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<thead>
<tr>
<th>Option</th>
<th>Price</th>
<th>Ready built Price</th>
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<tr>
<td>RS232C interface kit</td>
<td>£20.00</td>
<td>£410.00</td>
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<tr>
<td>Floppy disc interface</td>
<td>£65.50</td>
<td>CORTEX B – Basic machine</td>
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<tr>
<td>Pair of 5½” disc drives</td>
<td>£300.00</td>
<td>+ RS232C</td>
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<tr>
<td>Hardware kit &amp; connectors</td>
<td>£49.50</td>
<td>CORTEX C – as above + disc drives £895.00</td>
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<tr>
<td>TDX300</td>
<td>Dimmer Light</td>
<td>£14.30</td>
</tr>
<tr>
<td>TDX500</td>
<td>Daylight Motion</td>
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</tr>
<tr>
<td>TDX1000</td>
<td>Extension to 2 way</td>
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B007 COMPLIMENTARY PNP POWER TRANSISTORS TO N007. Equiv M0025-1,
TO-220 Special Price £1.50 mixed
10 off £0.80
Use your credit card. Ring us on Ware 3182 NOW and get your order even faster. Goods normally
sent 2nd Class Mail. Remember you must add VAT at 15% to all orders.
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Send your order to: DEPT BI-PACK PB BOX 6, WARE, HERTS.
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TICKETS WITH CASH, SAME DAY POST. ACCESS
BARCLAYS CARD ALSO ACCEPTED. TEL. FAX 0923 70637, GDB 1000 01.
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ICS have helped thousands of ambitious people to move up into higher paid, more secure jobs in the field of electronics, T.V., electrical engineering—now it can be your turn. Whether you are a newcomer to the field or already working in these industries, ICS can provide you with the special training so essential to success.

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FREE CAREER BOOKLET

Train for success in Electronics Engineering, T.V. Servicing, Electrical Engineering—or running your own business!

In the cut-throat world of consumer electronics, one of the biggest questions designers apparently ponder over is: "Will anyone notice if we save money by cheapening this out?" In the domestic TV set, one of the first casualties seems to be the sound quality. Small speakers and no tone controls are common and all this is quite sad, as the TV companies do their best to transmit the highest quality sound. Given this background a compact and independent TV tuner that can provide you with the sound quality you and others will appreciate is the TV Sound Tuner.

This TV Sound Tuner offers full UHF coverage with pre-selected tuning controls. It can also be used in combination with your video recorder. Dimensions: 11/8" x 6" x 4", E.T.I. kit version of above without case, case and hardware: £12.95 plus £1.50 p&p.

PRACTICAL ELECTRONICS

STEREO CASSETTE RECORDER KIT COMPLETE WITH CASE

ONLY £31.00 plus £2.75 p&p.

- NOISE REDUCTION SYSTEM
- AUTO STOP
- TAPE COUNTER
- SWITCHABLE E.Q.
- INDEPENDENT LEVEL CONTROLS
- TWIN V.U. METERS
- POWER & FLUTTER 0.1%
- RECORD/PLAYBACK I.C.
- ELECTRONIC SWITCHING
- FULLY VARIABLE RECORDING BIAS FOR ACCURATE MATCHING OF ALL TYPES

Kit includes tape transport mechanism, fully printed and cut quality circuit board and all electronic parts (i.e. semiconductors, resistors, capacitors, hardware, top cover, printed state and mains transformer). You only supply supply & hook-up wire. Features in April P.E., reprint 5th. Free with kit.

STEREO TUNER KIT

This easy to build stereo AM/FM tuner kit is designed in conjunction with P.E. (July '81). For ease of construction and alignment, it incorporates three Millau 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 sail. 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 panel size 10¼" x 2¼", approx. Complete with diagram and instructions.

SPECIAL OFFER! £13.95 + £2.50 p&p.

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SPEAKER BARGAINS

2 WAY 10 WATT SPEAKER KIT

Built and tested

£42.95 + £2.00 p&p.

For ease of construction and alignment, it incorporates three Millau 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 sail. 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 panel size 10¼" x 2¼", approx. Complete with diagram and instructions.

SPECIAL OFFER! £13.95 + £2.50 p&p.

125W HIGH POWER AMP MODULES

The power amp kit is a module for high power applications - discos, ettäters, public address systems and even high power 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 sized components, result, a high powered rugged unit.

ACCESSORIES: Stereo/mono mains power supply kit with transformer, £19.50 plus £2.00 p&p.

AUDAX 8" SPEAKER

HIGH QUALITY 40 WATTS RMS BASS/MIDRANGE ideal for either Hi-Fi or disco use this speaker features an aluminium voice coil a heavy 70mm diameter magnet. Frequency res. 20Hz to 7KHz, Impedence 8 ohms.

AUDAX 40W Ferro-Fluid Hi-Fi Tweeter X-over on 5kHz, 22kHz 60mm square, 8 ohms.

All mail up

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Note: Goods described to P.E. price applies only. All items subject to availability. Prices correct at 31/5/83. ICS reserve the right to change without notice. Please allow 14 working days from receipt of order for delivery. ICS Limited reserve the right to inspect your products without notice. All returns send S.A.E. Telephone or mail orders by ACCESS welcome.

ICS

Practical Electronics December 1983
The document contains a variety of information about electronics and security systems. Here is a structured summary:

### SX 1000 Electronic Ignition
- Inductive discharge
- Extended dwell circuit stores greater energy in coil
- Three position changeover switch
- Contactless or contact breaker triggered
- Clip-to-coil or remote mounting
- Rugged die-cast case
- Contactless adaptors included for majority of 4 & 6-cylinder vehicles

### SX 2000 Electronic Ignition
- Reactive discharge
- Combines inductive & capacitive energy storage
- Gives highest possible spark energy
- Patented clip-to-coil fitting
- Easy assembly sequence
- Contact breaker triggered
- Includes bounce suppression circuit

### TX 1002 Electronic Ignition
- Inductive discharge
- Extended dwell circuit stores greater energy in coil
- Three position changeover switch
- Contactless or contact breaker triggered
- Clip-to-coil or remote mounting
- Rugged die-cast case
- Contactless adaptors included for majority of 4 & 6-cylinder vehicles

### TX 2002 Electronic Ignition
- Two separate systems in one unit
- Reactive discharge OR inductive discharge, with three position changeover switch
- Gives highest possible spark energy
- Clip-to-coil or remote mounting
- Rugged die-cast case
- Contactless or contact breaker triggered
- Contactless adaptors included for majority of 4 & 6-cylinder vehicles

### AT-40 Electronic Car Alarm
- Guards doors, boot, bonnet from unauthorized entry
- Armed/disarmed from inside vehicle
- Can be wired to exterior key switch
- 30 second delay-to-arm: 7 second entry delay
- Can be alternately be wired to external key switch
- Flashes headlights & sounds horn intermittently for 60 seconds when activated
- Security loop protects accessories
- Low consumption CMOS circuitry

### AT-80 Electronic Car Security System
- Guards doors, boot, bonnet from unauthorized entry
- Armed/disarmed from outside vehicle by magnetic key fob passed across sensor pad adhered to inside of windscreen
- Individually programmable code
- 30 second delay-to-arm
- Flashing headlights and sounds horn intermittently for 60 seconds when activated
- Security loop protects accessories
- Function lights to assist setting-up
- Low consumption CMOS circuitry

### VOYAGER Car Drive Computer
- 12 functions centred on Fuel, Speed, Distance and Time
- Single chip microprocessor
- Large high brightness fluorescent display with auto-dimming feature
- High accuracy distance & fuel transducers included
- Displays MPG, L/100km and litres at the flick of a switch
- Visual & audible warnings of excessive speed, ice, lights-on
- Independent LOG & TRIP functions
- Low consumption crystal controlled circuitry

### MAGIDICE Electronic Dice
- Triggered by waving hand over dice
- Completely random selection
- Bleeps & flashes during 4 sec tumt, Throw displayed for 10 seconds then flashes to conserve battery
- Low consumption CMOS circuitry

### Prices Reduced
- SX 1000: £112.95 Reduced to £101.95
- SX 2000: £189.95
- TX 1002: £127.95 Reduced to £111.95
- TX 2002: £132.95 Reduced to £110.95
- AT-40: £99.95 Reduced to £92.95
- AT-80: £249.95 Reduced to £224.95
- ULTRASONIC: £179.95 Reduced to £162.95
- VOYAGER: £629.95 Reduced to £559.95
- MAGIDICE: £119.95 Reduced to £109.95

### Special Offers
- FREE MAGIDICE KIT with ALL ORDERS OVER £40.00

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**SPARRITE**

A Division of Stadium Ltd | 82 Bath Street, Walless, WS1 3DE, England

Tel: (0922) 614791
AMPLIFIERS

Over the last few years we have received feedback via the general public and industry that our products are from Taiwan, Singapore, Japan, etc... ILP are one of the few 'All British' electronics Companies manufacturing their own products in the United Kingdom. We have proved that we can compete in the world market during the past 12 years and currently export in excess of 60% of our production to twenty different countries - including USA, Australia and Hong Kong. At the same time we are able to invest in research and development for the future, assuring security for the personnel, directly and indirectly, employed within the UK. We feel very proud of all this and hope you can reap some of our success.

I.L. Potts - Chairman

WE'RE INSTRUMENTAL IN MAKING A LOT OF POWER

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

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

---

BIPOLAR MODULES

<table>
<thead>
<tr>
<th>Module Number</th>
<th>Output Power</th>
<th>Watts</th>
<th>Load Impedance</th>
<th>DISTORTION</th>
<th>Supply Voltage</th>
<th>Size</th>
<th>WT gms</th>
<th>Price inc. VAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>HY10</td>
<td>15</td>
<td>4.8</td>
<td>0.1%</td>
<td>&gt;0.006%</td>
<td>8.18</td>
<td>76 x 58 x 40</td>
<td>240</td>
<td>(£8.40)</td>
</tr>
<tr>
<td>HY100</td>
<td>30</td>
<td>4.8</td>
<td>0.1%</td>
<td>&gt;0.006%</td>
<td>8.25</td>
<td>120 x 78 x 40</td>
<td>420</td>
<td>(£8.89)</td>
</tr>
<tr>
<td>HY1000</td>
<td>10 - 30</td>
<td>4.8</td>
<td>0.1%</td>
<td>&gt;0.006%</td>
<td>8.25</td>
<td>120 x 78 x 40</td>
<td>410</td>
<td>(£20.75)</td>
</tr>
<tr>
<td>HY241</td>
<td>60</td>
<td>8</td>
<td>0.1%</td>
<td>&gt;0.006%</td>
<td>8.25</td>
<td>120 x 78 x 50</td>
<td>520</td>
<td>(£25.47)</td>
</tr>
<tr>
<td>HY2410</td>
<td>120</td>
<td>4</td>
<td>0.1%</td>
<td>&gt;0.006%</td>
<td>8.25</td>
<td>120 x 78 x 50</td>
<td>520</td>
<td>(£25.47)</td>
</tr>
<tr>
<td>HY361</td>
<td>120</td>
<td>8</td>
<td>0.1%</td>
<td>&gt;0.006%</td>
<td>8.45</td>
<td>120 x 78 x 100</td>
<td>1030</td>
<td>(£38.41)</td>
</tr>
<tr>
<td>HY90</td>
<td>180</td>
<td>8</td>
<td>0.1%</td>
<td>&gt;0.006%</td>
<td>8.45</td>
<td>120 x 78 x 100</td>
<td>1030</td>
<td>(£38.41)</td>
</tr>
</tbody>
</table>

Power Supply Units (for supporting our own transformers)

<table>
<thead>
<tr>
<th>Module Number</th>
<th>For Use With</th>
<th>Price inc. VAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSU 2XK</td>
<td>1 or 2 HY20</td>
<td>£11.93</td>
</tr>
<tr>
<td>PSU 4XK</td>
<td>1 or 2 HY60, 1 x HY200, 1 x HY241</td>
<td>£13.83</td>
</tr>
<tr>
<td>PSU 4XX</td>
<td>1 x HY18</td>
<td>£15.90</td>
</tr>
<tr>
<td>PSU 5XX</td>
<td>1 x MOS1278</td>
<td>£16.70</td>
</tr>
<tr>
<td>PSU 5XK</td>
<td>1 x HY241</td>
<td>£17.07</td>
</tr>
</tbody>
</table>

MOSFET MODULES

<table>
<thead>
<tr>
<th>Module Number</th>
<th>Output Power</th>
<th>Watts</th>
<th>Load Impedance</th>
<th>DISTORTION</th>
<th>Supply Voltage</th>
<th>Size</th>
<th>WT gms</th>
<th>Price inc. VAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOS 128</td>
<td>60</td>
<td>4.8</td>
<td>&lt;0.005%</td>
<td>&gt;0.006%</td>
<td>8.45</td>
<td>120 x 78 x 40</td>
<td>120</td>
<td>(£8.41)</td>
</tr>
<tr>
<td>MOS 214</td>
<td>120</td>
<td>4.8</td>
<td>&lt;0.005%</td>
<td>&gt;0.006%</td>
<td>8.45</td>
<td>120 x 78 x 40</td>
<td>120</td>
<td>(£8.41)</td>
</tr>
<tr>
<td>MOS 366</td>
<td>180</td>
<td>4</td>
<td>&lt;0.005%</td>
<td>&gt;0.006%</td>
<td>8.45</td>
<td>120 x 78 x 40</td>
<td>120</td>
<td>(£8.41)</td>
</tr>
</tbody>
</table>

Protection: Able to cope with complex loads without the need for very special protection circuits (those will suffice).


Input Impedance: 100K ± 50kHz. Damping factor: 100K ± 400kHz.

NEW to ILP! In Car Entertainments

C15

Mono Power Booster Amplifier to increase the output of your existing car radio or cassette player to a nominal 15 watts rms.

Very easy to use.

Robust construction.

Mounts anywhere in car.

Automatic switch on.

Output power maximum 22w peak into 4 Ohms.

Frequency response 1-3dB 15Hz to 20kHz. T.H.D. 0.1% at 10w 1KHz.


C15S

Stereo version of C15. Size 95 x 50 x 30. Weight: 410 gms.

£17.19 (inc. VAT)

---

For use with PSU 61 K.

<table>
<thead>
<tr>
<th>Module Number</th>
<th>For Use With</th>
<th>Price inc. VAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSU 5XK</td>
<td>2 x HY124</td>
<td>£17.07</td>
</tr>
<tr>
<td>PSU 5XK</td>
<td>2 x MOS1278</td>
<td>£17.85</td>
</tr>
<tr>
<td>PSU 5XX</td>
<td>1 x HY241</td>
<td>£19.52</td>
</tr>
<tr>
<td>PSU 5XK</td>
<td>2 x HY244</td>
<td>£21.75</td>
</tr>
</tbody>
</table>

For use with PSU 5XK.

<table>
<thead>
<tr>
<th>Module Number</th>
<th>For Use With</th>
<th>Price inc. VAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSU 5XK</td>
<td>2 x HY248</td>
<td>£17.07</td>
</tr>
<tr>
<td>PSU 5XK</td>
<td>1 x HY364</td>
<td>£17.85</td>
</tr>
<tr>
<td>PSU 5XK</td>
<td>1 x MOS1278</td>
<td>£19.52</td>
</tr>
<tr>
<td>PSU 5XK</td>
<td>2 x MOS248, 1 x MOS506</td>
<td>£21.75</td>
</tr>
</tbody>
</table>

For use with PSU 5XK.

<table>
<thead>
<tr>
<th>Module Number</th>
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<th>Price inc. VAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSU 5XK</td>
<td>2 x HY248</td>
<td>£17.07</td>
</tr>
<tr>
<td>PSU 5XK</td>
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<tr>
<td>PSU 5XK</td>
<td>1 x MOS1278</td>
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</tr>
<tr>
<td>PSU 5XK</td>
<td>1 x MOS1278</td>
<td>£19.52</td>
</tr>
<tr>
<td>PSU 5XK</td>
<td>2 x MOS248, 1 x MOS506</td>
<td>£21.75</td>
</tr>
</tbody>
</table>
The toroidal transformer is now accepted as the standard in industry, overtaking the obsolete laminated type. Industry has been quick to recognise the advantages toroidal offers in size, weight, lower radiated field and, thanks to I.L.P. to PRICE.

Our large standard range is complemented by our SPECIAL DESIGN section which can offer a prototype service within 7 DAYS together with a short lead time on quantity orders which can be programmed to your requirements with no price penalty.

<table>
<thead>
<tr>
<th>VA</th>
<th>15</th>
<th>25</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 x 24mm</td>
<td>0.395Kg</td>
<td>Regulation 18%</td>
<td></td>
</tr>
<tr>
<td>80 x 30mm</td>
<td>0.8Kg</td>
<td>Regulation 13%</td>
<td></td>
</tr>
<tr>
<td>120 VA</td>
<td>0.97</td>
<td>Regulation 11%</td>
<td></td>
</tr>
<tr>
<td>160 VA</td>
<td>1.2</td>
<td>0.8Kg</td>
<td></td>
</tr>
<tr>
<td>225 VA</td>
<td>2.2Kg</td>
<td>Regulation 7%</td>
<td></td>
</tr>
<tr>
<td>300 VA</td>
<td>2.6Kg</td>
<td>Regulation 8%</td>
<td></td>
</tr>
<tr>
<td>400 VA</td>
<td>4Kg</td>
<td>Regulation 4%</td>
<td></td>
</tr>
</tbody>
</table>

**Why a Toroid?**
- Smaller size & weight to meet modern 'simline' requirements.
- Low electrically induced noise demanded by compact equipment.
- High efficiency enabling conservative rating whilst maintaining size advantages.
- Lower operating temperature.
- Why I.L.P?  
  - Ex-stock delivery for small quantities.
  - Gold service available. 21 days manufacture for urgent deliveries.
  - 5 year no quibble guarantee.
  - Realistic delivery for volume orders.
  - No price penalty for call off orders.

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**BIMBOXES**

2000 Series, ABS. Guides for vertically mounting PCB's. Bimini mates for horizontal mounting. PC Board sizes

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Size</th>
<th>Price</th>
</tr>
</thead>
</table>
| BIM 002/12 | 100 x 25 x 6 | E25
| BIM 002/13 | 112 x 22 x 3.5 | E27
| BIM 002/14 | 120 x 25 x 6 | E30
| BIM 005/15 | 150 x 50 x 15 | E60
| BIM 008/15 | 150 x 50 x 18 | E75
| BIM 009/15 | 150 x 50 x 25 | E95
| BIM 100/15 | 150 x 50 x 35 | E150
| BIM 100/25 | 150 x 50 x 75 | E225
| BIM 100/30 | 150 x 50 x 150 | E300
| BIM 100/40 | 150 x 50 x 200 | E350
| BIM 100/50 | 150 x 50 x 350 | E475
| BIM 100/75 | 150 x 50 x 500 | E675
| BIM 100/100 | 150 x 50 x 1000 | E1200

**BIMCASES**


<table>
<thead>
<tr>
<th>Part No.</th>
<th>Size</th>
<th>Price</th>
</tr>
</thead>
</table>
| BIM 002/1 | 161 x 30 x 33 | E18
| BIM 006/1 | 215 x 47 x 120 | E28

**Prices including VAT **

- £19.75 + £2 per item.

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**BIMSALES**

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**ALL PRICES INCLUDE VAT**

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**SECONDARY MIRROR**

---

**PRIMARY MIRROR**

---

**NEOPRENE WASHERS**

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**ALARM ADE A**

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**I.BULL (Electrical) Ltd**

Established 1970

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**A PRESTEL UNIT — Complete except for 6 plug-in IC’s, so far we have suppliedkits which are currently in production.**

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**VIEWDATA EQUIPMENT**

**ORACLE VB 100 PCB**

This is the heart of many viewdata systems, including the Prestel Unit which we are currently selling. This board uses 25 IC's, 2 Transistors, several diodes and many more components. It has a 1 TV serial input and a TV UHF input. It is UL, TEMS21, UHTEC 1233, U2T23. It is completely enclosed, very small, and completely replaces 60 of the 29 IC's in C5 15. The plug-in headers for the missing IC's are on the wired board ready to receive them.

---

**MINIKY SERIES KL**

This is an American made microphone keyboard with eight contacts as used on Prestel to dial into the British Telecom phonic system. It is really miniature, only 60mm x 65mm x 5mm thick. It has 16 press buttons, giving standard 5-9 numbers and ABCD functions. There are two other buttons for up and down. This is an extremely well made board.

---

**TELEPHONE LINE TERMINATION UNIT**

As used with Prestel but undoubtedly useful for other applications. Important components are phantom supply transformer and 2 Clare Reed Relays. All mounted on a PCB with IC's. This component PCB size approximately 8 x 8.75 x 1.1 cm — £6.50

---

**3M FACSIMILE EQUIPMENT (send or receive documents) and facsimile equipment for sending letters and almost any data through the telephone system — "Mail by Phone". The machines we have are the 3M 6000-B with automatic complete with an automatic and connections.

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**RADIO INTERCOM SETS**

We supply all these sets of equipment, it is not said. In fact it was used only for about 11900 8911, believed to be in good order and certainly a very good condition — £600.00. We will accept £500.00 for the buyer to examine and take away on a "as seen" basis.

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**RADIO INTERCOM MOUNTS**

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**STANDARD BLEDGE STABLED POWER SUPPLY**

As used with Prestel this has a mains input transformer with a 12V — 0.3 — 0.3 volt mains transformer and mains transformer for the output approximately 4.2 volt. This excellent DC regulator is 27 x 12 x 84 with a weight of 2.1 kg. — £4.50

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**CASH, P.O. or cheque with order. Orders must be accompanied by credit card details.**

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**STEEL DISHED WASHER**

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**OUTER INSULATION**

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**SECONDARY MIRROR**

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**PRIMARY MIRRORS**

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**NEOPRENE WASHERS**

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**ALARM ADE A**

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**I.BULL (Electrical) Ltd**

Established 1970

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**CHECKBULGAR ALARM & DYSYSTEM**

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**MAIN DISTRIBUTOR**

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**A.D. ELECTRONICS DEPT. PE**

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**BIMDRAIN**

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**STEEL DISHED WASHER**

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**OUTER INSULATION**

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**SECONDARY MIRROR**

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**PRIMARY MIRRORS**

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**NEOPRENE WASHERS**

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Practical Electronics December 1983
POP SOFTWARE

The personal computer has now been with us for five years and in that time has moved from a strictly specialist hobby item to a mass interest consumer product. The problem is that the real reasons for the development of the microprocessor and ultimately the personal microcomputer, for problem solving, accounting, design and development, filing and similar tasks, have been overshadowed—in the eyes of most consumers—by the ability of the micro to play exotic klingon-zapping games.

The sales of software cassettes for games are rivalling pop records and record companies are being forced into interface other areas where mundane tasks are performed "by hand" while the staff are surrounded by high technology.

As regular readers will know, PE alas from: Practical Electronics Advertisements, King's Reach Tower, Stamford Street, London SE1 9LS. Cheques, postal orders and international money orders should be made payable to IPC Magazines Limited. Payment can also be made using any credit card and orders placed via Teledata. Tel. 01-200 0200.

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Back Numbers and Binders

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

Binders for PE are available from the appropriate State year and volume required.

months ago parents encouraged their children to learn electronics—the technology of the future—but they seem to feel computing is more important, let's not forget we need to know how the damn things work. For those that are interested our Introduction to Digital Electronics course is essential reading.

Incidentally we find it frustrating to buy some software in a microcomputer shop and have to wait while the assistant laboriously writes out a sales docket with full name and address and then separates the copies before taking the money. With all that high technology around surely just one micro could be switched from games to perform a sensible task of stock control and mailing list recording. Or is that just too much to expect?

We would be interested to hear of other areas where mundane tasks are still performed "by hand" while the staff are surrounded by high technology.

Practical Electronics December 1983
ELAN’S ENTERPRISE

The home-micro market is without doubt an expensive and difficult place in which to compete for business. By the spring Elan Computers will add their machine to the list, which by that time is likely to exceed 30 options under £250. Elan feel they will not be missing out on the Christmas sales bonanza by launching the Enterprise 64K in the spring. “It’s a product of the future” they say, and are confident that it will remain when its contemporaries bite the dust.

The Enterprise has 69 contoured full travel keys with an extra 8 being user-definable. On the right of the keyboard is an integral joystick that can be used for games or text manipulation. Two memory options are available, the 64K and the 128K, both are ultimately expandable to 4 Megabytes with add-on units.

The machine has a built-in word processor and can handle 56 lines of text at any one time, each with 84 columns. Two cassette recorder connections enable the user to read text or data from one tape machine while writing on the other, an indicator ensuring correct volume level setting when loading programs.

Another unique feature is stereo sound, via connection to a hi-fi or to headphones. The graphics and sound are both controlled from customised chips. The colour of each pixel is controllable and therefore high-resolution graphics are a reality rather than a claim. Four sound sources are available each with full volume control on stereo output. Tone generation is from 30Hz to 125kHz giving a musical range of a full 8 octaves. Multiple combinations of white noise generation, low/high pass filtering and ring modulation are possible.

The peripherals are modular and designed to stack together in an effort to make interconnecting spaghetti-junctions redundant. The machine is connected to the stack ‘base unit’ via a flexible ducting which contains all the necessary wiring. The base unit has an adaptor which supplies all the peripherals in the stack with their needs.

Separate 64K ROM cartridges can be plugged into the machine, with games and education dominating this aspect. Languages include FORTH and LISP with BASIC as the norm.

ULTRASONIC MOVEMENT DETECTOR

Riscomp Limited have just launched the US 5063 which is an ultrasonic movement detection module employing digital techniques for processing the received signal. Such an approach not only provides a superior performance when compared to the conventional analogue circuitry, but also allows a choice of three levels of discrimination against false alarms. An exit delay and fixed alarm time have been incorporated, together with a selectable entrance delay. The transmitter section of the module is crystal controlled which allows several units to be used without inter-action problems where large areas are to be covered. A ‘hold’ facility, together with a built-in l.e.d. indicator, is provided for setting-up purposes. Priced at £13.95, the module is supplied with a comprehensive data sheet.

Riscomp Ltd., 21 Duke Street, Princes Risborough, Bucks HP17 OAT (084 44 6326).

LOGIC PROBES

Two brand new logic probes from Trio are now available from House of Instruments, DP-71 for TTL and CMOS up to 50MHz and the DP-70 for TTL up to 30MHz.

Logic probes enable the quick determination of the operational state of logic circuits, providing the user with a powerful troubleshooting and development tool.

These new probes feature response to input frequencies up to 50MHz and pulse widths down to 20ns, achieved by an extremely short ground lead, inherent in the clever design. A light compact plastic case that can be held neatly in one hand, houses the probe and l.e.d.s, while switches have been grouped for easy viewing and use on one side only.

The operational status of logic circuits is clearly indicated by three l.e.d.s, one for logic high (1), one for logic low (0) and one to indicate the existence of a continuous pulse. By placing the probe to memory mode, single pulses down to 20ns in width, leading or trailing edges, can be detected with a reset switch to return to normal pulse mode.

Inputs are protected up to ±100V d.c. continuous and ±250V d.c. or 175V r.m.s. up to 15 seconds. DP-70 with a 50kohm input impedance, operates from internal batteries, while DP-71 has a 1Mohm impedance and may be powered from 4.5 to 18V d.c. source.

The DP-70 is priced at £24.00 plus p&p and VAT and the DP-71 is priced at £49.00 plus p&p and VAT.

Quiswood Ltd. 30 Lancaster Road, St. Albans, Herts AL1 4ET (0799 24922).

POINTS ARISING...

INGENUITY UNLIMITED

Pseudo Telephone Ringer Sept. 83

IC2 should be a 7490 decade counter—not a 555 timer as printed.
Thermionic Integrated Circuits

A valve renaissance? Thermionic valve versions of integrated circuits, for real No need to check, this is not the April issue, nor are integrated thermionic circuits (i.t.c.s) the work of Ireland’s Ballygobackwards. They are, according to a report in Electronic Times, the joint creation of Arizona University and Los Alamos Scientific Laboratory. Circuits are delineated using conventional i.c. photolithographic techniques. Everything one would expect is sputtered onto an insulating sapphire substrate—substrate grids, cathodes, anodes and heaters (the latter in the form of metalisation films).

But why? Because the i.t.c. will run at 600 deg. C compared with silicon’s ceiling of 150 deg. C. And i.t.c.s, with as many as 1000 switches per square inch, are radiation resistant. Los Alamos, which had to develop a high temperature ceramic package for the device, decided i.t.c.s which could be used commercially right now, although, as yet, there are no takers.

Cool Chips

An ingenious and cost-effective system for keeping i.c.s cool is being marketed by Welwyn Electric after experimental work in conjunction with British Telecom’s engineers at Martlesham. The chip carriers are mounted on a flexible p.c.b. which has holes punched through it. Each i.c. is sited over one of these holes, holes which accommodate steps, or pillars, in an alloy backplate type heatsink. The flexible p.c.b. ensures that each i.c. is tensioned against its metal pillar to give good thermal contact, and to evenly distribute mechanical stress. Thermally conductive grease is used to improve heat transfer from the chip carriers to the heat sink.

During production of an assembly, the fact that the flexible polyimide circuit has holes in it makes it easier to clean off flux. Once assembled, another plate is clipped to the top of the module to create a sandwich of only a few centimetres thick, which may be stacked one upon another.

DISC SYSTEM FOR MICRO-B

Advanced Memory Systems have produced the smallest possible disc system for the BBC Microcomputer using the new Hitachi 3" drives.

The drives are casued in rigid steel and cost £225 and £399 for the single and double versions. The system comes complete with cables, manuals, utilities on disc and EPROM as well as free discs.

The Hitachi drive has a brushless direct motor and when cased fits neatly on top of the BBC Micro. The casing has been textured and painted to match the computer.

Each side holds 100K of storage. The small light on the drive casing reminds you which side you are using.

At present the product is only available by mail order from Advanced Memory Services Ltd., Woodside Technology Centre, Green Lane, Appleton, Warrington. (0925 62682).

BATTERY DMM

The TM356 is a battery-operated 3½ digit multimeter with a large 0.5" liquid crystal display. It has a full measurement capability of d.c. and a.c. volts, d.c. and a.c. current, resistance and diode check in 29 ranges permitting measurement of voltages from 100µV to 1000V (750V a.c.), current from 100nA to 10A, and resistance from 100mΩ to 20MΩ.

Battery life from alkaline 'C' cells is typically in excess of 3000 hours and a low battery indicator shows when approximately 10% of life remains.

The instrument is housed in a tough ABS moulded case with carrying handle/stand making it suitable for portable applications as well as bench work.

The TM356 is priced at £85.00 plus VAT. Thandor Electronics Limited, London Road, St. Ives, Huntingdon, Cambs. PE17 4HJ (0480 64646).

Silicon News Corner

Bulletins announcing new semiconductor devices arrive at PE daily, so it is possible only to describe them briefly. Details of how to obtain further information are included, however.

Motorola

Darlington added to 25kVA line are complements to MJ10042/45/47. The MJ10041 handles 25A @ 850V. MJ10047 handles 100A @ 250V. MJ10044 handles 50A @ 450V.

Formerly available 350-600V (150W) n-channel TMOS power MOSFETs now available in TO-218AC package.

48 complimentary transistors added to bipolar line (TO-220 package) are direct replacements for GE devices, available as D44C, D45C, D44H & D45VH series.

MOSFET Energy Management series raises power by 25%. Typical device: 100A/60V @ 20mΩ on-resistance.

MC10H016 high speed binary counter joins MECL 10KH line. Has improved propagation delay over Fairchild F10016.

TL431 is a 3-terminal adjustable shunt regulator 2.5–36V with low temp. coeff. 1–100mA range, & dynamic impedance of 220mΩ.

MC3424 is a dual channel supervisory chip for power supply protection. Every function on board to sense overvoltage transients, regulator failures, input line loss etc.


Litonix/Siemens Intelligent alpha-numeric displays calls DL1814. 8 x 17 seg. 0–112° chars incorporating CMOS memory, decode & drive etc.

35 dot intelligent display is DLO 7135 series. In red, yellow or green, produces full ASCII range characters. On board memory, decode & drive simplifies row/address signalling from µP.

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10k V r.m.s. opto-isolator HIL10. Synchro Services, High St., Harrold, Bedford.

Practical Electronics December 1983
The most heartening event for industry and the general economic climate this year was the Trades Union Congress. It followed, of course, the general election which revealed that fewer than 40 per cent of union members supported the Labour Party while the majority voted either Conservative or Liberal/SDP Alliance.

Congress had few doubts on the survival of trade unions but many on the credibility of their traditional ally—the Labour Party, which they had themselves created and supported financially.

Thus, at the 115th Annual Congress, questions which would have been unthinkable only a few years ago were now being openly asked. Should Congress now consider distancing itself from Labour if not actually parting company completely? Would not the membership benefit more by co-operation with the Government in union reform rather than resisting? Is it not time for union leaders to recognise that they are servants of their members rather than their bosses? Was it not just conceivable that the union leadership had got it all wrong, in policies, in union management, in leadership itself?

Of course there were cries of betrayal, invocation of memories of the Tolpuddle Martyrs, the tradition of working class solidarity. But all this sounded hollow in 1983 when the majority of members are property-owning consumer-oriented men and women inclined to consider themselves middle rather than working class.

The truth is that the membership has changed while the leadership has been left behind. The cloth cap and choker, traditional badge of the union member, is in decline, the business suit and briefcase in the ascendancy. Service industry membership now exceeds that of the industrial shop floor.

Yes, Congress would re-consider general policy, would talk to the Conservatives, would participate in the 'little N Neddy' working parties. The old hard-liners still had their way through block votes on withdrawal from the Common Market, on anti-nuclear policy but not convincingly.

The new look unions which could emerge in the year ahead might include that the interests of trade union members are best served through generating new wealth by co-operation rather than by obstruction and old-fashioned confrontation. Much of the old rhetoric was still mouthing at Congress but one detects a positive shift to moderation.

**ACORNS INTO OAKS**

Those who complain of the power of the big corporations and multi-nationals often conveniently forget that they all started as virtually one-man bands and this includes even mighty IBM. And the opportunities of the small business to grow are as great today as ever they were. Anyone can join at any time in getting a start. Success, however, is dependent on entrepreneurial flair, the right product or service offered, hard work, sound financial management and a modicum of luck.

The Racal Group started off with two partners and £100 capital. In the last six years of general economic recession Racal's peripheral small companies, the odds and ends making accessories and components, are now recording over £120 million in sales, equal to the whole Group turnover as recently as 1977. So growth is possible even in recessionary periods.

The Racal founders worked at Plessey before deciding to break out on their own. History repeats itself with two Racal employees breaking out in 1978 to form their own company, Telemetrix. Roy Cole and John Westover offered their expertise first as consultants, later becoming manufacturers as well, mainly through a subsidiary company, Westward Micro Systems, building graphic terminals. Telemetrix, after five years, are turning over £5 million a year with profits of £1.5 million and have made their debut on the Stock Exchange.

So new are the new, micro-electronics millionaires and potential millionaires grow. Cole and Westover had good jobs in Racal. Now they have better jobs and a fortune in prospect. Any hard feelings? Not at all. Racal is a valued customer of Telemetrix, as are GEC, Plessey and Ferranti.

Another newcomer to the Stock Exchange is Oxford Instruments. When I first came across this company it was a tiny outfit working closely with the Clarendon Laboratory, Oxford University, on their programme of cryomagnetic research which involved the use of powerful magnets operating at cryogenic temperatures. The company's founder and deputy chairman, Martin F. Wood, is a mechanical and mining engineer who joined the Clarendon in 1955 and designed all their plant magnets, later leaving to start Oxford Instruments but with the Clarendon still a major customer.

Today Oxford Instruments is still in a competitive race against Racal's peripheral small companies, the other suppliers of small companies. 

**PRICE WAR**

Meantime, the price characteristic of so many computer games is now matched, if not exceeded, by the violence of price competition between personal computer manufacturers. Some have already been forced out of business, others are subject to panic 'rescue' measures.

The long hot summer carries some of the blame as demand slumped when millions took to the beaches and forgot about shopping for electronic novelties. But the autumn is the build-up period for stocks in preparation for the Christmas rush and many companies hadn't the cash-flow nor the financial backing in support. Such are the hazards of the consumer market.

Viewing the current scene and recalling what happened to the pocket calculator and the digital watch it is understandable that investors are jittery. As prices tumble so margins are squeezed. This must mean that more of the hardware will be made in low-cost areas in the Far East, leaving most of the profit, if any, in software.

If the expected Christmas boom turns out to be a bust, look out for real give-away prices in the New Year.

**OUTLOOK**

Economists remain in stubborn disagreement on the general economic outlook although the optimists still appear to outnumber the pessimists. The August unemployment figures were down for the first time in four years but still depressingly high and forecast to rise again. But three million unemployed needs to be set against 23-5 million who are employed and record car sales, video recorders and other consumer durables don't exactly give a picture of a nation on its knees. Nor do the record crowds at Test matches and other sporting events, not to mention the level of overseas holidays and simultaneous record personal savings.

Of course the distribution of wealth is unequal both geographically and financially in the UK, it always has been. Attempts by governments over the past 30 years at levelling have been universally unsuccessful. But with information technology and light industry (e.g. electronics), the distance from the centre is becoming less critical and herein lies the hope that manufacturing and prosperity can be more equally spread.
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Broadcast Battle in USA

In the USA, there's currently a pitched battle on the open market over AM stereo broadcasting. There are five different systems of transmitting mono-compatible stereo on AM and the Federal Communications Commission originally intended to choose a single system as the US standard. But now the FCC has adopted the free market approach. Record radio stations across America can use any system they like. In theory, the broadcasters, press, electronics trade and public are supposed to choose the best system. But of course, in practice it's not working that way. Receiver manufacturers won't invest in any one system until it is a standard. Nor will the public. So almost no-one receives the broadcast transmissions in stereo.

In an effort to break the deadlock, Leonard Kahn, inventor of one of the five systems, is patenting a multi-system receiver. His British patent application 2105556B gives a useful run down on the five systems proposed. One uses a mixture of amplitude and frequency modulation; another uses phase modulation instead of frequency modulation; a third uses compatible quadrature amplitude modulation; the fourth is a modification of the third, compatible phase multiplex; and the fifth is an independent sideband system which modulates the carrier so that the left channel is on the lower side band and the right channel is on the upper side band. Although they are different, all five systems have one feature in common. They all rely on a pilot tone to switch the receiver into stereo mode. Kahn observes that the pilot frequencies are different for each system. For AM/FM it's 20Hz, for AM/PM it's 5Hz, for CQUAM it's 25Hz, for CPM it's 55–96Hz and for ISB it's 15Hz. What Kahn proposes is a multi-system AM stereo receiver which has tone sensing circuitry and can decode two or more of the five systems.

The circuit in Fig. 1 can cope with ISB, AM/PM and CQUAM signals.

Logic circuit 96 determines which system is being received from the frequency of the pilot tone. It then switches gates 48, 4B and 50 for appropriate decoding; gates 102, 110 are used where the decoder can handle other systems. Of course, some of the circuitry for one system can be used for another system, but it is still an inelegant approach which underlines the dangers of a free market choice.

Instant Digital Disc

Although it was Philips who invented the Compact Disc system, Sony contributed valuable improvements to the digital coding and error correction. The company is now pushing ahead with further improvements. One is described in British patent application 2106698. The aim is to offer broadcasters a Compact Disc player with instant start.

When a Compact Disc player is in the stand-by mode, the disc is spinning and the laser keeps skipping back and forth over the same tracks to expand the music in time. The broadcast player also incorporates forward and reverse and slow playback modes. These allow a broadcaster to "spot" a chosen passage of a recording down to 0.292 seconds, because the data stream coming off the disc is running at over 4 megabits a second.

Fig. 1 is a cut-away view of a typical disc player to which this system may be applied. The broadcast player also incorporates forward and reverse and slow playback modes. These allow a broadcaster to "spot" a chosen passage of a recording down to 0.292 seconds, because the data stream coming off the disc is running at over 4 megabits a second.

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WITH "white goods" manufacturers at last coming to terms with microelectronics control, we are fast moving away from the world of springs and contacts towards an era in which flexibility, convenience and efficient energy management will be taken for granted. The latter is of particular importance now that fuel is no longer cheap—domestic gas consumers are still smarting from swingeing increases—and yet the average gas central heating system wastes this precious fuel in two ways.

As for those springs and contacts, they will not disappear overnight, and many of us (author included) still depend upon them in equipments of an earlier generation. In a typical gas central heating system, the boiler is fired when the gas valve is opened, this valve being energised by a simple thermo-mechanical switch. This presettable thermo-mechanical switch, known to the user as the "Water Temperature" thermostat, is linked to the nearby boiler jacket. Heat from the jacket travels slowly along a heat-conducting copper wire to the thermostat, causing it to cut off the gas valve again when the required temperature is reached. Alas, this is a sluggish process in which the thermostat is expensively out of step with the boiler. Also, an ideal gas controller would sense the temperature of the hot water storage tank in addition to the boiler, but presumably the average-priced system could not be stretched to include this feature—certainly a heat-conductive copper wire could not be stretched as far as the tank, usually a "cool" distance away from the boiler/control unit. Even were this extra sensor at the tank to be included, what would the thermostat do with two inputs? If, on a cost basis, the manufacturer of the day had ruled out electronics, whilst electronics was the only technology capable of the logic necessary in a two-input thermostat, then we may hazard a guess at why gas central heating storage tanks are generally minus a temperature sensor.

CONVENTIONAL GAS SYSTEMS

Gas central heating systems vary in detail, Gas Saver being designed to improve the efficiency of the author's particular system, this being an "Ideal Standard Concord". Gas Saver will almost certainly make any comparable system run much more economically. The type this applies to is described in Fig. 1, in which the circulation pump is energised only whilst radiator heating is required. It can also be seen that only the boiler temperature is sensed, and that the thermostat is at the opposite end of a heat-conducting copper wire—a linkage that is painfully slow to respond, and which takes no account of the temperature of the hot water storage tank. Both of these shortcomings cost the consumer money. Fig. 2 shows the gas ignition pattern and temperature curves of the conventional CH system outlined.

GAS SAVER

If nothing else, Gas Saver senses the boiler water temperature electronically, and therefore responds instantaneously to changes in heat level. But more importantly than this "secondary" economising mode, it senses the temperature of the hot water tank, in order to compute more logically the control signal to the gas burner. What this means, in short, is that with the radiators off, once the hot water tank has reached its preset temperature the system will shut down until hot water is next drawn off. And with
the radiators on, Gas Saver will ignore the tank water temperature but at least regulate the gas burner duty cycle more precisely than the conventional system. Fig. 4 shows how Gas Saver behaves with the radiators turned off—its "primary" economising mode.

The entire project was designed to be as cheap as possible to construct, without compromising reliability and safety—essential requirements in such a utility.

Gas Saver, when installed, renders the original water thermostat redundant, water temperature from then on being set by potentiometer VR1, and controlled via a triac mains switch that replaces the electrical contacts of the old thermostat (see Fig. 3). The original thermostat may be left in place, so that should a fault develop in Gas Saver, it is possible to convert quite quickly back to the original system. The plans given in this article adhere to a policy of plug-and-socket interconnection compatibility with the central heating's own distribution panel. If this policy is complied with, the original system, albeit less efficient, is always only a few seconds away from standby operation. Gas Saver can take its mains supply from the timer switch, and its only other claim on the central heating unit's wiring is the direct in-out rerouting of the circulation pump wires.

Once the heat sensor at the hot water tank is installed (which will probably require drilling through an internal wall) the Gas Saver is virtually an add-on device.
CIRCUIT DESCRIPTION

The circuit (Fig. 5) is easier to understand once the three criteria of the design are appreciated. The three functions are:

1) To take an instruction from the user to establish the water temperature required, this being achieved via the "Temperature" control VR1, and then regulate the gas burner duty cycle to average that temperature. The boiler temperature sensor, TR1, is the controlling agent for this function. As with a conventional controller, the temperature selected applies to both the radiators and/or the hot water storage tank.

2) To temperature-sense the hot water storage tank (TR4), and shut down the system when the water in the tank has reached the preselected temperature (this is the primary economising mode) and is achieved by inhibiting function 1.

3) To sense whether or not the radiator circulation pump is energised, and if so, release function 1 from the override capability of function 2. In other words, if the system is shut down because the water tank is up to the required temperature, switching on the radiator heating will again allow the gas to ignite, irrespective of the hot water tank condition. By sensing the pump itself, the system will respond, whether the radiators are turning on and off due to the hall thermostat, or due to manual intervention.

In essence, the circuit section comprising TR1 and IC1a onwards takes care of function 1. The identical circuit comprising TR4 and IC1b onwards takes care of function 2. This latter circuit, the tank-sense circuit, overrides the boiler-sense circuit at IC4a. Function 3 is realised by a simple mains voltage detector, using T3 for step-down and isolation. This is followed by a PSU style circuit which drives TR7 into conduction whenever the pump is energised. Therefore, whilst the radiator heating is on, the tank circuit's ability to inhibit the boiler control section is removed (at IC4c). There is, in effect, a cascaded override function.

Fig. 3. Pictorial/block diagram showing how Gas Saver works, along with the immediately relevant parts of a typical gas CH system. See SAFETY

Fig. 4. Gas Saver shuts down the burner whilst there is no demand

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BC109 silicon transistors are used as temperature sensors. Although each circuit could have monitored the voltage generated across a silicon junction diode, transistors were chosen because in a three-terminal mode they offer gain at the sensors themselves.

Taking the boiler half of the circuit as an example, what happens is this: the chosen temperature setting manifests itself as a voltage on the wiper of VR1a, and ignoring the voltage follower IC1a for a moment, this voltage is delivered to the base of the sensing transistor TR1. When this transistor is cold, the threshold, or “knee” voltage between its base and emitter is higher than the potentiometer voltage, and so the transistor is switched off. It follows then, that TR2 will be switched fully on, and likewise TR3. When illuminated, D3 shows that the boiler is below the preset temperature. To IC4a, the conduction of TR3 represents a logic 1 and so, unless overridden by the second sense circuit, IC4a outputs a 0. This output is tapped via R8 to provide positive feedback, modifying the original VR1 potentiometer voltage by something equivalent to a few degrees C. Thus the conditions which hold TR1 off are enhanced. This hysteresis is necessary for stable operation.

With the circuit in this state IC4b output is at logic 1, which enables the 555 oscillator, IC5. The pulse transformer is pulsed, the triac driven into conduction, and the gas valve opened. With the gas fired, the temperature of the boiler begins to rise, and with it the temperature of TR1.

At the preset temperature, TR1 will begin to conduct. This is because its base-emitter “knee” voltage will have fallen to, or below, the voltage generated by VR1. As TR1 moves into conduction, TR2 and TR3 are forced out of conduction, producing a logic 0 at pin 1 of IC4a.

Any temptation for the circuit to “hover” in a half-switched state is eliminated by the positive feedback via R8 and D1. Because now R8 is no longer stealing current from VR1’s potentiometer network, the voltage to the base of TR1 will rise, tipping that transistor further into conduction. IC4 is a Schmitt trigger NAND, adding to the “snap” action of this bistable circuit.

The presets VR2 and VR3 are included in the potentiometer network because, like human beings, no two transistors are identical. It is necessary to be able to modify VR1’s voltage swing by an amount capable of offsetting the Vbe production spread of BC109s. TR1 and TR4 should at least switch at the same temperature even though VR1 is
not calibrated in deg. C at its dial, and the procedure for setting up presets for this is described later.

Returning to IC1; this is merely an impedance converter, or voltage follower, necessary because the silicon junction is a current device and will switch more rapidly if driven from a low impedance source. Impedance conversion would not be needed if dual-ganged 100 Ohm potentiometers were readily available to the hobbyist. Such potentiometers as appear “off the shelf” begin at 4k7 or 5k, and so one of these was selected, and its characteristics modified by a cheap op. amp. Resistor R2 protects the transistor from overdrive, whilst C1 acts as a short-circuit to r.f. interference picked up along the cable to the sensor. Ideally, this capacitor should be positioned at the sensing transistor end of the cable, but this may be mechanically inconvenient. It works perfectly well within the main unit on the prototype system, even though this effectively puts it in series with the lead inductance as far as the transistor is concerned.

Independent regulation for the two identical circuit sections is provided (by IC2 and IC3) so that neither is affected by the other’s switching transients.

The circulation pump-sense override is now described. Obviously, if the central heating radiators are turned on, then the fact that the hot water tank has reached its required temperature should no longer be allowed to inhibit the gas burner. It is therefore necessary to detect whether or not the radiator circulation pump is running, and if so, to lock out the hot-tank signal. The pump detector is a simple PSU type circuit, taking its mains input when the pump does. This PSU simply inhibits the hot-tank signal by driving TR7 into conduction.

The illumination of D7 indicates that the radiators are being driven by the circulation pump, and it will thus light up and go out again repeatedly, in step with the hall thermostat (air temp.). Actually, although D7 lights up immediately as the pump energises, there is a delay of about four seconds before going out, due to the time constant of C14 and R30. This is of no consequence. The transformer, T3, may seem a wasteful item for detecting the state of the pump, but it is quite the cheapest, and the idea of this project is, after all, to avoid wasting money.

**DRIVING THE GAS VALVE**

The gas valve in the author’s central heating system was found to be highly inductive. As a result, the pulse frequency from IC5 needed to be quite high; and more importantly, capacitor C17 had to be included for power factor correction. In plain English, this last point means that because current builds up slowly in an inductor, and because a triac is a current avalanche device it will fail to fire early enough for a full 360 degree conduction angle. Capacitor C17 provides some “lead” current for the triac to latch on to. If the gas valve makes an audible buzz, C17 may not be large enough (assuming nothing else is wrong). If the gas valve makes any kind of noise, switch off the system until the fault is rectified. Do not try to achieve a smooth triac action by connecting a capacitor/resistor snubber network across the triac itself, as this will probably leak enough current to prevent the gas valve dropping out again, once energised.

**HEAT SENSORS**

Transistors make economic, and conveniently linear temperature sensors—as long as the operating parameters are within certain limits. Silicon devices, including specifically designed silicon temperature sensors, will work up to 150 deg. C, a figure which gives a 50% safety margin in the application of sensing water temperature to boiling point at atmospheric pressure. So, unless an explosion is imminent, the two metal cannistered BC109s are not likely to run away thermally. If they were to, they would shut down the gas burner anyway!

A transistor used in its natural three-terminal mode of operation can integrally perform the dual function of being both temperature sensor and comparator. A potentiometer provides the reference voltage, whilst the transistor’s base-to-emitter threshold provides the temperature related voltage. This technique is not original though; it is seen in P. J. McFarlane’s “Ice Warning & Lights Reminder” of P.E. March ’83.

On a more practical note, the boiler sensor TR1 should be situated so as to detect the water temperature near the top of the boiler jacket, not the hot gases rising from the burner. The transistor should, therefore, be positioned with this in mind. Some CH boilers, probably most, have a receptacle at the top-centre of the boiler jacket to accommodate the conventional heat sensor, and this, in the case of the prototype installation, was eminently suitable. It was possible to push the transistor sensor well inside, without removing the original.

Both heat sensor transistors, TR1 and TR4, should be mounted and sleeved as shown in Fig. 6.

**CONSTRUCTION**

As can be seen in the photographs, Gas Saver is built using stripboards. The main control electronics board is housed...
in a diecast alloy box, which is situated inside the CH boiler unit. The Potentiometer box (plastic), also containing the I.e.d.s and impedance converter op. amps, is mounted against the outside of the CH boiler housing in such a way that the temperature control knob (VR1) is readily accessed. The two boxes are linked by a multicore cable. This umbilical link should ideally be a 14-way screened cable, although 15 instrument wires bound by "spiral wrap" will probably suffice, or even ribbon cable. The stripboard and box layouts are shown in Figs. 7-9.

This dual box approach was dictated by the geometry of the author's CH system, and the fact that the boiler unit is fitted tightly in a corner with little external space. An alternative approach, if there is space around the boiler housing, would be to put all the electronics, including the potentiometer, in the alloy box, and mount it externally. This could make use of a p.c.b., or a large stripboard (although in the latter case the mains transformers should still be mounted on a separate non-clad board). The "single box" approach would have a number of advantages, one being the avoidance of the multiway connector and cable (and metalwork to fit it). Another is that of finding sufficient space within the boiler unit (space which is not subject to too much heat from the boiler itself) to take the main control box. It also involves one less mounting bracket, for those who do not enjoy metal bashing.

There are no special points concerning construction. Any hobbyist experienced enough to undertake this project will find the illustrations adequate, and will know that the CMOS 4093 requires careful handling and should be mounted in an i.c. socket.

Insulation should be placed beneath each of the component boards in the alloy box. PVC tape can be used, but in the prototype, plastic sheeting cut to the same dimensions as the boards themselves are used. These were cut from a jumbo bleach bottle, drilled with the same fixing holes as the stripboards, and dropped over the stand-offs first.

The main unit board is mounted on p.c.b. stand-off clips, and the high voltage (mains) board is mounted on 4BA screws with locking nuts—this providing greater security for the heavy transformers. The easiest and most accurate way of ensuring that the holes in the boxes line up with the mounting holes in the component boards, is to use the component boards as templates for marking out. The stripboards make ideal templates once they have been cut and drilled, but before any components have been mounted on them.

All mains earths must be observed when wiring the main control box, and these earths must be affixed to the metal box itself, using a nut and screw and solder tag for reliable connection.

**INSTALLATION**

Apart from making brackets appropriate to the particular installation layout, it is necessary to hack out a fairly large hole (about 60mm square) through the side of the boiler housing. This can be done with an Abrafile or nibbler, after which the edges are filed smooth and covered with polythene grommet strip. This hole is required to pass the interconnecting cable between the two boxes (prototype layout), or to carry the pump, valve and other CH unit cables through to the electronics control box (in the case of the "single box" alternative layout).

An extended masonry drill will undoubtedly be necessary to drill a hole through an internal wall separating the boiler unit from the hot water tank (airing cupboard). This is to carry the hot water tank temperature sensor lead. If this lead is more than four feet long it will be wise to consider the use of screened three-core cable, this to be wired as shown in Fig. 6.

**SETTING UP**

The only setting up required is that of VR2 and VR3. The simplest way to do this is to power up Gas Saver with the gas valve socket disconnected, and place both sensors in some recently boiled water. VR2 and VR3 are then adjusted...
COMPONENTS...

Resistors
R1, R13, R15 47k (3 off)
R2, R5, R16, R19 100 (4 off)
R3, R7, R17, R21 1k (4 off)
R4, R18 1k2 (2 off)
R6, R20 180 (2 off)
R8, R22 82k (2 off)
R9, R23 2k2 (2 off)
R10, R11, R24, R25, R27, R28, R30 10k (7 off)
R12, R26, R29 680 (3 off)
R14 120k
All resistors 0-25W high-stab carbon film

Potentiometers
VR1 5k dual rotary, lin law
(may be 4k7)
VR2, VR3 100 vert preset (2 off)

Capacitors
C1–4, C8–10, C12, C16 100n disc cer (9 off)
C5, C11 10µ/16V elect. radial (2 off)
C6 1n ceramic
C7 10n ceramic
C13, C15 470µ/25V elect. axial (2 off)
C14 100µ/15V elect. axial
C17* 150n/400V (may be 100n)*
*See text

Integrated circuits
IC1 747
IC2, IC3 78L05 (2 off)
IC4 4093BE
IC5 555
IC6 7812
IC7 79L12

Semiconductors
TR1, TR4 BC109 (2 off)
TR2, TR5, TR7 BC182L (3 off)
TR3, TR6 BC212L (2 off)
D1, D2, D4, D5 1N914 or 1N4148 (4 off)
D3, D6 0.2" yellow led (2 off)
D7 0.2" red led
D8 1N4001
REC1, REC2 W005 (2 off)
CSR1 BT139 triac

Plugs & Sockets
SK1 P430SE (line socket)
SK2 P650
SK3 SA2404
PL1 P429 (chassis plug)
PL2 P649
PL3, PL4 SA2403 (2 off)
Note: These were the plugs and sockets required to install Gas Saver into the author's 'Ideal Standard Concord' central heating system, in which PL2 and PL3 already exist. In other systems it will be necessary to inspect the interconnecting arrangements before ordering parts.
PL6 Any 24-way plug
(Maplin YX37S + male pins)
SK5 Any 24-way socket
(Maplin YX43W + female pins)
Note: If the suggested Maplin "Multicon" 4 x 6 contact connectors are used the "receptacle" type socket will require a 28 x 18mm cut-out.

Transformers
T1 Pulse transformer (RS 196–369 or Maplin MX61C)
T2 12V+12V, 3VA mains (p.c.b. mounting)
T3 8V+8V, 3VA mains (p.c.b. mounting)

Miscellaneous
Plastic case* (65 x 100 x 52mm) type TEKP2P (West Hyde)
Diecast alloy case (171 x 121 x 5mm)
Brackets for mounting the above cases/cases
Stripboards: Main = 35 holes x 34 tracks
High voltage = 45 holes x 16 holes
(no copper tracks)
Potentiometer= 30 holes x 20 tracks
6mm stand-offs, or nylon nuts and bolts
Fig. 8. High Voltage (mains) board layout, and overall wiring of main box. The High Voltage board is unclad.

- Capacitor C17 mounted on underside of board
- (FROM ORIGINAL PUMP OUTPUT) TO PL4
- Clearances area for PL1
- SK2 (TO GAS VALVE)
- SK3 (TO PUMP)
- MAIN BOARD
- CLEARANCE AREA FOR PL1
- HIGH VOLTAGE BOARD
- EARTH
- 6 VAC
- 12 VAC
- LINK
- T1
- T2
- T3
- I
- II
- III
- I
- (FROM OR CANAL PUMP OUTPUT) TO PL4

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SK5
See wiring table
until both sensing transistors can be made to switch at exactly the same point on VR1's scale. The front panel I.e.d.s will indicate the switching points. In fact, it is most probable that Gas Saver will function correctly with VR2 and VR3 both set to midway position, without conducting this test.

The dial on VR1 can be numbered, or simply lettered subjectively warm, hot, very hot, with intermediate temperatures being interpolated by the user. The point on VR1's dial that switches the I.e.d.s on and off whilst setting up VR2 and VR3 will, if using recently boiled water, serve as a marker for very hot.

SAFETY

Naturally, safety is all important in any equipment using gas and electricity simultaneously, particularly when running continuously without supervision. No short cuts should be taken during construction, and any part of the electronics housed within the boiler unit should be cased in a well ventilated metal (fireproof) box.

The possibility of a lost connection during service has to be considered. For example, it would not be desirable to lose a connection to any one of the wires to a heat sensor, and come home to a loft swirling with steam, or worse! A completely independent "over-temperature" cut-out must be considered, that will cut off power to the control box should the boiler water temperature rise above 100 deg. C.

An obvious solution exists; the original thermostat! Other than ignoring its electrical contacts in the new system, it is left fully functional, so why not wire its contacts in series with the mains supply to the electronics controller? Then, if this original thermostat is turned up to a temperature setting way above those being selected for everyday use, it will limit the gas duty cycle should boiler overheating occur due to an electronic "latch-up". With this safety feature, the plug-and-socket compatibility for quick reversion to conventional operation might need to be partially sacrificed.

The safety option described here will not shut down the system indefinitely in the event of the type of failure that keeps the gas on, but will limit the gas duty cycle to a "ceiling" temperature. At least a hot bath may be taken whilst the fault is considered.

QUANTITY, AND THE TANK SENSOR

The hot water tank sensor need only be tucked in between the side of the tank and the insulation jacket. The position of this sensor will be about halfway down.

Since hot water builds up from the top of the tank downwards (it is possible to have cool water at the bottom and piping hot water at the top) the vertical position of TR4 needs to be considered with this in mind.

SAVINGS

The important question is: How much money does a Gas Saver save? Just a short summertime test has so far been possible (hot water only), during which Gas Saver reduced fuel consumption by 21%. One manufacturer of a similar energy conservation device guarantees a minimum saving of 16%. Savings also depend upon how efficiently the old "pot luck" mechanical system happened to be working, and the operating regime in any particular household.

Throughout 1981/82, gas prices increased four times, each time between 10-15%. It seems that the consumer is to be financially coerced into more efficient use of this "precious" fuel, whilst at the same time being sold equipment that wastes it! After-sale conservation devices will often provide the consumer's only escape route.

**SK5 WIRING TABLE**

<table>
<thead>
<tr>
<th>FROM (main unit)</th>
<th>PIN</th>
<th>WIRE COLOUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>+12V</td>
<td>1</td>
<td>D7 (CH I.e.d.) anode</td>
</tr>
<tr>
<td>R29</td>
<td>2</td>
<td>D7 cathode</td>
</tr>
<tr>
<td>R26</td>
<td>3</td>
<td>D6 (TANK I.e.d.) anode</td>
</tr>
<tr>
<td>OV</td>
<td>4</td>
<td>D6 cathode</td>
</tr>
<tr>
<td>R12</td>
<td>5</td>
<td>D3 (BOILER I.e.d.) anode</td>
</tr>
<tr>
<td>OV</td>
<td>6</td>
<td>D3 cathode</td>
</tr>
<tr>
<td>-12V</td>
<td>7</td>
<td>-12V</td>
</tr>
<tr>
<td>+12V</td>
<td>8</td>
<td>+12V</td>
</tr>
<tr>
<td>R16</td>
<td>9</td>
<td>IClb pin 10</td>
</tr>
<tr>
<td>R2</td>
<td>10</td>
<td>IClb pin 12</td>
</tr>
<tr>
<td>R18</td>
<td>11</td>
<td>VRb c.c.w.</td>
</tr>
<tr>
<td>R20</td>
<td>12</td>
<td>VRb c.c.w.</td>
</tr>
<tr>
<td>OV</td>
<td>13</td>
<td>VR1a c.c.w.</td>
</tr>
<tr>
<td>R4</td>
<td>14</td>
<td>VR1a c.c.w.</td>
</tr>
<tr>
<td>R6</td>
<td>15</td>
<td>Screen*</td>
</tr>
<tr>
<td>PIN 21</td>
<td>16</td>
<td>VR4 (TANK) base</td>
</tr>
<tr>
<td>PIN 17</td>
<td>17</td>
<td>VR4 emitter</td>
</tr>
<tr>
<td>PIN 18</td>
<td>18</td>
<td>VR4 collector</td>
</tr>
<tr>
<td>PIN 22</td>
<td>19</td>
<td>TR1 (BOILER) base</td>
</tr>
<tr>
<td>PIN 23</td>
<td>20</td>
<td>TR1 emitter</td>
</tr>
<tr>
<td>PIN 24</td>
<td>21</td>
<td>TR1 collector</td>
</tr>
</tbody>
</table>

NOTE: c.w./c.c.w. = clockwise/counter-clockwise viewed from rear of pot.
OTHER CH SYSTEMS

Alas, the author is no expert on central heating systems in general, and therefore not in a position to suggest modifications to Gas Saver to adapt it to all other systems.

However, one common departure from the type of central heating Gas Saver was designed to work with, is one in which the circulation pump runs continuously. In this type, it is believed that for geometric reasons thermal currents cannot be relied upon to transfer hot water from the boiler to the storage tank—perhaps because the airing cupboard is no higher than the boiler. Consequently, a permanently energised pump is needed to circulate hot water from the boiler to the tank, and a motorised valve is used to bring in the radiators when required.

At first, it might seem that the obvious modification to Gas Saver is merely to sense the state of the motorised valve instead of the pump (sensor C of Fig. 3). The problem with this, is that whilst the gas burner is off for prolonged periods (as in the “primary” economising mode shown in Fig. 4) the pump will remove hot water from the tank and circulate it through a cold boiler jacket—the exact opposite to heating! It is not certain that Gas Saver will deserve its name in this situation.

A further modification is therefore necessary if Gas Saver is to be put to work fruitfully in such a CH system, and a suggested way to do it is illustrated in Fig. 10. It is emphasised that this modification has not been built and tested. The additional circuit is intended to shut down the circulation pump as soon as the boiler jacket becomes cold (having no more useful heat to impart), and re-energise the pump again as soon as the boiler is at least as hot as the storage tank. Any constructor embarking on this version of Gas Saver will need to run the system under observation, and arrive at his/her own conclusions as to its merits.

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**CHROME C60 & C90**

<table>
<thead>
<tr>
<th>Type</th>
<th>Price (including VAT and postage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR02 C60 Cassette</td>
<td>90p each (minimum of 5); 80p each (minimum of 25)</td>
</tr>
<tr>
<td>CR02 C90 Cassette</td>
<td>115p each (minimum of 5); 105p each (minimum of 25)</td>
</tr>
</tbody>
</table>

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**FERRIC C90 AUDIO**

<table>
<thead>
<tr>
<th>Type</th>
<th>Price (including VAT and postage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C90LH Cassette</td>
<td>55p each (minimum of 5); 53p each (minimum of 25).</td>
</tr>
</tbody>
</table>

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**DECEMBER ISSUE ON SALE**

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This project has its origins in a production meeting of an amateur stage review, when the author was foolish enough to suggest a sci-fi sketch.

The main requirement was for a number of lightweight hand guns, capable of producing a flash of 'death rays' when fired, having a rapid recharge rate and a negligible standby power drain. Directed energy weapon technology being what it is, the source of 'death rays' reduced to a Xenon photographic flash tube. Most commercial flash gun circuits will not fulfil the last two criteria however, and so a suitable circuit was developed.

The other requirement was for the sound which every 'death ray' is presumed to produce, i.e. the 'zap'. Flash tubes themselves are embarrassingly quiet, and so a tone generator was developed, to be triggered by the flash. Such a circuit can be made to work in normal light, even fluorescent, because of the very rapid rise time of the flash tube output. In practice, reflection from dull surroundings at distances of up to 50 ft or so is sufficient to trigger the circuit.

**TONE CIRCUIT**

The tone generator circuit is shown in Fig. 1. Here IC1 operates as a current to voltage converter, the output of which is high pass filtered by C1 and R1, to produce a spike on receipt of a sudden increase in the light level by way of the phototransistor TR1.

VR1 sets the gain, and VR2 sets the trigger threshold of the comparator IC2.

IC3 is a retriggerable monostable, and VR3 sets the period, and hence the 'sustain' of the tone generated. The output at pin 6 charges C5 via D1, holding the voltage high until IC3 turns off, when C5 discharges at a rate set by VR4. The voltage on C5 is used to control IC4, a PLL chip used only as a voltage controlled oscillator. This has a square wave output which is not really ideal, but it was used because it conveniently switches off when the control voltage drops to zero.

Increase VR2 until triggering due to circuit noise and residual hum ceases. Obtain a photographic flash gun and charge it up then switch on the

**COMPONENTS . . .**

**TONE GENERATOR**

<table>
<thead>
<tr>
<th>Resistors</th>
<th>Capacitors</th>
<th>Semiconductors</th>
<th>Potentiometers</th>
<th>Miscellaneous</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1 220k</td>
<td>C1 10n</td>
<td>IC1 CA3140</td>
<td>VR1 1M</td>
<td>S1 — Single pole switch,</td>
</tr>
<tr>
<td>R2 68k</td>
<td>C2 47μ 16V</td>
<td>IC2 741</td>
<td>VR2 5k</td>
<td>Veroboard, pins</td>
</tr>
<tr>
<td>R3 68k</td>
<td>C3 100μ 16V</td>
<td>IC3 4098</td>
<td>VR3 1M</td>
<td></td>
</tr>
<tr>
<td>R4 10k</td>
<td>C4 470n</td>
<td>IC4 4046</td>
<td>VR4 500k</td>
<td></td>
</tr>
<tr>
<td>R5 1k</td>
<td>C5 4470</td>
<td>D1 1N4448</td>
<td>VR5 100k</td>
<td></td>
</tr>
<tr>
<td>All resistors 1/2W 5% carbon</td>
<td>C6 47n</td>
<td>TR1 FPT100A</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C7 10μ 16V</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**FUN PROJECT**

VR5 sets the frequency range of the sweep. The amplitude of the output is reduced by R4 and R5. Control of the tone may be achieved in the power amplifier used.

The tone generator is constructed on Veroboard as in Fig. 2. On completion first set VR1 and VR4 to maximum, VR2 to minimum and VR3 and VR5 to mid position. A jack plug should be connected to a suitable power amplifier and loudspeaker and inserted at JK1.

![Tone generator circuit diagram](image-url)
tone generator and fire the flash. If o.k. the circuit will 'sound off' with a briefly sustained tone and then die.

**GUN CIRCUIT**

The heart of the gun circuit is a push-pull inverter (Fig. 4) each half being driven by non-overlapping square wave inputs. The drive waveforms from the gates (Fig. 3) are inverted and buffered by TR1 and TR3, and the emitter followers TR2 and TR4 drive the output pair, TR5 and TR6. It is important that the output transistors are of the metal can variety, as the plastic versions have a lower minimum current gain, and may not completely saturate. Under normal operating conditions little heat is dissipated and large heatsinks are not needed. D4 and D5 protect the output transistors against reverse biasing voltages, and D6 and D7 with R11 and C5 limit positive going spikes to approximately 2V.

The high voltage output from T2 is rectified by D8–D11 and charges the main storage capacitor C6. The voltage on C6 is sensed by the potential divider R15/16 and R2, and compared with the reference voltage of D15 through IC1. When the voltage on C6 is less than about 230V, the output of IC1 is high, enabling the CMOS astable oscillator, IC2(a) and providing an inhibit signal to the trigger circuit to prevent the gun being fired before it is fully charged. The output of the oscillator has an unequal mark-space ratio, which is gated by IC2(c) and (d) and IC3, a dual 'D' type flip-flop. This produces the non-overlapping drive waveform.

As the voltage on C6 rises to about 240V, IC1 output goes low, inhibiting the inverter, and arming the trigger circuit, TR7 etc. Two possible trigger circuits are given: a single shot circuit (for the bad guys); and a continuous repeat 'automatic fire' trigger (for the good guys). The single shot
Fig. 3. Low voltage part of gun circuit. In the prototype the single shot trigger was used. An alternative continuous trigger is shown lower left

**COMPONENTS...**

**GUN CIRCUIT**

<table>
<thead>
<tr>
<th>Resistors</th>
<th>Capacitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>C1 5n</td>
</tr>
<tr>
<td>R2</td>
<td>C2,9 100n (2 off)</td>
</tr>
<tr>
<td>R3</td>
<td>C3 10n</td>
</tr>
<tr>
<td>R4</td>
<td>C4 220µ 16V</td>
</tr>
<tr>
<td>R5</td>
<td>C5 47µ 40V</td>
</tr>
<tr>
<td>R6</td>
<td>C6 32µ 450V</td>
</tr>
<tr>
<td>R7</td>
<td>C7 47n 450V</td>
</tr>
<tr>
<td>R8</td>
<td>C8 47µ 16V</td>
</tr>
<tr>
<td>R9</td>
<td>1k</td>
</tr>
<tr>
<td>R10</td>
<td>1k</td>
</tr>
<tr>
<td>R11</td>
<td>680R</td>
</tr>
<tr>
<td>R12</td>
<td>18k</td>
</tr>
<tr>
<td>R13</td>
<td>1k</td>
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<tr>
<td>R14</td>
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<td>R15</td>
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<td>R17</td>
<td>1M</td>
</tr>
<tr>
<td>R18</td>
<td>180R</td>
</tr>
<tr>
<td>R19</td>
<td>22k</td>
</tr>
<tr>
<td>R20</td>
<td>180R</td>
</tr>
</tbody>
</table>

**Transformers and tube**

- Pri: 12 + 12 turns of 24 s.w.g. enamelled wire
- Sec: 800 turns of 42 s.w.g. enamelled wire
- Xenon trigger transformer (Maplin YQ63T)
- Xenon tube (Maplin YQ62S)

**Miscellaneous**

- S1 D.P.S.T. toggle switch
- S2-S3 S.P.D.T. toggle with single bias to one position
- 20in length of 3 x 3in plastic trunking, VR1—100K
- B1—PP3, B2—PP9

**Semiconductors**

- TR1, 3, 7, 8, 9
- TR2, 4
- TR5, 6
- D1, 2, 3, 12, 13, 14
- D4—11
- D15
- CSR1
- IC1
- IC2
- IC3

The continuous firing trigger circuit uses C9, R19 and D13 to differentiate the positive going edge generated when S3 wiper connects with TR7 collector, and IC1 output is...
low. This pulse briefly turns on TR9, firing CSR1 and hence the tube. The recharge cycle begins, with IC1 output going high, and when C6 is fully charged, going low again. TR7 collector goes from low to high, and if S3 wiper is still connected, this transition initiates the triggering, and so the cycle repeats until S3 is opened.

**TRANSFORMERS**

The construction of T1 deserves some comment. The primary winding consists of 12 plus 12 turns of 24 s.w.g. enamelled wire, bifilar wound on the core bobbin, and then insulated with a layer of tape. The secondary is made up of 800 turns of 42 s.w.g. enamelled wire, wound in four layers, each insulated from each other by a layer of tape. Sleeving should be placed over the free ends of the windings before covering with insulation to avoid chafing. The core used was a 36mm diameter item, of Siemens T26 material (available from Electrovalue).

T2 may be obtained from Tandy, Maplin, or may be recovered from a complete flash gun. Physical construction may vary so modify layout accordingly. Tubes for the prototype models were obtained complete with reflectors by purchasing a quantity of used photographic flash guns from a dealer (four for £6). Most Japanese items are suitable; tubes from German made units seem to require a higher supply voltage.

**TESTING**

The circuit may seem rather complex, but it has the virtue
that the standby current is only a few milliamps and only fires when fully charged. Recycle time depends on the value of C6 and the internal resistance of the power source. With the value shown, and a PP9 supplying power to the output stages, recycling takes about 0.55. The prototype automatic version used two 6V lantern batteries in series to give a very satisfying flash rate.

Test the low voltage section of the circuit first. Connect TR1 and TR3 bases to Vc, via R7 and R9 to inhibit the output stages. Ground ICI pin 2, and check that the oscillator is operating. Next, connect a high wattage resistor of about 15–20k in place of C6, and connect the inverter output stages to IC2, still keeping IC1 pin 2 at OV. About 300V should appear across this resistor. Tune VR1 for a voltage maximum before restoring the circuit to its original form.

Note that if the circuit is tested with a bench power supply, the current trip will almost certainly operate, as the current demand is large.

HOUSING
The prototype units were built into 20in lengths of 3 x 3in plastic electrical trunking, with the flash tube secured in the gutted body of a defunct flash gun. Chamfered lengths of broom handle were screwed and glued to the trunking to act as butt and steady, and a biased toggle switch made a very effective trigger.

Six prototypes were built to this circuit and the only problems encountered were due to mechanical considerations, inasmuch as the finished products were thrown about with gay abandon by a troupe of scantily uniformed imperial stormtrooperettes.

Off The Rails
Sir—With reference to Tom Gaskell’s article in the August edition Semiconductor Circuits—ICL 7660, the stated absolute maximum voltage of +10.5V applies for the chip when it is used in its negative voltage generating mode only. If the chip is used as a positive to positive voltage converter then this maximum can be increased. An example of this is to provide a +7.5V supply from a +15V rail when using the ICL 7650 chopper stabilized operational amplifier. The 7660 can also be used as a negative to negative voltage converter in a similar manner. The circuit configuration is shown in Fig. 1:

Tom Gaskell comments:
My thanks to Mr. Owen for providing us with an ingenious application for the ICL 7660. He is quite right in stating that this circuit allows operation from a +15V rail, rather than the specified +10.5 volts. In practice, though, the +10.5 volt limit still stands; it is the maximum permitted voltage between pin 3 and pin 8 (the 'OV' pin and the +ve supply pin).

In Mr. Owen’s circuit, the i.c. is ‘floated’ up to a nominal +7.5 volts; the ‘negative’ output of the i.c. pin 5, is connected to 0 volts, which (in combination with a +15 volt supply) forces pin 3 to +7.5 volts; this is our new supply rail. Reference was made in the original article to a diode in series with pin 5; this should ideally be included (between pin 5 of the i.c. and everything else) for supply voltages in excess of 13 volts (i.e. twice 6.5 volts). Allowance should be made for its forward voltage drop. The maximum permitted supply voltage with this circuit arrangement is +21 volts.

 Altogether, a most useful and interesting application of the device, showing that even fairly simple i.c.s such as this can often be extraordinarily versatile!

Finally, please note that there is a small but important error in Fig. 3 of August’s Semiconductor Circuits, on the ICL 7660: The caption should read DI is not necessary for supplies <6.5V, not >6.5V as printed.

Help Sought
Sir— I have just purchased a BBC model ‘B’ micro and the high resolution graphics, on a large colour TV are good.

I do not normally use a large colour TV, however, for my computing, having instead a 14" monochrome portable. A problem which your readers may be able to help me with is that the characters tend to flicker at the edges when this monochrome TV is used. My previous computer, a UK 101, exhibited the same effect until I changed the value of capacitor C60 as advised in the manual, when the display became rock steady and clear.

Is there a corresponding cure for the BBC? I would also be interested to hear of a good user group for this micro.

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- Z80 Assembler, line and 2 pass
- 8K BASIC interpreter (Extra)
- 8K FORTH (Extra)
ROM: 8K Monitor (full listing and comments)
RAM: 4K CMOS (2 x 6116)
Input/Output: 48 system I/O lines
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   2. Specification (hardware and software).
   3. Description of Operation. 4. Operating the MPF-1 Plus. 5. 44 Useful Sub-Routines.
2. Experiment Manual. 16 experiments.
3. Monitor Program Source Listing with full commenting.
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- SGB-MPF-1P: Sound Synthesizer Board.
- I/O-MPF-1P: Input/output board

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BRIAN BUTLER visits...
Although hydro-electric power is a very efficient method of producing electricity—you simply collect a few million gallons of water, store it in a dam and then dispose of it through a turbine-generator placed somewhere well below the water level—an ingenious alternative to the traditional hydro-electric plant has been developed by the CEGB (Central Electricity Generating Board) at Dinorwig, North Wales. The massive underground plant is a pumped-storage system which can supply 1300MW of electricity to the national grid system in just 10 seconds, overcoming the costly business of stand-by stations.

With the introduction into our homes of infinite numbers of electrical appliances over the last couple of decades came the inevitable load on the national grid system. The coal- and oil-fired power stations of the fifties proving less and less capable of supplying large amounts of electricity to the grid system when a sudden demand occurs. To keep these stations in a stand-by mode, awaiting a peak demand, is a costly business.

At the same time as these significant changes were occurring in the daily pattern of electricity demand it was realised that there was an increasing need for reserve generating capacity to make up for the sudden loss of a large modern generator.

EARLY STUDIES

In the late sixties it was estimated that the stand-by capacity needed to cover the worst possible unplanned loss of large generators during the two following decades were calculated by the CEGB to be about 1300MW within some six seconds (a tall order, indeed).

It was therefore decided to compare the engineering and economic merits of gas turbines with pumped-storage, for providing generating capacity able to respond rapidly to sudden demands for electricity in the long term. Pumped-storage generation offered a significant advantage for this duty because of its unique ability to spin without load, ready for generation within a few seconds. This technique allows the turbines to be spun on compressed air via hydraulically controlled valves when neither generating or pumping, thus allowing a quick-start time for either operation. The results of the economic studies in the late sixties demonstrated that overall system costs were in favour of pumped-storage. The system costs represented the overall life-time capital, fuel and other operational charges, but of course the fuel estimates did not anticipate the subsequent drastic change in oil costs. This provided an even more attractive case for pumped-storage, and also changed the balance in favour of nuclear energy compared with fossil-fired stations.

ENGINEERING MARVEL

Construction began in 1975 and the station is now undergoing its final commissioning deep beneath the old Dinorwig slate quarry at Llanberis in North Wales. The site was chosen for its geological characteristics, hydrology and reservoir potential, construction requirements, power transmission line routes, environmental impact and, of course, pure economics.

Marchlyn Mawr, an existing lake, has been enlarged to provide Dinorwig's upper reservoir. Llyn Peris, a lake about 500 metres (1,640 feet) below, has also been enlarged to provide the lower reservoir. The high head of water (over 500 metres) available from the top reservoir gives the advantage of a smaller reservoir capacity for a given station output and it was possible to use Llyn Peris with very little extra capacity being required to form the lower reservoir. Indeed work was carried out on both reservoirs to optimise their usage for their precise roles in this project.

At all times during construction the CEGB placed paramount importance on the effect to the environment. Dinorwig is almost invisible from above ground which makes it all the more difficult to relate just how massive the underground workings really are.

This £425 million project is civil engineering on a vast scale. Around three million tonnes of slate has been excavated to create the station's network of huge tunnels and caverns, requiring the use of some 4,500 tonnes of gelignite. The main civil engineering contract was believed to be the largest ever let in the UK when it was placed in 1975. The underground chamber housing the main plant is one of the largest excavated caverns in the world—twice as long and half as wide as a football pitch and higher than a 16-storey building.

HYDROLOGY

Dinorwig uses more than 6.6 million cubic metres (1.462 million gallons) of water during a full generating cycle. The water is retained in Marchlyn Mawr by a 600-metre-long rock fill dam, landscaped on the downward face to blend with the scenery. The upstream side is faced with asphalt to provide the necessary water seal and the flexibility to meet the pressure changes caused by such a vast weight of water being continually moved in and out of the lake.

As can be imagined when the generators are shut-down there is a tremendous back pressure created in the feed tunnel and for this reason a massive surge shaft was incorporated in the hydraulic system. Being open ended the 43 metres high, 10 metres diameter surge shaft allows the excess pressure to be dissipated; it surmounts the 439 metre deep, high-pressure shaft.

Maximum station water demand is 420 cubic metres per second, and the system velocities were selected by balancing the cost of various tunnel sizes and their energy losses within limits of previous experience to ensure a satisfactory tunnel lining and
accepturable pressure surge levels. The power/time criterion was also an important factor in tunnel sizing because of the need to accelerate the 2km water column from standstill to full flow in just a few seconds.

THE STATION LAYOUT

The underground tunnels were integrated with caverns housing the mechanical and electrical plant and access tunnels for construction and operation. An important factor in settling the

Inset photograph (1st page) taken here, showing high-pressure inlet tunnels under construction

1 Access tunnels
2 Tailrace tunnels
3 Transformer hall
4 Main inlet valve gallery
5 Draft tube valve gallery
6 High pressure tunnels
7 Machine hall
8 Cable tunnel
9 Ventilation shaft

The underground complex showing tunnel systems and plant layout. In all the labyrinth incorporates 10 miles of tunnelling

Section through station. Electricity generated in the machine hall at 18kV is conducted via aluminium bus-bars to the transformer hall, then at 400kV to the national grid system through a 6 mile underground tunnel.

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Practical Electronics  December 1983
level of the main cavern was the submergence needed by the pump-turbines below the bottom reservoir to minimise air bubbles forming which could damage the pump-turbines. Other important features include: the cavern width, determined by the structural and water-bearing properties of the rock, provisions for maintenance, disposition of electrical busbars, the number of machines connected to transformers which supply the power to the high voltage grid system, equipment for starting the machines when they are operated as pumps, location of high voltage switchgear, control rooms and welfare facilities.

The 24 metre wide main cavern houses the six pump-turbines, and has adequate maintenance and plant provisions. In elevation, the cavern is a three-level arrangement dictated by access to the turbine/generators (Fig. 2.). The control room and equipment, low voltage switchgear and batteries utilise the space above the machine busbar routes. Workshops are arranged at one end of the main cavern with direct access to the plant. Three main busbar galleries, one per pair of machines, connect the machines and transformers. These galleries also house high voltage switchgear.

The six vertical pump-turbines are directly coupled through intermediate shafts to the generator motors mounted immediately above them. Each pump-turbine is reversible and has a single runner which rotates in one direction as a turbine when generating, and the other direction as a pump when being driven by the generator motor.

Although this may look like a Star-Wars android, it is, in fact, one of the six main inlet valves. Its diameter is some 2.5 metres and each of the counterbalances weigh 16 tonnes.

TURBINE/GENERATORS

Each generator unit, operating in the turbine/generating condition, has a nominal water flow of 65 cubic metres per second, and delivers 300MW to the national grid. Flow regulation is achieved by 24 guide vanes which incorporates a restraint device to prevent extreme movement. The vanes, operating in conjunction with an electro-hydraulic governor, are powered by balanced double acting servo motors acting on a regulating ring.

The air-cooled generator motors, rated at 330MVA, are designed for direct coupling to the pump-turbine via intermediate shafts. The rotating parts are supported by a thrust bearing above the top joint of the generator-motor. Eight air coolers using circulating water from the lower reservoir are located on the stator frame which is totally enclosed within a concrete housing. Electrical and mechanical braking systems are included so that the operating mode of generating and pumping can be quickly changed.

Under normal working circumstances a generator unit may be required to perform 5,000 start/stops per year. The generator shaft is the largest mild steel forging ever produced by British Steel. The total weight of the rotating parts of each of the generator motors is 484 tonnes.

The construction of the generator assemblies was completed on site, as transportation limitations precluded shipment of the huge one-piece stators.

It is planned that under normal working conditions only four of the six generator units will be used, the remaining two will be reserved for emergency and sudden demand use. These two stand-by units have a slightly different winding in order that comparisons may be made between the two types with regard to circulating current losses, cost and installation considerations. The basic specification remains the same.
CONTROL SYSTEMS

The control room is situated in the main cavern overlooking the machine hall. Automatic operation is provided for all generating and pumping conditions, including changing from full load pumping to full load generation.

The control room was designed for use by a single operator but the layout allows for two operators if necessary.

The electronic analogue control system enables the equipment racks to be mounted remotely from the control panels and the system is built up from function modules which, in addition to basic control elements such as high/low alarms etc., include computing functions that enable complex signal manipulation to be carried out.

Other interesting control features include environmental equipment, turbine vibration monitoring and pressure resonance detection equipment used to monitor the underground hydraulic system and guard against damaging resonance phenomena. Level switches have been incorporated to guard against station flooding. An ingenious "radiating feeder" communication system has been incorporated throughout the underground network. A narrow co-axial cable can be found all through the labyrinth, this being a feeder cable that "leaks" radio signals which would otherwise be screened by the mass of solid rock; this system enables immediate radio contact to be maintained within the plant. Radio pagers are also incorporated for staff location.

INDUSTRIAL RELATIONS

From the outset of this project the CEGB placed great importance on using local labour wherever possible. For this reason a multi-skill training centre was established at Dinorwig to train the 95% strong local labour force in the many skill requirements needed. Highly experienced representatives were drafted in from each of the contractors supplying equipment to Dinorwig, and it was they who passed on their skills to the new workforce. Of course, there already existed an important skill which only the Welsh could supply, namely their invaluable knowledge of local slate mining techniques.

ACKNOWLEDGEMENTS

The technical data in this article was supplied by the CEGB who also furnished the photographs and illustrations.
WE HAVE seen in the PE Logic Tutor how useful it is to be able to indicate logic states using I.e.d.s. This idea may be extended further to the point where the output of a logic network is actually intended to drive I.e.d.s as the primary function of the circuit. For example, with the advent of different coloured I.e.d.s, model engineers are now able to build replica traffic lights using I.e.d.s driven by logic. The problem, however, is how to interface the logic gates to the I.e.d.s?

In order to drive an I.e.d. to reasonable brightness, it is necessary to pass a current of around 10mA to 20mA through the diode. In general, a nominal 10mA will produce adequate brightness for red diodes, with the other colours often requiring somewhat more (due to their lower efficiencies). A typical red I.e.d. will have a voltage drop of approximately 2V across its terminals under these conditions, other colours slightly more (up to around 2.5V). This in effect is a description of the characteristics of the load which we want to drive from a logic circuit. We must now look again at the capabilities of TTL gate outputs to see if this is possible directly, or whether some intermediate circuitry is necessary.

We have already seen that a standard TTL gate output is capable of sinking a current of at least 16mA in the low state. In this condition we know, from the TTL level definitions, that the output voltage will not exceed 0.8V. This means that it is possible to connect a load between the gate output and the +5V supply, and draw 16mA through it, with a voltage of 4.2V (minimum) being dropped across the load.

A voltage drop of 4.2V is too great for an I.e.d. on its own. However, if we connect a resistor in series with the I.e.d., as shown in Fig. 3.1, the current then flows through both the resistor and diode. Selecting the value of resistor allows us to set the volt drop across the diode to an appropriate value. Assuming the worst case, we calculate the resistor value such that it will drop (5-I.e.d. drop) volts at the selected operating current, which must be less than 16mA. Thus, typical resistor values are around 220Ω to 270Ω, although 330Ω is also a common value. Using this method, we can still use the gate to drive normal logic loads, although the effective fan-out has been reduced by approximately six.

The second method offers an alternative which overcomes this minor problem.

Looking at the drive capabilities of a TTL gate in the 1 state, we might think that this could not be used directly to drive an I.e.d.; only 400µA of drive is available. The voltage in the 1 state is a minimum of 2.4V, and is typically 3.4V. So much for the theory. In practice, if we are willing to accept that using a gate output to drive an I.e.d. will make its output unavailable for other uses, then something can be done. In fact, the result is one of the simplest ways of driving an I.e.d., since it requires no additional components. Simply connect the diode between the gate output and 0V, as shown in Fig. 3.2, and all should be OK. The question now is "Why does it work at all?".

![Fig. 3.1. Driving an I.e.d. from a TTL gate in the 0 state](image1)

![Fig. 3.2. Driving an I.e.d. from a TTL gate in the 1 state](image2)

The reasons once again relate to the detailed characteristics of the TTL gate output circuit. Suffice it to say that the load represented by the I.e.d. is such that the output voltage of the gate falls to approximately 2V at a current of around 5 to 10mA. This is exactly what is required to drive the I.e.d., even though it is not a legal TTL logic level. All-in-all a very simple (and safe) way of driving an I.e.d. from a TTL circuit. This is in fact a common way of using up 'spare' gates in i.c.s when the main circuit design has been completed without needing all of the gates in
LOGIC INTEGRATION

With the advent of integrated circuit technology, the electronic sub-assemblies which had previously been used in the construction of logic circuits disappeared. In their place came ranges of integrated circuits (i.c.s) which contained standard gates fabricated on silicon 'chips'. As the technology has advanced, it has become possible to include more numerous and more complex circuits inside such i.c.s. We have seen, from the TTL i.c.s described so far in the series, that one effect of this progress has been the inclusion of more than one of a particular gate within a single package. Indeed, the number of gates is now often limited solely by the number of pins available on the package. In the interests of standardisation, the number of pins is restricted to 14 or 16 wherever possible, although 18- and 24-pin devices are now becoming increasingly common.

To try and give some idea of the scale of integration involved, a typical TTL gate currently occupies a piece of semiconductor which measures less than 0.2mm square; smaller than the proverbial pin head! By comparison, the black package of a 14-pin i.c. is approximately 19mm by 6mm. With such a degree of integration available at low cost (e.g. a 7408 costs around 20p), it is not perhaps surprising, therefore, to find that even more complex logic functions are being integrated into single i.c.s. It is interesting, therefore, to look at some of the reasons behind this move, and some of the advantages which result.

One of the first things that we notice when we look at complex logic circuits is that they can involve quite a number of i.c.s. This in turn means that there are many interconnections, and that the boards required for the circuit become quite large. Two consequences of this are that such circuits are expensive to make, and that they are less reliable due to the greater number of components. Ideally, the rule in this respect is the smaller the physical circuit, the better. If, therefore, we can identify arrangements of logic gates which occur frequently, it should be possible to make the complete arrangement inside an i.c., and so keep the number of i.c.s required to a minimum.

Much of the rest of this series is concerned exactly with these types of logic elements, i.e. standard arrangements of basic logic gates. Originally, many logical functions were performed by circuits made up from arrangements of discrete gates, but as the TTL family has developed, many of these arrangements have themselves become available as 'standard' components. In this part of the series we will begin by looking at some simple combinations of the basic gates covered so far. Future parts will then move on to look at some of the more complex logic elements which are available in the TTL family. We will also be looking at the ways in which even these familiar gates can be built up from only a single type.

THE NAND GATE

In many discussions of logic, the first gate discussed is the NAND gate. This is often for no other reason than that it is the gate which is fundamental to the TTL family. The internal circuit for a TTL gate shown in part one of the series was in fact that for a 2-input NAND gate. This, however, is incidental to any progressive introduction to logic, and we have therefore waited until this point to consider the NAND gate. We will look on the NAND gate at this point as a gate which represents a combination of two of the basic logical functions already described.

The NAND gate combines the action of an AND gate and an inverter (NOT gate). Fig. 3.3 shows the way in which these gates may be connected to make up a NAND gate. Table 3.1 shows the truth table for a 2-input NAND gate.

Table 3.1. Truth table for 2-input AND and 2-input NAND gates

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>AND</th>
<th>NAND</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Much of the usefulness of the NAND gate stems from the fact that it produces an inverting action, and Fig. 3.4 even shows how a 2-input NAND gate may be connected to behave exactly like an inverter. We shall be returning to this point again later on, but for the moment we will take a look at a practical NAND gate in the TTL family.

7400 TTL NAND GATE

The 7400 is a quadruple 2-input NAND gate whose pin configuration is shown in Fig. 3.5. As before, each of the four gates is identical, and the power supply connections are quite standard. The 7400 is perhaps the most commonly used of all the TTL family. There are those, perhaps cynically inclined, who would claim that this is only because it is first in any list of TTL i.c.s! Whilst there may be some truth in this, it is nevertheless true that a 7400 will always 'do' to implement any logic function, and so it is probably deserving of at least some of its popularity.

In the previous section we introduced the NAND gate as a combination of an AND gate and a NOT gate (inverter). If we connect a further inverter to the output of the NAND gate, therefore, we would expect to get back to a simple AND gate, since two inverters connected in series behave as a buffer. Fig. 3.6 shows a circuit which allows us to investigate this AND and NAND gate action available from the
7400. Indicator D3 should respond as an AND, while D4 should respond as a NAND, in accordance with Table 3.1.

![Fig. 3.6. Test circuit for NAND and AND operation from 7400](image)

This circuit is set up by inserting a 7400 into the B socket, with pin 1 in position B1, and adding the following links.

- S3 to B1 (Input signal A)
- S4 to B2 (Input signal B)
- B3 to D4 (NAND o/p signal)
- B3 to B4 (Link)
- B4 to B5 (Tie i/p together)
- B6 to D3 (AND o/p signal)
- B7 to 0V (Supply)
- B16 to +5V (Supply)

In this circuit we have used a NAND gate connected as previously shown in Fig. 3.4 to behave as an inverter. The B socket has been used for the IC in preference, however, to the usual A socket simply to spread the wear and tear on the breadboarding sockets!

As a final test of skill in constructing truth tables, the circuit in Fig. 3.7 is offered as a challenge. To which 2-input gate does the behaviour of this circuit correspond? The circuit is set up using the same IC as above, but with the following (different) set of links.

- S3 to B1 (Input signal A)
- B1 to B2 (Tie i/p together)
- S4 to B11 (Input signal B)
- B11 to B12 (Tie i/p together)
- B3 to B4 (Inverted A i/p)
- B10 to B5 (Inverted B i/p)
- B6 to D3 (Output signal)

B7 to 0V (Supply)
B16 to +5V (Supply)

We will now go on to look at another common combination of basic gates, the NOR gate.

**THE NOR GATE**

As with the NAND gate, the NOR gate combines the action of an already encountered gate with that of an inverter. Fig. 3.8 shows how a NOR gate can be considered to be made up of an OR gate and an inverter, and the truth table for the arrangement is shown in Table 3.2. The output from a NOR gate will be a 0 unless both of its inputs are a 1, in which case the output changes to a 1.

![Fig. 3.8. The NOR gate as a combination of OR and NOT gates](image)

Table 3.2. Truth table for 2-input OR and 2-input NOR gates

<table>
<thead>
<tr>
<th>INPUTS</th>
<th>OUTPUTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

If both of the inputs of a NOR gate are connected together, as shown in Fig. 3.9, it behaves in the same way as a similarly arranged NAND gate, and produces an inverting action. The figure also shows an alternative method of constructing an inverter, using the second input tied to the 0 volt supply rail.

The NOR gate can equally well be used to construct any of the logic gates in the TTL family. The NAND gate is usually used in preference, however, since its internal gate circuit involves significantly fewer components and also dissipates less power. Either gate type will nevertheless produce an equally valid solution, and in different applications one type may require fewer physical gates than the other.

**7402 TTL NOR GATE**

The 7402 is a quadruple 2-input NOR gate whose pin configuration and internal layout is shown in Fig. 3.10.

![Fig. 3.10. Pin configuration for the 7402 quadruple 2-input NOR gate](image)

Each of the four gates is electrically identical, but it should be noted that the layout of inputs and outputs does not follow the pattern of the previous 2-input gates. The power supply connections are, however, quite standard.

The 7402 essentially completes the basic set of 2-input gates for the present. We are now able to select the most appropriate IC for the task in hand, knowing that many of the gates may also be adapted to perform the functions of other ICs, thereby allowing us to keep the total number of ICs in a circuit to a minimum. As a final demonstration for the present, Fig. 3.11 shows two NOR gates connected as a NOR-NOT pair. The circuit is set up by inserting a 7402 in the C socket (for another change), with pin 1 in position C1, and adding the following links.

- S3 to C2 (Input signal A)
- S4 to C3 (Input signal B)
- C1 to D3 (NOR o/p signal)
- C1 to C5 (Link)
- C6 to OV (Tie i/p to ground)
- C4 to D4 (OR o/p signal)
C7 to 0V (Supply)  
C16 to +5V (Supply)

It is interesting to check the overall operation of the circuit against the truth table. In addition, however, certain similarities may be noticed between the behaviour of this circuit and that shown in Fig. 3.7, and we shall return to this point later. Another point to note is the effect of disconnecting the link from C6, and observing that the result is the same as setting the input to a logic 1.

**BOOLEAN ALGEBRA**

In Part Two we discovered that the actions of gates can be described in the form of truth tables. A truth table indicates the output that will be obtained from a gate for any given combination of inputs. The technique can be applied equally well to individual gates, and to gate combinations. When more than two inputs are involved, however, the truth tables very quickly become quite large and cumbersome. Each additional input to be considered doubles the number of lines in the table. There is then a very real danger that the overall function of the circuit will become obscured by the sheer quantity of information presented in the table.

What we need then is a more compact way of representing the logical functions involved in logic circuits. It is also useful if any such representation can subsequently be expanded into a truth table should it prove necessary. What we are effectively grasping for here is a form of logical shorthand; something whose meaning we can readily understand, but which can expand at will to provide the same detail as the truth table. To be useful, therefore, we must choose a shorthand which has a very close relationship to the gates whose workings are being represented, and one which is widely understood. The most common shorthand in use today is known as Boolean Algebra.

Boolean Algebra is a logical shorthand which was developed by an English mathematician, George Boole, long before the introduction of digital electronics. Its purpose was to provide a simple way of writing the complicated logical statements encountered in the study of logic. The idea was to be able to determine rapidly whether a particular statement was true or false, depending on the outcome of other related statements. If we now relate logical statements to digital logic gates, and the result true/false to gate outputs of 1/0, we can see how easily Boolean Algebra can be applied to the analysis of logic circuits. It also helps to explain why we so often see digital gates referred to as logic gates.

**BOOLEAN EXPRESSIONS**

In order to be useful, a shorthand must have an established set of symbols. Algebra in turn must have a set of rules in order to be able to determine the outcome of a particular problem. We will start by looking at the way in which Boolean Algebra allows logic situations to be expressed in what are known as Boolean Expressions. Later on we will return to look at some of the basic rules of Boolean Algebra itself, which will allow us to manipulate such Boolean expressions.

The fundamental gate actions of digital logic are, as we have already seen in this series, those of AND, OR and NOT. Boolean Algebra uses special symbols to represent each of these gate actions, and these are shown in Table 3.3. As with any shorthand, alternative symbols are sometimes used, but the symbols shown in the table are those in common use, and they will therefore be adopted for this series.

Now that we have a set of shorthand symbols, it is appropriate to see how they are used in practice. We will stay, for the moment, with the three basic gate actions of AND, OR and NOT. Fig. 3.12 shows three examples of the use of the shorthand notation introduced above. In the first example, concerning the AND function, the expression shown as X = A. B indicates that the X output signal is the result of passing signals A and B through an AND gate. Put another way, X equals A and B; X is 1 if, and only if, both the A and B inputs are at a logic 1.

The second example treats the OR gate in a similar way. The output from

<table>
<thead>
<tr>
<th>LOGICAL FUNCTION</th>
<th>EXAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>AND</td>
<td>A + B</td>
</tr>
<tr>
<td>OR</td>
<td>A + B</td>
</tr>
<tr>
<td>NOT</td>
<td>A</td>
</tr>
</tbody>
</table>

**Fig. 3.12. Boolean expressions for basic gate functions**
the gate, \( X \), is shown as \( X = A + B \), indicating that \( X \) is the result of passing signals \( A \) and \( B \) through an OR gate. The action of the gate is \( A \) or \( B \), and \( X \) is 1 if either \( A \) or \( B \) is a logic 1. The action of the inverter, shown in the third example, is to cause the output \( X \) to become equal to \( \overline{A} \), read as \( A \)-bar or NOT-\( A \).

Now that we have a shorthand for writing down Boolean expressions, let us pause for a moment to look at the circuit shown in Fig. 3.13. In this circuit the signals still have simple names (\( A, B, C \), etc.), even though these would be replaced in a real circuit by the names of actual signals. The circuit has outputs labelled with their appropriate Boolean expressions, but can you think of a use for this type of circuit? Hint: this is actually available as a standard function in the TTL family. (74LS157)

NEGATIVE LOGIC

At this point it is perhaps timely to stand back for a moment and ask ourselves about the way in which we describe and use logic signals. For example, when we call a signal Motor On or Light Off, what do we actually mean? The answer is hopefully self-evident; we assume that the motor will be turned on, or the light turned off, respectively, whenever the signal is at a logic 1. So far, so good, but is this the only way to use logic signals?

If we always have logic signals of the type described above, there can be unexpected, but predictable, problems with TTL circuits. Consider, for example, part of the motor control circuitry for a milk float, shown in Fig. 3.14. As we can see, the control unit is situated in the driver’s cab and only requests motor movement when the ignition key is on, when the driver has pressed the foot pedal, and has also selected either 1st or 2nd gear. Unless all of these conditions are satisfied (i.e. all necessary inputs are 1), the Motor On signal will be 0, and the milk float will therefore not move. When all of the necessary conditions are satisfied, the Motor On signal will change from 0 to 1. The signal will then pass to the motor compartment, and the motor will be activated via a suitable buffer. In reality there is likely to be further stages between the buffer and the motor, but the principle is unchanged. The circuit seems to work ideally, so what is the problem?

As with many situations in the real world, the danger in this circuit is when something goes wrong. The most common problem in this type of situation, where different parts of the circuit are physically separated, is that the interconnecting wiring may become broken. This is an unexpectedly common occurrence, and may be caused by vibration, traffic damage, or even the printed circuit board containing the control unit being removed from its socket for testing. In any event, the situation we then have is that the link between points \( X \) and \( Y \) on the circuit is broken, at least in electrical terms. This is where the trouble really starts!

Although the control unit output may be a 0 (say the driver has turned the ignition key to off), because the \( X-Y \) link is now broken, the input to the buffer in the motor compartment will float high, turning the motor on. What we have then is a runaway milk float.

The example above is obviously rather contrived, and hopefully non-representative of milk floats, but it does show the type of situation which we must avoid at all costs. The simplest solution to this type of problem is to use what are known as Negative Logic control signals. What we have explained so far in this series is known as Positive Logic; the signal condition is true (e.g. the motor is to be turned on) when the signal (Motor On) is at a logic 1. In negative logic, we use the opposite convention, and the signal condition is true when the signal level is a logic 0. In order to distinguish between the two types of signal, we use the bar notation introduced earlier. In this way, Motor On should turn the motor on when at a logic 1, whereas Motor On will turn the motor on when at a logic 0.

To illustrate this idea in practice, the motor control circuit described earlier has been re-designed in Fig. 3.15 to make use of negative logic. Should there be any doubt about the correct operation of the circuit, a truth table will demonstrate that the motor is only turned on when the appropriate combination of negative logic signals are input.

MORE ON BOOLEAN ALGEBRA

In the discussion above we have seen that there are many situations where it is useful to use inverted logical signals. Boolean Algebra has, as we have seen in Fig. 3.12, a shorthand way to indicate the operation of logical NOT, using the over-rule notation. This is readily extended to cover all types of negative logic signals, as shown by the Boolean representations for NAND and NOR in Fig. 3.16.

The general rule for logical inversion, therefore, is that an over-rule is added to the output signal whenever the gate performs an inversion. Thus the output from a NOR gate whose inputs are `A

![Fig. 3.14. Milk float motor control circuit](image-url)

![Fig. 3.15. Motor control circuit using negative logic](image-url)
and B will be \( A + B \). If the output from this gate is now fed through an inverter, as shown in Fig. 3.17, the output will then have two over-rules, \( A + B \). If we draw the truth table for this circuit, we can probably deduce that a double over-rule of this type has a very simple equivalent, but what is it?

![Fig. 3.16. Boolean shorthand for NAND and NOR gates](image)

**SLOW SIGNALS**

In Part One we saw the way in which the output of a TTL buffer changes as a steadily increasing voltage is applied to its input. We saw that the output will be below 0.8V until the input has risen to over 0.8V. Similarly, we saw that the output will be at least 2.4V whenever the input voltage exceeds 2.0V. In the middle range, however, where the input is between 0.8V and 2.0V, the behaviour of the gate is somewhat unpredictable.

The output could be either above 2.4V or below 0.8V, or anywhere in between, without any real guarantee of where it might be. These features are summarised in Fig. 3.18, in what is known as the Transfer Characteristic of a TTL gate. From this graph we are able to predict the behaviour of a TTL gate which has an input signal level that is not within the indeterminate region. There are, however, problems which can arise when a signal crosses this indeterminate region.

If we look at a signal which has a slowly changing level (in TTL terms at least), we see that, as it varies between 0 and 1, it crosses and re-crosses the indeterminate region. Fig. 3.19 shows a typical such input waveform, together with a corresponding output signal. This seems at first sight to be quite straightforward, but in fact there are a number of hidden problems. The first is that the point at which the output changes from 0 to 1 can be quite variable, being particularly sensitive to changes in temperature and supply voltage. The results of this effect are shown by the dotted lines in Fig. 3.19, and a degree of uncertainty therefore exists in predicting the instant at which the output will change.

The next problem, however, can have a much more dramatic effect on the overall behaviour of a logic circuit. The difficulty arises from the fact that, in any real circuit, the laws of physics dictate that there will always be some electrical noise present. This will usually be small by comparison with the standard TTL levels and, even when it becomes superimposed on the logic signals, it is not usually enough to upset the 0 and 1 levels. The effect of the noise, however, is to cause the signals to vary slightly above and below their ideal levels. The amounts, and the intervals between these variations are random, but they are usually fairly small, and it is only unusually that we have a slowly varying signal that this noise can become troublesome.

As before, the problems arise near the point at which the gate output switches between 0 and 1. Near the switching point, the noise on the input signal can be sufficient to take the input above and below the switching point a number of times, before it finally settles down. At all times, the general trend of the signal (which is equivalent to a perfect, noise-free signal), remains steadily upwards or downwards through the indeterminate region. It is while the signal is near the switching point, however, that noise can upset the expected smooth transition of the output level.

The overall effect of noise on the output of a gate being used to process a slowly varying input signal can be as shown in Fig. 3.20. The output here can be seen to 'chatter' quite a number of times, before finally settling down. If the circuit following the input gate is counting pulses, or is affected in any way by the number of transitions, the result of this chattering can be quite dramatic; errors of up to 500% can easily occur for slowly varying input signals. It should be remembered here that TTL gates switch in a very small fraction of a micro-second, so many signals unexpectedly fall into the category of 'slow'.

So much for the problem, but what about a solution? What we ideally require here is a gate which has a 'snap-action' transfer characteristic. By this we mean that, once the input signal has passed a defined level, a significant change in the opposite direction is required in order for it to have any effect. This characteristic would result in the circuit which is immune from small changes in level around the switching point, and would obviate the possibility of the chatter effect. As might have been guessed, special TTL gates exist which have such a snap-action property, and they are known as Schmitt Gates.

**SCHMITT GATES**

The most important feature of a Schmitt-input TTL gate is its behaviour in the so-called indeterminate region. In almost every other respect a Schmitt gate behaves just like any other TTL gate, but it is more versatile since...
Schmitt gates can be used in place of ordinary gates, but not necessarily vice versa.

The transfer characteristic for a Schmitt buffer is shown in Fig. 3.21. When looking at this characteristic, it is important to note the directions of the arrows, otherwise the figure can make no sense at all. If we consider, by way of illustration, an input signal which varies smoothly from 0V to +5V, and then back again, this will help us explain the shape of the graph.

The input signal starts at point A with a level of 0V, and the corresponding output here is less than 0.8V, as for any other type of TTL gate. As the input voltage increases from zero towards point B, the output stays at or around this level. At point B, the first switching threshold is reached, and the output jumps (snap-action), from below 0.8V, to above 2.4V. Further increasing the input voltage, towards the maximum allowed input at point C, has little or no effect. Thus, with a steadily increasing input voltage, the gate behaviour follows the path A-B-C.

Following the reverse path, the output level stays above 2.4V until the input level falls to the second switching threshold, at point D. The snap-action switching effect is then repeated, but in the reverse direction, and the output falls to below 0.8V. For the steadily falling input voltage, therefore, the gate behaviour follows path C-D-A.

The real points to note here are the snap-action switching behaviour and the difference that exists between the two switching thresholds known as the 'hysteresis'. Once the gate has switched, therefore, change of input level equal to at least the hysteresis of the gate and in the opposite direction, is required in order to make the gate output change state again. This combination of snap-action switching and the hysteresis of Schmitt gates combine to substantially remove the problems associated with slow signals. Other uses of Schmitt gates will be examined later in the series. For the present, however, we will look briefly at some practical details of Schmitt gates.

Typical circuit symbols or Schmitt gates are shown in Fig. 3.22, from which it can be seen that the standard outlines are used, but with an additional symbol inside. The extra symbol is, in fact, the form of the transfer characteristic shown earlier in Fig. 3.21. One of the most common Schmitt gates in the 7400 TTL family is probably the 7414 the Schmitt equivalent of the 7404 hex inverter. The pin-out is shown in Fig. 3.23, and it can be seen that the 7404 and the 7414 are pin-compatible.

This circuit is wired by placing a 7404 in socket A, and a 7414 in socket B, and adding the following wire links.

VAR to A1 (Variable supply i/p)
A1 to B1 (Tie i/p together)
A2 to A3 (Link)
B2 to B3 (Link)
A4 to D1 (Ordinary gate o/p)
B4 to D2 (Schmitt gate o/p)
A7 to O V (Supply)
B7 to O V (Supply)
A16 to +5V (Supply)
B16 to +5V (Supply)

The variable supply (VAR) may be taken either from a 0 to +5V supply or, as shown, from a potentiometer connected between the two supply rails. As the input voltage is slowly increased, it should be noted that a point is reached where D1 will flicker on and off for small adjustments of input voltage. D2, on the other hand, will have a definite snap-action, with two quite distinct and separate switching points. It is an interesting exercise to try and plot the transfer characteristics for the two types of gate on the same axes for comparison; the differences are quite noticeable!

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Complete kits for the Logic Tutor are available from the following suppliers:

- **Howard Associates**, 59 Ootlands Avenue, Weybridge, Surrey KT13 9SU (03932 42376)
- **Riscomp Limited, Electronic Component Distributors**, 21 Duke Street, Prince's Risborough, Bucks HP17 0AT (0844 44362)
- **TK Electronics**, 11 Boston Road, London W7 3SJ (01-579 2842)
- **Magenta Electronics Ltd.**, 135 Hunter St., Burton-on-Trent, Staffs DE14 1ST (0283 65436)
- **G. D. & P. Cowan Services**, 9 Harcourt Terrace, Headington, Oxford (0865 60741)
- **Electronics World**, 1C Dews Road, Salisbury SP2 7SN
- **Microstate Ltd.**, 5 Northfield Close, Fernhill Heath, Worcester WR3 7XB (0905 56322)
- **Bi-Pak**, PO Box 6, Ware, Herts (0920 3182)

**PLEASE NOTE**
The R19 shown on the Logic Tutor Board next to link 3 should be R15. Under the heading 'Initial Tests' diode D9 is referred to as diode D5; diodes D5 and D6 are referred to as D6 and D7 whilst diodes D7 and D8 are referred to as D8 and D9.
Space Watch...

NEW USSR RADAR

A new radar installation has appeared in central Siberia. Since it is near to the heavy missile fields of that region it is to be assumed that it is for the detection of ballistic missiles. If this is so, then it will be highly sensitive as an early warning device. The actual site is situated at approximately 58.08°N and 92.4°E.

The United States discovered this late last July. It was not detected earlier because for reasons of economy America had restricted activity for some months. The Americans used a Big Bird satellite and analysts have now verified this installation. A map has been released showing where the principal missile bases are together with the radar sites. According to this map there is every sign of readiness exhibited. There has been quite a large coverage of the subject recently. As has been pointed out on previous occasions it is not the policy to deal with these matters in Spacewatch. The excuse for bringing it forward now is that the event of the Korean jet airliner has brought the matter to serious proportions and many people in all parts of the world now seem more concerned with accidents precipitating events leading to a holocaust.

THE SHUTTLE

The success of the latest shuttle flight was a new venture, a night landing and the highly successful launch of another satellite, this time for India. The mission has considerably enhanced the prestige of NASA. Naturally officials are full of a very real pride in all concerned.

An aspect of night landings is the 'seeing' ability available to the crew. The last critical phases of the touch down were very important in this respect. The portable lighting system was set up on the lake bed at runway 17. Lights were also available for the ground crew. The shuttle could not be seen by observers at Edwards until it entered the Xenon beams before touchdown, but a rumbling sound could be heard before the craft came into view.

A statement made by Lt. General J. A. Abrahamson, a NASA associate administrator, confirming the advantages of night landings, went on to say, "this opens up another 12 hour door for launching at Kennedy. It is vital because then we can take advantage of the best weather." Abrahamson also said that it was certain that night landings in future would exceed those made in daylight. The Orbitor turnround was delayed because of manifold drainage problems. Altogether there was a 16 hour delay, the reason for this lengthy procedure was the result of playing it safe. There were often minor faults which were referred to investigation.

The set manoeuvres carried out were done so successfully, much new information on the shuttle operation. They identified, hitherto there has been a radio blackout during the landing phase, and there is a suggestion that the aerials on the top of the vehicle should be used. The method of penetrating the ionized atmosphere was overcome some years ago in manned satellite investigation and was given some success. However it could be done with existing equipment it will save weight. It is to be hoped that the American government will not inflict economies on space activity for scientific and commercial purposes, since there is much to be done if the full use is to be made of advances in these fields.

GERMANY

The German Infrared Laboratory has now completed its first tests and design review. It now remains for the German government to give assent to proceed with the project. The observatory was planned as a successor to IRAS. The plans were set at a launch date around September 1987. This is hoped to be attained, and launch is to be by shuttle. The Laboratory was approved by an independent review board in July. The further work required is for the manufacture of the qualification and flight models of the laboratory. Four scientific experiments are proposed and the estimated cost is some 1.9 million pounds. The experiments will be made by subcontractors.

The satellite is expected to provide more detailed observations than is possible with IRAS and is expected to be as much as ten times more sensitive. It will use the infrared survey being carried out by IRAS and help to select targets for more detailed study. The laboratory would be in space for several years before two other observatories are ready. These will be the infrared facility on the Shuttle and the Infrared Space Observatory put up by the European Space Agency. The time scale for these is 1990 for the American telescope and 1992 for ISO. The purpose of these vehicles will be complementary.

The immediate German programme will hope to gather information that could help to clarify whether the Universe is 'closed' or 'open'—that is to discover if there is enough matter in the Universe to generate gravitational force to prevent expansion. Other questions to be settled include 'Is the Universe made of hydrogen and protostars like Jupiter?' More details of the equipment and programme will be available when the vital question of the funding is settled.

JAPANESE ACTIVITIES

The Japanese are planning a new launcher with a capacity of two tons of payload. They expect to launch 78 satellites between now and the year 2000. It is Japan's stated intention to compete with America. They are asking for an annual increase in funding of up to 10% per annum for 17 years.

The programme is for launching several satellites at the same time. This is necessary because of an agreement with local fishermen. The fishermen claim substantial losses at each launch. The agreement being—the authorities will only launch during February and August of each year. A detailed list of the launch plans will be available at a later date.

The long term plan would be to offer launch services to construct ground stations and to develop software.

SOYUZ RENDEZVOUS FAILURE

The Russian Soyuz crew failed to rendezvous with the Salyut 7 Space Station earlier this year. This was because the radar antenna would not deploy and an optically guided approach to the station had to be aborted in darkness when the cosmonauts feared a collision between the two vehicles. The Soyuz crew did not attempt to dock. Mission Commander Vladimir Titov said "I was unable to approach closer than some 525 feet."

The Soyuz problems began on the second orbit when the crew found that the dish antenna mounted on a large boom had only deployed partially. This antenna is a key element in the Soyuz automatic docking system. The crew received ground control permission to make several attitude control manoeuvres at rates high enough to swing the antenna into position. The attempt failed. Titov said that Soyuz mission rules dictate that after such a failure no attempts to try other methods are allowed. Nevertheless the crew sought and obtained permission to attempt a rendezvous with Salyut by optical means with the aid of ground radar signals. Such a situation was new and the crew had little hope of success.

Without ranging data to provide distance and closing information Titov had to tell the ground 'how large' the Salyut appeared compared with the reticle markings on the sight and then the ground team computed what type of manoeuvres to perform. On the 19th orbit Titov saw the Salyut in his alignment sight and reported the data. The ground control told him to fire the spacecraft's manoeuvring engine for 30 seconds. He then reported to the ground that the Salyut was closing.

At that point both vehicles flew out of the ground radar sight for 35 minutes. Titov was able to approach within 1000 feet of the Salyut and shine a searchlight from Soyuz onto the passing Salyut station until they went into darkness. Commander Titov tried braking and other methods without success. When they were again in radar sight they were found to be about 2.5 miles apart. Further attempts were abandoned. It was then decided to return to earth. Titov was naturally disappointed. Subsequently another vehicle made the rendezvous without any trouble at all.

When one looks back it is quite remarkable that beyond these limited scares, spaceflight seems safe enough.
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- DC Current: 50uA-50mA-500mA-2.5A
- Resistance: Up to 2M Ohm in 3 ranges
- Accuracy: 2% DC - 4% AC
- Dimensions: 173 x 86 x 29 mm
- Weight: 200g
- Supplied with soft carrying case and spare fuse

Write or phone for details
Evan Steadman is 45 years old and well-built. He's tastefully tailored, except perhaps for the tie-of-the-day—the badge of your true extrovert. The abundance of greying hair is studiously ruffled and he keeps his loose change—which, in his case, could include a £5 note—in a little purse. A minus point this. Men of substance should at least appear to be less concerned about their petty cash. But I quibble.

Evan is a man who's unoffended, even tickled, to be labelled an exhibitionist. He knows that in the sense people use the description about him it has nothing to do with the dictionary definition of 'one who has a compulsive desire to attract attention by exag- gerated behaviour or boasting'. Or, in another listed sense, 'by indecent exposure'.

He is one of the wonderfully few 'characters' who has survived the creeping standardisa- tion of so much about the electronics industry and whose drive and personality is behind many of the best-known and most-successful high-technology exhibitions to which hun- dreds of thousands of hobbyists and professionals alike flock year after year. A one-time schoolteacher, he entered the world of publicity via Fleet Street as a feature writer. "My only gift," he says, "was an ability to turn out 1,500 words to order on any subject my editor demanded. It was usually sheer bloody rubbish, of course. But no matter." This led to work with advertising agencies and publicists and eventually to the post of European advertising and publicity manager for Texas Instruments.

"But deep down," he said, "there was this congenital desire to go off and do my own thing—if only because this was the sole way I could make more money. I was based in the South of France at the time of the big decision. I was living in Christian Dior's villa, if that matters, and life was magnificent. My salary was on an American scale, but even so I managed to spend it. Very naughty of me. So I made tracks for the UK and set up a PR business in the bedroom of the house I'd kept on in Cambridge. My capital was £75."

Today he owns three advertising agencies and three PR companies. "I don't work much on them personally because it wouldn't be cost-effective. I devote the bulk of my time to exhibitions. The sums of money involved here are fantastic. Take the Antiques Fair at Grosvenor House, London—the only non-technical show I handle. There's a £5 entrance fee, the catalogue costs £4 and we get around 20,000 visitors. That, if your maths are right, adds up to £180,000 in cash taken at the door. Even so, mine's a chance game. When an exhibition fails I lose a lot of money. When it works I make a lot. But when it fails it only fails once. When it works it works several times."

He pays tribute to the professionalism of the talented guys who run his companies. "But they find exhibition work too nauseating, too stressful, too tough. I thrive on stress and toughness. Don't ask me why. But if you find you like it you try it again."

The All-Electronics Show—an all- Steadman production—started nine years ago at Grosvenor House with 180 stands. The idea was born when some of his clients said to stage the IFA and RECMF exhibi- tions at Birmingham when the electronics in- dustry was based mainly in the South was ab- solute nonsense. "I agreed. And I told them that they didn't have to go to Birmingham. I'd put on a show right here. It worked, and it's been working ever since. Now I've become involved with two major annual exhibitions—all in the high-technology sector—plus six conferences. And the list is growing at a rate of four a year."

I asked Evan whether he ever found his lack of formal training in high-technology a drawback. He was visibly affronted. "You underestimate me, madam," he replied with some coolness, putting me by way of riposte into a sexual category to which I clearly do not belong. "I've spent the last 13 years right in the thick of high-technology. And it hasn't been simply a matter of learning the buzzwords. It's been a matter of seeing on definitions and opportunities and employing lateral thinking."

"I thrive on stress and toughness."

not belong. "I've spent the last 13 years right in the thick of high-technology. And it hasn't been simply a matter of learning the buzzwords. It's been a matter of seeing on definitions and opportunities and employing lateral thinking."

"I thrive on stress and toughness."

"Let me give you another illustration. I recognised when the time was ripe for a p.c.b. exhibition. Interneuron used to cover the sub- ject, but then gave it up and became simply a major general electronics exhibition held on the South Coast. The baby had been passed out with the bath water. So I knew it was time to act."

"So now you'll see why I marginally resent the suggestion that old Evan hasn't got the qualifications, because he bloody well has. Anyone with an IQ of 140 has all the qualifications he needs."

What material rewards has his energy, im- agination, acumen and, in large measure, audacity brought? He's quite frank about that. "Oh I'm a millionaire (he might well have been telling me he was an expert on the banjo). I've a chauffeur-driven Bentley, three houses and a farm. I also own the building we work from."

I asked the stock question: had he yet reached the height of his ambitions? "I've hardly started," he replies. Yet the really ambitious never really achieves the ultimate. He goes on. "I don't mean that it's a sort of drug. It's like a way of life. But it's not just for money, power, sex with your secretary or the other things that people believe that ambitious men seek. It's the need to get into things where there is an aching void which you think you can fill. Nature abhors a vacuum. And I'm one of Nature's abhorrens. There are not millions of us like that, but there are lots who are prepared to grasp the nettle, given the chance.

Evan Steadman does not rely for his remarkable stamina on such aids as specially prescribed diets, Swedish exercises or transcendental meditation. "I believe in excess in everything," he freely admits. "As a result I'm exhausted all the time. I'm fat. I've got spots before the eyes and spots on the skin and I'm all hyped-up. But, for me, sitting down relaxing in the sun for a couple of hours would be the kiss of death."

"Mind you, that doesn't mean that I haven't any relaxation at all. I've lots of children and I'm heavily into child culture. One son is a drummer and I have a daughter who is a singer. There are my homes, the farm and so on. These need a lot of attention and in a way this adds up to a kind of hobby. Also, I've a private cinema in one of my homes. It's always there if I want it. And I'm a voracious reader. I get through two or three books a week. But the best type of relaxation is the business of living."

For all the success he has enjoyed and the excitement of his life, Evan Steadman is not a man I envy. Anyhow he envies me. As he says, his life style demands a hefty price. It can mean stress, ulcers, long hours, over-indulgence in most of the things which should be taken in moderation. "But," he says. "If you're like me you'll know that it's all part of what your body's been telling you to do since the day you were born. Better to have been a been than a have not."

"Joy, you know, is never present. You always feel you've failed to get to the point you wanted to reach. That's why you go on. You'll find it hard to believe that sometimes when I climb into the Bentley and say: 'Take me home Bernie, I feel pain.'
EXPANDING THE

PART THREE  SAM WITHEY

OUTPUT DRIVER BOARD . . .

FOR AROUND £12

THE next stage in interfacing the Vic 20 involves the dedication of lines as outputs and inputs. As these lines are now to connect the computer to external electrical devices, it becomes necessary to physically isolate the computer from such devices. We can carry this out by using opto-couplers and relays. This makes the interface rather more costly than the I.e.d.s and switches board, but it opens up exciting new fields for the serious computer enthusiast and hobbyist, and turns the home computer into a useful precision control instrument.

After much deliberation about the allocation of output and input lines, it was decided to give first consideration to dedicating all lines to output applications. This gives great potential to those who wish to control models and small motors, as well as those who wish to experiment with light displays.

This article deals with two output control boards and an input control board.

INPUT/OUTPUT CONTROL BOARDS

In the first interface, all 8 lines are set up as outputs. They are isolated by relays suitable for use with voltages up to 50V, and current handling capabilities up to 500mA.

The second interface uses opto-isolated triacs capable of controlling mains voltages and currents up to 1.2A. In both circuits, disabling of the outputs, when not under computer control is carried out by pulling the output lines down to ground potential. This must incorporate the use of insulated mechanical switches as with the I.e.d.s and switches board.

Whilst most control applications are likely to be in output mode, there are many instances when the computer has to be called upon to sense inputs. These can include counters and alarm sensors of many types.

The input board (to follow next month) uses opto-isolators.

All these options can be mixed by using a simple connector block suggested in this article.

LOW VOLTAGE OUTPUT BOARD

The principal devices used in the first control interface are the ULN2803A, octal driver integrated circuit and 700R, 500mA relays. See Fig. 3.3.

The ULN2803A is an 18 pin d.i.l. integrated circuit, which contains 8 open collector, darlington driver stages with a maximum operating voltage of 50V and each capable of sinking 500mA. Each stage incorporates a diode, which offers protection when switching inductive loads.

Applications include relay, lamp, solenoid and small motor switching, and individual stages may be paralleled to increase the output sink current.

The relays used incorporate a 6 to 9 Vd.c., 700ohm coil, and normally-open contacts rated at 500mA, 200Vd.c., 10 Watt maximum; whilst other similar relays have contacts rated at 200mA, 50Vd.c., 5 Watt maximum. No diode is included in the encapsulation, but the top of the moulded case of both types clearly illustrate the position of the coil and contacts.

See Figs. 3.4 and 3.5 for construction.

Provision has been made for 4 way, 0.2in. pitch terminals, but these are optional.

There are many options available from the ULN2803A, being capable of directly driving lamps, solenoids and small motors up to 50Vd.c. and the additional advantage of being able to parallel the stages to increase the output sink current. Here it must be remembered that the Vic 20 is only capable of providing 100mA @ 5V, making the external power supply necessary. Also, without relays, there is not complete electrical isolation between the computer and peripheral.

The cost of the i.c. and relays is in the region of £10, whilst the inclusion of terminal blocks would increase the cost by approximately £3. Of course, there is no need to completely build the board at first, as each line of the port can be used individually. Each board can be just partially furnished for initial experiments and extended as required.

The principle of operation is similar to that of the I.e.d.s and switches board. A logic "1" at the port is inverted by the driver. The logic "0" at the output of the driver, being low relative to the supply voltage induces current to flow through the coil, the electromagnetic field of which causes the contacts of the relay to close.
Again, provision is made for disabling the logic "1" at the port by pulling the output down to ground potential. This could be brought about by microswitches to limit the travel of a moving piece of apparatus, the level of liquids or the lapse of a preset period of time.

Making up this connector will allow flexible use of the expansion boards.

COMPONENTS...

OUTPUT CONTROL BOARD (low voltage)

Resistors
R1–R8 470 kΩ 5% (8 off)

Semiconductor
IC1 ULN2803A

Miscellaneous
RLA–H 6–9V 700 ohm 500mA reed relay (8 off)
S1–S8 (external) S.p.s.t. toggle (8 off)
TB1–4 4-way 0.2in. pitch terminal block (optional) (8 off)
P.c.b.

Constructors' Note
Project prices quoted are based on home etched p.c.b.s and "shop around" component prices, therefore some general purpose components are not specified to exact manufacturers or part numbers. If p.c.b.s are found to be unavailable from PE's usual suppliers, they may be obtained from Bradley P.c.b.s Ltd.

Fig. 3.1. Single stage schematic of ULN2803A

Fig. 3.2. ULN2803A octal Darlington driver i.c.

Fig. 3.3. Low voltage output control board circuit diagram
FEEDBACK

The current series on *Expanding the Vic 20* has brought a new and enthusiastic group of computer fans to the pages of *P.E.* A group which, having gained valuable experience at programming techniques, now wants to turn its machines to further use about the home. Some readers with little or no experience in construction have asked for some information on soldering and making p.c.b.'s, whilst others, having some difficulty in understanding the Vic 20 manual, have asked for a little more information on connections to the RAM/ROM Blocks. There is difficulty in choosing the most economical method of buying components. Some want more information about the Super Expander/Vicmon ROMs, and where to get them. Enquiries also concern the feasibility of getting even greater versatility from the RAM and ROM boards. Others ask for an extension of the series to include other computers.

The last request is the easiest to answer, because all the rest of the series, whilst aimed primarily at the Vic 20, is equally suitable for use on any home computer, having been developed some time ago for Nascom. All that is required is a suitable connector for your computer I/O port and some adaptation of the sample program routines.

NEXT MONTH: All the above points will be gone into, the topics being based on readers’ letters during the series. A high voltage (mains) driver board will be featured, and an opto-isolated input board, along with details of construction and manufacturers’ applications notes.
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PREVIOUS articles in this series have detailed the design and construction of a modular logic analyser. The basic unit as described has TTL compatible inputs. This final article in the series presents a fifth option, allowing the analyser to be adapted for use with CMOS circuitry.

REQUIREMENTS

Let us consider the requirements. Although today most computer systems run from a 5V supply rail, many other circuits use CMOS technology running from higher voltage levels. Thus the first requirement is to be able to level shift the CMOS power rails and logic levels to those compatible with TTL. The next requirement is of sufficient drive capability of the circuit under test. A LS TTL input represents on the average a tenth of the drive capability of a TTL output. Therefore using the analyser on TTL circuitry will not affect the operation of the circuitry (very seldom do good circuit designers allow TTL outputs to drive the maximum number of inputs). On the other hand, however, a common limit to the drive capability of CMOS outputs (as far as TTL is concerned) is two LS TTL inputs. If one, or two LS TTL gates have already been used in the design being tested, another LS TTL load may affect the operation of the circuitry. So the load applied to the circuit by any test probe should be as small as possible, and in the design presented here, is the equivalent of a single CMOS input. A third consideration, closely connected to drive capability, is of test lead length. Long leads, necessary to reach into the circuit being tested, represent capacitive loads to the drive circuitry as the frequency of the signals increase. Circuits with low drive capability may not be able to drive these capacitive loads, and the switching from one true logic level to another may be prevented. To overcome this problem, the input circuitry must be as close as possible to the test points of the circuit being tested.

SOLUTION

There are a few possibilities for the required solution. One would be to use comparators as input buffers, but many i.c.s would have to be used making the p.c.b. large and cumbersome. A better way is to use i.c.s specifically designed for the task. Two such i.c.s are available. The first is the RCA CD40116 high speed 8-bit bi-directional CMOS/TTL converter, and is ideal for the application. Propagation delays through the i.c. are typically 15 ns—of the order of those in the analyser itself. There are two disadvantages to this i.c. A minor one is that the CMOS side maximum level is 12V. Some CMOS circuits work on 15V. The other one, somewhat larger, is the availability of the i.c., and especially its price, which does not make it (at present!) economical to use. The second i.c., a RCA CD40109B, is more readily available and is much cheaper. This device was designed to be a low-to-high voltage converter, but can be used in the opposite mode, as is done in the circuit to be described. There has to be a trade-off in performance to approximately 1 MHz. If higher speeds are to be encountered (fast CMOS i.c.s are becoming available today) then it is recommended that a design using the first i.c. be considered. Although the i.c. is not pin-for-pin compatible with the one being used here, the three CD40109Bs can be replaced with two CD40116Bs with suitable modification to the p.c.b. layout. Remember, though, that the analysis maximum inputs frequency is 5 MHz, and it is possible to test circuitry at lower speeds, as discussed in previous articles. Another problem arising out of slow propagation delays is that of data skew. (See part 1.) To avoid this problem, it is important that all the signals being observed (and being used for control, such as the clock modifiers etc) must be connected through the translator. This will ensure equal propagation delays, and all signals will arrive at the analyser simultaneously.

CIRCUIT DESCRIPTION AND CONSTRUCTION

Fig. 5.1 shows the logic diagram of a single translator. There are four translators per i.c., and using three i.c.s allows twelve lines to be translated. There are thirteen input lines to the analyser. It was decided that a fourth i.c. was not necessary for translating only one line, and the CQ3 input is therefore not used in this option. Referring to Fig. 5.2, the unused CQ3 input is held high by R513. (When using the analyser, the CQ3 input switch should be in the 'don't care' position.) In Fig. 5.2, all the Vcc inputs and the enable inputs are commoned, and taken to point A. All the translator inputs are also held 'high' to this common line via resistors R501–R512. These resistors present minimal loading, and prevent open inputs from floating (and possible damage). Linking A to B makes the option compatible with circuitry using 12V supplies. Linking A to C connects the option to the +Vin line, which must be connected to the supply line of the circuitry being tested. Input voltage range is +5V to +15V. A choice can be made at the construction stage as to which link to use. Alternatively, a small switch can be mounted on the case allowing easy change-over. VDD, the TTL level side of the i.c.s, is supplied by the 5V supply in the analyser. The supply line is decoupled by C501.
COMPONENTS

Integrated Circuits
IC501-503 40109B (3 off)

Resistors
R501-R512 1M 5% (12 off)
R513 10k 5%

Capacitors
C501 10µ 16V Tant

Miscellaneous
Ribbon cable, Eezy-hooks, plastic case, p.c.b. SPDT switch (optional)

Fig. 5.3. Track side p.c.b. layout of CMOS input option board (actual size)

Fig. 5.2. CMOS input option circuit diagram

Fig. 5.4. Component-side p.c.b. layout of CMOS input option board (actual size)

Fig. 5.5. Component layout
Construction of the unit is straightforward. Use soldercon i.c. socket strips for the i.c.s. Handle the i.c.s with care as they are CMOS devices. All necessary through-hole connections are made with component leads soldered to pads on both sides of the board. Extra pins are not necessary.

Link A to B or C, or if a switch is to be used, connect some lead wire to the p.c.b. 16-way ribbon cable is used to connect the p.c.b. to the analyser. This cable can be up to 0.5m long, and is connected to the analyser using the same method as the probe described in Part 2. The order of the connections from the p.c.b. match the order of the inputs to the analyser, so connections are made one-to-one. Part 2 shows these connection details. Note that the -12V supply is not used, and remember that CQ3 is not used. A piece of 14-way ribbon cable, no longer than 100mm, is used between the p.c.b. and the circuit under test. Coloured Eezy-hooks are again used as convenient probes on the circuit under test side. The p.c.b. can be mounted in a small plastic case, and the optional switch installed. The nearest sized, commercially available case is the Vero 202-21029J. This may be a little long, though. The author used a suitable plastic case found in the junk-box. Slots are cut on each side of the box to allow cable entry and exit.

**TESTING**

A circuit similar to that shown in Part 3 can be used for testing. Replace the 74LS90 with a 74C90, and use, say, 12V as a supply voltage. The clock input used must also be a signal switching from OV to +12V. Use the +Vin line connected to the test circuit supply. (If A was linked to B, then use a supply voltage of 12V, but the +Vin line need not be connected.) A similar display to that seen during the original testing (Part 3) should be observed.

This concludes the series. It is hoped that those who have built the project have found the instrument useful, and those who have just followed the series have learnt something of interest. Finally, the author would like to thank P. Duggan for his assistance in checking the analyser timing diagrams.

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**FREE! READERS' ADVERTISEMENT SERVICE**

**RULES**

Maximum of 16 words plus address and/or phone no. Private advertisers only (trade or business ads. can be placed in other classified columns). Items related to electronics only. No computer software. PE cannot accept responsibility for the accuracy of ads. or for any transaction arising between readers as a result of a free ad. We reserve the right to refuse advertisements. Each ad. must be accompanied by a cut-out valid *date corner*. Ads. will not appear (or be returned) if these rules are broken.

**WANTED**

- **Acoustic Research Turntable type XB.**
- **Electric Research Turntable type XR.**
- **SEIKOSHA GP 100A graphics printer.**
- **Panasonic AF 2000 stereo cassette recorder.**
- **Acoustic Research Type AN Remote.**

Please publish the following small ad. FREE in the next available issue. I am not a dealer in electronics or associated equipment. I have read the rules. I enclose a cut-out valid *date corner.*

Signature Date

Please read the **RULES** then write your advertisement here— one word to each box. Add your name, address and/or phone no.

**COUPON VALID FOR POSTING BEFORE 2 DECEMBER 1983** (One month later for overseas readers). I **SEND TO**: PE BAZAAR, PRACTICAL ELECTRONICS, WESTOVER HOUSE, WEST QUAY ROAD, POOLE, DORSET BH15 1JG.

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For readers who don't want to damage the issue send a photostat or a copy of the coupon (tacked in of course) with a cut-out valid *date corner*.
ATARI VARIABLES

OWNERS of Atari 400/800 machines may be interested in this program, sent in by C. Leech of Leicester. It lists the names of all scalar and string variables referenced by BASIC, along with their current values. Once loaded, the BASIC program can be deleted and the m/c program called by an X = USR (ADR(VARILISTS)) command.

C. Leech of Leicester. It lists the names of all variables referenced by BASIC, along with their current values. Once loaded, the BASIC program can be deleted and the m/c program called by an X = USR (ADR(VARILISTS)) command.

TRANSMISSION LINE CALCULATIONS

Sir—This program, for UK101, is derived from the standard transmission line equations, but assumes a loss-free line, sufficiently accurate for the lengths used by radio amateurs. It is more convenient to use than the Smith chart, and numerous cut-and-dry results can be obtained rapidly.


30 PRINT "THE MEASURED IMPEDANCE AT LINE INPUT IS R+/-jX"
40 PRINT "OHMS. THE LOAD ON THE LINE IS A+/-jB OHMS"
50 PRINT "ENTER A OR B FOR REQUIRED TRANSFORM"
60 PRINT "A-LINE IMPEDANCE FOR GIVEN LOAD IMPEDANCE"
70 PRINT "B-LINE IMPEDANCE TO GIVE REQD. INPUT IMPEDANCE"
80 INPUT AS
90 IF AS="A" THEN 310
100 IF AS="B" THEN 340
110 INPUT AS
120 IMPEDANCE
130 PRINT "ENTER THE SERIES REACTIVE COMPONENT (SMITH CHART ABS)
140 PRINT "ENTER THE SERIES REACTIVE COMPONENT (SMITH CHART ABS)
150 PRINT "ENTER THE SERIES REACTIVE COMPONENT (SMITH CHART ABS)
160 PRINT "ENTER THE SERIES REACTIVE COMPONENT (SMITH CHART ABS)
170 PRINT "ENTER THE SERIES REACTIVE COMPONENT (SMITH CHART ABS)
180 PRINT "ENTER THE SERIES REACTIVE COMPONENT (SMITH CHART ABS)
190 PRINT "ENTER THE SERIES REACTIVE COMPONENT (SMITH CHART ABS)
200 PRINT "ENTER THE SERIES REACTIVE COMPONENT (SMITH CHART ABS)
210 PRINT "ENTER THE SERIES REACTIVE COMPONENT (SMITH CHART ABS)
220 PRINT "ENTER THE SERIES REACTIVE COMPONENT (SMITH CHART ABS)
230 PRINT "ENTER THE SERIES REACTIVE COMPONENT (SMITH CHART ABS)
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770 PRINT "ENTER THE SERIES REACTIVE COMPONENT (SMITH CHART ABS)
780 PRINT "ENTER THE SERIES REACTIVE COMPONENT (SMITH CHART ABS)
790 PRINT "ENTER THE SERIES REACTIVE COMPONENT (SMITH CHART ABS)
800 PRINT "ENTER THE SERIES REACTIVE COMPONENT (SMITH CHART ABS)
810 PRINT "ENTER THE SERIES REACTIVE COMPONENT (SMITH CHART ABS)
820 PRINT "ENTER THE SERIES REACTIVE COMPONENT (SMITH CHART ABS)
830 PRINT "ENTER THE SERIES REACTIVE COMPONENT (SMITH CHART ABS)
840 PRINT "ENTER THE SERIES REACTIVE COMPONENT (SMITH CHART ABS)
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870 PRINT "ENTER THE SERIES REACTIVE COMPONENT (SMITH CHART ABS)
880 PRINT "ENTER THE SERIES REACTIVE COMPONENT (SMITH CHART ABS)
890 PRINT "ENTER THE SERIES REACTIVE COMPONENT (SMITH CHART ABS)
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960 PRINT "ENTER THE SERIES REACTIVE COMPONENT (SMITH CHART ABS)
970 PRINT "ENTER THE SERIES REACTIVE COMPONENT (SMITH CHART ABS)
980 PRINT "ENTER THE SERIES REACTIVE COMPONENT (SMITH CHART ABS)
990 PRINT "ENTER THE SERIES REACTIVE COMPONENT (SMITH CHART ABS)
100 PRINT "ENTER THE SERIES REACTIVE COMPONENT (SMITH CHART ABS)
The voltage regulator i.c. has been with us for many years, and is an almost indispensable part of the design and construction of simple, compact, and low cost regulated power supplies. Although occasional variants do appear, most regulator i.c.s are the simple three terminal type: 7805, 7812, 7815, LM340, and similar series. This situation is about to change, however, because a new American company, Linear Technology, has produced a brand new and innovative design of 5V regulator: the LT 1005CT.

The i.c. contains two voltage regulators, one providing a 'main' output with supply currents of up to 1A, and the other providing an 'auxiliary' output for lighter loads of up to 50mA. Furthermore, an 'enable' control is provided which allows the main output to be turned on and off by suitable logic or voltage control. This enable facility has no effect on the auxiliary output which remains at +5V irrespective of the state of the main output.

Both outputs are short circuit protected, and the main output has thermal shutdown protection. Again, any such shutdown or fault condition on the main output has no effect on the auxiliary output.

**POTENTIAL APPLICATIONS**

For such an apparently simple device, the LT 1005CT has a vast array of potential applications in power control and voltage regulation. Because of its unique enable circuitry it can be used as a very effective control element for motors, lamps, and many other types of d.c. equipment. Several i.c.s can be connected together with suitable timing circuitry to ensure the correct sequencing of power supplies in systems which require the power to be turned on in a certain specific order. Finally, power to a system can be split, to provide areas of RAM with power continuously. This would enable the bulk of a microprocessor system to be shut down while not in use, while certain areas of RAM could be kept powered up for the storage of important data, for example. Alternatively, any combination of ROM and RAM could be powered up or down, and data transferred between them as required.

The pin out and specifications of the LT 1005CT are shown in Fig. 1. The specifications show quite reasonable performance for both regulators; note that the 'aux' regulator can operate with input voltages down to 6.8V, half a volt less than the main regulator, making it even more suitable for battery use. Also note that the enable input to the i.c. (pin 2) can have up to 20V applied to it; even if the 'input voltage' is lower than this, no damage will be done.

**USING IT**

Fig. 2 shows a functional diagram of the i.c. As with most i.c. voltage regulators, it is good practice to bypass both the input and the outputs with capacitors, C1, C2, and C3. These should be as close to the i.c. as possible. C1 should be a 1µ tantalum bead, and the other two should be 220µ or more; 1µ tantalums will be satisfactory here, too. The use of the enable input is very simple; a logic 1 level (high) turns the main output on, and a logic 0 level (low) turns it off. It should be connected directly to pin 4 or 5 when this facility is not being used. The input is compatible with both TTL and CMOS, although a pull up resistor will be needed if open collector TTL is used.

Fig. 3 shows a simple example of a circuit using the enable facility for optimising battery usage. A potential divider formed by VR1 and R2 controls the voltage fed to the enable pin. Once the battery discharges to below a certain voltage the main output regulator is disabled. Hence, most of the circuitry is turned off and the power consumption falls. The aux output can then feed warning circuitry, critical areas of the main circuit, etc. R3 adds hysteresis to the system, without which the increase in battery voltage when the load is suddenly turned off could cause the regulator to oscillate. The aux output will continue to supply power, of course, until the battery voltage drops to approximately 6.8V.

Many applications of the LT 1005CT will fall broadly into the category shown in Fig. 4. A small block of circuitry is powered from the aux output, and this circuitry is used to control the enable input to the i.c., amongst other

---

**Table: Pinout and Specifications of LT 1005CT**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Notes</th>
<th>Min</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Max supply voltage</strong></td>
<td>All specs measured over full range of 7.5-20V d.c.</td>
<td>20</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td><strong>Quiescent current</strong></td>
<td>Measured at junction</td>
<td>0</td>
<td>125</td>
<td>°C</td>
</tr>
<tr>
<td><strong>Output voltage</strong></td>
<td>Enabled (lout = 5mA-1A)</td>
<td>4.8</td>
<td>5.2</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>Disabled (Load = 1k)</td>
<td>0.3</td>
<td>0.3</td>
<td>V</td>
</tr>
<tr>
<td><strong>Load regulation</strong></td>
<td>lout = 5mA-1A</td>
<td>25</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td><strong>Ripple rejection</strong></td>
<td>Vin = 8V, Freq = 50-500Hz</td>
<td>54</td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td><strong>Thermal regulation</strong></td>
<td>V as measured at junction</td>
<td>0.02</td>
<td>°/W</td>
<td></td>
</tr>
<tr>
<td><strong>Max output current</strong></td>
<td>1.0 A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Short circuit current</strong></td>
<td>lout = 5mA-1A</td>
<td>2.2</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td><strong>Min input voltage</strong></td>
<td>lout = 5mA-1A</td>
<td>7.3</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td><strong>Output voltage</strong></td>
<td>lout = 0-35mA</td>
<td>4.8</td>
<td>5.2</td>
<td>V</td>
</tr>
<tr>
<td><strong>Load regulation</strong></td>
<td>lout = 0-35mA</td>
<td>25</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td><strong>Line regulation</strong></td>
<td>V as measured at junction</td>
<td>1.5</td>
<td>mV/V</td>
<td></td>
</tr>
<tr>
<td><strong>Ripple rejection</strong></td>
<td>Vin = 8V, Freq = 50-500Hz</td>
<td>60</td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td><strong>Max output current</strong></td>
<td>50 mA</td>
<td>150</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td><strong>Short circuit current</strong></td>
<td>lout = 30mA</td>
<td>6.8</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td><strong>Enable input (pin 2)</strong></td>
<td>For logic 1 (high) level</td>
<td>2</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>For logic 0 (low) level</td>
<td>1</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td><strong>Max input voltage</strong></td>
<td>V as measured at junction</td>
<td>20</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td><strong>Input current</strong></td>
<td>For input of 0V</td>
<td>150</td>
<td>µA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>For input of 2.4-20V</td>
<td>1</td>
<td>µA</td>
<td></td>
</tr>
</tbody>
</table>

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TOM GASKELL B.A.(Hons)
things. This is exactly the arrangement used in this month's applications circuit. (Note that bypass capacitors C1, C2, and C3 have been omitted for clarity in Figs. 3 and 4; in practice, they are still necessary).

**APPLICATIONS CIRCUIT**

Fig. 5 shows the circuit diagram of a power supply regulator with automatic shut-down and start-up facilities. The system responds to a short on its main output by shutting down that output, eliminating the large short circuit currents which would otherwise flow for the duration of the short. The circuit tries to turn the regulator on again for brief periods every few seconds. If it fails after seven attempts it is powered from the aux supply, making it independent of any shorts or other faults in the main system.

When a short occurs, IC4d pin 11 goes to logic 1, which causes IC5a pin 3 to go to logic 0. This then causes IC5b pin 4 to go to logic 1, starting IC2 oscillating at a very low frequency. When IC5a pin 3 goes to logic 0, it also turns off the enable input to IC1, via IC5c and IC5d. The oscillator, IC2, gives out a very short pulse every three seconds, the wide mark/space ratio being achieved by the use of D2 in an otherwise standard '555' circuit. The output pulses from IC2 enable IC1 (via IC5c and IC5d) for short periods, and also clock the decade counter IC3. If the short circuit across the main output of IC1 is removed, the next pulse from IC2 will cause the main output of IC1 to go to +5V. This will produce a pulse through C4 which in turn will reset IC3 via IC4c. IC2 will be disabled via IC5b, preventing further pulses from being generated. If, however, the short remains, IC3 will count up until pin 11 goes to logic 1, at which point it will turn on the audio frequency oscillator formed by IC4b, which drives a suitable heatsink for IC1, as large currents can be passed during perfectly normal operation of the main circuitry. Many small piezo ceramic sounders will suffice for producing the warning tone, although their mounting arrangements may vary; do ensure, though, that the sounder chosen only requires a current of a few milliamps at the most; i.e. it is compatible with a suitable switch. The main output can be turned off permanently by connecting the two 'disable' pins together again via a suitable switch. D3 is lit by TR1 whenever a pulse is put out by IC2, showing that the circuit is actually 'trying' to turn on the main supply again.

**ASSEMBLY**

The Veroboard layout for the circuit is shown in Fig. 6, and is largely self-explanatory. Allow plenty of space for a suitable heatsink for IC1, as large currents can be passed during perfectly normal operation of the main circuitry. Many small piezo ceramic sounders will suffice for producing the warning tone, although their mounting arrangements may vary; do ensure, though, that the sounder chosen only requires a current of a few milliamps at the most; i.e. it is compatible
OSCOLOSCOPE Scopecs. Dual trace 10MHz £165. Regulated 0.001% 0-30V £100. R.F. Generator 100kHz-500MHz £27. C. P. Dunlop, 11 Buckingham Gardens, Hurst Park, East Molesey, Surrey KT7 9TH. Tel: 01 979 9102.

MK14 and MK 14 p.c.b. IN88060 3 x 2708 EPROM x Nascom operating system. Offers. M. Gynane, 164 Stockbridge Lane, Liverpool L36 8HE Tel: 051 449 2041.

CLEF Microsynth perfect £175. Pair OHM 100V Speakers new £150. Pair 2 x 12 180W suit disco £200. Allan Bradford, 76 Holly Lane, Aldershot, Hants. Tel: 0476 860421.


200 transistors, equivalents to popular types—s.a.e. £5. Ten large assorted IC's £10. Jon Dykes, 2 Aire Place, Winsford, Cheshire CW7 3LW. Tel: (060651 51303.

VOLTAGE STABILISER For sale. Excellent condition. Never been used. £28 each (three to sell). P. Lowman, 4 Glen View, Honiton, Devon EX14 8NT.

SWR measurement. £10 watt power amplifier: 100W. 4 x 2 12V. All as new. £20. All for £35. Flat 32, Evergreens, Butterwick, Boston, Lincs. PE22 9HF. A. Petrovic.

CASES, i.c.s., components, key, locks, alarms books, displays, etc. List large s.a.e. No callers please. G. A. Noble, 50 Crotthill Road, Slough, Berks. SL2 1HF.


OLIVETTI PR 1350 dot matrix printer. Complete with service and reference manuals. £130 o.n.o. or swap. Twin beam oscilloscope.

RELIABLE circuit diagram wanted for 78-1MHz Portable transceiver. Project for local A.T.C. cadets (amplitude modulated). R. K. Rees, 16 Eskdale Road, Telford Estate, Shrewsbury. Salop SY2 5UE. Tel: Shrewsbury 59340.

ZX81 wanted. Must be in good condition. Swap for 30 pounds of electronic components. Steven McNeil, 35 Sutors Avenue, Nairn IV12 5AZ.

COLLECTOR seeks any old transistors and diodes. Good prices paid for rare specimens. Write for details. Andrew Wylie, 18 Rue De Laume, 1201 Geneva, Switzerland.

APPLE II Europlus 48K + software + books. Private ownership v.g.c. £500 o.n.o. For details telephone 01 981 0604 (evenings).

ZX81 + 16K with 11 software tapes including ZX Chess II and set of quizzes. Tel: 01 361 0930. M. Hollingworth, 17 Leslie Rise, Tividale, West Midlands. (Not on phone).
For groups, bands, discos and amateur dramatics, this compact portable unit comprises a lighting mixer allowing two eight channel sections of lighting to be set and changed over with manual or automatic crossfade. Each channel also has a flash button which can both increase and reduce light output. In addition to the mixer there is an eight program automatic super chaser with optional crossfading between stages and two sound to light effects. Finally there are four independent controls for projectors, mirror balls etc.

**CAMERA TRIGGER**

An ultrasonic system particularly useful for wild life photography. In effect this unit allows the subject to take its own photograph. Straightforward construction with variable time delay.

**FEATURE ARTICLE**

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2000V 5p £0.24
6000V 5p £0.24
Diods £0.35 each
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DIL

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Stocking parts other stores cannot teach!

RESISTORS

<table>
<thead>
<tr>
<th>Value (Ω)</th>
<th>Grade</th>
<th>Qty.</th>
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<tbody>
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<td>400</td>
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<tr>
<td>10 2W</td>
<td>±1%</td>
<td>100</td>
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<tr>
<td>100 1W</td>
<td>±1%</td>
<td>100</td>
</tr>
<tr>
<td>1 2W</td>
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<td>100</td>
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<tr>
<td>1K 1W</td>
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WIRE

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<td>2540502</td>
<td>0.50mm²</td>
<td>Blue &amp; Black</td>
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<tr>
<td>2726101</td>
<td>0.32mm²</td>
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SOLDER

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VIBRO

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RECHARGE BATTERIES

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POLYCARB 95% DISC PLATE

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SOLDERING IRON (150W)

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HIGH VOLTAGE CAPACITORS

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VACUUM TUBE TESTER

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