PE TELETEXT

with INFRA-RED REMOTE CONTROL

Also inside...

PE MAGNUM ... METAL LOCATOR
NEW GIANT SUPERPRINTS
PLUS FREE FILM
for every one you send for processing
by the Practical Electronics
Colour Print Service

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Photography can cost you a lot less these days if you know how to go about it. Hundreds of thousands of magazine readers are delighted with this reliable Colour Print Service — and the replacement films that come FREE every time they use it! So why don’t you give it a try? Here’s what you do. Send any make of colour print film inside the envelope enclosed in this issue. Or fill in the coupon below and send it with your film in a strong envelope to: Practical Electronics Colour Print Service, Freepost, Teddington, Middlesex, TW11 8BR. No stamp is required.

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One album voucher is sent with each film we process. Collect 3 vouchers and we send you a set of FREE album sheets.

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From: Practical Electronics Colour Print Service, Freepost, Teddington, Middlesex, TW11 8BR. Please print my film Superprint/Standard Enprint size (delete size which is not required).

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Postcode __________________________

Prints are normally despatched within four working days of receipt of film.
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OUR SEPTEMBER ISSUE WILL BE ON SALE SATURDAY, 16 AUGUST 1980
(for details of contents see page 29)
Casio Pocket and Clock

Casio FX-100D, £45.00. 10 digit, 5 scientific functions with 6 fixe, 120 memory locations. 14.5x9.5x2cm. £19.00.

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WITH LIGHT SHOW & DISPLAY

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AP200 2000W 6CH £119

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Access/Barclaycard. Telephone orders accepted For Credit Sales & Enquiries Ring SUE ABBEGG (01) 864 8007/0988

TRANSFORMERS + VAT 15%

<table>
<thead>
<tr>
<th>TRANSFORMER</th>
<th>12 OR 24V OR 0-12 OR 24V</th>
<th>PRICE</th>
<th>P.P.</th>
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<tr>
<td>30 VOLT RANGE</td>
<td>Pri 220/240V Voltages available 3, 5, 8, 9.10, 12, 15, 20, 24, 30, 60 or 120V-0-15V-120V</td>
<td>Deposit £74</td>
<td>£12 mth &amp; £9.22 &amp; 24 mth = £5.17</td>
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CONTINUOUS RATINGS
All voltages given are at full load

<table>
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<th>TRANSFORMER</th>
<th>REF</th>
<th>AMPS</th>
<th>PRICE</th>
<th>P.P.</th>
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<tr>
<td>30 VOLT RANGE</td>
<td>Pri 220/240V Voltages available 3, 5, 8, 9.10, 12, 15, 20, 24, 30, 60 or 120V-0-15V-120V</td>
<td>Deposit £74</td>
<td>£12 mth &amp; £9.22 &amp; 24 mth = £5.17</td>
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AUTO TRANSFORMERS
Voltage for step up or step down

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<th>TRANSFORMER</th>
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<th>PRICE</th>
<th>P.P.</th>
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<tr>
<td>Mains Eliminator</td>
<td>6-3500</td>
<td>100W</td>
<td>£24.80</td>
<td>£19.80</td>
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</tbody>
</table>

TERMS
20% Deposit
200 WATT
100% VAT

£30 FREE!

Vouchers with our new disco counter over 200 items of
disco systems, lighting and accessories. Send £1.00 now.

EXAMPLES:
- Fuzz lights £26.75
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- Echo chambers £77.50
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Mixers, mics, amplifiers,
grooves, light units, buble machines, mirror ball, helicopers, bins, consoles, and much more.

AND IF WE HAVEN'T GOT IT - WE'LL GET IT!

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NEAREST TUBE STATIONS: ALDGATE & LIVERPOOL STREET

3

Practical Electronics August 1980
Also our Micro chips are at micro prices. Don’t be fooled by low price. We do not offer for
Colleges, Universities and Authorities accepted. Please refer to “Ordering Information” before ordering. Official orders from Schools, Colleges, Universities and Government Departments.

<table>
<thead>
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<th>Component</th>
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Practical Electronics August 1980
D.I.Y. KITS FOR SYNTHESISERS, SOUND EFFECTS

PHONSONICS

MAIL ORDER SUPPLIERS OF QUALITY PRINTED CIRCUIT BOARDS, KITS AND COMPONENTS TO A WORLD-WIDE MARKET

P.E. MINISONIC MK2 SYNTHESISER
A portable mains operated miniature sound synthesiser with keyboard controls. Although having slightly fewer facilities than the large Formant and P.E. synthesizers the functions offered by this device is large and versatile.
Set of basic components kits (incl. KBD & having pots – see list for options available) and PCBs (incl. leaflet chart).
“Sound Design” booklet £0.10

P.E. 128-NOTE SYNTHESISER
Enables a voltage controlled synthesiser to automatically play pre-programmed tunes of up to 32 pitches and 128 notes long. Programs are keyboard initiated and note length and rhythmic pattern are externally variable.
Set of basic comps, PCBs and charts.
Set of text photocopies KT76-7 £39.90

P.E. 160-NOTE SYNTHESISER
Sequences of up to 16 notes may be programmed by the user using external panel controls and fed into most voltage controlled synthesizers.
Set of basic comps, PCBs and charts.
Set of text photocopies £1.36

P.E. STRING ENSEMBLE
A multi-speed polyphonic string instrument synthesizer.
Set of basic comps, PCBs & charts
KT77-9 £107.86

ELEKTOR ELECTRONIC PIANO
A flexible musical production unit using the least integrated circuit techniques for the keyboard and envelope shaping, and virtually eliminating “bee-hive” noise inherent in previous electronic instruments.
5-octave set of basic comps and PCBs (as publ.)
KT80-9 £146.86
Additional 3-octave extension and basic parts and PCBs (as published)
KT80-10 £56.36
Set of text photocopies £1.81

ELEKTOR FORMANT SYNTHESISER
A very sophisticated synthesiser for the advanced constructor who puts performance before price.
Set of basic comps, PCBs (as publ.)
KT66-4 £262.48
Set of text photocopies £7.83

ELEKTOR DIGITAL REVERB UNIT
A very advanced unit using sophisticated i.e. techniques instead of mechanical spring lines. The basic delay range of 24 to 90mS can be extended up to 450mS using the extension unit. Further delays can be obtained using more extensions.
Main unit basic comps and PCB (as publ.)
KT78-5 £150.40
Extension unit basic comps and PCB (as publ.)
KT78-6 £56.77
Text photocopies £16p

ELEKTOR ANALOGUE REVERB
Using L.C. instead of spring lines the main unit has a maximum of delay up to 100mS, and the additional set extends this up to 200mS. May be used in either mono or stereo mode.
Main unit basic component set
KT83-1 £195.48
Additional basic components
KT83-2 £205.07
PCB (as publ. to hold both kits) PC99973 £6.52
Text photocopies £67p

ELEKTOR RING MODULATOR
Compatible with the Formant & most other synthesizers.
Set of basic comps & PCB (as publ.)
KT97-2 £16.84
Text photocopies £38p

NEW KITS

ELEKTOR CHOROSYNTH
A 24-octave Chorus synthesizer with an amazing variety of sounds ranging from violin to cello and flute to clarinet amongst many other fascinating constructors can readily extend the octave coverage.
Basic comps, PCBs and charts but excl. sw.
KT108 £44.39
Text photocopy 70p

ELEKTOR SEVAR
For use with Elektor analogue reverber to give greater flexibility to the reverber effects.
Basic comps, PCB (as publ.)
KT101-1 £22.53
Text photocopy 60p

ELEKTOR FUNNY TALKER
Incorporates a ring modulator, chopper & frequency modulator to produce fascinating sounds when used with speech & music signals.
Basic comps, PCB (as publ.)
KT99-1 £9.60
Text photocopy 60p

ELEKTOR FREQUENCY DOUPLIER
For use with guitars & other electronic instruments to produce an output one octave higher than the input. Inputs and outputs may be mixed to give greater depth.
Basic comps, PCB (as publ.)
KT98-1 £5.48
Text photocopy 20p

P.E. SPLIT-PHASE TREMOLO
A simple but effective substitute for a rotary cabinet. The output of an internal generator is phase-split and modulated by an input signal from an electronic guitar or other instrument. Output 1 octave lower & rate variable. May be fed to one or two amplifiers.
Basic comps, PCB & chart
KT102-3 £17.58
Text photocopy 85p

P.E. MINISONIC WAVEFORM CONVERTER
A simple converter that modifies the Minisonic sawtooth waveform to produce triangle and sine outputs. Ideally one should be used with each Minisonic VCO.
Basic comps. PCB & chart KT96-1 £3.98

DISCO-CROSS FADER
The cross-fade between 2 decks is switch-initiated and can be preset on the panel for a cross fade of between 1 sec & 24 sec. Binaslly a stereo unit but may be used in mono.
Basic comps, PCB & chart KT94-1 £11.83

P.E. GUITAR MULTIPROCESSOR
An extremely versatile sound processing unit capable of producing, for example, flanging, vibrato, reverb, fuzz and tremolo as well as other fascinating effects. May also be used with most electronic instruments.
Set of basic comps, PCBs & charts
KT85-5 £54.66
Text of set photocopies £2.52

P.E. AUTOMATIC TREMOLO
Converts a saw-tooth waveform into sawtooth, mark-space sawtooth, regular triangle, or square-wave with variable mark-space.
Basic comps. PCB & chart KT98-1 £9.68
Text photocopy 60p

ELEKTOR WAVEFORM CONVERTER
Converts a saw-tooth waveform into sinewave, mark-space sawtooth, regular triangle, or square-wave with variable mark-space.
Basic comps. PCB & chart KT98-1 £9.68
Text photocopy 60p

P.E. AUTO-WAH UNIT
Automatically gives vibrato or swell sounds with each note played.
Basic components, PCB & chart KT75-1 £6.73
Text photocopy 16p

P.E. PITCH CHANGER
The well acclaimed and highly versatile large scale mains operated synthesiser. Other circuits in our list may be used with it to good advantage.
Basic comps, PCBs & charts
KT55-1 £13.74

ELEKTOR VIBRATO UNIT
Maintains the natural attack whilst extending note duration.
Basic components, PCB & chart KT75-1 £6.73
Text photocopy 16p

P.E. AUTO-WAH UNIT
Automatically gives vibrato or swell sounds with each note played.
Basic components, PCB & chart KT58-1 £9.68
Text photocopy 60p

ELEKTOR WAVEFORM CONVERTER
Converts a saw-tooth waveform into sinewave, mark-space sawtooth, regular triangle, or square-wave with variable mark-space.
Basic comps. PCB & chart KT85-5 £54.66
Text of set photocopies £2.52

P.E. SWITCHED TONE TREBLE BOOST
Provides switched selection of 4 preset tonal responses.
Basic components, PCB & chart KT89-1 £4.54
Text photocopy 78p

P.E. TREBLE BOOST UNIT
A simple treble boost unit with manual control depth.
Basic components, PCB & chart KT53-1 £2.92

P.E. SYNTHESISER
The well acclaimed and highly versatile large scale mains operated synthesizer. Other circuits in our list may be useful with it to good advantage.
Basic comps, PCBs & charts
KT55-1 £13.74

PRONOSONICS - DEPT PE83 - 22 HIGH STREET - SIDCUP - KENT DA14 6EH

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U.K. orders: £2.00 inc. VAT. Overseas orders add £2.00 to total cost. Most orders must be added to total cost of kits, discount post & handling on all U.K. orders. Overseas orders: Contact our Sales Dept. for applying to Exports, or photocopies.

ADD: 15% VAT (or current rate if changed). Must be added to full total of kits, discount post & handling on all U.K. orders. Overseas orders: Contact our Sales Dept. for applying to Exports, or photocopies.

EXPERIMENTAL ORDERS ARE WELCOME but to avoid delay we request you to state your order for postage rates. All payments must be made in good writing order. In sterling or International Money Order or through an English Bank. To the nearest £1, please add.

TERMS: C.O.D. MAIL ORDER OR COLLECTION BY APPOINTMENT (TEL 01-320 6164)

August 1980
KIMBER-ALLEN KEYBOARDS AND CONTACTS

KIMBER-ALLEN KEYBOARDS as required for many published projects. The manufacturers claim that these are the finest moulded plastic keyboards available. All octaves are C to C, the keys are plastic, spring-loaded, fitted with actuators, and mounted on a robust aluminium frame.

3 Octave (£7.62) 4 Octave (£8.19) 5 Octave (£8.75)

CONTACT ASSEMBLERS (gated-plied wire) = 1 required for each KBD note:
- Type GJ = SPDQ 33p ea.
- Type GA = 1 pr of contacts, normally open 33p ea.
- Type GB = 2 pr NO 37p ea.
- Type APS = 3 pr NO/NO 37p ea.

P.E. V.C.F.
A voltage controlled filter extracted from P.E. Minisonic project.
Basic components, PCB & chart KIT 65-1 £8.45

P.E. RING MODULATOR
Extracted from P.E. Minisonic project.
Basic components, PCB & chart KIT 59-1 £6.35

WIND & RAIN EFFECTS UNIT
A slightly modified version of the original P.E. unit.
Basic components, PCB & chart KIT 28-1 £8.84
Text photocopy 28p

P.E. ENVELOPE SHAPER WITHOUT VCA
Provides full manual control over attack, decay, sustain and release functions, and for use with an existing VCA.
Basic components, PCB & chart KIT 44-1 £6.73
Text photocopy 49p

P.E. ENVELOPE SHAPER WITH VCA
Has an integrated Voltage Controlled Amplifier, and has full manual control over the A.D.S.R. functions.
Basic components, PCB & chart KIT 50-1 £9.03
Text photocopy 58p

P.E. TRANSIENT GENERATOR
An ADSR envelope shaper without VCA, and additionally providing Repeat-triggering enabling a synthesiser to be programmed for mandolin or banjo effects.
Basic components, PCB & chart KIT 63-2 £7.62
Text photocopy 58p

P.E. EXTERNAL-INPUT SYNTHESISER-INTERFACE
Allows external inputs such as guitars, microphone etc., to be processed by synthesiser circuits.
Basic components, PCB & chart KIT 81-1 £3.90

P.E. TUNING FORK
Produce 84 switch-selected frequency-accurate tones with an LED monitor clearly displaying beat-note adjustments.
Set of basic components, incl. power supply, PCBs & charts KIT 48-3 £23.32
Text photocopy 97p

P.E. TUNING INDICATOR
A simple 4-octave frequency comparator for use with synthesizers and other instruments where the full versatility of KIT 48 is not required.
Basic components, PCB & chart, but excl. sw. KIT 69-1 £6.15
Text photocopy 56p

P.E. DYNAMIC RANGE LIMITER
Preset to automatically control sound output levels.
Basic components, PCB & chart KIT 62-1 £5.31

P.E. CONSTANT DISPLAY FREQUENCY COUNTER
A 4-digit counter for Hz to 99kHz with Hz sampling rate. Readouts do not count visibly or flicker due to blanking.
Basic components, PCB & chart KIT 79-4 £31.35
Text photocopy 79p

P.E. 6-CHANNEL MIXER
A high specification stereo mixer with variable input impedances.
Basic components, PCBs & charts.
KIT 90-8 £81.28
Extra 2-channel set with PCB KIT 90-9 £11.62
Set of Test photocopies £15.60

STEREO HEADPHONE AMPLIFIER
Extracted from P.E. 6-channel mixer.
Basic components, PCB & chart KIT 92-1 £5.68

DIGITAL EXPOSURE UNIT
Controls up to 750 watts in 1 second steps up to 10 minutes, with build-in audio alarm.
Basic components, PCBs & charts KIT 53-3 £23.27
Text photocopy 12p

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A channel light show controller giving a choice of sequential, random, or full strobe mode of operation, and with extra audio input.
Basic components, PCB & chart KIT 57-2 £25.12
Text photocopy 78p

RHYTHM GENERATORS
Several available, including programmable 16 beat 64-pattern, 128 beat almost infinite patterns, and pre-programmed 15 pattern using either M252 or M253 rhythm chips. A selection of effects instrument circuits is also available.

P.E. VOICE OPERATED FADER
For automatically reducing music volume during talkover – particularly useful for discos.
Basic components, PCB & chart KIT 30-1 £4.37
Text photocopy 29p

P.E. DYNAMIC NOISE LIMITER
Very effective stereo circuit for reducing the noise found in most tape recordings.
Basic components, PCB & chart KIT 37-1 £9.07
Text photocopy 79p

PHONOSONICS

PRICES ARE CORRECT AT TIME OF PRESS.
E & O.E. DELIVERY SUBJECT TO AVAILABILITY.

AND OTHER PROJECTS

PHOTOGRAPHS in this advertisement show two of our units containing some of the P.E. projects built from our kits and PCB's. The cases were built by ourselves and are not for sale through a small selection of other cases is available.

LST—Send stamped addressed envelope with all U.K. requests for free live giving fuller details of PCBs, kits and other components.

OVERSEAS enquiries for list Europe—send 33p; other countries—send 75p.

P.N. 968 C.H. 4 Octave (49 notes)

25.12 £39.75
28p £25.12
58p £23.27
49p £11.62
78p £4.37
28p £97p
45p £23.32
23p £7.62
58p £23.27
£32.25
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PRICES ARE CORRECT AT TIME OF PRESS.
Battery protection (80109). Forgetting to turn off the headlights need no longer be a motorist’s nightmare. The project is designed to monitor the battery voltage and switch off the lights automatically in all kinds of motor vehicles. £5.15

Transistor ignition (80084). A system which combines all the most significant advantages of the different systems including the conventional system. £20.45

A dip-stick probe (80102). There are all kinds of indicators and warning lights in modern cars, but in all oil temperature indicators are rare. The easiest way to add this type of indicator to an existing car is to mount a thermometer in the dip-stick. Project without dip-stick £3.65 Dip-stick with indicator (short) £11.00 Dip-stick with indicator (long) £11.45

Intelligent wiper delay (80086). This wiper delay only needs to be told once what is required of it. It will then carry out your orders until you change them, which you can at any time, instantly. £15.85

Active car serial (80088-1+2). If there is one place to use a good aerial in a car. £13.85

Stop thief! (80097). There are all sorts of systems for protecting cars, but this one is unusual; it is discretion, rather than protection... £4.20

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HOW TO ORDER
Send a cheque or postal order to Doram Electronics Ltd, Planty House, Market Place, Swaffham, Norfolk PE37 7QH. All prices include VAT, please add 40p for postage and packing. 24 Hour Answering Service available for ACCESS orders.

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System One is complemented by a range of totally compatible eurocards including:

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<th>Description</th>
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<tr>
<td>8K+8K Static RAM and EPROM</td>
<td>£95</td>
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<td>Colour Prestel Compatible VDU Interface</td>
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<td>Versatile (serial, parallel, RS232 etc) Interface</td>
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<td>Printer Interface (for 12 data 3 strobe)</td>
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<td>Laboratory Interface (isolated inputs, high current outputs)</td>
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<td>6809 CPU Card</td>
<td>£98</td>
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<tr>
<td>Professional Keyboard (parallel ASCII encoded)</td>
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<td>AIM 65 Bus Interface adaptor</td>
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Available soon:
- 80 x 24 character VDU Interface
- 32K Dynamic RAM Card
- 5V/12V Switched mode power supply (1” deep)
- In circuit emulator (block relocating)

...and the absolute professional
System Three

System 3, contains the 6502 CPU, 16K RAM with DOS and BASIC, VDU Interface, Disc controller and 5” drive, Printer Interface, backplane and power supplies. The entire unit costs about £1,000 and can be added to or reformatted as required.

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The CT4000 has been designed to present the same fun off of hour outputs at four times per day in 7 days in advance, enabling the unit to control tape recorders, appliances, central heating, lights, toys, garage doors etc. The times are set on a 0.1" high red LED display by means of a keyboard and the output states are displayed on four LEDs. Each output can switch up to 20mA at 9V. For mains loads use our Solid State Relay for more than 20mA switching.

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MINI KITS

These kits form useful subsystems which may be incorporated into larger designs or used alone. Kits include PCB, short instructions and all components.

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Ideal for switching motors, lights, heaters etc. from logic. O.Drive isolation with zero voltage switching. Supplied without triac. Select the required triac from our range. £2.80

Mk3 B.A.R/Dot Display
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Mk4 Proportional Temperature Controller
Based on the TDA1024 2.5V swinging switch, this kit may be used to form a "burn in" power controller or a "proportional temperature" controller enabling the temperature of an enclosure to be maintained to within ±0.5°C. 1.8K 6.25 3K 5.55

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Based on the Z1034/2 Timer IC this kit will control a mains load on/off for a preset time from 20 minutes to 15 hours. Longer or shorter periods may be realised by mixing component changes. Maximum load 1KW £4.50

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Practical Electronics August 1980
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1µF to 10,000µF £24 range
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10,000µmF
Voltage ranges 25v: 40v: 63v:
100v: 150v: 220v: 250v:
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Prices £0.07 to £0.63.

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The Kit contains all parts needed to
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We also offer a calibration service
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The multimeter is also available fully assembled
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Practical Electronics August 1980
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**GENTS QUARTZ LCD**
- Hours, minutes, secs, month, date, backlight.
- Only £4.95

**GENTS QUARTZ LCD**
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- Slim Chronograph. 11-function. Hours, mins, secs, 6 digit-month, date, day of week, 1/100 sec stopwatch, split and lap modes, backlight.
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Send stamped addressed envelope for Colour Brochure of 120 other bargains.
Britain's first complete computer kit.

**The Sinclair ZX80.**

£79.95

**Price breakdown**
- ZX80 and manual: £69.52
- VAT: £10.43
- Post and packing FREE

Please note: many kit makers quote VAT-exclusive prices.

You've seen the reviews... you've heard the excitement... now make the kit!

This is the ZX80. 'Personal Computer World' gave it 5 stars for 'excellent value.' Benchmark tests say it is faster than all previous personal computers. And the response from kit enthusiasts has been tremendous.

To help you appreciate its value, the price is shown above with and without VAT. This is so you can compare the ZX80 with competitive kits that don't appear with inclusive prices.

'Excellent value' indeed!

For just £79.95 (including VAT and p&p) you get everything you need to build a personal computer at home... PCB, with IC sockets for all ICs, case, leads for direct connection to a cassette recorder and television (black and white or colour); everything!

Yet the ZX80 really is a complete, powerful, full-facility computer, matching or surpassing other personal computers at several times the price.

The ZX80 is programmed in BASIC, and you can use it to do quite literally anything from playing chess to managing a business... from playing the ZX80 to building a personal computer at home.

Your ZX80 kit contains...

- Printed circuit board, with IC sockets for all ICs.
- Complete components set, including all ICs - all manufactured by selected world-leading suppliers.
- New rugged Sinclair keyboard, touch-sensitive, wipe-clean.
- Ready-moulded case.
- Leads and plugs for connection to domestic TV and cassette recorder. (Programs can be SAVEd and LOADed on to a portable cassette recorder)
- FREE course in BASIC programming and user manual.
- **Optional extras**
  - Main adaptor of 600 mA @ 9 V DC nominal unregulated (available separately - see coupon).
  - Additional memory expansion boards allowing up to 16K bytes RAM. (Extra RAM chips also available – see coupon).

*Use a 600 mA @ 9 V DC nominal unregulated mains adaptor. Available from Sinclair if desired (see coupon).

The unique and valuable components of the Sinclair ZX80:

- The ZX80 is not just another personal computer. Quite apart from its exceptionally low price, the ZX80 has two uniquely advanced components: the Sinclair BASIC interpreter, and the Sinclair BASIC manual.
- The unique Sinclair BASIC interpreter offers remarkable programming advantages:
  - Unique 'one-touch' key word entry: the ZX80 eliminates a great deal of tiresome typing. Key words (RUN, PRINT, LIST, etc.) have their own single-key entry.
  - Unique syntax check. Only lines with correct syntax are accepted into programs. A cursor identifies errors immediately. This prevents entry of long and complicated programs with faults only discovered when you try to run them.
  - Excellent string-handling capability - takes up to 26 string variables of any length. Strings do not need to be dimensioned. Strings can undergo all relational tests (e.g. comparison).
  - BASIC language also handles full Boolean arithmetic, conditional expressions, etc.
- Exceptionally powerful edit facilities, allows modification of existing program lines.
- Randomise function, useful for games and secret codes, as well as more serious applications.
- Timer under program control.
- PEEK and POKE enable entry of machine code instructions, USR causes jump to a user's machine language sub-routine.
- High-resolution graphics with 22 standard graphic symbols.
- All characters printable in reverse or under program control.
- Lines of unlimited length.

Fewer chips, compact design, volume production - more power per pound!

The ZX80 owes its remarkable low price to its remarkable design: the whole system is packed on to fewer, newer, more powerful and advanced LSI chips. A single SUPER ROM, for instance, contains the BASIC interpreter, the character set, operating system, and monitor. And the ZX80's 1K byte RAM is roughly equivalent to 4K bytes in a conventional computer - typically storing 100 lines of BASIC. (Key words occupy only a single byte.)

The display shows 32 characters by 24 lines. And benchmark tests show that the ZX80 is faster than all other personal computers.

No other personal computer offers this unique combination of high capability and low price.
The Sinclair teach-yourself BASIC manual.

If the specifications of the Sinclair ZX80 mean little to you – don’t worry. They’re all explained in the specially-written 128-page book free with every kit! The book makes learning easy, exciting and enjoyable, and represents a complete course in BASIC programming – from first principles to complex programs. (Available separately – purchase price refunded if you buy a ZX80 later.) A hardware manual is also included with every kit.


The ZX80 kit costs a mere £79.95. Can’t wait to have a ZX80 up and running? No problem! It's also available, ready assembled, for only £99.95.

Demand for the ZX80 is very high: use the coupon to order today for the earliest possible delivery. All orders will be despatched in strict rotation. We’ll acknowledge each order by return, and tell you exactly when your ZX80 will be delivered. If you choose not to wait, you can cancel your order immediately, and your money will be refunded at once. We want you to be satisfied beyond all doubt – and we have no doubt that you will be.

ZX80 software – now available!

See the advertisements in Personal Computer World (June) and Electronics Today International (July).

New dedicated software – developed independently of Science of Cambridge – reflects the enormous interest in the ZX80. More software available soon – from leading consultancies and software houses.


To: Science of Cambridge Ltd, 6 Kings Parade, Cambridge, Cambs., CB2 1SN.

Remember: all prices shown include VAT, postage and packing. No hidden extras.

Please send me:

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<td>Includes ZX80 BASIC manual, excludes mains adaptor.</td>
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<td>Mains Adaptor(s) (600 mA at 9 V DC nominal unregulated).</td>
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<td>Memory Expansion Board(s) (each one takes up to 3K bytes).</td>
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<td>RAM Memory chips – standard 1K bytes capacity.</td>
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<tr>
<td></td>
<td>Sinclair ZX80 Manual(s) (manual free with every ZX80 kit or ready-made computer).</td>
<td>5.00</td>
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TOTAL £

NB. Your Sinclair ZX80 may qualify as a business expense.

I enclose a cheque/postal order payable to Science of Cambridge Ltd for £

Please print

Name: Mr/Mrs/Miss

Address

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Tel: 0223 311488.

Practical Electronics August 1980
The pack contains all the electronic components to build the radio, you supply only the wire and solder as featured in the Practical Electronics March issue.

The P.E. Traveller features pre-set tuning with five push button options, black illuminated tuning scale, with matching rotary control knobs, one, combining on/off volume and tone-control, the other for manual tuning, each set on wood simulated fascia.

The P.E. Traveller has a 6 watts output, negative ground and incorporates an integrated circuit output stage, a Mullard IF module LP1181 ceramic filter type, pre-aligned and assembled and a Bird pre-aligned push button tuning unit. The P.E. Traveller fits easily in or under dashboards.

Complete with instructions.

**CONSTRUCTORS PACK 7A**

Suitable stainless steel fully retractable locking aerial and speaker (approx 6" x 4") is available as a kit complete.

£1.95 Per Pack, p & p £1.00.

Pack 7A may only be purchased at the same time as Pack 7.

NOTE: Constructor's Pack 7A sold complete with radio kit £15.20 including p&p.
PE TELETEXT

BACK in June '79 an announcement was made that we would be publishing a Teletext system in the near future. A lecture on Teletext was presented by PE at the Great British Electronics Bazaar and development was under way. Since that time our Projects Editor David Shortland has been developing a system. Why has it taken so long? A brief look at the problems we have had to overcome will answer this question and we are sure will be interesting to all readers.

The PE Teletext was first discussed at a meeting in London involving two representatives of Mullard (who had developed the chips and system we were to use), a director and technical representative of Marshall's (who were, as a Mullard distributor, to provide parts and technical expertise) and the Editor.

After that meeting things started to move quite fast, a range of components and boards were supplied by Marshall's and David set to work building a system that would interface directly to the set. It was felt that this was the most satisfactory way to obtain the quality of picture we required, and Mullard claimed to have a number of interface circuits for various sets that they would make available to us.

Work proceeded at a reasonable pace until David came to build the interface board to match the system to his own Philips set. Mullard provided a "circuit idea" which did not give enough information, so David approached Philips who were using the chips in their set. Philips of course own Mullard so we expected some "company" line and agreement.

Philips informed us that what we were trying to do would not work. A visit to Philips followed. More investigation and more questions to Mullard indicated that the interface circuits they had supplied were theoretical. What was more worrying was that we were discovering a very high proportion of existing sets were not suitable for a direct interface, mainly due to the i.f. not being good enough.

Having wasted a few months because of misleading information we decided that we had two options: 1) Drop the whole thing, 2) Redesign to incorporate a.u.h.f. modulator so that the system could plug in the aerial socket of any set.

We chose the latter option, Marshall's supplied more parts and David started work again. The system looked good, we planned publication for the April issue and were only waiting for a colour modulator board to set the whole thing up for cover shots. Then more problems, the quality of the final picture was not up to the standard we required and relied too heavily on a high signal strength. A criticism we had of other systems and a problem we were determined to avoid.

It looked for the second time as if the whole project would come to grief. This time we were saved by some developments at Mullard. A new PAL encoder chip had been developed and Mullard kindly supplied us with pre-production units to try in our system. The new chips worked well and at last we had the quality we were after.

But wait! Mullard had yet to decide to produce the chip so again we were in danger of loosing the project. Luckily they have gone ahead and we are finally able to publish the long awaited system.

The change to an external plug-in unit and the use of the new developments from Mullard have pushed up the anticipated price. But we believe the quality now available is better than any other plug-in system and we are proud to bring you PE Teletext.

The story has been shortened—for instance, our main contact at Mullard left and Marshalls' technical man left before we had got very far. Some of the chips originally used are now in short supply, so alternatives have had to be found. David's wife gave birth to twins, severely testing his development time and concentration! Looking back it's a wonder anything came forth. Part one starts on page 38.

Mike Kenward.
Market Place

Items mentioned are usually available from electronic equipment and component retailers advertising in this magazine. However, where a full address is given, enquiries and orders should then be made direct to the firm concerned. All quoted prices are those at the time of going to press.

by
David
Shortland

GUNNED DOWN
Anyone who is rewiring their house, or installing microbore central heating pipes would find their job made easier by the use of one of the Arrow range of tacking guns, now available from Telequip of Bristol.

Four different sizes of gun and twelve different sizes of staple are available, and cable sizes from 5 to 15mm diameter can be fastened with a considerable saving in time and money over conventional cable clips.

All guns retail at £20.90 plus VAT, and further details of the range can be obtained from: Telequip, 2 Oakfields Road, Clifton, Bristol BS8 2AL. (0272 312271)

ERASE YOUR EPROMS
A range of ultraviolet EPROM erasers, manufactured by the U.S. Spectronics Corporation, is now available in this country from Chiptech Ltd.

Claimed to be the fastest and most efficient erasers of their size on the market, they have been designed primarily for the small systems and computer enthusiast at a cost which is well within their reach.

The cheapest of the range, the PE-14, has the capacity to erase up to 6 EPROM chips in as little as 19 minutes. A similarly rated unit, the PE-14T, is fitted with a 60-minute timer to automatically shut off the unit.

The PE-24T, which is a faster and more powerful version of the PE-14 series, will erase up to 9 EPROMS at once, in as little as 15 minutes.

All erasers are fitted with safety interlocks and housed in gold anodised aluminium casings, which combine to make them extremely safe.

Prices for the range are as follows: PE-14—£56; PE-14T—£76.58; PE-24T—£111.22. Further information is available from: Chiptech Ltd., Unit 1, Tewin Court, Welwyn Garden City, Hertfordshire AL7 1AU. (07073 33260)

SAXON CATALOGUE
Saxon Entertainments are well known among the disco fraternity, and their 1980 catalogue is now available, and packed with everything from jack plugs to complete disco consoles.

Saxon's comprehensive range includes some exciting lighting effects units, and as well as the "pay and play" complete systems, there are chassis speakers, turntables, cabinet fittings—in fact everything you need to build your own disco system.

The catalogue also contains ten vouchers worth a total of £30. One voucher may be used towards each £30 worth of equipment purchased.

To obtain your copy of the catalogue, send £1 to: Saxon Entertainments 327/333 Whitehorse Road, West Croydon, CR0 2HS (01-684 0098)

PET PROGRAMMER
A hardware/software package which turns the Commodore Pet into a powerful and flexible programmer for 4K type 2532/2732 EPROMs is now available from GR Electronics Ltd. of Newport, Gwent. It complements the company's existing programmer for.

WORK CENTRE
One of the best multi-position work holders to come on the market so far is the new 324 work-centre, made by Panavise and distributed by Toolrange, which provides a versatile and compact unit for constructors working on p.c.b.s.

The 324 consists of the 312 Tray Base mount with six useful component compartments, the standard 300 vice base, permitting positioning through a 360 degrees hemisphere, the 315 P.C.B. Holder and the 371 Solder Station.
GOT A LIGHT, MIC?

A new, small, lightweight microphone, with appearance, handling and performance features ideally suited to highly professional on-cameras or on-stage use, has been announced by Shure Electronics Limited.

Designated the SM63-CN, the new unit is less than six inches long and weighs only 2.8 oz., making it significantly more comfortable to handle and considerably less obtrusive in performing situations than any other comparable microphone.

Owners of the 3016, large keyboard Pet who use the package to give themselves up to 12K of custom-written firmware housed in the machine's three spare EPROM sockets. Older type 2001 Pets can also benefit, but using an adaptor for the memory expansion connector.

The new programmer is for 5V rail type 2532/2732 EPROMs, and comprises a plug-in circuit board which uses the IEEE port for data, the user port for control lines and takes 5V power from the Pet's external cassette drive. Full EPROM programming software is supplied on cassette, with functions including READ/WRITE to and from RAM and EPROM, sequencing, verification and READ/WRITE/MODIFY with addresses and data in hex.

And extension socket is also available for the convenience of users programming EPROMs in batches. It incorporates a header, extension cable and plinth-mounted zero insertion force socket which allows all device handling to be carried out adjacent to the Pet's keyboard.

Although both 2532 and 2732 (Intel) EPROMs can be programmed with the GR Electronics device, only the 2532 is directly compatible with the new Pet's internal ROM sockets.

The price of the programmer board and software is £80 plus VAT, and the extension is £35 plus VAT. Both may be obtained direct from GR Electronics Ltd, Fairoak House, Church Road, Newport, Gwent NP7 7EJ. (0633 214147)

SIMWOOD

The latest DMM from Simwood is the MC545. This 4½ digit meter has a measurement capability of 19999 and a basic d.c. accuracy of 0.05 per cent. The 545 will operate from either a.c. mains or batteries with rechargeable cells available as an option.

Press-button selection is available for all functions and ranges (five functions and 26 ranges). Typical measurement accuracies are:

between 0.15 and 0.8 per cent on the resistance range; 0.05 per cent on the d.c. voltage range and 0.5 per cent on the a.c. voltage range.

The 545 which has overload protection on every function and range measure 180x64x200mm and weighs approximately 4.2 kg. Each instrument is supplied complete with an operator's manual, test leads, spare fuses and batteries. The 545 is priced at £139.00.

Simwood Limited, Garreta Hall, Shalford Green, Essex.

HI-FI ON THE MOVE

If high fidelity is important to you wherever you are, you will no doubt drool over the three new portable radio/cassette recorders recently introduced by JVC. All three models have the facility of metal tape compatibility which will certainly help to give you the sound quality you're after.

The RC M80L (FM/ MW/ LW/ SW) uses a portable version of the JVC synthesiser tuning system with 32 i.e.d. indicators, and has a 12 station random preset capability, with automatic station scanning.

A twin motor, full logic, solenoid operated tape transport, and optional remote control are particularly noteworthy features of the RC M60L, while the 15 watts per channel RC M70L has a 16 programme multi music scanner.

Once you have decided which model best suits your needs, all you then need to do is find between two and three hundred pounds. Recommended prices for the three models are as follows: RC M60L—£220; RC M70L—£240; RC M80L—£290, though if you shop around, you should be able to get about ten per cent off. Pictured above is by far the best looking of the three, the RC M70L.

SOUND BOX

A simple tone generator sound box which is suitable for use with both the UK101 and the Ohio Superboard II is now available from John Mortimer Electronics.

The unit is not based on the GIM AY-3-8910 sound chip, but employs a VCO which can be activated direct from the keyboard. It is available either ready assembled and tested or in kit form. All that is required to construct the kit, comprising a couple of CMOS chips, transistors, and about ten phototransistors, is a soldering iron, solder and wire cutters. When assembled the unit is easily connected to either computer and will run off the on-board power supply unit. Unlike more sophisticated sound generators, this unit is easy to control, with hardware volume control and tuning, and can produce music from a simple program of keyboard row address POKEt.

Each box comes complete with full instructions and a cassette of interesting effects. The kit is priced at £14.95 or assembled for £19.95 (including VAT and p&p).

John Mortimer Electronics, PO Box 71, Norwich NR6 7JE.

MK14

The long awaited full-length programming guide for the Science of Cambridge MK14 will be available in September. The book which is called Understanding Microprocessors with the MK14 contains just about every aspect of MK14 Assembly language/machine code programming, from number systems and addressing modes to number crunching, interrupts, DMA, multiprocessing and real-time applications. The appendices include a useful instruction set summary, a full listing for the "Hi-lo Game" (used in the text as an example of designing a complex program), and circuits for a 14K memory expansion.

Priced at £5.95 plus 35p p&p the book will be available direct from Tony Watson, Globe Book Services, Little Essex Street, London WC2.
The winning combination offering you the world of do-it-yourself organ making – at a price you can afford.

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Irish Expansion

Ireland's Industrial Development Authority (IDA) is reported as having forecast that the Republic will be Europe's 'Silicon Valley' by the early 1980s. A touch of euphoria is perhaps forgivable since Mostek decided to set up a plant on the outskirts of Dublin as the best backdoor through which to enter the European Common Market.

The immediate work flow is wafer fabrication in Dallas, dicing and assembly in Malaysia and final test in Dublin. Future development is expected to result in wafer fabrication in Ireland by 1983 and some 1,200 people employed by 1984.

There are now some 70 electronics manufacturing plants in the Republic, over 60 percent being American with the balance almost entirely from Europe. This is a remarkable performance by the IDA in selling Ireland as an electronics base. Particularly so as the country has no history or reputation in engineering industry of any sort compared, for example, with Scotland which has also been dubbed a 'Silicon Valley' with its first semiconductor plants set up some 20 years ago and since mightily expanded.

Ireland is a fine country for both visiting executives and local workforce. A good vacation area with marvellous fishing, riding and other outdoor amenities: But the real attraction appears to be the low cost of entry. The IDA smooths the path with incentives such as low-cost factories and tax-free arrangements for profits on exports amounting to indirect subsidy. The IDA has spent £75 million on factories for the immigrants companies.

On the debit side there is no great pool of cheap labour as in offshore operations in the Far East, inflation is high, the cost of living is higher and industrial unrest greater than in the UK. There is also a chronic shortage of engineers and technicians, so much so that the Irish Government pays £2,000 towards the cost of a house to attract key people, mainly from the UK.

Ireland has an export growth rate in electronics of 50 percent per annum. It sounds fantastic until you remember the base line of absolute zero only ten years ago. In fact by world standards the true figures of size are not outstanding. One of the oldest-established American companies in Ireland is Digital Equipment Corporation, who set up an operation in Galway in 1971 but still employs only just over 1,000 workers.

Present projections are that total electronic exports of all types will reach a level of £400 million this year, roughly equivalent to the turnover of a company the size of Racal in the UK.

Ireland has done remarkably well as an off-shore assembly area but has as yet little indigenous innovative capability. There is therefore no real threat to high technology countries. Nonetheless Ireland has a foot on the ladder and deserves watching.

UK Employment

With so much talk of recession and redundancies a heartening note appeared in the annual report of the Electronic Engineering Association which covers the activities of companies solely engaged in the electronic capital goods sector of the market. The employment trend remains upwards with almost 100,000 people employed (a two percent increase) and this despite the fact that widespread use of ICs and now LSI is continually reducing the labour content of assembly and wiring.

Output of the capital goods sector rose by 20 percent in 1979 to over £1.4 billion which allowing for inflation is an underlying growth rate of five percent. Direct exports are running at the rate of 42 percent to which should be added the equipment sold to others in the UK for export in their own products such as aircraft and ships.

Forward order books are at their highest ever level and still lengthening. The only serious cause for concern is that too many employers are competing for too small a pool of high skilled people', a situation in which the EEA's outgoing President, J. W. Sutherland, comments that 'the scope for immediate remedy is sorely limited'.

This year's EEA President is Dr. P. E. Trier who graduated as a Mathematical Wrangler from Cambridge. After war-time and post-war employment with the Royal Naval Scientific Service he joined the Philips Group and was director of the Mullard (now re-named Philips) Research Laboratories at Redhill from 1953-69. He is now a director of Philips Industries, the parent organisation of all the Philips Companies in the UK.

As a mathematician, engineer and industrialist, Dr. Trier ought to be uniquely qualified to find out why there are always conflicts between Industry and Customs and Excise exports statistics. Even if improved correlation of the figures won't tell us where we are going it would at least tell us with greater certainty where we have been.

Scanner Sold

The sale by Thorn-EMI of their X-ray scanner business to US General Electric for £17 million is a sad end to an enterprise once so full of promise. EMI's breakthrough in medical diagnostics was sensational. So, at first, were the profits. US GE came in as a me-too company and then still more companies elbowed into the business. In the end EMI couldn't stand the losses, some £26 million in the past two years, and the recently formed Thorn-EMI just had to give up.

It is a pity that a brilliant invention which has done so much for suffering humanity should have seen such vicious in-fighting for market shares. There were patent disputes all round and part of the deal with US GE is that Thorn-EMI will now receive royalties in return for a licence on the patents.

Thorn-EMI is not, however, entirely out of the business. They still have their latest model which, apparently, US GE didn't want, and they have an interest in a new body-scan technique using the principle of nuclear magnetic resonance in place of traditional X-rays. An experimental machine is to be tried out at Hammersmith Hospital. But it is clear that Thorn-EMI will approach further entries into the scanner market with more than usual caution.

Good News

Britain's first System X telephone exchange is entering service this month (July) six months ahead of schedule. Other big BPO up-date programmes include extending the radio paging system to cover most of the UK through more than 250 VHF transmitters, and replacement of all the pay phones with a new type controlled by microprocessor. On the broad front there will be a 50 percent increase in telephone system capacity by 1980.

Among recent defence orders is one worth £50 million for Type 2016 sonar systems for the Royal Navy and a £75 million development contract for a Mk 2 version of the British Aerospace Sky Flash radar-guided air-to-air missile. The aerospace sector of industry which includes radar, radio and electronic navigation aids exported nearly £400 million of equipment in the first quarter, all set for yet another record year.

New Scotland Yard is to have a £40 million up-date of command and control systems for the Metropolitan Police. The BPO has ordered 215 noise measuring sets from Eddystone Radio to enhance detection and rectification of radio interference sources. Robot enthusiasts will be delighted to hear that 28 of them are being installed on the new Mini Metro production line at Derby's BPO factory. The BPO has completed ahead of schedule a second earth satellite terminal worth £1.75 million in Bahrain, the 17th Marconi major earth terminal to enter service throughout the world.
This review should start—"from little acorns, giant oak trees grow". The machine is Science of Cambridge's modular computer system, starting with System One and ending with System Four. The photographs show the System Three level lent by S. of C. for review. To a great extent it is the Software which distinguishes this machine; and, as the photograph shows, its compatibility as a Prestel terminal for the Post Office's new remote processing link. The video from the machine is in full colour, which unfortunately cannot be appreciated from accompanying photos.

Hardware and prices

There are four system levels of the computer—the first, called System One, is more commonly known as the Acorn Computer (see PE review Sept. 79). This consists of two boards—a 6502-based processor and memory board, plus the display, keyboard and cassette interface p.c.b. The photograph here shows what happens to the basic Acorn when it is expanded. Facia panels are added along with sockets to fit a backplane. The keyboard and display sections are removed and the two p.c.b.s slotted into a backplane and rack of the 19in. Eurocard variety.

The System One costs £65, and the System Two with card frame, backplane (and four sockets), CPU board, cassette and VDU interface, 4K RAM, Software monitor and 4K BASIC will set you back £285 as a kit. A further £200 will buy a fully assembled and tested version, with the additions of case, 5V 3A PSU, buffered backplane and 8 sockets, 4K more of RAM, front panels, connectors and an 8K BASIC. At the time of writing, software was being supplied in EPROM (2732's) and an EPROM surcharge of £50 on the System Two was in force. Each additional component is available separately from S. of C., and this is one of the great advantages of the device, a small start does not imply that you'll need to buy a different computer to gain greater sophistication.

The System Three takes the user to mini-floppy disk storage, all neatly fitting into the rack, and the System Four adds another rack to give maximum expandability for the system up to full memory and two 5½" drives. The System Three photographed here has three 8K RAM boards, CPU card, cassette interface card, VDU card, PSU, fully socketed card rack (with one blank panel here) and mini floppy. The total cost without TV monitor would be around £1,300 assembled and tested (including an ASCII keyboard, which comes cased). S. of C. will also sell you a Sony Trinitron colour monitor for £350. The total disk storage included is 80–90K.

Physically, the p.c.b.s are a high-quality plated-through product which seem easy enough to assemble and are, of course, fully solder-resist coated. The VDU Controller used is the 6845, which is fast becoming the industry standard, and the disk controller—the 8271 chip. S. of C. supply data sheets on all the devices used within their system at £1 each.

Expansions to the basic system include a Universal Interface board with parallel and serial ports, for hardware control, and a 6809 board to evaluate this processor via a software monitor (which is also included).

The photographs of the working system show a picture of the Post Office's "Busby" logo for a very good reason—S. of C. provide software and hardware to interface with the Prestel and Teletext System.

Disk operating system

The Disk Operating System (DOS) has some pleasant and sophisticated features which make its operation neat and less time-consuming than some others. Generous abbreviations are allowed, and qualifiers may be used to separate out a portion of the catalogue for special use. All the usual features are present—definition of drive number (0 and 1 only, as a maximum of 2 drives exist), protection for given files etc. Eight
characters are allowed for a file name on disk, and these may be non alpha-numeric. Error messages are quite informative and not just numeric.

Automatic "booting" of a program stored on disk is possible on RESET, and the disk is given an "option" number by the OPTION command to allow the following modes:
- Option 0: do nothing upon RESET (i.e. stay in DOS)
- Option 1: load the file "BOOT"
- Option 2: run the file "BOOT"
- Option 3: execute the file "BOOT"

The last option allows the file called "BOOT" to contain Commands as if typed in from the keyboard. Thus, if BOOT contains the Bytes "BASIC" (a five-byte string: B,A,S,I,C), then, assuming the BASIC interpreter is resident on the disk, BASIC will be booted in automatically on RESET.

Any other commands may be contained in "BOOT" for this option, and BOOT is called a "command" file—very useful for some clever software tricks.

Automatic messages may be produced upon accessing given files, and these give programs a more professional and "turnkey" air when used along with Option 3 above. Other DOS commands available are the usual LOAD, SAVE and DELETE for disk files; EXEC and GO for executing machine-code routines directly and INFO to find out about the files stored in a disk, usually after a CAT command, to display the catalogue of existing files. The information returned is: qualifier, whether or not protected, file name, LOAD and RUN addresses, length of file and start-sector on disk.

The DOS also produces a familiar set of disk error messages such as "clock error", "sector not found" etc., which can help to locate bugs in the hardware of the drive if necessary.

SOFTWARE AVAILABLE ON THE SYSTEM

The languages available for the system are BASIC, LISP and 6502 Assembler, while the potentially ubiquitous PASCAL is in preparation. In addition to these, many games are in existence, and a word-processing package (described below) is also in existence.

BASIC

The Basic on disk has some very interesting and uncommon features, as it was originally conceived to control psychology experiments. Multi-statement lines are allowed, separated by semicolons; and abbreviations (with a full stop) are allowed for all the BASIC keywords, down to the minimum number of letters necessary to make the word unique (this is as for DOS). Additionally, spaces are more important than usual in BASIC. A useful feature is that the "@" sign stands for a variable which determines the fields within which numbers in a PRINT statement are printed. If @ equals 5, for instance, then 5 spaces (including sign if negative) are reserved for printing each number (right justified) when commas are used in the PRINT list.

The processor card contains 1K of RAM and 104 of these locations are reserved especially for the upper-case single-letter variable names (A,B,C, etc.). These are always tested first, and provide a set of fast-access variables. In addition, single lowercase letters are available for line labels. Thus:

10 a PRINT "hello"
20 Goto a

would put "hello" endlessly onto the screen.

A feature called "word indirection" is available whereby the result of a calculation can be stored directly into a given set of four contiguous addressed bytes. In such a process, direct access to the Addresses of data bytes is thus greatly simplified. In addition, hexadecimal numbers may be used directly within a calculation by using the £ sign as a prefix. Thus, PRINT £AF gives the result 175, on the screen. Thus Hex numbers may be added and printed using:

PRINT £AF + £13

this gives the result C2—great for hex calculations! The DO—UNTIL statement is provided in System Three BASIC, allowing loops to be processed until a given condition is satisfied. This can be useful in numerical methods for instance, or in control functions.

The statement "LINK" allows machine code statements to be run from BASIC, in a similar manner to the more familiar "USR" function. Bytes, complete frames of 4 bytes and strings, may be "got" from and "put" to sequential data files using the usual variety of statements which one would expect in a disk BASIC. All the familiar BASIC statements are available, with the usual optional use of LET and END statements. No ELSE is allowed in IF statements, and the basic BASIC supplied has no floating point package. This is available as an extension.

Another extension is the graphic package which functions as follows: The screen is divided into 78 x 75 dots or Pixels (picture elements). The Busby picture shows the resolution of the system. Individual pixels are rather large, but adequate for Teletext and Prestel.
To set up a pattern on the screen, several commands are available. CLEAR clears the screen and places it in graphics mode, as well as setting the colour of the pixels to be plotted. PLOP, MOVE and DRAW then allow lines and points to be displayed on an X,Y Co-ordinate system based at the bottom left-hand corner of the screen.

FLOATING POINT EXTENSION
The F.P.E. allows accuracy of $9\frac{1}{2}$ digits in a range from $10^{-38}$ to $10^{+38}$, approximately. All the standard integer BASIC statements have F.P. equivalents—mostly using the prefix F. For instance, FINPUT is as for INPUT, but uses a floating point variable only. In this way, the F.P.E. is a true add-on and is not fully integrated into the BASIC on the machine.

SCREEN EDITOR
This program allows the computer to be used, effectively, as a word-processor. Files containing letters or documents may be input from the keyboard and printed out on a hard-copy printer. Normally, a word-processor would organise words on the screen to prevent their being split from one line to the next. This does not appear to be the case with the screen editor, though upon print-out the words are organised so that no splits occur, and the text can be justified. The absence of "arrow keys" to move the cursor around the screen is a drawback from the operator point of view. He has to memorise which of the keys perform which cursor movement commands—though the keys are arranged in a logical manner on the keyboard.

Special letters are left in the text to signal particular printing modes, such as justification, given line-widths and the centering of a heading on the page. Strings may be located, deleted, and changed as normal. Only one character may be inserted after the cursor for each use of the insert command, which is rather limiting as far as speed is concerned. Text is entered one page at a time, and the operator must not exceed this limit, or an overflow message occurs. A page is defined as a full screen.

The version of the editor supplied with the machine for review appeared rather cumbersome and slow to use compared with other packages, but this may well have been due to the rather scant and embryonic documentation accompanying the program.

LISP
Finally, the language LISP is supplied if required. This package, produced by OWL Computers, appears to be well thought out and reasonably documented, though perhaps a little difficult to follow for the beginner—the program is adapted from a version written for the Apple computer.

LISP is a language which is orientated towards the processing of strings and lists of characters as opposed to scientific and numerical calculations, though calculations are possible. Complex data structures are easy to construct, and the language can process and act upon complex "Boolean" or logical conditions. This type of programming is suitable for highly interactive routines using human language for communication. The computer can easily be made to act as if it understands syntax and grammar. As an example, as a demonstration of LISP's capabilities, OWL computers have a program called DOCTOR which pretends to be your psychiatrist, and asks personal questions in an English conversation—could become addictive!

CONCLUSION
The system is modular, as mentioned before, and appears to be well conceived from a hardware point of view, if rather expensive. The software is still in development, but is quite wide. My version only ran a converted colour monitor, and it would be interesting to see the resolution through the encoder and UHF modulator on a domestic TV.

The exact market place of the machine is difficult to assess. Medium-sized business applications would be difficult with such small disk space, and the system would have to be cheaper for the hobbyist to buy it. That leaves Education and hardware control. Both of these would surely benefit from the modularity and Input/Output expansions available.
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Our new book PE Popular Projects is now on sale at newsagents and component stores; the contents of this book are shown above. The book costs £1.25 from retail outlets and is also available for £1.50, UK post paid or £1.80, overseas surface post paid, from Post Sales Department (PE Popular Projects), IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 OPF.
A problem that can confront the electronic musician is fitting a further amplifier and speaker system to an existing installation. Though apparently simply in theory, the task can be complicated if the instrument is not provided with a pre-amplified output and the end product is supplied only to the speaker terminals.

MATCHED PAIR
The practical difficulty is matching the main speaker signal to a further amplifier. It is possible, of course, to find a preamplified source somewhere in the instrument’s circuitry but the main speaker signal can be useful in other respects: for the moment we will assume that the speaker signal has to be the starting point.

Another speaker in parallel would seem to be the simplest solution, but would not only result in a mismatch but probably endanger the output transistors. Placing a (say) 50k potentiometer across the main speaker and feeding the extension amplifier from its slider will give results of sorts but losses in tonal quality will perhaps be unacceptable.

Ruling that out, we try a step-up transformer: here the primary can act as a dummy load if the main speaker is to be switched out. Although this will give better results than using a simple pot., there will still be losses in tonal quality.

UNCOMMON
In the early days of the transistor, available types were of low gain, high leakage and very restricted in their cut-off frequency. It was not unusual to have to resort to common base configuration in order to handle even the i.f. of a suphet receiver—perhaps operating at 470kHz. Today’s device is a totally different matter and alpha cut-off is no problem anyway where audio frequencies are concerned. Where common (or grounded) base is employed, the stage will handle low impedance inputs and provide a high impedance output with voltage gain—which is precisely what we are looking for in this instance. The input signal is fed to the emitter, the base ground to a.c. but biased as usual and the signal taken from the collector. A suggested circuit is shown in Fig. 1.

Power for this stage can be derived from the extension amplifier, using a suitable series resistor to ensure that the Zener diode’s dissipation is within bounds. If the constructor intends to use the extension system for a doppler-effect speaker, a dummy load must be presented to the main amplifier if switching is envisaged.

LIMITER
The main speaker signal is useful as the source for driving a spring unit, so both this drive and the signal for the common base amplifier can come from the same point. Assuming that one side of the main speaker signal is earthed, Fig. 2 shows a suitable system that was used by Hammond in their M-100 series instruments. An appropriate lamp to use is 6V 0.36W, where the filament has a d.c. resistance of some 14Ω. It acts as the volume limiter and is only likely to glow on loud passages. The reverberation spring can be driven directly as indicated in Fig. 2 or the same signal can be reduced resistively and fed to the reverberation drive amplifier if it is already incorporated in the spring unit. With a little care, the pre-amplified signal from the spring unit can be mixed with the output from the common base stage so that the extension amplifier handles both signals. It is a wise precaution to refer to the instrument’s service manual to ensure that the main speaker is not provided with a push-pull, centre tapped to earth, signal. If this is the case, suitable resistors will have to be inserted after the limiter to avoid losing half of the signal because of the common earth between the main and extension amplifiers.
Whilst dealing with practical aspects, the musician reader will hardly need reminding that recording at the keyboard can be problematical at the best of times. However, nothing is more annoying than having to use a pre-amplified tape recorder that has to be carted to the hi-fi system (possibly in another room?) to check each result. Some organs can be used to play back tape—though this may have to be monophonic—but headphone facilities are ideal. In order to preserve the musical train of thought, the simple circuitry of Fig. 3 may be found useful.

This can be built in mono or stereo form on the smallest stripboard available (both amplifiers being identical) and possibly mounted somewhere inside the recorder, borrowing power from that source. The nominal 10V is not critical but allows small electrolytics to be used: the series resistor must again be chosen to limit the zener diode’s dissipation. Quiescent current is some 2mA and the quality of reproduction is excellent for this purpose. Two components call for comment: the 1MΩ feedback resistor controls volume and can be varied to suit individual taste, whilst the 330K inverting input resistor may require amendment according to the tape recorder’s output signal.

Headphones with mylar diaphragms can be extremely sensitive and, should there be any tendency to overload, a series resistor—say 100Ω—in each output lead of this type of phone will overcome the problem. A simple but effective system of checking musical efforts quickly is a great help in getting the required result—eventually!

**Fig. 3. Stereo Headphone Amplifier**

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Practical Electronics August 1980
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PRACTICAL ELECTRONICS

OUR SEPTEMBER ISSUE WILL BE ON SALE SATURDAY 16 AUGUST 1980
J.A. Barrow describes—
An indicator which gives a silent flashing display to the hard of hearing or in noisy environments and logs calls in your absence

HERE is a useful gadget for the deaf, the hard of hearing, or, the enthusiast who likes to play music very loudly! Primarily designed to overcome the problem of not hearing someone at the door by providing a visual indication, it has the additional feature of a memory, which indicates whether you missed a caller while you were out.

The complete unit can be made very compact as it can be simply connected to the existing bell-push wires.

CIRCUIT
IC1a and b, R3, R4 and C3 in Fig. 1 form a low frequency oscillator which is switched on when the threshold voltage at pin 2/IC1a is exceeded. The output is connected to TR1 via R5 which drives the l.e.d.s D3 and D4. The power for the circuit is from the bell battery.

Consider the circuit in the following state with C2 fully charged and pin 4/IC1d at logic '1'. A logic '0' at pin 2/IC1a ensures the oscillator is off. Pin 11/IC1b is at logic '0' so no l.e.d.s are lit. Shorting point 'A' to 'B' causes C2 to discharge rapidly through D2, so when the power returns to the circuit (i.e. when the bell push is released) C2 starts to charge via R2 causing a logic '1' to be present at pin 2/IC1a—the oscillator then functions and the l.e.d.s flash for a period determined by R2, C2 (about 30 seconds with values shown). During oscillations pin 3/IC1a goes to a logic '0' causing the latch (gates c and d) to change state. Pin 4/IC1d becomes logic '0'. This state remains until S1 is pressed when pin 11/IC1b then becomes a logic '1' and the l.e.d.s light, indicating that the oscillator has been activated. While the switch is held depressed, capacitor C4 will charge via R8 and the logic level at pin 6/IC1d will change to a '0' after about 2 seconds, resetting the latch and cancelling the lit l.e.d.s.

ALTERNATIVE SUPPLY
The circuit was designed for use with battery operated bells, but use with a.c. types up to a maximum of 10V r.m.s. is possible using additional circuitry shown in Fig. 1.

Diode D1 prevents circuit damage if input connections are reversed during installation, in which case the bell will ring continually.

CONSTRUCTION
The components are mounted on 0.1 in Veroboard as shown (in Fig. 2) which in turn is mounted onto the lid of a small plastic box. Two holes were drilled in the lid to form a...
FROM A. C. BELL

Fig. 1. If used with a battery operated bell connect A and B to the existing bell-push switch wires. For a.c. bells (3-10V) connect the rectifier circuit as shown.

Fig. 2. (Below) Veroboard layout for monitor

"key-hole", which enabled the unit to be fitted on a wall with one round-headed screw—the keyhole locating over the head of the screw.

CHECKING

After making connections to the bell-push wires, press the switch and release. L.e.d.s should flash for about 30 seconds then extinguish. Press S1 and hold, the l.e.d.s should light for about 2 seconds then extinguish. Press S1 again and the l.e.d.s should remain off.

The unit should be sited, of course, where it can be easily seen—perhaps close to the television or stereo.

In normal operation it looks after itself—switching itself off 30 seconds or so after the bell push was pressed. When, however, the memory facility is required, the push button on the unit should be depressed until the l.e.d.s extinguish before going out. Then, on your return, press the button again—if the l.e.d.s do not light, then visitors did not call in your absence.

POINTS ARISING

SPLIT-PHASE TREMOLO (May 1980)
1) The bottom end of VR1 should go to earth (as defined by the centre point between the power supply lines) and not to the -6V supply.
2) The 'In' and 'Out' positions on switch S1, as marked on the circuit diagram, should be interchanged.
3) The three jack sockets (J1, 2 and 3) should all have their screens connected to earth, and not to the -6V supply.

Either R10 or R13 may be replaced by a preset variable resistor of value around 4k7. The setting of this variable resistor should be so as to cause the signal amplitude across it to be the same as the signal amplitude across the remaining fixed resistor. Omission of this adjustment may cause the extremely discerning listener to observe that the modulation depths on the two channels is not quite identical. The difference in modulation depths is, of course, caused by the emitter load having a signal generated across it by virtue of the base current which flows through it. Adjustment of the preset variable resistor as described above results in the cancellation of this effect.
MAGNUM METAL DETECTOR

Construction details in this issue.

All electrical components available from Maplin Electronic Supplies Limited.

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Practical Electronics August 1980
DESSERT ISLAND CHIPS

If like me, you feel that some things are better left as they are, unimproved by generous helpings of electronic technology, then your interest in my first two devices this month may be tinged with something of a sense of foreboding.

The Stylophone was tolerable, no worse in fact than the kids tin drums and xylophones which preceded it, I even manage a wry smile when greeted by a perky rendition of "Colonel Bogey" from one of those dreadful musical door bells. I do get just a little peaved, though, when forced into a corner with one of those "Space Invaders" games which makes continuous rude noises while I'm trying to enjoy my pint, but at least I can leave them behind in the pub.

The thing that worries me about the new 7910 series of six integrated-circuit-musicians is that they are so easy to use and so cheap that I have a vision of our homes being inundated with musical food mixers, vacuum cleaners, clocks, tooth brushes, and biscuit tins in the not too distant future.

The 7910 series can provide a tune for every occasion including "Home on the Range", "Mary had a little Lamb" and "Greensleeves", and four of the chips can also imitate door chimes and produce bleeping alarm noises. Two specials in the range are dedicated for clock applications, producing ersatz "Westminster Chimes" no less.

The thing which sets these chips apart from the microprocessor door bells of yesteryear is the fact that they (a) come in diddy 16 pin DIP packages (b) run from a single 1.5V battery, with a standby drain of typically 2 microamps and (c) they are selling; even in small quantities, at less than £2 each.

The secret seems to be that the 7910 series is not based on a true microprocessor architecture but on a dedicated design with no "fat". The tunes are produced by an on chip combo which consists of an oscillator, two envelope generators, an output pre-amp and a collection of ROMs. The ROMs define the tunes, and custom programming is therefore possible at the mask level. The melody ROM, twelve bits wide and 128 words deep, can store 128 notes or rests, the tempo ROM provides cadences from prestissimo to largo, and the control ROM welds the whole thing together by keeping track of start addresses, tune selections, and sequence repetitions.

The pre-amp provides at least 150 microamps of base current for an external pair of transistors in a push-pull configuration, but apart from those devices, only a few cheap passives and a pen cell are all you need to drive you and your friends crazy.

The 7910 series are only available in the U.S.A. at the moment, from Epson America Inc., (who I've never heard of). If you can't wait, they live at 23844 Hawthorne Blvd., Torrance, CA 90505.

SPEAKING CLOCK

As if the threat of musical biscuit tins were not enough, it seems we are also faced with the prospect of alarm clocks which rouse us from our slumber's with a spoken announcement of the time, no doubt delivered in a supercilious tone of "voice". This terrifying prospect is brought to us courtesy of ITT Semiconductors, in the shape of a forty pin NMOS integrated circuit coded UAA1003.

All those pins are needed because the new device is designed to be connected to the seven-segment multiplexed display outputs of your favourite digital clock chip in parallel with the display LEDs. Yes, that's right, it not only speaks, it understands digital clock-eese too.

The UAA1003 can speak up to 25 separate words, and can be programmed to string these in any sequence to amaze and delight your friends. Each word consists of a number of staircase shaped pulses lasting 10 milliseconds and produced via an on-chip 7 bit digital-to-analogue converter to give 128 possible amplitude levels.

One problem though, they haven't taught the UAA1003 to speak English yet, only French and German, so unless you relish the thought of being awakened by "Bon-jour. Il est sept heures et demi" (Followed no doubt by a quick burst of "Mary had a little Lamb" from the Teasmaid), you will have to wait a few weeks before "modding" your trusty alarm clock. Your alarm clock should still be recallable to 25 bits of count data (6 x 4 bits and 1 bit for overflow status) can be stored in an MNOS array by application of a 10 millisecond SAVE pulse, and recalled rapidly when required so that the count can continue from where it had stopped, when the power failed for example.

The other devices in the series have certain decades changed into divide by six counters to provide a timer function. The MN9107 counts 99 hours, 59 minutes, 59 seconds and the MN9108 counts 9999 hours 59 minutes (or 9999 minutes 59 seconds).

The nonvolatility of these counters makes them suitable for applications where in the past only electro-mechanical gadgets could be used, things like car odometers, hours-run indicators and production line parts counting could all benefit from NOVOL technology.

The MN9106 series all operate from a 12 volt supply, can be interfaced to CMOS or TTL logic, and come in 24 pin packages.

made by Plessey (yes they really are British) and their strength lies in the clever combination of high speed but volatile MOS memory and slower but non-volatile MNOS latches. The mixture yields memory devices which can be written-to and read-from like any other memory part in normal operation, with the added advantage that the contents of the memory can be saved almost indefinitely, even without power, after the application of a short SAVE pulse to effect a transfer to the MNOS section. This technology is invaluable where the loss of data due to power loss must be avoided and the data must also be easily changed during normal operation with power applied. When power is reapplied to a NOVOL device, the data stored in the long-term MNOS latches can be recalled by applying a five micro second pulse to a RECALL input.

The only reservations I have had about NOVOL in the past have concerned the limited number of "save" cycles possible (about a million), and the fact that only small arrays, such as four bit latches for example, were available.

Well, the first problem is a fact of life with MNOS, but I withdraw my second reservation now that I have seen data on the MN9106/7/8 series of NOVOL counter chips. The MN9106 is a six decade up-counter complete with a multiplexed seven segment display driver and overflow logic, capable of counting up to 200kH2. The 25 bits of count data (6 x 4 bits and 1 bit for overflow status) can be stored in an MNOS array by application of a 10 millisecond SAVE pulse, and recalled rapidly when required so that the count can continue from where it had stopped, when the power failed for example.
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30AX. The perfect slimline.
WHAT IS electrochemistry? And whatever it is, why is chemistry rearing its ugly head in a magazine devoted to electronics? Taking the quick answers to these questions, we can say first that electrochemistry is that branch of science which deals with the frontiers between electricity and chemistry. Just how important this little branch of science is, one must judge for oneself. Suffice to say that it underlies the working of batteries, and accumulators; it provides the explanation of corrosion, and at the same time suggests how we might combat it. It is the means used for production of all the world's aluminium, much of its magnesium, all of its chlorine and many other vital chemicals besides. Electroplating and anodising, electrophoretic paint deposition on cars or refrigerators, the monitoring of medical parameters, prevention of damp in old buildings by electro-osmotic action—one could go on and on!

As for the second question, the Editor has decided to run a series of projects (not consecutively) which will encompass the complete range of the major instruments required to study or demonstrate this important discipline, either in research laboratories or in colleges or secondary schools. These instruments will be specified to the full professional level required for research at the highest level. In many cases, they will not be cheap to build—but then their commercial counterparts with comparable performance would cost many times the same amount. In many cases too, options will be shown by means of which the builder can construct a less expensive machine, to be upgraded at a later date when funds permit.

THE SCOPE OF ELECTROCHEMISTRY

One of the best-known electrochemists today, Professor J. O'M. Bockris, of Texas, has shown how the subject can be divided into "Ionics" and "Electrodics". The first term relates to events taking place in solutions of conducting media, for example salts or acids dissolved in water, while the second relates to the interface between a metal or other conductor, and the solution in which it is immersed.

IONICS

Far and away the most important measurement we make in relation to water and other species dissolved in it, is pH, or acidity. To a first approximation, we can define this as:

\[ \text{pH} = - \log [H^+] \]

and in the laboratory, in the food, drug or chemical industry, we are constantly concerned with the acidity of whatever we are making, for not only must the value be right but also we can use it as a guide to all sorts of other things happening. But then the biologist, the gardener or soil scientist, the aquarist, the doctor and vet, are all concerned with the application of this same term to their own discipline. There are many ways in which we can measure this quantity. But the most commonly used one is to use a pH electrode, and, having first calibrated it against solutions whose pH is known, we can measure pH by measuring the potential difference generated between this electrode and another one, the response of which is not affected by the pH of a solution. This voltage must be measured with a circuit of moderately high impedance, of the order of 10^6 Ohms or so, and this requires special design. Formerly this was done with electrometer valves, but now we have FET op. amps. The technique of pH measurement with an electrode is some 40 years old or so. But in the last decade a staggering advance has been made, in that we now have a series of Ion-specific Electrodes which can be used in very much the same way, to measure the concentrations of Cl<sup>-</sup>, F<sup>-</sup> or Na<sup>+</sup> in a solution.

Numerous ion-selective electrodes are now available. Their number increases every year. There cannot be an easier way of measuring the calcium levels in milk or the amount of nitrate in drinking water than by using one of these new electrodes. The principles on which they operate are very similar to the glass electrodes used to measure pH, and both devices follow more or less closely the relationship known as Nernst's Equation:

\[ E = E_0 + \frac{2.3RT \log [Cl^-]}{nF} \]  

where \( E_0 \) is a constant, and \( E \) is the measured voltage. The other terms relate to the concentrations of the ions we wish to measure. In practical terms, these electrodes are still a little more difficult to use than the pH electrodes which preceded them. The actual slope of the relationship between log (X), where X is a species and the measured voltage is not always that suggested by equation (1), where the factor

\[ \frac{2.3RT}{nF} = 0.059 \text{V at room temperature} \]

but can deviate some way from it. Therefore these instruments must incorporate variable slope controls.
From the measurement of pH or pX, it is only a step to an instrument which uses this information to actuate some means for controlling the same parameter. This is sometimes known as a pH stat or auto-titrator and the commonest use is perhaps in the treatment of effluent discharges from factories, where a discharge must be held between pH 6 and 8 to be acceptable. The actual pH of the effluent is measured and if it is too acid, a valve is actuated, to effect addition of some alkali.

**ELECTRODICS**

The second major branch of electrochemistry, electrodics, deals with the passage of a current from a metal electrode and into solution. Though much research has been published in the past hundred years in this exciting field, a great deal remains to be done, not least in the field of electro-organic chemistry; that branch which deals with the reactions of organic molecules at electrodes, where they are reduced or oxidised (at the cathode or anode respectively) or can undergo a range of other fascinating reactions such as dimerisation (doubling up). Here is a vast territory for novel ideas and research, and what is more, as such things go, the tools for this research are far less costly than those required for almost any other branch of chemistry. Indeed, apart from certain items of glassware, the instruments required will be those it is planned to present in the coming series.

The first laws of electrolysis are those laid down by Sir Michael Faraday, over a hundred years ago, in which he stated that a given quantity of electrical charge (the Faraday 96,500 coulombs) will liberate one gramme-molecule of a given substance for every electron required in the reaction. This opens up a number of important experiments, for we now know that by passing a certain charge (a known current for a known time), we can release precisely determined amounts of material. Indeed, the ampere is defined as a standard in these terms, as the actual pH of the effluent is measured and if it is too acid, a valve is actuated, to effect addition of some alkali.

**Practical Electronics August 1980**

...
such as hydrogen evolution or oxygen evolution (both involved in the “hydrogen economy”) or for the chlorine evolution reaction. A more sophisticated instrument for following the relationship between current and voltage, is the potentiostat. This, unlike the constant current supply (or galvanostat) is a feedback device which measures the potential between the electrode whose behaviour we are anxious to study (working electrode) and the reference electrode, and compares this value with a pre-determined voltage which has been set up. By regulation of the current flowing in the circuit working electrode to counter electrode, that is to say variation not only of the magnitude but also the sense of this current, the desired potential is held constant. We may, in some cases, wish not so much as to hold this potential constant, but rather to vary it in a linear manner as a function of time. In such a case, we need a ramp generator, which is coupled to the sensing side of the potentiostat.

**MAKING MEASUREMENTS**

With these instruments, we have the essentials for doing electrochemical experiments. However a certain number of other peripherals are also desirable. The measurement of current and voltage call for some thought. Current can be measured either using a d.c. ammeter in series with the instruments, or by measurement of voltage drop across a fixed-value precision resistor. Electrochemistry is unusual as a discipline, in that currents in a single experiment may vary from a few microamperes to an ampere or more. Thus, auto-ranging current measurement devices, though not widely used at present, would be useful. A further difficulty arises because, for reasons that will be explained, the resistor across which the p.d. is measured (sometimes known as the “counting resistor”) may well stand 50V off earth potential, or even more. This calls for a voltage follower with rather special properties. The same wide span of currents (expressed as voltage drop across a resistor) could also suggest a log-response amplifier.

Application of a given current with measurement of the resulting voltage, or the converse process of maintaining a defined potential in order to observe the current, are the two most basic techniques we use in electrochemistry. By changing either the applied voltage or current and observing the value of the other parameter, we can obtain a graph of current vs. voltage, and from this graph a great deal can be learned about the nature of the reaction. Is the current responsive to stirring? What is the effect of change of temperature or pH or concentration of any other species? There is nothing like a little simple automation, and application of a simple voltage ramp either to the potentiostat or the galvanostat allows us to monitor one parameter while the other is continuously changing. We can feed the input and output to an X–Y chart recorder and go away for our tea until the scan is complete. For a faster scan, we shall use an oscilloscope to record the i–V trace, though more recently this has been challenged by the transient-recorder.

**SOME EXPERIMENTS**

In the project series, it is intended that all the instrumentation required for the study of electrochemistry will be described. That is to say a pH or pHX meter, a constant current unit, a potentiostat, a function generator and a log amplifier. If space permits peripheral are also desirable. The measurement of current and voltage call for some thought. Current can be measured either using a d.c. ammeter in series with the instruments, or by measurement of voltage drop across a fixed-value precision resistor. Electrochemistry is unusual as a discipline, in that currents in a single experiment may vary from a few microamperes to an ampere or more. Thus, auto-ranging current measurement devices, though not widely used at present, would be useful. A further difficulty arises because, for reasons that will be explained, the resistor across which the p.d. is measured (sometimes known as the “counting resistor”) may well stand 50V off earth potential, or even more. This calls for a voltage follower with rather special properties. The same wide span of currents (expressed as voltage drop across a resistor) could also suggest a log-response amplifier.

Application of a given current with measurement of the resulting voltage, or the converse process of maintaining a defined potential in order to observe the current, are the two most basic techniques we use in electrochemistry. By changing either the applied voltage or current and observing the value of the other parameter, we can obtain a graph of current vs. voltage, and from this graph a great deal can be learned about the nature of the reaction. Is the current responsive to stirring? What is the effect of change of temperature or pH or concentration of any other species? There is nothing like a little simple automation, and application of a simple voltage ramp either to the potentiostat or the galvanostat allows us to monitor one parameter while the other is continuously changing. We can feed the input and output to an X–Y chart recorder and go away for our tea until the scan is complete. For a faster scan, we shall use an oscilloscope to record the i–V trace, though more recently this has been challenged by the transient-recorder.

**SOME EXPERIMENTS**

In the project series, it is intended that all the instrumentation required for the study of electrochemistry will be described. That is to say a pH or pHX meter, a constant current unit, a potentiostat, a function generator and a log amplifier. If space permits current followers and voltage followers as well as coulometers will also be described. Other equipment which is useful is an oscilloscope and, or, a V–t chart recorder. What sort of experiments can we do with this equipment? All sorts of ideas come to mind. The following simple experiments are suggested:

1. Take 2 lead plates and place them in a beaker with dilute sulphuric acid. Apply a d.c. current (approximately 100mA per cm² for a few hours) and we have now formed a simple lead acid battery. Measure the voltage at open circuit. It should be approximately 2.01 Volts. Now connect the constant current unit across the two plates and pass current in the reverse direction. The “battery” will be discharged. Measure the voltage while this is being done and it will slowly decrease for several minutes (or longer if you have a low current or a good battery) until suddenly the voltage will plunge downwards. This is called the knee of the discharge curve, and if we measure the charge passed (in amphere hours) from start of discharge till the knee, we obtain the capacity of the battery—it won’t be as good as an Exide!

2. Make up a solution with small amounts of copper, iron and zinc salts in it, in dilute acid. Using a 25mV per sec. voltage ramp from the function generator connected to the potentiostat observe the current traced out. It should show three distinct plateaus corresponding to the three metals in solution and this principle forms the basis of polarographic analysis, each metal plating out as the potential becomes more negative.

3. Using a functions generator and a dilute solution of sodium hydroxide (take care this does not splash!) follow the rate of hydrogen evolution at electrodes made of silver, gold, lead, iron or other metals. See how some are much better electrodes and evolve the same amount of gas at a lower voltage. Use a burette upturned to collect the hydrogen and verify Faraday’s law (but do not forget to correct for water vapour pressure).

4. Using a potentiostat as a zero-resistance ammeter, connect a piece of steel and a piece of copper through the ammeter to one another. When both are immersed in water, you will observe a current flow and after a time, evidence of the corrosion of the steel will be seen. With this instrument, which measures current without imposing any “meter resistance” even at the micro-ampere level, we can follow the corrosion process. Similar experiments can be done using stainless steel, only here the currents will rapidly decrease as the metal passivates and forms its protective skin. Scratch that skin and the current will shoot up again.

5. Make up a solution with small amounts of copper, iron and zinc salts in it, in dilute acid. Using a 25mV per sec. voltage ramp from the function generator connected to the potentiostat observe the current traced out. It should show three distinct plateaus corresponding to the three metals in solution and this principle forms the basis of polarographic analysis, each metal plating out as the potential becomes more negative.

The foregoing experiments are intended only as a guide to show some of the wide range that can be tackled with the equipment whose construction will be described in detail in later issues. These being scientific instruments, it follows that there is a wide range of textbooks in which electrochemistry is explained and discussed and ideas for experiments are suggested. A list of these books will be supplied by the author on request. It must be confessed that it is mainly with schools and colleges in mind that the present series has been launched, and the authors of the various articles will be happy to help interested readers in every possible way, whether in the construction of their instruments or in using them once they are built. Where possible, queries will be referred to the nearest known scientist working in the field to the address of the questioner. Happy experimenting!
PART ONE...

The PE Teletext system, which has been designed around the Mullard set of dedicated LSI chips, enables a TV set to decode and display the magazine information services transmitted by both the BBC and ITV networks (Ceefax, Orbit and Oracle).

The teletext information is transmitted in digital form along with the normal television signal using the spare lines in the field blanking interval which is usually of 25 lines duration. Some of these lines are used for test and signalling purposes and although any of them can be used for teletext transmissions, only lines 17(330) and 18(331) are used at present.

To reduce setting up and alignment problems the decoder board is available fully aligned and tested. The video summer board which has been designed by Mullards enables an excellent teletext display to be obtained via the aerial socket of a TV.

**BLOCK DIAGRAM**

A block diagram of the system is shown in Fig. 1.1. The aerial signal is fed to the tuner board where the video and audio information is extracted. The audio signal is then taken direct to the video summer board. The tuner board is also used for remote control channel changing. If a channel change key is pressed on the infra-red transmitter then a four-bit binary signal is sent to the tuner from the receiver to operate the changeover.

The video signal is fed to the decoder board where the teletext information is retrieved and then checked for errors. The decoder board also generates all the timing signals for the teletext display. After checking, the information is stored in two 1K x 4 static RAMs ready to be displayed. When enabled the RAM outputs are converted by a character generator into a dot matrix pattern. The matrix is in a 7 x 5 dot form for each character but as the character generator also has a character rounding facility to improve character definition, this effectively increases the matrix to 14 x 10 dots. The outputs from the decoder board are then taken via an interface daughter board to the video summer board where the colour burst and audio signals are added to the...
comprising video signal which is then sent via a UHF modulator to the TV.

The system is connected to the TV via its aerial socket and in order to receive a good teletext display the aerial must be capable of delivering a strong signal to the set. If there are any problems with the reception then the teletext display information will be corrupted with random data and if the corruption is very bad then no text at all will be displayed.

When the system is first switched on or the reset button pressed BBC1 is automatically selected. Either of the other two channels can be chosen by pressing the appropriate button. The channel change buttons on the remote control are dual function: in the teletext mode they are the page selection numbers 1, 2, 3, etc.

REMOTE CONTROL FUNCTIONS

When the teletext mode is first selected after switch on, page 100 is automatically selected. Any other page in the magazine can be selected by pressing the appropriate page selection numbers (0 to 9) in turn. As each digit is entered the page number is built up in the left-hand corner of the screen. When the final digit, of the three digit number, has been entered the page header turns green (all except the left-hand page number) and the green page number in the header will "rotate" showing each page number as it is transmitted. When the selected page is transmitted the page number stops rotating and after the page has been captured the header reverts to white and the page is displayed.

HOLD

Some of the pages in the system contain more information than can be displayed on the screen at one time. To overcome this they are divided into a number of sub-pages and a different page is transmitted during each sweep of the system. As each sub-page is sent it is automatically displayed. The particular page in the series being shown is displayed in the right-hand corner of the screen, below the time (e.g. 1/4, 2/4, etc, etc). The hold key facility enables any rotating page to be held indefinitely. After pressing the hold key the word hold will appear in the top-right hand corner of the screen in place of the 24hr clock. The hold command can be cancelled by pressing the text button.

TIME

If the time button is pressed when the television picture is being viewed the 24hr clock will be inset in the video picture. The clock will disappear after 5 seconds.

TEXT

The text command switches the system into the teletext mode and page 100 (the index) of either Ceefax or Oracle is
displayed depending on which channel was selected before the text button was pressed. This does not apply to BBC2 as the Orbit index is on page 200.

TOP, BOTTOM AND NORMAL
When in the teletext mode the top and bottom buttons select the double height characters and displays one half of the page for easier viewing at a distance. The normal button changes the display back to a full page. If a new page is selected whilst the double height characters are being used the top half of the new page will appear irrespective of which half page was previously selected.

REVEAL
Pages in the system which have parts of their display concealed (i.e. quiz pages) can have these parts displayed by pressing the reveal button.

PICTURE
To switch the system back to the television picture when it is in the teletext mode, press the picture mode.

TIMED TEXT
The timed text button enables any single page in the system to be stored for viewing at a pre-determined time. To use the timed text mode, switch the system into text and select the teletext page to be stored, then press timed text. This will replace the 24hr clock with the letter 'T' followed by a flashing 00:00 display. The page selection buttons can then be used to set the time the page is to be viewed (e.g. for 8:35 pm press 2035). When this has been completed press the cancel button to return the system to the picture. When the pre-determined time is reached the page number appears in the top left-hand corner of the screen. The page can be viewed by pressing the text button. The time code can be cleared from the decoder by pressing the cancel time text key.

STATUS
The television channel being viewed can be identified at any time by pressing the status button. The channel is displayed in the left-hand corner of the screen for 5 seconds.

RESET
The reset button puts the system into the television mode and cancels all previous teletext commands.

MIX
The mix button will inset the page header into the television picture.

NEWSFLASH
If the new page is a newsflash or subtitle page then the system automatically switches back to the television video and the newsflash or subtitle information is inset into the picture. Switching back from a newsflash or subtitle page automatically turns the video off.

REMOTE CONTROL TRANSMITTER
The infra-red remote control unit which is used to control all the teletext functions is based on time-ratio discrimination and does not require any accurate timing components. The circuit diagram of the transmitter unit which is shown in Fig. 1.2 has been designed around the SAA5000 LSI chip and can transmit up to 32 commands.

To protect the system against interference of reflections the data is encoded as shown in Fig. 1.3. When a command is entered on the keypad a short pseudo-random sequence is transmitted followed by a 24-bit data stream which comprises a 7-bit start code and a 5-bit message. This 12-bit
sequence is then inverted and transmitted again. When a key is pressed the whole data stream is automatically transmitted so the user does not have to keep the key depressed for any specific period of time. The receiver will not respond until the whole 24-bits have been received and checked.

The transmitter automatically 'powers up' when a key is pressed and will revert to standby when the transmission is completed. The push buttons are connected to 12 pins of IC1 with pins 10 to 15 being held high. When a button is pressed a high is connected to one of the input pins (4 to 9). These pins are connected to ground via resistors R1 to R6 which are pull-down resistors used to determine the input sensitivity of the chip. As the circuit 'powers up' an on chip oscillator produces a 24-bit data stream at pin 16. The oscillator is timed via resistor R7 and capacitor C1 with its frequency being used to determine the output data bit rate. The output signal is fed to TR1 which provides the base current to operate TR2. The resistor R13 defines the current for the epitaxial gallium arsenide l.e.d.s which when forward biased emit radiation in the near infra-red region. As high currents are used in the transmitter (approx 4 amps), which is supplied by C3, great care should be taken not to touch the pins of IC1 when the transmitter is being operated. This is because the time duration of the current pulses through the output diode can be greatly increased resulting in the diodes being permanently damaged.

**CONSTRUCTION**

The transmitter circuit is mounted on a double-sided p.c.b. which is shown in Fig. 1.4. Before any components are mounted on the board all the through board links, shown in Fig. 1.5, by the square pads, should be soldered using tinned copper wire. After soldering, check all the links for continuity with a multimeter. The components are mounted on one side of the board and the switches on the other. The push-button switches can be soldered next and as they can only be mounted one way round, carefully check the orientation before soldering. With the switches soldered, turn the board over and mount the components. Make sure the components are mounted as close as possible to the p.c.b. especially the transistor TR2. An i.c. socket should be used for IC1.

The two infra-red diodes are fitted into the end of the case using l.e.d. holders. The wiring for the diodes is shown in Fig. 1.6 along with the p.c.b. mounting details.

The p.c.b. should be mounted into the case before the i.c. is inserted. The case should be drilled to allow the 23 push-button switches to pass through. The p.c.b. should be mounted using 6BA counter sunk screws and the board spaced away from the case using either 6BA nuts or a spacer. When the board has been fitted into position check that each key operates correctly without fouling the case.

The keys can be annotated using rub-on transfers either on the key tops or on the case. If they are put on the keys then clear varnish should be used to protect them from wear. The battery can be held in place using double-sided tape.

**RECEIVER CIRCUIT**

The receiver circuit shown in Fig. 1.7 detects the infra-red signals from the transmitter via the photo-diode D5. A gyrator circuit designed around TR3 improves the rejection.
COMPONENTS

TRANSMITTER BOARD

**Resistors**
- R1-R6: 6M8 (6 off)
- R7: 220k
- R8,R10: 10k (2 off)
- R9: 470
- R11: 47
- R12: 22
- R13: 105 2.5W

All resistors 1W 10% except where otherwise stated

**Capacitors**
- C1: 180p
- C2: 1n8
- C3: 330µ 10V elect.

**Semiconductors**
- D1: BZV46 C2V0
- D2: BAV62
- D3,D4: CQY89 (2 off)
- TR1: BC328
- TR2: BD433
- IC1: SAA5000

**Miscellaneous**
- PP3 battery
- Battery connector
- Holders for i.e.d.s (2 off)
- Case pac-tec type HP
- P.c.b.
- Switches (23 off)
- Holder for i.c.

**RECEIVER BOARD**

**Resistors**
- R14,R15,R20: 1M (3 off)
- R16: 330k
- R17, R23: 10k (2 off)
- R18: 47k
- R19: 8k2
- R21: 470k
- R22: 4.7k
- R24: 27k

All resistors 1W 10% except where otherwise stated

**Capacitors**
- C4: 1n
- C5: 470n
- C6: 2µ 10V elect.
- C7: 22n
- C8: 68µ 10V elect.
- C9: 27p

**Semiconductors**
- D6,D7: BAW 62 (2 off)
- TR3,TR4: BC159 (2 off)
- TR5: BC148
- TR6: BC149
- IC2: SAA 5012A

**Miscellaneous**
- P.c.b.
- Holder for i.c.

*See Fig. 1.7.

**Constructor's Note**

A complete kit of parts or individual boards for the PE Teletext system will be available from A. Marshall's (London) Ltd., Kingsgate House, Kingsgate Place, London NW6 4TA. The main decoder board, which is mounted on a double-sided p.c.b. with plated-through holes, will be supplied ready built, tested and aligned. The board is not suitable for home construction and its design will not be published.

of low frequencies whilst allowing the maximum response to the narrow transmitted pulses. The output from the diode (D5) is a.c. coupled to the voltage amplifier of TR4 and TR5. The response of the amplifier which is controlled by C6 and the feedback capacitance of TR5's collector has been designed to cut off low and high frequency interference. The high frequency cut off also improves the stability of the amplifier. The output of the amplifier is a.c. coupled via D6 and D7 to the base of TR6. The diodes D6 and D7 eliminate any noise which is generated in D5.

The 24-bit message code is applied to pin 22 of IC2 where it is decoded and checked for errors. The DATA output (pin 5) pin of IC2 provides a 7-bit output, 5 bits of which are identical to the input message code and the other two bits control the mode of the system (i.e. TV or teletext). The DLIM output of the chip (pin 7) is clocking pulse which is used to clock the output data from IC2. The internal functions of the circuit are controlled by an oscillator which is timed by the resistor and capacitor connected to pins 18 and 19. The 4-bit outputs from the chip (pins 2, 3, 8 and 21) are used to select the TV channel to be viewed.

Fig. 1.6. Wiring diagram for the infra-red diodes (D3 and D4) and the mounting details for the p.c.b.
Fig. 1.4. Double-sided p.c.b. design for the Transmitter

Fig. 1.5. Component layout for the transmitter board which also shows the through board links (square pads)
Fig. 1.7. Circuit diagram of the Receiver unit. The range of the transmitter can be increased by fitting a plastic lens in front of D5.

Fig. 1.8. Receiver p.c.b. design

Fig. 1.9. Component layout

RECEIVER CIRCUIT

The receiver circuit is mounted on the p.c.b. shown in Fig. 1.8. All the components, except for the photo-diode D5, should be mounted on the board as shown in Fig. 1.9. A holder should be used for IC2 and after all the components have been soldered into position the p.c.b. can be turned over and the diode D5 soldered onto the track side of the board taking care that it is correctly orientated.

The inter wiring for the receiver board and the complete system will be covered after the construction of the rest of the boards.

NEXT MONTH: CONSTRUCTION CONTINUED
200 Mullard ceramic capacitors with drawer £6.50 including VAT p. & p.

130 Siemens layer capacitors with two drawers £13.50 including VAT p. & p.

We have arranged that these special offer packs are available to PE readers from Marshalls. The packs represent excellent value for money, the ceramics are normally sold by Marshalls at 6p each and the Siemens layer type at 7p to 36p each (depending on value).

PACK 1. 200 Mullard 63V d.c. working miniature ceramic plate capacitors, 0-1 inch lead spacing.
   Tolerance—1-10pf ±0.25pF
   22-330pf ±2%
   470p-1n ±5%
   2n2-10n 10%

   The pack contains 10 each of the following values: 1p, 2p2, 3p3, 4p7, 6p8, 10p, 22p, 33p, 47p, 68p, 100p, 220p, 330p, 470p, 680p, 1n, 2n2, 3n3, 4n7, 10n.

PACK 2. 130 Siemens self-healing layer capacitors with polyester dielectric, 7mm pin spacing except 1u which is 10mm.
   Tolerance ±10%
   250V or 400V up to 100n, 100V 220n to 1u.

   The pack contains 10 of each of the following values: 1n, 2n2, 4n7, 6n8, 10n, 22n, 47n, 68n, 100n, 220n, 470n, 680n, 1u.

Mail order only

<table>
<thead>
<tr>
<th>Please send me</th>
<th>Pack 1 Ceramic</th>
<th>Pack 2 Layer</th>
</tr>
</thead>
</table>

Capacitor packs at £6.50 (Pack 1) or £13.50 (Pack 2) each
Enclose PO/Cheque No. ........ Value

Name ...........................................
Address ........................................

Please allow 28 days for delivery
OFFER CLOSES FRIDAY, 26 SEPT. 1980

Name ...........................................
Address ........................................

To: Marshall's (PE Capacitor Offer), Kingsgate House, Kingsgate Place, London NW6 4AT. Tel. 01-624 0805

Practical Electronics August 1980
Appearing every two months, Micro-Bus presents ideas, applications, and programs for the most popular microprocessors: ones that you are unlikely to find in the manufacturers' data books. The most original ideas often come from readers working on their own systems, and payment will be made for any contribution featured.

The five topics in this month's Micro-Bus are all totally unrelated, and include an automatic Morse-code generator, a game for the ZX80, and a program to multiply enormous numbers together.

MORSE-CODE GENERATOR

The following program was developed on an Mk14 microcomputer by Andrew Chadwick of Hull to produce Morse code as a teaching aid for a Scout troop. The program has other uses, such as the automatic generation of call signs and test sequences, and can easily be modified to generate Morse code from characters as they are typed in. The message to be transmitted is simply set up in memory and, using a look-up table, the program translates the message into Morse-code format and transmits it via the flag outputs of the microprocessor. The message is written using the simple code of 1 for A, 2 for B, etc., as shown in Fig. 1. A blank (39) must be inserted between each word, and the message must finish with the end-of-message character 37. A simple modification would enable the program to generate Morse code from a message written in ASCII.

The output can be fed directly to a high-impedance speaker by connecting the speaker between flag 0 or 1, and ground. Alternatively the output can feed a tape recorder via the simple interface shown in Fig. 2, which reduces the output to about 400 mV peak to peak, suitable for an auxiliary input.

MORSE CODE

The Morse code for the letters and numbers consists of a series of up to five dots and/or dashes, and the program uses a look-up table to convert the character to be transmitted into a single byte which specifies the Morse code; see Fig. 3. The three low-order bits of this byte, DO to D2, indicate how many dots or dashes there are in the Morse code for the character, and whether or not they will be sounded. Values of one to five imply one to five dots and dashes which will all be sounded, whereas six and seven imply one and two dots/dashes respectively which will not be sounded. This format enables spaces to be treated in a similar way to characters.

The upper five bits in the byte, D4 to D7, give the Morse code itself, a one representing a dash and a zero representing a dot. D4 corresponds to the first dot or dash.

MORSE PROGRAM

The program, shown in Fig. 4, takes up the whole of the Mk14's standard 256 bytes of RAM. It is divided into three sections: a look-up table from OF1B to OF43 containing the Morse-code bytes for the various characters, the main program from OF44 to OFC2, and a subroutine from OFC3 to OFF6. The subroutine generates either a tone or a space of length equivalent to either a dot or a dash. Which of these possible outputs is produced is determined by the two variables DDF (Dot/Dash Flag) and MSSF (Master Sound/Silence Flag) which are set up by the main program before the subroutine is called.

Setting DDF to 0 gives an output of dot length whereas 1 gives an output of dash length.

Fig. 1. List of characters with their Morse codes, and the hexadecimal codes used by the program in Fig. 4.

CHARACTER HEX CODE MORSE CODE

<table>
<thead>
<tr>
<th>CHARACTER</th>
<th>HEX CODE</th>
<th>MORSE CODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>29</td>
<td></td>
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<td>8</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>36</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 2. Interface circuit to enable the Mk14 to drive the auxiliary input of a tape recorder.

Fig. 3. Examples showing how the Morse codes for the characters are stored within one byte.
a hexadecimal number in the location WPM (OF12). On running the program, pointer 1 is set to point to the location of the first character in the message; in the listing of Fig. 4 this is at address OE00, but for the extra RAM on a standard Mk14 this would be OB00. Pointer 2 is set to the beginning of the standard RAM (OF00), and pointer 3 to the start of the subroutine.

The section of program between OF56 and OF64 divides 256 by the specified speed of transmission to give the appropriate value for the subroutine's inner-loop counter. At OF65 the character code is loaded from the message, converted from base 10 to base 16, and then used as a displacement to fetch the corresponding Morse-code byte from the look-up table. The instructions from OF70 to OF83 sort out the information stored in bits D0 to D2 of the Morse-code byte, and set the appropriate variables.

The main loop, beginning at OF9B, deals with the code stored in bits D3 to D7 of the Morse-code byte, and transmits it a dot or a dash at a time by giving the two variables DDF and MSSF the necessary values, and then calling the subroutine. A dash has three times the length of a dot, and the space between each dot and dash is the same length as a dot. The space between each character is three dots long, and between each word is seven dots long. The required spaces between dots and dashes, and between letters, are inserted by the instructions between OFA9 and OFAD, and OFB4 to OFB5, respectively.

When the end-of-message character has been transmitted and the program returns to the monitor. The timing throughout the program is based on a system using a 4.43 MHz crystal, and will have to be altered for any other clock frequency. Note that, with the program as it stands, only the standard alphanumeric characters, whose Morse code runs to a maximum of five dots or dashes, can be produced; characters with six or more dots or dashes, such as punctuation marks, are not possible.

BULLS AND COWS FOR ZX80

The following program to play 'Bulls and Cows', which is probably better known in the form of the plastic peg game 'Mastermind', is the first program feature in Micro-Bus to run on the Sinclair ZX80 BASIC-programmed microcomputer. It was devised by S. Murrell of Sunderland. The computer generates a random 4-digit 'code' which the player must try and deduce in eight or less attempts. Each digit in the code can be from 1 to 6, and each guess is entered as a string of four digits followed by a NEWLINE. The computer replies with a solid rectangle for each 'Bull', or correct digit in the correct position, and a shaded rectangle for each 'Cow', or correct digit in the wrong position. Each digit may only contribute towards one Bull or one Cow.

PROGRAM OPERATION

The program, shown in Fig. 5, works as follows. The computer first generates a code in the array Z(0) to Z(3). The guess string is then entered into GS, and the program converts it into an array of four numbers in G(0) to G(3). The computer then compares the two arrays, and prints a message indicating whether the guess is a Bull, a Cow, or neither, and in how many of each. If the guess is correct, the program returns to the monitor. If not, the message 'Bulls and Cows' is printed, and the player is invited to try again.

The computer makes a copy of its code in X(0) to X(3), and compares this, element by element, with the guess array. If there is a match a Bull is scored, and a white block is printed. The matching numbers in X and G are converted to 10 and 11 respectively so that they will not be counted as Cows later on. Next, the number of Cows is obtained by comparing every element of the array X with every element of the array G; for every match a shaded rectangle is printed, and again the elements are set to 10 and 11 so that they will not be counted again. Finally, if the score is four Bulls the code has been correctly guessed, and the human has won; otherwise the computer will declare a victory after the eighth attempt.

In the program listing of Fig. 5 ** is used to indicate that a tone is to be produced.

Program Operation:

1. Start:
2. Generate code:
3. Read guess:
4. Compare:
5. Bull:
6. Cow:
7. Neither:
8. Break:
9. Restart:
10. End:

Example:

Bull: 1-1-0-0
Cow: 1-0-0-1
Neither: 0-0-0-0

---

Fig. 4. Program for the Mk14 generates Morse code from a message stored in memory.

Fig. 5. Mastermind program for the ZX80; the task is to guess the computer's code.
represent a solid rectangle, which is obtained on the 2X80 by typing SHIFT-W, and "+" represents a shaded rectangle, which is obtained by typing SHIFT-T.

64-DIGIT MULTIPLY

The following short program for the humble Mk14 can multiply two numbers together to give a result of up to 64 digits, thus amply demonstrating the superiority of the microcomputer over the pocket calculator! The program, shown in Fig. 6, was written by Geoff Phillips who edits the Mk14 Users Group magazine 'Complement and Add' where the program first appeared.

The two numbers to be multiplied are stored in BCD format, two decimal digits per byte; the first number may be up to 30 decimal digits long, and the second up to 32 decimal digits long. The result is produced as a BCD number of up to 64 digits. The program is surprisingly short, yet takes only two seconds, on average, to perform the calculation.

The numbers should be entered into memory as follows:

OB00 Highest digits of first operand
OB10 Highest digits of second operand
OB1F Lowest digits of second operand

The program should then be executed from OF12, and the answer will be put into memory as follows:

OB20 Highest digits of answer
OB3F Lowest digits of answer.

INVERTED CHARACTERS ON VDU

The Mk14 VDU interface can be adapted to display reverse-video characters (black character on white background) mixed in with normal characters (white character on black background) with the addition of the simple circuit shown in Fig. 7. The program was sub-

CIRCUIT OPERATION

The circuit checks that the byte presented to the VDU is in fact for display by checking that the flip/flop will toggle correctly. That is, the Q output, not to the flip/flop input as shown, so that the flip/flop will toggle correctly.

BEGIN

Fig. 7. Circuit to enable an Mk14 VDU to display characters in reverse video.

mittingly by Anthony D. Love of Swansea, and is designed so that the state of bit 6 of the character determines how the character is displayed. If the bit is zero, the character is displayed in reverse video: otherwise it is displayed normally. Thus, for example, X'41' will give an A displayed normally, and X'01' will give a reversed A.

CIRCUIT OPERATION

The circuit checks that the byte presented on the data bus is in fact for display by checking that the tri-state address-line buffers are enabled; i.e. that pin 1 of IC9 or IC10 is low. The graphics/characters input is also checked to ensure that the VDU board. All the unused inputs are connected through a 1k resistor to the positive supply rail.

Fig. 7. Circuit to enable an Mk14 VDU to display characters in reverse video.

Fig. 9. Modification to the 'Low Cost SC/MP System' which appeared in the April Micro-Bus are recommended by the author, Andrew Aitken.

ADDENDUM

The following modifications to the 'Low Cost SC/MP System' which appeared in the April Micro-Bus are recommended by the author, Andrew Aitken.

DIGITAL ALARM-CLOCK

The following program will make an Acorn (System One) function as an alarm clock. The time is displayed as 'hours-minutes-seconds' on the 7-segment displays, and at the set alarm time A's replace the dashes on the displays and the output line PBO oscillates at 0.5 Hz so that a buzzer or relay can be operated; the normal display is resumed after one minute. The program, shown as a hex dump in Fig. 8, was submitted by Peter Mayne, whose 'Data Find Routine' was featured in the last Micro-Bus.
FOR THE YEAR 2000

The year 2000 is the present target date for the Satellite Power System. Already some five years of intensive research has shown that there are many facets to the ultimate success, some with spin-off and some showing a whole new field of technology. In this issue of Spacewatch a general outline of what is to be the main approach to the utilisation of Solar Energy by the United States will be reviewed. This will show not only the magnitude of the concept but also the attention to the environment and the philosophy of living in the next century. It can be seen perhaps that the thinking is not only world wide in its operation but initiates the practical possibilities and benefits for mankind.

In this project is embodied the basic dreams for a future in which man turns technology toward the concept for "The resources of the Earth for the benefit of the people of the Earth" and leads that benefit toward every man, woman and child that lives and will continue to live on Planet Earth.

THE SYSTEM

The basic principle is the collection of the energy of the Sun and its conversion into electromagnetic waves transmitted to an aerial on Earth for the benefit of the people of the Earth and leads that benefit toward every man, woman and child that lives and will continue to live on Planet Earth. The frequency of operation will be 2.45GHz. This frequency is chosen because it has been established that at a power of 23mW/cm² it will have negligible effect on the environment and hum as animal life.

The satellite would be put first into a low earth orbit (LEO), then later raised to the geostationary orbit (GEO). The satellite would be put first into a low earth orbit (LEO), then later raised to the geostationary orbit (GEO).

The first impact of the magnitude of the items in the satellite and the physical extent involved, leads to some queries. It is perhaps easier to accept the receiving antenna dimensions on the ground and be less concerned with any hazards that might be involved. Each situation needs some answers. In order to get to the psychological aspect in perspective and relieve anxieties of misunderstanding, the fears will be answered in advance.

The question that first arises is the safety of such large units even at the distances from the Earth when geostationary orbits are considered. Questions like: will it be stable? Can it be de-orbit like Skylab? Is it likely to be a danger to people on the ground? The answer is that the density of the atmosphere at the geostationary orbit level is very low and generally satellites are considered to have a very long lifetime; indeed theoretically an indefinite lifetime. The construction of the SPS satellite is however rather different from the usual type of satellite. It will have a much smaller mass to area ratio than previous satellites and would be more subject to atmospheric drag.

The SPS satellite has been designed for a 30 year life and the orbital decay would lie between 0.25 and 2,500 metres. That is less than one part in ten thousand in the worst condition. The other associated components such as the work platforms, the normal construction facilities, the personnel and their vehicles would be less influenced since these would have higher to area ratios. There would be perturbations from solar radiation and from lunar and solar gravity effects. Also there are the variations like the ellipticity of the Earth. These effects would be slightly larger than the atmospheric drag but it would be a normal part of station-keeping to correct such conditions.

NO HAZARD?

Perhaps the short answer is that there is no reason to suppose that there would be any increased hazard to these large assemblies and little likelihood of danger situations. The units can be large because gravity is small.

Another question that might be raised is: How vulnerable will the units be to random events like meteor showers? This is not very likely. The large scale is such that built-in redundancy would take care of this. It must however be said that overt action military or otherwise could do damage, but when examined this is unlikely except in case of deliberate hostilities. This aspect will be considered later.

Another question might be: What is the possible danger from terrorism or the activities of rival states? The answer here is that when the system is fully operational there would be 60 satellites and a similar number of ground units (rectenna and associated facilities). Here the very nature of the organisation is such that normal security would be of such a nature as to take care of such possibilities. Therefore, short of war, the possibility is remote, since a pilot beam first is needed to enable the system and give the instruction to the satellite to focus the beam on the rectenna. If the transmitting antenna is pointed away from the rectenna the beam will at once de-focus. In this case there would only appear a level of background which would preclude any damage from the antenna pointed to the Earth.

One of the areas where doom thinking has taken root is the question of damage to the ozone layer and the creation of a "Greenhouse Effect".

The answer to this can be positive. Most of the ozone is between 10 and 40km in the Stratosphere. Intensive investigation of this area has continued over the past ten years. The effects from the effluents from SPS rocket launches is negligible. Above the 50km level the ozone is less than 1 percent of the peak value in the Stratosphere. However there is the possibility that over the 70km level there may be an increase of ambient water concentrations. There are complex chemical mechanisms which control ozone at these levels, but is still not considered to be a hazard.

So far as the Greenhouse Effect is concerned, this is more difficult to deal with though there is no expectation that the situation would be aggravated by the advent of the satellites.

NEW NIGHT SKY

Some people are concerned about the aesthetic effects on the night sky. This has been considered carefully and the answer is that the satellites will be visible on clear nights. The actual brightness would be about 1/1000 of the light of the moon. In the night sky the satellites would be most noticeable at midnight and the equivalent of seven Binoculars with a magnification of seven would show them as rectangular objects and not as points of light. It could be said that they will enhance the aesthetics because of the general appearance. There would be a contrast between the random stars of the constellations and they would present an apparent straight line of objects of equal brightness. They would appear to be separated by a distance of slightly less than that of the stars in Orion's belt.

At intervals of six months, the satellites would be eclipsed and would pass through the Earth's shadow at about midnight for a number of days in succession. This would be an occurrence similar to a lunar eclipse. The satellites would first dim and then redden when reaching the edges of the shadow then darken and appear a few minutes later.

Consideration of these matters is continuing and being constantly updated. The next issue of Spacewatch will contain more technical details of the design and the conversion systems from the microwave transmissions to the feeding of the power lines for general distribution. After this aspect then, the possible effects on the future of meteorological conditions will be noted with the ecological and resource effects.
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CHEAP metal detectors are usually disappointing in use, whilst good ones tend to be very expensive. Although there is a lot of work involved in building the machine in this article, it can be completed for around £40-50, less than a quarter of the cost of most ready-made ones of similar performance. It is not strictly a design for the beginner to attempt, but a step by step construction and test procedure has been devised to make it as simple as possible. The only absolutely essential item of test equipment required is a reasonable quality test meter.

Until now, most metal detector designs for the home constructor have been BFOs. True, there have been one or two notable exceptions, but even these were relatively unsophisticated examples of their type, so readers might be interested in a brief description of the basic methods of detection and the reasons for the choice of system used in this design.

TYPES OF DETECTOR

Broadly speaking there are five main ways of detecting metal; BFO (beat frequency oscillator), induction balance, pulse induction, off resonance, and the magnetometer. The latter works by detecting small anomalies in the Earth's magnetic field strength. It's fascinating but quite useless for treasure hunting since it can detect only ferrous objects. The BFO and off resonance types both operate by detecting the small changes in the search coil inductance which occur when a metal object is present. Both suffer from a basically poor sensitivity. Some sophisticated attempts have recently been made to produce a really good off resonance machine, so far without obvious success.
Pulse induction detectors are another matter however; good ones are very sensitive indeed and some of the most expensive detectors currently available are these. They operate by exposing the ground to powerful pulses of magnetism and listening between the pulses for signals due to eddy currents set up in any metal objects present in the field. Despite their sensitivity they have a couple of important drawbacks. Their battery consumption is heavy due to the power required by the pulsed transmitter, and they are extremely sensitive to even tiny ferrous objects. Their use is thus primarily restricted to beach searching, where objects are likely to be buried at considerable depths, and where large holes can be easily and rapidly dug. On inland sites, their users can become discouraged by the frequent digging of large holes in hard ground to recover rusty nails, etc.

This leaves the induction balance types which have become more or less the standard general purpose detector for both serious treasure hunters and detecting hobbyists alike. It has two coils in its search head, one of which is fed for both serious treasure hunters and detecting hobbyists become more or less the standard general purpose detector for hobbyists. Their users can become discouraged by the frequent digging of large holes in hard ground to recover rusty nails, etc.

This leaves the induction balance types which have become more or less the standard general purpose detector for both serious treasure hunters and detecting hobbyists alike. It has two coils in its search head, one of which is fed with a signal which sets up an alternating field around it. The alike. It has two coils in its search head, one of which is fed with a signal which sets up an alternating field around it. The other coil is placed so that normally the field it balances and it has no electrical output. A metal object approaching the coils will distort the field, resulting in an imbalance so the the pickup coil will produce an output. This can be amplified and used to inform the operator of a "find" in a variety of ways. Frequently in simple detectors an audio modulated transmitted signal is used, the output from the pickup coil then being amplified and demodulated like an AM radio signal. There are many possible coil arrangements, but most detectors available today use one of the two shown in Fig. 1. Fig. 1(a) shows a "widescan" coil, so called because its most sensitive area (shaded) extends right across the coils Fig. 1(b) shows a "pinpoint" type, also known as a "48". In the author's experience the pinpoint is by far the better coil in use, as widescans have poor pinpointing ability and tend to give false signals for ferrous objects off centre, coins on edge and the like. It’s noticeable that many of the best imported American machines use pinpoint coils.

**DISCRIMINATION**

All of this is fine, but there are a couple of extra refinements necessary in a really good metal detector. One of these is the ability to discriminate between unwanted junk such as silver paper, scraps of iron etc. and desired objects. The other is some means of eliminating false signals due to "ground effect". Ground capacitance effects can easily be prevented by Faraday shielding around the coils, but most inland soils contain a proportion of iron oxide which gives a signal similar to a piece of ferrite. Beaches wet with seawater the other hand are slightly conductive, and this too causes false signals to be produced in the pickup coil. Obviously some means of "tuning out" these effects will improve the detector considerably.

Fortunately the signals from the search coil consist of more than just amplitude variations; they also contain information in the form of phase shifts which differ markedly according to the type of object causing the signal. With a relatively simple phase sensitive detector therefore, a machine can be designed which will totally reject ground effects and can also, with practice on the part of the user, eliminate the majority of the rubbish detected without the necessity of having to dig it up!

**NOMENCLATURE**

Some of the terms used by manufacturers to describe their machines in recent years have been somewhat confusing so, before we proceed, a note on these may not be amiss. 'VLF' stands for "very low frequency". The ability to discriminate from phase information against thin section objects like foil depends on frequency. At higher frequencies, 'Skin effect' eddy current conduction makes such discrimination ineffective. Therefore manufacturers began using lower and lower frequencies, at least one machine actually worked at less than 2kHz. This created problems of its own, as at such low frequencies sensitivity to cupro-nickel coins is not so good and "Q" problems arise in the coil design. Most detectors nowadays operate somewhere between 10 and 20kHz, where discrimination is still excellent but sensitivity and coil design problems do not arise. "GEB" means "ground exclusion balance" and refers to the phase sensitive means of excluding ground effect. "TR" means "transmit-receive", and is often used to describe the discriminate mode, suggesting that the machines operate with different frequencies or coil configurations in the different modes—they don’t; the only thing that is changed between modes is the phase reference point. It is not possible to avoid ground effect and discriminate at the same time, so one normally searches in GEB mode, and on finding an object, checks it with the discriminate mode before digging. Beer can pull rings can be rejected by the way, but machines capable of doing this will also reject any cupro-nickel coin smaller than a 10p when set to do so. It is probably better to tolerate the rings—many charities now collect these anyway.

**BLOCK**

Fig. 2 (dotted) shows a schematic of the Magnum detector. The drive oscillator sets up a field around the search coil, and the pickup coil is positioned so that it only gives an electrical output when a metal object distorts this field. The operating frequency of these stages is approximately 15kHz. Signals from the pickup coil are amplified, buffered and then inverted so that non-inverted and inverted versions of it are simultaneously available. These are fed to the two inputs of an electronic changeover switch, operated by a reference signal derived from the drive oscillator. This reference signal has first been passed through a phase shifting network which can be adjusted as required by the user. The output from the switch is passed through a 3rd order low-pass active filter with a cut-off point set at 40Hz, which removes practically all of the 15kHz signal, leaving only the average d.c. level.

Any given signal producing object causes changes in both magnitude and phase of the received signal, so by adjusting the phase shift network correctly a point can be found where these changes either cancel out or cause a net fall in the d.c. level, enabling unwanted signals from ground, foil, iron etc., to be eliminated. Incidentally, most similar designs to date have used either pulse sampling phase detectors, or have selected only half-cycles of the input signal. The use of the
inverter and changeover switch requires very few extra com-
ponents and greatly improves the signal-to-noise ratio, ul-
timately resulting in more sensitivity.

After the filter, the d.c. signal is amplified. It is only
changes in the signal that are of interest, so a means of “tun-
ing out” the initial standing d.c. level is required. In simple
machines this is a manual control, but the need for readjust-
ment after each operation of the phase controls—say
switching from “ground” to “discriminate”—makes some
form of automatic tuning desirable. On most commercial
machines a “tune” button resets the output to zero every
time it is pressed, but these are notoriously prone to drift.
Attempts to use continuously resetting systems have been
made, but this tends to lower the overall sensitivity as most
manufacturers use rather crude filtering, resulting in con-
siderable delay in the response to a detected object. In effect
the autotune tries to reset the output to zero at the same
time as the detected object is trying to cause it to rise! The
highly efficient filtering used in this design ensures an ins-
tant response to a signal, so a continuously resetting tuning
system can be used. This “goes away with all the drift
problems, and allows the machine to be used continuously
at maximum sensitivity if required. A “freeze” button is
provided to stop the tuning action whilst pinpointing the ex-
act position of finds or discriminating.

After the autotune and amplifier stage the signal is fed to
a centre-zero meter; in “discriminate” this indicates positive
for “good” finds and negative for “bad” ones. Then it goes to
a further amplifier with a control which sets the point at
which the audio output is to start. The output from this is of
course still d.c., so it is chopped up by an audio oscillator,
providing a signal which only needs a power output stage to
drive the loudspeaker.

CIRCUIT

Fig. 2 shows the complete circuit of the machine. TR1 and
associated components form the drive oscillator, which
provides a very pure 15kHz sinewave output. IC1 buffers
part of this signal and the circuitry around IC2 introduces the
phase shift as required. In “ground” the available shift is
about -10 to +40 degrees, whilst in “discriminate” and
“beach” it is about 0 to -170 degrees. IC3 is a comparator;
the 3130 was chosen for its high slew rate and good output
drive signal for the CMOS switch IC6. TR2 is the received
signal preamp and is connected as a common base amplifier.
This and oscillator TR1 are both based on designs which
have been used in several manufactured machines because
they are simple and work well. The receive coil L2 is un-
tuned; this, coupled with the low impedance input load of
they are simple and work well. The receive coil L2 is un-
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drive signal for the CMOS switch IC6. TR2 is the received
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they are simple and work well. The receive coil L2 is un-
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| Resistors |
|---|---|
| R1, 4, 5, 7, 8, 19, 20, 29, 35, 38, 46, 48,—10k |
| R2, 16,—15k |
| R3,—3k3 |
| R6, 9, 21, 47,—4k7 |
| R10,—3k9 |
| R11, 49, 50,—2k2 |
| R12,—1k |
| R13, 17, 30,—100k |
| R14,—180k |
| R15, 28, 32, 34, 43,—22k |
| R18,—2M2 |
| R22, 23, 44,—33k |
| R24, 25—27k |
| R26, 27,—39k |
| R31, 39,—1M |
| R33, 37,—220k |
| R36,—270k |
| R40,—47k |
| R41,—6R8 |
| R42,—470k |
| R45,—2k7 |

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<th>Potentiometers</th>
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<tr>
<td>VR1, 2,—47k log carbon.</td>
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<td>VR3,—1M lin. carbon.</td>
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<td>VR4,—100k lin. carbon.</td>
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<tr>
<td>VR5,—10k log. with switch.</td>
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<td>VR6,—10k preset, sub min horizontal.</td>
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<td>C1, 10,—47n polyester</td>
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<td>C2,—470n polyester</td>
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<tr>
<td>C3, 7, 9, 16, 21,—10n polyester</td>
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<tr>
<td>C4, 5,—6n polystyrene</td>
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<td>C8, 12, 13, 14, 15,—100n polyester</td>
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<td>C11,—22p polystyrene</td>
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<td>C17,—1µ polycarbonate</td>
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<td>C20, 24, 25, 26,—470µ 16V electrolytic</td>
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<td>C22,—470µ 25V electrolytic</td>
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<td>C23,—10µ 25V electrolytic</td>
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<td>D9,—BZ886 5V6, 5.6 volt Zener.</td>
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<td>TR2, 5, 6, 8,—BC184L</td>
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<td>TR3,—2N3819.</td>
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<td>TR7,—BFX29.</td>
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<tr>
<td>C3,—CA3130 8-pin d.i.l. or T079.</td>
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<tr>
<td>C4, 9, 10,—CA3140 8-pin d.i.l. or T079.</td>
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<tr>
<td>C6,—4007UBE (CMOS).</td>
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<tr>
<td>IC1,—ICM7555—low power 555 timer 8-pin d.i.l.</td>
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<tr>
<th>Miscellaneous</th>
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| S1, 4-pole 3-way rotary switch, S2, pushbutton, miniature, press to make, Meter, 100-0-100 microamp centre zero, LS1,—2pin. 8ohm Loudspeaker, 12 off 8-pin d.i.l. i.c.
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| SWG enamelled copper wire, 5A bare tinned copper fuse
| wire, 2 metres of 4-core individually screened cable, Case, Vero type 75-1411-D, 6 control knobs, approx 25mm skirt,
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offset the input voltage. A change in the input voltage will now be reflected in a change in the output voltage, the gain being given by \( R_2/R_{in} \). In this way an amplifier can be constructed using only one op-amp which will offset large d.c. input voltages and yet provide high d.c. amplification of very small input voltage changes.

In the main circuit TR3 provides a means of connecting the output to the input. The output is divided by R33 and R34 and fed through R31, so that the reset rate is relatively slow but continuous, as TR3 is normally conducting. If the tuning error is very large however, as it would be after switching on or operating the discriminating controls, D5 or D6 will conduct and greatly accelerate the tuning rate. D3 and D4 prevent the gate junction of TR3 from becoming forward biased at any time.

VR4 sets the threshold of IC10 and is normally adjusted to that it's output is at negative rail voltage. On receipt of a signal it rises towards positive. IC11 is a low-power 555 timer connected as an astable oscillator, giving very short (about 100 microsecond) negative pulses at about 400Hz. Thus TR5 is normally on and turns off only during these pulses so after R40 any output from IC10 is chopped into short positive going pulses. This is the ideal waveform to create lots of noise with an economic power consumption. The volume control in a design such as this is normally only required to limit the maximum noise level, so in this design VR5 and TR4 act as an adjustable clamp. In this way the sensitivity is not reduced if the volume has to be kept turned down. TR6 and TR7 are a complementary Darlington pair, their current gain enabling the signal to drive the loudspeaker or headphones.

SUPPLIES
Two separate power supplies are used in this machine. The bulk of the circuitry is supplied with 18 volts from two PP3 batteries in series, regulated by the circuit around IC12 and IC13. With so many op-amps its far easier to arrange the design around a centre-tapped supply, so the reference generated by the Zener is buffered by IC13. It is then doubled by IC12, TR8 and TR9, to give a regulated positive rail of twice the Zener voltage, nominally +11.2 volts. This arrangement has been used in preference to an integrated regulator since it will operate until the battery voltage has fallen to only 0.1 volt above the regulator output. Most integrated regulators require a differential of at least 2 volts, which in practice means that the batteries have to be replaced rather more frequently. The total power consumption of all this circuitry is about 20mA, less than many radios at normal volume.

Power for the loudspeaker output stage comes from a separate 9 volt battery, as this is the simplest way of avoiding decoupling difficulties in this very sensitive circuit. An extra PP3 is far smaller than the decoupling capacitors which would otherwise be required! Only the one power supply switch is required as the output draws no current unless an input signal is present.

CONSTRUCTION
Construction is on two printed circuit boards and should be adhered to as this is a very sensitive circuit indeed; the result of any changes may well prove to be severe instability! The two boards are stacked vertically in the final assembly resulting in a control box which is smaller and neater than many very expensive manufactured products.

The board containing the power supply, autotune and output should be built first as the power supply will be required for testing the "front end" board (Fig. 5).

ASSEMBLY DETAILS
Start construction by fitting the six links. The fit R45 to R48, C22 to C25, ZD1, TR8, TR9, IC12 and IC13. Apply the 18 volt battery via a 100mA meter and a 220 ohm series resistor, which will limit the current if any faults are present. It's as well to use this resistor throughout the testing of both boards. After a brief surge as the electrolytics charge the current should settle to about 5mA. Check that about 11 volts appears across C25, and about 5-5 volts across C24. This completes the power supply section.

Continue by fitting R40 and R41, C19 and C20, TR6 and TR7. Hook up the speaker, apply the 9 volt power supply via the 100mA meter and a 100 ohm resistor, again in case a fault is present. After a brief surge the current drawn should drop to zero. A finger on R40 and the battery positive at the same time should cause a crackle and an indicated current flow. Fit R42 to R44, C21, TR5 and IC11. IC11 is the low-power 555 timer; despite the manufacturers' notes to the contrary these are a little sensitive to handling so treat it with care and use a holder. i.c. holders are advisable throughout in fact; there is ample room for them. Apply both power supplies. A finger on 9 volts positive and on R40 should now produce the 400Hz output tone, albeit possibly at rather low volume. After this the 100R resistor can be left out of the 9 volt supply during testing, although the 220R in the 18 volt supply should be retained. Fit TR4 and hook up VR5. Apply power supplies, place fingers on R40 and 9 volts positive, and check that the volume can be controlled with VR5. This is one of those many jobs in electronics for which one requires three hands!

Fit R33, R34, R36 to R39, C18, and IC10. IC10 may be in

![Control fascia of P.E. Magnum detector. Note 'Tune Hold' switch on handle.](image-url)
Fig. 4. Connections to controls and headphone jack socket. Other connections as marked on p.c.b. overlays

BOARD ASSEMBLIES

Power supply, autotune and output board

Front-end board in position
Fig. 5. Etching detail and board layout for power supply, autotune and output

either an 8-pin d.i.l. package, or the round metal T079 version. You can now hook up VR4 and apply power. It should be possible to turn the output tone on and off with VR4—gradually, since the input of IC10 at this stage is effectively taken to the supply centre-tap via R33 and R34 which reduces its gain somewhat. If there is no output tone check that the volume isn’t turned right down.

FINAL TEST

Fit all the remaining components to this board. Hook up S2, VR3 and the meter. Short the input point to the battery centre-tap. Apply power; the meter should return to zero within a couple of seconds due to the autotune action. Adjust VR4 to just below the tone threshold point. Touch the 18 volt battery positive with one hand, and, taking a 10M resistor in the other, touch the top end of R29 via the resistor. This should produce a brief burst of tone and a positive jump on the meter, which will then return to zero. Repeat this procedure whilst pressing S2—the sound and meter deflection produced should then be continuous. Press the button, and touch either of the 18 volt battery leads and the bottom of C17. This should cause the meter to drive fully up or down, and its full scale deflection can then be adjusted with VR6.

Next month: details will be given of the remainder of the construction and using the detector.
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<table>
<thead>
<tr>
<th>Product</th>
<th>Price</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 EuroBreadBoard</td>
<td>£6.20</td>
<td></td>
</tr>
<tr>
<td>2 EuroBreadBoards</td>
<td>£11.70</td>
<td></td>
</tr>
<tr>
<td>3 EuroSolderBoards</td>
<td>£2.00</td>
<td></td>
</tr>
<tr>
<td>1 EuroSolderSucker</td>
<td>£7.25</td>
<td></td>
</tr>
</tbody>
</table>

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LOW-LIGHT VIEWFINDER

English Electric Valve Company Ltd. patents (BP 1 559 586, filed in 1976 under the old laws) a greatly simplified low-light tv system. Such a system can, for example, be used as the viewfinder for a camera operating in the invisible infra red (or ultra-violet) regions. Normally an infra-red camera, with a vidicon tube of the thermal-imaging or pyro-electric type, requires a separate monitor as a viewfinder which in turn requires external synchronization. This is expensive and the aim is to provide an inexpensive viewfinder built into the camera.

In many respects the new invention borrows from ideas as old as television—i.e. mechanical scanning by synchronously locked discs in the Baird system. A pyro-electric tube produces an output signal only when its target area is either heating up or cooling down under the influence of infra-red. No output is produced in a steady state condition so the tube must be associated with a shutter which regularly interrupts the infra-red image. Normally, the tube target gives a positive signal from areas that are warming up and a negative signal from areas that are cooling down. The negative signals are then all inverted electronically so that a constant polarity output is fed to a display tube viewfinder. But clearly synchronization between the tubes is all important.

Figure 1 shows a camera with a pyro-electric pick-up tube 1 and an imaging lens 2. Monitor display tube 3 provides the reconstituted image on phosphor screen 4. The image from lens 2 is chopped by cylindrical shutter 5 which rotates with a cylinder 8 on axis 12 around both the pick-up and display tubes. The shutter can provide one cut-off per revolution (Figure 2) or two cut-offs per revolution (Figure 3). The crux of the invention is the provision of deflection coils on the body of the cylinder 8. These thus rotate in mechanically locked synchronism with the shutter; so both the tv tubes display a deflection pattern which is synchronously locked irrespective of the speed at which the cylinder rotates.

An AC scanning field is fed to the deflector coils and the reproduced picture is superimposed on a tv raster pattern. Although, as shown in Figure 5, this may well be non linear, i.e. the raster lines may be non parallel, this is of no consequence. Both the camera tube and the display tube are mechanically locked to exactly the same scan pattern, so the displayed picture shows no distortion of shape.

THIRD MADLEY AERIAL

WORK HAS started on a new space communications aerial for the PO at Madley in Herts. This erection is necessary to keep pace with the enormous volume of overseas telephone calls from the UK, currently ten million a month, and doubling every four years. With telex and computer data increasing as fast, the £7.5m project will add to the satellite earth station’s £17m worth of existing hardware. The PO is spending an overall £1000m annually on new plant to constantly update Britain’s communications with the rest of the world.

A £3m contract goes to Marconi Communications Systems, who will supply everything except the dish itself, and its control electronics and receivers. The remainder of the aerial and its electronics will be supplied by the Mitsubishi Electric Corporation. To be completed in 1981, the aerial will work with a satellite in a geostationary orbit 23,000 miles above the Indian Ocean, one of the eight satellites now operating the Intelsat (International Telecomms Satellite Organisation) global system. “Madley Three” will be a 32m diameter dish capable of transmitting 2000 telephone calls and two TV programmes simultaneously. Its satellite is capable of handling up to 12,000 calls at once.

TI 58/59 CLUB

A NATIONAL TI 58/59 calculator club has been started by Mr. R. M. Murphy of the Dept. Electronics Engineering, University College Swansea, Singleton Park, Swansea. The basis of the club will be direct exchanging of programs, or purchase of programs at 50 pence each. There will be a newsletter every two months, and since a PDP 11/32 computer is to be used for administration, the club should be very efficient. Guide books on conversion, upgrading and such things as a cheap cassette interface, will be available.

Work is taking place to interface a SC/MP micro to the calculator to drive a 10-digit, 16-segment alphanumeric display.

Membership will cost £5, or £3 to those who include a program plus flow diagram and instructions.
WHEN dealing with purely electronic circuits, whose resistance changes little with time, it matters little whether one uses a constant current or constant voltage source, and indeed most electronic engineers are quite content to use the latter. However as soon as we move either to heavier current loads—where resistive heating becomes significant—or to more complex systems such as electrolyses, where total cell impedance depends on the sum of resistance through the electrolyte and reaction impedance, a constant current source becomes mandatory for any quantitative measurements. Briefly to elaborate on the foregoing terms, it will be obvious that passage of any significant current through the electrolyte will cause resistive heating and thus lower the solution resistance. In this, its behaviour differs from the resistance coefficient of a metal, which is of opposite sign. It will be noted that the sign of the solution temperature coefficient, like that of an electric arc or a fluorescent tube, could induce a runaway condition. The second component is the so-called reaction impedance, that is to say, the resistance to passage of current at the electrodes themselves. This is a function of electrode materials, their size and not least, the type of electrolysis taking place. In short, the simplest electrolysis can in practice require a voltage increase of 50% or more in order to maintain a given current. Nothing could better demonstrate the need for the type of equipment to be described here. Knowing that current remains invariant with time, enables us to perform experiments such as the experimental verification of Faraday's Laws, where total charge passed is current x time. Then too, using the same principle, we can pass a known charge and thereby generate a given quantity of a chemical or a metal ion. Such techniques are widely used in analysis where they correspond to an electrochemical means of "weighing out" from a bottle, but are far more accurate in most cases. Used with an oscilloscope the constant current source can tell us about species adsorbed on an electrode surface, for as long as many species exist, the potential will change only slowly, if at all. Once they are all gone, it will rise sharply. Last but not least, by passing a constant current, and measuring the rate of potential change of an electrode, we can determine the effective capacitance, from the simple equation:

\[
i = C \frac{dV}{dt}
\]

That capacitance is directly related to surface roughness, or the presence of foreign species adsorbed on its surface. In short, this is a most useful tool.

Early constant current sources consisted simply of a high voltage—up to 100V DC connected across the electrolysis cell through a substantial resistance (which of course was required to dissipate a substantial wattage without too much temperature rise). But some years ago, solid state power sources began to find favour.

**DESIGN AND SPECIFICATION**

Our specification will depend on the purposes for which we use the constant current source, or galvanostat, as it is often known. The prime question relates to the current output. For such work, an output of 20mA will suffice, especially when electro-analysis is the major interest. But for much other work, such as studies in electrolysis of brine, or battery research, a higher output, such as 1–2A is more useful, in that it enables us to do what we wish on electrodes of reasonable size, say 1–5cm² in area. The second feature must of course be current stability, and this is defined both with respect to time, into a constant load, and also with respect to load variation, over a short space of time. A one per cent constancy would be the lowest acceptable value, while a figure such as 0.3 per cent would be better. Again, the effect of ambient temperature on output current should not be neglected here, and can be lumped into the above figures.

Finally we have two further specifications to meet. Ripple content should be less than 0.1 per cent and then there is the question of rise-time which depends very much on the proposed duty. But in some applications the device is switched onto load extremely fast, using a mercury-wetted reed relay or a CMOS and VMOS switch. Into a purely resistive load, the rise time should be fast—of the order of 1 microsecond.

Various circuits have been published, from time to time, which fulfil these specifications.

We shall show here the construction of two units. The simpler one, based on a design of Dr. Colin Vincent, of the University of St. Andrews, is a single transistor galvanostat.
It will deliver up to 22mA. The more sophisticated instrument is based on a design that was evolved at Salford University. It will deliver from 5 microamperes to 3 Amperes in 6 switched ranges. To extend the utility of the latter instrument, we have included a switch to convert it from constant current to constant voltage mode. The range switch and ten-turn potentiometer then provide a voltage range from 0V to 30V.

A further feature incorporated in this instrument is an input socket which allows an applied voltage function to control the current output as a function of time. Thus by application of a square wave voltage function, the corresponding current output will be produced. Suitable function generators are readily available commercially, though their construction will form the basis of a future article in this series.

20mA GALVANOSTAT

a) Circuit
The circuit consists of a full wave rectified power supply comprising:—T1, D1, D2, C1, C2 and R1 which delivers approximately 30V D.C. Transistor TR1 operates in the common base mode giving a very high impedance collector circuit. The current flowing in the load (collected current) is determined by the voltage applied to the transistor base $V_B$ and the value of $R_3$, and is approximately equal to:

$$I_L = \frac{V_B - V_{BE}}{R_3}$$

where $V_{BE}$ is the potential drop across the base emitter junction; this being about 0-6V for a silicon transistor.

Therefore the maximum load current for the circuit is

$$\frac{6.2 - 0.6}{270} \approx 0.020$$

By varying the base voltage using VR1 the output current can be varied between 1 and 20mA. The circuit will keep the current constant to 0-1 per cent for 1 hour after reaching working temperature. In order to keep the circuit under load and at working temperature when not in use, a standby clearing load has been incorporated consisting of S2 and R4. The ability to supply maximum output current into high resistance loads is restricted by the available output voltage of 30V.

CONSTRUCTION
The circuit is constructed on a small printed circuit board no particular problems being envisaged.

The original circuit was constructed in a small metal box measuring 135 x 80 x 55mm.

CALIBRATION
The circuit was loaded with a 100 ohm 0-5 watt resistor and allowed to warm up for one hour.

The scale was then marked by adjusting VR1 and measuring the output current with a meter.
**COMPONENTS . . .**

**Resistors**
- R1 100
- R2 2k7
- R3 270
- R4 430
All 0.5W 2% Thick Film

**Potentiometers**
- VR1 5k lin

**Capacitors**
- C1, C2 100µ
- 63V Electrolytic (2 off)

**Semiconductors**
- D1, D2 1N4001 (2 off)
- D3 BZY88 6.2V 400mW
- TR1 BFY50 (2N3053)

**Transformer**
- T1 240V primary
  - 20-0-20 V r.m.s. Secondary 1.2VA
  - Printed circuit mounting
  - R.S. Components 207-908

**Miscellaneous**
- S1 DPDT Min. toggle
- S2 SPDT Min. toggle
- Fuseholder +1A Fuse
- 240V Neon
- P.c.b.
- Output socket

---

**3A GALVANOSTAT**

**CIRCUIT**

The circuit provides an output voltage of up to 30V d.c. at currents up to 3A.

The circuit functions as either a constant voltage or constant current power supply, depending on the position of function switch S3.

The output voltage or current is dependent on how much output transistors TR2 and TR3 are turned on by operational amplifier IC1, and TR1.

Initial setting of voltage or current is achieved by adjusting the voltage at the non-inverting input of IC1 using VR1 to vary the reference voltage derived from the Zener diode stabilising network R1, D9, R2, D10 and C2. Resistors R3 and R4 determine the limits within which VR1 operates.

The circuit can be controlled externally, e.g. from a sweep generator via the external input socket SK1. For full output a control voltage of one volt d.c. is then required.

In the constant current mode, one of the resistors R8–R13, selected by range switch S4, is connected in series with the load. Voltage developed across this resistor is fed back to the inverting input of IC1 so that if the output current increases the voltage across R8–R13 will increase thus causing the output voltage of the circuit to decrease holding the output current constant. The reverse occurs should the output current drop.
Fig. 4. Full circuit diagram of 3A Galvanostat

Fig. 5. Printed circuit for op. amp. power supply board (actual size)

Fig. 6. Component overlay for above
COMPONENTS...

**Resistors**

<table>
<thead>
<tr>
<th>Resistor</th>
<th>Value</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>4k7</td>
<td>Thick Film</td>
</tr>
<tr>
<td>R2</td>
<td>1k5</td>
<td>Thick Film</td>
</tr>
<tr>
<td>R3</td>
<td>5k1</td>
<td>Metal Oxide</td>
</tr>
<tr>
<td>R4</td>
<td>1k10</td>
<td>Metal Oxide</td>
</tr>
<tr>
<td>R5</td>
<td>39k</td>
<td>Thick Film</td>
</tr>
<tr>
<td>R6, R7, R12</td>
<td>1R</td>
<td>2.5W Wirewound (3 off)</td>
</tr>
<tr>
<td>R8</td>
<td>10k</td>
<td>Thick Film</td>
</tr>
<tr>
<td>R9</td>
<td>1k</td>
<td>Thick Film</td>
</tr>
<tr>
<td>R10</td>
<td>100R</td>
<td>Thick Film</td>
</tr>
<tr>
<td>R11</td>
<td>10R</td>
<td>Thick Film</td>
</tr>
<tr>
<td>R13</td>
<td>0.33</td>
<td>2.5W Wirewound</td>
</tr>
<tr>
<td>R14, R15</td>
<td>1k</td>
<td>Thick Film (2 off)</td>
</tr>
<tr>
<td>R16</td>
<td>270</td>
<td>Thick Film</td>
</tr>
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</table>

All resistors ±W 2% unless otherwise stated.

**Potentiometers**

<table>
<thead>
<tr>
<th>Potentiometer</th>
<th>Value</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>VR1</td>
<td>1k</td>
<td>3W 10 turn linear</td>
</tr>
<tr>
<td>VR2</td>
<td>10k</td>
<td>Enclosed cermet preset linear</td>
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**Capacitors**

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<th>Value</th>
<th>Voltage</th>
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<tbody>
<tr>
<td>C1</td>
<td>4700µ</td>
<td>63V</td>
</tr>
<tr>
<td>C2</td>
<td>1000µ</td>
<td>25V</td>
</tr>
<tr>
<td>C3, C4</td>
<td>100n</td>
<td>Disc</td>
</tr>
<tr>
<td>C5, C6</td>
<td>220µ</td>
<td>63V</td>
</tr>
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</table>

Can electrolytic
Wire ended electrolytic
Ceramic (2 off)
Wire ended electrolytic

In the constant voltage mode R8-R13 are shorted by S3B and IC1 inverting input is grounded via R5 by S3A. Capacitors C3 and C4 provide supply decoupling for IC1. The output voltage is provided by T1, D1-D4 and C1, and IC1 has a separate power supply providing +30V and -7.5V. Switch S5 was also incorporated to reverse the polarity of the output.

**Semiconductors**

<table>
<thead>
<tr>
<th>Semiconductors</th>
<th>Value</th>
<th>Type</th>
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<tbody>
<tr>
<td>D1-D4</td>
<td>4A</td>
<td>200V Bridge rectifier</td>
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<tr>
<td>D5-D8</td>
<td>1A</td>
<td>50V Bridge rectifier</td>
</tr>
<tr>
<td>D9</td>
<td>BZY88</td>
<td>15V 400mW Zener diode</td>
</tr>
<tr>
<td>D10</td>
<td>BZY88</td>
<td>5-1V 400mW Zener diode</td>
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<tr>
<td>D11, D12</td>
<td>BZX61</td>
<td>30V 1.3W Zener diode (2 off)</td>
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<tr>
<td>D13</td>
<td>BZY88</td>
<td>7.5V 400mW Zener diode</td>
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<tr>
<td>TR1</td>
<td>2N3053</td>
<td></td>
</tr>
<tr>
<td>TR2</td>
<td>2N3055</td>
<td></td>
</tr>
<tr>
<td>TR3</td>
<td>2N3055</td>
<td></td>
</tr>
<tr>
<td>IC1</td>
<td>MC1436 CG (Motorola)</td>
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**Transformers**

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<th>Primary</th>
<th>Secondary</th>
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<tbody>
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<td>T1</td>
<td>240V</td>
<td>0-15V, 0-15V 100VA</td>
</tr>
<tr>
<td>T2</td>
<td>240V</td>
<td>0-20, 0-20 6VA</td>
</tr>
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Components printed circuit mounting

**Switches**

<table>
<thead>
<tr>
<th>Switch</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>S1, S2</td>
<td>DPDT Miniature toggle: 250V AC 1A (2 off)</td>
</tr>
<tr>
<td>S3</td>
<td>DPDT Miniature toggle</td>
</tr>
<tr>
<td>S4</td>
<td>1P 6W Rotary 6A 30V DC</td>
</tr>
</tbody>
</table>

**Miscellaneous**

Fuseholder and fuse
Neon
Sockets
Printed circuit board
Heatsinks
Case

TR2 and TR3 were mounted on a heatsink with a thermal capacity of 1.1°C per watt, which was mounted away from the case on 10mm spacers to give improved ventilation. A small clip-on heatsink was also fitted to TR1.

**SETTING UP AND USE**

Firstly the offset null is adjusted. With both inputs of IC1 grounded, adjust VR2 to give 0V at IC1 output.

The circuit will supply between 10µA and 3A in six overlapping ranges, although when using the 1A and 3A ranges, the output transistors will become quite hot (up to 65°C), and load resistances of not less than 1Ω should be used on the 1A range and 8Ω on the 3A range.

When used as a constant voltage power supply the output current should be restricted to 1A.

CONSTRUCTION

The prototype circuit was constructed on two printed circuit boards, one for the main circuit and one for the operational amplifier power supply. C1 was mounted separately and resistors R8-R13 were mounted directly on S4.

64 Practical Electronics August 1980
Harrogate International Festival of Sound Aug. 16–19 (18 & 19 trade).
The Exhibition Centre + hotels. X
Laboratory Sept. 9–11. Grosvenor Ho., Park Lane, London. E
Intron 80 Sept. 9–11. RDS, Simmons court Pavillon, Dublin. V
West England Electronics Exhibition Sept. 9–11. Bristol Exhibition Centre. Q
Electrathon (Lucas battery vehicle race) Sept. 13, 1980. Fashioned on last year’s event, this “whispering Grand Prix” is a contest for home made electric vehicles. It will again be held at Donington Park Race Circuit, nr. Derby. Details: +44 01285 5252.
Avionics (symposium) Sept. University of Surrey. S1
Emix Oct. 7–8. Centre hotel, Newcastle. I
Engineering Ireland Oct. 15–18. Leopardstown Exhibition Centre. V

Compec Nov. 4–6. Olympia. Z1
BEX Nov. 5–6. Sophia Gardens, Cardiff. K
Semiconductor International Oct. 25–27. Metropole Convention Centre. T1
Breadboard Nov. 26–30. Royal Horticultural Halls, Westminster. T

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A selection of readers' original circuit ideas. It should be emphasised that these designs have not been proven by us. They will at any rate stimulate further thought. Why not submit your idea? Any idea published will be awarded payment according to its merits.

Articles submitted for publication should conform to the usual practices of this journal, e.g. with regard to abbreviations and circuit symbols. Diagrams should be on separate sheets, not inserted in the text. Each idea submitted must be accompanied by a declaration to the effect that it is the original work of the undersigned, and that it has not been accepted for publication elsewhere.

A HEX KEYPAD

The accompanying circuit shows a hexadecimal keyboard interface which can be used as both a peripheral to a microprocessor or for inserting data under DMA. It gives visual indication of the output on a bank of eight LEDs.

Each key is strobed low in turn by the configuration of IC1 and IC2. When a closed key is found, C1 is discharged and the clock IC6b stopped. IC2 clocks on the up-stroke, so IC6a is included to stop extra pulses reaching the counter. As the voltage on C1 falls, it produces a clock pulse for IC5, which is wired as a divide by two counter. Falling edges on IC5's output, latch the four bit number on IC2 (representing the button pressed) alternately into IC3 and IC4. C1 debounces the keys.

If the circuit is used for DMA, the output can be connected to the data bus. The two hex digit byte is entered and the Chip Enable pin of the memory strobed low to insert the byte. If a wrong number is entered, it can be re-entered before the CE line is strobed.

If the circuit is used as a peripheral, then it must be interfaced through a tri-state buffer like the 74125, in which case it would have to be polled. A cheaper method of interface is via a 7401 NAND gate with open collector outputs. Because this performs an inversion, the data should be taken from the Q outputs of the 7475.

D. Greaves, Romsey, Hants.
The circuit is of a four digit multiplexer, which was designed to facilitate the use of a multiplex connected type of I.C. display. The circuit can also be used to advantage with unmultiplexed I.C. displays, but the total current which may be drawn from each digit driver is limited to 40 mA. Alternatively discrete transistor drivers could be used. The type of display for which this circuit was intended is the miniature calculator displays now available at low cost. With the values of R5–R11 the current per segment is just over 3 mA, which will give adequate brightness in most applications. The circuit is for common cathode I.C. displays.

The circuit functions as follows: IC1 and IC2 form a divide by four counter with decimal outputs, which is used to scan the digits and multiplexer gates, simultaneously.

IC9 is an inverting buffer with 40 mA open collector outputs. These are wired together to enable the BCD outputs of the counters to be connected to the inverters of IC7 and so to the decoder driver i.e., one after the other in sequence. With their respective digits. IC7 reverts the BCD information because it becomes inverted by the NAND gates. R1–R4 pull up the open collector outputs of the NAND gates.

IC8 is the BCD to decimal decoder driver IC and is for common cathode type displays. R5–R11 are the current limiting resistors for the digits. The remaining two inverters of IC7 are used to form a multivibrator which is used to clock the divide by four decimal counter. C3 and C4 are supply decoupling capacitors and should be spaced approximately 4 IC’s apart. Common anode type displays could be used with a 7447 for IC8. Discrete digit drivers must be used. More than four digits could be displayed by the use of more 7401s and a suitable decimal decoded counter.

C. F. Shorto, Weymouth, Dorset.
This circuit produces a 4 bit binary word for a key pressed on a keyboard. IC1 is wired in its astable mode. Pulses produced at pin 3 are taken to IC2, a 4 bit binary counter. The three most significant digits are taken to IC5, a BCD to decimal decoder. The outputs of this are low on select. As IC2 counts, one row of the keyboard matrix is low, followed by the next in sequence, thus the scanning action is produced. If a key is pressed then that row becomes low when IC5's "scan" reaches it. One of IC3b's inputs also becomes low at this moment, the output going high. ICs 3a and 4a detect when the clock is high and the output "A" of IC2 is low. IC4b detects when IC3b and IC4a are high and enables the latch, IC6. The "D" input to IC6 is derived from a column which contains the lower eight keys of the keyboard. A correct four bit binary code will then be obtained.

If a new key is pressed, its binary code will be accepted regardless of the code already present. Both true and complementary outputs are obtainable.

The whole circuit was constructed on stripboard, with ribbon wire interfacing the keyboard. Outputs were accessible via solder con pins for easy connection to a breadboard. Two 100n ceramic capacitors are also necessary for decoupling especially near IC1.

A. Piper
Newport Pagnell, Bucks

---

Inexpensive A-to-D Converter

The circuit shown converts the input voltage from VR2 into a four bit binary number suitable for many computer games (e.g. lunar landing). More bits can easily be added, however this method of conversion will not be sufficiently accurate for more than eight bits. Four i.e. packages are used.

Initially counter IC1 is set at zero; however it is quickly clocked by the astable configuration IC4c and IC4d. As it counts, the four resistors R1 to R4 produce an increasing voltage proportional to the count. When this voltage is higher than the voltage at the wiper of VR2, IC3's output swings to +5V which saturates transistor TR1 and stops the clock. Now the counter on IC1 points to the input voltage and it can be read via the buffer IC2. IC4a and IC4b detect the end of the reading and reset the counter so the cycle re-starts.

Although during the counting period the reading on IC1 is incorrect, this will never be noticed because it is pointless reading the converter more than twice a second, as the user will not have appreciably moved VR2. VR1 is set to give a full scale setting of VR2 of all ones (1111).

D. Greaves,
Romsey,
Hants.
THE circuit diagram is shown up above and if the logic is followed through, the circuit operation should be fairly self explanatory.

To start a game the "Reset" button is pressed to clear any scores on the counters. A player then serves by pressing his "Serve" button. After a period of time the "ball" reaches the other player. This is signified by his l.e.d. lighting up. While this is lit he must press his "Bat" button to return the ball. If he fails to press the button at the right time, this is a miss and registers a point on his opponent's score counter. If he hits it then, after a period of time, it reaches the first player lighting up his l.e.d., he tries to hit it and so on. Each miss is counted as a point on the other player's counter.

Some skill is required in playing this game since the time taken for the "ball" to cross the "court" does not remain constant. Rather the time taken decreases during play until either a player misses a ball or the counter has gone through the eight speeds. At this time it reverts to the slowest speed and gets faster again.

Serving triggers the monostable IC3a and b or IC5a and b. At the completion of its cycle it sends a pulse, which is generated by IC3c and d or IC5c and d, to the other player's circuitry. The period of monostables IC3a and b and IC5a and b is determined by the resistor selected by the counter IC6. Each second hit advances the counter until it is reset.

A suggested top-panel layout is shown right.

Incidentally, a sort of doubles game can be produced by inserting another push switch across each of the "Bat" switches. Thus if one player missed the "ball", the other would have a good chance of hitting it.

P. Bailey, Rutherglen, Glasgow.
Velikovsky: Pure Myths

Sir—While leafing through my father's copy of *PE* (June 1980) I was rather surprised to find a serious letter supporting the ridiculous theories of Immanuel Velikovsky. In the letter, Mr. Austin "looks forward to reasoned argument" on the subject. For those readers interested in such, I should like to recommend the book *The Stars in Their Courses* by Dr. Isaac Asimov which contains, among other fascinating essays, a chapter entitled "Worlds in confusion", from which I shall draw a few comments to the attention of your readers.

Velikovsky's book was claimed to be the work of a scientist (which Velikovsky is not) who had proved the Bible to be true. The basis of his theory is that Jupiter spewed out a huge comet, leaving behind the Red Spot, which careered about the solar system causing no end of interesting effects, before settling down to become Venus. The book is full of nonsense physics and ludicrous assumptions. For example, Velikovsky states that the laws of astronomy predict that a satellite will rotate slower than its planet and then points out that this is not so for the inner planet of Mars, thus demonstrating that all astronomical laws are wrong. It looks very nice but is nothing but transparent twaddle. There is nothing any astronomical law predicts about the speeds of rotation, which depend only on the primary and satellite distance and mass. In fact, the inner satellite of Mars has a rotational period of exactly that predicted by physics.

Velikovsky also makes heavy use of medieval Jewish legends and the writings of the ancients, taking metaphor and legend as fact, and constructs his own chronology to fit his "facts". His theory contains glaring errors of chemistry and physics that could be spotted by an A-level student (in one part he transforms hydrocarbons into carbohydrates in the space of a paragraph although the two classes of compound are completely different), and misinterpretations of scientific observation. He uses scientific results when they agree with his theory and throws them away when they do not. He draws heavily on the spectroscopic analysis of comets tails without explaining why scientists who cannot handle the simple calculations of celestial mechanics should be trusted with such complex analysis!

When he needs a rain of fire to explain certain biblical tales he hits on the theory that the hydrocarbons in comets tails will burst into flame when passing through the Earth's atmosphere. Is this plausible? No sir, not a chance. Gas does not come much thinner that that in comets tails and it certainly would not burn in the atmosphere. You may say how do we know? Well, in 1910 we passed through the tail of Halley's comet and absolutely nothing happened! (as predicted by the scientists and completely opposite to the prophets of doom).

I could go on, but do not think it necessary. In short, Velikovsky's work is nonsense and demonstrates nothing except the gullibility of the non-scientific public. It has more in common with crank mail (Dear Sir, I have recently disproved the theory of relativity, etc., etc.) than a serious work. Copernicus developed his Sun-centred theory only because he was a thorough student of the Earth centred theories; Einstein developed relativity while a thorough student of Newtonian mechanisms. Point taken?

David G. W. Birch, B.Sc.,
Swindon.

The AY-3 Saga

Sir—Last year I wanted a GIM integrated TOG, the AY-3-0214, to make a copy of the Wersi master oscillator for my Maplin organ. Recent comment in your magazine reminds me of this.

GIM very promptly sent me their product guide, and the data sheet on their music i.c.s. In the back of the product guide are listed their distributors so I set out to contact them. (I had already tried about 10 of the retailers who advertise the AY-1-0212 and other GIM ICs in the various hobby magazines and they were all useless, so I suggest that Mr. Partridge's solution does not work!) (Readout May 1980). Of the distributors, one was down-right rude, two just did not want to know. Crellon Electronics were helpful but said that they had to order a minimum of 25, and did not wish to be left with 24. They could only supply if I would have 25, at £13-50 each!—fair enough.

I then wrote to GIM again and thanked them for the information but suggested that it was a pity that their excellent i.c.s were not available, and told them why. Within a week or so I received a letter from them, stating that if I wrote to Semiconductor Specialists at West Drayton, they would now be able to supply me, which indeed they did for the sum of £13-80. Previously they had "not got it in stock." and "had never had it" and "didn't want to know about getting it".

So if your readers are trying without success to obtain GIM i.c.s then I suggest they write to: General Instruments MicroElectronics Ltd., Reference House, 1A Warwick Street, London W1R 5BW. They won't supply directly, but they do seem to be quite good at waking their distributors up!

Lastly, since buying that i.c. I have seen that it is on the "Doram" list at £10-10. Oh well, you can't win them all.

A. Jaques,
Urmston, Manchester.

CPUs: The Last Word

Sir—Re the letter by C. R. Harris in your June issue, I would like to point out that the article was originally credited to Roy Featherstone, not at Edinburgh researching into artificial intelligence, and secondly, that the ultimate CPU described has the advantage over its silicon rivals of being mass produced by unskilled labour!

Tim Sutherns,
President, S.U. Computer Club,
Southampton.

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<td>100dB</td>
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