VAT</th>
<th>Price ex VAT</th>
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<tbody>
<tr>
<td>HY 30</td>
<td>15w x 4 @ 200V</td>
<td>0.01%</td>
<td>350V @ 50Hz-40</td>
<td>120 x 78 x 50</td>
<td>1025</td>
<td>£36.00</td>
<td>£31.68</td>
</tr>
<tr>
<td>HY 60</td>
<td>30w x 2 @ 200V</td>
<td>0.01%</td>
<td>350V @ 50Hz-40</td>
<td>120 x 78 x 30</td>
<td>765</td>
<td>£72.00</td>
<td>£65.76</td>
</tr>
<tr>
<td>HY 120</td>
<td>60w x 2 @ 200V</td>
<td>0.01%</td>
<td>350V @ 50Hz-40</td>
<td>120 x 78 x 20</td>
<td>410</td>
<td>£144.00</td>
<td>£129.76</td>
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<tr>
<td>HY 200</td>
<td>100w x 2 @ 200V</td>
<td>0.01%</td>
<td>350V @ 50Hz-40</td>
<td>120 x 78 x 20</td>
<td>410</td>
<td>£240.00</td>
<td>£216.00</td>
</tr>
<tr>
<td>HY 400</td>
<td>200w x 2 @ 200V</td>
<td>0.01%</td>
<td>350V @ 50Hz-40</td>
<td>120 x 78 x 20</td>
<td>410</td>
<td>£480.00</td>
<td>£424.00</td>
</tr>
</tbody>
</table>

Bipolar Standard, without heatsinks

<table>
<thead>
<tr>
<th>Model No.</th>
<th>Output power Watts</th>
<th>Distortion</th>
<th>Supply voltage</th>
<th>Size (mm)</th>
<th>Weight (Kg)</th>
<th>Price inc. VAT</th>
<th>Price ex VAT</th>
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<tbody>
<tr>
<td>HY 60P</td>
<td>60w x 4 @ 200V</td>
<td>0.01%</td>
<td>350V @ 50Hz-40</td>
<td>120 x 78 x 30</td>
<td>765</td>
<td>£72.00</td>
<td>£65.76</td>
</tr>
<tr>
<td>HY 120P</td>
<td>120w x 4 @ 200V</td>
<td>0.01%</td>
<td>350V @ 50Hz-40</td>
<td>120 x 78 x 20</td>
<td>410</td>
<td>£144.00</td>
<td>£129.76</td>
</tr>
<tr>
<td>HY 200P</td>
<td>200w x 4 @ 200V</td>
<td>0.01%</td>
<td>350V @ 50Hz-40</td>
<td>120 x 78 x 20</td>
<td>410</td>
<td>£240.00</td>
<td>£216.00</td>
</tr>
<tr>
<td>HY 400P</td>
<td>400w x 4 @ 200V</td>
<td>0.01%</td>
<td>350V @ 50Hz-40</td>
<td>120 x 78 x 20</td>
<td>410</td>
<td>£480.00</td>
<td>£424.00</td>
</tr>
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</table>

Heavy Duty with heatsinks

<table>
<thead>
<tr>
<th>Model No.</th>
<th>Output power Watts</th>
<th>Distortion</th>
<th>Supply voltage</th>
<th>Size (mm)</th>
<th>Weight (Kg)</th>
<th>Price inc. VAT</th>
<th>Price ex VAT</th>
</tr>
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<tbody>
<tr>
<td>HD 150</td>
<td>150w x 4 @ 200V</td>
<td>0.01%</td>
<td>350V @ 50Hz-40</td>
<td>120 x 78 x 30</td>
<td>765</td>
<td>£72.00</td>
<td>£65.76</td>
</tr>
<tr>
<td>HD 200</td>
<td>200w x 4 @ 200V</td>
<td>0.01%</td>
<td>350V @ 50Hz-40</td>
<td>120 x 78 x 30</td>
<td>765</td>
<td>£144.00</td>
<td>£129.76</td>
</tr>
<tr>
<td>HD 400</td>
<td>400w x 4 @ 200V</td>
<td>0.01%</td>
<td>350V @ 50Hz-40</td>
<td>120 x 78 x 30</td>
<td>765</td>
<td>£288.00</td>
<td>£257.28</td>
</tr>
</tbody>
</table>

Heavy Duty without heatsinks

<table>
<thead>
<tr>
<th>Model No.</th>
<th>Output power Watts</th>
<th>Distortion</th>
<th>Supply voltage</th>
<th>Size (mm)</th>
<th>Weight (Kg)</th>
<th>Price inc. VAT</th>
<th>Price ex VAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>HD 150P</td>
<td>150w x 4 @ 200V</td>
<td>0.01%</td>
<td>350V @ 50Hz-40</td>
<td>120 x 78 x 30</td>
<td>765</td>
<td>£72.00</td>
<td>£65.76</td>
</tr>
<tr>
<td>HD 200P</td>
<td>200w x 4 @ 200V</td>
<td>0.01%</td>
<td>350V @ 50Hz-40</td>
<td>120 x 78 x 30</td>
<td>765</td>
<td>£144.00</td>
<td>£129.76</td>
</tr>
</tbody>
</table>

Protection: All line, MOISTURE SHORT CIRCUIT (ideal for disco/group-use should evidence of short circuit not be immediately apparent). The Heavy Duty range can claim additional output power devices and complementary protection circuitry with performance specs as for standard types.

How to order: Use this coupon, or a separate sheet of paper, to order these products, or any products from other ILP Electronics/advertisements. No stamp is needed if you use an Airmail envelope. Cheques and postal orders must be crossed and payable to ILP Electronics Ltd. Any products from other ILP Electronics advertisements. No stamp is needed if you address these products.

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Send me the following:  ILP modules

<table>
<thead>
<tr>
<th>Number of</th>
<th>Module</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HY 30</td>
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<tr>
<td></td>
<td>HY 60</td>
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<tr>
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<td>HY 120</td>
</tr>
<tr>
<td></td>
<td>HY 200</td>
</tr>
<tr>
<td></td>
<td>HY 400</td>
</tr>
</tbody>
</table>

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Practical Electronics January 1982

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Our KIT features a bi-directional sequence, speed of response and sequence of direction change being variable by means of potentiometers. Incorporates memory boards for up to 60 entries.

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<tr>
<th>Type</th>
<th>H No. of Drawers</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1118</td>
<td>11 15 2 1</td>
<td>£10.75</td>
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<td>22 60 - -</td>
<td>£18.55</td>
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<table>
<thead>
<tr>
<th>Price</th>
<th>Special stock pack 60 values, 10 off each £5.50</th>
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</thead>
<tbody>
<tr>
<td>£1.60</td>
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</tbody>
</table>

DIODES: IN4148 3m each, Min. order quantity - 15 items

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<thead>
<tr>
<th>Price</th>
<th>£1.40 per hundred</th>
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</thead>
<tbody>
<tr>
<td>£1.40</td>
<td></td>
</tr>
</tbody>
</table>

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<tr>
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<th>£0.50 per 100</th>
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<tbody>
<tr>
<td>£0.50</td>
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PRE-AMPS

<table>
<thead>
<tr>
<th>Model No.</th>
<th>Module</th>
<th>What it does</th>
<th>Current</th>
<th>Price ex VAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>HY 6</td>
<td>Mono pre-amp</td>
<td>Provides inputs for mic/mag. cartridge/tuner, +4b/4b mono, with volume/bass/treble controls.</td>
<td>10 mA</td>
<td>£7.41</td>
</tr>
<tr>
<td>HY 6</td>
<td>Stereo pre-amp</td>
<td>Two channels, mag., cartridge, mic + volume control.</td>
<td>10 mA</td>
<td>£7.71</td>
</tr>
<tr>
<td>HY 12</td>
<td>Mono pre-amp</td>
<td>Mutes two signals into pre-amp, with bass/mid/treble range/bal. controls.</td>
<td>10 mA</td>
<td>£7.71</td>
</tr>
<tr>
<td>HY 66</td>
<td>Stereo pre-amp</td>
<td>Two channels, with inputs for mic/mag, cartridge/tuner, +4b/4b mono, with volume/bass/treble balance.</td>
<td>20 mA</td>
<td>£14.02</td>
</tr>
<tr>
<td>HY 69</td>
<td>Mono pre-amp</td>
<td>Two input channels: mag., cartridge mic + volume and mix mono/bass/treble/balance.</td>
<td>20 mA</td>
<td>£10.45</td>
</tr>
<tr>
<td>HY 71</td>
<td>Dual stereo pre-amp</td>
<td>Provides four channels for mag., cartridge, mic, with volume control.</td>
<td>20 mA</td>
<td>£12.36</td>
</tr>
<tr>
<td>HY 73</td>
<td>Guitar pre-amp</td>
<td>Provides for two inputs (guitar) and mic, with separate volume/bass/treble/balance.</td>
<td>20 mA</td>
<td>£12.36</td>
</tr>
<tr>
<td>HY 75</td>
<td>Stereo pre-amp</td>
<td>Two channels, each mixing two signals into one with bass/mid/treble range/treble controls.</td>
<td>20 mA</td>
<td>£12.36</td>
</tr>
</tbody>
</table>

For easy mounting, we recommend B66 mounting board for modules HY6-HY13. £0.45 inc VAT. £0.50 inc VAT. HY180 mounting board for modules HY16-HY77 £1.65 inc. VAT (£1.25 inc. Vat). All modules are encapsulated and include 10 pin edge connectors. All operate from 5V minimum to ±15V maximum, needing drop-out resistors for higher voltages. Modules HY6 to HY13 measure 45 x 20 x 40mm; HY16 to HY77 measure 90 x 20 x 40mm.

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MIXERS

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<thead>
<tr>
<th>Model No</th>
<th>Module</th>
<th>What it does</th>
<th>Current price (ex VAT)</th>
<th>Price inc VAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>HY 1</td>
<td>Mono mix</td>
<td>Mixes signal inputs into</td>
<td>£16.50</td>
<td>£18.50</td>
</tr>
<tr>
<td>HY 2</td>
<td>Stereo mix</td>
<td>Two channel, one driving four signals into one</td>
<td>£25.00</td>
<td>£28.00</td>
</tr>
<tr>
<td>HY 3</td>
<td>Mono mix</td>
<td>Mixes signal inputs into one</td>
<td>£13.50</td>
<td>£15.00</td>
</tr>
<tr>
<td>HY 4</td>
<td>Stereo mix</td>
<td>Two channel, each merging two signals into one</td>
<td>£23.50</td>
<td>£26.00</td>
</tr>
<tr>
<td>HY 5</td>
<td>Stereo mix</td>
<td>Two channel, each merging two signals into one</td>
<td>£26.50</td>
<td>£29.50</td>
</tr>
<tr>
<td>HY 6</td>
<td>Stereo mix</td>
<td>Two channel, each merging two signals into one</td>
<td>£31.50</td>
<td>£35.50</td>
</tr>
</tbody>
</table>

AND OTHER EXCITING NEW MODULES

<table>
<thead>
<tr>
<th>Module</th>
<th>What it does</th>
<th>Current price (ex VAT)</th>
<th>Price inc VAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>HY 12</td>
<td>Mono 2/3/4 channel mixer</td>
<td>£8.50</td>
<td>£9.50</td>
</tr>
<tr>
<td>HY 17</td>
<td>Stereo head phone driver</td>
<td>£16.50</td>
<td>£18.50</td>
</tr>
<tr>
<td>HY 19</td>
<td>Stereo head phone driver</td>
<td>£22.50</td>
<td>£25.00</td>
</tr>
<tr>
<td>HY 20</td>
<td>Stereo mixer</td>
<td>£35.00</td>
<td>£39.00</td>
</tr>
<tr>
<td>HY 24</td>
<td>Stereo mixer</td>
<td>£50.00</td>
<td>£55.00</td>
</tr>
</tbody>
</table>

For easy mailing reference:

B 6 Nothing box to modules HY1-HY13 £1.12 inc VAT (0.99 ex VAT)
B 6 requiring part to modules HY14-HY17 £1.12 inc VAT (0.99 ex VAT)

All modules are encapsulated and include clip-on edge connectors. All operate from 12V minimum, mains power supplies for higher voltages. HY1 can be used only with the PSU modules power supply unit. Modules HY2-HY13 measure 45 x 20 x 10mm, HY14-HY17 measure 50 x 25 x 10mm.

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High Quality audio amplifier Module ideal for use in record players, tape recorders, radios and cassette players etc. Full data and back up diagrams with each module.

Specifications:
- Power Output: 5 watts RMS
- Load impedance: 8 ohms
- Frequency response: 20Hz - 20kHz
- Distortion: 1% at 2 watts
- S/N ratio: 85db

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BI-PAK BARGAINS

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<table>
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<th>Part No.</th>
<th>QTY</th>
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<td>S115</td>
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Prices S125-112 contain a range of Carbon Film Resistors of assorted values from 22 ohms to 2 2meg. Save on your resistors now! and have a lull range to cover your projects. Quantities approximate, count by weight.

"CAPABLE CAPACITOR PAKK"

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<th>Part No.</th>
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<td>S131</td>
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Prices S126-131 contains a range of assorted value Capacitors from 0.1uF to 22uF. Save on your Capacitors now and have a lull range to cover your projects. Quantities approximate, count by weight.

"STILL MORE! SLIDER POTENTIOMETERS"

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<td>S515</td>
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Prices S511-515 contains a range of assorted value Slider Potentiometers from 5k to 1M. Save on your Potentiometers now and have a lull range to cover your projects. Quantities approximate, count by weight.

"NEW COMES DYNAMICS OF THE WORLD"

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<th>Specification</th>
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<td>Current</td>
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Prices S126-131 contains a range of assorted value Dynamics of the World components from 0.1uF to 22uF. Save on your Dynamics of the World components now and have a lull range to cover your projects. Quantities approximate, count by weight.

"AUDIO PLUGS, SOCKETS AND ACCESSORIES"

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<th>Part No.</th>
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<td>S226</td>
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Prices S222-226 contains a range of assorted value Audio Plugs, Sockets and Connectors from 0.1uF to 22uF. Save on your Audio Plugs, Sockets and Connectors now and have a lull range to cover your projects. Quantities approximate, count by weight.

"BI-PAK'S OPTO BARGAIN OF THE YEAR!"

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<td>S152</td>
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Prices S151-152 contains a range of assorted value BI-PAK's Opto Bargain of the Year! components from 0.1uF to 22uF. Save on your BI-PAK's Opto Bargain of the Year! components now and have a lull range to cover your projects. Quantities approximate, count by weight.

"IC SOCKETS"

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<th>Price</th>
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<tr>
<td>£1.25</td>
<td>20 30 50 100</td>
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Prices £1.25 contains a range of assorted value IC Sockets from 0.1uF to 22uF. Save on your IC Sockets now and have a lull range to cover your projects. Quantities approximate, count by weight.

"VOLTAGE REGULATORS"

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<td>£1.25</td>
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Prices £1.25 contains a range of assorted value Voltage Regulators from 0.1uF to 22uF. Save on your Voltage Regulators now and have a lull range to cover your projects. Quantities approximate, count by weight.

"BI-PAK BARGAINS"

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"SEMICONDUCTORS FROM AROUND THE WORLD"

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<th>Description</th>
<th>Price</th>
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<tr>
<td>2N3055 - 100 Silicon PNP Transistors - all perfect</td>
<td>£2.50</td>
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<tr>
<td>2N3056 - 100 Silicon NPN Transistors - all perfect</td>
<td>£2.50</td>
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Prices £2.50 contains a range of assorted value Semiconductors from around the world 2N3055 - 100 Silicon PNP Transistors - all perfect and 2N3056 - 100 Silicon NPN Transistors - all perfect. Save on your Semiconductors from around the world now and have a lull range to cover your projects. Quantities approximate, count by weight.
COMING OF AGE!

This issue marks the start of a new year for PE—our 18th. Yes, even though we still think of ourselves as a "new" magazine, publication of PE started with the November 1964 issue. Hopefully many readers also continue to feel PE is "new", since this indicates we are keeping up with their needs and continuing to break new ground on projects and technology.

Before we forget it, let us take this opportunity of thanking you for your support over the years and wishing you seasonal greetings and a prosperous new year. We are planning some further steps forward for PE during 1982 and we hope you will all take them with us:

'81 CHANGES

We came some way in '81, though times have been difficult for many with the recession really biting. Unfortunately, it now seems that we will have to weather its ravages for the best part of next year as well. It is generally felt that even the "iron lady" will have to bend towards the end of the year so that things improve before the next election!

Another effect of the recession has been to attract more commercial companies into producing and marketing electronic projects as a means of keeping stock and financial turnover at a reasonable level. Thus there are probably more specialist professional engineers now working on projects for the "amateur" than ever before.

UK sales of PE have increased during the last six months and are higher now than they have been for 18 months, even though cover prices have had to rise and people's general wealth has fallen. Our overseas sale, which is in excess of 20,000 copies, is also very buoyant especially in the emerging nations.

One change, made earlier in the year, which readers may not have noticed was the introduction of a new front cover logo. This rather subtle increase in lettering size came in the July issue—check if you don't believe us! Thankfully, we have been able to continue to produce many "first time" projects; CB has come; we gave readers a Free Instrument Case, an I.C. Removal Tool and four suppliers' catalogues during the year. All of which were well received and we believe proved useful.

Our aim has been to make PE the best possible value for money and this will continue in '82. If we can be even better at this time next year everyone will be pleased. After all it's the "newness" of the mag, that keeps staff and readers interested and the whole thing on the boil. The quality, range and ingenuity of our projects is now better than ever.

CB

As we go to press we are hearing disturbing stories that European standard CB rigs and a.m./f.m. rigs are being sold as legal equipment with a CB 27/81 label on them. Readers should therefore be very careful when buying a rig to ensure that it is built to the British specification. Our rig review will assist with identification.

Mike Kenward
More Micros in Schools

Mr Kenneth Baker MP, Minister for Information Technology, recently announced an extension of the Department of Industry’s Micros in Schools scheme to secondary schools which already have computer facilities.

Speaking at the launch of Information Technology '82 he said:

“The Micros in Schools scheme has proved a great success. Since the scheme was opened on June 1, almost 1900 applicants have been approved for 50% funding towards the cost of a microcomputer. Both maintained and independent schools in England, Wales, Scotland and Northern Ireland are participating.

“The Department of Industry estimated 2500-3000 secondary schools were without equipment and so we are well on the way to achieving my first objective of a micro in every secondary school by the end of 1982.

I am pleased to announce that, as from January 1, 1982, this scheme will be extended so those secondary schools already with equipment may take advantage of the grant.

With the back up teacher training provided for in the scheme, this initiative is a vital complement to the Microelectronics Programmes under way by the Education Departments. I hope teachers from all disciplines will be able to take advantage of these programmes so that an awareness of new technology is an integral part of all pupils’ experience across the curriculum.”

SECONDS AWAY!

The wonder of liquid crystal never ceases to amaze, and one of Casio’s latest offerings uses the ubiquitous l.c.d. to take the “executive toy” to new heights.

Casio’s BG15 is based on the now familiar clock/calculator format, with the usual added attraction of a game. But, instead of Alien Invaders, you have a boxing match, with excellent animated graphics and a realistic scoring system. Now you can beat the stuffing out of your opponent without sustaining a single bruise yourself!

The one criticism that could be levelled at the BG15 is that the instruction booklet is rather an epic work which takes a long time to get through—particularly the chapter on the game.

Anyone who has had a trying day and feels like inflicting a touch of GBH on their boss will find this machine a far less troublesome way of letting off steam. It is available at a discount price of £16.95 (inc VAT and p&p) from Tempus, Dept. PE, Freepost, 164-167 East Road, Cambridge, CB1 1DB. (0223 312866)

POINTS ARISING...

ULTRASONIC CLEANER (Jan. '80)
PE CONGRESS (April '80)
Wicca Electronic Systems Ltd, who supplied kits for the above projects have recently ceased trading. While components for the Congress should be available from other sources, we do not know of another supplier of certain parts for the Ultrasonic cleaner. However, a complete kit for a similar device is currently available from Heathkit. Further information is available from them on 0452 29451. Technical queries should be addressed to us.

DON’T!

Rodnay Zaks, computer scientist, author, and president of the publisher Sybex Inc., has been putting pen to paper (or perhaps finger to word processor) again. The latest book we have received is called:

Don’t! (Or How To Care For Your Computer).

The front cover is striking, and with quotations of wisdom from Shakespeare’s Macbeth through to Confucius leading you in to each chapter, it makes fulfilling reading. The book is openly “dedicated to the allegedly mythical trouble-free computer”. It shows how most hardware problems are either directly or indirectly brought on by mishandling.

Make your hobby room comfy for humans and your home computer will like it too, says Mr. Zaks of temperature, vibration and dust considerations.

Among the often quite funny cartoons, photographs and diagrams you will find such “horror” stories as that recounted of the man who was unwittingly ruining discs by writing identity information on their sleeves with a hard ball-point pen, thereby embedding loose grit into the oxide.

You are also warned against smoking near disc drives. One picture shows the relative sizes of common pollutants. With the flying height of the head at 100µ, the cross section of a human hair shown adjacent looks something like a football next to the gap under the door. The least offensive, fingerprint oil, would be more than enough to swamp the gap! And that effluvium donated to the atmosphere so freely by our smoking companions looks as though it could cause havoc, comprising sticky particles of 300µ diameter.

The book’s title, Don’t!, applies to its own diagrams on page 157 if you are European, which illustrate typical NEMA receptacles and their mains wiring. In the USA there is no such thing as a brown “Live” wire, it’s black, and it’s “Hot” (probably pronounced “hut”). The book is written at a light-hearted level and makes enjoyable and informative reading.

You could say it is aimed at interfacing the low event horizon user to leading edge technology practices. Honestly, you could!

This soft-back is available through Computer Bookshop, 30 Lincoln Road, Olton, Birmingham, which is the UK outlet for Sybex. It costs £9.65 and consists of 213 pages measuring 150 x 230mm.
Briefly...

To cope with the shortage of training aids in microwave engineering, the Microwave Products Division of Marconi Instruments, a GEC–Marconi Electronics company, have introduced a new low cost audio-visual course—"Understanding Microwave Equipment". It consists of six C90 cassettes held in a ring binder containing 175 supporting diagrams and photographs. This course can be used by anyone who has an interest in microwave equipment.

The six sessions cover a survey of microwave systems and devices, transmission lines and components, solid-state sources, tubes, low-noise receivers, antennas, radar, telecommunications and electronic warfare systems.

The cost of the course is £65. Further details are available from Harold Read, Marconi Instruments Ltd., Longacres, St Albans, Herts AL4 0JN (0727 59292).

Thousands of budding organists and pianists struggling through the first stages of learning to play will welcome a new electronic tutor developed by a Preston company.

Called Prelude, it gives an instant visual guide to more than 600 chords as well as all major and minor scales. It's a small, hand-held device with keys for the musical notes, chords and inversions, and a liquid crystal keyboard display.

The unit is designed to help tutored or self-taught students learn the basic 'alphabet' of music; to teach classically-trained musicians modern harmony and to help string or wind players to convert to keyboards.

Two professional organ teachers who helped in Prelude's design say that it is far easier and quicker to use than a printed tutor. Not only does it show notes making up the basic chord, but the user can add progressively more complex components, and show all the inversions—the different ways of playing it.

Prelude is priced at £19.95 including VAT, plus 40p p&p, and is available from Speedyplain Ltd., Freepost, Longton, Lancs PR4 5YL.

Items mentioned are available through normal retail outlets unless otherwise specified. Prices correct at time of going to press.
Step-by-step fully illustrated assembly and fitting instructions are included together with circuit descriptions. Highest quality components are used throughout.

SX1000
Electronic Ignition
- Inductive Discharge
- Extended coil energy storage circuit
- Contact breaker driven
- Three position changeover switch
- Over 65 components to assemble
- Patented clip-to-coil fitting
- Fits all 12v neg. earth vehicles

SX2000
Electronic Ignition
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- Unique Reactive Discharge
- Combined Inductive and Capacitive Discharge
- Contact breaker driven
- Three position changeover switch
- Over 730 components to assemble
- Patented clip-to-coil fitting
- Fits all 12v neg. earth vehicles

MAGIDICE
Electronic Dice
- Not an auto item but great fun for the family
- Total random selection
- Triggered by waving of hand over dice
- Bleeps and flashes during a 4 second tumble sequence
- A throw displayed for 10 seconds
- Auto display of last throw 1 second in 5
- Muting and Off switch on base
- Hours of continuous use from PP7 battery
- Over 100 components to assemble
- Supplied in superb presentation gift box

TX2002
Electronic Ignition
- The ultimate system
- Switchable contactless
- Three position switch with
  - Auxiliary back-up inductive circuit
  - Reactive Discharge Combined capacitive and inductive
  - Extended coil energy storage circuit
  - Magnetic contactless distributor trigger head
  - Distributor triggerhead adaptors included
- Can also be triggered by existing contact breakers.
- Die cast waterproof case with clip-to-coil fitting
- Fits majority of 4 and 6 cylinder 12v neg. earth vehicles.

VOYAGER
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- A most sophisticated accessory
- Utilises a single chip microprocessor incorporating a unique programme designed by EDA Sparkrite Ltd.
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- Visual and Audible alarms warning of Excess Speed, Frost/Ice, Lights-left-on
- Facility to operate LOG and TRIP functions independently or synchronously
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- Over 300 components to assemble

AT-80
Electronic Car Security System
- Arms doors, boot, bonnet and has security loop to protect fog/spot lamps, radio/tape, CB equipment
- Programmable personal code entry system
- Armed and disarmed from outside vehicle using a special magnetic key fob against a windscreen sensor pad adhered to the inside of the screen
- Fits all 12V neg. earth vehicles
- Over 250 components to assemble

EDA SPARKRITE LIMITED
82 Bath Street, Walsall, West Midlands, WS1 3DE England. Tel: (0922) 614791

Please allow 28 days for delivery

CUT OUT THE COUPON NOW!
the others in presenting the brutal facts of life, did not ram home more forcefully the message that there is only one formula for industrial success—the right product at the right time at the right price. Only then can profits be generated to satisfy the social conscience in welfare and other benefits. The principle, simple as it is, applies right across the board from toilet rolls to jet aircraft. Government macroeconomics can help or hinder. But it is management and workers who produce the goods.

I can see no industrial future in the school of thought which recommends wholesale nationalisation, withdrawal from the EEC, import controls, currency controls, plus hostility to multinational operation which, in electronics, is the life-blood of all the larger companies including those which are British-based.

To institute central government control in place of free enterprise which stimulates technological progress, would certainly not benefit the electronics industry. There is a real-life model on which I base this observation. It has the uninspiring title of the State Collective Electronic Communications Combine of the Soviet Union. Its products are also uninspiring. Could this be the fate, say, of GEC in 10 years time?

**Turnround**

Not that electronics has been universally successful. Few companies win all the time. ICL is running through a bad patch as I write and it is somewhat humiliating, even though common sense, that Japanese technology is being injected to boost sales. The same, of course, applies to BL with the Triumph (i.e. Honda) Acclaim. But in business you need to bend with the wind and seize every advantage.

Decca was on the skids. Now no longer so. How was this achieved?

When Raceal-Decca signed, paying £106 million at what was then thought to be a silly price, the new management made no secret of what they were after. It was capital goods in growth areas with electronic warfare in the lead. Racial knows electronic capital goods and its markets but didn’t want to know music or domestic TV. These Decca activities were sold off to those who could make better use of them.

Similarly, Racial saw no point in maintaining an imposing Thames-side headquarters in the middle of London. So Decca House on the Albert Embankment is being sold at a figure in the region of £6 million.

The Decca companies have been re-organised into eight major product or business areas, defence systems, marine radar, navigation—each of the new Racial-Decca companies is expected to stand on its own feet and generate products or services, and profit. Marine radar is still losing money but is expected to get back in the black in the current financial year.

True, Decca is somewhat slimmer than before. But this is a small and necessary price to pay for ensuring jobs for the great majority now and in the future. Racial-Decca accounts for 30 percent of all Racial Electronics Group business and now, for the first time, Racial has joined the elite club of companies who can boast a world-wide turnover of a billion dollars.

One of Racial-Decca’s real growth areas is in underwater exploitation. It is strong in North Sea oil, and it was Racial-Decca Survey Ltd who supplied the know-how, the men and the equipment to locate the wreck of HMS Edinburgh, sunk in World War 2 in the Barents Sea, from which £45 million of gold bullion was recently salvaged.

**Sugar-sweet**

If you’ve got a product or service that people want to buy there is never a slump. On the general consumer front Marks and Spencer have turned in record results. A consistent high flyer with a value-for-money reputation.

In the more specialised field of consumer electronics, always a topic of gloom, we have Alan Sugar, heading up Amstrad, who took his company to the public in April 1980. His forecasts looked optimistic, if not downright rash, in the prospectus. But the public backed him to their own, and his, profit.

At the end of his first year of trading as a publicly quoted company, Sugar achieved 61 percent increase in turnover and 75 percent increase in profit. Not bad in a period of ‘the greatest recession ever experienced’. Sugar is forecasting further gains in the current year and on his track record he should succeed.

**Hooray for Russia!**

Russian military aid to the third world countries is turning out to be good business for British electronics. Shifting political allegiance has left many countries with vintage Soviet defence hardware, out of date but in fair physical shape.

Modernising is not a new game but when you have fallen from grace with your benefactor you can hardly go back to him, and if you haven’t native skills you must look elsewhere to those who have.

Thus, the prospect of over £500 million of work on modernising eight Russian-built destroyers in service with the Chinese navy. They will be fitted with new missile systems, new radars and other sensors, and new operations rooms. Contracts are reported to be near signing with British Aerospace as principal contractor for the missiles and electronics systems.

Elsewhere in the world there are hundreds of Russian tanks recently up-dated with British radio and gun-ringing equipment and Russian radar systems with new British signal processing and display systems.

**Talking Exchange**

Britain’s 1,000 blind telephone operators will have the benefit of a speaking PABX exchange. GEC, British Telecom and the Royal National Institute for the Blind have devised a plug-in black box for the latest Monarch 120 PABX. This microprocessor-controlled exchange has a visual display. Any information displayed is automatically ‘spoken’ to the blind operator via a speech synthesizer.
EVERYONE must make decisions on a routine basis. The microelectronic revolution has provided us with hand held calculators to assist us in handling day-to-day number problems. Why not apply this same technology to day-to-day decision making?

This project has been developed after years of research into the decision making patterns of the man on the street. Operation has been made as simple and straightforward as possible. Gone are the days of feeding a computer with information for hours on end and spending the same amount of time deciphering what the computer's exact response was. Modern advances in microelectronic technology have enabled us to design and build one of the most sophisticated and powerful decision making aids in the world. It is as easy to operate as flipping a coin which can only provide an answer based on chance. This modern marvel of engineering ingenuity can not only provide instantaneous answers based on the information presented by the operator and its relationship with time and space but also eliminates the fatigue problem caused by flipping coins.

The basic model has been designed to offer the optimum responses to the widest range of questions that can be presented. The computer's basic responses are:

YES  RE-THINK  MAYBE  RE-ENTER  NO

ALTERNATIVES

There are many other response patterns that can be programmed into the computer. Some examples of these are shown:

Pilot's Collision Avoidance Computer
RIGHT  LEFT  PANIC  UP  DOWN

Navigator's Decision Computer
NORTH  EAST  PANIC  SOUTH  WEST

Diplomat's Decision Computer
PERHAPS  MAYBE  POSSIBLY  CONCEIVABLY  POTENTIALLY

Pay Rise Computer
NO CHANCE  IMPOSSIBLE  NO  NEVER  TRY NEXT YEAR

Idi Amin's Decision Computer
MAIN  EXECUTE  KILL  MURDER  VANISH

Components

Resistors
- R1–R20  10M (20 off)
- R21  10k
- R22–R24  1M (3 off)
- R25  470k
- R26  10
- All 10% ±W

Capacitors
- C1–C3  4µ7 10V tantalum bead
- C4  10n polyester

Integrated Circuits
- IC1–IC2  4011B (2 off)
- IC3  4022B
- IC4  4049B

Miscellaneous
- B1—9V battery, D1–D5—Red I.e.d. 0.2in.
- All parts can be obtained from Compu-Tech Systems, Gaymer Way Industrial Estate, North Walsham, Norfolk NR28 OAN

Indecision Eliminator

W.C. DICKINSON

EENY... MEENY...
MINY....
MO!
OPERATION

The two touch contacts on the front panel are provided to accept data via direct contact with the operator. The operator's brainwaves are conducted into the unit and enter a brainwave to digital data converter. This data is instantly accepted and simultaneously locked to time and space vectors.

Upon acceptance of the information the five data output indicator I.e.d.s will begin to flicker, indicating that your input data is being processed. The unit is now searching for parity between time and space vectors and your question. Process time has been extended to approximately three seconds in order to ensure compatibility with the optic nerve.

After the data has been processed the scanning of the I.e.d.s will cease and one of the data output I.e.d.s will remain illuminated. If the 'RE-ENTER' I.e.d. illuminates parity did not exist between time and space vectors and your question. In other words you asked the question at the wrong time.

If the 'RE-THINK' I.e.d. illuminates the computer has found a fundamental error in the data presented to it. In other words you asked it a question that it could not answer.

The remaining three I.e.d.s are the computer's response to your question after an analysis of all data presented and the relevance of your question to the overall operation of the universe.

Once the computer has given a response the I.e.d. will remain illuminated for approximately three seconds and then return to the quiescent but ever alert state. In the power down state negligible current is drawn from the batteries thus eliminating the need for an on-off switch.
This easy to build 3 band stereo AM/FM tuner kit is designed in conjunction with Practical Electronics (July issue). For ease of construction and alignment it incorporates three Mullard modules and an I.C. IF. System.

FEATURES: VHF, MW, LW Bands, interstation muting and AFC on VHF. Tuning meter. Two back printed PCB's. Ready made chassis and scale. Aerial: AM - ferrite rod, FM - 75 or 300 ohms. Stabilised power supply with C-core mains transformer. All components supplied are to P.E. strict specification. Front scale size 10"x 2½" approx. Complete with diagrams and instructions.

SPECIAL OFFER!

- Matching J.C. 10+10 Stereo Power amplifier kit (usually £3.95 + £1.15 p&p)
- Mullard LP1183 built in preamp. Suitable for ceramic and auxiliary inputs (usually £1.95 + 70p p&p)
- Matching power supply kit with transformer (usually £3.00 + £1.95 p&p)

ONLY £21.95 plus £3.80 p&p

STEREO AMPLIFIER KIT

- Featuring latest SGS/ATES TDA 2006 10 watt output IC's with built-in short circuit protection.
- Mullard Stereo Preamplifier Module.
- Suits any AR type finish cabinet. 9"x 8½"x 3½" (approx)
- 10+10 Stereo converts to a 20 watt Disco amplifier.

To complete you just supply connecting wire and solder. Features include: din input sockets for ceramic cartridge, microphone, tape or tuner. Outputs: tape, speakers and headphone. By the press of a button it transforms into a 20 watts mono disco amplifier with twin deck mixing. The kit incorporates a Mullard LP1182 pre-amp module, plus power amp assembly kit and mains power supply. Also features 4 slider level controls, rotary bass and treble controls and 8 push button switch output. Silver finish fascia with matching knobs and contracting cabinets. Instructions available, price 50p. Supplied FREE with the kit.

£14.95 plus £2.90 p&p

SPECIFICATIONS:

- Suitable for 4 to 8 ohm speakers.
- Frequency response 40Hz - 20kHz.
- Input sensitivity P.U. 150mV. Aux. 200mV.
- Tone controls Bass ±12db at 60Hz Treble ±12db at 10kHz
- Distortion 0.1% typically @ 8 watts
- Mains supply 230 - 250 volts 50Hz.

STereo MagnetiC Pre-amp Conversion Kit includes: FREE Magnetic cartridge with diamond stylus. All components including p.c.b. to convert your ceramic input on the 10+10 to magnetic. Only available with 10+10 amp. £2.00 includes p&p.

8" SPEAKER KIT two 8" twin cone domestic speakers. £4.95 per kit plus £1.70 p&p. When purchased with amplifier, available separately £6.75 plus £1.70 p&p.

PRACTICAL ELECTRONICS CAR RADIO KIT

SERIES II

2 WAVE BAND

- MW - LW
- Easy to build.
- 5 push button tuning + Modern design.
- 6 watt output + Ready stched and pachted PCB + Incorporates suppression circuits.

All the electronic components to build the radio, you supply only the case and the aerial, featured in Practical Electronics March issue. Features: pre set tuning with 5 push button options, black aluminium tuned scale. The P.E. Traveller has a 6 watts output neq, ground and incorporates an integrated circuit output stage, a Mullard IF Module LP1181 ceramic filter type pre-aligned and assembled, and a Bird pre-aligned push button tuning unit.

£10.50 plus £2.00 p&p.

Suitable stainless steel fully retractable aerial (locking) and supplied with 16"x4" (approx.) available as a kit complete. £1.95 pack. Plus £1.15 p&p.

CALLERS ONLY

323 Edgware Rd, London W2. Tel: 01-723 8432. Open 9:30am - 5.30pm. Closed all day Thursday. Persons under 16 not served without parents authorisation.

ALL PRICES INCLUDE VAT AT 15%.

and subject to change without notice. RTVC Limited reserve the right to update their products without notice.

HIGH POWER AMPLIFIER MODULES

READY BUILT OR IN KIT FORM

KIT BUILT

- 125 WATT MODEL
  - £10.50
  - Plus £1.15 p&p
  - £11.65

- 200 WATT MODEL
  - £14.95
  - Plus £1.15 p&p
  - £16.10

BUILT

- 125 WATT MODEL
  - £14.25
  - Plus £1.15 p&p
  - £15.40

- 200 WATT MODEL
  - £18.95
  - Plus £1.15 p&p
  - £20.10

SPECIFICATIONS:

- Max. output power (RMS) 125 watts 200 watts
- Operating voltage (DC) 50 - 80 vac max. 70 - 95 max.
- 4 - 16 ohms

Frequency response measured @ 100 watts 25kHz - 20kHz 25kHz - 20kHz

Sensitivity for 100 watts 400mV @ 47K 400mV @ 47K

Typical T.H.D. @ 10 watts: 0.1%

Dimensions (both models) 205 x 90 and 190 x 36mm.

The power amp kit is a module for high power applications - disco units, guitar amplifiers, public address systems and even high powered domestic systems. The unit is protected against short circuiting of the load and is safe in an open circuit condition. A large safety margin exists by use of generously rated components, result, a high powered rugged unit. The PC Board is back printed, etched and ready to drill for ease of construction and the aluminium chassis is preformed and ready to use. Supplied with all parts, circuit diagrams and instructions.

ACCESSORIES:

- Suitable LS coupling electrolytic for 125watt model
  - £1.00 plus 25p p&p

- Suitable LS coupling electrolytic for 200watt model
  - £1.25 plus 25p p&p

- Suitable mains power supply unit for 125watt model
  - £7.50 plus £3.15 p&p

- Suitable Twin transformer power supply for 200watt model

MONO MIXER AMPLIFIERS

50 WATT

- Six individually mixed inputs for two pick ups (or 1 or Mag J). two moving coil microphones and two aux-iliary for tape, tuner, organs, etc. Eight slider controls - six for level and two for master bass and treble, four extra treble controls for mic and aux inputs. Size: 13½"x6½"x3½" (approx).
- Power output 50 watts R.M.S. (continuous) for use with 8 ohm speakers. Attractive black vinyl case with matching fascia and knobs. Ready to use.


100 WATT

- Brushed Aluminium fascia and rot-ary controls.
- Size: approx. 14½"x4½"x4⅛" (approx)
- Five vertical slider controls, master volume, tape level, mic level, deck level, PLUS INTERDECK FADER for perfect graduated change from record deck No. 1 to No. 2, or vice versa. Prew level controls (PFL) lets YOU hear the next disc before fading it in.
- VU meter monitors output.
- 500W RMS output (2000w peak).

£76.00 Plus £6.40 p&p.

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Note: Goods despatched to UK postal addresses only. For further information send for instructions 20p plus stamped addressed envelope. Please allow 28 days for delivery.
1802 UPGRADE

About the only thing good you can say about the RCA 1802 microprocessor is that it is a CMOS device and therefore uses very little power. That simple fact has assured it a place in the micro hall of fame, despite the fact that only masochists would choose to use it if they were not forced to by power supply limitations!

There are other CMOS devices of course, like the NM6100 which was an early competitor and even more ghastly than the 1802 in some respects, and the much newer NSC 800 which looks as though it will be a winner once National have learned how to make it in quantity and the price has dropped. For the moment however, if you want a cheap CMOS microprocessor with reasonable hardware and software support it has to be the cranky old 1802, which is why any improvements RCA can dream up are very welcome indeed.

RCA are selling 1802s at an ever increasing rate (over a million in 1980, according to their ads.) but they do realise that those unfortunate enough to be toaster about how we would like our toast becoming more intelligent conversation with our electric toaster and supercilious coffee machines will not be solved, and it will be some time before the day dawns when we can expect to hold an intelligent conversation with our electric toaster about how we would like our toast done today (Thank goodness!).

TALK CONTROL

Electronic speech synthesis is now a lost art which, before long, all self-respecting vending machines and domestic appliances will be bending our ears with condescending announcements from their built-in speech chips and loudspeakers. Speech recognition, on the other hand, is a more difficult problem for the chip makers to solve, and it will be some time before the day dawns when we can expect to hold an intelligent conversation with our electric toaster about how we would like our toast done today (Thank goodness!).

THE BLUE LAMP

The possibility of a wall sized flat TV display unit based on i.e.d. lamps has now moved a step nearer with the introduction of a new semiconductor material which emits BLUE light when forward biased. RED and GREEN light emitting diodes based on gallium phosphide material are already with us of course, but the new devices based on silicon carbide complete the primary colour triad essential for the full colour spectrum of television reproduction.

The silicon carbide process has been developed by Sanyo in Japan, and rather than just offer a new colour for panel lamps the ingenious designers have recognised the potential for TV type applications and have mounted the new chip alongside red and green emitters in the same package. The four package pins allow independent control of brightness for each colour, but allowance has to be made for the different lamp characteristics. One of the impressive advantages of the 1802 is its potential for TV type applications and the ability of the 1804 processor to do the whole job single handed in many applications since it has a built-in 64 byte RAM array and a mask programmable 2Kbyte ROM to hold programs or data, in addition to its ability to address 64Kbytes off-chip. Add to this the fact that the 1804 is largely pin and instruction set compatible with the 1802 and it becomes a very attractive chip indeed.

Of course, not everyone needs the luxury of on-chip masked ROM programs, and so there is a companion device with all the other goodies but without the ROM, coded the 1805.

It looks as though RCA have managed to snatch out the "I Hate the 1802" movement before I even managed to get the badges made!

Electronic speech synthesis is now a lost art which, before long, all self-respecting vending machines and domestic appliances will be bending our ears with condescending announcements from their built-in speech chips and loudspeakers. Speech recognition, on the other hand, is a more difficult problem for the chip makers to solve, and it will be some time before the day dawns when we can expect to hold an intelligent conversation with our electric toaster about how we would like our toast done today (Thank goodness!).

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THIS is a monochrome television camera you can build yourself, which is ideal for closed circuit home video or security applications. This camera requires only a 24V/1A supply and may be wired using a single coax lead carrying both signal and power. The output is UHF modulated for direct ‘aerial socket’ input to a standard television receiver.

**POWER SUPPLY**

The unit may be powered by a simple 24V PSU without semiconductor regulation circuits. That is to say, the standard ‘transformer-bridge-capacitor’ configuration will do, although the line should be protected with a 1A quick-blow fuse.

Also, the supply line from wherever it may be derived, should include the filter circuit of Fig. 1.1 to allow the same wire to carry both signal and power.

24 volt power from point A is passed through L1 without hindrance, via the coaxial socket on the front panel, to the camera. The sheath of the coaxial cable is at earth potential, the core being at 24V. The d.c. is, however, blocked from going into the television set as C1 can be regarded as an open circuit to d.c. voltages. UHF received from the camera is blocked by the small inductor L1 preventing it from being dropped to ground by the low impedance of the power supply. Capacitor C1 has a very low reactance at UHF and allows the passage of the UHF signal to the television receiver.

Thus it can be seen that this simple circuit allows us to utilise the same coaxial cable to deliver power to the camera and convey signals from the camera to the television sets. When the unit has been fully assembled, and the voltage at point “A” checked, about 24V d.c. should be found at the centre pin of the coaxial socket on the front panel with respect to the case.

**INVERTER AND HIGH VOLTAGE BOARDS**

The PE (Seescan) camera is of modular construction, with the printed circuit boards connecting together with the coil assembly and back plates to form an extremely robust unit.

The inverter and high voltage power supply boards are used also as “cross-members” in the structure. The inverter board steps up the low voltage camera supply to about 400V which is used to provide all the high voltages required to drive the pick-up tube (Vidicon in standard camera kit). The high voltage power supply board uses this 400V a.c. to produce several regulated d.c. outputs at the levels required by the picture tube. This board carries the three primary set-up adjustment presets for the pick-up tube, namely beam current, electrostatic focus, and target voltage. These three controls are easily accessible from the rear of the camera to make the final setting-up easy.
INVERTOR CIRCUIT DESCRIPTION
The invertor, a small p.c.b., mounted vertically in the camera, is used to step up the low voltage camera power supply rail to a high d.c. voltage suitable for driving the Vidicon pick-up tube. As can be seen from the circuit diagram, the invertor electronics are fairly straightforward. Line sync. pulse from the logic board are used to drive TR15 into saturation. Therefore, an inverted replica of the line sync pulse is developed across R202. This signal is used to drive T15 which acts as a switch, applying current pulses to the invertor transformer TR200. R203 and C201 decouple the output transformer from the main regulated 12V supply. C202 tunes the transformer to peak the large fly back pulse produced, thereby increasing efficiency. As all switching in the transformer takes place during line blanking there is no problem with any interference produced appearing on the camera picture.

HIGH VOLTAGE POWER SUPPLY CIRCUIT
This small sub-board is used to rectify the high frequency a.c. from the invertor board and regulate the d.c. output to supply the necessary voltages for the pick-up tube. Both positive and negative voltages with respect to ground are required for the tube, and both are produced on this board. Rectifier diode D13, half-wave rectifies the 350V a.c. and the resulting d.c. is smoothed by C43. It should be noticed that D13 is a fast recovery diode, and it is important that the types specified should be used. If ordinary general purpose rectifiers are used, the efficiency will be lower, and sharp switching spikes will be generated in the invertor, which will appear as lines on the television picture. R78 and C49 further decouple the supply at high frequencies before being applied to D15–D19. These series connected Zener diodes crudely regulate the high voltage supply at about 350V, which is applied directly to the mesh of the Vidicon tube. R79, VR80, R81 and VR82 form a potential divider chain, voltages for the second grid, focusing anode and target, all being tapped at various points from this divider. C49 and C46 are used to decouple the grid and target respectively.

D8 is a fast recovery rectifier diode used as a half-wave rectifier, the d.c. from which is smoothed by C44. Diode D14 is used to stabilise the supply at round about -95V with respect to ground. Resistor VR84 allows a negative grid bias (Beam current) to be set between 0V and -95V. R83 and C45 effectively decouple the supply at high frequencies from G1.

**Fig. 1.3. High voltage board**

<table>
<thead>
<tr>
<th>Test voltages</th>
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<td>A</td>
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<tr>
<td>B</td>
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<tr>
<td>C</td>
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<tr>
<td>D</td>
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<td>E</td>
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<tr>
<td>F</td>
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</tbody>
</table>

All voltages are measured with respect to Ground and are measured with a meter having greater than 25K ohms per volt sensitivity. All voltages are measured with no light reaching the Vidicon target. The voltages at these test points should be within 5% of the stated values.
Note: The photographs of the prototype show the original invertor board, which has since been redesigned to use only one power transistor.

ACKNOWLEDGEMENT
We would like to thank the Bondi Judo Club of Poole for their assistance with our front cover photograph.

COMPONENTS

Invertor and High Voltage Boards

Resistors
- R78 120k
- R79, R83 470k (2 off)
- R81 1M5
- R85 100k
- R201 22k
- R202 470
- R203 22 1W

All resistors 1W 5% unless otherwise specified

Potentiometers
- VR80, VR82, VR84 1M Cermet preset (3 off)

Capacitors
- C49 22µ
- C43 100n
- C44 100n/400V
- C45, C46 10n/750V (2 off)
- C48 100n
- C201 47µ/16V
- C202 2n2

Transistors and Diodes
- TR15 BFX85
- TR16 BC182
- D8, D13 BY207 (2 off)
- D14, D16, D17, D19 100V 1-3W Zener (4 off)
- D15 51V 1-3W Zener

Miscellaneous
- Invertor p.c.b.
- High Voltage p.c.b.
- Varelco connectors (for PL1–PL4)
- Heatsink for TR15
- Heatsink jointing compound
- Screws 6mm M3 (2 off)
- Nuts M3 (2 off)
- Transformer T200 (special)

Constructor’s Note
A complete kit of parts is available from Marshall’s of Kingsgate House, Kingsgate Place, London NW6 4TA.
In the matter of processed data, the presentation to the world at large varies a great deal as to time of release. Sometimes this is short and sometimes long. Usually the final release proves that science had profited. Such a situation arose in 1979. On August the 30th 1979 the Naval Laboratory coronagraph on board a spacecraft photographed a collision between a comet and the Sun. The reason for the delay in making this outstanding event public is that the data has only recently been analysed.

The coronagraph known as the Solwind, was designed to occult the disc of the Sun so that the corona is clearly visible—particularly the outer corona where there is much to be studied. In this special event a great deal of debris resulting from the encounter with the Sun was thrown out into this area. The spacecraft which carried the coronagraph is a Ball Aerospace vehicle which is similar to the NASA orbiting observatories. Because there were delays in releasing the data to the Naval Research Laboratories for analysis, the details have only just been discovered. It is thought that this comet may be one of a group of about eight comets which are known as Sun grazers. During the last three hundred years these eight comets have been observed from time to time. Because of the difficulty in making observations of any bodies close to the Sun and also the difficulty of recognising a body which when away from the Sun might be seen only by accident.

The images were to reveal that the tail of this comet going to its death was of the order of three million miles long. The closing speed was estimated to be about 645,000 miles an hour. The result of the impact threw the comet away from the solar surface. The comet was not actually reported as being seen from Earth even though the images returned show that it was as bright as Venus since the planet was in the frames of the photographs with the Sun itself.

In RETROSPECT

Frank W. Hyde

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Doubtless more of such events will be observed and the secret of the comets with the mission to Halley's comet in 1986 should finally be within mankind's knowledge. Had there yet been any forecasts of dire events? Did August the 30th 1979 mark something or other?

SOVIET SPACE RELATIONS

TAKE A NEW TREND

It is so often said of the old adage "It's an ill wind that blows nobody any good" that it is a way of excusing benefits in the face of sore distress. Originally there were wide and comprehensive hopes for the special combined missions to extract the maximum data and number of observations of Halley's comet. Much of the hope seemed to evaporate because of fiscal difficulties and part at least of the co-operative plans were delayed and then dropped. The Soviet Union offered a modification of one of their missions to Venus in an effort to maximise the failing situation.

It now seems that this has grown into a much wider possibility of joint effort. A joint planning meeting in Italy last September laid foundations for an international framework involving the Soviet Union, Italy, the European Space Agency, Japan and the United States. It is fortunate that these plans are now under way with greater momentum. If this pass of the comet inside the Earth's orbit were missed the opportunity would not come again until 2061.

The Soviet plan for two spacecraft is confirmed. The Japanese and the European Space agency have their programmes. Only the United States is yet uncommitted. However the American contribution at the moment will come through the involvement in the international Halley Watch. NASA has plans at the Jet Propulsion Laboratory and a proposal for a mission to collect samples from the comet. This however is not yet funded.

The Soviet dual mission is part of the separate plan to launch two spacecraft in December 1984 which will include a Venus pass in 1985 with comet encounter in 1986. The Venus study will be by two probes which will descend into the Venusian atmosphere and be deployed down to the surface. The spacecraft will then pass on to the Halley rendezvous. A drawback to this plan lies in the fact that the speed of the spacecraft will be higher than the comet during the encounter. Data transmission will be about 85 kilobits a second. Approximately 30 kilobits of this data will be devoted to the television cameras with wide and narrow angle facilities.

It was stated by an official of the Soviet group dealing with the mission that the camera system will be brought into the operational mode two days before the closest approach. At this time there will be general observations of the nucleus. Some three hours of observations will be made during the closest approach. The automatic operation of the system is set for the cameras to seek the brightest parts of the comet.

In addition to the imaging experiments there will be a three channel spectrometer, an infra-red spectrometer and a dust spectrometer. There will also be a dust particle counter with magnetometers and analysers of plasma waves at both high and low frequencies. Both the spacecraft will be through the same launch window late in December 1984. This will require accurate planning because it means two launches within a short period of a few days.

Japan's contribution will be the Planet-A spacecraft in August 1985. The launch vehicle will be an upgraded Mu launcher. The spacecraft will monitor the ultra-violet radiation from the comet and also measure the solar wind plasma near the comet. The two probes will be spin stabilised. The European Space Agency Giotto has already been described in a previous Spacewatch issue. The programme as it stands at the moment is for the launch by Ariane launch vehicle through a window in July 1985. The encounter is planned for a date in March 1985. The actual encounter will be on March 12/13 1986. The planned sequence of manoeuvres will begin about 30 hours before the time of closest approach. During this period there will be a two hour rehearsal of the experiment and calibration checks. It is hoped that the encounter will last at least 4 hours. The expected time of this event is 3hrs 45min. before the closest point of approach. The visible corona will be entered at about 1hr before the closest approach point. It is hoped that it will be possible for this to occur in real time.

THE USSR AND FRENCH TECHNOLOGY

Since September a Soviet spacecraft, the Arcad satellite, has been undergoing tests and now it begins its programme. The joint payload vehicle is in an orbit 1,192 miles at apogee and 236 miles at perigee, inclining 45.26 deg. It weighs 2,200lb. The French share of this project is four of the experiments with onboard programming and the telemetry unit.

The data programme is directed at the magnetosphere in the higher levels of the atmosphere, particularly at higher altitudes. The instrumentation is contained in a cylindrical body. The power is derived from eight solar panels spaced round the main body. The operation was carried out with mixed personnel, and the facilities in both the USSR and France were used.

THE SHRINKING SUN AGAIN

A new paper in support of this experiment regarding the shrinking sun gives more information that the regular pulsation with a period of 76 years is confirmed and a new statement that the accepted radius of the Sun is greater than that hitherto used for the calculations.

SUBMILLIMETRE WAVELENGTHS

At a recent conference on submillimetre wavelengths in radio astronomy new important information was revealed. Using the special airborne observatory, which is able to fly above the blanket of absorbing water vapour in the atmosphere, revealed a neutral atomic gas cloud near the centre of the Galaxy. The gas was detected by its emission from neutral oxygen, 63-2 micrometres.
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Practical Electronics January 1982
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INFRA-RED REMOTE CONTROL
IN COMMON with other hand-held transceivers, the PE Ranger in its most basic form is primarily intended for short-range portable communication and, although the operational range can be considerably extended by the use of an external supply and aerial, there may be many occasions when additional coverage is required. The Base and Mobile Adaptor unit described not only increases the r.f. output power from 0.5W to 4W (the maximum permitted) but also provides some additional r.f. amplification and selectivity on receive. The result is a three to four-fold increase in effective range when compared with the basic unit with the same antenna system. Furthermore, an audio power amplifier is also incorporated and this is particularly useful when the Ranger is to be used in a relatively noisy mobile environment. The Base and Mobile Adaptor operates from a nominal 12V d.c. supply and also provides power for the Ranger transceiver. A 240V a.c. supply may also be used by the addition of the optional mains power unit which is also described. Transmit/receive control switching is automatic and a meter is provided to indicate the strength of received signals and the relative power output. To comply with Home Office regulations a 10dB switched attenuator is incorporated within the equipment. Two I.e.d.s provide 'at a glance' status indication; an important consideration when the equipment is to be used mobile. The unit is housed in an identical size case to that used for the basic Ranger transceiver.

SYSTEM DESCRIPTION

The Base and Mobile Adaptor performs three basic functions:

(a) r.f. power amplification (Transmit)
(b) r.f. pre-amplification (Receive)
(c) a.f. power amplification (Receive)

The block schematic of Fig. 1.1 shows the basic arrangement of the unit and, as can be seen, the transmit and receive paths within the unit are quite separate. Switching is achieved by means of a relay and this provides a high degree of isolation between the two circuits.

On transmit the output signal of the Ranger is applied to a single stage power amplifier which provides a gain in excess of 10 dB. This implies that, when driven with a nominal 0.5W from the Ranger, the r.f. output power from this stage will be somewhat greater than 5W. The r.f. amplifier stage is followed by a band-pass filter which improves the spectral purity of the output signal by imposing a high rate of attenuation both below and above the design cut-off frequencies. Since the filter exhibits a loss of the order of 2dB, the actual r.f. output to the aerial will be approximately 4W. The precise value of r.f. output power can be adjusted by setting the r.f. output control within the Ranger transceiver itself.

The unit also incorporates a simple form of switched output attenuator which provides an approximate 10 dB reduction in output power when required by the terms of the Home Office licence.

On receive the incoming signal from the aerial is applied to a single stage r.f. pre-amplifier. This stage provides a modest value of gain which, although not strictly necessary, does help to improve the performance when receiving weak signals under quiet band conditions. A further advantage of this stage is that the additional tuned circuit provides further rejection of the image channel (910kHz below the wanted signal frequency) and this is all important in reducing interference from strong local signals operating in the illegal band around 26.9MHz. The gain of the r.f. stage is variable and offers a typical range of adjustment of some 40dB or more. At minimum gain settings the r.f. pre-amplifier stage effectively acts as an attenuator. This is beneficial in reducing the levels of strong signals and thus prevents overloading in the front-end stages of the Ranger.

The audio power amplifier operates in the receive mode only and increases the audio power when an external loudspeaker is used. The unit also incorporates a dual function meter which is used to indicate the strength of received signals in the receive mode and power output in the transmit mode. The S-meter signal is derived within the Ranger by means of an optional add-on module which consists of an amplifier/detector operating on the 455kHz i.f. signal. Connections to the Ranger and external power sources are shown in the block diagram of Fig. 1.2. Only two interconnecting cables are required; one to carry the control voltages, audio and S-meter signals and one to carry r.f.
Fig. 1.1. Block schematic of the Base/Mobile Adaptor

Fig. 1.2. Interconnection arrangement for the Base/Mobile Adaptor (N.B. Dotted lines indicate optional items)

CIRCUIT DESCRIPTION

The circuit diagram of the base station is shown in Fig.1.3. Red and green I.e.d.s, D1 and D2, provide status indication for 'transmit' and 'receive' respectively. The relay, RLA, operates whenever the transmit supply rail from the Ranger is enabled. The a.f. power amplifier, IC1, employs a conventional arrangement with voltage gain determined by R4 and R5. The supply voltage for the a.f. power amplifier is derived from the receive supply rail within the Ranger thus obviating the need for additional changeover contacts on the relay. The r.f. power amplifier, TR2, uses a silicon r.f. power transistor designed specifically for use in 27MHz CB equipment. The device is operated in common emitter mode under class-C conditions. Input matching to the base is provided by VC1, VC2, L3 and C11 while output matching from the collector is by means of L6, VC3 and VC4. The harmonic content of the output signal is reduced by two bandpass filter modules. The first of these removes the bulk of the spurious before the signal arrives at the changeover relay. The second is directly connected to the aerial socket and provides a 'last ditch' trap for unwanted harmonic signals. These two filters are required, as in the basic Ranger

SPECIFICATION

RF POWER AMPLIFIER
- Power output: 4W
- Input/output impedance: 50Ω
- Attenuator: 10dB (nominal)
- Power gain: 10dB (nominal)

AF POWER AMPLIFIER
- Power output: 2W (into 4Ω)
- Load impedance: 4Ω to 16Ω
- Input impedance: 100kΩ
- Voltage gain: 5

RF PRE-AMPLIFIER
- Voltage gain: 16dB
- Input/output impedance: 50Ω
- Gain variation: 40dB (approx.)

GENERAL
- Power supply: 11–14.5V d.c. negative ground
- Status indicators: Transmit (red), receive (green)
- Controls: Power on/off, r.f. gain
- External connections: Aerial and transceiver (SO239), Control and audio (6-pin d.i.n.), External d.c. input, Loudspeaker
- Meter: Power output (transmit), signal strength (receive)
- Dimensions: 200mm x 120mm x 40mm
- Weight: 0.8kg
transceiver, to ensure that the equipment meets the Home Office specifications concerning spurious emissions from CB equipment.

As with all r.f power amplifiers careful consideration has to be given to supply rail de-coupling and this is provided by R10, C12 and C13. These components ensure that the supply rail exhibits a negligible impedance over a very wide range of frequencies. D9 and D10 sample the r.f. output level and provide a signal for the power output meter. When an attenuated output is required to comply with the Home Office regulations concerning elevated aerial systems, R9 is switched into the r.f. power amplifier's supply rail by means of S2. This series resistor reduces the d.c. input power to the stage and consequently reduces the r.f. output power. The result is an approximate 10dB reduction in output from the amplifier stage.

The receive pre-amplifier, TR1, employs a junction gate f.e.t. operated in common gate configuration. This provides a high value of power gain coupled with a low input and high output impedance. Noise performance is of comparatively little concern at 27MHz due to the residual level of co-channel signals and thus no attempt has been made to optimise the stage for low noise performance. The r.f. gain is made adjustable by varying the static drain-source current whilst silicon diodes, D5, D6, and D7, D8, provide input and output protection for the pre-amplifier. This protection is important in the case of an inadvertent misconnection of the r.f. input/output or in the event of a failure in the changeover relay. The equipment is also protected against reverse polarity supply connection. When the supply is wrongly connected D4 conducts and this causes the fuse to rupture. This may appear to be somewhat crude but it is highly effective and can prevent extensive and costly damage to the rest of the circuit.

NEXT MONTH: Construction and alignment of the Base and Mobile Adaptor plus details of the S-meter module.

Fig. 1.3. Circuit diagram of the Base/Mobile Adaptor
### COMPONENTS

**Resistors**
- R1, R2, R6 680 (3 off)
- R3 82 kΩ
- R4, R8 100 (2 off)
- R5 22
- R7 1k
- R9 10 2W (see text)
- R10 1.2 5W (Wirewound)
  
  All resistors are ±1% carbon unless otherwise stated

**Potentiometers**
- VR1 100k lin
- VR2 1M preset

**Capacitors**
- C1 2μ2 16V elect
- C2 220μ 16V elect
- C3 470μ 16V elect
- C4, C6, C8, C10, C13 100n ceramic (5 off)
- C5 2.2n 25V elect
- C7, C12, C15, C16 4μ7 ceramic (4 off)
- C9 22p ceramic
- C11 100p ceramic
- C14 5p6 ceramic
  
  All electrolytic capacitors are vertical p.c.b. mounting types

**Variable capacitors**
- VC1–VC4 60p min solid dielectric (4 off)

**Inductors**
- L1/L2, L3
- L4–L6
- KXNSK 4612 (2 off)
  
  see text

**Semiconductors**
- D1 red i.e.d.
- D2 green i.e.d.
- D3, D5, D6, D7, D8 IN4148 (5 off)
- D4 IN4001
- D9, D10 OA91 (2 off)
- IC1 TDA 2002
- TR1 2SK55, 2N3819 or a T1S588A
- TR2 MRF472

**Miscellaneous**
- RL1 Relay type 221 D012 p.c.b. mounting 12V
  
  2p c/o
- M1 200µA meter 'Signal strength/Power output'
- S1, S2 s.p.s.t. min. toggle (2 off)
- SK1 6-way d.i.n. socket
- SK2 Non-reversible chassis plug
- SK3 2.5 jack socket
- SK4, SK5 Round SO239 socket (2 off)
- FL1 Bandpass filter module (see text)
- FL2 Bandpass filter module (see text)
  
  Case with front panel
- P.c.b.
- Knob
- 12V d.c. lead fitted with non-reversible socket

**Constructor's Note**

A complete kit of parts for the base station is available from Autumn Products Ltd, Park Drive, Baldock SG7 6EW

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WATCH PRESS FOR FORTHCOMING ANNOUNCEMENTS
To complete assembly of the Band-Box, the Display board requires to be joined to the System board and various interconnecting leads prepared. A seven pin DIN socket is also required to be fitted to the Master Rhythm to provide the necessary control pulses and drum audio to the Band-Box.

**CONSTRUCTION OF THE SYSTEM BOARD**

Fig. 9 shows the track layout and component overlay for the p.c.b. and it is advisable to closely inspect this before proceeding. All components apart from the composition keyswitches and power I.e.d. are mounted from the side containing least tracks, and should be carried out in the order of resistors, diodes, track pins, i.c. sockets, capacitors, output sockets and switches.

It should be noted that a number of resistors require soldering on both sides of the p.c.b. and that the orientation of the keyswitches is important as indicated by the flat portion.

All rotary switches, apart from the key selector, require to be set to operate on the first four positions before insertion into the board. This is achieved by first turning the switch fully anti-clockwise to position one and then removing the mounting nut and washer. A metal ring, concentric with the shaft, will be seen when the washer is removed and it contains a small tab which will be pushed in one of the holes in the plastic body. The ring should be removed and repositioned such that it enters the hole between the numbers 4 and 5 marked on the plastic. The ring is retained in position when the washer and fixing nut are replaced. To obtain the twelve position action required by the key selector the metal ring should be discarded.

After mounting the switches on the p.c.b. bare metal links can be used to connect the switch tags, with an insulated conductor to the centre tag or tags. Before inserting i.c.s it is well worth the additional quarter of an hour required to check for shorts between adjacent tracks using a meter.

**CONSTRUCTION OF THE DISPLAY BOARD**

The Display board contains displays, input keyswitches with caps, and mounting positions for potentiometers. Track layouts and the component overlay are shown in Fig.10. The two diodes are mounted on the back of the board, and it should be noted that the 24 pin sockets have spare pins beyond the outer edge of each display pair when inserted.

**JOINING THE BOARDS**

Twenty-six solid wire links are required to join the System board to the Display board and will provide sufficient mechanical support during initial testing provided that reasonably careful handling is given to the system. When mounted in the case the boards will be approximately 1-2mm apart so that a small amount of adjustment slack should be covered by giving the links a comfortable radius.

The links are shown in Fig. 11, as are all remaining interconnections within the Band-Box. When the links have been fitted, the three Level potentiometers should be wired to the corresponding pins on the System board using twin core screened wire. Note that the lead orientation for each set of terminals is different. A mounting hole is provided for a P-clip which will help retain the relatively heavy screened cable in a comfortable position. The required lead lengths are shown in the diagram against each relevant potentiometer.

**MASTER RHYTHM LINK**

Twelve inch leads should be prepared to connect between the System board and the seven pin DIN plug used for the Master Rhythm link. A screened cable is used to carry the audio into the Band-Box and its screen makes the ground connection between board and plug. The connections are shown in Fig. 11 and represent the view from the back of the plug showing the actual solder points.

**MICROCONTROLLER LINKS**

Power for the Microcontroller is provided from the pins on the left-hand side of the System board and terminates in a three pin connector which plugs into the Microcontroller board. The Molex connector tags can be crimped to the end of the wires using pliers, and if the special tool is not available a small amount of solder can be used to ensure that a good joint is made. Only +12V and ground are required to power the Microcontroller, the third (3V6) connection is provided to supply the System board with the secondary battery back-up voltage which may then be routed to the Master Rhythm if required as discussed later.

A 16 pin double ended jumper is used to link the Microcontroller signals to the System board mating with standard DIL sockets. This type of jumper is very convenient when splitting the system, but contacts can be a danger and
it is recommended that the pins are very slightly bent inwards with the fingers before the first insertion into the socket. The jumper plugs are marked with pin numbers and orientation should be carefully checked.

**MAINS CONNECTION**

All mains components are mounted in the lower half of the case. The mains lead enters at the side, protected by a plastic grommet, and terminates with live to the fuse, neutral to the switch, and earth to a tag in the case. A P-clip clamps the cable to the base. A link is made between the fuse holder and switch, and the two transformer input wires soldered to the switch. The top two tags on the switch should be used for neutral in and out, whilst the bottom (hidden) tags should be used for live connections.

A Molex connector is used to transmit the two 9 volt a.c. windings and the earth to the System board.

**MASTER RHYTHM SOCKET**

A seven pin DIN socket requires to be fitted to the front of the Master Rhythm box in order to provide the connections shown in Fig. 12. The connections are shown on the rear of the socket in the actual solder tag positions. Play and Rest switch connections are taken from the live side of each switch and a common connection from the ground track below the switches. The clock pulse is obtained from the track at pin 11 of IC2 and is a 5–6 volt positive pulse occurring at one per measure in the Master Rhythm. The Start signal is taken from pin 1 of IC3 and is at ground when the Master Rhythm is at Rest, rising to 5–6 volts when playing. This signal level ensures that the Band-Box knows when to play and also resets the Band-Box to the beginning of a score when the Master Rhythm stops. The connection to the Long Cymbal pin on the Control board provides rhythm pulses for the Chord Instrument in the Band-Box and replaces the connection to the Master Rhythm instrument board. If the constructor prefers to use one of the other instrument triggers in the Master Rhythm to provide this facility they are all identical in terms of the pulses required. The audio can be obtained by a screened lead soldered to the output jack socket. The screen should be connected at the jack end but not at the DIN socket.

This modification does not affect normal operation of the Master Rhythm which may still be removed from the Band-Box and used on its own. The new connections provided allow for Play/Rest footswitch connections and also give all the signals required for external sequencer operation.

**MECHANICAL ASSEMBLY**

A photograph was shown on page 39 of the November issue which indicated the mechanical mounting of the System board, Display board, and Master Rhythm. The latter is fixed to brackets, which suspend from the upper half of the case, using self-tapping screws, whilst the two boards are fixed with 6BA screws at various mounting points. In order to obtain the correct distance from the front panel a screw is first inserted through the case, then a ¼ in plastic spacer is placed over the thread and retained with a 6BA half nut. The boards should slide onto the mounting points and are retained with a further set of nuts.

Since little clearance exists between the body of the seven pin DIN plug and the Display board it is useful to clip protruding display socket pins close to the board. This point should also be taken into account when fixing the position of the Master Rhythm socket.

The Microcontroller is fixed to the lower half of the case with a spacing from the base of two full nuts.
Fig. 10. Track and component overlay for Display board
Assembly of the two halves of the case requires some care due to their relative shapes. The right-hand end is first slid into position and then the case moved to the left. This operation should not be carried out with mains connected to the unit.

**POWER OPTION FOR MASTER RHYTHM**

Three connections have been incorporated into the System board which can supply power to the Master Rhythm if required; however, a number of options are open to the constructor on how to make use of the facility.

The simplest option is to leave the Master Rhythm as a battery-operated unit which will ensure that it always retains its rhythm pattern information independent of the Band-Box. The disadvantage involved is remembering to switch the Master Rhythm off when the Band-Box is not in use.

The second option is permanent connection of the +5 volt, 3V6 and ground rails to the Master Rhythm, discarding the battery. If this is chosen, the link to the Microcontroller, which contains the secondary battery for storage, should never be broken and soldering used in preference to connectors.

A third option is shown in Fig. 13, and gives the dual possibility of battery/mains operation. With this system it is still essential to be careful to ensure that battery power is available from the Microcontroller when the power socket is connected to the Master Rhythm.

It is recommended that all testing of the complete Band-Box is carried out with a normal configuration Master Rhythm with 4 X HP7 batteries, and possible power conversions considered when the full system is operating satisfactorily.

**THE BAND-BOX IN OPERATION**

As promised at the beginning of the series, a detailed step by step operating procedure is now given for the Band-Box. The earlier warning is repeated that the procedures are more difficult to describe than execute, but it is hoped that the information in Figs. 14 to 17 will assist the operator in the early stages.

**Next Month.** Completion of the series.
Fig. 13. Optional power supply to the Master Rhythm for battery/mains operation

**Playback procedure**

1. Switch on mains
2. Display reads 01 CLEF En.
3. If not press Reset
4. Now press Enter
5. Display reads En. PAGE No.
6. Key page number (e.g. 03)
7. Display reads En. PAGE 03
8. Press Enter
10. Key line number (e.g. 15)
11. Display reads En. LINE 15
12. Press Enter
13. Display reads 03 —GO—15
14. Press Play on Master Rhythm
15. Score plays and display is blank
16. *Press Rest on Master Rhythm
17. Display reads 03 —GO—15
18. If score is not required again press Reset
*Rest will not normally be used to stop playback. The coda key allows the score to continue to its natural end at which automatic stop will occur. Coda is pressed to indicate that a further repeat chorus is not required and subsequent actions will depend on the programme in the score store as explained later.

Fig. 14. Summary actions for the playback procedure

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Chord type—1–14 plus Tacet (Silent)</td>
<td>1–15 En. 1–8 &gt;</td>
</tr>
<tr>
<td>1b</td>
<td>Chord duration—measured in beats (8 maximum)</td>
<td>0 En. 0–11 &gt;</td>
</tr>
<tr>
<td>2</td>
<td>Change chord group to</td>
<td>0 En. S. &gt;</td>
</tr>
<tr>
<td>3</td>
<td>Start repeat here—Segno abbreviated S</td>
<td>0 En. d. &gt;</td>
</tr>
<tr>
<td>4</td>
<td>Repeat from Segno—Dal Segno abbreviated d</td>
<td>0 En. J. &gt;</td>
</tr>
<tr>
<td>5</td>
<td>Spare instruction—Labelled J</td>
<td>0 En. F. &gt;</td>
</tr>
<tr>
<td>6</td>
<td>Finish—Fin abbreviated F</td>
<td>0 En. F. &gt;</td>
</tr>
</tbody>
</table>

Fig. 15. Instructions recognised by the score store

**Composition procedure**

1. Press Reset
2. Display reads 01 CLEF En.
3. Press > which indicates that the composition mode is required
4. Display reads En. PAGE No.
5. Key page number (e.g. 03)
6. Display reads En. PAGE 03
7. Press Enter
8. Display reads En. LINE No.
9. Key line number (e.g. 15)
10. Display reads En. LINE 15
11. Press Enter
12. Display reads RE SET !!
   This is the automatic lock which deters unauthorised meddling. If Reset is pressed the machine reverts to the start of the normal playback procedure
13. To unlock—Key “9”, then “0”
14. Any other combination will return to the playback procedure
15. Key first chord group required (e.g. 1)
16. Display reads En. Chrd. GP
17. Press Enter
18. Display reads 15 1 ’X Y
   This displays the Instruction X, Y stored at page 3.
19. Line 15 of the score together with the current chord group (1)
   Either > or < keys may now be used to inspect the contents of the next (16) or previous (14) line without alteration to the contents of the store. See text for score modification procedures.

Fig. 16. Summary actions for the composition procedure

**Contents of display**

<table>
<thead>
<tr>
<th>Score Symbol</th>
<th>Score Line</th>
<th>Chord Group</th>
<th>Instruction Format</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM (4)</td>
<td>00</td>
<td>0</td>
<td>1 En. 4 &gt;</td>
<td>4 beats CM</td>
</tr>
<tr>
<td>F6 (4)</td>
<td>01</td>
<td>0</td>
<td>4 En. 4 &gt;</td>
<td>4 beats F6</td>
</tr>
<tr>
<td>CM (4)</td>
<td>02</td>
<td>0</td>
<td>4 En. 4 &gt;</td>
<td>4 beats CM</td>
</tr>
<tr>
<td>G7 (4)</td>
<td>03</td>
<td>0</td>
<td>4 En. 4 &gt;</td>
<td>4 beats G7</td>
</tr>
<tr>
<td>SEG.</td>
<td>04</td>
<td>0</td>
<td>4 En. 4 &gt;</td>
<td>4 beats G7</td>
</tr>
<tr>
<td>CM (2)</td>
<td>05</td>
<td>0</td>
<td>1 En. 2 &gt;</td>
<td>2 beats CM</td>
</tr>
<tr>
<td>Am (2)</td>
<td>06</td>
<td>0</td>
<td>2 beats Am</td>
<td>2 beats CM</td>
</tr>
<tr>
<td>Dm7 (2)</td>
<td>07</td>
<td>0</td>
<td>2 beats Dm7</td>
<td>2 beats CM</td>
</tr>
<tr>
<td>G7 (2)</td>
<td>08</td>
<td>0</td>
<td>2 beats G7</td>
<td>2 beats CM</td>
</tr>
<tr>
<td>G7S (2)</td>
<td>10</td>
<td>0</td>
<td>2 beats G7 susp 4th</td>
<td>2 beats CM</td>
</tr>
<tr>
<td>GP.5</td>
<td>11</td>
<td>0</td>
<td>0 En. 5 &gt;</td>
<td>Change to chord group 5</td>
</tr>
<tr>
<td>FM7 (2)</td>
<td>12</td>
<td>0</td>
<td>1 En. 5 &gt;</td>
<td>Change to chord group 5</td>
</tr>
<tr>
<td>GP.0</td>
<td>13</td>
<td>0</td>
<td>0 En. 0 &gt;</td>
<td>Change to chord group 0</td>
</tr>
<tr>
<td>G7 (2)</td>
<td>14</td>
<td>0</td>
<td>2 beats G7</td>
<td>2 beats CM</td>
</tr>
<tr>
<td>D.S.</td>
<td>15</td>
<td>0</td>
<td>0 En. d. &gt;</td>
<td>Repeat from SEG</td>
</tr>
<tr>
<td>CM (4)</td>
<td>16</td>
<td>0</td>
<td>4 En. 4 &gt;</td>
<td>4 beats CM</td>
</tr>
<tr>
<td>F6 (4)</td>
<td>17</td>
<td>0</td>
<td>4 En. 4 &gt;</td>
<td>4 beats F6</td>
</tr>
<tr>
<td>G7 (4)</td>
<td>18</td>
<td>0</td>
<td>4 En. 4 &gt;</td>
<td>4 beats G7</td>
</tr>
<tr>
<td>CM (3)</td>
<td>19</td>
<td>0</td>
<td>3 beats CM</td>
<td>3 beats CM</td>
</tr>
<tr>
<td>FIN</td>
<td>20</td>
<td>0</td>
<td>0 En. F. &gt;</td>
<td>End</td>
</tr>
</tbody>
</table>

Fig. 17. Keying procedure for an example chord sequence. The two control keys used in composition are shown next to the instruction format and do not appear in the display.
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a.c.I: 3mA, 30mA, 300mA, 3A.
Ohms: 0-1kΩ, 10kΩ, 100kΩ, 1MΩ.
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Part 6 Numerical Systems

In the series so far we have touched briefly on codes and numbers; decimal, binary and 7-segment. This month we are going to look in more depth at numerical representation and manipulation within logic circuits.

BASICS

The logic systems that we have been discussing are all based on a 'binary' concept: 'binary' meaning two-level. All normal conditions in a logic circuit can be represented by a logic 0 or a logic 1. 0's and 1's can be used to represent any two-state condition: On or off, open or closed, in or out, high voltage or low voltage, etc. Combinations of 0's and 1's can also be used to represent numbers. To see how this is done we must first look at our 'conventional' decimal numbering system.

Consider the number three thousand five hundred and twenty one:

<table>
<thead>
<tr>
<th>THOUSANDS</th>
<th>HUNDREDS</th>
<th>TENS</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>5</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

You will probably remember the units, tens, hundreds and thousands columns from schooldays! The number is made up by taking one from the units column, two from the tens column, five from the hundreds column, and three from the thousands column, then adding them all together:

$$1 + 20 + 500 + 3,000 = 3,521$$

This numerical system is based on tens; the columns are 'powers' of 10:

- $1 = 10^0$ (any number to the power 0 = 1)
- $10 = 10^1$
- $100 = 10^2$
- $1,000 = 10^3$

So, our original 3,521 number can be drawn in columns marked as shown:

\[ 10^3 | 10^2 | 10^1 | 10^0 \]

\[ 3 | 5 | 2 | 1 \]

Obviously, as you move further to the left in the sequence of columns, the powers go higher; to the left of $10^2$ comes $10^4$, then $10^6$ etc., as the number becomes larger. To change the 'base' of 10 to binary, which has a base of 2, simply replace all the tens by twos:

\[ 2^3 | 2^2 | 2^1 | 2^0 \]

(20 = 1, 21 = 2, 22 = 4, 23 = 8, etc.)

The least significant digit (column $2^0$) is in units, the next digit ($2^1$) is in twos, the next is in fours, the next is in eights, and so on in multiples of two. In each column there can only be a 0 or a 1, NOT a two; that would be a 1 in the next column to the left. So the binary number:

\[ 2^3 | 2^2 | 2^1 | 2^0 \]

\[ 1 | 0 | 1 | 1 \]

is equal to the decimal number eleven: One one, plus one two, plus no fours, plus one eight; total, eleven. The first sixteen numbers (including zero) of this binary code are shown in Table 1.

The binary table, of course, is one that we've come across before. You will remember that binary (and decimal) counters and dividers are readily available in CMOS and TTL integrated circuits. Binary, and as we shall see shortly 'BCD' code inputs and outputs from i.c.s are frequently labelled QA, QB, QC and QD, or even just A, B, C and D. A or QA is the least significant bit, i.e. 'units', and D or QD is the most significant bit, i.e. 'eights'.

<table>
<thead>
<tr>
<th>DECIMAL</th>
<th>BINARY</th>
<th>GRAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>14</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

TABLE 1 The binary code

Note that each vertical column of Table 1 changes state regularly as we count through the table. The 1's column changes alternately between 0 and 1, i.e. it changes every one step. The 2's column changes every two steps, the 4's column every 4, and the 8's column every eight. If this principle is remembered, it becomes very easy to draw up binary tables of any size, or any number of bits, when required; the starting point is always zero, since all binary bits are 0 for a count of zero.
BCD
You may have noticed that there is a slight anomaly in this table, in the decimal column; it changes part way down the column from being a single digit number to being a two digit number (9 to 10). This can cause problems in circuit design. If three binary counters are being used to represent a three digit decimal number, for example, then each one should represent the numbers 0 to 9. This corresponds to binary numbers 0000 to 1001. After binary number 1001 has been reached, the next count should cause that counter to start again at 0000, and the next counter in the chain should then increase by one; in other words, a 'carry one' operation.

Self-resetting circuitry can be added to implement this return-to-zero effect, but in most cases it is easier to use an i.c. with the circuitry already built in. This is known as a 'BCD' device, which stands for Binary Coded Decimal. Each BCD number is a direct equivalent to a single digit decimal number. There are no BCD numbers higher than this; they would be invalid, and have no meaning.

HEXADECIMAL
To represent the decimal numbers 0 to 9, four bits of binary information are needed, as can be seen from Table 1. Imagine a circuit used to route, store and control these four bit numbers. There would have to be four bit latches, groups of four flip-flops, four bit registers, groups of four gates, etc., for each decimal number to be represented. Unfortunately, there is a great inefficiency in our system, because we are only using ten combinations of 0's and 1's, whereas there are a possible sixteen! We are 'Not Allowed' to use binary numbers:
1010
1011
1100
1101
1110
1111

because they all correspond to a two digit decimal number, and the second digit must be represented by a different four bit binary number. So, these six extra codes are wasted.

To optimise the use of the circuitry, a new code must be introduced which allows the use of these extra six numbers. This code is known as "HEXADECIMAL", coming from Hex (six) plus decimal (ten), i.e. a numerical system with a base of 16, rather than 10 or 2. To represent 'Hex' (as it is shortened to) numbers in a fairly familiar way, we use decimal numbers for the first 10 states, then letters A to F for the last six. A is equivalent to ten, B to eleven, C to twelve, etc. The full table of decimal, binary BCD, and Hex numbers is shown in Table 2.

It should be remembered that Hex is only a notation for 4 bit binary numbers. It does not have patterns of 0's and 1's exclusive to itself, but merely represents binary numbers in a 'short hand' way. There are other similar systems (the 'Octal' code represents 3-bit binary numbers, for example) but the 4 bit binary numbers of Hex are the most useful to represent, since groups of 4 bits, and groups containing multiples of 4 bits, occur very frequently in logic circuits and systems.

The Hex system can consist of multi-digit numbers of course, in the same way that binary and decimal systems can, and again these are arranged in powers of 16. Comparing Hex with decimal:
3A is equivalent to (3 x 16) + (10 x 1) = 58
B9 is equivalent to (11 x 16) + (9 x 1) = 185
2AF is equivalent to (2 x 163) + (10 x 16) + (15 x 1) = 687

Hex numbers are most usually seen these days in computer programs. When writing programs, it is ridiculous to use long lists of 0's and 1's to represent data and instructions, so the simplest abbreviation of this is to represent 8 bit binary numbers by 2 digit Hex numbers. (Most modern microcomputer systems use 8 bit logic circuitry). Conveniently, an 8 bit binary code can represent 256 different numbers; exactly the same as a 2 digit Hex code can! These 2 digit Hex numbers are known in computer jargon as 'object code', and so this explains the reason for those long lists of numbers such as 3A, 0E, 3F, A2, B2, 23, 23, 47, etc., that you may have seen written down in computer program listings.

7-SEGMENT DISPLAYS
The principles of the 7-segment display are quite straightforward and were covered earlier in the series. Briefly, seven bars of light can be used to represent all the numbers 0 to 9, and many stylised letters of the alphabet, including the letters A, B, C, D, E, F, with upper and lower case versions. This is convenient for Hex number representation.) The 7 segments of the display are lettered a,b,c,d,e,f, and g (there is usually a decimal point, 'd.p.', provided too,) and are arranged in the layout shown in Table 2. The segments lit for each code number are also shown in Table 2.

Integrated circuits are readily available to convert binary codes into 7-segment codes. Usually, these i.c.s have extra functions built into them, such as latches, or output driver stages to directly drive the display segments without extra buffers or amplifiers. The Dual-Digi-Dice 'mini-project' this month uses two of these i.c.s built into them, while the other i.c.s are able to drive several displays, in a multi-digit arrangement, simultaneously. We shall look closer at display driving techniques, and alternative display technologies, next month.

THE GRAY CODE
Although binary, BCD and Hex and 7-segment are the most regularly used electronic codes, there are many others of which the majority are very specialised indeed. The 'Gray Code' is one of the more widely used of these alternative codes. To be completely accurate, the term Gray code, sometimes known as a 'reflected' code, can encompass a range of different codes, but we shall only look at the most common one.
The Gray code is primarily used in positional encoders. These are electromechanical devices which convert a physical movement or rotation into an electronic code which has a value proportional to that movement or rotation. In essence, they are multi-way switches giving a coded output, and are used to feed positional information from machinery or instruments, into logic circuits. The switching action can be by electrical contacts, or by optical means using marked discs passing between light sources and detectors.

Binary codes could be used in these applications, but would suffer from race hazards; if the shaft was just on the point of changing from one binary number to another, it may be that some bits had changed state, while others were about to change. This would give a completely false binary number. For example, if 0111 was to count by one to 1000, the three least significant bits may change state fractionally at a time, so each count only differs from the previous and succeeding counts by the change of state of one bit. By this means, the greatest uncertainty of value that can ever be is plus or minus \( \frac{1}{2} \). The complete code, with binary shown alongside for reference, is given in Table 3. Although the Gray code might look rather complex, it is very easy to convert from binary to Gray, and vice versa. The circuits to do this are shown in Fig. 6.1, and can be expanded for any number of bits from one upwards! In each case, the most significant bit is common to both codes, and the other bits follow the interconnection pattern shown.

THE GRAY CODE

The Gray code is primarily used in positional encoders. These are electromechanical devices which convert a physical movement or rotation into an electronic code which has a value proportional to that movement or rotation. In essence, they are multi-way switches giving a coded output, and are used to feed positional information from machinery or instruments, into logic circuits. The switching action can be by electrical contacts, or by optical means using marked discs passing between light sources and detectors.

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OTHER CODES

The only other code that you will be likely to come across regularly is the ASCII code: the American Standard Code for Information Interchange. This is a fairly universal code used for representing symbols, characters and control signals, and has wide application in the field of computing. ASCII is a 7 bit binary code, and is used in association with large keyboard assemblies to provide coding for upper and lower case letters of the alphabet, numerals, punctuation, and control functions such as reset, backspace, carriage return, etc. The same codes are also used for character generation: when fed into suitable ’character generator’ i.c.s they cause a specifically encoded signal to be produced which is then suitably modulated and displayed on a video monitor or domestic television. In these instances, most of the keyboard control functions are replaced by fairly complex graphic symbols which allow the programmer greater flexibility in the symbols that he can write up onto the screen.

Since there are 128 different ASCII codes, we shall not list them all here; they are easily accessed via character generator, microcomputer, or keyboard encoder i.c.s data sheets. The generation of these 7-bit codes from the contacts of the keyboard switches, together with character de-bouncing and other basic timing and control functions, is normally carried out by i.c.s on the actual keyboard p.c.b. itself.

It should be noted that code converters can be easily designed using Boolean algebra, as discussed in the first part of the series. Each digit (or bit) of the ’new’ code has its own Karnaugh/Veitch map, drawn up from all the digits (or bits) of the ’old’ code. In most cases, of course, there are readily available i.c.s to perform the complete conversion so these techniques need only be employed for very specialised code conversions.

BINARY ARITHMETIC

All digital calculators, microprocessors and (of course) computers, at their most fundamental level, use binary codes for their numerical representation. On these codes must be performed arithmetic operations, mostly additions, subtraction, multiplication and division. To see how this is done in practice it is first necessary to determine the rules of binary arithmetic, which follow ’conventional’ arithmetic techniques to a large extent.

ADDITION

This works in a very straightforward way, the only difference between binary and decimal addition being that we ’carryone’ to the next most significant digit when the sum exceeds 9 in decimal, whereas in binary we carry one when the sum exceeds 1. So we can see that:

\[
\begin{align*}
0 + 0 &= 0 \\
0 + 1 &= 1 \\
(\text{Similarly, } 1 + 0 &= 1) \\
1 + 1 &= 0 \text{ carry 1}
\end{align*}
\]

Examples: a) 11010 b) 0100 c) 100101

\[
\begin{align*}
\text{plus } &00010 &\text{equals } &11000 \\
\text{plus } &00001 &\text{equals } &100101 \\
\text{plus } &00110 &\text{equals } &110010 \\
\end{align*}
\]

\( \text{carry} \ 1 \\
\text{carry} \ 1 \\
\text{carry} \ 1 \\
\)

Practical Electronics January 1982
**SUBTRACTION**

This is a rather more complicated procedure than addition, due to the requirement to 'borrow' digits. The way that most systems overcome this difficulty is to complement one number, then add the other number to this complement. 'Complementing' simply means turning a negative number into a positive one, or vice versa; i.e. in terms of decimal numbers.

\[ 16 - 4 = 12 \]
\[ 16 + (-4) = 12 \]

Using this method, we can use the same circuits as for the addition process, with only an extra complementing circuit needed. There are a number of different ways of deriving a negative binary number from a positive one. We shall look at the most common system, known as 'Two’s Complement':

To form the two’s complement of a number (i.e. turn a positive binary number into a negative one), perform the following steps:

1) add an extra 0 on the left of the number (i.e. the most significant bit)
2) invert all the bits (1 becomes 0, 0 becomes 1)
3) add 1 to the resulting number.

**Example:** a) Turn 17 into -17

\[ 17 \text{ in binary is: } 10001 \]
\[ \text{add 0 to the left: } 010001 \]
\[ \text{invert all the bits: } 101110 \]
\[ \text{add 1: } 000001 \]

Result: 101111

Hence, 101111 is the two’s complement representation of -17.

**Example:** b) Turn 3 into -3

\[ 3 \text{ in binary is: } 11 \]
\[ \text{add 0 to the left: } 011 \]
\[ \text{invert all the bits: } 100 \]
\[ \text{add 1: } 001 \]

Result: 101

Hence, 101 is the two’s complement representation of -3.

In both these examples it is necessary to know that two’s complement arithmetic is being used, and hence the left hand bit is an 'extra' one; in the latter case, for example, we know that the result 101 is not 5 in decimal because the original number was a 2 bit number, and our 2’s complement method results in a 3 bit number.

When building subtraction systems, circuitry to perform the two’s complementing of one number is followed by addition circuits, to add the result of the two’s complement process to the other number. The final result is a subtraction!

Note that if a positive and a negative number are added and if the most significant bit of the result 'carries by one', i.e. the result is one bit larger than either of the two original numbers, then this most significant bit can be discarded, i.e. ignored.

For example, take

\[ +3 -3 = 0 \]
\[ +3 \text{ in binary } = 101 \]
\[ -3 \text{ in binary } = 111 \]

Adding together, the RESULT = 1000

Discard

Hence, the result = 000 (zero)

**HALF AND FULL ADDERS**

Combinational circuitry is used to implement binary addition. The most basic addition circuit is known as a 'half adder', since it is used when two bits only are to be added; it has no 'carry in' facility. See Fig. 6.2. To include carry in requires two half adders to be connected together with an extra gate, as shown in Fig. 6.3. Note that in Fig. 6.2 and 6.3 the circuits are based on the use of NAND and NOR gates, since these are most usually found in discrete circuitry. To simplify the circuits still further, EX-OR gates are often used in place of several gate combinations.

A 4-bit CMOS full adder i.c. is readily available, the 4008, which has extra circuitry provided to give a 'fast' carry out signal. If this extra circuitry was not provided, the carry out signal would have to ripple through the adder stages, incurring considerable delay and potentially giving rise to hazards in the operation of the following circuitry. The majority of adder circuits today are, of course, buried deep within microprocessor and calculator i.c.s. The principles outlined here still apply, nonetheless. The circuitry for binary subtraction need not be shown, since it is merely a set of inverters with an extra half adder to add one to the complemented binary number, followed by a set of full adders as detailed above.

**MULTIPLICATION AND DIVISION**

There are three different approaches which can be adopted when designing multiplication and division circuits. The first is to use a fairly complex but fast arrangement of full adders and control circuitry to perform 'long multiplication' and 'long division':

For example, multiply 01101 by 1010:

**MULTIPLY:** 01101 (13 in decimal)
**BY:** 1010 (10 in decimal)

\[ \frac{00000}{01101} \]
\[ \frac{00000}{10101} \]

**TOTAL:** 10000010 (Adding all four multiplications together)

**Discard**

The result is 10000010, or 130 in decimal.

Since the process was simply a 'shift-and-add' routine, this is obviously implemented by using a large number of full adders, suitably interconnected, with inputs gated on and off by the bits of the second number (1010). Division is carried out by a similar process.

In many calculators and microprocessors, the rather complex and specialised circuitry needed for these operations is unnecessary; a far simpler, though slower, method can be used. It is analogous to the way a supermarket check-out operator totals up many identical purchases:
The original number to be multiplied or divided is merely the result is therefore, move divided by i.e. the result is therefore, move i.e. the result is therefore, move i.e. the result is 

Example 1:  
multiplied by  
i.e.  
therefore, move  
the result is  
2 extra  
0's added  

Example 2:  
multiplied by  
i.e.  
therefore, move  
the result is  
3 extra 0's added  

In the case of division, as many bits must be discarded as the number of places being shifted to the right:  
Example 3:  
divided by  
i.e.  
therefore, move  
the result is  

discard these two bits.  

This shifting procedure is tailor-made for the shift register! If the number that you are to multiply or divide by is an integer power of two (this is surprisingly a regular occurrence) then the shifting technique is by far and away the easiest way to implement this arithmetic operation.  

**THE ARITHMETIC LOGIC UNIT**  
When several full adders and some control logic are added together in one circuit, in combination with some external parallel in-parallel out registers, we end up with a very flexible and versatile multi-function unit capable of performing a number of arithmetic and logic operations on sets of binary information. This is known as the ALU (Arithmetic Logic Unit) and is at the heart of every computer, microprocessor and most calculators. The ALU is normally treated as a 'black box'; it's detailed internal operation need not be known, it is merely a block of circuitry capable of addition, subtraction, complementing, multiplications, division (these two functions sometimes requiring the use of extra external registers), logical operations such as AND-ing and OR-ing of binary numbers, and other similar operations.  

To achieve this flexibility and versatility of operation, the interconnections between the various registers, control logic, full adders, etc., must be fairly complex. In order to vastly simplify these interconnections and to give some semblance of order to the internal structuring of microprocessor and calculator circuitry, the 'BUS' system is used.  

**THE BUS**  
A bus is a set of common parallel interconnections between many different devices and circuit subsections in a system. It has a certain 'width' measured in binary bits, which usually corresponds to the maximum number of bits in the binary numbers to be manipulated within the equipment. The 8 bit bus is very common these days, so this bus physically consists of eight separate tracks on the p.c.b., or inside the i.c. chip. Sometimes extra bits for control purposes are added to the bus; the most regularly seen types being known as 'flags', which are used for control signalling between parts of the circuitry.  

Some devices feed their outputs onto the bus, others take their inputs from the bus, and some even do both! Not all this happens simultaneously, though. Device A might feed onto the bus while device B takes it's input from the bus, in which case the output of A is fed to the input of B. These two then stop using the bus, while device C feeds onto the bus, and device D takes it's input from the bus; the output of C then feeds into the input of D, without affecting either A or B. The bus is often known as a 'data highway' with devices...
and circuit sections taking it in turn, two or more at a time, to be connected with each other via it.

To achieve all this without excessive loading or shorting out of gate outputs, a 'tri-state' (three state) logic system is employed on all device outputs feeding onto the bus. When the tri-state outputs are turned on, they can be at either logic 0 or logic 1 levels, as used in the rest of the system, but when the tri-state outputs are turned off they become very high impedance points, capable of floating in voltage, with negligible loading of other circuitry feeding the bus. Hence, only the device selected at any time by the controlling logic can feed onto the bus. Inputs to devices are enabled by the control logic in a fairly conventional way. The bus can therefore be considered 'bidirectional'; binary information flows up and down it in rapid succession as different parts of the circuit use it to perform their various interconnections.

It is usual for complex digital systems to have more than one bus. The other bus or buses can carry information to different areas, or carry other forms of information, for example when the tri-state outputs are turned off they become very high impedance points, capable of floating in voltage, with negligible loading of other circuitry feeding the bus. Hence, only the device selected at any time by the controlling logic can feed onto the bus. Inputs to devices are enabled by the control logic in a fairly conventional way. The bus can therefore be considered 'bidirectional'; binary information flows up and down it in rapid succession as different parts of the circuit use it to perform their various interconnections.

A simplified bus arrangement is shown in Fig. 6.4. The 'accumulator' is a register, similar to the B, C, and D registers, but dedicated to the ALU. It's input is always fed from the ALU, while its output always goes to one of the two main ALU inputs, and can also feed, via tri-state enable gates, onto the bus. By careful internal timing of the system, binary numbers can be fed out of any of the B, C or D registers into the ALU, mathematically processed with the output of the accumulator, and the accumulator can latch into itself the result of this mathematical process, which can then be fed onto the bus and either back into the ALU again, or into one of the registers. For example, the sequence of events to add the contents of register B to those of register C, and put the result in register D, would be:

1) Reset accumulator (output equals zero).
2) Feed output of register B onto the bus, and enable inputs to the ALU.
3) Add ALU input 1 (i.e. the number in register B) to input 2 (zero).
4) Latch the output of the ALU into the accumulator.
5) Feed the output of register C onto the bus, and enable the inputs to the ALU.
6) Add ALU input 1 (the contents of register C) to input 2 (the number which originally came from register B).
7) Latch the output of the ALU into the accumulator.
8) Feed the output of the accumulator, via the tri-state enable gates, onto the bus and enable the inputs to register D.

Although this sounds a complex procedure most computers, calculators or microprocessors can carry out this series of steps in no more than a few microseconds; many in considerably less time than this! We're now starting to get an insight into the internal operation of microprocessor and computer central processing units, or 'CPUs'. We'll cover the subject more fully in the final article of the series. Before that, however, in next month's article we shall look at the use of analogue techniques within digital logic circuitry. This includes complex display driving, analogue transmission gates, conversion between analogue and digital signals, and (of course) those all-important memories!

**DUAL-DIGI-DICE**

This project accurately simulates the rolling of a pair of dice, with fairly authentic i.e.d. face patterns. When the ‘ROLL’ switch is pressed, both dice faces start changing and flickering rapidly, then gradually slow down and stop at a final result. The changes are completely random; they do not simply ‘count up’ numerically. Approximately 10 seconds after the final result has been obtained, the two i.e.d. dice displays switch off to conserve battery power.

**PRINCIPLES**

The circuit design is based upon the fact that dice face patterns change in a way that is approximately a binary count. Referring to the pattern of i.e.d.s, we can compare the dice face i.e.d.s lit with a sequence of binary numbers, as shown in Fig. 6.5. There is obviously a direct correlation between the i.e.d.s lit and the binary count; the 'A' i.e.d.s is lit by the least significant binary digit, the 'B' i.e.d.s by the middle digit and the 'C' i.e.d.s by the most significant digit. Hence a binary counter can be used to provide the correct code for the dice face, as long as the invalid 0 and 7 states, which never occur on a dice, can be avoided.

<table>
<thead>
<tr>
<th>NUMBER</th>
<th>DICE FACE I.E.DS LIT</th>
<th>BINARY CODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>INVALID (NONE LIT)</td>
<td>0 0 0</td>
</tr>
<tr>
<td>1</td>
<td>a</td>
<td>0 0 1</td>
</tr>
<tr>
<td>2</td>
<td>b</td>
<td>0 1 0</td>
</tr>
<tr>
<td>3</td>
<td>a &amp; b</td>
<td>0 1 1</td>
</tr>
<tr>
<td>4</td>
<td>c</td>
<td>1 0 0</td>
</tr>
<tr>
<td>5</td>
<td>a &amp; c</td>
<td>1 0 1</td>
</tr>
<tr>
<td>6</td>
<td>b &amp; c</td>
<td>1 1 0</td>
</tr>
<tr>
<td>7</td>
<td>INVALID (NONE LIT)</td>
<td>1 1 1</td>
</tr>
</tbody>
</table>

**Fig. 6.5. Dice face i.e.d. patterns**

**CIRCUIT DESCRIPTION**

IC4 is a dual binary counter; two separate synchronous counters in one i.c. package. The 'C' output of the first counter is used to clock the second counter, so the two halves are 'cascaded' asynchronously. The slight race between the two counter halves is unimportant in this case; any static hazards caused are irrelevant, as the counters are clocked randomly by a noise source anyway! The output of each counter is fed into a Quad D-type latch, the Q outputs of which drive the i.e.d.s via conventional transistor buffers. (Note that the 'B' and 'C' i.e.d.s are arranged in series pairs to cut down current consumption, although it would be unwise to put all four 'C' i.e.d.s in series since the total voltage drop across them could be as high as 10 volts, which would not allow for sufficient variation of power supply voltage.) TR3, TR4, R16 and R17, and TR5, TR6, R15 and R18 form Darlington driver configurations, each to supply current to all the i.e.d.s in a dice face display. These configurations are fed in turn from IC7a. The inputs of IC7a are connected to a very long time period pulse stretcher — D4, C8 and R14. When S3 is pressed and released, IC7a pins 1 and 2 are held at logic 1 for approximately 15 seconds, causing the output pin 3 to go to logic 0, turning on the two Darlington drivers and hence the displays. After the time period of 15 seconds has ended, pin 3 goes high again and the Darlington drivers turn off, so the i.e.d. displays also turn off, conserving valuable battery power! This time period can obviously be varied by charging R14 or C8. S2 is provided to permanently switch off the 'A' dice display when only one dice is being used.

The random changes of dice face display are obtained by
Fig. 6.6. Circuit diagram of the Dual-Digi-Dice
using a random noise source to clock the counters, then latching the counter outputs in IC5 and IC6 as frequently as required to give the effect of the dice rolling. The clocking of the counter occurs very rapidly and the latching fairly slowly, so for each latch pulse, IC4 will have counted through its entire range of numbers many times. Each successive dice face shown, therefore, will be chosen completely at random.

The noise source is formed by reverse biasing the base-emitter junction of TR1, with the collector left disconnected. This is buffered and amplified by TR2 (with R2, R3 and C1) then amplified again by IC1. R4 and R7 set the gain of IC1, while R5, R6 and C3 set the non-inverting input to a reference point of approximately +5.8 volts. The noise output of IC1 swings almost to each supply rail, and needs only to be fed through a Schmitt trigger gate, IC7d, to clean up the waveform into correct logic levels, before feeding into the clock input of the counter, IC4 pin 1. Note that a high battery voltage for the unit is needed (12 volts) in order that a satisfactory noise voltage can be obtained from the reverse biasing of the TR1 junction. Although a 9V battery could be used, it would require special selection of TR1 to find a transistor with a particularly high noise voltage. Diode D1 is provided to protect the unit against accidental reverse connection of the batteries with a particularly high noise voltage. Diode D1 biasing of the TR1 junction. Although a 9V battery could be used, it would require special selection of TR1 to find a transistor with a particularly high noise voltage.

The output of IC2, pin 3, has short pulses derived from it by C4, D2 and R8. These are then used to latch IC5 via IC7b and IC6b, and IC6 via IC7c and IC6c. The invalid conditions of the counter IC4, 000 and 111 (as shown in Fig. 6.5.) are prevented from occurring by IC9c, IC9d and IC8b (for the ‘B’ dice) and IC9a, IC9b and IC8d (for the ‘A’ dice). In each of these networks, the outputs of the two EX-OR gates are both at logic 0 if their respective binary counts are 000 or 111. This, via the following NOR gate, disables any latch pulses passing to IC5 or IC6 (as appropriate), thereby preventing an invalid code from ever being latched and displayed.

CONSTRUCTION

The matchboards should be built up as shown in Fig. 6.7, leaving the l.e.d.s OFF the boards for the moment and fitting the wire links on each board after all the components have been added. The l.e.d.s are then soldered to the REVERSE side of the board (i.e. the copper foil side) with their tops protruding approximately 10mm above the surface of the p.c.b. Note that the ‘a’ (centre) l.e.d. has to have its leads bent outwards to fit the holes in the board. Ensure that these bends are made well away from the l.e.d. body.

The case can then be drilled to take the switches and the two match-boards’ support pillars, and rectangular cutouts should be made to allow viewing of the l.e.d. displays; these cutouts can then have a piece of red tinted transparent perspex or plastic glued behind them to improve visibility and contrast of the l.e.d.s. The interwiring between boards, and to the switches, can now be added in flexible (multistrand) wire, and the boards can be screwed to the front panel of the case using suitable spacers: ½ inch x 6 BA.

Semiconductors

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>1N4002</td>
</tr>
<tr>
<td>D2, D3, D4</td>
<td>1N4148 (3 off)</td>
</tr>
<tr>
<td>D5 to D18</td>
<td>red l.e.d. (14 off)</td>
</tr>
<tr>
<td>TR1</td>
<td>BC109</td>
</tr>
<tr>
<td>TR2, TR7</td>
<td></td>
</tr>
<tr>
<td>TR3, TR5</td>
<td>BC558 (2 off)</td>
</tr>
<tr>
<td>TR4, TR6</td>
<td>BF303 (2 off)</td>
</tr>
<tr>
<td>IC1, IC3</td>
<td>7411 8 pin i.c. (2 off)</td>
</tr>
<tr>
<td>IC2</td>
<td>ICM 7555 CMOS timer</td>
</tr>
<tr>
<td>IC4</td>
<td>4520 CMOS Dual binary counter</td>
</tr>
<tr>
<td>IC5, IC6</td>
<td>4042 CMOS Quad latch</td>
</tr>
<tr>
<td>IC7</td>
<td>4093 CMOS Quad Schmitt NAND gate</td>
</tr>
<tr>
<td>IC8</td>
<td>4001 CMOS Quad NOR gate</td>
</tr>
<tr>
<td>IC9</td>
<td>4070 (or 4030) CMOS Quad EX-OR gate</td>
</tr>
</tbody>
</table>

Miscellaneous

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 off</td>
<td>Matchboard Exp-300PC Global Specialties</td>
</tr>
<tr>
<td>S1</td>
<td>Double pole miniature toggle switch</td>
</tr>
<tr>
<td>S2</td>
<td>Single pole or double pole miniature toggle switch</td>
</tr>
<tr>
<td>S3</td>
<td>Momentary button switch</td>
</tr>
<tr>
<td>2 off</td>
<td>Battery holders, with connecting leads (each 4 x HP7)</td>
</tr>
<tr>
<td>1 off</td>
<td>Design Mate Case DMC2, Global Specialties</td>
</tr>
<tr>
<td>8 off</td>
<td>⅜ in. x 6BA threaded spacer</td>
</tr>
<tr>
<td>6BA</td>
<td>screws and wire to suit</td>
</tr>
<tr>
<td>2 small</td>
<td>pieces of red gelatine, perspex, etc (see text)</td>
</tr>
</tbody>
</table>
taped pillars are ideal. The battery holders can be fixed to the case baseplate using 'sticky fixers', and the batteries should then be added.

The project is now finished! If it seems that the noise source is not operational (no logic changes at IC7d pin 11) try changing TR1, or lowering the value of R4 to 1kΩ, and make sure that the supply voltage is high enough. The rate at which the dice face displays slow down their changes can be varied by altering the values of R11, R12 and R13, but note that too slow a 'slowing down' may result in the dice face never actually finally stopping before the displays switch themselves off! For testing purposes, removing C2 and C4 will enable you to use a logic pulser (on IC7d pin 11 and IC8a pin 1), to simulate the action of both the random noise generator and the latching pulse generator, and thereby debug any faults that there might be. Finally, there is plenty of room in the case to add a simple mains power supply if preferred, as shown in Part 2 of this series; any voltage from 12 to 15V will work very well indeed.

**NEXT MONTH**

Multiplexing of displays, complex displays (liquid crystal, gas discharge and similar). Analogue switches, transmission gates etc, A to D and D to A converters.
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*BC179 1
*BC149
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4019 35

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LF351
A4043
A4042
4048
A4046
A4045
LM725 350
LM393 100
28
70
85

2N3702 6
ZTX300 14
TIP30555
TIP31A 45
MJ2955

50
76
80
120
185
150

TDA1032 125
TDA1032 125

BC478 30
BC477 30
25236917
ZTX500 16
ZTX302 15
110

79HG5A TO -3 adj neg
78H5A TO -3 12v pos
78G 1A TO -3 adj pos
78G 1 A TO -220 adj pos

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3 pin
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20p
20p

8MHz
4MHz

BC237
BC307

22p
22p

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2SC1775A

3 or 5mm yellow 14p
3mm red 16p, green 17p,

3mm yellow 14p

Miniature OP DT slide 14p.

VCXO 17p.

22p
22p

38
50

11p; 220n, 13p; 330e. 20p; 470n,
50p

7805 45
01704

2SK55 28p
2SK66 28p

2SK66 28p
2SK66 28p

2SC660 8p
2SC660 8p

2SK66 28p
2SK66 28p

2SK66 28p
2SK66 28p

35p
FITTING the flow and speed sensors, installation, calibration and a description of the program controlling the computer.

There is the option of a combination lock facility which could be used to operate an ignition cutout or alarm. The combination consists of three digits and can be changed up to seven times without erasing the PROM.

FITTING THE FLOW SENSOR

Because of the wide variety of fuel systems, precise instructions cannot be given to cover every make of car, but fitting the flow sensor is in fact an easier job than many would imagine, providing the following guidelines are observed.

The flow sensor is fitted in the petrol pipeline between pump and carburettor, and after the fuel filter. The arrow on the side must point in the direction of flow as seen in Fig. 11.

The fuel line, which may be of metal, plastic, rubber or a combination of all three, must be cut or otherwise parted in order to insert the flow meter. In the case of a flexible hose, it is simply necessary to slacken the hose clamp, preferably at the fuel pump end (assuming it is a mechanical engine driven pump), pull off the hose and join the flow meter to the pump outlet pipe by means of the polyurethane pipe supplied. In the case of a metal fuel line, it is better to remove the pipe from the engine before cutting, to enable the ends to be satisfactorily deburred and avoid swarf entering the fuel system.

The usual plastic fuel line is made of nylon and is best cut with a sharp knife. It is normally rigid enough to accept a flexible pipe and clamp without collapsing.

The flow sensor is not normally affected by vibration and because of its light weight, it may be mounted so that it is suspended in the fuel line. It should however not be positioned so that it is subjected to direct radiant heat from the exhaust manifold. If close proximity (less than 6in) is unavoidable, a metal heat shield should be fitted between.

It should ideally be mounted vertically, but if it has to be mounted horizontally or close to the horizontal, it should be fitted with the fuel passage above the detector housing. It is not susceptible to electrical interference but it is advisable to avoid close proximity to high tension leads.

If no filter is present, we recommend that a standard type of in-line paper element fuel filter be fitted just ahead of the flow sensor, taking care to note the direction of flow.

So far so good. Now for the snags. Some of you might have a car in which the fuel is not only pumped up to the carburettor, but is pumped back to the tank as well; in fact it hurtles around the fuel system at a much faster rate than your engine could ever use it. Obviously, if you stick your flow sensor in line with that lot, the answer is going to be rather wrong.

The presence of a second fuel pipe connected to the carburettor, which disappears back to the fuel tank means that you have a recirculating fuel system. It is standard on the Range Rover, Rover 3500 (pre SD1), Fiat, Audi and many other types. If you are in any doubt, your local agent will enlighten you.

FITTING THE SPEED SENSOR

Locate a suitable part of the speedometer cable to fit the sensor, probably fairly near the bulkhead in the engine compartment, and draw four lines on it as in Fig. 12. Detach the cable from the back of the speedometer and withdraw the inner cable. Using a hacksaw cut the outer cable at the two inner lines and throw away the section. Slide a jubilee clip along each part of the outer cable.

Refit the inner cable and re-connect to the speedometer, leaving the inner cable hanging from the cut end of the outer.

Push the inner cable through the sensor, the side of the sensor with the screw heads being nearer the speedometer.
This will take a certain amount of force as there is a friction grip on the cable.

Keep feeding the cable through until the outer cable is entering the slotted end tube of the sensor, pulling the inner cable at this point rather than pushing the outer. Allow the outer cable to enter the tube until the drawn line is level with the end of the tube, then release the inner cable and pull back the outer cable about 0.5mm/0.02in. Drop the jubilee clip over the slotted tube and do it up to clamp the cable.

Check that the inner cable is free to rotate when pushed towards the sensor and pulled from it. Thread the inner cable through the rest of the outer, feeding the outer cable so that its line is level with the end of its slotted tube. Fit the jubilee clip as before.

**Fig. 12 Speedometer cable marking**

**MAIN UNIT**

Fit the main unit in a suitable position. If screws are to pass through the plastic box make sure that they will not foul anything inside. Double sided adhesive pads can be used to mount the flat side of the box to a flat surface or to a bracket, and these hold well. Thread the cable to a suitable point and connect up as follows. This is for -ve earth vehicles.

- **Black wire** — Terminal block 1, also to chassis.
- **Red wire** — Unswitched battery power (+ 12 volts).
- **Yellow wire** — Power switched by ignition switch (or auxiliary).
- **Orange wire** — Power switched by light switch (e.g. a panel light).
- **Brown wire** — Terminal block 2 (+5 volts).
- **Violet wire** — Terminal block 3 (Speed signal).
- **Green wire** — Terminal block 4 (Flow signal).

Connect to the sensors as follows.

- **Terminal block 1** — Blue wires from both sensors.
- **Terminal block 2** — Brown wires from both sensors.
- **Terminal block 3** — Green/Yellow wire from speed sensor.
- **Terminal block 4** — Green/Yellow wire from flow sensor.

**CALIBRATION**

The flow sensor will be supplied with two numbers, one for litres, one for gallons. This number is the number of pulses per litre or gallon divided by 256.

With the unit installed in the car and the ignition switched on, press 'Enter', 'F.Cal', the number, 'End'. Note that if this number is greater than 128, fuel use will read distance/fuel (i.e. miles per gallon), if less than 128 it will read 100 x fuel/distance (i.e. litres per 100 kilometres).

The new calibration constant is:

\[
\text{Old calibration constant} \times \frac{\text{Computer reading}}{\text{Actual quantity}}
\]

The reading for the display is obtained by dividing the number of pulses counted by (256 x calibration constant). The litres figure is 0.219 x the gallons figure. The fuel could therefore be expressed in any form, for example cost, giving the readout of pounds, miles per pound and so on. The totals are not affected by changes in the calibration number.
The calibration numbers, entered numbers, entered start and stop values and totals will be held in the unit's memory until changed from the keyboard as long as the unit is connected to power. If the battery is disconnected or allowed to go flat the calibration numbers will have to be re-entered. The 1000µ capacitor, C9, will hold the power for a very short while.

The unit is intended to work on negative earth vehicles, but can be adapted for positive earth by connecting the light return wire to the +ve supply wire and constructing a simple transistor invertor for the ignition wire as shown in Fig. 14.

![Fig. 14 Transistor invertor for the ignition wire](image)

**COMBINATION LOCK**

Pin 35 of IC1 is an output of a combination lock facility incorporated in the computer. This could be used to operate an alarm or ignition cutout, and the operation is as follows. If 'Enter', 'Average/Low' is pressed, the display will show an 'L' in the function digit and blank the rest of the display. If the ignition is now switched off, when it comes on again pin 35 of IC1 will be high. To cause it to go low again a three digit combination must be entered, then 'End' pressed. The number is held in the 2716 program memory, and will normally be supplied with a random number, though a specific number could be supplied.

The signal on pin 35 will not go from low to high (locked) with the ignition switched on. This is needed with an ignition cutout as a safety measure as otherwise it could switch off the engine going along, but in addition to this, some sort of 'fail safe' circuit should be used, such as that shown in Fig. 15. R1 should be mounted inside the box, the other components outside. The reason for this is to keep interference noise out of the unit. The relay disabled the ignition by shorting out the contact breakers, or inductive or photocell pick up. If the wire to the computer is cut with this circuit, shorting out the contact breakers, or inductive or photocell noise out of the unit. The relay disables the ignition by

![Fig. 15 Ignition disable circuit](image)

**CHANGING THE COMBINATION**

The three digit combination number is held in the 2716 program memory and can be changed up to seven times without erasing the PROM, making use of the fact that individual memory locations in a 2716 can be programmed. The initial number is held in locations 7FE and 7FF (hex), but the unit will search for a number from locations 7FO upwards (in pairs), and use the first that it finds that is not FF. The first new number can thus be entered by programming into locations 7FC and 7FD, the next to 7FA and 7FB and so on. The low order location contains the two low digits of the combination, the high order location a hex 'D' (Binary 1101) and the high order digit of the combination.

So to change the number to 123, location 7FC is programmed with 23 hex and 7FD with D1 hex. To change again to 456, program location 7FA with 56 and location 7FB with D4.

**PROGRAM**

The operation of the car computer is controlled by the program contained in IC2. It is not practical to describe in full this program, or even to list it, but what follows is a brief description of how it operates.

The various sections of the program are:

- **Interrupt**—Every 500µs approximately, the program receives a time interrupt.
- **Keyboard**—When a key has been pressed, this routine carries out the appropriate action.
- **Calculation**—This routine takes the information from the appropriate stores, under the control of the function selected, and performs the necessary arithmetic on it, for feeding to the display.
- **Sample**—Every second, or eighth of a second, this routine updates the instantaneous stores.
- **Start-Stop**—If the start-stop mode is active, this routine compares the result from the calculation routine with the start stop information and carries out a reset, or sets the hold condition as required.

**INTERRUPT**

The interrupt routine (a) updates the timebase and time store (b) samples the speed and flow inputs (c) every fourth interrupt it samples the keyboard, and advances the strobe and multiplexed data output.

The main stores for holding total time, fuel and distance are each three bytes long. The low order time byte is also the high order timebase byte, the timebase being two bytes long, and each interrupt the combined 4 byte store is incremented.

The speed and flow inputs are compared with their states at the previous interrupt. If one is now high and was low, the corresponding total store is incremented. A separate one byte store used for the instantaneous signal is also incremented, and the timebase copied to a start store if this is the first count in a sample, or to a stop store otherwise. This
is done to improve resolution as there could be only a small number of counts in a sample.

Every fourth interrupt the keyboard lines are sampled. If one is high, the line and timebase information is copied into a current key store. The strobe lines are all made low, the data lines set to the next digit and the new strobe information sent, derived from the timebase.

Note that the timebase information that was copied into the current key store corresponded to the next strobe line. This is why the keyboard is scanned one strobe early. At the end of four strobos the current key store is compared with a previous key store, then copied to that. If the two were different, then a new key has been pressed and a flag is set to instruct the keyboard routine to action the key.

**KEYBOARD**

If the new key flag is set, it is cleared, and the keyboard routine run. The key is first checked for nothing—releasing a key also sets the new key flag. There is a main flag with eight states which controls the keyboard.

If the key is 'End' the flag is set to zero. In this state with the key 1 to 5, the function store is set to the key number and the average/low and remainder flags are cleared.

When the key is 6, the average/low flag is set. Depressing 7, the total stores are set to zero. If the start-stop mode is active, then the Start flag is set. With 8, the hold flag is set and the start-stop flags cleared. At 9, the hold flag is cleared.

If the start-stop request flag is set, the start-stop active flag is set, the start number subtracted from the stop number and the sign of the result copied to the start-stop direction flag.

With 0 keyed, the keyboard flag is set to 1. If the key is 'Enter', the keyboard flag is set to 3.

If the keyboard flag is 1 then if the key is 1 to 5 it is copied to the function store and to a remainder function store. The flag is set to 2 and the remainder flag set. Any other key, the keyboard flag is set to 0 and the key handled as for a flag of 0.

If the keyboard flag is 2 and if the key is 1 to 3 it is copied to the remainder function store. The keyboard flag is set to 0. Any other key, the keyboard flag is set to zero and the key handled as for a keyboard flag of 0.

If the keyboard flag is 3 and if the key is 6 then the lock routine is executed. If 8 the start-stop request flag is set. If 4, 5 or . it is ignored. Otherwise the key is copied to a destination store, the keyboard flag is set to 4 and the contents addressed by the destination store are sent to the display.

If the keyboard flag is 4 then the results digits are cleared, the key added to the display store and this copied to the address pointed to by the destination store.

If the keyboard flag is set to 5 then as before except that the results digits are not cleared. Whenever the keyboard flag is set to a number other than zero, a countdown flag is set to 7.

**CALCULATION**

There are five basic calculations, as follows

- **Total**—function 1 to 3
- **Instantaneous**—function 4 or 5
- **Average**—function 4 or 5
- **Remaining total**—function 1 to 3
- **Remaining average**—function 4 or 5

The total is calculated by taking the contents of the total store addressed by the function store and dividing by the corresponding calibration number. The calibration number for time is generated internally. If the low flag is set, this is now divided by 0.01 (the same as multiplying by 1000). If this causes an overflow, the low flag is cleared.

Instantaneous functions are obtained by taking the instantaneous distance divided by its calibration and dividing this by either instantaneous time (a constant for speed, or instantaneous fuel for fuel use, again divided by its calibration number. If fuel use and the calibration number is less than 128 then 100 is divided by the result obtained (for litres per 100 kilometres).

Average functions are the same except that totals rather than instantaneous quantities are used.

It starts to get complicated for remaining totals. In the description following total function refers to the total addressed by the function store, entered remainder refers to the entered quantity addressed by the remaining function store, and so on.

The total remainder is divided by its calibration, copied to a temporary store then divided by the total function divided by its calibration. The result is stored in a second temporary location. The contents of the first temporary location are now subtracted from the entered remainder, and this divided by the contents of the second temporary store to give the result.

Remaining averages are obtained as for averages except that the difference between the entered stores and the totals are used rather than the total stores.

**SAMPLE**

When the timebase low byte becomes zero in the interrupt routine, the sample routine is entered. This is approximately eight times per second. If the lower three bits of the timebase high byte are also zero, i.e. every second, then the countdown flag is decremented. If it is now zero, the keyboard flag is set to zero. The main sample routine is entered. If the lower three bits are not zero, then if the start-stop active flag is not set, the sample routine is skipped. If either the flow or distance counts (instantaneous) is less than 2 the sample routine is skipped, otherwise the main sample routine is executed, as follows.

The instantaneous count for flow is divided by the difference between the start and stop numbers, the result being instantaneous flow. This is repeated for distance. The instantaneous counts are cleared. The input signals are thus measured for both frequency and period giving good resolution even at low frequencies.

**START-STOP**

There are three flags controlling start-stop operation, start-stop request/started, start-stop active and start-stop direction. The latter is set if the start number is greater than the stop number. The request flag is set when 'Enter', 'Stop' is entered from the keyboard and the active flag when 'Run' is pressed and the request flag is set.

If the active flag is clear, the start-stop routine is ignored.

If the request/started flag is set then the start store is used for the following comparison, otherwise the stop store.

The result is subtracted from the start or stop store and the sign of the result exclusive ORed with the start-stop direction flag. If the result of this is a '1' no further action is taken, otherwise:

If the request/started flag is set, it is cleared and the main totals reset to zero. The timebase and instantaneous counts are also reset.

If the request/started flag was clear, the hold flag is set and all start-stop flags are cleared.
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☐ RADIO AMATEUR LICENCE
☐ MICROPROCESSORS
☐ LOGIC COURSE
☐ OTHER SUBJECTS

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

CBS of New York has filed a string of European patent applications (under number 0 031 692) on an electronic circuit for simulating the sound of a Leslie loudspeaker, as often used to reproduce the sound of an electronic organ.

Figure 1 shows a loudspeaker of the Leslie type. The drive unit 10 rotates about a vertical axis while reproducing the sound. In the speaker position shown in Figure 1, no direct sound reaches the listener L; only sound reflected from the walls of the cabinet. As the speaker rotates towards position 2, the reproduced sound rises in pitch due to Doppler effect. At the same time direct sound starts to reach the listener so there is an increase in amplitude along with increase in perceived frequency.

This continues up to a maximum at position 3. Further rotation away from position 3 towards position 4 produces a perceived decrease in frequency and amplitude. The term “pulsato” conveniently describes the combination of tremulo and vibrato which is heard. Conventionally there is a switched choice between slow pulsato, at 0.7Hz, and fast pulsato, at 7Hz.

Figure 2 shows the CBS electronic equivalent to this well known mechanical arrangement. A musical tone at input 20 is fed to variable delay device 22, which can be a bucket brigade delay line. The delay is driven by clock 24 which is under the control of a sine wave generator. This is adjustable between 1Hz and 7Hz for slow and fast operation. The control waveform is shown at Figure 3A.

The output of delay 22 is filtered at 28, to remove any clock pulses impressed on the signal, and the filtered output is shown at Figure 3B. As the delay 22 is modulated by the clock signal it causes the phase of the musical tone to advance and retard, making it sharp or flat with respect to the input. This mimics the Doppler effect created by a rotary speaker.

The frequency modulated signal (B) at the output of filter 28 is applied to the input of amplitude modulator 40. This is also controlled by sine wave oscillator 26. Modulator 40 provides 80% amplitude modulation of the frequency modulated signal B to produce a composite signal. As shown at Figure 3C the amplitude of this composite signal is maximum at the transitions from sharp to flat pitch and minimum at the transitions from flat to sharp pitch. The modulator 40 inverts the phase of the signal, and high frequency components are removed by filter 42. The filtered, amplitude-modulated signal (C) is summed at 46 with the constant amplitude, frequency-modulated signal B. Capacitor 54 transmits only the high frequencies of signal B for summing at 46 with the phase inverted signal C. So only high frequencies are amplitude modulated in summing circuit 46 by the AM, FM signals from modulator 40. This produces a composite envelope as shown in Figure 3D. Amplitude modulation of the higher frequencies is in opposite phase relative to that of the lower frequencies, and the percentage of modulation varies with frequency. This complex, amplitude-modulated, AM signal is reproduced by stationary speaker 50 and the less complex, FM signal is reproduced by stationary speaker 34. The overall effect, with acoustic summing of the two sound signals, is said to resemble that produced by a rotary Leslie system.

BUY BRITISH!

The Director of Leeds Library reminds us that British, American, European and PCT patents can be inspected free of charge at public libraries in Birmingham, Glasgow, Leeds, Manchester and Newcas-
tle, as well as in the libraries attached to the London Patent Office. This reminder follows our warning that it can be very expensive to purchase a copy of a lengthy foreign application: up to £20 each in the case of the two very bulky PCT patents applications on Robert Carver's power amplifier and sonic holography circuits. There is also another way of avoiding the high cost of purchasing foreign applications.

When the British equivalent application to a foreign patent is published it is of course possible to obtain a full copy of the British version for the standard price of just £1.45. The trick is to wait for the British version of lengthy foreigners. Take for instance the example of PCT 80/02219, the Robert Carver patent on sonic holography. The equivalent British patent application has now been published as no. 2 058 524. Although the British document is only a single printed page synopsis which cross references with the lengthy PCT case, the British Patent Office is obliged to provide a full photocopy of the PCT case for the all-in price of £1.45, instead of the £20 or so it would cost to obtain the same patent by ordering it under the PCT number!
THE MOTOR control boards which fit on the wheel base of the M101, control the two 1/10 h.p. 12 V motors which provide its motive power. The controls implemented by these boards are forward, reverse, stop and variable speed.

DISPLAY BOARD
This gives a visual indication of the microprocessor’s control mode and an audible indication of incoming data.

POSITION DETECTOR BOARD
This is the only electronics inside the bases of the Genesis S101, P101 robots. It is used to suppress mains hum and generally improve the signal from the position detector coils sending it at low impedance to the interface board.

MANUAL CONTROL KEYBOARD
All the position control and programming switches fit to this unit. Information from it is either by infra-red link for the M101 or by wire link for the S101 and P101.

RECEIVER
This detects the infra-red transmissions sent to the M101 mobile machine.

Fig. 3.1. Display board circuit diagram

Fig. 3.2. Motor driver board circuit diagram
DISPLAY BOARD
Refer to Fig. 3.1. The seven segment display which indicates the memory page number (0 to 7) is driven by decoder IC1. An open collector TTL buffer drives I.e.d.s indicating such functions as RECORD, PLAY, MEMORY (1/2 full) and motor control. The bleeper announces the arrival of data.

MOTOR CONTROL
Refer to Fig 3.2. The wheel base is driven by two independently operated 1/10 h.p. motors equipped with special shafts in direct contact with the rubber wheels. The gearing is by virtue of the difference in diameter of the shaft and the wheel. Steering is accomplished by operating the motors at different rates. The castors are not driven and are for stabilisation of the wheel base only.

There is one control board per motor, which is a 12V d.c. 90 watt device. When the motor is turned on, the initial current is 15 amps, falling to 7-5 amps after 0.3 seconds. This hefty current is handled by power transistors TR3 and TR4. On/off control is a TTL signal (A). Motor reversal is produced with a changeover relay, again under TTL control (B). The motor speed is controlled using mark/space modulation with a period of about 40ms. The control box has two motor controls. One is forward-stop-reverse, and the other is steering. Both controls are specified with a three bit code. The software decodes these two parameters and generates the appropriate B signals and mark/space modulated A signals. When no control data is received by the interface board a stop signal is generated which turns off both motors. This prevents the mobile unit travelling beyond its reception range.

BOARD 10 WAY SIGNAL WIRE COLOUR
PIN No. MOLEX NAME NUMBER
1 M5-9 DA3 7/0.2 WHITE
2 M5-3 DA0 7/0.2 ORANGE
3 M5-10 GND 7/0.2 BLACK
4 M5-7 DA2 7/0.2 MAUVE
5 M5-5 DA1 7/0.2 GREEN
6 M5-6 DA5 7/0.2 BLUE
7 M5-1 +5V 7/0.2 BROWN
8 M5-8 DA4 7/0.2 GREY
9 M5-2 DA7 7/0.2 RED
10 M5-4 DA6 7/0.2 YELLOW

* CABLE LENGTH 12", USE 6mm SLEEVING
HEATSINK
TR1,3,4,5 ARE ALL MOUNTED ON INSULATING KITS

Fig. 3.5. Motor Control board p.c.b. (actual size)

Fig. 3.6. Motor Control board component layout

Fig. 3.7. Two views of the motorised wheel base of the M101
COMPONENTS...

MOTOR CONTROL (2 off on mobile unit only)

Resistors
- R1, R7 1k (2 off)
- R2, R8, R12 2k7 (3 off)
- R3 47k
- R4, R5 100m 2W (2 off)
- R6 100
- R9 560
- R10, R11 10102 (2 off)

Transistors and Diodes
- D1, D2, D4, D5 1 N4002 (4 off)
- D3, D6 -81N4148 (4 off)
- TR1, TR5 TIP29 (2 off)
- TR2 BC182L
- TR3, TR4 TIP3055 (2 off)
- TR6, TR7 BC212L (2 off)

Miscellaneous
- Printed circuit board RMBa
- p.c.b. mounting fuse holder
- 8A fuse
- 4-way screw terminal
- Relay 2p-2w, 10A contacts
- 5-way Molex p.c. terminals
- heatsink bar (special product)
- 6BA pan head j/n. plus nut (4 off)
- Insulating kit for TIP 3055 (2 off)
- Insulating kit for TIP29 (2 off)

DISPLAY BOARD

Resistors
- R1-10 220 (10 off)
- R11 47

Capacitors
- C1 220μ/10V

Diodes and Displays
- D1, D3 Red l.e.d. 0.2in. (2 off)
- D2 Green l.e.d. 0.2in.
- X1 Common anode 7-segment

Integrated Circuits
- IC1 74LS47
- IC2 7407

Miscellaneous
- Printed circuit board
- WD 1 audible warning device P82130
- 10-way lead (10 x 7/0.2)
- 10-way Molex shell 6471-10
- Crimp terminals 4809TL
- 7/0.2 wires
- 6mm p.v.c. sleeving

Fig. 3.8. Signal and axis directory

<table>
<thead>
<tr>
<th>AXIS No.</th>
<th>DRIVE COIL</th>
<th>DETECTOR COIL</th>
<th>MUX PIN (E25)</th>
<th>MOBILE - AXIS</th>
<th>MOBILE + AXIS</th>
<th>STATIC - AXIS</th>
<th>STATIC + AXIS</th>
<th>STATIC - AXIS</th>
<th>STATIC + AXIS</th>
<th>SOLENOID + DRIVE</th>
<th>SOLENOID - DRIVE</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>DCO</td>
<td>M8-8</td>
<td>13</td>
<td>M101</td>
<td>M101</td>
<td>S101</td>
<td>P101</td>
<td>S101</td>
<td>P101</td>
<td>S0+ M3-8</td>
<td>S0- M3-9</td>
</tr>
<tr>
<td>1</td>
<td>DC1</td>
<td>M8-5</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>S1+ M3-10</td>
<td>S1- M2-7</td>
</tr>
<tr>
<td>2</td>
<td>DC2</td>
<td>M8-4</td>
<td>15</td>
<td></td>
<td></td>
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<td></td>
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<td>S2+ M2-8</td>
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<td>3</td>
<td>DC3</td>
<td>M8-10</td>
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<td></td>
<td></td>
<td>S3+ M2-1</td>
<td>S3- M2-9</td>
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<td>4</td>
<td>DC4</td>
<td>M8-1</td>
<td>1</td>
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<td></td>
<td></td>
<td>S4+ M2-3</td>
<td>S4- M2-2</td>
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<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>S5+ M2-5</td>
<td>S5- M2-4</td>
</tr>
</tbody>
</table>

* Indicates position feedback
POSITION DETECTOR BOARD

The first stage of the position detector electronics provides a signal gain of 20dB (times 10). The second stage is a 100Hz high pass filter that suppresses any picked-up mains hum (50Hz) by 12dB (a factor of 4) relative to the 100Hz feedback signal. The output signal is typically a sine wave that varies in amplitude from 160mV p.p. to 1.6V p.p. as the hydraulic actuators move over their full range. This signal is then fed to the interface board where it is turned into a d.c. voltage. See Figs. 3.9, 3.10 and 3.12.

MANUAL CONTROL KEYBOARD

This hand-held controller provides up to 27 push-button commands plus two analogue channels for use with the mobile M101 to which data is transmitted by infra-red whilst the S101 and P101 use a 4-core cable link. See Figs. 3.13 and 3.14.

E10 is an oscillator set to run at 2KHz. E4 divides this frequency by two and generates complementary squarewave outputs. These are differentiated and then squared up by the Schmitt triggers E5 thus producing complementary marker and data pulses. The data pulses drive a binary counter E3, which then drives row and column multiplexers (E2 and E1). This causes the keyboard switches to be sequentially scanned. When a key is pressed data pertaining to that key will appear at E2 pin 3. The timing diagram shows that there are 64 data pulses per complete scan of the unit. The first 40 are reserved for push buttons (only 27 are used), next come two blocks of 8 that are used for analogue to digital conversion and the last block of 8 is a sync period. The ADC units operate by comparing a ramp waveform with the d.c. voltage that is to be digitized. When the ramp voltage exceeds the d.c. voltage the output of the comparator E8 goes high and appears at the output of E9 on the next marker clock pulse. As the d.c. voltage is varied the ADC will produce zero to 8 data pulses in its respective time slot. E6 and E7 combine the keyboard and ADC data with the marker pulses and the sync period. The M101 unit uses infra-red diodes to transmit the data. The diodes need current pulses of about 1 to 2 amps and so a Darlington transistor pair had been used (TR1, TR2).

Two component layouts are given (next month), one for the M101 unit and one for the S101 and P101 units neither of which have ADCs or an infra-red link.

HAVE A BISCUIT

Fig. 3.9. Position Detector board circuit diagram

Fig. 3.10. Component values for Position Detector board
Fig. 3.11. (top left) Position Detector board p.c.b. (actual size)

Fig. 3.12. (top right) Position Detector board component layout

The P101 with its PSU and controller
DIRECT SOLENOID CONTROLLER
It is possible to control the robots directly without any electronics by use of this board. Switches S1-S12 are used to turn on the Darlington drivers E1-E4 which supply the power to the solenoid operated valves.

INFRA-RED RECEIVER (next month)
The infra-red pulses are detected by two reverse biased diodes (D3, D4). The signal from these diodes is amplified by E1, and level shifted by the first part of E2. The second part of E2 is a voltage comparator which is used to recover the original pulses from somewhat noisy infra-red signal. The data is then sent to the decoding section on the interface board. TR4 and TR5 turn on the i.e.d. (D5) when data is being received.

MICROPROCESSOR SECTION: HOW THE CONTROLS WORK (next month)
On power up the bleeper sounds five times, the play and record i.e.d.s go off, and the sequence number indicates zero. The controller is now in reset mode. Only from this mode can the sequence number be changed or can the current sequence be cleared.
Reset mode can always be reached by pressing the RESET button.

CHANGING THE SEQUENCE NUMBER (RESET MODE ONLY)
Pressing the SEQ+ button will advance the indicated sequence number (up to 7). Pressing the SEQ- button will decrement the indicated sequence number (down to 0).
For correct functioning of a new unit (or one in which the CMOS memory had been powered down) it is necessary to clear each sequence memory before you attempt to record a sequence.

To clear a sequence, enter reset mode (if not already in this mode), and select the required sequence number. Hold down the CLEAR button; whilst holding this button down, momentarily press the EDIT button, then release the CLEAR button. The unit responds by bleeping and flashing the display.

COMPONENTS...

POSITION DETECTOR BOARD

<table>
<thead>
<tr>
<th>Resistors</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1, R7, R13, R19, R25</td>
<td>1k (5 off)</td>
</tr>
<tr>
<td>R2, R3, R8, R9, R14, R15, R20, R21, R26, R27</td>
<td>10k (10 off)</td>
</tr>
<tr>
<td>R5, R11, R17, R23, R29</td>
<td>13k (5 off)</td>
</tr>
<tr>
<td>R6, R12, R18, R24, R30</td>
<td>91k (5 off)</td>
</tr>
<tr>
<td>R31-35</td>
<td>15 (5 off)</td>
</tr>
</tbody>
</table>

For R4, R10, R16, R22 and R28 see Fig. 3.10
All resistors 1/2W 5%

<table>
<thead>
<tr>
<th>Capacitors</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1-C3, C5-C7, C9-C11, C13-C15, C17-19</td>
<td>47n (15 off) (Siemens B32560 type)</td>
</tr>
<tr>
<td>C4, C6, C12, C16, C20</td>
<td>10u elect. (7 off)</td>
</tr>
<tr>
<td>C21, C22</td>
<td>10u elect. (7 off)</td>
</tr>
</tbody>
</table>

For C23-27 see Fig. 3.10 (should be Siemens B32560)

Integrated circuits

IC1-3 | LM324 (3 off)

Miscellaneous

Printed circuit board RPD
14 pin sockets for i.c.s (3 off)

NEXT MONTH: Manual control and manual control board electronics
IN THIS month's Micro-Bus the emphasis is on graphics. Two novel hardware modifications for the Acorn Atom provide noise-free graphics, with virtually no loss in speed, and a previously inaccessible eight-colour graphics mode. Also featured are two graphics programs for the ZX81.

NOISE-FREE ATOM GRAPHICS

When the Atom's 6502 processor accesses the video memory, screen interference is produced in the form of white specks. The following simple hardware modification completely removes this problem, producing interference-free video-RAM access. It was discovered by Chris Dunning of Bristol who writes:

"The 6502 processor used in the Acorn Atom only accesses memory when its clock is high, so if the video output circuit is arranged so that it only accesses memory when its clock is low the micro and the video controller will never clash for memory access and no interference will be produced on the screen.

"To achieve this on the Atom carry out the following modifications, shown in Fig. 1:
1) Solder a wire link across C10.
2) Remove that 4MHz crystal.
3) Connect a wire from pin 8 to IC9, the inverted 3.58MHz clock used by the 6847 CRT controller.
4) Connect the other end of this wire to the hole left by removing the crystal, which is connected to pin 3 of IC45.

The effect of these modifications can be shown most strikingly by the following test. Before making them, assemble and execute the following machine code in the screen memory by typing:

P = #8000
IJMP P
LINK P-3

The text will become completely masked by screen noise produced by accessing the graphics memory. Repeating the test after having made the modifications gives a perfectly clear screen, with no noise.

"Since the micro's 80 clock is now 0.895MHz instead of the previous 1MHz the cassette interface is no longer CUTS standard; this is presumably why the Atom uses independent crystals for the display and the processor. You could of course re-record all your programs at the new frequency, or the modification can be made switchable. The best way to do this is probably to cut the track to pin 13 of IC44 and connect this via a changeover switch to pin 2 of IC45 (with C10 and the crystal still in place) and pin 8 of IC9; see Fig. 2. The switch can now be used to change the clock to 1MHz for reading tapes or 0.895MHz for clean graphics. Note, however, that you should always hold down the break key when operating the switch or the contents of memory may become corrupted."

NEW ATOM GRAPHICS MODE

The second of this month's hardware modifications to the Acorn Atom computer shows how to plot in an eight-colour graphics mode. This mode is provided by the 6847 Video Display Generator chip, and is called the "Semigraphics Four" mode; it is not directly accessible on the Atom, but can be obtained with two simple circuit modifications.

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Fig. 1. Modifications to the Acorn Atom give noise-free graphics

Fig. 2. Modification to the Atom switches between noise-free graphics and full-speed operation

Fig. 3. Eight-colour graphics mode: (a) character-cell pixel arrangement; and (b) corresponding memory byte

The text will become completely masked by screen noise produced by accessing the graphics memory. Repeating the test after having made the modifications gives a perfectly clear screen, with no noise.

"Since the micro's 80 clock is now 0.895MHz instead of the previous 1MHz the cassette interface is no longer CUTS standard; this is presumably why the Atom uses independent crystals for the display and the processor. You could of course re-record all your programs at the new frequency, or the modification can be made switchable. The best way to do this is probably to cut the track to pin 13 of IC44 and connect this via a changeover switch to pin 2 of IC45 (with C10 and the crystal still in place) and pin 8 of IC9; see Fig. 2. The switch can now be used to change the clock to 1MHz for reading tapes or 0.895MHz for clean graphics. Note, however, that you should always hold down the break key when operating the switch or the contents of memory may become corrupted."
To clear to mode 0a the statements:
CLEAR 0; ? #B002 = 8

The two points between which the line is
to be drawn are supplied to the program as
variables X1, Y1 and X2, Y2, where X1 >= 0,
X2 <= 63, Y1 >= 0 and Y2 <= 43. The num-
ber of plotting points between the end-points
is first calculated as L (line 9000). To plot the
points two separate linear equations are used.

HARDWARE MODIFICATION

To access the eight-colour graphics mode
the following modifications should be made to
the Atom circuit board:
1) Remove the 6847 IC31, from its
socket.
2) If the i.c. socket gives access to the prin-
ted circuit board beneath it, locate the track
which links pins 31 and 34 to pin 2 (on the
component side of the board). Make two cuts
in this track, as close as possible to pins 31
and 34, to isolate these pins from the circuit.
Replace IC31.
3) Alternatively, bend pins 31 and 34 of
the 6847 outwards, and replace the i.c. into
its socket with these pins sticking out sideways.
4) Connect a wire from pin 31 if the i.c.
(INT/EXT) to pin 1 (earth).
5) Connect a wire from pin 34 of the i.c.
(A/S) to pin 39 (CSS)

The normal switch-on mode will be text, as
required, a switch could be inser-
ted to give a choice of either mode.

PLOTTING POINTS

A BASIC routine 'p' to plot points in mode
0a is shown in Fig. 4, lines 100 to 110. The
coordinates are passed to the routine in
variables X and Y, where X = 0, Y = 0
corresponds to the bottom-left-hand corner
of the screen, and X = 63, Y = 31 is the top
right-hand corner of the screen. The value of
C determines the colour in which the point is
plotted, and this can have the values 0 to 7 as
shown in Fig. 3(b). Note that plotting a point
is performed by lines 30 to 60, draws a
series of concentric coloured circles. The
equation in line 50 gives a number whose
value depends on the distance from the centre
of the screen; this value is then used to select
the colour for plotting. The resulting display,
shown in Fig. 5, is very colourful, although the
black-and-white photograph does not really
do justice to it.

Fig. 4. Atom program plots circles in
the eight-colour graphics mode

To the right of Fig. 4 the BASIC program has
been supplied to plot circles in eight colours
on a graphics terminal, and shows how to
select the eight-colour graphics mode.

Fig. 5. Display produced by the
program of Fig. 4

To clear to mode 0a the statements:
CLEAR 0; ? #B002 = 8

can be used. Note that pressing escape will not
reset the graphics mode to the text mode; to
do this it is necessary either to type:
? #B002 = 0 or to press BREAK followed by typing OLD

The BASIC plotting routine could be con-
verted into machine-code and patched into the
Atom's graphics to give fast line drawing in
the new mode.

COLOURED CIRCLES

As an example of the use of this routine the
program in Fig. 4, lines 40 to 60, draws a
series of concentric coloured circles. The
equation in line 50 gives a number whose
value depends on the distance from the centre
of the screen; this value is then used to select
the colour for plotting. The resulting display,
shown in Fig. 5, is very colourful, although the
black-and-white photograph does not really
do justice to it.

LINES ON ZX81

Drawing a straight line between any two
points is one of the fundamental graphics
operations. The subroutine of Fig. 6 devised
by S. J. Duggins of Birmingham performs
this operation in just seven statements, im-
proving over the routine given in the ZX81
manual (on page 121) which takes 26 state-
ments.

Fig. 6. ZX81 routine plots a line be-
 tween X1, Y1 and X2, Y2

The program shown in Fig. 7 was submit-
ted by G. Wheaton of Bolton, and turns the
1K ZX81 into an etch-a-sketch machine so
that designs can be drawn using the cursor-
movement keys 5, 6, 7 and 8. Mistakes can be
rectified by pressing the 0 (rubout) key, and
plotting resumed by pressing the 1 key.
Diagonal lines are possible by careful use of
the 0 and 1 keys between plotting.

Fig. 7. Etch-a-sketch program for
the ZX81 uses the cursor controls to
draw pictures

The program should be fairly self-
explanatory. Plotting is performed by lines 30
to 80, and unplotting by lines 90 to 150. When
unplotting the cursor flashes (lines 90 and 95)
to indicate its position.

HORSE-RACE ADDENDA

"The Horse-Race program for the Mk14
VDU in August's Micro-Bus is excellent, once
it works!" writes W. R. Osborn of Tyne and
Wear, who has pointed out some misprints.
Three jump offsets are incorrect, and should be
altered as follows:
AD2 should read E1 not D1
AD8 should read OD not OC
AIDE should read 07 not 0C

Also, the XPPC 3 at the end of the program
does not return to the monitor, since
P3 is altered in the program. The code shown
in Fig. 8, added to the end of the program,
overcomes this problem and also displays the
number of the winning horse; hitting any key
(except ABD) then runs the game again.
To run the modified game GO to OB4B.

Fig. 8. Addition to the Mk14 Horse-
Race game displays the number of the
winning horse

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Fig. 8. Addition to the Mk14 Horse-
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All cells are brand new full spec devices from reputable manufacturers. All Nickel Cadmium cells (except PP3) are supplied complete with solder tags and are "VENTED" devices suitable for first charge.

Chargers: Single or dual O/P to charge PP3 for 12-14 hrs (charge, 4 hrs off) to charge ‘C’ & ‘D’ cells but with longer charging times. Units supplied complete in plug top case with flying leads. Number of cells to match in series and parallel to charge is specified for each required O/P when ordering.

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ATOM CONNECTORS

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SOMA ............................................................. 10

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**COMPUTER COMPONENTS**

**CPUs**

- 750p
- 8085
- 8086
- 8088

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- 512K
- 1M

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**TIP33A**

**TIP120**

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**BU406**

**BU205**

**BRY39**

**RO-3-2513LC 7000p**

**TIP36C**

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**TIP120**

**TIP122**

**BU406**

**BU205**

**BRY39**

**RO-3-2513LC 7000p**

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P.O. Box 3, Rayleigh, Essex.
Tel: Southend (0702) 552911/554155

Note: Order codes shown in brackets. All prices include VAT & shipment by datapost.
(Errors excluded).
What CB?

Guide to Legal Rigs

This guide covers all the currently available legal rigs we could find. Please note that the prices quoted are only intended as a guide and will vary depending upon the supplier.

The DNT range of rigs which are marketed by Radiotechnic Ltd., Bel Royal, St Lawrence, Jersey C.I. include the B40 FM (top left), the F40 FM (top right), the HF13/40 (bottom left) and the HF12/3 (bottom right).

The Radiomobile 201 and 202. Radiomobile Ltd., Goodwood Works, North Circular Road, London NW2 7JS.

The Cybernet Beta 1000, 2000, 3000. Goodmans Loudspeakers Ltd., Downley Road, Havant, Hants.

The M2 mobile and the Diplomat 40 base station. John Woolfe Racing, Electronics Division, Woolfe House, Norse Road, Bedford.
What CB?

Guide to Legal Rigs

The CB900 and CB901. Amstrad Consumer Electronics Ltd., 1-7 Garman Road, Tottenham, London

The JCB 863 from York which is marketed by Sulkin (UK) Ltd., 73 Grosvenor Street, London W1X 9DD

The Reftec 934 is a 20 channel for 934 MHz. RF Technology Ltd., Leyton Avenue Industrial Estate, Mildenhall, Suffolk

The Realistic TRC-2000

The Realistic TRC-1001

The Midland 2001 (top), the 3001 (left), and the 4001. Midland Telecom, 133 Flixley Road, Stechford, Birmingham B33 9HQ

The Realistic TRC-2001. The Realistic range of rigs is available from all Tandy stores
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What CB?
Guide to Legal Rigs

The Grandstand base station. Beeware Ltd., Ripon Way, Harrogate, North Yorkshire

The Harrier CBX from Dixons, Dept. DS33, Camera House, Cartwright Road, Stevenage

The Binatone Phone Breaker (top) and the 5-star. Binatone House, Beresford Avenue, Wembley, Middlesex

The Voxson Tenvox. Voxson Audio Ltd., Nuffield Way, Abingdon, Oxfordshire

The CB1000. Fidelity Radio, Victoria Road, London

The Grandstand Buzzing Bee

The Transcom GBX 2000 (top) and the GBX 4000. Transcom International, 1-12 Market Street, Bracknell, Berks

Practical Electronics January 1982