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Practical Electronics  October 1978
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### TRIACS

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### ORDERING

Do not forget to slate order number and your stamp end and address.

V.A.T.
Add 15% to prices marked * 5% to those unmarked Items marked ** are two rate.

### BI-PAK CATALOGUE

NEW EDITION NOW AVAILABLE
Send for your copy of our revised catalogue and price list NOW! It contains 127 pages packed with literally hundreds of semiconductors, components and our famous range of BI-KITS audio modules.

DEPT PE10, P.O. BOX 6, WARE, HERTS.
SHOP 18 BALDOCK ST., WARE, HERTS.
OPEN 9 to 5.30 MON-SAT.
KITS FOR SYNTHESIZERS, SOUND EFFECTS

P.E. MINISONIC MK. 2 SYNTHESIZER
A further multi-function Miniature Sound Synthesizer, with keyboard circuits. Although having slightly fewer facilities than the large P.E. Synthesizer the function offered by this design gives a great scope and versatility. Consists of 2 log VCOs, VCF, 2 envelope shapers, 2 voltage controlled amplifiers, keyboard hold and control circuits, HF oscillator and detector, ring modulator, noise generator, manual power supplies. Set of basic component kits from £61.00 Set of printed circuit boards £8.99

P.E. SYNTHESISERS (P.E. Feb 73 to Feb 74)
The well acclaimed and highly versatile large-scale mains-operated Sound Synthesizer complete with keyboard circuits. Other circuits in our lists may be used with the Synthesizer to good advantage.

The Main Synthesizer: PSU, 2 linear VCOs, 2 ramp generators, 2 input amplifiers, sample hold, noise generator, reverber amp, ring modulator, peak level circuit, envelope shaper with voltage-controlled amp. Set of basic component kits £78.09 Set of printed circuit boards £13.20

The Synthesizer Keyboard Circuits (can be used without the Main Synthesizer to make an independent musical instrument): 2 logarithmic VCOs, divide, 2 hold circuits, 2 modulation amps, mixer, 2 envelope shapers and PSU. Set of basic component kits £47.34 Set of printed circuit boards £7.66

GUITAR EFFECTS PEDAL (P.E. July 75)
Modulates the attack, decay and filter characteristics of an audio signal not only from a guitar but from any audio source, producing 8 different switchable effects that can be further modified by manual controls, popularly by the most interesting of all the low-priced sound effects units in our range. Circuit does not duplicate effects from the Guitar Overdrive Unit.

Component set with special foot operated switches £7.69 Alternative component set with panel switches £5.05 Printed circuit board £1.43

SOUND BENDER (P.E. May 74)
A multi-purpose sound controller, the functions of which may be expanded by the use of a separate pedal assembly for controlled add of audio signal. Includes manual and automatic fader, automatic fader and frequency-dependent. Set of basic component kits £8.17 Printed circuit board £1.81

PHASING UNIT (P.E. Sept 73)
A simple but fully manually controlled unit for introducing the phasing sound effect into live or recorded music.

Component set (incl PCB) £3.20

PHASING CONTROL UNIT (P.E. Oct 74)
Fits for use with the above Phasing Unit to automatically control the rate of phasing.

Component set (incl PCB) £4.74

SOPHISTICATED PHASING AND VIBRATO UNIT
A slightly modified version of the circuit published in Elektor, December 1976, includes manual and automatic control over the rate of phasing and vibrato. Printed circuit board £17.38 £5.83

WAH-WAH UNIT (P.E. Apr 76)
The Wah-Wah effect produced by this unit can be controlled manually or by the integrated automatic controller.

Component set (incl PCB) £6.83

AUTOWAH UNIT (P.E. Mar 77)
Automatically produces Wah-pedal and Swell-pedal sounds each time a new note is played. Complete component kit £10.95 Technical foot switches £7.67 Component set and PCB, with panel switches £8.83

P.E. JOANNA PLUS ORGAIN VORICING
The basic five octave electronic piano (P.E. May/Sept 76 and Sound Design) has switchable alternative voculars for Honky-Tonk, ordinary pianos, and Harpsichord or a mixture of any of these three, together with facilities including bass and solo tremolo, loud and soft pedal switching, and sustain pedal switching. The modification retains all the circuitry associated with the piano but in addition provides an organ voice envelope facility with 5 switchable pitches, variable attack and sustain, phasing and vibrato.

Set of components (except for PSU, frequency generator, pitch and noise dividers, envelope shapers, vibrato and control circuits, (Order as Kit 71-5) £99.25

P.E. SYNTHESIZER TUNING UNIT (P.E. July 77)
A 4-note frequency comparator for use with synthesizers and other instruments where the full versatility of the P.E. Tuning Fork is not required.

Component and PCB (but excl SW) £7.49

GUITAR FREQUENCY DOUBLER (P.E. Aug. 77)
A modified and extended version of the circuit published.

Component set and PCB £4.52

GUITAR SUSTAIN (P.E. Oct 77)
Maintains the natural attack whilst extending note duration.

Component set, PCB and audio filters £5.13 Component set, PCB and panel switches £3.71

WIND AND RAIN UNIT
A manually controlled unit for producing the above named sounds.

Component set (incl PCB) £4.26

GUITAR OVERDRIVE UNIT (P.E. Aug. 76)
Sophisticated, versatile Fuzz Unit, including variable and switchable controls affecting the fuzz quality whilst retaining the attack and decay, and also providing filtering. Does not duplicate the effects from the Guitar Effects Pedal and can be used with it and other electronic instruments.

Component set using dual slider pot £7.68 Component set using single rotary pot £6.89 Printed circuit board £1.62

FUZZ UNIT
Simple Fuzz unit based upon P.E. "Sound Design" circuit.

Component set (incl PCB) £2.06

TREMOLO UNIT
Based upon P.E. Sound Design circuit.

Component set (incl PCB) £2.94

TREBLE BOOST UNIT (P.E. Apr. 76)
Gives a much quieter quality to audio signals fed through it. The depth of boost is manually adjustable.

Component set (incl PCB) £2.51

P.E. TUNING FORK (P.E. Nov 75)
Produces 84 switch-selected frequency-accurate tones. A LED monitor clearly displays all beat note adjustments. Ideal for tuning acoustic or electronic musical instruments.

Main component set (incl PCB) £14.93 Power supply set (incl PCB) £6.28

New Electronic Piano. Details in our list.

PHONOSONICS

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

COMPUTER SETS include all necessary resistors, capacitors, semiconductors, potentiometers and transistors. Hardware such as line testers, voltmeters, keyboards, etc. are not included but most of these may be bought separately. Fuller details of kits, PCB's and parts are shown in our list.

CIRCUIT AND LAYOUT DIAGRAMS are supplied free with all PCB's unless "as published".

PHOTOCOPIES OF P.E. TESTS for most kits of the most kits are available—prices in our lists.

CONSTANT DISPLAY FREQUENCY METER (P.E Aug 78)
A 6-digit frequency counter for 1Hz to 999999Hz with a 1Hz sampling rate. Readout does not count visibly or flicker due to display blanking.

Component set £24.05 Printed circuit board £3.03

ENVELOPE SHAPER WITHOUT VCA (P.E. Oct 75)
Provides full manual control over attack, decay, sustain and release functions and is for use with an existing voltage controlled amplifier.

Component set (incl. PCB) £6.77

ENVELOPE SHAPER WITH VCA (P.E. Apr. 78)
The unit has its own voltage controlled amplifier and has full manual control over attack, decay, sustain and release functions.

Component set (incl. PCB) £6.88

TRANSIENT GENERATOR (P.E. Apr. 77)
An envelope shaper, without VCA, having the usual attack, decay, sustain and release functions, and in addition also provides a "Repeat Effect" enabling a synthesizer to be programmed to imitate such instruments as a mandolin or banjo.

Component set £4.87 Printed circuit board £1.62

WAVEFORM CONVERTER
Slightly modified from a circuit published in "Elektor". Converts a saw-tooth waveform into four different waveforms sine wave, grant space, saw-tooth, regular triangle and and square wave with an externally variable mark: space ratio.

Component set (incl. PCB but excl. SW) £8.40

VOLTAGE CONTROLLED FILTER (P.E. Dec 74)
This is a P.E. Minisonic now released as an independent kit for use with other synthesizers.

Component set (incl PCB) (Order as Kit 65-1) £17.17

RING MODULATOR (P.E. Jan 75)
Part of the P.E. Minisonic now released as an independent kit for use with other synthesizers.

Component set (incl PCB) (Order as Kit 59-1) £5.90

NOISE GENERATOR (P.E. Jan. 75)
A noise generator, not the P.E. Minisonic now released as an independent kit for use with other synthesizers.

Component set (incl PCB) (Order as Kit 60-1) £3.84

SOPHISTICATED POWER SUPPLIES
A wide range of highly stabilised low noise power supply kits is available—details in our lists.

MICROPHONE PRE-AMP (P.E. Apr. 77)
Component set (incl PCB) £3.82

VOICE OPERATED FADER (P.E. Dec 73)
A voice controlled output unit for use with other electronic instruments.

Component set (incl PCB) £3.97

DYNAMIC RANGE LIMITER (P.E. Apr 77)
Automatically controls sound output to within a preset level.

Component set (incl PCB) £4.88

PHONOSONICS - DEPT P60 - 22 HIGH STREET - SIDCUP - KENT DA14 6EH MAIL ORDER AND C.W.O. ONLY SORRY BUT NO CALLERS PLEASE

NOTES:
- All prices exclusive of VAT unless otherwise stated.
- All information is correct at time of going to press (October 1978).
- Export and overseas orders are welcome, though we advise that a current copy of our list should be obtained before ordering as it also shows Export: postage rates. All payments must be made in cash, cheques in Sterling and preferably by International Money Order or through an English Bank. To obtain list send 50p.
KIMBER-ALLEN KEYBOARDS AND CONTACTS

Kimber-Allen Keyboards as required for many published circuits. 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.

Printed Circuit Boards: Type GH: 5 pairs of contacts, each pair normally open each 581p Type GE: 4 pairs of contacts, each pair normally open each 562p

PRINTED CIRCUIT BOARDS FOR KITS 76-1 & 3 (PCB 76A) £2.10
PCB (as published) for KITS 76-2 & 4 (PCB 76B) £2.54
PCB for Chorus Generator (PCB 77C) £9.75
PCB for KITS 76-1 & 3 (PCB 76B) £2.54

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

OVERSEAS enquiries for list giving fuller details of PCBs, kits and other components send 20p; other countries—send 50p.

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- Electronic 
- Mechanical 
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- Aeronautical 
- Electrical 
- Architectural 
- Business 
- Banking 
- Computing 

POSTAL COURSES

bracketed.)


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NEW PRODUCTS - NEW PRODUCTS

POWER AMP KIT

The kit includes all metalwork, instruction and hardware to build any two of our power amp modules plus a power supply. It is contemporary styled and its quality is consistent with that of our other products. Comprehensive instructions and full back-up service enables you to build it with confidence in a few hours.

ADVANCED PRE-AMP CPR1

This stereo module accommodates pre-amplification of disc and other inputs in an irreplaceable component. The disc input has no common mode distortion effects, thd of .001%, 40dB overload, 70 or 160pV for 3.5mV output. This stereo module accomplishes pre-amplification of disc and other inputs to an impeccable quality.

MC1S, CPR1S

POWER AMPLIFIER MODULES

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<th>CE 1004</th>
<th>CE 1707</th>
<th>CE 1708</th>
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<td>60W/8ohms 35-0-35v</td>
<td>100W/8ohms 35-0-35v</td>
<td>170W/8ohms 60-0-60v</td>
<td>170W/8ohms 60-0-60v</td>
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<td>£16.20</td>
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POWER SUPPLY

The regular module, REG 1 provides 15-0-15v to power the CRP 1 and MC 1. It can be used with any of our power amp supplies or our small transformer TR 6. The power amp kit will accommodate a REG 1.

REG 1, CPR1S, MC1S

POWER AMPLIFIER KIT

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<th>CE 608</th>
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NEW PRODUCTS

MOVING COIL PRE-AMP MC1

ADVANCED PRE-AMP CPR1

.bridge driver, 80W/8ohms 1.33v, 35-0-35v, 70 or 160pV for 3.5mV output.

POWER KIT

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POWER SUPPLY

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<th>TR 6</th>
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| FROM 14p | £2.40 |

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Tel: Wilmslow 26213 for Hi-Fi
SMUG

We all like to feel a bit smug some times and we hope P.E. has a right to this month—though not for long! The V.D.U. System construction project which appears in this issue is believed to be the first design published in Britain, and makes use of an excellent Thomson CSF chip which has recently become available on the amateur market. The new chip incorporates most of the electronics required to produce a memory mapped system.

The unit provides, at a relatively low price, one of the most useful peripherals for the home computer man. All components, including the modulator, are on one “small” p.c.b. which includes 1K of user RAM mounted in a novel way.

The second item which we feel is worthwhile is the sheet of STICKIES, free with this issue. We have said they are worth 60p, which is true, but in fact with postage etc. you would have to spend 80p to get this product. Since they are so useful (see page 1093) we are sure most readers will consider them a very worthwhile gift. They are, of course, worth more than the cost of the issue!

VALUE

With the inclusion of more editorial pages per issue in recent copies of P.E.—and such items as the free STICKIES, 8-page supplement next month and some planned special offers etc., we have been doing our best to give good value for money and will, of course, continue in this way. However, as we said above, we won’t be staying smug for too long as next month the price of P.E. will rise to 50p.

The last price increase was with the November 1977 issue—exactly a year ago and, as we all know, inflation has and no doubt will, continue. Our costs go up and reluctantly these must eventually be passed on. We hope you will still consider P.E. good value for money.

SAVING

Over the years we have presented a number of projects to help readers to save money in one way or another and our Fuel Consumption Meter in this issue is no exception. The price of oil regularly makes the headlines and no doubt it will not be long before this happens again. With the aid of our consumption meter better fuel economy can be achieved—something we can all benefit from in one way or another.

If readers have devised other cost saving circuitry we would be pleased to hear from them. Even if you have an idea for some equipment a letter to us could set a few minds going and maybe a designer working?

To give an idea, a spontaneous invitation for suggestions from the office brought forth the following:

An independent timing device to display the cost of a telephone call (local or distant), and along similar lines, a meter for mains power consumption reading pence per hour.

PARTICIPATION

We try to keep Readout interesting each month and publish the “bad” with the “good” and sometimes even the “ugly”—see page 1102—but so much depends on you transmitting your views and thoughts! It is good to see some interesting and constructive submissions to Microbus this month and, as always we have plenty of I.U.’s, but please don’t forget that Readout is your page so keep the letters coming and we will keep publishing the interesting and informative ones.

Mike Kenward

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Mike Kenward

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Mike Abbott TECHNICAL EDITOR

Alan Turpin PRODUCTION EDITOR

David Shortland TECH. SUB EDITOR

ART EDITOR

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Copies of PE are available by post, inland or overseas, for £10.60 per 12 issues, from: Practical Electronics, Subscription Department, Oakfield House, Perrymount Road, Haywards Heath, West Sussex RH16 3DH.

Back Numbers and Binders
Copies of most of our recent issues are available from: Post Sales Department, IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 0PF, at 65p each including Inland/Overseas p & p.

Binders for PE are available from the same address at £2.85 each to UK addresses, £3.45 overseas, including postage and packing, and VAT where appropriate. Orders should state the year and volume required.

Cheques and postal orders should be made payable to IPC Magazines Limited.

Letters
Queries regarding articles published in PE should be addressed to the Editor, at the Editorial Offices, and a stamped, addressed envelope enclosed. We cannot undertake to answer questions regarding other items, nor to answer technical queries over the telephone.

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West Quay Road, Poole,
Dorset BH15 1JG
Phone: Editorial Poole 71191

We regret that lengthy technical enquiries cannot be answered over the telephone.

Advertising Offices:
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Phone, Advertisements 01-261 5000
Telex: 915748 MAGDIV-G

Make Up and Copy Dept.
Phone: 01-261 6601
Market Place

Items mentioned are usually available from electronic equipment and component retailers. However, where a full address is given, general enquiries may be made direct to the firm concerned. All quoted prices are correct at time of going to press.

by Alan Turpin

Wonderboards

Fresh in from across the big pond, Wonderboard is a solderless breadboard system using holes filled with a conductive elastomer (rubber) as the connecting points. The contact points are accessible from both sides of the board enabling components to be mounted on one side and wire linking to be made on the other. Hole pitch is 0.1in and there are six rows of 31 holes allowing up to a dozen 14 d.i.l. devices to be mounted. Each contact point will hold up to six wires.

Specifications given are as follows:
- Contact resistance 10mΩ, current capacity 7A, breakdown voltage 9kV, insulation resistance 10,000MΩ, min/max wire diameters 0.2 to 0.8mm (32 to 20 gauge), contact life 150 insertions, useful temperature range -55 to +100°C. No noise/frequency figures were given but have been requested.

Wonderboards are available singly at £2.50 from Charcroft Electronics, and distributor enquiries are invited.

Charcroft Electronics, Charcroft House, Sturmer (Haverhill), Suffolk. Tel. 0440 5700.

and David Shortland

Compact Temp Controller

Capable of switching or controlling 3kW directly, the CAL 6103 high power, compact temperature controller is a panel mounted unit with a DIN standard 48mm² bezel, and a ±1 per cent accuracy (typical) under steady load conditions.

The CAL 6103 is available to order in temperature ranges from 0°C to 1,600°C. Any specified thermocouple input, or PT100, can be supplied.

Its proportional control system avoids the unnecessary “hunting” encountered in other compact on/off temperature controllers. Time cycling is set to a “standard” 20 secs which suits most applications. However, CAL will supply units with cycle times from 5 secs to 120 secs to order.

For resistive loads the output/control relay will switch 14A at a.c. mains voltages. A static output can also be provided to accommodate remote thyristor control systems.

For further information contact Controls & Automation Limited, Regal House, Boreham, Essex.

Extractor Tool

Designed for the specific task of automatically extracting i.c.s from p.c.b.s on completion of the desoldering operation, the DIP-OUT tool from Vero Electronics eliminates the danger of damage to i.c. legs by virtue of its “even pull” action. When used with a desoldering block it provides a fast and efficient method of removing i.c.s. The price of the tool is £5.67 plus VAT.

3-Rail Power Supply

A three-rail Eurocard power supply announced by Lascar Electronics is suitable for most circuits where digital and linear devices are mixed.

The supply features one output of 5V 1A, and dual tracking outputs adjustable between ±5V and ±15V with a maximum of 100mA per rail. The 5V and twin-rail supplies are isolated from each other and feature short-circuit, over-temperature and fold-back over-current protection. Input voltages 220V a.c. or 240V a.c. The supply is fitted with terminal blocks on the input and outputs, and is assembled on a p.c.b. measuring 160 x 100mm, with a maximum height of 47mm.

For details contact Lascar Electronics Limited, PO Box 12, Module House, Billericay, Essex.

For further information contact Vero Electronics Limited, Industrial Estate, Chandler’s Ford, Eastleigh, Hampshire.
MICRO-BOARD

With the increasing use of $100$ boards and bussing systems in microcomputers, Vero Electronics have released a universal $100$ bus-compatible prototyping board. Designed for the manufacture or breadboarding of microprocessor, memory or interface assemblies, the board will, without modification, mount directly into any equipment using the $100$ bus system.

The board has an $100$ edge connector configuration (100 gold-plated contact fingers on 3-175mm/0.125in pitch) and is fully pierced with 1.02mm/0.040in diameter holes on a 2.54mm/0.1in matrix. Provision is made for mounting up to four standard TO-220 plastic package regulators together with heatsinks for on board regulation, and the voltage plane is capable of being divided to provide up to four separate positive or negative supply rails. The component side of the board carries a ground plane which can be used for terminations or screening and the wiring side carries both voltage and ground planes, thus providing for up to five planes.

A wide range of compatible standard accessories such as DIP sockets, pins, headers, ribbon cables, etc. is available, enabling the prototyping board to cope with virtually any microprocessor or microcomputer circuit requirement.

For further information contact Vero Electronics Limited, Industrial Estate, Chandler’s Ford, Eastleigh, Hampshire.

PROGRAMMABLE TV GAMES

General Instrument Microelectronics have introduced a new set of MOS microcircuits for use in cartridge-based programmable TV games. Known as SYSTEM 8601, the circuits include a clock generator, colour encoder, modulator and a selection of cartridge microcircuits—enabling fully programmable games systems to be built at low cost.

Each game system will consist of a console into which individual game set cartridges are slotted. Each console will contain clock, encoder and modulator, as well as game controls, switches, power supplies, etc. Each cartridge contains individual games microcircuits, plus interface circuitry, and all sets will feature realistic sound generation and on-screen scoring.

Some of the cartridge-mounted microcircuits are already available, including the 8610 “Supersport” (20 games), the 8765 “Motorcycle” (8 games) and the 8603 “Road Race” set (3 games). Three more circuits—the 8607 “Target” (12 games), the 8606 “Wipeout” (24 games) and 8605 “Warfare” (10 games)—will go into production within two months, with more to follow before the end of the year. For further information contact General Instrument Microelectronics, Regency House, 1-4 Warwick Street, London, W1R 5WB.

CRUSH PROOF DMM

A new series of true r.m.s. 4½-digit multimeters for bench and field use has been introduced by Systron-Donner Limited. This new series consists of four models, available with a choice of d.c. accuracies of either 0.02 per cent or 0.05 per cent, and with a choice of current or dB measuring modes.

All models feature auto and manual range selection with a.c. and d.c. voltages from 10 microvolts to 750V and 1000V respectively, measured in five ranges. A true r.m.s. a.c. converter permits accurate measurements of triangles, pulses, square waves or distorted sinewaves up to 20kHz.

The resistance mode offers six ranges allowing measurements from 0-01Ω to 20MΩ. All ohms ranges are protected against input overloads of up to 350V r.m.s.

This multimeter will also measure dBs from -60 to +60 in five manual ranges. This capability is especially useful in checking long line voice communications. The dB mode is offered in place of the 5 d.c. and a.c. manual current modes which cover measurements from 1 microamp to 2 amps.

The cost of a DMM is directly related to the d.c. accuracy specification. Since applications can vary, Systron-Donner decided to offer its new Portable DMM with two different basic d.c. accuracies. The Model 7141A, which is the lowest priced has a d.c. accuracy of ±0.05 per cent of reading ±0.05 per cent of full-scale for a full 6 months. The Model 7141B offers a basic d.c. accuracy of ±0.02 per cent of reading ±0.01 per cent of full scale for a full 6 months. Care was taken in designing the circuit to choose components that minimised drift.

Two extra cost options can be specified: one adds an analogue meter to the front panel. This gives the user the ability to make nulling and/or peaking measurements and the other is a battery pack. An internally mounted set of six nicad batteries provides approx. 2½ hours of continuous operation between charges.

Portable DMMs need to be packaged to withstand frequent handling and accidental drops. To prevent damage, the unit is installed in a clamshell-shaped case made from Cycloy—the new ABS/Polycarbonate plastic alloy. The result is a case which is drop-proof and crush-proof.

For further information including price contact Systron-Donner Limited, St Mary’s Road, Sydenham Industrial Estate, Leamington Spa, Warwickshire.

£100 SCOPE

The Elmac 4810 single beam oscilloscope will interest many constructors because of its low cost (£99.00 plus VAT) and excellent specification which includes 4in CRT, d.c. to 5MHz bandwidth (vertical axis), 1MΩ input impedance and a maximum input voltage of 600V peak to peak.

For further information contact Gemini Electronics, Newton Building, Newton Street, Manchester 1.
4-DIGIT PRESET COUNTER

A new 4-digit counter module claimed to be capable of almost all counting functions has been recently introduced by Lascar Electronics. Working from a -5V d.c. supply, the module incorporates 0-43m high efficiency i.e.d.s and is capable of counting at rates up to 2MHz. Besides normal counting from input pulses, the display can be set from external BCD sources.

The module also incorporates an internal register. When counter and register are level, an “equals” output is produced giving many applications in batch counting, machine control etc. Thumbwheel switches can be used to set levels in both cases.

TTL/CMOS compatible, the module also features carry-borrow and zero outputs and count inhibit and store controls.

The count input has a Schmitt trigger making the module suitable for use in noisy environments.

For details contact Lascar Electronics Limited, PO Box 12, Module House, Billericay, Essex.

IRON CONTROLLER

Miniaturisation of components and increasingly complex printed circuit board design have brought in their turn the need for precise operator control of soldering irons. Apart from the likelihood of expensive damage caused by poorly earthed soldering instruments the operator now has to position the soldering bit more carefully, often in close proximity to heat or voltage sensitive components.

To provide maximum operator control, Adcola Products Ltd has designed a new Unit 101 TS model which features a far shorter and lighter soldering instrument.

The main circuit design is based on a thermocouple positioned at the rear of the soldering bit feeding an operational amplifier which is switched via a zero crossing integrated circuit. This design avoids the need for moving parts which may wear and eliminates voltage transients in “Spiking”, RF interference and the generation of magnetic fields. Proportional control also ensures a precise temperature to within ±2 per cent of the indicated dial temperature—the dial may be locked onto any specific temperature within the range of 120-380°C.

The unit is earthed from the supply to the soldering bit to provide maximum safety against leakage currents, making the tool suitable for use with the majority of voltage sensitive components including FETs and CMOS.

For further details and a full specification on the unit contact Adcola Products Ltd, Adcola House, Gauden Road, London SW4 6LH.

ROCKWELL’S AIM

Rockwell, who recently announced a single chip microcomputer called the R6500/1, have just introduced a single board microcomputer system which features an on-board 20 column printer and display with a full alphanumeric keyboard.

Designated the AIM 65 the system is intended as an educational aid for first time users and a general purpose microcomputer for engineers.

The AIM 65 is available in 1K and 4K byte RAM versions, is designed around the 6502 CPU which has 64K address capability with 13 addressing modes and is the microprocessor at the heart of other popular systems such as KIM 1, PET and APPLE. An 8K ROM resident monitor programme provides all peripheral control and user programming functions. Spare sockets are included to further expand on-board program memory via user PROM-based programs or Rockwell’s assembler, text editor and BASIC interpreter plug-in ROM options.

The AIM 65 board also has a connector that allows external access to the system bus for memory and I/O expansion. A separate application connector interfaces a teletype and two standard cassette recorders, and includes a user-dedicated Versatile Interface Adaptor. The VIA features three 8-bit bidirectional ports (two parallel, one serial) and two 16-bit interval timer/event counters, thus allowing the user to interface his own system, in many cases without the need for extra interface devices.

The system which is priced at under £250 is stocked by Pelco (Electronics) Ltd., Enterprise House, 83/85 Western Road, Hove, Sussex.

VIDEO SYSTEM

The consumer’s choice in video recorders is further extended this month with the arrival of National Panasonic’s VHS (video home system) NV8600.

The unit, which is similar in operation to an audio cassette deck with controls for play, stop, rewind and fast forward also has a remote “pause” control to enable easy editing of unwanted material from a programme.

Three, two and one hour tapes are available at £13.50, £10.50 and £8.00 respectively and these tapes can run on any of the other VHS recorders on the market in this country.

Lining up with National Panasonic to offer video home systems are Akai, Hitachi, JVC, Mitsubishi, Sharp and Thorn.

The NV8600 which is priced at £750 including VAT is available through High Street TV retailers.

The system which is priced at under £250 is stocked by Pelco (Electronics) Ltd., Enterprise House, 83/85 Western Road, Hove, Sussex.
PLUTO

Once again doubts about the most distant planet yet to be discovered in the solar system arise. It is a reminder that each new set of data which becomes available can seriously upset previous ideas. There have been many expressed doubts about Pluto, more perhaps than in regard to the other bodies revolving round the Sun.

Only a short while ago the size of Pluto was re-assessed. It demoted the planet from an estimated size of near to that of the Earth and of the same density, to the size of the Moon. Quite plausible reasons were given for this. The density was suggested to be about 0.01 of that of the Earth.

The acceptance of this meant that in no way could the perturbations of Uranus be linked with the effects of Pluto and its proximity. As previously reported in SPACEWATCH about three years ago the Soviet Union had calculated that there were possibly two planets beyond Pluto.

The two planets were shown to respond to a tool to measure the parent body.

Robert Harrington, of the Naval Observatory, has given the centre to centre distance between the planet and the satellite as 17,000 km. Its diameter is set at about 40 per cent of Pluto. If this is so, then the satellite is the largest, in proportion to its parent, such body in the solar system. The orbital period is 6-4 days. This means that it is stationary over one point on Pluto's surface, as Pluto's own period of rotation is calculated at 6-4 days. The estimate of density of the satellite indicates that Pluto has a density of 0.002 of Earth.

This alters entirely the current picture of the Planet. Now it confirms the model that Pluto (because its density is less than that of water) may well be nothing but a snowball. That is a snowball of frozen gases. The infra-red observations confirmed that a plentiful covering of the gas methane (frozen) was apparent on the surface.

Brian Marsden of the Smithsonian Astrophysical Observatory who is responsible for the coordination of new discoveries has said that perhaps Pluto should be re-classified as a minor Planet.

Theories have been offered by Robert Harrington and T. Van Flandern of the Naval Observatory. The foremost hypothesis is that an unknown planet at some time in the past passed through the satellite system of Neptune and that Pluto was ejected Pluto to become a planet of the Sun.

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This agrees with a previous study in 1972 by Rawlins and Hammerton were searching for another planet. They suggested that the motion of Neptune was consistent with a body of 2 to 5 Earth masses at a distance of between 50 and 100 astronomical units. The suggested longitude would be between 310° and 350°. At the same time they made it quite clear that they did not think that there was such a planet. The reason for this was that at the time of the search for Pluto the Lowell Observatory covered so much of the sky in their search that if there had been a body of reasonable brightness it would not have been overlooked. However a spherical coverage was not made.

Here is the point where present space activity meets with astronomy and this recent discovery. August SPACEWATCH gave details of the mission for the exploring of the areas around the Sun out of the plain of the ecliptic. This could very well reveal such a body or indeed the two bodies suggested by the Russian astronomers.

The classical theory of Pluto's origin is that it was once a satellite of Neptune. It was thought that it orbited Neptune every 6-4 days but came to near collision with Triton, another Neptunian satellite. The result of this encounter threw Triton into its present retrograde and ejected Pluto to become a planet of the Sun.

There is another matter to be considered and that is whether in fact Pluto and its satellite is a binary unit. With the present figures it would suggest that the two bodies revolve about a centre 6800 km from the centre of Pluto. Thus there would be a system which behaved in the manner of a body 13,600 km in diameter. This aspect well deserves some consideration.

A mission to investigate seems a must. Could it be that the Halley comet probe might do this after the cometary encounter. There seems to be a good case for knowing once and for all whether Pluto does have a significance in the Solar system.

MORE FROM THE USSR

The success of the Soyouz-30 and the Progress-2 mission is already established. The space-walk also marks another satisfactory point in the progress of Soviet ventures.

The new furnace known as Kristall has been in use to produce pure monocrystals by the zone-melting technique. The furnace was used to form a monocrystal of gallium arsenide from a high temperature solution. The new furnace is installed in the transfer tunnel of Salyut-6. The crew have also been working on the Splav furnace to obtain new semiconductor materials and compounds of aluminium and tin and molybdenum.

COPERNICUS DISCOVERS BLACK HOLE

Among the instruments on the Orbiting Astronomical Observatory known as Copernicus there is an X-ray telescope from University College, London. It is this instrument which observed the X-rays of the super-giant double star in the constellation of Scorpio. Work which began in the 70's under Norman Walker of the Royal Greenwich observatory had shown that the super-giant had an unseen companion. The star is about 5,000 light years from Earth. The amount of X-rays received indicate that the unseen object must be a collapsed star.
The design is based around the new chip by Thomson-CSF which carefully controls the display timing with a minimum of extra chips. This i.c. also generates a flashing cursor with full position control, and allows the screen to be scrolled in the fashion of a roll of teletype paper in action (all hardware functions within the chip). This is described in detail later.

The VDU has ten address, eight data and seven control lines which interface to the standard bus systems of most MPU designs. The timing of the unit is generated using a 1MHz quartz crystal.

All character information is in standard ASCII character coding. It is advisable to keep, close at hand, a copy of the hexadecimal equivalents to each of the 64 characters in the 2513 character generator.

To interface a VDU to a computer system, some basic software is required. The VDU programme which suits your machine will depend upon its resident monitor. The basic elements, however, of a VDU programme will be common to most MPU systems. A general example is presented later to help with VDU utilisation.

OPERATION

The heart of the system is the Cathode Ray Tube Controller (CRTC). The clock requirements of this chip are supplied by a TTL oscillator circuit which is then divided by eight and fed to the clock input of the CRTC. To understand the working of this device, it is necessary to appreciate that the brightness of a TV line is proportional to the voltage level applied to its video input.
As the line of a TV picture strobes across and down the screen, it must lighten and darken at exactly the right moment to build up a complete picture. Only two levels are used here: logical one, and logical zero, giving white and black. These ones and noughts are stored in the 2513 read-only memory employing it as a character generator, and it is the CRTC which controls the exact moment at which these are available to be displayed on the TV screen. A TV line is continuous and needs the ones and noughts in a sequential manner, hence the use of the “parallel-in serial-out” device, whose speed of transmission is determined by the TTL oscillator.

In order to send the correct character to any position on the screen, the CRTC generates the addresses for the RAM block which sends back the characters for display in the form of ones and noughts along its data lines. These are latched and form the address inputs for the 2513. The CRTC places white regions between characters by disabling the 2513 in those time slots.

In this mode of operation, the address buffers between the CRTC and the RAM are enabled (at zero level), and the data buffers into the RAM and the address buffers from the MPU are disabled. The RAM is also held in a “read” condition, being a one on the read-write (R/W) line. When the MPU wishes to address the RAM, the states of these buffer-enables are changed to allow the MPU to read or write to or from the RAM. The R/W line is controlled accordingly.

The final block of the system is a UHF modulator to allow the VDU to interface to an unmodified TV set. The definition of the display is always partly degraded by this technique. For those with a monitor or a modified TV set, a video output is provided which gives a highly stable and clear display.

**CONTROL LINES**

The VDU-select line is decoded from the upper address lines of the MPU system and is active-low. The enable line is a control generated by most MPU systems to enable only
when the address information is valid, thus preventing a false read or write. This line is fed from VMA & $\overline{O}_2$ in a 6800 system and is also active-low. R/W is generated by MPU systems to distinguish between a read (R/W = 1) and a write (R/W = 0) operation.

This leaves only the CRTC control lines C9, C1, C2 and ST. They are specific to this chip and allow hardware control of the cursor (a flashing character permanently on display). The cursor may be moved up, down, left or right, by applying the appropriate ones and noughts on C9, C1 and C2. ST is used to inform the CRTC that a control word is present.

**OPERATING SYSTEM**

Displaying information on the screen is a very straightforward operation with this VDU. Characters are displayed by writing their ASCII codes to memory locations in the VDU. The exact addresses involved depends upon where in memory the VDU RAM has been placed.

It should be remembered that the display consists of 1024 ASCII characters arranged so that the top left position on the screen is the lowest address in the block. Thus, a user may decide to place this additional 1 kilobyte block of user RAM at address 0000 to 03FF (hex), for instance. These particular addresses are best used for other things in a 6800 system, however, and a better suggestion is to place it at, say, 1000 to 13FF. This means that the ten lower address lines, A9 to A0, are necessary to distinguish between each address on the screen. The upper six lines must be decoded to address this particular block of memory as opposed to any other. This occurs when A15 to A10 have values 000 100 respectively. That is, when the MPU places these six values on the respective address lines, the VDU Select line must go low. The first 10 address lines of the MPU are fed to the VDU and take care of addressing within the VDU RAM automatically.

A typical display operation is illustrated by the following example. Suppose the word "hello" followed by spaces, is to be displayed on the top line. The letters of "hello" are first converted into their hexadecimal equivalents in ASCII:

\[
\begin{align*}
H & = 48 \text{ (hex)} \\
E & = 45 \text{ (hex)} \\
L & = 4C \text{ (hex)} \\
0 & = 4F \text{ (hex)} \\
\text{SPACE} & = 20 \text{ (hex)}
\end{align*}
\]

A small program is now written to store 48, 45, 4C, 4C, 4F, in consecutive memory locations starting at 1000, in the above system. This displays the word at top left of the screen. Another program is then written to store 20 in locations 1005 through 103F. This fills the rest of the top line with blanks. In this way, any program, while running, simply stores the ASCII equivalents of its output somewhere in the VDU RAM.

Another important use of the VDU comes in program writing. Several ways may be used to check on what has just been written. The program may simply be input to the MPU system by a bootstrap loader. This is the type most commonly found in MPU monitors. A "dump" of the contents of a block of memory containing this program may then be displayed on the screen for checking. Some monitors already contain a formatted dump, and it is then simply a question of ensuring that the VDU RAM is enabled at the correct addresses for this monitor. The writing of this sort of software is quite straightforward and well worthwhile. Another important method of checking during program development is to display the program one byte at a time as it is written.
COMPONENTS

Resistors
- R1: 8.2MΩ
- R2, R3: 560Ω (2 off)
- R4: 47kΩ
- R5, R11: 1kΩ (2 off)
- R6: 220Ω
- R7: 3.3kΩ
- R8: 12kΩ
- R9: 2.7kΩ
- R10: 1kΩ
(all 1/2W 5% carbon film)

Potentiometers
- VR1: 100kΩ min vert preset
- VR2: 1000Ω min vert preset

Capacitors
- C1: 0.22µF Disc ceramic
- C2: 100pF Sub min ceramic plate
- C3: 82pF Sub min ceramic plate
- C4: 33pF Sub min ceramic plate
- C5: 47pF Sub min ceramic plate
- C6: 10nF Disc ceramic
- C7: 33µF 10 volt Tantalum bead
- C8: 220µF 16 volt electrolytic
- C9: 47µF tant bead (10V)

Semiconductors
- IC1, IC2-IC9: SFF96364 plus socket
- IC10: 2102LF (350nS) (8 off)
- IC11: 2513 (single supply type) plus socket
- IC12: 74174
- IC13-IC16: 74LS132, 7402
- IC17: 74LS132
- IC18: 7402
- TR1: BC184
- TR2: 2N3663
- XTAL 1: 1MHz

Miscellaneous
- SK1: chassis mounted coaxial TV socket plus nuts and bolts for fixing
- Two pieces of Veroboard (0.1-in matrix)
  - 46 x 25mm each
- PP3 battery connector
- 0.5 metre of 8-way ribbon cable
- Pins for through-board connection
- Switches: S1 s.p.d.t. S2 s.p.s.t.

Constructor’s Note
A complete kit of parts including a drilled plated through p.c.b. will be obtainable from Technomatic (01-204 4333). Details next Month.
A limited number of assembled and tested boards will also be available exclusively from Technomatic Ltd., 17 Burnley Road, London NW10.
Normally this would be done as follows. A byte is loaded from the keyboard into some memory location. A jump to a display routine is then performed, which puts the address just loaded plus its old and new contents onto the screen. This is repeated until some control character tells the load routine to end.

The importance of a cursor, plus good screen management or formatting in this process cannot be over emphasised. Fortunately, the CTRC has a set of quite sophisticated cursor control commands, as previously mentioned.

A particularly effective and striking feature of the CRTC is its hardware scrolling function. If a Cursor Down (line-feed) command is given when the cursor is on the bottom line, the entire screen’s contents jump up one line with the top line jumping to the bottom. This also occurs if Cursor Right operation is commanded with the cursor in the last position on the screen.

After such a scrolling function, the lowest address of the 1 kilobyte RAM is no longer displayed at the screen’s top left. Instead, it is at the extreme left of the lowest line. A write operation to this address causes a character to appear in a position on the screen dependent upon the number of scrolls which has been performed. However, the Cursor Home operation forces the whole display to “de-scroll” and the display reverts to normal, with the cursor at top left.

The cursor operation required at any time is converted into a code of ones and noughts and applied to \( C_0 \), \( C_1 \), and \( C_2 \) according to Table 1.

The technical specifications of the CRTC demand that the \( ST \) control line (normally in a high state) should complete a low pulse of at least 1μs a minimum of 8.3ms after any code is applied to \( C_0 \), \( C_1 \), and \( C_2 \) (apart from Cursor Home). This informs the CRTC of the presence of a cursor control word. The Cursor Home command requires at least 132ms between the control word and the \( ST \) pulse. This is best done in software by the simple loop shown in Fig. 2.

The speed of operation of your MPU decides whether you should load \( A \) in the above with 00 (hex) initially or some higher number which will revert to 00 in fewer loop steps. A simple VDU routine is shown in Fig. 3. This routine assumes that a character to be displayed is stored in ASCII code in a register (called the A register here). The cursor position address is also assumed to be stored in a register (called the X register). Characters are written to the bottom of the display and a carriage return operation causes the screen to scroll upwards. Spaces are then written to the end of the current line, and the cursor is moved to the start of the line. Information thus enters on the bottom line, following the cursor, and then scrolls up the screen.

This completes the description of the system and in the next issue, constructional details and setting up procedures will be given.

The reader is urged to obtain a copy of the data sheet for the CRTC and 2513 chips for additional information.

Table 1. Cursor control codes

<table>
<thead>
<tr>
<th>OPERATION</th>
<th>( C_0 )</th>
<th>( C_1 )</th>
<th>( C_2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>cursor home</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>cursor home left</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>line feed</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>cursor left</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>cursor up</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>cursor right</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

The next month: Assembly of p.c.b. and construction of high density RAM module.

**POINTS ARISING**

**DIMWIT (July 1978)**

Some constructors may find that during the period between the dim-out sequence and when the relay drops out, the lamp flickers. A cure for this is to shunt the I.d.r. (R13) with a 220k resistor.

**KILN CONTROLLER (June 1978)**

In Fig. 2 page 733 the value of R8 should be 10kΩ and the voltage rating of C2 in Fig. 4 should be 450V.

The setting up procedure on page 734 refers to the output of IC2 instead of IC3.

**LINEAR CAPACITANCE METER (June 1978)**

Unfortunately another error in this article has come to light. IC4 and IC7 should be wired between +6V and -6V. In Fig. 4 they are shown connected to OV.
Be the first one down your street to land on the moon. Sixty seconds to make a gentle landing with only a limited amount of fuel. You have a readout of height, velocity and fuel remaining but if your efforts fail you can still push the panic button and run on medicinal whisky.

**POWER FETS**

A feature on the new semiconductor technology which is challenging the supremacy of the bipolar transistor in many power applications.

**SPECIAL!**

**CAR DEVICES**

8 Page Supplement

2 SOLDERING IRON OFFERS

**PRACTICAL ELECTRONICS**

Fuel Consumption Meter

J. McCarthy

This unit does not show the average m.p.g., but gives an instantaneous fuel consumption related factor. You can check your driving efficiency. As your foot goes down on the accelerator, down goes the m.p.g., and up it comes again when your foot does!
This article describes a fuel consumption meter which has been operating successfully for many months. The attributes of the system are:

(a) Two digit digital display
(b) Mainly low-price TTL
(c) Interfaces to the car via a simple connection to the SU electric fuel pump, and an easy modification to the car's speedometer.

An SU electric fuel pump may be fitted to any car using a mechanical fuel pump, provided that the former can provide the fuel at a satisfactory rate. In the author's case, a 1725cc Hillman Hunter was fitted with a fuel pump borrowed from and aged side-valve Morris Minor. The Hunter never showed any signs of fuel starvation despite very hard driving. Fig. 2 shows a simplified diagram of such a pump. As the pump operates, the voltage at point "A" alternates between +12V and 0V (for -ve earth vehicles).

The measurement system may conveniently be considered as two interconnected sections, as depicted in Fig. 1. Referring to this diagram, the distance monitor counts pulses derived from the speedometer, whilst pulses at a slower repetition rate derived from the fuel pump cause the generation of a series of internal control pulses which halt the speedometer counting process, store and display the count to date, and reset the counter. This effectively generates a measure of distance covered per operation of fuel pump, which it may be noted is of the same dimensions as miles per gallon, or for that matter, kilometres per litre, although it is clearly not in these units. Fig. 3(a) shows the counter module circuit, which utilises a total of six TTL chips which drive a pair of 3015F seven-segment displays. Its function is as follows: Provided that the reset line is kept low, pulses into the gated speedo input, or to be more specific, negative going edges, will cause the two tandemed 7490s to count. Pulses to the strobe cause the 7475s to latch their outputs to the count generated at their inputs by the 7490s. The 7475s outputs are converted by a pair of 7447s into seven-segment display code.

The signals applied to this module, in relation to the signal received from the vehicle sensors, relative to time, are in Fig. 4, which is not necessarily to scale. For each rotation of the speedometer cable, one pulse is applied to the gated speedo input, until the fuel pump operates, at which point the strobe and reset lines are sequentially pulsed in order to display the count since the last pump operation, and to reinitialise the counters.

Fig. 3(b) shows the second module; this circuit matches and converts the signals obtained from the speedometer and the fuel pump sensors into those suitable for TTL logic.

**SPEEDOMETER SENSOR**

At this point, it is necessary to describe the method of application to the speedometer of a sensor. The method used by the author, which should be applicable to the majority of cars, was to mount a photo-sensitive device in the rear of the speedo in such a way that light is reflected from the speedometer illuminating bulb via a part of the rotating mechanism, onto the photo-device. The point at

![Fig. 1. Simplified block diagram of Fuel Consumption Meter](image)
Fig. 2. Diagram shows the fundamental arrangement of an electric fuel pump, and how the sense signal is derived. One-way valves direct the flow of fuel as the diaphragm oscillates which this is mounted has to be carefully selected, and it may be necessary to paint parts of the internal workings of the speedometer with matt-black paint. It is also necessary to make a minor change to the speedometer illumination system, entailing severing the wire connecting the speedometer bulb to the sidelight system, and connecting it instead to the ignition switch, such that it is on, whenever the ignition is on. The photo-device is then connected to the module of Fig. 3(b) via screened cable. This precaution has been found to be essential in view of the high impedance nature of the phototransistor, when no light is falling on it.

The current changes caused within the phototransistor due to changes in the incident light are then used to drive a p.n.p. Darlington pair, the output from which is taken to a variable Schmitt trigger comprising a 741 with adjustable positive feedback, a level-shifting n.p.n. transistor, and finally a 7413 to generate suitable TTL levels. The setting of the three variable resistors will be described later. The signals from this section of the unit are then sent to the counter module for processing.

**FUEL PUMP**

The pulses from the fuel pump which have additional unwanted spikes in both the positive and negative sense, are first clamped to TTL levels by a pair of diodes, one of which prevents negative pulses from entering the remainder of the circuitry, the other of which clamps the input level to less than 5V. The pulses then go to a pair of retriggerable monostables, held in one package, the 74123. The two monostable multivibrators have periods of $T_1$ and $T_2$ where $T_1$ is very much greater than $T_2$. The output of the monostable of period $T_2$ is used to drive the subsequent circuitry, while the output of the other monostable is used to inhibit false triggering caused by contact bounce, ringing and so on.

The subsequent circuitry comprises a pulse sequence generator to generate the reset and latch strobe pulses, and to inhibit the input of speedometer derived pulses. The heart of this system comprises a divide-by-eight counter, part of a 7490 (IC8) and a clock oscillator, part of 7413 (IC9). A pulse from the monostable driver will force the counter to reset, which allows the oscillator to function. This causes the counter to count from zero to four, in so doing, generating the required control pulses. When the counter achieves a count of four, the rising of IC8 pin 9 output inhibits the function of the clock oscillator.

**COMPONENTS . . .**

**Resistors**

- R1, R3: 27Ω (2 off)
- R2: 2.2kΩ
- R4: 270kΩ
- R5, R6: 249kΩ 2% (2 off)
- R7: 6.2kΩ 2%
- R8: 27kΩ

All resistors ±1% W 5% unless otherwise stated.

**Potentiometers**

- VR1, VR3: 100kΩ vertical preset (2 off)
- VR2: 1MΩ vertical preset

**Capacitors**

- C1, C2, C8, C9, C10: 1nF (5 off)
- C3: 0.01μF
- C4: 100μF/20V electrolytic
- C5: 10nF
- C6: 10nF
- C7: 22μF

**Transistors and Diodes**

- TR1, TR2: OC200 (2 off)
- TR3: 2N3705
- TR4: BF101, TDB7805 or equivalent
- D1, D2, D3: OA202 (3 off)

**Displays**

- X1, X2: 3015F (2 off)

**Integrated Circuits**

- IC1, IC2, IC8: 7490 (3 off)
- IC3, IC4: 7475 (2 off)
- IC5, IC6: 7447 (2 off)*
- IC7: 7413
- IC9: 7400
- IC10: 7404
- IC11: 74123
- IC12: 7411
- IC13: 7805 regulator

**Miscellaneous**


* Not needed for meter display

**Constructor’s Note**

The BP101 is available from Electrovalue. OC200 transistors are available from Watford Electronics, and Semiconductors Suppliers, Orchard Works, Church Lane, Wallington, Surrey, SM6 7NF.
Fig. 3(a). Counter module circuit (built on separate board)

Fig. 3(b). Interfacing module circuit diagram. This part of the system matches the sense signals to the TTL
Fig. 4. Sensor and control signals relative to time. These are not to scale.

ANALOGUE DISPLAY

The author's unit employs a pair of seven-segment displays, but it might be felt preferable by some constructors to use an analogue meter display. These may easily be done by replacing the displays and their associated 7447s with the circuit of Fig. 5. In this circuit, the inverted outputs of the two 7475s are used to drive a 6-bit resistive digital to analogue converter, the resulting current from which is amplified by TR4, and used to drive a 1mA meter movement. The emitter of TR4 is set to around 2.2V below Vcc by the effect of the three diodes D3, D4 and D5.

The use of a metal case is advisable for effective screening; the 5V regulator can then be mounted on the rear of the unit for excellent cooling. The driver will probably be most curious about the fuel consumption reading when accelerating hard; a time when increased concentration on the road is required, and so care should be taken in the use on this instrument.

COMPONENTS...

FOR METER DISPLAY

Resistors

- R8: 390kΩ + 10kΩ
- R9: 47kΩ + 2.7kΩ
- R10: 180kΩ + 18kΩ
- R11: 100kΩ
- R12: 470kΩ + 27kΩ
- R13: 1MΩ (2 off)
- R14: 270kΩ
- R15: 2.7kΩ

Potentiometers

- VR4: 5kΩ preset
- D3, D4, D5: 1N4148 (3 off) or 2VZ Zener (1 off)
- Meter: 1mA f.s.d.

CONSTRUCTION

The circuit layout is in no way critical, and in the author's case, the equipment was built on two small sheets of Veroboard, with each board corresponding to one of the modules described previously. The above having been said, it is important to observe two important rules: The decoupling capacitors on the 7490s on the counter module board are essential to the counter chips' correct operation. They should be connected as closely as possible to the chip supply pins. In view of the electrically noisy environment within a car, due to ignition, and other radiation, the equipment should be constructed within an earthed metal box; failure to do so may result in spurious operation.
SETTING UP
The only specific adjustment required in the system is that relating to the circuitry interfacing the speedometer to the TTL, and three preset adjustments have been found necessary.

Adjustment may most easily be done with the equipment in the car, and both driving wheels securely jacked-up clear of the road. With the engine started and idling slightly faster than normal, gently engage first gear. The three preset potentiometers should be initially set as follows:

VR1 mid-position.

VR2 maximum resistance.

VR3 maximum resistance.

A test meter should be set to around the 5V d.c. range, and connected to the output of the 741.

VR1 should be adjusted in either direction as necessary until the meter reading pulsates at a speed proportional to the speedometer reading. VR2 should then be adjusted until the pulsations just stop, and then increased by about 10 per cent. VR1 should be adjusted to the middle position of the range in which speedometer pulses are detected. So far, a centre point for the input pulses has now been determined, and by setting the positive feedback to the maximum acceptable, any rough tops to the waveform will be "ironed out". The number held by IC10 should now be checked; this should be the value 4. If this is not the case, momentarily trigger the 74123 by connecting the pump sense wire to earth for a brief period. If after a very short period of time, the 7493 does not halt in the mentioned rest state, something in this area is not in order and the circuitry should be checked. If all is well, transfer the test meter probe to the input of the 7413, and reduce the value of VR3 until the pulsations appear from the output of the 741, and then at the output of the 7413. The equipment is now ready for use.

INTERPRETING THE RESULTS
During normal driving, the readings presented by the equipment will fluctuate with changes in fuel consumption. It should be noted that two sources of inaccuracy can occur. The first of these occurs because the float-chamber systems of most carburettors are gravity operated, and any violent disturbance in the car's motion, such as violent braking or cornering will affect the amount of petrol allowed into the float-chamber by the needle-valve, causing a momentary upset in the readings obtained.

Secondly, as is well known by Morris Minor, and doubtless other drivers, a marked lowering of the level of fuel in the petrol tank causes the pump to operate very rapidly as air, rather than petrol is ingested. The settings of the timing components on the 74123 is such that a cycle during which air is ingested occurs before the 74123 pulse of time T1 has finished, thus ensuring that the pulses from the pump are ignored when air is being drawn in. Accuracy is still effected by this phenomenon however, and the fuel level should not be allowed to fall this low in normal running if accurate results are required from the equipment.

Interfacing section circuit board. Use Fig. 3 for interwiring. This board should be mounted so that the displays show through the front panel directly.
When learning about electronics, one of the earliest things that we find is that for a resistor the voltage across it and the current driven through it are related by Ohm's Law

\[ E = IR \]

where \( E \) is the voltage across a resistor with resistance \( R \) and \( I \) is the current. These three quantities are generally measured in volts, ohms and amps respectively. We then discover that capacitors and inductors produce a similar relationship, which is written as \( E = iZ \) where \( Z \) is the impedance of the component and \( E \) and \( i \) are assumed to be sinusoidally varying a.c. voltage and current respectively.

The reason for this assumption is that non-sinusoidal waveforms are effectively a mixture of more than one frequency. Since the impedance of many components varies with frequency, the current flowing will not then be directly proportional to the driving voltage. It is worthwhile noting, as an aside, that the way that non-sinusoidal waveforms are dealt with is to break them up into the sum of sinusoidal parts, each of a different frequency. Each of these parts can then be dealt with using \( E = iZ \), the impedance of the combination would not be a simple product of the individual parts.

In order to use the above formula we need to know the value of the impedance \( Z \) for the circuit. For a capacitor the impedance (often called the reactance) is given by \( 1/2\pi fC \), where \( f \) is the frequency of the signal in hertz, \( C \) is the capacitance of the capacitor in farads (a unit which we soon find out is about a million times larger than is useful), \( \pi \) is 3.1416. Similarly the impedance of an inductor is \( 2\pi fL \) where \( L \) is the inductance of the inductor in henrys.

Given this starting point it soon becomes apparent that there is much more to the impedance of capacitors and inductors than their simple numerical value. Consider, for example, the case when we have a capacitor and an inductor which both have an impedance of, say, 10Ω at a particular frequency that we shall apply. If we connect these components in series and apply an a.c. voltage we might expect that the impedance of the combination would be 20Ω, but this is not the case. The total impedance is in fact zero! Furthermore if we connect the components in parallel the impedance is not 5Ω, it is infinitely large.

The above example demonstrates that we require rather more information if we want to calculate the impedance of a combination of elements.

**Complex Numbers**

We now introduce the concept of a complex number which consists of two parts: called the real part and the imaginary part. A complex number is written like this

\[ x + yi \]

Here \( x \) is the real part and consists of a real number, whilst \( y \) is the imaginary part. \( i \) is the important symbol ( \( j \) is often used instead) which represents a number which when squared gives minus one

\[ i \times i = -1 \]

If that is a little difficult to conceive of it doesn’t matter—just think of it as a symbol which labels the imaginary part of the complex number. Examples of complex numbers are: \( 3 + 4i \), \( 10 - 3i \), \( -3.6 \times 10^4 + 6.7i \). Real numbers such as \(-7\) and \(43.6\) may also be thought of as complex numbers whose imaginary part is zero. Similarly there are numbers such as \( 6i \), \(-0.2i\) or even \( i \) (which is the same as \( 1i \)) in which the real part is zero.

**Arithmetic**

Fig. 1 demonstrates a way in which complex numbers can be shown on a diagram. In the figure the complex number is \( 3 + 4i \). It is represented by a line which goes from the origin of co-ordinates (marked 0) to the point which lies on the lines; real part = 3 and imaginary part = 4. This line has a certain length \( r \), and makes a certain angle to the real axis \( \theta \). Note that the complex number can be specified in terms of \( r \) and \( \theta \), and these two numbers completely specify a particular complex number, just as \( x \) and \( y \) do.

Given the representation of a complex number as \( x + yi \) or as \( r \) and \( \theta \), it is always possible to convert from one representation to the other.

**Pythagoras' Theorem**

Applying Pythagoras' Theorem to Fig. 1

\[ r = \sqrt{x^2 + y^2} \]

This is by far the most often needed conversion. For the more mathematically minded we will give the other formulae

\[ r \cos \theta = x \], \[ r \sin \theta = y \], \[ \tan \theta = y/x \]

Of these the last is the most important.

Addition of two complex numbers simply involves adding the real and the imaginary parts separately as shown below

\[ (x + yi) + (a + bi) = (x + a) + (y + b)i \]

For subtraction you just subtract real and imaginary parts separately—be careful to get the signs right!

\[ (x + yi) - (a + bi) = (x - a) + (y - b)i \]
Multiplication is a little more complicated
\[(x + yi) \cdot (a + bi) = (xa - yb) + (xb + ay)i\]

Unfortunately dividing complex numbers is more difficult than the preceding cases—hopefully the following steps should make the process clear. Assume we want to evaluate
\[x + yi\]
\[a + bi\]

First we multiply both the top and the bottom of this expression by one — bi. Since this is the same as multiplying the original expression by one, our division can now be written as
\[\frac{(x + yi) \cdot (a - bi)}{(a + bi) \cdot (a - bi)}\]

If we now multiply out (a — bi) we get \(a^2 + b^2\) which has no imaginary part at all, so our expression is the same as:
\[\frac{(x + yi) \cdot (a - bi)}{a^2 + b^2}\]

and we know how to multiply the top to get
\[\frac{(xa + yb) + (ya - xb) i}{a^2 + b^2}\]

and this is the same as
\[\frac{(xa + yb)}{a^2 + b^2} + \frac{(ya - bx) i}{a^2 + b^2}\]

There is just one more thing before we finish our maths lesson and that is how to multiply and divide complex numbers when they are in \(r\) and \(\theta\) form. This is simpler than for numbers in \(x + yi\) form: to multiply you multiply the "\(r\)"s and add the "\(\theta\)"s; to divide you divide the "\(r\)"s and subtract the "\(\theta\)"s.

In these examples the complex numbers are written as \((r, \theta)\); thus \((2,36')\) stands for the complex number with \(r = 2\) and \(\theta = 36'\).

(i) \((3, 15') \cdot (4, - 12') = (3 \cdot 4, 15' - 12') = (12, 3')\)
(ii) \((16, 186') \cdot (3, - 26') = (16 \cdot 3, 186' - 26') = (48, 160')\)
(iii) \(2,17' = 2, 5, 27' = 5, -10'\)

But remember that 360' is a full circle, so that -10' is the same as
\[+350' = \frac{\pi}{5}, -10' = \frac{\pi}{5}, 350'\]

It is now time to use these numbers.

**COMPLEX IMPEDANCES**

Any impedance which is a combination of resistances, capacitances and inductances can be represented as one complex number. Sinusoidally oscillating voltages and currents are also represented by complex numbers. Using the arithmetic of complex numbers that we have described, it is now possible to use Ohm's law to give the correct answer and we can combine impedances in the same way as we used to combine resistances.

Let's see how this works.

Resistors have no imaginary part to their impedance, it is just their resistance \(R\).

Capacitors have no real part to their impedance, it is given by \(-i/2\pi C\). The symbols all have the same meanings as before.

Inductors too have no real part to their impedance, it is given by \(2\pi fL\).

It is easiest to represent voltages and currents in \(r\) and \(\theta\) notation. First it is essential that you know about the phase difference between two sinusoidal waveforms of the same frequency.

The phase difference is given by the distance between the peaks of the two waveforms and is specified by an angle which is worked out by defining the angle between two successive peaks of the same wave to be 360'.

Reference to Fig. 2 should make this clearer.

The complex impedance of the series tuned circuit in Fig. 4 (a) is found simply by adding together the complex impedances of the capacitor and the inductor to get
\[\left(2\pi fL - \frac{1}{2\pi fC}\right)\]

Note that the impedance still has no real part. Hence in \(r\) and \(\theta\) form it has
\[r = \left(2\pi fL - \frac{1}{2\pi fC}\right)\] and \(\theta = 90'\).

You may notice that \(r\) might be negative in the above formula, in which case \(\theta\) would be 270'—but negative \(r\) in the direction of 90' is the same as positive \(r\) in the direction of 270'.

It isn't usually worth bothering about these things, they almost always work out alright in the end!

Now suppose that we want to know what current flows in the circuit. We know that \(E = IZ\), so \(l = E/Z\). Choose the input voltage to be the reference quantity for the circuit—it will then have \(r = V\) (the peak value) and \(\theta = 0'\). To work out the current flowing we divide \(E\) by \(Z\), remembering to divide the "\(r\)"s and subtract the "\(\theta\)"s. So I has
\[r = \frac{V}{2\pi fL - \frac{1}{2\pi fC}}\] and \(\theta = 0 - 90' = -90'.\]
So the current is 90° out of phase with the voltage, remembering that leading by 90° is the same as lagging by 90°. We have a rather peculiar expression for the peak value of the current \( r \). Notice how this expression is positive for high frequencies but negative for low ones. Thus the arrangement of the waveforms in is given by

\[
I = \frac{V}{Z} = \frac{V_{in}}{R - \frac{1}{2\pi fC} i}
\]

Now the output voltage is produced by the current \( I \) flowing through the resistor \( R \) so, using Ohm's Law, we obtain

\[
V_{out} = \frac{V_{in}R}{R - \frac{1}{2\pi fC} i}
\]

To evaluate this we had better put it into \( r \) and \( \theta \) form. \( V_{in}R \) is simple—since it is just an ordinary number with no imaginary part it has \( r = V_{in}R \) and \( \theta = 0° \). To convert the bottom half of the expression we need to use the formulae for \( r \) and \( \theta \) in terms of \( x \) and \( y \) that we mentioned earlier: namely \( r = \sqrt{x^2 + y^2} \) and \( \tan \theta = y/x \) (this last part can be done by scale diagram). Putting the \( x \) and \( y \) values of

\[
r = \frac{R + \frac{1}{2\pi fC} i}{\sqrt{R^2 + \frac{1}{4\pi^2 f^2 C^2}}}
\]

into these formulae gives the value of \( r \) to be

\[
r = R^2 + \frac{1}{4\pi^2 f^2 C^2}
\]

and \( \theta \) is going to be the angle for which

\[
y = \frac{-1}{x} \times 2\pi fRC
\]

Using the rule for division in \( r \) and \( \theta \) form we can now calculate the value of

\[
\frac{V_{out}}{V_{in}} \quad \text{the r part is}
\]

\[
r = \sqrt{R^2 + \frac{1}{4\pi^2 f^2 C^2}}
\]

and the \( \theta \) part is minus the angle for which

\[
y = \frac{-1}{x} \times 2\pi fRC
\]

—if you draw a diagram you can see that this is the same as the angle for which

\[
y = \frac{1}{x} \times 2\pi fRC
\]

The \( r \) value gives us the amount by which the amplitude of the voltage is decreased. When

\[
R^2 = \frac{1}{4\pi^2 f^2 C^2}
\]

this attenuation factor is about .707 (or, using the decibel scale, about -3dB). Rearranging this formula and getting rid of all the squares gives

\[
f = \frac{1}{2\pi fRC}
\]

This is often called the break point for the filter.

What do all these complicated-looking formulae mean as regards the performance? Well, when the frequency is very high the term is very small and so \( \frac{V_{out}}{V_{in}} \) becomes very close to one. This indicates that high frequencies pass through the filter almost unobstructed. In contrast, when \( f \) is very small the term is going to be far larger than the \( R^2 \) term so we can ignore the \( R^2 \) term without too much loss of accuracy. We then have

\[
\frac{V_{out}}{V_{in}} = \frac{R}{\sqrt{R^2 + \frac{1}{4\pi^2 f^2 C^2}}}
\]

Notice that the \( \frac{V_{out}}{V_{in}} \) figure halves every time the frequency halves. This sort of relationship is best shown on a decibels versus logarithmic frequency plot as shown in Fig. 6 (a).

Taking 0dB at the input level, the output level of the filter is fairly constant down to just above the break point: the output then curves down, finally falling off at about 6dB per octave (halving of frequency) which is 20dB per decade.

We have not yet used the information we have calculated about \( \theta \). For actual values of \( R, C \) and \( f \), \( \theta \) can be evaluated either by drawing a diagram or by working out

\[
\theta = \arctan \frac{1}{2\pi fRC}
\]

on a scientific calculator. We can see roughly what is going to happen: at very high frequencies when the filter is passing almost all of the input voltage, \( y/x \) is very small which means that the output voltage has almost the same phase as the input voltage. As the frequency decreases it will reach

![Fig. 4 (b)](image)

![Fig. 6 (a)](image)
the break point where
\[ \frac{1}{2\pi fRC} = 1 \]
—this means that the output will lead the input by 45°. As the frequency keeps on decreasing the phase lead will continue increasing, getting ever nearer to 90° but never quite getting there as shown in Fig. 6 (b).

![Fig. 6 (b)]

When working with filters such as this one, it is generally true that the attenuation versus frequency graphs (on logarithmic scales) can be simplified considerably. To do this you just assume that the response is flat down to the break point, whereupon it falls off immediately at a rate of 6dB per octave = 20 dB per decade. This approximation is shown dotted in Fig. 6 (a)—the approximation is very accurate except for a decade or so around the break point when it can be up to 30 per cent out.

MORE COMPLICATED FILTERS

As a slightly more complicated example let us try to design a filter which passes high frequencies unattenuated and attenuates low frequencies by 10. We want the middle point to be at 1kHz (the full attenuation is 20dB so call the mid point the 10dB attenuation point). We would also like some idea of the phase performance.

![Fig. 7]

The obvious way to do this is shown in Fig. 7. At very low frequencies the effect of the capacitor is insignificant so
\[ \frac{V_{out}}{V_{in}} = \frac{R_2}{R_1 + R_2}, \]

which we want to equal
\[ \frac{1}{10}. \]

Choose as fairly sensible values \( R_1 = 9k \Omega \), \( R_2 = 1k \Omega \). Whether these are sensible will, of course, depend on the impedance of the source we are using to drive the filter and the impedance that is being driven by the filter. Say for the sake of simplicity that the driving impedance is a few ohms and that the driven impedance is at least several tens of kilohms. Now down to work:

Using the symbol \( R_{ij}C \) to mean the impedance of the parallel combination of \( R_1 \) and \( C \) we have
\[ \frac{V_{out}}{V_{in}} = \frac{R_2}{R_1 + R_{ij}C} \]

But \( R_2 = 1k \Omega \) and \( R_1 = 9k \Omega \) so
\[ R_{ij}C = \frac{9000 (\frac{-1}{2\pi fC}) i}{9000 - \frac{1}{2\pi fC} i} \]

and
\[ \frac{V_{out}}{V_{in}} = \frac{90000 - \frac{5}{\pi fC} i}{90000 - \frac{50}{\pi fC} i} \]

The "r part" of this expression can be found by dividing the r part of the top by the r part of the bottom
\[ r = \frac{\sqrt{(90000)^2 + \frac{5}{\pi fC}^2}}{\sqrt{90000^2 + \frac{50}{\pi fC}^2}} \]

since we require this to be equivalent to an attenuation of 10dB when \( f = 1kHz \) and 10dB is a voltage ratio of \( \sqrt{10} : 1 \).

Square both sides and multiply out which gives
\[ 9 \times 81 \times 10^6 = \frac{2500 - 250}{\pi^2 f^2 C^2} \]

this is for \( f = 1kHz \) so
\[ C^2 = \frac{2250}{9 \times 81 \times 10^8 \times \pi^2 \times 10^6} = \frac{3 \times 127}{10^{-15}} \]

and finally we get to the value of the capacitance \( C = 5 \times 6 \times 10^{-6} \) farads = 0-056\( \mu \)F. If we substitute this value into the original formula for the r part we get
\[ \frac{\sqrt{(90000)^2 + \frac{8 \times 10^{14}}{f^2}}}{\sqrt{(90000)^2 + \frac{8 \times 10^{16}}{f^2}}} = \sqrt{\frac{1 + \frac{10^5}{f^2}}{1 + \frac{10^7}{f^2}}} \]

A graph of this is the attenuation of the filter, as shown in Fig. 8 (a).

![Fig. 8 (a)]

PHASE PERFORMANCE

To get some idea of how the phase difference between the input and the output varies with frequency we see that at high frequencies the capacitor is going to have far more effect than \( R_1 \), so the phase shift will go to zero, just as it did for the simple high-pass filter. Also at very low frequencies the effect of the capacitor will be negligible and the phase shift will go to zero again. What happens in between? If we substitute the value for the capacitance into
\[ \frac{V_{out}}{V_{in}} = \frac{90000 - \frac{5}{\pi fC} i}{90000 - \frac{50}{\pi fC} i} \]

we end up with
\[ \frac{V_{out}}{V_{in}} = \frac{1 - \frac{316}{f}}{1 - \frac{3160}{f}} \]

From this we can work out the phase shift for any frequency; for example at 1kHz we have
\[ \frac{V_{out}}{V_{in}} = \frac{1 - 0-316 i}{1 - 3-16 i} \]

Now \( \theta \) for \( 1 - 0-316 i \) is about \(-171^\circ \)
and \( \theta \) for \( 1 - 3-16 i \) is about \(-724^\circ \), so \( \theta \) for
\[ \frac{V_{out}}{V_{in}} = \frac{-171^\circ}{-724^\circ} = 55^\circ \]

![Fig. 8 (b)]

In fact this is the maximum phase shift for any frequency. A graph of phase shift versus frequency is also shown on Fig. 8 (b).
This article describes a high performance power supply with voltage control down to zero (yes, zero, not two and a half volts or five and a quarter or, as in the case of many supplies, whatever the Zener voltage used in the system happens to be) and current limit from a few milliamps to several amps.

This ability to have current limit down to such low values allows one to, for example, work with low power circuitry knowing that even if something drastic happens nothing will be destroyed. One can even use this facility for measuring the values of larger electrolytic capacitors!

### Specification

- **Voltage Control**: 0–30V
- **Current Control**: 2mA–2A
- **Output Resistance**: Less than 0.001Ω
- **Ripple and Noise**: Less than 0.001%
- **Line Regulation**: Less than 0.001%
- **L.e.d. indicator current limit mode**
- **Sharp voltage/current mode transition**
- **Instant switch off**

### Circuit Action

The reference voltage is generated in the circuitry around IC1 (see Fig. 1). D5 is a 5.6V Zener diode run at its zero temperature coefficient current. Values of most Zener series (BZY88 in particular) exhibit positive temperature coefficient below 5.6V and varying degrees of negative t.c. above this value.

R5 and R6 set the output of the reference generator at twice the Zener voltage and in addition a low output impedance feed to the rest of the p.s.u. is guaranteed by the high degree of feedback employed.

The circuit operates as follows; the output of the op amp IC1 increases until D8 conducts, whereupon the circuit stabilises with the Zener voltage appearing across R5. Negligible current flows into the non-inverting input of IC1 and therefore all the current in R5 flows into R6 yielding twice the Zener voltage at the output of IC1.

### Amplifier

Unlike most power supplies, instead of providing voltage control by means of varying the feedback factor in a control system, this design uses what is in effect a "uni-phase power amplifier" arrangement.

The reference section provides $2 \times 5.6 = 11.2\,\text{V}$, and we require 30V out, hence the gain of the amplifier is $30/11.2$. The resistors R11 and R12 determine the gain, and this is given by:

$$A_v = \frac{R_{11} + R_{12}}{R_{11}}$$

which can be re-written in terms of $V_{\text{ref}}$ (11.2V), and the output voltage $V_{\text{out}}$ (30V) as the ratio of the two resistors:

$$\frac{R_{11}}{V_{\text{ref}}} = \frac{R_{12}}{V_{\text{out}} - V_{\text{ref}}} = 0.59$$

### Preferred Values

Two preferred values which give this ratio whilst at the same time approximately maintaining an equivalent impedance looking back from either the inverting or non-inverting inputs of the op amp (this keeps temperature drift effects in the input bias currents common-mode and therefore self-cancelling) are 33kΩ and 56kΩ.

### Advantages

One of the advantages of using a "power amplifier"-type system in the voltage section is that the control of output voltage down to zero can be achieved easily. Other designs allow this to be performed but solutions sometimes can appear somewhat contrived. With the amplifier system zero input means zero output.

For perfectionists a preset has been provided which allows one to trim out any remaining millivolts which can be caused by offset in the 741 or possibly the voltage control potentiometer not yielding exactly zero output voltage when turned fully anti-clockwise.

### Current Limit System

The current limit system sets the maximum output current available from the p.s.u. and also provides an indication that the unit has shifted from constant voltage mode to constant current mode.

Current limit comes into operation when the voltage across a sensing resistor (R7) reaches a predetermined value. This value is set by VR3 and is derived from the reference voltage line from IC1.

### Operation

All the current that flows from the output terminals must also flow through R7. If we now consider the circuitry around IC3: the inverting input is biased at 0V via R21, whilst the non-inverting input can be adjusted to any voltage between 0 and 2V. Say it is set at 1V and the output voltage at several volts. If the load is increased the voltage output will be held at a constant value by the voltage amplifier section and the presence of R7 will have a negligible effect due...
to its low value and because it is situated outside the feedback loop of the voltage control circuitry.

It is interesting to note that if the load is constant (a resistor for example) and the voltage output is constant, then the current through R7 is constant and substantially independent of any ripple in the incoming supply.

If the load is now increased to cause the voltage across R7 to reach 1V, IC3 comes into action.

**COUPLING**

The output of IC3 is coupled to the non-inverting input of IC2 (essentially the input to the voltage amplifier arrangement) with a diode. Thus the current control can "cut in" and override the voltage control, but at all other times is totally disconnected from it. Hence, when in our example the voltage across the sensing resistor reaches the predetermined 1V, IC3 adjusts the input to IC2 in such a fashion as to maintain this voltage across the resistor and thereby form a second dominant control system—except this time controlling output current and not voltage.

C8 provides compensation in this loop to maintain stability.

**INSTANT "SHUT-DOWN"**

In order to prevent any spurious effects that may occur as the negative rail voltage decays away when power is removed from the unit, transistor TR1 removes drive to the output stage as soon as the rail collapses.

Under normal operation TR1 is held off by R14, but when the negative rail fades TR1 comes on and holds the output of IC2 low. This does no damage to the i.e. as the 741 has comprehensive internal output current limit circuitry built into it which limits its output current to a safe 15—20mA.

The fact that the output from the p.s.u. disappears virtually instantaneously can be an asset when doing test or experimental work. It allows one to kill the supply and perform circuit modifications without having to wait first for the power supply's internal capacitor to slowly discharge.

**CONSTRUCTION**

Construction should commence with the etching of the p.c.b. and then assembling components onto this as shown in Figs. 2 and 3. As this layout has been proven, it is wise to stick to it as much as possible to ensure stability. The remaining peripheral components should then be connected.

**SUPPLY CURRENT**

There is a small amount of current which flows through R7 which does not go to the load. This constitutes the negative supply current to IC1 and the Zener current. This is the reason for R17. It allows voltage appearing across R7 due to this current, and also any due to remanent resistance in VR3 (when fully anti-clockwise) to be offset. Normally it should lie in the range 0-100Ω (typically about 33Ω).

**NEGATIVE RAIL GENERATOR**

The circuitry around C2 and C3 forms the negative rail generator. This is required to enable IC2 to control the output voltage down to zero. Similarly since IC3 has to control the input of IC2 down to zero, it too requires a negative supply. IC1 is operating under fixed conditions, however, and therefore can be run between the positive unregulated input and earth.

The negative generator is simply a pump system with simple stabilisation on its output (R3 and D7).

**TESTING**

When building p.s.u.s, power amps. etc. initial switch-on can be a little nerve racking, as small mistakes can easily result in drastic burn-ups. Ideally a Variac should be used here, as then the input current to the system can be watched whilst the input voltage is slowly increased. If it is seen that the current has risen beyond a reasonable value then the circuit can be checked and the replacement of burnt, charred components is happily avoided.

However, in the absence of a Variac a low value resistor (20-50Ω) of a Watt or so rating can be used in series with the secondary of T1, together with a multimeter set to 1A a.c.

When power is applied the meter should just give an initial kick and then settle down to a low value (10-30mA). A fault condition exists if the resistor overheats and/or the current is substantially higher than the above readings.

Assuming the first switch on has been successfully accomplished and the unit is drawing the correct current.
short out the series resistor and make sure the current is still around 30mA.

Now check that the output of IC1 is between 11V and 12V with respect to the negative output terminal. Check that pin 3 of IC2 varies in voltage with the position of VR1, and that when VR1 is fully anticlockwise there is in fact zero volts at this point.

Next check that the negative supply pins of IC2 and IC3 are at between -5V and -6V with respect to the negative output. After this check the output of the supply can be varied from zero to 30V. With VR1 fully ant-clockwise adjust VR2 to trim out any remaining millivolts.

**CURRENT LIMIT**

Once the voltage system is known to be satisfactory the current limit system can be checked. Diode D9 connects the output of IC3 to the non-inverting input of IC2 and it is worth noting that if IC3 output is staying low for some reason this will override VR2. If it is suspected that there is a fault in the current limit system, D3 can be removed and the two systems isolated. It should of course be replaced before the current limit system is examined.

To check the current limit system, first make sure that pin 3 of IC3 varies from 0V to about 2V when VR3 is adjusted. Turn VR3 to a minimum. If D12 lights it means R17 is too

---

**Fig. 2. P.c.b.**

**Fig. 3. Component layout.** If bridge rectifier used R1 can be connected directly to C1

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low. Ensure first though that it is not a fault condition.

Now turn VR1 to give zero output voltage (check this with a multimeter). Set the multimeter to about 100mA d.c. and slowly turn up the output voltage with VR1. If all is well, D12 should light and the current should limit at a low value (2-5mA). If this does not happen check D9 and IC3 and associated circuitry, with the usual attention being payed to such things as dry joints and solder splashes.

When this stage has been reached a value can be given to R17 if D12 still comes on at VR3 minimum setting. As mentioned above it should allow current control down to 3-5mA.

**METERING**

A meter is a very useful feature to have on a power supply. It is possible to do without one by having calibrated voltage and current controls but this does restrict the unit somewhat.

A circuit which allows switchable current/voltage monitoring is given in Fig. 4. Current is measured by monitoring the voltage across R7. This means the unit's very low output impedance is preserved.

![Fig. 4 Monitoring circuit](image)

R, and R, are determined by the meter sensitivity and resistance. If the meter sensitivity is 1mA for f.s.d. and it has a resistance of R,Ω, then R, will be obtained from:

\[ R_x = \left( \frac{30}{1} \times 1000 - R_x \right) \Omega \]

Similarly R, is obtained from:

\[ R_y = \left( \frac{1}{1} \times 1000 - R_y \right) \Omega \]

If two meters are available, of course, both voltage and current can be monitored simultaneously and S1 can be done away with.

**HEATSINKING**

Any linear power supply with a reasonable output should be equipped with generous heatsinks, and this is no exception. The worst-case condition for these 'linear' type supplies is when they are supplying a high current at a low voltage. The dissipation in the series pass transistor can reach as high as 50W in this case and to keep the junction temperature of the series transistor down to a safe value a heatsink of around one degree C per Watt or better should be used.

The constructor's discretion can be resorted to here: if it is apparent that the unit is severely overheating and the transistor TR3 far too hot to touch (don't get misled however, they can take junction temperatures in excess of 150 degrees C) then greater heatsinking should be employed.

**COMPONENTS...**

<table>
<thead>
<tr>
<th>Resistors</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1 2.2kΩ 1W</td>
</tr>
<tr>
<td>R2 100Ω</td>
</tr>
<tr>
<td>R3 220Ω</td>
</tr>
<tr>
<td>R4 4.7kΩ</td>
</tr>
<tr>
<td>R5 10kΩ</td>
</tr>
<tr>
<td>R6 10kΩ</td>
</tr>
<tr>
<td>R7 0-3Ω 2W</td>
</tr>
<tr>
<td>R8 27kΩ</td>
</tr>
<tr>
<td>R9 2.2kΩ</td>
</tr>
<tr>
<td>R10 330kΩ</td>
</tr>
<tr>
<td>R11 33kΩ</td>
</tr>
<tr>
<td>R12 56kΩ</td>
</tr>
<tr>
<td>R13 10kΩ</td>
</tr>
<tr>
<td>R14 1-5kΩ</td>
</tr>
<tr>
<td>R15 1kΩ</td>
</tr>
<tr>
<td>R16 1kΩ</td>
</tr>
<tr>
<td>R17 0-100Ω (33Ω typ. see text)</td>
</tr>
<tr>
<td>R18 56kΩ</td>
</tr>
<tr>
<td>R19 2-2kΩ</td>
</tr>
<tr>
<td>R20 10kΩ</td>
</tr>
<tr>
<td>R21 10kΩ</td>
</tr>
<tr>
<td>R22 4.7kΩ</td>
</tr>
</tbody>
</table>

All ½W carbon except where otherwise stated

<table>
<thead>
<tr>
<th>Potentiometers</th>
</tr>
</thead>
<tbody>
<tr>
<td>VR1 3 good quality 10kΩ log.</td>
</tr>
<tr>
<td>VR2 100kΩ miniature carbon preset</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Capacitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1 4.700µF 40V elect.</td>
</tr>
<tr>
<td>C2 100µF 40V elect.</td>
</tr>
<tr>
<td>C3 100µF 40V elect.</td>
</tr>
<tr>
<td>C4 100µF polyester</td>
</tr>
<tr>
<td>C5 220µF 63V plastic or ceramic</td>
</tr>
<tr>
<td>C6 47pF plastic or ceramic</td>
</tr>
<tr>
<td>C7 4.7µF 35V tantalum (or elect.)</td>
</tr>
<tr>
<td>C8 330pF plastic or ceramic</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Semiconductors</th>
</tr>
</thead>
<tbody>
<tr>
<td>IC1-3 741 (any manufacturer as long as good quality, esp. for IC2)</td>
</tr>
<tr>
<td>TR1 BC182L</td>
</tr>
<tr>
<td>TR2 2N3053</td>
</tr>
<tr>
<td>TR3 2N3055</td>
</tr>
<tr>
<td>TR4 BC157</td>
</tr>
<tr>
<td>D1-4 Any 3A 50V bridge (or 4 discrete 3A diodes) e.g. RS type 261-457</td>
</tr>
<tr>
<td>D5-6 1N4148, 1N914</td>
</tr>
<tr>
<td>D7-8 2Z948-5V6</td>
</tr>
<tr>
<td>D9-10 1N4148, 1N914</td>
</tr>
<tr>
<td>D11 1N4001</td>
</tr>
<tr>
<td>D12 Any suitable I.e.d. (TIL 209 etc.)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Miscellaneous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mains transformer 240V primary, 20 to 25V, 2A secondary. Heatsink for TR3, approx. 1 deg. C per Watt (plus mica insulation kit) RS type 401-607</td>
</tr>
<tr>
<td>Box to suit, on-off switch etc.</td>
</tr>
<tr>
<td>Meter (if required) see text</td>
</tr>
<tr>
<td>Switch (S1) if required (d.p.d.t.) + R, &amp; R values (see text)</td>
</tr>
</tbody>
</table>
HAVING formed a general picture of the workings of the analogue computer, the complete circuit of a computing element can now be described. This is shown in Fig. 2.1. The basic circuits of input and feedback, components connected around the op-amp can be readily recognised. The input comprises four resistors, $R_1$ to $R_4$, which are connected to sockets in the patch panel and to the inverting input of the op-amp, via switches $R_{LA2}$, $S_{1c}$, and $S_{1b}$. The feedback circuit consists of $R_5$, $C_1$ and $C_2$, which can be selected by means of switch $S_{1a}$ and sockets ($C_7$, $B_6$ and $C_6$) on the patch panel.

Consider switch $S_{1a}$ set so that $R_5$ is selected in the feedback loop. The computing element now becomes a summer. By recalling the equation for the addition circuit that was described last month and by substituting the values for $R_5$, $R_1$, $R_2$, $R_3$, and $R_4$ it can be seen that a voltage applied at inputs 1 and 2 will be multiplied by unity,\[
\left( \frac{R_5}{R_1 \text{ or } R_2} \right) = \frac{1}{1} = 1.
\]
whereas inputs 3 and 4 will multiply an input voltage by 10.
\[
\left( \frac{R_5}{R_3 \text{ or } R_4} \right) = \frac{1}{0.1} = 10.
\]

With capacitor $C_1$ selected in the feedback loop, the computing element is converted to an integrator and if values are substituted in the equation for the integrator, it can again be shown that inputs 1, 2 and 3, 4 give a gain of 1 and 10 respectively. The selection of $C_2$ in the feedback loop increases the gain of all inputs by a factor of 10. This is usually referred to as a nose gain of 10. The symbols used to denote adders and integrators with the relevant gain values are shown in Fig. 2.2.

The "Initial Condition" resistors $R_6$ and $R_7$ are brought into the circuit by means of switches $R_{LA2}$ and $S_{1d}$. $VR_1$ is a 10kΩ potentiometer, which provides the op-amp with external offset nulling. This is connected across pins 1 and 5, with the pot slider taken to the negative supply rail. The non-inverting input of the op-amp is grounded via $R_8$. The value of this resistor should be chosen for good thermal drift performance. The optimum resistance would be equal to the parallel value of the input and feedback resistances. Since in this case there are two values of input resistances, a compromise solution is necessary.

The circuit of Fig. 2.1 represents just one computing element and analogue computers may have many such elements. The prototype has ten computing amplifiers which is an adequate number for the solution of fairly complex problems.

Fig. 2.1. Circuit diagram showing one of the ten computing elements of the Analogue Computer
Mode Control is achieved by means of relay contacts RLA2 and RLB2. Relays are necessary because all ten amplifiers need to be controlled simultaneously. Table 1 shows the positions of relay and other switches for mode control of summers and integrators.

<table>
<thead>
<tr>
<th>SWITCH</th>
<th>SUMMER</th>
<th>INTEGRATOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>RLA2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>RLB2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>S1a</td>
<td>OPEN</td>
<td>CLOSED</td>
</tr>
<tr>
<td>S1b</td>
<td>OPEN</td>
<td>CLOSED</td>
</tr>
<tr>
<td>S1c</td>
<td>CLOSED</td>
<td>OPEN</td>
</tr>
<tr>
<td>S1d</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

**TABLE 1**

Fig. 2.5 shows how the ten computing amplifiers are arranged on a printed circuit board with the component overlay shown in Fig. 2.7. At the extreme ends of the board the two four-quadrant multiplier i.c.s are accommodated. This main p.c.b. is connected to other points in the computer by means of edge connectors.

**The Four-Quadrant Multipliers**

So far it has been shown how to multiply a variable voltage by a constant. This is easily done, using the coefficient multiplier, in conjunction with the amplifier gain. The formation of the product of two variables is much more difficult to obtain. Of the many methods that have been devised, most have involved the use of devices with certain characteristics, e.g. a diode function generator can be set up to provide a square law action, or a log-antilog action. Op-amps are usually employed with these circuits.

For the sake of simplicity and compactness it was decided to use two four-quadrant multiplier i.c.s in the prototype. As their name implies these can multiply in four quadrants, which means that either or both voltages can be positive or negative. This dispenses with the need to have an absolute value circuit preceding the multiplier, as is the case with other methods.

The particular device chosen for the prototype was the AD533JD integrated circuit (shown in Fig. 2.3). This is not the cheapest four-quadrant multiplier on the market, but it has the advantage of being simple to operate, with the minimum of external components. The i.c. comprises a transconductance multiplying element, a stable reference, and an output operational amplifier on a single monolithic silicon chip.

The AD533JD multiplies with a transfer function of $\frac{XY}{10}$.

The division by 10 should not worry the programmer but it should always be borne in mind when solving a problem. The op-amp output provides $\pm 10$V at 5mA, and is fully protected against short circuits to ground or either supply voltage. The inputs are fully protected against overvoltage transients.

**The Overload Warning Circuit**

The operation of the overload warning circuit is very simple. The output of every computing amplifier is sampled and compared with a positive and a negative reference voltage. If the amplifier output goes higher than the positive reference voltage, an i.e.d. is switched on, to indicate that the amplifier is saturating in the positive sense. Similarly, if the amplifier output falls below the negative reference voltage another i.e.d. is switched on to indicate saturation in the negative sense. The prototype uses $\pm 11$V as the reference voltages. An overload warning circuit is shown in Fig. 2.4. Only one pair of comparators and i.e.d.s are shown but ten pairs are necessary to serve the ten computing amplifiers. This circuit is arranged on a separate p.c.b. shown in Fig. 2.6 with the component overlay shown in Fig. 2.8.

**Fig. 2.3. Circuit diagram of the Four Quadrant Multiplier**

Resistor R9 and potentiometers VR11 and VR12 are connected across the positive and negative supply rails to form a potential divider that generates the positive and negative reference voltages of $\pm 11$V and $-11$V. These voltages are applied to the inverting inputs of the twenty comparators as shown. The output of each computing amplifier is applied to the non-inverting inputs of the corresponding pair of comparators. The comparators drive the warning i.e.d.s, the brightness of which is set by preset potentiometers. The 741 op-amp was also used here as a comparator. Experience with the prototype has shown that the 741 is capable of driving the i.e.d.s with reasonable brightness without overheating.
Fig. 2.5. Main p.c.b. containing the ten computing elements and the two Fo

Fig. 2.6. The Overload Warning p.c.b.

Fig. 2.7. Component layout for the main p.c.b.
Fig. 2.8. Component layout for the Overload Warning Circuit

Fig. 2.9. P.c.b. design for the Relay Board
The Relay Mode Control P.C.B.

With ten amplifiers and two relay contacts per amplifier there is a need for twenty relay contacts. Complete mode control could be achieved with two ten-pole relays, one operating the RLA and C switches and the other the RLB and D switches. Ten-pole relays are difficult to find however and the prototype uses four six-pole relays operating in pairs. (The coil connections for the four relays are shown in Fig. 2.11.) This arrangement leaves four unused poles, which may become useful if it is decided to extend the computer.

Case Construction

The front panel requires a large surface area to accommodate the patch panel, potentiometers, switches, i.e.d.s etc. Because of this it will be difficult to obtain the right shaped case off the shelf. The prototype case was constructed from aluminium sheet. Two square panels form the front and the back of the case and the sides, top and bottom are cut and shaped as shown in Fig. 2.10, using the
same gauge aluminium sheet. A bench vice, folding bar, and a sheet metal mallet are useful for this purpose. Fig. 2.10 shows the positions and dimensions of the holes required in the front panel. A lot of patience is required for the process of drilling, due to the large number of holes and the fact that a badly positioned hole will be detrimental to the appearance of the layout. This is particularly true in the case of the patch panel holes. A pitch of 12mm in both directions is enough to give a reasonable tolerance for positioning errors and at the same time avoid excessive gaps between the sockets. For the larger holes the use of sheet metal punches is recommended. Having drilled or punched all the holes, the front panel should then be labelled using dry letter transfers and sprayed with a clear lacquer fixative. The suggested labelling is shown in the photograph of the front panel.

The Patch Panel

The patch panel is constructed using 3.2mm sockets arranged in a matrix and packed together as closely as possible. There are 148 of these sockets and because identifying each one is difficult a colour coding system was used. Fig. 2.12 shows the arrangement of the sockets for one amplifier, one coefficient multiplier and one four-quadrant multiplier.

The pattern for the amplifier and coefficient multiplier shown in Fig. 2.12 is repeated ten times for the ten computing elements. The eight coefficient multipliers use 16 sockets on the top row. Two of the remaining four sockets are connected to the two panel meters and the other two are connected to batteries to provide reference voltages. Both positive and negative reference voltages will be needed for the solution of certain problems.

For the four-quadrant multipliers four sockets are needed per multiplier and these are positioned on the extreme left and right of the patch panel.

**COMPONENTS . . .**

**Resistors**

<table>
<thead>
<tr>
<th>Resistor</th>
<th>Value</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1, R2, R5</td>
<td>1MΩ 1/2W 2% metal oxide</td>
<td>30 off</td>
</tr>
<tr>
<td>R3, R4</td>
<td>100kΩ 1/2W 2% metal oxide</td>
<td>20 off</td>
</tr>
<tr>
<td>R8</td>
<td>270kΩ 1/2W 5% carbon</td>
<td>10 off</td>
</tr>
<tr>
<td>R9</td>
<td>100kΩ 1/2W 5% carbon</td>
<td></td>
</tr>
<tr>
<td>R10</td>
<td>7.5kΩ 1/2W 5% carbon</td>
<td>2 off</td>
</tr>
</tbody>
</table>

**Potentiometers**

<table>
<thead>
<tr>
<th>Potentiometer</th>
<th>Value</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>VR1, VR8</td>
<td>4.7kΩ</td>
<td>2 off</td>
</tr>
<tr>
<td>VR2–VR7</td>
<td>22kΩ</td>
<td>6 off</td>
</tr>
<tr>
<td>VR9–VR30</td>
<td>22kΩ</td>
<td>22 off</td>
</tr>
<tr>
<td>VR31–VR40</td>
<td>10kΩ 0.5W Lin</td>
<td>10 off</td>
</tr>
</tbody>
</table>

**Capacitors**

<table>
<thead>
<tr>
<th>Capacitor</th>
<th>Value</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>1μF 160V</td>
<td>10 off</td>
</tr>
<tr>
<td>C2</td>
<td>0.1μF 160V</td>
<td>10 off</td>
</tr>
</tbody>
</table>

**Semiconductors**

<table>
<thead>
<tr>
<th>Semiconductor</th>
<th>Model</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>IC1–IC30</td>
<td>741 op amp</td>
<td>30 off</td>
</tr>
<tr>
<td>IC31–IC32</td>
<td>AD533JD</td>
<td>2 off</td>
</tr>
<tr>
<td>D1–D20</td>
<td>TIL 209</td>
<td>20 off</td>
</tr>
</tbody>
</table>

**Miscellaneous**

- 4 off 6 way changeover relays
- 4 off mounting sockets for relays
- Holders for i.c.s (if req.)
- 4 off 6 way changeover relays

**CONSTRUCTOR’S NOTE:** The AD533JD Four Quadrant Multiplier is available from Analog Devices Ltd., Central Avenue, East Molesey, Surrey.

Stage by Stage Construction

The computer has been designed so that it can be built in stages. At this point in the construction, ie, with the aluminium case and the p.c.b.s constructed and drilled, the constructor has to make a decision, as to whether he wants to opt for a stage construction. His choice can be very flexible. For example, one may decide that initially, all ten computing amplifiers are not absolutely necessary for the solution of simple problems with which the inexperienced programmer will be involved. Four amplifiers are enough to carry out fairly interesting experiments. Later, when more experience is gained, more computing amplifiers can be added as necessary. The same applies to the coefficient multipliers and the panel meters.

It should be mentioned that if four 6-pole relays are used for the mode control, as is the case with the prototype, at least two of these will be necessary even if only one or two amplifiers are used initially. Two 6-pole relays can provide mode control for six amplifiers.

Another area in which stage by stage construction can be applied, concerns the overload warning circuit. Here, the comparators and the l.e.d.s can be added following the addition of more amplifiers. Alternatively it may be decided to leave the warning circuit out altogether initially. This will make life difficult for the programmer, but it will not affect the operation of the computer.

NEXT MONTH: WIRING AND TESTING
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.

**CAPACITOR CONTINUITY TESTER**

The capacitor continuity tester is built around a 4011 i.c. using the basic oscillator circuit shown in Fig. 1. The frequency is approximately, \( f = \frac{1}{1\cdot7\, RC} \) Hz and this relationship was used to determine the values of \( R \) for a given value of \( C \) and a nominal frequency of 1kHz.

The working values of \( R \) and the corresponding ranges of \( C \) are given in the table and the actual tester circuit in Fig. 2.

Rather than leave the two unused gates idle, another oscillator was constructed and this formed the continuity tester, Fig. 3. The two testers were combined as shown in Fig. 4. The output was fed to the BC108/loudspeaker driver and the combined tester was powered by a PP3 battery.

This tester proved to be a very useful item especially when dealing with ex-computer type components etc.

A. W. Cunningham, Strathblane, Stirlingshire.

**TABLE:**

<table>
<thead>
<tr>
<th>Capacitor Range</th>
<th>Resistor</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–1,000pF</td>
<td>R1 3.3kΩ</td>
</tr>
<tr>
<td>1,000pF–0.01µF</td>
<td>R2 430kΩ</td>
</tr>
<tr>
<td>0.01µF–0.1µF</td>
<td>R3 47kΩ</td>
</tr>
<tr>
<td>0.1µF–1µF</td>
<td>R4 4.7kΩ</td>
</tr>
<tr>
<td>1µF–10µF</td>
<td>R5 3.3kΩ</td>
</tr>
<tr>
<td>10µF</td>
<td>R6</td>
</tr>
</tbody>
</table>

**Figures:**

1. Basic oscillator circuit.
2. Actual tester circuit.
3. Continuity tester circuit.
The circuit shown loads digital information into an 8-bit shift register when S1 is in position "B". In this version the information is supplied from a telephone dial. The dialling contacts generate a number of pulses which are used to clock a 7490 decade counter.

IC2 and 3 provide contact bounce suppression. The length of the output pulse may have to be varied slightly by adjusting the relevant timing components.

When the dial is released the second set of contacts open and this is used to reset the counter and advance the shift registers. During the loading of information S3 should be in position A. When the 8 bits of information are loaded, S1 is set to position A and S3 to position B. The shift registers are then advanced by the 555 astable at a rate dependent on VR1. The output from the shift registers is then loaded into a digital-to-analogue converter, consisting of IC17 and 18 and associated components. The values assigned to each data bit can be varied by VR2-5. This enables the output to be "scaled" so that each word of digital information can be given the required value. The overall output level is controlled by VR6.

S2 is used to reset the shift registers to zero.

The circuit as shown lends itself readily to modification. The telephone dial circuitry could be replaced by any device producing digital information, as long as a means is provided for advancing the shift registers.

The 7490 counter could be replaced by a 7492 or -93, giving a greater range of output values. The D-A converter could be replaced by a 4-10 line or 4-16 line decoder, and with due regard to loading of the outputs could provide totally independent control over the value of each data word.

There are many more variations which could be added to this list. The final version chosen would depend on the application and on the equipment available.

The device could be expanded to handle multiples of 8 words by adding further shift registers in series with those already in circuit.

B. Hatton,
Southampton,
Hants.
**THE circuit shown produces the same effect as the Synchronome described in PE March 1976, but at less than half of the cost.**

An astable multivibrator generates pulses variable from approximately 60 to 200 per minute which are fed to a NAND gate (IC3a) connected as an inverter. C3 and R5 converts the output pulses from IC3a to spikes which switch TR3 on, producing a distinct click in the speaker.

The accent is produced by three J-K master slave bistables arranged as a 3 bit binary counter. The multivibrator pulses are fed directly to the clock input of IC1a and depending on the position of S1 a pulse is sent via C4 and R6 to the base of TR4, on the second, third or fourth beat producing duple, triple and quadruple time respectively.

For example, consider quadruple time. In every fourth beat, the Q output of IC2a goes to logic 1 which resets the counter via IC3b. In every third beat from the reset condition an accent pulse is produced and applied to TR4. This is louder than the single beats since a resistor is not included in the emitter of TR4. R7 reduces the current through the speaker on single beats. It should be noted that J-K bistables trigger on the trailing edge of the clock pulse, therefore IC3a was included so that the accent was synchronised with the single beats. S2 is used to switch off the accent when it is not required.

D. A. Seddon, Widnes, Cheshire.
Referring to the circuit diagram, TR1 is a simple variable-gain preamplifier. The amount of gain is controlled by VR1, and this in turn influences the sustain time produced.

TR2 and its associated components form the clipping stage which produces the fuzz effect. The coupling capacitors are kept small to prevent lower notes from the guitar over-powering the unit when chords are played. R3 and VR2 form a potential divider which provides bias for TR2. For the clipping stage to operate correctly, it is necessary for the bias to be set quite precisely (as described later).

The reason for this can be best understood by considering the graph. This shows the variation in the voltage at the collector of TR2 as VR2 is varied from zero resistance to 1000kΩ. The limiting occurs if the resistance is set between the points A and B. If an a.c. voltage is then applied via C4, then positive half-cycles will cause the collector voltage to limit at about 0.3V, and negative half-cycles will cause limiting at 0.8V. Between these two points, the gain is approximately linear and so the decay characteristic of the guitar note is preserved (after a period of sustain).

The simplest method of setting VR2 is to connect the unit to a guitar and amplifier and adjust VR2 until the note is audible. (The required position is approximately half-way). VR2 can then be finely adjusted so that the note decays without moving off or becoming distorted. Once set, the unit will only require adjusting occasionally, to compensate for falling battery voltage. Even so, it is advisable to have VR2 accessible from the outside of the cabinet.

The values of C* and R* depend on the tone required. In the prototype 0.002µF and 2.2kΩ were used to give a sharp, biting tone. A silicon diode can be substituted for the 0A81 but with a consequent loss of sustain time.

The unit is very simple, has a very low movement consumption (0.5mA) and gives extremely good results, particularly when used with the phasing unit (PE 'Sound Design') or treble booster (PE April 1976).

D. McCabe, Manchester.

---

The following is a description of an AM/FM stereo indicator for use with a stereo radio tuner. It is based on a seven segment I.E.D. display. The segments are so connected that an "A" lights up for AM, an "F" for FM, and an "S" for FM stereo.

A touch switch, identical to that which appeared in the April 1975 issue of "Everyday Electronics", actuates a relay. This is connected in place of the AM/FM switch in the tuner. The voltage at the collector of TR3 is taken to a NOR gate connected as an inverter. A further signal is taken from the stereo decoder of the tuner in place of the stereo beacon which is removed. IC1 encodes these two signals into a form suitable to give the required display.

It will be noticed that segments A, F and G are permanently connected to the positive supply line. This should be at no more than 15V, or else the I.C. will be damaged. The supply should be capable of supplying both the relay current and 60mA for the I.E.D. display. The remaining circuitry consumes little current.

D. P. Akerman, Dagenham, Essex.
The unit shown will allow external inputs such as guitars, microphones etc. to be processed by the circuits within the synthesiser.

IC1 is an amplifier and VR1 should be adjusted to give 2V r.m.s. at A with the output of the input source at maximum amplitude. This will give about 400mV r.m.s. at the “signal output” which is adequate enough for most synthasisers.

IC1 also feeds a comparator IC2 whose reference level is variable and thus the length of time between the first and last positive pulses that will appear at the output is variable due to the nature of sound envelopes.

IC2 feeds another comparator IC3. The components D1, R7 and C3 make sure IC3 receives constant positive input level when a signal is inputted into the circuit. The time constant of R7 and C3 is about 100ms which is more than adequate to cope with the negative half of each cycle of the input frequency but is not too large as to impair performance if two notes are played very quickly one after another.

Thus with no input signal the output of IC3 will be sitting at positive saturation but when an input signal is applied the output of IC3 will go to negative saturation for a length of time determined by the duration of the input signal and the setting of VR3 and will then go back into positive saturation.

If a synthesiser system is being used where a positive going trigger voltage is required for the envelope shapers the following changes should be made: R4 and R7 to +9V instead of -9V, R9 to -9V instead of +9V and D1 should be reversed. If the trigger output is to go from 0V to -8V or from 0V to +8V then diodes can be put on the output as required.

With a normal electric guitar envelope VR3 can adjust the trigger pulse length from about 10ms to about 3s.

Many interesting effects can be obtained using an electric guitar with the unit from envelope reshaping to triggered “Wah” and triggered “Phase” if the synthesiser has a voltage controlled phaser. Also white noise can be triggered and mixed to create strange rushing sounds with each note played.

The unit should work well with both the P.E. Sound Synthesiser and the Minisonic I and II.

P. G. Ludgate, Wycombe Marsh,
Bucks.

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**BOOK REVIEWS**

**THE FIRST BOOK OF KIM-1**
Edited by J. Butterfield, S. Ockers and E. Rehnke
Published in Europe by Human Electron GmbH
Available from Memec Ltd., The Firs, Whitchurch, Nr. Aylesbury, Bucks.
210 x 145mm. Price £7-50

This is a book “Dedicated to the person who has just purchased a KIM-1 microprocessor system and doesn’t know what to do with it” and as such, it undoubtedly fills a very large void! The KIM-1 system itself is a microprocessor board based on the 6502 chip. It features a hexadecimal keyboard, a cassette interface, a full IK of program RAM and a high standard of documentation. (A full review of KIM-1 was published in the Feb ’78 issue.)

This new book makes the KIM-1 an even more attractive proposition because it takes the beginner by the hand with a chapter entitled “A beginner’s guide to KIM programming” and then goes on to discuss and document no fewer than twenty-nine different programs for “Games and diversions” and another thirteen “Utility” programs designed to expand KIM capabilities and aid system testing. After the programming section come further chapters on “Expanding your KIM”, “Connecting to the world” and “Pot Pourri” which is a collection of useful information and tips.

The book is well written in an easy going style which does not assume that all readers already sport a degree or two in computer science and electronics, as do so many other microprocessor books! Despite its low-key approach and its accent on games and diversions though, this book is a mine of valuable knowledge which should prove both instructive and useful to all present or prospective KIM owners whether software or hardware orientated.

I feel that I can even recommend this book to readers who do not actually intend the purchase of a KIM system, but who thirst after this kind of knowledge for its own sake. All the programs in the book include a brief description and a full hexadecimal/mnemonic listing so that they can be easily understood and/or entered into a KIM system when required. Examples of the games programs listed are: Asteroid, Bandit, Black Jack, Clock, Farmer Brown, Lunar Lander, and Music Box. Utilities include: Directory, Hypertape, Relocate, Sort, and Verify Tape. Readers with a different microprocessor system should find these programs a source of inspiration and may even find it possible to convert some of them to run on a different system, with a little effort.

My last word comes from the Pot Pourri section of the book. Remember: Computers are dumber than humans but smarter than programmers!

R.C.
Opportunity!

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Practical Electronics October 1978
Data has to be protected from unauthorised access and theft. Installations need to be protected from damage. Efficient measures are needed to ensure the smooth running of an organisation and to preserve competition. The type of information held may be subject to control. The effects of information systems on organisational structures and the consequent wider social implications will be significant.

Each issue of the journal will deal with a selection of the above topics and will contain five or six papers, industry news and international reviews of working groups, legislation and practice, conference reports, book reviews, calendar and literature reviews.

Topics covered will include: Techniques; Legislation; Information Systems; Working Group Activities; Case Studies; Computer Crime Casebook; Organisational Aspects; Current Interest Section.

Readership will be international and aimed at: Computer Engineers and Designers; Systems Analysts and Programmers; Data Processing Managers; Management services and top management; Legal Advisers; Beneficial users; All professionals who deal with computer based information systems.

Further details can be obtained from G. W. Jones, IPC Science and Technology Press Ltd., IPC House, 32 High Street, Guildford, Surrey GU1 3EW.

MICRO POWER PACK

Designed especially for Series/80 microprocessor-boards but applicable to other microprocessor systems, is a new multi-level power supply from the Computer Products Group of National Semiconductor, which combines precise line and load regulation with current limiting, over-voltage protection and power-failure detection.

The BLC 635 power supply provides +12V at 2.0A, +5V at 14.0A, −5V at 0.9A and −12V at 0.8A. Incorporated are circuits to limit current at 1.2 times rated values at all levels, and over-voltage circuits which trip at 1.16 to 1.32 times rated voltage.

Load regulation is 0.1 per cent for a 50 per cent load change and line regulation is 0.1 per cent for a 10 per cent variation. Ripple is 10mV peak-to-peak, from d.c. to 500kHz, on all outputs. Stability is 0.05 per cent for 8 hours with constant line, load and temperature. Remote sensing is provided for the +5V level and all outputs may be trimmed ±5 per cent from nominal values.

An a.c. power failure detection circuit supplies a TTL compatible high-level signal when line voltage drops 10 per cent below normal. The signal returns low when line voltage reaches 8 per cent of normal value. For orderly shut-downs, all d.c. levels remain within specification for 2ms after low line conditions and 7.5ms after complete power loss.

The line transformer is tapped for 100V, 115V, 200V and 230V a.c. The 100/115V and 200/300V lines are separately fused. Input frequency is 47Hz to 63Hz. The BLC635 measures 81 x 161 x 320mm and weighs 5.9kg (13lbs).

COMPUTERS GALORE CLUB

The north London Hobby Computer Club will be opening on Wednesday, October 5. The Department of Electronic and Communications Engineering of the Polytechnic of North London will be making available much of their equipment for the club. They have two PETs, (third coming soon), four 6800 based computer systems, floppy disc, printers, VDUs, and some KIM and Motorola microcomputer systems. Can’t be bad if you live in the area and are looking for some “hands on” experience, because the club is open to all, not just the students.

It is hoped that a few “home-brewed” activities get going before Christmas, and some meetings are expected to be centred around talks by manufacturers and discussions on programming. However, from the new year it is anticipated that three sets of activities will run concurrently (or sequentially depending upon membership numbers), and these are: short courses on programming in Basic, and at machine level, a home-brew section using the department facilities (up to 35 people can solder and test at the same time), and introductory talks and discussions for those intending to run their own systems.

The club is being organised by members of the Amateur Computer Club, as well as lecturers in digital electronics. If you are interested, hop on the Piccadilly Line to Holloway Road Station, and you’ll find it all happening in Room 47 of the old polytechnic building opposite the tube station. The inaugural meeting starts at 6:30 p.m.
THE unit to be described here is a two range timer which is capable of generating either 0–10 sec or 0–100 sec variable timing periods depending on the range selected. The construction and calibration of the unit is straightforward with its output voltage capable of driving either an I.e.d. or small reed relay for the duration of the set time period.

The timer was originally constructed for photographic use where its good repeatability ensured consistent results when multiple print processing; but with it being portable and reasonably small, it has found many other general purpose applications.

CIRCUIT DESCRIPTION

The complete circuit diagram of the Two Range Timer is shown in Fig. 1 with the range required being selected by S1.

If when S1 is in the position shown (0–100 second range) and S3 is pressed C1 is discharged and the timing period is initiated. After S3 has been released the output voltage of the comparator (IC1) is switched high and the relay energised.

IC2 which is connected as an integrator has its non-inverting input (pin 3) held positive by the potential divider R2, VR3 and VR4 with respect to its inverting input (pin 2). This causes the output to IC2 to generate a positive going ramp waveform the slope of which is determined by C1, R1, VR3 and VR4. With IC2 acting as a constant current generator the slope of the ramp is linear.

This ramp voltage is applied to pin 2 of the voltage comparator (IC1) which compares it with a reference voltage set by VR1 and VR2. When the positive voltage on pin 2 reaches a level which is a few millivolts positive of pin 3 the output of IC2 is switched low and the relay de-energised.

TR1, R3 and D4 provide a stable 11.5V supply to the circuit and D1 eliminates the slight glow in the I.e.d. due to the saturation voltage of the i.c. when the unit has timed out.

CONSTRUCTION

In the prototype the components were soldered onto 0.1 in. Veroboard using the layout shown in Fig. 2. After soldering, the board and other components were fitted into an 110mm dia. metal case which should be drilled or punched as shown in Fig. 3.

The layout of the components inside the case is shown in the photograph with the push button mounted on the lid.

The cursor which is made of Perspex can be curved by warming it over a hot soldering iron and gently bending it to

Fig. 1. Complete circuit diagram of the Two Range Timer
shape. The index line should be scribed using a sharp knife and then the small knob should be fixed to the cursor using an epoxy adhesive.

The scale is thin white card, cut to the size shown and marked off with 100 two millimetre divisions and it is mounted on the case with its mid-way point opposite the centre point of the potentiometers shaft rotation. Alternatively the scale can be left blank except for the 0 and 10 marks and calibrated as described in (b) (for more accurate time periods).

CALIBRATION
(a) Using a pre-marked scale.
(1) Switch on and set the range switch to the 10 second range.
(2) Set the cursor to 0 and push S3, and relay or I.e.d. should energise for a short while before dropping out; VR2 should then be adjusted so that when the button is pressed, the relay or I.e.d. is energised for as short a period as possible (less than 0-1 seconds).
(3) Set the cursor to 10 and press the button; using a stop watch or clock, time the period before the relay or I.e.d. drops out.
(4) Adjust VR4, press the button and re-time; adjust VR4 again if necessary. Repeat until a 10 second delay is obtained.
(5) Switch to the 100 second range and repeat steps 3 and 4 using VR3.
(b) Using an unmarked scale.
Go through items 1, 2, 3, 4, 5 then select an intermediate time (on either range) and set the cursor somewhere near; push S3, time it through and thus adjust the cursor closer to the desired point. Repeat until the time period is exact and mark to scale, other times are obtained by the same method.

OTHER RANGES
The timing range generated by the unit is a function of the value of VR3, VR4, C1 and R1.
Therefore to double the ranges (0 to 20 seconds 0 to 200 seconds) C1 could simply be doubled in value; although due to the new components tolerance a small recalibration may be required.
**News Briefs**

**UNDERGROUND CAMERAS**

Never jump to the conclusion that because you are alone, you are not being watched. We are beginning to take for granted those rooftop cameras watching busy junctions and stretches of motorway. We have reported in this column, remote control cameras monitoring bus queues as part of public transport schemes. You see them at automatic railway crossings, department stores and public places.

Here is another news brief concerning those ever accumulating eyes. A closed-circuit television transmission and switching system is to monitor the three stations on London Transport's new Piccadilly Line extension to Heathrow Airport. Designed by British Relay (Electronics) to a London Transport specification, the system provides video switching facilities at each of the three stations for local monitoring, and a transmission system to Earls Court (a distance of 13 miles), for remote monitoring of the station platforms by the line controller.

It has been provided as an operational aid to control passenger flows, particularly during emergencies or abnormal traffic conditions. It is intended to enable incidents to be detected and potential problems to be anticipated, thus allowing remedial action to be initiated quickly and station staff to be deployed more efficiently.

Cameras viewing strategic areas at each station can be selected by means of a new 12-input/8-output matrix designed and produced by British Relay. The matrix design also allows any one camera to be monitored by all outputs without deterioration of the composite video signal.

Local monitoring facilities are provided at Heathrow Central and platform-only monitoring of all three stations is provided for the line controller situated at Earls Court.

The transmission system comprises a wide-band 30-MHz 3-channel stacked carrier multiplex system over a single coaxial cable running the whole length of the line between Earls Court and Heathrow Central (a type of system particularly immune from electrical track interference). The carrier frequencies of the two existing channels employed are 4-43MHz and 13-30MHz but a third channel of 24-7MHz carrier frequency can be provided by the addition of an appropriate modulator at the required locations and a demodulator at Earls Court.

A feature of the system is that it can be easily extended by the addition of line repeater and directional coupler assemblies which would amplify and allow connection to other sites along the line without deterioration of the existing modulated composite video signal.

British Relay are also supplying London Transport with CCTV switching and transmission equipment for other important central area stations including the new ones being built under stage-1 of the Jubilee Line.

Perhaps it will eventually become a way of life to be visually "monitored" whilst out and about.

---

**STEAM ADVICE**

Most people are by now aware that there are going to be some changes made in the ether on 23 November this year, when a new international frequency agreement comes into force. This provides for a considerable increase in the number, and power of transmitters used in Europe.

As a result of these new regulations, and to make best use of the frequencies available, the BBC is reorganising its arrangements for broadcasting Radios 1, 2, 3, and 4 on the medium- and long-wave bands.

- **Radio 1** will be transmitted on 1053 and 1089kHz (285 and 275 metres) MF instead of 1214kHz (247 metres) MF. The low-power transmission on 1485kHz (202 metres) MF at Bournemouth will be retained.
- **Radio 2** will be transmitted on 693 and 909kHz (433 and 330 metres) MF instead of 200kHz (1500 metres) LF and 1484kHz (202 metres) MF (Scotland).
- **Radio 3** will be transmitted on 1215kHz (247 metres) MF instead of 64kHz (464 metres) MF.
- **Radio 4** will be transmitted on 200kHz (1500 metres) LF instead of 692, 908 and 1052kHz (434, 330 and 285 metres) MF. There will be an additional transmission on 603kHz (496 metres) for Tyneside; 720kHz (417 metres) for Northern Ireland; 1449kHz (207 metres) for Aberdeen; and 1485kHz (202 metres) for Carlisle.

Services that are unchanged (except for a very small increase in frequency):
- Radio Scotland (810kHz/371 metres)
- Radio Wales (882kHz/341 metres)
- Radio Ulster (1341kHz/224 metres)
- Radio 1 Bournemouth (1485kHz/202 metres).

There are no changes to the BBC's VHF transmissions. Only the BBC's MF and LF radio services are affected by the changes.

Further details on the above changes and their effects can be obtained from: Radio Changes, BBC, Broadcasting House, London W1A 4WW.

A number of additional transmitters are being installed and listeners should not assume that their present reception of a particular frequency is necessarily any indication of the reception it will provide under the new plan. Maps are being prepared to show which frequencies are expected to provide the best service in each part of the country.

If you are considering purchasing a wireless and would like some free advice on three band receivers, aerials, car radios, tuning scales etc., send a 9 by 6 in. S.A.E. to Engineering Information Department, BBC, Broadcasting House, London W1A 1AA.

The Beeb will send you a booklet with six pages of useful recommendations, the most important of which is to get a three-band model.

---

**HERE'S TO PROGRESS**

Raise your glasses—but don't drink! Not if you're driving anyway, because technological progress might be waiting to nab you just down the road. A new portable instrument is out which makes instant analysis of breath alcohol giving accuracy to within 12mg/ml of actual blood alcohol level. There's no marching you down to the local "nick" to blow a bag up because your co-operation is not required, other than to continue breathing. Indeed, the device can be used on the unconscious.

The instrument, called the Alcolmeter type AE-M2, was invented by Dr T. P. Jones, and a small hand-held version designed for initial roadside screening purposes has been in production for nearly two years. The new Alcolmeter overcomes the limitations in precision of the pocket sized version while remaining small in size, completely portable and very simple to use. The instrument enables on-spot breath alcohol analysis to be carried out by passing an accurately metered volume of expired breath over a specially-sensitised fuel cell, housed in a hand-held unit linked to the equipment.

The cell is activated by alcohol vapour and generates an electrical signal proportional to the alcohol content of the sample. The electrical signal is amplified and displayed on a panel meter.

The Alcolmeter is currently in extensive use with the Spanish police authorities and has also been accepted for use in Nigeria, Switzerland and several American states. The instrument is also widely used in hospitals and alcohol clinics throughout the UK.

---

1090

Practical Electronics October 1978
The Sinclair PDM35.
A personal digital multimeter for only £29.95
(+8% VAT)

Now everyone can afford to own a digital multimeter
A digital multimeter used to mean an expensive, bulky piece of equipment.

The Sinclair PDM35 changes that. It’s got all the functions and features you want in a digital multimeter, yet they’re neatly packaged in a rugged but light pocket-size case, ready to go anywhere.

The Sinclair PDM35 gives you all the benefits of an ordinary digital multimeter – quick clear readings, high accuracy and resolution, high input impedance. Yet at £29.95 (+8% VAT), it costs less than you’d expect to pay for an analogue meter!

The Sinclair PDM35 is tailor-made for anyone who needs to make rapid measurements. Development engineers, field service engineers, lab technicians, computer specialists, radio and electronic hobbyists will find it ideal.

With its rugged construction and battery operation, the PDM35 is perfectly suited for hand work in the field, while its angled display and optional AC power facility make it just as useful on the bench.

What you get with a PDM35

3½ digit resolution.
Sharp, bright, easily read LED display, reading to ±1.999.
Automatic polarity selection.
Resolution of 1 mV and 0.1 nA (0.00014 A).
Direct reading of semiconductor forward voltages at 5 different currents. Resistance measured up to 20 MΩ.
1% of reading accuracy.
Operation from replaceable battery or AC adaptor.
Industry standard 10 MΩ input impedance.

Compare it with an analogue meter!

The PDM35’s 1% of reading compares with 3% of full scale for a comparable analogue meter. That makes it around 5 times more accurate on average.

The PDM35 will resolve 1 mV against around 10 mV for a comparable analogue meter – and resolution on current is over 1000 times greater.

The PDM35’s DC input impedance of 10 MΩ is 50 times higher than a 20 kΩ/volt analogue meter on the 10 V range.

The PDM35 gives precise digital readings. So there’s no need to interpret ambiguous scales, no parallax errors. There’s no need to reverse leads for negative readings. There’s no delicate meter movement to damage. And you can resolve current as low as 0.1 nA and measure transistor and diode junctions over 5 decades of current.

Technical specification

DC Volts (4 ranges)
Range: 1 mV to 1000 V.
Accuracy of reading 1.0% ± 1 count.
Note: 10 MΩ input impedance.

AC Volts (40 Hz - 5 kHz)
Range: 1 V to 500 V.
Accuracy of reading 1.0% ± 2 counts.

DC Current (6 ranges)
Range: 1 nA to 200 mA.
Accuracy of reading 1.0% ± 1 count.
Note: Max. resolution 0.1 nA.

Resistance (5 ranges)
Range: 1 MΩ to 20 MΩ.
Accuracy of reading: 1.5% ± 1 count.
Also provides 5 junction-test ranges.

Dimensions: 6 in x 3 in x 1¼ in.
Weight: 6½ oz.
Power supply: 9 V battery or Sinclair AC adaptor.
Sockets: Standard 4 mm for resilient plugs.
Options: AC adaptor for 240 V 50 Hz power. De-luxe padded carrying wallet. 30 kV probe.

The Sinclair credentials
Sinclair have pioneered a whole range of electronic world firsts – from programmable pocket calculators to miniature TVs. The PDM35 embodies six years’ experience in digital multimeter design, in which time Sinclair have become one of the world’s largest producers.

Tried, tested, ready to go!
When you buy your PDM35 it comes complete with leads and test probes, carrying wallet and comprehensive operating instructions.

The PDM35 is a new concept in multimeters – but over 20,000 have already been sold! If you’d like to know more about the PDM35, and how to get one, complete the coupon and post it to us. We’ll send you detailed information by return. Send the coupon today!

Sinclair Radionics Ltd, London Road, St Ives, Huntingdon, Cambs., PE17 4HJ, England.

To Sinclair Radionics Ltd, London Road, St Ives, Huntingdon, Cambs., PE17 4HJ.
Please send me more information on the Sinclair PDM35 personal digital multimeter.
Name

Occupation

Address

World leaders in fingertip electronics
SAVE POSTAGE! We pay UK postage & pkg. on orders FOR ANY 5 PACKS! MAIL ORDERS TO PROOPS BROS. LIMITED, Dept. PE, The Hyde Industrial Estate, Edgware Road, Hendon, London, NW9 6JS. Tel. 01-205 8006.

PERSONAL SHOPPERS: 52 Tottenham Court Road, London, W1P OBA. 9-6 Mon. to Sat.

SPADE & RING CONNECTORS as used in cars and domestic appliances. Pack of approx. 100 connectors, balanced selection, insulated and plaited, pkg. 25p.

SPRINGS good selection, various sizes and tensile strengths in packs of 25.

RUBBER GROMMETS good selection, always useful for the motorist, radio enthusiast, etc. Varied assort- ment, pkg. 15p.

VIDAFLEX SLEEVING Pack of 4 x 25 yard lengths. 1.5mm bore, pkg. 30p.

MAINS NEONS in glass tubes, with leads and resistor. Pack of 5, pkg. 1sp.

MAINS NEONS miniature type with leads and resistor. Pack of 20, pkg. 1sp.

CROCODILES Pack of 10, good selection of useful sizes, various lengths and diams., pkg. 25p.

FLAT WIRE Approx. 100 in assorted lengths, pkg. 15p.


DIODES low powered germanium diodes, forward current 8ma. Pack of 25, pkg. 15p.

LIGHT GUIDES yes, you can bend light round corners with these high quality glass fibre optical 1mm active area, 2 metres, pkg. 15p; OR 2mm active area 1 metre, pkg. 15p.

JACK PLUGS & SOCKETS 2-way, pkg. of 4 plugs and 4 sockets, pkg. 15p.

Useful selections of a wide range of components, materials, etc., in convenient packs. Just send £1 plus p&p.

BARCLAYCARD AND ACCESS ACCEPTED - ORDER BY PHONE OR POST.

FRESNEL LENSES 2 for £1.70 Supplied as two separate lenses or mounted together as condenser assembly - state preference. Stably imprintable or entirely suit- able for IMAGE BRIGHTENERS, MAGNI- FERS, INTENSIFIERS, OVERHEAD AND BACK PROJECTION OPTICS. CREATIVE LIGHTING EFFECTS.

MICROSWITCHES useful pack of 8 switches, pack to make/break or changeover, pkg. 20p.


TRANSFORMER double wound, 24v. input, 12v. 200mA. output. Specs approx. 1in. x 1in. x 1in. Pack of 2 pkg. 35p.

REED SWITCHES Ideal for burglar alarms, limit switches, position indicators. Introductory pack of 3 switches, rating 1A, 3 circular magnets and 1 reed switch coil, pkg. 20p.


SELF TAPPING SCREWS a generous 1lb. mixture of about 500 screws in useful sizes and lengths from 3in., various heads, pkg. 50p.

STEEL WASHERS about 500 in a useful 20oz. mixed pack that every tool box needs, pkg. 50p.

SHAKEPROOF & STAR WASHERS about 500 in a good, varied selection of sizes, weighing 60p., pkg. 25p.


POP RIVETS approx. 100 in balanced selection of 4 sizes, pkg. 25p.

SOLENOIDS 1 volt. Small but relatively powerful solenoid with hundreds of uses for the modeler. Overall size approx. 2.5 x 2 x 10mm. Call approx. 8mm diam., x 15mm long. Range of travel (0.5mm approx.) can be varied if desired. Pack of 4, pkg. 25p.

Connoisseur's New and Exceptional SAU4 Pick Up Arm

Especially designed for modern high compliance cartridges and featuring...

1. Light weight metal headshell
2. Calibrated downforce pressure weight
3. Ball spirit level for visual indication of central balance
4. De-coupled counter balance weight
5. Viscous damped unipivot
6. Lateral balance weights
7. Viscous damped raise/lower device
8. Light weight aluminium tube

Write for further details to:
A. R. Sugden & Co. (Engineers) Ltd.
Manufacturers of Connoisseur Sound Equipment, Connoisseur Works, Atlas Mill Road, Bingley, West Yorkshire HD6 1ES.
Telephone: Bingley 0944/712142, Telex: 517144 Sugden G

Telegram: C onsnoi se r Bingley.
No doubt you will by now have found your free sheet of STICKIES. The ones you have are for the popular 7400 series of TTL i.c.s plus a few blank 14 and 16 pin ones that can be filled in as required. Sheets of CMOS (4000 series) are also available—details later.

**FAULT FINDING**

Our photograph shows one of the main uses of these labels. Having constructed a piece of equipment it helps with circuit checking and fault finding if each i.c. has its corresponding label attached. Each pin is then either labelled or its internal connection is shown in schematic form.

**P.C.B. LAYOUT**

STICKIES are also very useful for designing p.c.b.s. Simply stick them down on a sheet of paper and join the pins with pencil lines. They then provide immediate identification of each i.c. and its pins and form a reference for the i.c. size and pin positions.

**PROTOTYPING**

Many amateurs and professionals employ some type of plug in breadboard for prototyping. When using unfamiliar i.c.s STICKIES can provide an immediate pin reference, helping to speed up interwiring and eliminate mistakes. Of course once the i.c. is labelled it can be used later and the STICKIES will always provide pin identification without recourse to charts or reference books.

**STORAGE**

STICKIES should be stored away from direct sunlight avoiding extremes of tem-
perature and humidity. The adhesive used is a general purpose removable type which is suitable for use between -40 and +70 degrees C.

The data printed on STICKIES has been carefully checked and is believed to be entirely reliable; however, no responsibility can be assumed for inaccuracies.

**ABBREVIATIONS**

Some abbreviations have been used on STICKIES which may not be obvious to all readers. These are:

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car Out</td>
<td>Carry out</td>
</tr>
<tr>
<td>Cik</td>
<td>Clock</td>
</tr>
<tr>
<td>Clr</td>
<td>Clear</td>
</tr>
<tr>
<td>EN</td>
<td>Enable</td>
</tr>
<tr>
<td>ext</td>
<td>External</td>
</tr>
<tr>
<td>G</td>
<td>GND</td>
</tr>
<tr>
<td>Inh</td>
<td>Inhibit</td>
</tr>
<tr>
<td>(L)</td>
<td>Left</td>
</tr>
<tr>
<td>MOD</td>
<td>Mode</td>
</tr>
<tr>
<td>Pre</td>
<td>Preset</td>
</tr>
<tr>
<td>(R)</td>
<td>Right</td>
</tr>
<tr>
<td>Rst</td>
<td>Reset</td>
</tr>
<tr>
<td>Sel</td>
<td>Select</td>
</tr>
<tr>
<td>SER IN</td>
<td>Serial in</td>
</tr>
<tr>
<td>Sh</td>
<td>Shift</td>
</tr>
</tbody>
</table>

**DIFFERENT I.C.s**

The STICKIES given in this issue cover 61 different I.C.s, however, by the use of the "logically identical" table below this can be extended to 86 I.C.s.

<table>
<thead>
<tr>
<th>I.C.</th>
<th>USE</th>
</tr>
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<tbody>
<tr>
<td>7403</td>
<td>7400</td>
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<tr>
<td>7405</td>
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<td>7407</td>
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<td>7420</td>
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<tr>
<td>7426</td>
<td>7400</td>
</tr>
<tr>
<td>7437</td>
<td>7400</td>
</tr>
<tr>
<td>7438</td>
<td>7400</td>
</tr>
</tbody>
</table>

**MORE!**

We are sure you will find your 120 free ones very useful and will in due course need some more. Please don’t write to P.E., be thankful for the 60p’s worth we have given you and next time send your money to Concept Electronics, B Bayham Road, Sevenoaks, Kent. The cost, including an information sheet, plastic wallet, VAT and postage is 80p for a sheet of 120 (either 7400 or 4000 series—state which is required), Alternatively, a 480 I.C. pack is available for £2.80. Concept will also give discount for quantity orders, their "phone number is 0293 514110.

---

**TELETEXT COURSE**

**by Mike Abbott**

_Teletext_ you’ve probably seen Teletext by now, if not at an exhibit, then through a television dealer’s window at least. Teletext could become the newspaper and magazine of the future, and if you’re still not clear how this potentially revolutionising advancement works, there is still a chance to leap in on the course of lectures to be held at the main building of the South London College.

This short course of nine special lectures on receiver decoders will be held in the Lecturer Theatre on consecutive Tuesday evenings from 6.30 to 8.30, commencing 10th October 1978. Slides will be shown and demonstrations given.

The course is intended for television and telecommunications technicians and engineers, and will be presented by specialists from the College and a member of the College staff, as follows:


J. R. Chew of BBC Research Department, Tadworth, October 24: The Teletext signal; October 31: Character codes and generation.

J. R. Kinghorn of Mullard Central Applications Laboratories, Mitcham, November 7: Introduction to decoders—general requirements for reception of teletext; November 14: The decoder architecture; November 21: Data acquisition circuits; November 28: Memory circuits and character generation; December 5: Control of the system. Likely developments.

The course fee is £6.50, and early enrolment is advised. Contact: A. A. Rowlands, South London College, Knights Hill, London SE27 OTX.

---

**PATENT VICTORY**

T_he Japanese Patent Office has issued a patent to Texas Instruments Inc. covering virtually all miniature electronic calculators.

The patent is for personal-sized, battery-operated calculators which have their main electronic circuitry in a single integrated-circuit chip. The Japanese patent is based on US Patent 3,819,921, which was granted to Texas Instruments on the 25th June, 1974.

The Japanese decision represents a significant milestone for Texas Instruments because its pocket calculator invention was subjected to stringent opposition by the patent system in Japan—_where many electronic calculators are made_, and was determined to be patentable over opposition arguments.

Official publication of the TI miniature calculator invention was made by Japan’s Patent Office on the 24th August, 1974. Following this publication for opposition, 12 leading Japanese calculator companies objected. They cited a total of 25 references as a basis for their argument that the TI invention was not patentable. The Japanese Patent Office, on the 27th June, 1978, rejected the opposition arguments, awarding a patent to TI.

Under the Japanese patent, Texas Instruments will have the right to claim royalties retroactively to the date that the TI miniature calculator invention was officially published by the Japanese Patent Office. Texas Instruments will actively seek to licence this patent.

To date, 19 countries have issued patents to Texas Instruments for the calculator invention, among them the United Kingdom.

The calculator described in the Texas Instruments patent was the result of work done at TI in the mid-1960s. The US patent was originally filed in 1967. This miniature calculator, the world’s first, employed a large-scale integrated semiconductor array containing the equivalent of thousands of discrete semiconductor devices. Measuring only 108 x 155 x 44mm, it was the first miniature calculator to have the high degree of computational power, found at the time only in much larger machines.

Other elements of this early example of the miniature calculator included a small keyboard with 18 keys and a visual display in the form of a semiconductor thermal printer for printing out calculations of up to 12 decimal digits.
Now circuit designing is as easy as pushing a lead into a hole.

No soldering.  
No de-soldering.  
No heat-spoilt components.  
No manual labour.  
No wasted time.

With a Proto-Board you can hook your circuit together as quickly as you can think.

And you can have second thoughts, and third thoughts, equally quick and easy, till you've got the whole thing right.

Then you can solder up if you want to, but most engineers don't because the Proto-Board push-fit connectors are highly reliable.

And everything is visible: come back next week and you 'read' the circuit immediately.

Contact terminals are arranged in sets of five, each connected across the back, and in the Model 203A illustrated you get 1770 contacts, in six rows of 59 x 5, plus four double power rails, each with 100 contacts connected lengthwise and two horizontal power units with 40 contacts each. Many other models; see chart. Proto-Board breadboards will accept transistors, ICs, LSI packages, resistors, capacitors, LEDs, trimmers, relays etc., most plug straight in.

Try one. You'll wonder how you ever managed without it.

<table>
<thead>
<tr>
<th>Model Number</th>
<th>No. of Solderless Tie-points</th>
<th>IC Capacity (14-pin DIPs)</th>
<th>Unit Price</th>
<th>Postage &amp; Package</th>
<th>VAT</th>
<th>Total Price</th>
<th>Other features</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB-6</td>
<td>630</td>
<td>6</td>
<td>£ 9.20</td>
<td>£1.00</td>
<td>£0.82</td>
<td>£11.01</td>
<td>Kit - 10 minute assembly</td>
</tr>
<tr>
<td>PB-100</td>
<td>760</td>
<td>10</td>
<td>11.80</td>
<td>1.00</td>
<td>1.02</td>
<td>13.82</td>
<td>Kit - with larger capacity</td>
</tr>
<tr>
<td>PB-101</td>
<td>940</td>
<td>10</td>
<td>17.20</td>
<td>1.25</td>
<td>1.48</td>
<td>19.93</td>
<td>8 distribution buses, higher capacity</td>
</tr>
<tr>
<td>PB-102</td>
<td>1240</td>
<td>12</td>
<td>22.95</td>
<td>1.25</td>
<td>1.94</td>
<td>26.14</td>
<td>Large capacity, moderate price</td>
</tr>
<tr>
<td>PB-103</td>
<td>2250</td>
<td>24</td>
<td>34.45</td>
<td>1.50</td>
<td>2.88</td>
<td>38.83</td>
<td>Even larger capacity; only 1.73 pence per tie-point</td>
</tr>
<tr>
<td>PB-104</td>
<td>3060</td>
<td>32</td>
<td>45.95</td>
<td>1.50</td>
<td>3.80</td>
<td>51.25</td>
<td>Largest capacity, lowest price per tie-point</td>
</tr>
<tr>
<td>PB-203</td>
<td>2250</td>
<td>24</td>
<td>55.15</td>
<td>1.50</td>
<td>4.53</td>
<td>61.18</td>
<td>Built-in 1% -regulated 5V, 1A low ripple power supply</td>
</tr>
<tr>
<td>PB-203A</td>
<td>2250</td>
<td>24</td>
<td>74.10</td>
<td>1.50</td>
<td>6.10</td>
<td>82.30</td>
<td>As above plus separate 1/2 Amp + 15V and - 15V internally adjustable regulated supplies</td>
</tr>
</tbody>
</table>

How to order. Telephone 01-890 0782 and give us your Access, Barclaycard or American Express number, and your order will be in the post that night. Or, write your order, enclosing cheque, postal order, or stating credit card number and expiry date. (Don't post the card!). Alternatively, ask for our latest catalogue, showing all CSC products for the engineer and the home hobbyist. (Prices are for UK only. For Europe add 10%, outside Europe add 12 1/2% to total prices.)
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In a superb STAINLESS STEEL case with MINERAL GLASS face,
THIS MUST BE THE ONE YOU HAVE BEEN WAITING FOR!
If you could write the specification for your own ideal
watch you would probably want everything this one has.
As for styling, without a close inspection nobody's
going to be able to tell the difference between this
watch and that world famous James Bond classic
to the penny. However, this one goes one better and
has 3 second measurement of net, lap and first & 2nd
place times with dual time facility.
- Constant LCD display of hours and minutes, plus
  optional seconds or date display, plus day of the
  week and am/pm indication.
- Perpetual calendar, day, date, month and year.
- 24 hour alarm with on/off indication.
- 3 second chronograph measuring net, lap and first
  and second place times.
- Dual time zone facility. Night light.
- Fully adjustable stainless steel bracelet.
- STAINLESS STEEL CASE. MINERAL GLASS.

This watch is not to be confused with cheaper models
with chrome plated cases and plastic lens.
Manufactured by National Electronics, it runs a close
second to Casio, Citizen and Seiko for quality and

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PH-48 4 digits 5 functions £9.95
PH-Chronograph 6 digits 6 sec. second
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times, lap times, 1st & 2nd place times
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All CASIO watches have a calendar display, night
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This watch is not to be confused with cheaper models
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43 Scientific funct. 3 sec. StopWatch. 5 ALARM/TIMERS,
Sequential (self-clearing) or repeat. 1 level parenthesis.
Memory, Deg, Rad, Gra. Standard Deviations.
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2SC-168 (square) £69.95
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SEIKO Calculator/Watch (F168) £135
CITIZEN MultiFunction (E385) £108
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LCD LC622 £10.95. LC76 £16.95
AQ-1000 + Alarm, stopwatch £21.95
CASIO SCIENTIFICS
DIGITRON: FX-31 £11.95. FX-39 £15.95.
FX-140 £17.95. FX-120 £19.95. FX-300 £49.95.

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All prices include VAT & P & P.

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Now a digital multi
meter at an analogue
price and look at it in
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A.C. 1% - 2%
S.A. CURRENT 1mA
200mA 1% indication.
RESISTANCE 10-200M£1.94 - 1 count.
DRIFT £27.95 inc VAT cash with order complete
with test leads, probe, 12mm wallet. De luxe padded
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Portable 3 digit 6 function
Multimeter.
DC volts 1mV to 1000V
AC volts 0.1mV to 350V
AC & DC current 1mA to 1A
Resistance 10 to 20M£.
Diode test 0.3 to 5mA
Temperature 100mV/m°C.
1.5% AC acc 1.5% 30H ±10KHz.
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Rigid plastic units intermesh in
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accessories available. Build up any
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And so the mistakes of the past are likely to be repeated with much talk and little or no action and in a technological situation in which hardly a day passes without advance. One rumoured plan for Britain is to set up and finance a mass-production unit for the 64K RAM market and site it in a depressed area. Even with technical assistance from Silicon Valley it is extremely doubtful whether production could be obtained in meaningful quantity by the time that others are working on the 256K RAM, expected to be on the market in a big way by 1982.

As far as MPs are concerned the proposed government aid aimed at encouraging their application in new products should be well worth while. The MPU is just another chunk of silicon, worthless until it is programmed to a useful activity. The hardware costs are dropping dramatically while programming costs are relatively increasing. It will be the ingenuity in programming and application that could keep Britain ahead in world trade.

One positive step forward in the Great Debate is that the Government has now come to recognise that there is an electronics industry in Britain and, moreover, that it is important. And that can't be bad.

Postal Automation

The introduction of automation in the postal services is going at a snail-like pace according to a Mr J. Gombinski in a recent letter to The Times. Although a little out-of-date (being based on information disclosed in 1975) his statistics are worth repeating.

Nine years after the introduction of automation, writes Mr Gombinski, only six per cent of machinable mail was sorted automatically and at the then rate of progress it would take 150 years to automate entirely. But while the Post Office hardly ever uses the postal codes he calculates that in 1975, given 150,000 million machinable items a week and allowing only 3 seconds to write in each of the unused codes, 750,000 working days were lost on a useless exercise in that year alone.

Talking Computers

Racial-Milgo could be on to a good thing taking on the marketing of WaveTek voice response systems in Europe, the Middle East and Africa. The system allows you to dial up a central computer by ordinary telephone, use a low-cost key-pad to enter your enquiry and the computer supplies the answer, not in data form but in a simulated human voice. It is a fast-response system, especially useful for verifying whether a credit-card customer is in credit and for similar routine enquiries.

The Consumer Market

If market analysts Frost & Sullivan are right in their forecasts, the consumer electronics market in Western Europe is now due for a revival. Predictably the growth areas will be in the newer fields of videorecorders, TV information services and TV games. Music centres are also tipped for big gains by 1985 and, perhaps surprisingly, radio receivers will also do well. Table-top monochrome TV sets, however, will virtually become extinct except for the poorest homes in the poorest areas. The growth forecast is based on the assumption that Western Europe is not yet market-saturated in consumer electronics.

Meanwhile UK suppliers continue to have a rough time. Even well-managed GEC lost £4 million on TV last year and after drastic action to remedy over-capacity only a break-even situation is forecast for this year.

Encouragement

The Caroline Haslett Memorial Trust and the Institution of Electrical and Electronics Technician Engineers are putting up an annual award of £250 for "The Girl Technician Engineer of the Year". The idea is to draw attention to electrical and electronics engineering as a worthwhile career for young ladies.

Fibre-Optic TV

Following long experimental tests of TV signal distribution by fibre-optic link in the UK by Rediffusion, the first consumer household in the world to receive its TV signals by fibre-optics is in Arnhem, Holland. The local company, Delta Kabel, is using the Dial-A-Program system developed by Rediffusion and operated by Delta Kabel under licence.

The optical link into the house is about 800 feet long and is intended to demonstrate that the idea is not only workable but can be achieved with low-cost components. Signal distribution by light duct could prove cheaper than copper wire and, having a wider bandwidth, will accommodate many more TV channels as well as stereo radio.

Satellite News

Marconi Space and Defence Systems has won an order worth £12 million for two new transportable earth terminals for NATO and for updates on a dozen existing earth terminals. The contract also includes the supply of the same updating equipment for five terminals being built in the USA by Ford Aerospace.

Racial Electronics Group, better known for manpack military radios and h.f. receivers and transmitters, has broken through into mobile satellite ground terminals with a substantial order from the Ministry of Defence. The Racial design is a small terminal which can be accommodated in light field vehicles such as the Land Rover.

Transatlantic communications, shared amicably over the past few years by complementary submarine cables and Intelsat satellites, is now the subject of dispute. Intelsat want a larger share of the traffic and the FCC is objecting to further cables, such as TAT-7, which would increase cable capacity. Europe wants the new cable. So does the US Defence Department who see the transatlantic cable as a necessary backup should the satellites be blown out of the sky by possible enemy action.
Practical Electronics

THE THREE topics in this month's Micro-Bus are all concerned with minimization in some way or other, with a supremely simple cassette interface system, some improvements to the number-sorting routines given in April's Micro-Bus, and a diminutive program for finding prime numbers.

MINIMAL CASSETTE INTERFACE

The cassette interface system to be described was received from Nick Toop of Cambridge, and it overcomes one of the main drawbacks of the lower-cost microprocessor kits currently available; namely that they provide no way of permanently saving programs. The system described makes it possible to store and load programs and data using a standard domestic cassette or tape recorder, and although it is primarily designed for SC/MP, it should be possible to develop a similar system for use with any other microprocessor.

"The cassette interface and programs were originally designed for use with a SC/MP Introkit with the Keyboard Kit, but they are currently being successfully used with a Science of Cambridge Mk14. The main objective in developing the system was to make the load-from-tape program as short as possible since this would have to be entered at the keyboard on powering up each time.

"On the other hand the length of the store-to-tape program is not so important since this can be loaded from tape each time it is needed, and so on this side the hardware was made as simple as possible. The programs were written to be relocatable so they can be fitted anywhere in memory without modification."

RECORDING FORMAT

"Data is coded as a series of 1kHz tone bursts; a zero bit is represented as a 4ms burst followed by a 28ms gap, and a one bit is coded as a 16ms burst followed by a 16ms gap. The bytes are transmitted low-order bit first, and there is no extra gap between successive bytes. To load from tape the start address is first entered at OFF9 (high-order byte) and OFFA (low-order byte) so that the monitor will put the address in P1 on entering the program.

"In systems without a monitor some instructions will have to be added at the start of the program to set up P1 correctly. The tape is played until the blank interval in front of the data is reached, and then the LOAD program is executed. The tone bursts from the tape are processed by the circuit of Fig. 1 which uses a single 4001 (or 4011) CMOS gate package with the four gates wired as inverters.

"The first inverter is biased into its linear region to act as a simple amplifier, and two more inverters form a demodulator which gives at its output the squared-up envelope of the pulse bursts. This is fed to the SENSE-B and SERIAL-IN inputs of the SC/MP microprocessor, and to an indicator I.E.D which flashes to indicate correct operation and helps in setting up the best level at the input potentiometer."

LOAD PROGRAM

"The LOAD program in Fig. 3 operates as follows. It first waits in a loop for an input at SENSE-B. On receipt of an input it delays for 14msec. and then shifts whatever is present at SERIAL-IN into the extension register using the SIO instruction; this will be a 0 if the pulse was short and a 1 if the pulse was long. The program delays for a further 14msec. and then returns to the previous loop.

"When eight bits have been shifted into the extension register the byte just formed is stored to the location pointed to by P1 using auto-increment addressing so that P1 is then pointed to the next address. When the indicator I.E.D has stopped flashing the reset button on the microprocessor should be pressed to escape from the program, and loading is complete.

"Since the load program allows you to specify any arbitrary starting address for the data being loaded, the cassette system also serves as a means of relocating programs in memory."

STORE PROGRAM

"To store to tape the start address is put at OFF9 (high-order byte) and OFFA (low-order byte), and the number of bytes to be stored is put, in hex, at OFFB; the address and length

Fig. 1. Nick Toop's load-from-tape circuit, a demodulator using a single CMOS package
The STORE program of Fig. 4 codes the data into a sequence of tone bursts at the FLAG-0 and FLAG-1 outputs on the SC/MP chip. FLAG-1 is set high between bursts so that when the two outputs are combined at the input of the tape recorder using the simple adder circuit of Fig. 2 the gap between pulses is at a mean level; this avoids sharp transients due to the pulse onsets which would make an automatic volume control adopt an unduly low sensitivity.

"The program generates either four pulses for a zero or 16 pulses for a one, using the together with the claim that they were believed to be the shortest programs possible. It now seems that this was a dangerous claim to make, and thanks are extended to all the readers, too numerous to mention, who sent in improvements.

The sort routines all used the exchange-sort method to order an array of up to 256 numbers, and the condition was made that the address and length of the array should be passed down to the routine in suitable registers. The routine for the Z80, which was taken from the Z80-CPU Technical Manual, received the greatest hammering and the shortest version, sent in by Eric Baddeley of Cheshire, reduces the number of program bytes from 38 to 231 necessary to test them. This improvement can be incorporated in the program of Fig. 5 with no increase in size simply by changing the instruction at 0014 to "JR NZ, SORT-S", and in the program of Fig. 5 by changing the position of the label AGAIN to the instruction "DEC A" in the previous line.

**PRIME PROGRAM**

Although the prime numbers are simple to define—they are numbers whose only divisors are 1 and the number itself—no explicit formula exists for generating them, and efficient programs to search for particular primes can be extremely complex. Note that 1 is not con-
In the hi-fi world there is currently considerable controversy over the "musicality" of amplifiers, that is to say the possibility that two amplifiers which measure the same on even the most sophisticated test equipment currently available may sound different when reproducing music. In Brit 1 499 939 Tokyo Shibaura Electric Company Limited of Japan patented an amplification circuit that is claimed to give improved results, through a particular connection of capacitors, but with the admission by the inventor that it is unclear why the improvement is achieved.

Essentially the claim is that the connection of extra nonpolar capacitors parallel with the electrolytics "can effectively improve the fidelity of reproduction", although the reason why "is not theoretically clear".

The audio amplifier of Fig. 1 is based on FETS 12, 13 in a complementary pair. Electrolytic capacitors 20, 21 are used as filters for the d.c. source and also for decoupling. The capacitors are formed of an aluminium film and are of high value e.g. 5,000 to 20,000µF. To capacitor 20 is connected in parallel a pair of nonpolar capacitors 22, 23 and to capacitor 21 is likewise connected a pair of nonpolar capacitors 24, 25. The capacitors 22, 23, 24, 25 are each chosen to have a capacity which is sufficiently low to leave the capacity of the electrolytics 20, 21 largely unaffected but sufficiently large to allow a substantial proportion of the audio frequency range to pass through them.

Capacitors 22, 24 are of metallized paper in the value range 10 to 100µF and the capacitors 23, 25 are of Mylar film type and similar value.

According to the inventor, "nothing is known about what effect is exerted on sound signals by the non-linearity of the inner loss of the capacitors relative to audio frequency" but he believes that electrolytics as used in audio amplifiers are non-linear in this respect.

He also believes that the connection of various given types of nonpolar capacitor in parallel with the electrolytics causes the collective inner loss-frequency characteristics of all the capacitors to be linear over the audio range. The number of nonpolar capacitors is not limited to two, and three or more may be used as necessary to provide linearity.
EMI Ltd. in BP 1497 394 describe an interesting approach to the eradication of low frequency noise or rumble from recorded or transmitted signals. The invention makes use of the fact that little or no directional information is derived from low frequency signals. EMI put the dividing line between high and low frequencies at 200Hz and although it is arguable that this figure is too high (i.e. that frequencies below 200Hz can carry directional information) this argument does not effect the basic theory of the invention.

As shown in Fig. 1 the recording or transmission system is fed with left and right channel signals L and R, each composed of high and low frequencies. Thus \( L = L_h + L_l \) and \( R = R_h + R_l \). The signals in the left channel \((L_h + L_l)\) frequency modulate a carrier frequency, e.g. at 300kHz, in modulator 3. The signals in the right channel are inverted at 4 and the inverted signals \((-R_h - R_l)\) frequency modulate at 5 a carrier of the same (or different) frequency. The frequency modulated signals are recorded at 6, which may be an f.m. tape recorder or disc.

The reproduction circuit is shown in Fig. 2. The f.m. signal is first demodulated at 8, 9. The demodulated signals will inevitably now contain some unwanted low frequency noise which is represented by \( r \). Because the two recorded channels have been derived from the same tape track, or record groove, the rumble components are virtually identical in magnitude and phase. Thus the signals in the left channel are, after demodulation, \((L_h + L_l + r)\) and the signals in the right channel are \((- R_h - R_l + r)\). The right channel signals are now inverted to produce \((R_h + R_l - r)\) so that the rumble components \( r \) in the two channels are now in exact anti-phase. They can thus easily be removed by the matrixing circuit 11. The final output is thus free from all the low frequency noise introduced by the process.

An idea for a meter which automatically changes scale to avoid under and overload and provide the most accurate read out available, is patented by Lawrence Large of Sussex in BP 1 507 466. Although the idea is simple it could well prove valuable.

As shown the meter scale 1 has a perforation 2 at the "higher" end. A photovoltaic cell 7 lies underneath this perforation and normally receives light from source 8. The meter pointer carries a blanking plate 3 which is dimensioned to obscure the perforation 2 as soon as the pointer is driven towards the dial stops. In this way light to the photo cell is blocked and this change of state is sensed to switch the meter scale to the next higher range.

A similar approach can be adopted at the low end of the scale with obstruction of another light path sensed to switch the meter down to a more sensitive scale. If successfully adopted such a system could prevent overload of a dial meter while at the same time optimising accuracy by selecting always the most sensitive, but safe, scale for the reading in hand.
MICROPITS ENGRAVED ON THE DISC OF AN OPTICAL READOUT SYSTEM

DISC FULL OF Holes

Many developments have been made over the last few years on various picture recording and playback systems for television. In 1968, THOMSON-CSF considered that one of the best ways to solve this significant problem and offer new applications, was an optically scanned videodisc system. The disc is recorded as a continuous spiral track. This track consists of a succession of 0.6-µm (approx.) wide micro-holes whose length and spacing varies in terms of modulation. The pitch between the spirals is about 1.6 mùm. Upon reading, the light beam originating from a low power laser focused onto the spinning disc through a large aperture lens is modulated when passing through the holes (variable diffraction). A set of photo-electric sensors located underneath the transparent disc collects this modulation and changes it into an electric signal. After demodulation, the resulting signal reproduces the recorded video signal.

Each revolution of the disc corresponds exactly to one television frame which permits indefinite freeze-framing (videotape can only be held for two seconds) and, providing more than 50 copies are produced from any one master, discs are cheaper than tapes. In addition, there is speedy random access to any of the 45,000 frames on each disc (taking about two seconds from selection to presentation), and the disc can be played forwards or backwards at normal, fast or slow speeds without any wear. The recording is made, initially, on a polished glass disc covered with a 0.15-µm thick photo resist coating, the information being recorded on this photoresist by a modulated laser. The final, flexible PVC videodiscs, stamped by an electroformed die, give approximately 30 minutes continuous play, or access to 45,000 individual still pictures in full colour.

Readers requiring a reply to any letter must include a stamped addressed envelope.
Opinions expressed in Readout are not necessarily endorsed by the publishers of Practical Electronics.

Cheaper Ports

Sir—I wonder if I might, albeit somewhat belatedly, comment on the Semiconductor Update of the July '78 issue. The method suggested of obtaining eight 8-bit ports using eight 74251s is of course valid, but is rather expensive, as according to one advertiser these will cost a total of £12.00. A way of saving around a 'fiver' with no loss of elegance is to use 10 chips as follows:

8 x 74151 exactly as described £6.48
2 x 4016 transmission gates £1.08
saving £4.44

All prices stated are from the same advertiser.

The two 4016s are connected between the outputs of the 74151s and the data bus and their eight control lines are connected to wherever the selects of the 74251 would have been connected.

A further advantage, over and above that of pure cost saving, is that, if a mishap should occur, and the databus drivers and the port controller should disagree as to who has the bus, it is likely that it would be possible to get away with replacing £1.08 worth of CMOS rather than £12.00 worth of 74251s.


Well-er!

Sir—I read with interest Mr D. J. Bradbury’s article in the August issue concerning Weller soldering irons. A few months ago I was faced with the same problem, namely running a 24V iron from a 12V source. My solution is, I think, far more elegant. It does away with DI, D2, D3, TR1, R1, C1 and C2 in Mr Bradbury’s project. In fact the only component necessary is a 12V element part number HE60 (12) for the TCP1 or part number HE2 (12) for the TCP2 iron. You must surely agree that the best circuit is always the simplest one!

N. Goldring, Reading.

We agree that the best circuit is the simplest—provided it does not have any drawbacks! The Weller element costs £4.80 and it is necessary to solder it in, so you must either purchase a complete 12V iron (at greater expense) or change the element every time—could be difficult if you only have the one iron! Seriously though, we were not aware that 12V elements were available—nor was our contributor, who works for a large British equipment and component manufacturer! However, our unit can be built for approximately the same price as the element and is very much more convenient to use.

No oh!

Sir—A slip of the pen seems to have gone into print in Walter Hediger’s neat little pH meter (August issue).

The scale is of course logarithmic in concept and so “0” should not appear on it. This may seem a small point but since all log. based scales can be divided ad infinitum it is a pity to spoil the effect by an error of principle.

Far better on log. scales to have a small “1” as the meter probe. A value of “0” would imply some “absolute acid” capable of dissolving anything—including the meter probe.

R. E. Hurst, Blackpool.
As the first stage of your training, you actually build your own Cathode ray oscilloscope! This is no toy, but a test instrument that you will need not only for the course’s practical experiments, but also later if you decide to develop your knowledge and enter the profession. It remains your property and represents a very large saving over buying a similar piece of essential equipment.

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  - Input Sensitivity: 0.775 V. R.M.S. (0.1B) at 25 K Ohms
  - Frequency Response: 20 Hz - 20 KHz
  - Hum & Noise: 100 dB Relative full output

**AMPLIFIER MODULES**
- Spec. Input
  - Sensitivity: 60 mV
  - For full output
  - Frequency response: 20 Hz - 20 KHz
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HY400
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FEATURES: complete pre-amplifier in single pack. multi-function equalisation, low noise, low distortion, high overload, two simply combined for stereo.

APPLICATIONS: hi-fi, disco, guitar and organ. public address.

SPECIFICATION: Input sensitivity - 500mV. Output Power - 25W R.M.S. into 8Ω. Load Impedance - 4-16Ω. Distortion - 0.04% at 25W at 1kHz. Signal Noise Ratio - 75dB. Frequency Response - 10Hz-45kHz -3dB. Supply Voltage - ± 25V. Size - 105 x 50 x 25mm

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HY50 leads I.L.P. s total integration approach to power amplifier design. The amplifier features an integral heatsink together with the simplicity of no external components. During the past three years the amplifier has been refined to the extent that it must be one of the most reliable and robust Hi-Fidelity modules in the World.

FEATURES: very low distortion, integral heatsink, only five connections, 7 amp output transistors, no external components.

APPLICATIONS: medium power hi-fi systems. low power disco, guitar amplifier.

SPECIFICATION: Input Sensitivity - 500mV. Output Power - 60W R.M.S. into 8Ω. Load Impedance - 4-16Ω. Distortion - 0.04% at 60W at 1kHz. Signal Noise Ratio - 90dB. Frequency Response - 10Hz-45kHz -3dB. Supply Voltage - ± 25V. Size - 114 x 50 x 25mm.

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HY200 (now improved to give an output of 120 watts) has been designed to stand the most rugged conditions such as disco or group while still retaining true hi-fi performance.

FEATURES: thermal shutdown very low distortion load line protection integral heatsink no external components.

APPLICATIONS: hi-fi, disco monitor, power slave. industrial: public address.

SPECIFICATION: Input Sensitivity - 500mV. Output Power -100W R.M.S. into 8Ω. Load Impedance - 4-16Ω. Distortion - 0.05% at 100W at 1kHz. Signal Noise Ratio - 98dB. Frequency Response - 10Hz-45kHz - 3dB. Supply Voltage - ± 25V. Size - 114 x 50 x 85mm.

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The HY400 is I.L.P. s Big Daddy of the range producing 240W at 1kHz. It has been designed for high power disco or public address applications. If the amplifier is to be used at continuous high power levels a cooling fan is recommended. The amplifier includes all the qualities of the rest of the family to lead the market as a true high power hi-fidelity power module.

FEATURES: thermal shutdown very low distortion load line protection no external components.

APPLICATIONS: public address. disco. power slave. industrial.

SPECIFICATION: Input Power -240W R.M.S. into 4Ω. Load Impedance -4-16Ω. Distortion - 0.1% at 240W at 1kHz. Signal Noise Ratio - 94dB. Frequency Response - 10Hz-45kHz -3dB. Supply Voltage - ± 25V. Input Sensitivity - 500mV. Size - 114 x 100 x 80mm.

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