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PRACTICAL

ELECTRONICS

JUNE 1981

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DIGITAL PRECISION pH METER

CASE COUPON inside!

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For every one you send for processing by the Practical Electronics Colour Print Service.

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Fast, efficient, high quality film processing is now as close to you as your nearest post box. Hundreds of thousands of magazine readers are delighted with this reliable Colour Print Film Service—and the replacement film that comes free every time they use it! So why don't you give it a try?

Here's what you do. Send any make of colour print film inside the envelope enclosed in this issue. Or fill in the coupon below and send it with your colour film in a strong envelope to:

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We are so confident in the reliability of the service and the quality of our prints, (each one is date stamped with the month and year of developing) that you don't pay until you have received them!

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You will be amazed at the beautiful colours and hi-definition sheen finish of the prints we supply . . . with elegant rounded corners and borderless to give you maximum picture area. And now with the new Giant Superprints you get 30% more picture area than the standard enprints at no extra cost.

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The new Giant Superprints cost you only 17p each and a further charge of £1 is made towards postage and packing. That's all you pay and, when we send your prints, a replacement film, of the size you use, is included absolutely free. That's a saving of up to £2.19.

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One album voucher is sent with each film we process. Collect 3 vouchers and we send you a set of FREE album sheets to fit into our specially designed album to show off both superprints and standardprints.

MORE BENEFITS TO YOU

You benefit in two additional ways. Firstly, you enjoy a personal service with every care taken over each individual order. And secondly, you pay only for what you get—with no credit vouchers as with many other companies. An invoice comes with your prints, so it is a straight business transaction.

Your prints will normally be despatched within five working days of receipt, but please allow for postal times and possible delays.

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In the event of any query, please write to: Customer Relations Dept., Colour Print Express Ltd., 19-21 Lower Square, Isleworth, Middlesex, or phone 01-568 6565.

Use this label if you have no envelope, or pass it to a friend. It is used to send your prints and FREE film.

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

Mr Ms ______________________

Address ______________________

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______________ Postcode ______________

PRACTICAL
ELECTRONICS

VOLUME 17 No. 6 JUNE 1981

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

OUR JULY ISSUE WILL BE ON SALE FRIDAY, 12 JUNE 1981
(for details of contents see page 33)

Unique in concept - the home computer that grows as you do!

-The Acorn Atom

NEW! Colour Encoder for full colour graphics **£21.50**

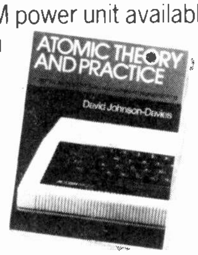
£120 plus VAT and p&p. An outstanding personal computer kit

Also available ready-built **£150** plus VAT and p&p

The ATOM – a definitive personal computer. Simple-to-build, simple-to-operate. But a really powerful full-facility computer. And designed on an expandable basis. You can buy a superb expanded package now – tailored to your needs. Or, you can buy just the standard Atom kit, and, as you grow in confidence and knowledge, add more chips. No need to replace your equipment. No need to worry that your investment will be overtaken by new technology. As you need more power, more facilities, you can add them!

*The picture shown demonstrates mixed graphics and characters in three shades of grey provided by the Standard Atom.

The standard ATOM kit includes:
● Full sized QWERTY keyboard ● Rugged polystyrene case ● Fibreglass PCB ● 2K RAM ● 8K ROM ● 23 integrated circuits ● Full assembly instructions including tests for fault-finding. (Once built, connect it to any domestic TV and power source) ● Power requirement: 8V at 800 M A. ATOM power unit available. See coupon. PLUS FREE MANUAL written in two sections – teach yourself BASIC and machine code for those with no knowledge of computers, and a reference section giving a complete description of the ATOM's facilities. All sections are fully illustrated with example programs.



The ATOM concept
Adding chips into sockets on the PCB allows you to progress in affordable steps to large-scale expansion. You can see from the specifications that the RAM can be increased to 12K allowing high resolution (256 x 192) graphics. Two further ROM chips, e.g. maths functions, can be added directly to the board giving a 16K capacity. In addition to 5 I/O lines partly used by the cassette interface, an optional VIA device can provide varied I/O and timer functions and via a buffer device allow direct printer drive. An optional module provides red, green and blue signals for colour. An in-board connector strip takes the ATOM communications loop interface. Any number of ATOMs may be linked to each other – or to a master system with mass storage/hard copy facility. Interface with other ACORN cards is simplicity itself. Any one ACORN card may be fitted internally.
So you can see there are a vast number of modular options and additions available, expanding with your ability and your budget.

The ATOM hardware includes:
● Memory from 2K to 12K RAM on board (up to 35K in case) ● 8K to 16K ROM (two 4K additions) ● 6502 processor ● Video Display allows high resolution (256 x 192) graphics and red, green and blue output ● Cassette Interface – CUTS 300 baud ● Loudspeaker allows tone generation of any frequency ● Channel 36 UHF Modulator Output ● Bus output includes internal connections for Acorn Eurocard.

The ATOM software includes:
● 32-bit arithmetic (±2,000,000,000) ● High speed execution ● 43 standard/extended BASIC commands ● Variable length strings (up to 256 characters) ● String manipulation functions ● 27 32-bit integer variables ● 27 additional arrays ● random number function ● PUT and GET byte ● WAIT command for timing ● DO-UNTIL construction ● Logical operators (AND, OR, EX-OR) ● LINK to machine-code routines ● PLOT DRAW and MOVE.

ACORN COMPUTER 4a Market Hill, CAMBRIDGE CB2 3NJ

Your ACORN ATOM may qualify as a business expense. To order complete the coupon below and post to Acorn Computer for delivery within 28 days. Return as received within 14 days for full money refund if not completely satisfied. **All components are guaranteed with full service/repair facility available.**

Quantity	Item	Item price inc VAT+p&p	TOTALS
	ATOM KIT – 8K ROM+2K RAM (MIN)	£140.00	
	ATOM ASSEMBLED – 8K ROM+2K RAM (MIN)	£174.50	
	ATOM KIT – 12K ROM+12K RAM (MAX)	£255.00	
	ATOM ASSEMBLED – 12K ROM+12K RAM (MAX)	£289.50	
	1K RAM SETS	£11.22	
	4K FLOATING POINT ROM (inc in 12K Version)	£23.30	
	PRINTER DRIVE 6522 VIA	£10.35	
	(inc. in 12K version) LS244 Buffer	£3.17	
	COLOUR ENCODER	£21.50	
	MAINS POWER SUPPLY (1.3 amps)	£10.20	
		TOTAL	

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Signature

Name (Please print)

Address

Telephone No.

Registered No: 1403810. VAT No: 215 400 220

PE/6/81

AND OTHER PROJECTS

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.
LIST—Send stamped addressed envelope with all U.K. requests for free list giving fuller details of PCBs, kits and other components.
OVERSEAS enquiries for list Europe—send 35p: other countries—send 75p.

KIMBER-ALLEN KEYBOARDS AND CONTACTS

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

3 Octave (37 notes) **£25.50** 4 Octave (49 notes) **£32.25** 5 Octave (61 notes) **£39.75**

CONTACT ASSEMBLIES (gold-clad wire) – 1 required for each K8D note:
Type GJ – SPCO **33p** ea. Type GB – 2 pr N/O **37½p** ea.

P.E. 6-CHANNEL MIXER

A high specification stereo mixer with variable input impedances

Basic comps, PCB & charts	KIT 90-8	**£56.43**
Extra 2-channel set with PCB	KIT 90-9	**£10.21**
Set of Text photocopies	TEXT 90	**£1.50**
Knob. sets, sw's		See our list

RHYTHM GENERATORS

Several available, including programmable 16 beat 64000 pattern, and pre-programmed 15 pattern using either M252 or M253 rhythm chips. A selection of effects instruments circuits is also available.

WIND & RAIN EFFECTS UNIT

A slightly modified version of the original P.E. unit.

Basic comps, PCB & chart	KIT 28-1	**£4.84**
Text photocopy	TEXT 8	**28p**
Knobs, skts, sw's	HW 28	**£1.65**

P.E. ENVELOPE SHAPER WITH VCA

Has an integral Voltage Controlled Amplifier, and has full manual control over the A.D.S.R. functions.

Basic comps, PCB & chart	KIT 50-1	**£8.03**
Text photocopy	TEXT 50	**58p**
Knobs, sets	HW50	**£1.32**

P.E. TRANSIENT GENERATOR

An ADSR envelope shaper without VCA, and additionally providing Repeat-triggering enabling a synthesiser to be programmed for mandolin or banjo effects.

Basic comps, PCB & chart	KIT 63-2	**£7.62**
Text photocopy	TEXT 63	**58p**
Knobs, skts	HW63	**£1.82**

P.E. EXTERNAL-INPUT SYNTHESISER-INTERFACE

Allows external inputs such as guitars, microphone etc., to be processed by synthesiser circuits.

Basic comps, PCB & chart	KIT 81-1	**£3.90**
Knobs, sets	HW 81	**£1.18**

P.E. TUNING FORK

Produces **84** switch-selected frequency-accurate tones with an LED monitor clearly displaying beat-note adjustments.

Set of basic comps, incl. power supply. PCBs & charts	KIT 46-3	**£23.32**
Text photocopy	TEXT 46	**97p**
Knobs, skts, sw's	HW 46	**£2.89**

P.E. TUNING INDICATOR

A simple octave frequency comparitor for use with synthesisers and other instruments where the full versatility of KIT 46 is not required.

Basic comps, PCB & chart	KIT 69-1	**£8.19**
Text photocopy	TEXT 69	**58p**
Knobs, skts, sw's	HW 69	**£1.56**

DIGITAL EXPOSURE UNIT

Controls up to 750 watts in ½ second steps up to 10 minutes, with built-in audio alarm.

Basic comps, PCBs	KIT 93-3	**£23.45**
Text photocopy	TEXT 93	**£1.20**
Knobs, skts	HW 93	**£2.48**

P.E. DISCOSTROBE

A 4-channel light show controller giving a choice of sequential, random, or full strobe mode of operation.

Basic comps, PCB & chart	KIT 57-3	**£19.37**
Text photocopy	TEXT 57	**78p**
Knobs, skts, sw's	HW 57	**£7.30**

P.E. CONSTANT DISPLAY FREQUENCY COUNTER

A 4-digit counter for 1Hz to 99kHz with 1Hz sampling rate. Readout does not count visibly or flicker due to blanking.

Basic comps, PCB & chart	KIT 79-4	**£31.61**
Text photocopy	TEXT 79	**78p**
Knobs, skts, sw's	HW 79	**£4.67**

P.E. VOICE OPERATED FADER

For automatically reducing music volume during talkover – particularly useful for discos.

Basic comps, PCB & chart	KIT 30-1	**£4.37**
Text photocopy	TEXT 30	**28p**
Skts	HW 30	**32p**

P.E. DYNAMIC NOISE LIMITER

Very effective stereo circuit for reducing the hiss found in most tape recordings.

Basic comps, PCB & chart	KIT 97-1	**£8.07**
Text photocopy	TEXT 97	**75p**

P.E. DYNAMIC RANGE LIMITER

Preset to automatically control sound output levels.

Basic comps, PCB & chart	KIT 62-1	**£5.31**
Skts	HW 62	**44p**

ALL KITS INCLUDE SPECIALLY DESIGNED PRINTED CIRCUIT BOARDS

MORE KITS AND COMPENENTS ARE IN OUR LISTS

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E. & O. E. DELIVERY SUBJECT TO AVAILABILITY.

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MICROCOMPUTER COMPONENTS

LOWEST PRICES — FASTEST DELIVERY

DEVICE	PRICE
CPU's	
6502	6.50
6800	3.82
6802	5.74
6803	14.53
6809	18.94
8085A	10.95
Z80 CPU	6.84
Z80A CPU	8.23
SUPPORT CHIPS	
6520	3.50
6522	6.50
6532	8.25
6821	1.93
6840	5.87
6850	1.95
6862	7.09
6871A1T	20.90
6880	1.07
6887	0.80
8212	2.25
8216	1.95
8224	2.50
8228	4.20
B251	4.75
8253	10.00
8255	4.80
Z80 CTC	4.75
Z80A CTC	5.78
Z80 DMA	17.62
Z80A DMA	21.02
Z80 DART	13.44
Z80A DART	16.13
Z80 P10	4.75
Z80A P10	5.78
Z80 S10-0	20.11
Z80 S10-1	20.11
Z80 S10-2	20.11
Z80A S10-0	24.17
Z80A S10-1	24.17
Z80A S10-2	24.17
MEMORIES	
2101	3.68
2102	2.54
2114 200ns	1.50
2708	2.00
2716 (5v)	3.35
2732	8.78
4116 150ns	1.60
4116 200ns	1.50
REGULATORS	
7805	0.55
7812	0.55
7905	0.65
7912	0.65
CRT CONTROLLERS	
9364AP	8.64
6845	11.72
BUFFERS	
81LS95	1.20
81LS96	1.25
81LS97	1.20
81LS98	1.25
8T26A	1.50
8T28A	1.50
8T95N	1.50
8T97N	1.50
8T98	1.50
MISC. SUPPORT CHIPS	
AY-3-1015	4.29
AY-5-1013	4.29
AY-5-2376	7.00
MC1488	0.75
MC1489	0.75
MC14411	8.75
MC14412	8.75
RO-3-2513L	7.82
RO-3-2513U	7.82
DATA CONVERTERS	
ZN425E	3.50
ZN426E	3.00
ZN427E	6.28
ZN428E	4.78
ZN429E	2.10
ZN432	28.09
ZN433	22.59
Data converter Handbook	1.00
74LS SERIES	
74LS00	0.14
74LS01	0.15
74LS02	0.14
74LS03	0.14
74LS04	0.15
74LS05	0.15
74LS08	0.14
74LS09	0.15
74LS10	0.14
74LS11	0.15

DEVICE	PRICE
74LS12	0.15
74LS13	0.29
74LS14	0.51
74LS15	0.15
74LS20	0.14
74LS21	0.15
74LS22	0.15
74LS26	0.19
74LS27	0.15
74LS28	0.17
74LS30	0.14
74LS32	0.14
74LS33	0.17
74LS37	0.17
74LS38	0.17
74LS40	0.14
74LS42	0.40
74LS47	0.42
74LS48	0.70
74LS49	0.62
74LS51	0.14
74LS54	0.15
74LS55	0.15
74LS73	0.22
74LS74	0.19
74LS75	0.30
74LS76	0.22
74LS78	0.25
74LS83	0.54
74LS85	0.77
74LS86	0.18
74LS90	0.36
74LS91	0.81
74LS92	0.40
74LS93	0.39
74LS95	0.48
74LS109	0.26
74LS112	0.26
74LS113	0.26
74LS114	0.26
74LS122	0.45
74LS123	0.57
74LS124	1.07
74LS125	0.29
74LS126	0.29
74LS132	0.51
74LS136	0.29
74LS138	0.40
74LS139	0.40
74LS145	0.78
74LS148	1.13
74LS151	0.35
74LS153	0.35
74LS155	0.50
74LS156	0.50
74LS157	0.36
74LS158	0.40
74LS160	0.43
74LS161	0.43
74LS162	0.43
74LS163	0.43
74LS164	0.51
74LS166	0.37
74LS173	0.77
74LS174	0.78
74LS175	0.60
74LS181	1.50
74LS190	0.61
74LS191	0.61
74LS192	0.69
74LS193	0.69
74LS194	0.42
74LS195	0.42
74LS196	0.68
74LS197	0.68
74LS221	0.64
74LS240	1.01
74LS241	1.15
74LS242	0.85
74LS243	0.85
74LS244	0.84
74LS245	1.21
74LS247	0.41
74LS248	0.74
74LS249	0.74
74LS251	0.46
74LS253	0.46
74LS257	0.57
74LS258	0.40
74LS259	1.15
74LS261	3.12
74LS266	0.25
74LS273	0.97
74LS279	0.37
74LS283	0.45
74LS290	0.60
74LS293	0.53
74LS365	0.39
74LS366	0.38
74LS367	0.38
74LS368	0.38
74LS373	0.79
74LS374	0.79
74LS375	0.50
74LS377	0.97

DEVICE	PRICE
74LS378	0.73
74LS379	0.56
74LS386	0.29
74LS390	0.68
74LS393	0.61
CMOS	
4000	0.14
4001	0.14
4002	0.14
4006	0.85
4007	0.18
4008	0.75
4009	0.39
4010	0.47
4011	0.17
4012	0.23
4013	0.42
4014	0.78
4015	0.80
4016	0.34
4017	0.68
401B	0.75
4019	0.44
4020	0.82
4021	0.88
4022	0.84
4023	0.23
4024	0.49
4025	0.19
4026	1,28
4027	0.44
4028	0.80
4031	1.85
4033	1.70
4034	1.99
4035	1.05
4036	2.75
4039	2.95
4040	0.83
4041	0.80
4042	0.68
4043	0.78
4044	0.78
4045	1.70
4046	0.95
4047	0.98
4048	0.54
4049	0.34
4050	0.37
4051	0.78
4052	0.78
4053	0.78
4054	1.28
4055	1.23
4060	1.08
4063	1.18
4066	0.46
4067	4.25
4068	0.25
4069	0.19
4070	0.29
4071	0.24
4072	0.24
4073	0.24
4075	0.24
4076	0.83
4077	0.29
4078	0.26
4081	0.24
4082	0.24
4085	0.57
4086	0.70
4093	0.53
4502	0.99
4507	0.45
4508	2.75
4510	0.83
4511	0.63
4512	0.79
4514	1.93
4515	2.98
4516	0.89
4518	0.89
4519	0.68
4520	0.89
4521	2.05
4522	1.45
4526	0.95
4527	1.20
4528	0.99
4532	1.15
4541	1.45
4543	1.45
4553	3.10
4555	0.50
4556	0.59
4566	1.90
4585	1.35
CRYSTALS	
4 MHz	2.20

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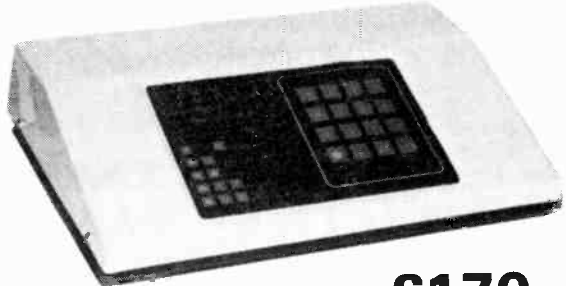

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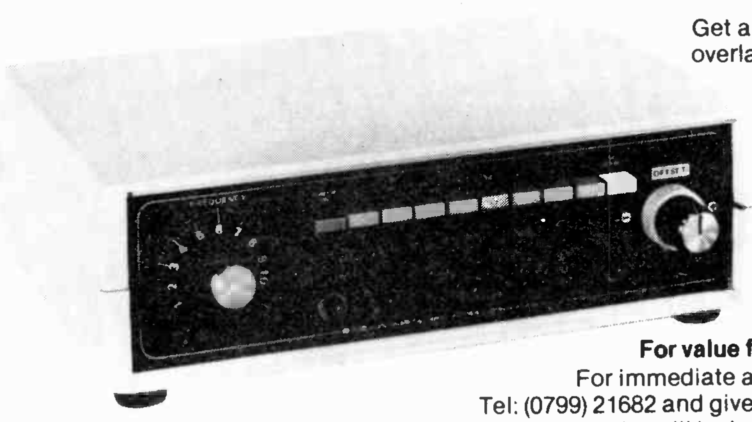
The 2001 sweeps the board at only £78*



Get all the waveforms you need – 1 Hz to ·1 MHz in five overlapping ranges: stable, low-distortion sine waves, fast rise/fall-time square waves, high linearity triangle waves — even a separate TTL square wave output. Plus high- and low-level main outputs.

An applied DC Voltage at the Sweep input can shift the 2001's frequency: or sweep up to 100: 1 with an AC signal.

A pushbutton activates the DC Offset control, which shifts the output waveform up or down on command.

For value for money the 2001 sweeps the rest off the board.

For immediate action — The G.S.C. 24 hour, 5 day a week service Tel: (0799) 21682 and give us your Access, American Express, Barclaycard number and your order will be in the post immediately or just clip out the coupon.

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Model 2001 Sweepable Function Generator	£91.42. (inc. P&P and 15% VAT)	Qnty Reqd.		For FREE catalogue tick box ☐

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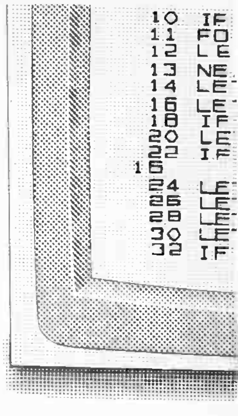
New! Sinclair ZX81 Personal Computer.

Kit: £49.95 complete



Built: £69.95 complete

Reach advanced computer comprehension in a few absorbing hours

1980 saw a genuine breakthrough – the Sinclair ZX80, world's first complete personal computer for under £100. At £99.95, the ZX80 offered a specification unchallenged at the price.

Over 50,000 were sold, and the ZX80 won virtually universal praise from computer professionals.

Now the Sinclair lead is increased: for just £69.95, the new Sinclair ZX81 offers even more advanced computer facilities at an even lower price. And the ZX81 kit means an even bigger saving. At £49.95 it costs almost 40% less than the ZX80 kit!

Lower price: higher capability

With the ZX81, it's just as simple to teach yourself computing, but the ZX81 packs even greater working capability than the ZX80.

It uses the same micro-processor, but incorporates a new, more powerful 8K BASIC ROM – the 'trained intelligence' of the computer. This chip works in decimals, handles logs and trig, allows you to plot graphs, and builds up animated displays.

And the ZX81 incorporates other operation refinements – the facility to load and save named programs on cassette, for example, or to select a program off a cassette through the keyboard.

Higher specification, lower price – how's it done?

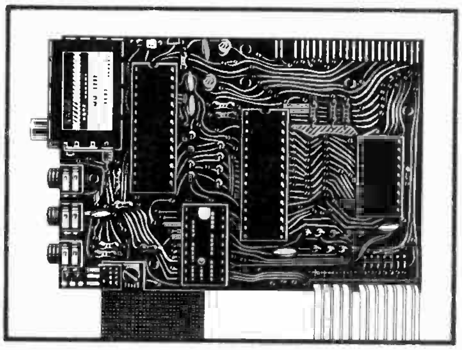
Quite simply, by design. The ZX80 reduced the chips in a working computer from 40 or so, to 21. The ZX81 reduces the 21 to 4!

The secret lies in a totally new master chip. Designed by Sinclair and custom-built in Britain, this unique chip replaces 18 chips from the ZX80!

Kit or built – it's up to you!

The picture shows dramatically how easy the ZX81 kit is to build: just four chips to assemble (plus, of course the other discrete components) – a few hours' work with a fine-tipped soldering iron. And you may already have a suitable mains adaptor – 600 mA at 9 V DC nominal unregulated (supplied with built version).

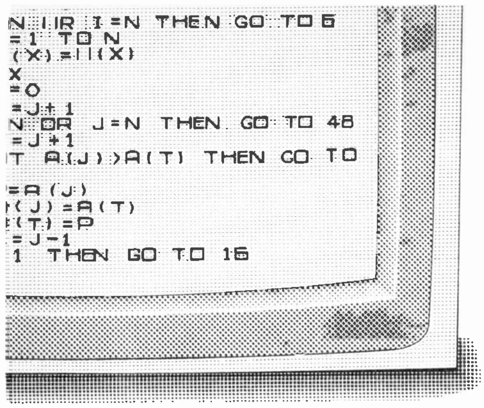
Kit and built versions come complete with all leads to connect to your TV (colour or black and white) and cassette recorder.



Proven micro-processor, new 8K BASIC ROM, RAM – and unique new master chip.

New Sinclair teach-yourself BASIC manual

Every ZX81 comes with a comprehensive, specially-written manual – a complete course in BASIC programming, from first principles to complex programs. You need no prior knowledge – children from 12 upwards soon become familiar with computer operation.



If you own a Sinclair ZX80...

The new 8K BASIC ROM used in the Sinclair ZX81 is available to ZX80 owners as a drop-in replacement chip. (Complete with new keyboard template and operating manual.)

With the exception of animated graphics, all the advanced features of the ZX81 are now available on your ZX80 – including the ability to drive the Sinclair ZX Printer.

16K-BYTE RAM pack for massive add-on memory.

Designed as a complete module to fit your Sinclair ZX80 or ZX81, the RAM pack simply plugs into the existing expansion port at the rear of the computer to multiply your data/program storage by 16!

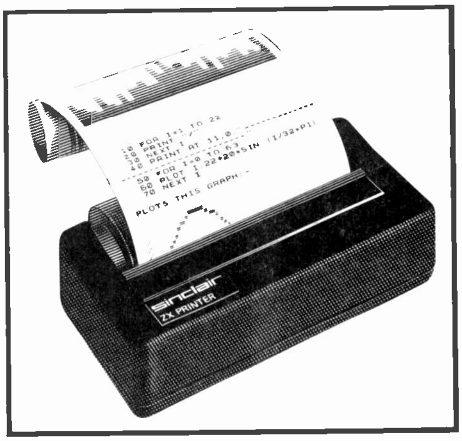
Use it for long and complex programs or as a personal database. Yet it costs as little as half the price of competitive additional memory.

New, improved specification

- Z80A micro-processor – new faster version of the famous Z80 chip, widely recognised as the best ever made.
- Unique 'one-touch' key word entry: the ZX81 eliminates a great deal of tiresome typing. Key words (RUN, LIST, PRINT, etc.) have their own single-key entry.
- Unique syntax-check and report codes identify programming errors immediately.
- Full range of mathematical and scientific functions accurate to eight decimal places.
- Graph-drawing and animated-display facilities.
- Multi-dimensional string and numerical arrays.
- Up to 26 FOR/NEXT loops.
- Randomise function – useful for games as well as serious applications.
- Cassette LOAD and SAVE with named programs.
- 1K-byte RAM expandable to 16K bytes with Sinclair RAM pack.
- Able to drive the new Sinclair printer (not available yet – but coming soon!)
- Advanced 4-chip design: micro-processor, ROM, RAM, plus master chip – unique, custom-built chip replacing 18 ZX80 chips.

Coming soon – the ZX Printer.

Designed exclusively for use with the ZX81 (and ZX80 with 8K BASIC ROM), the printer offers full alphanumerics across 32 columns, *and* highly sophisticated graphics. Special features include COPY, which prints out exactly what is on the whole TV screen without the need for further instructions. The ZX Printer will be available in Summer 1981, at around £50 – watch this space!



How to order your ZX81

BY PHONE – Access or Barclaycard holders can call 01-200 0200 for personal attention 24 hours a day, every day.
BY FREEPOST – use the no-stamp-needed coupon below. You can pay by cheque, postal order, Access or Barclaycard.
EITHER WAY – please allow up to 28 days for delivery. And there's a 14-day money-back option, of course. We want you to be satisfied beyond doubt – and we have no doubt that you will be.

To: Sinclair Research Ltd, FREEPOST 7, Cambridge, CB2 1YY. **Order**

Qty	Item	Code	Item price £	Total £
	Sinclair ZX81 Personal Computer kit(s). Price includes ZX81 BASIC manual, excludes mains adaptor.	12	49.95	
	Ready-assembled Sinclair ZX81 Personal Computer(s). Price includes ZX81 BASIC manual and mains adaptor.	11	69.95	
	Mains Adaptor(s) (600 mA at 9 V DC nominal unregulated).	10	8.95	
	16K-BYTE RAM pack(s).	18	49.95	
	8K BASIC ROM to fit ZX80.	17	19.95	
	Post and Packing.			2.95

TOTAL £ ______

Please tick if you require a VAT receipt ☐
*I enclose a cheque/postal order payable to Sinclair Research Ltd, for £ ______
*Please charge to my Access/Barclaycard account no.

*Please delete/complete as applicable. Please print.

Name: Mr/Mrs/Miss

Address

FREEPOST – no stamp needed. PRE06

sinclair ZX81

Sinclair Research Ltd,
6 Kings Parade, Cambridge, Cambs., CB2 1SN. Tel: 0276 66104.
Reg. no: 214 4630 00

PE VOLUME 17 No. 6 JUNE 1981

JAPAN — 10 YEARS AHEAD

NO the Japanese are not 10 years ahead in technology; we're talking about how they see their electronics industry in the next 10 years with regard to prospects, technological development and product demand — not a bad thing to investigate with most of the world in the midst of an economic depression. A 626 page report by the Japanese Electronic Industry Development Association has been published by the Fuji Ccrporation and is available at a cost of $400. We have seen a summary of it which makes interesting reading for anyone concerned with electronic technology in the UK and the rest of the world.

Having analysed the present aspects and trends the report provides a proposition of seven points for the future direction of the electronics industry in Japan. It is these seven points that show the way ahead, not only for Japan but for the rest of us.

They are: technological results are producing great ripple effects on other industries and form the core of innovations that will push the Japanese industrial structure to further heights. Consequently, the importance of the electronic industry should be recognised and efforts for its development undertaken.

In the 1980s, a time when low economic growth, resource conservation and energy-saving are taking hold, efforts will need to be redoubled to firmly establish the electronic industry's position as a key industry of Japan by fully utilising the special characteristics of the industry and at the same time to accelerate technological development.

While industry efforts will need to be channelled in basic research and development, there is an urgent need at national level for a clarification of research and development guidelines, appropriate financing and tax relief measures, systemising of the research and development programs, and furthering of co-operative and assistance arrangements.

From an international perspective, there will need to be a promotion of foreign trade activities, capital investment, industrial penetration into overseas markets, and technological transfer. It is imperative that efforts be made to respect the position of each foreign country and work out rules for mutual reconciliation.

Since the importance of software within the computer industry will continue to rapidly increase in the future along with the upgrading of hardware, efforts will need to be made to put software production on a more efficient basis.

For the private enterprises, there is an urgent need for in-company technical training, training for jobs in other fields and retraining for improving present skills.

In connection with the development of technology application, there is a need to undertake assessment in the practical application of technological development, and to eliminate any negative aspects that arise.

If the Japanese implement these suggestions and we simply sit back, where will we be in 10 years?

Mike Kenward

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We are unable to offer any advice on the use or purchase of commercial equipment or the incorporation or modification of designs published in Practical Electronics.

All letters requiring a reply should be accompanied by a stamped, self addressed envelope and each letter should relate to **one published project only.**

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

Back Numbers
Copies of some of our recent issues are available from: Post Sales Department (Practical Electronics), IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 0PF, at 95p each including Inland/Overseas p&p.

Binders
Binders for PE are available from the same address as back numbers at £4·30 each to UK or overseas addresses, including postage and packing, and VAT where appropriate. Orders should state the year and volume required.

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Copies of PE are available by post, inland or overseas, for £11·80 per 12 issues, from: Practical Electronics, Subscription Department, Oakfield House, Perrymount Road, Haywards Heath, West Sussex RH16 3DH. Cheques and postal orders should be made payable to IPC Magazines Limited.

...NEWS &

Edited by David Shortland & Jasper Scott

VIDEODISCS set for take off

The video market, which has continued to expand with the sale of video recorders increasing despite the recession will be further strengthened in the coming year with the introduction of video disc systems.

These systems are designed to playback pre-recorded programs stored on discs, with typical playback times of two hours.

Three companies are planning videodisc launches with Philips leading the way later this year with their LaserVision system followed by Thorn and RCA in 1982. The RCA Selecta Vision system launched recently in the USA amid a $20 million advertising campaign uses Capacitive Electronic Disc (CED) technology which combines a diamond micro-stylus with a conductive grooved disc. The Philips Laservision is an optical system which uses a light beam instead of a stylus to read the disc, whilst the Thorn system developed by JVC also uses the CED system but with smooth discs which enables the stylus to be easily moved across the disc. The pick-up head also includes an automatic tracking signal which ensures the head is correctly aligned on the disc during playback.

Once again as with VCR systems, these three disc systems are not compatible.

Fibre Optic TV

Strands of glass fibre, no thicker than a human hair, will be relaying television and radio programmes to 18 households in Milton Keynes by the end of this year.

The rental houses, at Oldbrook 1 near the city centre, have been chosen by British Telecom for their first public trials of transmitting TV programmes by fibre optic cable. A single fibre optic cable can carry as much information as a copper co-ax cable but is physically smaller.

Electrical signals, converted into pulses of light, will be carried over one optical fibre cable from the receiving station at Linford Wood to a distribution point near the houses.

From that point, smaller optical fibre cables will be laid to each house where the signals will be converted back into an electrical form suitable for reception on ordinary TV sets and radios.

The trial will be monitored by British Telecom for at least one year and there will be no additional costs involved for either the Milton Keynes Development Corporation or the residents.

BIRD BARGAIN

A car radio/cassette listed by Bird Audio in January 1980 at £180 plus VAT is now available for just £65·95 including VAT. The radio/cassette is the 8020 Combination Unit MW/VHF stereo radio and stereo cassette player with automatic eject. The radio has a digital frequency readout with pushbutton two level (local or distant stations) autosearch in either direction or manual tuning with single memory. The unit also incorporates a 24 hour digital clock with continuous display at ignition on or 15 second selectable display while the radio is on. The set employs the patented Philips/IAC interference suppression circuitry, has a mono/stereo reception switch, interstation muting and boasts 7 watts per channel output.

Other features include MW/VHF and stereo indicators, tone, balance and volume controls, clock set buttons and locking fast forward and rewind cassette switch. The output stages are neatly housed in a separate black steel enclosure. The set comes with inter-connecting leads and full installation instructions. One of the most comprehensive units around and not to be missed at this price. Limited quantities available to callers only (not mail order) from RT–VC, 323 Edgware Road, London W2.

Also available is the 7300 combination unit—basically the same without the digital clock and frequency readout, but including LW and l.e.d. station indicator. Previously listed by Birds at £156 plus VAT, now £53·95 inclusive from RT–VC, again limited quantities to callers only.

COMPONENT CATALOGUE

T&J Electronic Components, who specialise in Mail-Order, have recently published their latest catalogue, which is packed with electronic components and accessories. It is available to readers at a price of 45p, including postage.

T&J Electronic Components, 98 Burrow Road, Chigwell, Essex. (01-500 7073)

MARKET PLACE

Items mentioned are available through normal retail outlets unless otherwise specified. Prices correct at time of going to press.

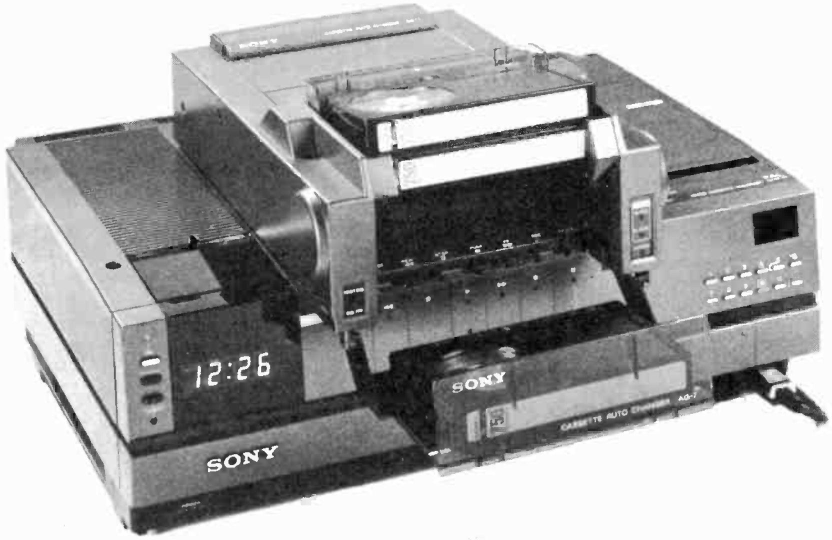
NIGHT OWL

Night Owl is a radar controlled courtesy light and intruder detector which can protect an egg shaped area with a forward range of 100 feet.

When the radar system detects a moving vehicle or person the house lights are automatically turned on. These lights stay on for an adjustable time period after the last movement has ceased. However if further movement is detected the lights will come back on. The unit is programmed to accept only continuous movements, an anti-flutter system rejects momentary and oscillatory movements (i.e., doors, curtains, trees etc.).

The detection range is adjustable from 6 to 100 feet and the light duration can be set from $\frac{1}{2}$ to 10 minutes. (If an audible alarm or extra light is required an extra set of contacts are built into the unit).

The unit which is priced at £150 is available from Loadpoint Ltd., Chelworth Industrial Estate, Cricklade, Swindon, Wilts.



SONY BETASTACK

The latest addition of Sony's range of high-quality video equipment is the Betastack — a video cassette autochanger which was recently introduced to the public at the Home Video Show.

The Betastack enables the Sony C7 video recorder to provide up to 13 hours of unattended recording. Because the C7/Betastack combination can be programmed to automatically record up to four TV programmes onto four separate cassettes of appropriate length, the user can conveniently record over tape no longer required yet save those programmes he wishes to see again. This added convenience also helps ensure the most cost-effective use of video tape.

The Betastack can be fitted to the C7 recorder by a Sony dealer (though some early machines may require minor adaptation), and new purchasers of the C7 recorder will be able to obtain the advantages of Betastack already fitted for £129·00. Supply and fitting to existing owners' C7 recorders will cost under £150.

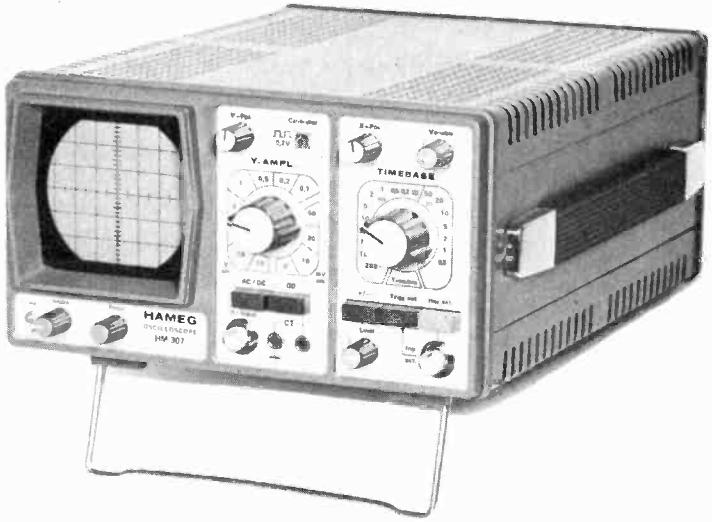
CHIP SHOP KITS...

An entirely new range of practical, easy-to-solder electronic kits, all retailing at £5·00 or less, will soon be available from High Street hobby shops. Called Chip Shop Kits, there are over 20 different electronic projects in the range, which have been specifically designed to introduce teenagers or adults to the world of electronics.

Each Chip Shop Kit contains all the components necessary to build the project described. All that is needed is a soldering iron and a 9 volt battery to power the circuit. Step-by-step instructions on construction are included in the box together with detailed educational notes about the individual circuit and advice about soldering techniques, with particular reference to safety precautions. All components are guaranteed. Projects currently available include a burglar alarm, electronic organ, lie detector, two transistor radio and a soldering iron.

Electroni-Kit Ltd., Rectory Court, Chalvington, Hailsham, East Sussex. (032 183 579).

NEW HAMEG 'SCOPE



The HM307 from Hameg is a lightweight single trace scope which has been designed for both the service technician and the advanced hobbyist. A principle feature of the MH307 is its' built-in component tester. This allows both passive and active components to be tested while still in circuit. Operation of the component tester is activated by push-button and during the test operation it is not necessary to change the oscilloscope settings.

If the component under test has a very high resistance or is open circuit, then the display is in the form of an almost horizontal line and a short circuit across the test terminals results in a vertical line. Medium resistances are indicated by a diagonal line on the screen.

Capacitors and inductors exhibit a phase differential between X and Y deflections giving an elliptical display. Because of the low frequency of the test signal (50MHz) only relatively large capacitors and inductors will exhibit this phase difference: capacitors between 10nF and 100μF.

The HM307 is priced at £138 plus VAT and p&p. Hameg Ltd., 74–78 Collingdon Street, Luton, Beds (0582 413174).

OK SOURCE

OK Machine & Tool's new battery charger will charge three different sizes of Ni-Cad battery—HP7, U11 and U2. Two or four batteries can be charged at a time, and any pair of same-sized batteries can be fitted in one section, with another pair of different sized batteries in the other section. Charging times range from 10 to 16 hours.

Another new product from OK is their Economy PCB Repair Kit, which they claim will pay for itself very quickly—after a few 'on the spot' salvage jobs. The kit includes master frames with tracks and fingers, eyelets and eyelet setting tools.

The Ni-Cad Battery Charger is priced at £11·38, and the Economy PCB Repair Kit at £46·80. Both prices are exclusive of VAT and p&p.

OK Machine & Tool (UK) Ltd, Dutton Lane, Eastleigh, Hants. (0703 610944).

POINTS ARISING . . .

DP200 MULTIMETER (May '81)

Please note: The price given for the complete kit of parts for the DP200 excludes the price of the case and LE-DPM200 panel meter.

MASTER RHYTHM (Jan '81)

In Fig. 7 C53 should connect to R49/59/69/79. The p.c.b. and overlay are correct.

MICROTUNE (Dec. '80 & Jan. '81)

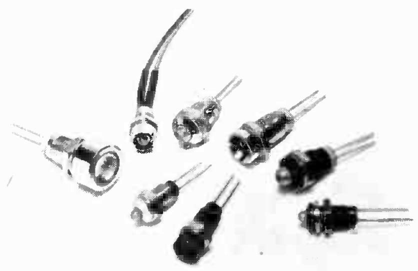
R19 should be 220k. R42 should be 10k and R43 should be 10k.

The second R42 shown on the circuit diagram as a 2k2 and missing on the component overlay, is unnecessary. This component may be ignored. R44 should be 220k. Resistors which appear in the components list only, may be ignored.

GRAPH DISPLAY UNIT (March '81)

The capacitor C4 should connect from pin 6 to pins 1/2. C3 from 3 to 4/5.

LIGHTING-UP



West Hyde Developments, who are well known for their "Bocon" range of cases, have now introduced a wide range of l.e.d.s manufactured by the German company Mentor.

The l.e.d.s are available in sizes of either 3mm or 5mm diameter, with a choice of four colours. There is also a choice of concave or convex reflectors finished in chrome or black.

In addition to this standard range, there is also a range of flashing variants with built-in circuitry. At the top of this range is an l.e.d. which provides either a continuous green or flashing red light.

For further details contact West Hyde Developments Ltd, Unit 9, Park Street Industrial Estate, Aylesbury, Bucks. (0296 20441).

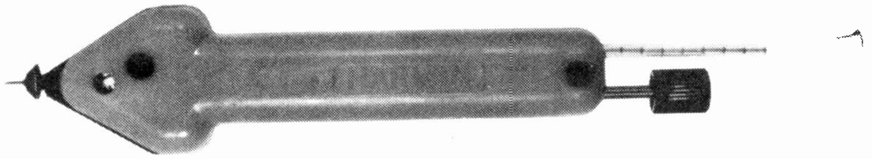
MARKET PLACE

Home Office in trouble with ASA

The Home Office has been in trouble with the Advertising Standards Authority who received a complaint concerning the national TV licence campaign. The complaint centred around the statement in the advertisement, 'If you own a TV set, you're actually required by law to own a licence', which is incorrect.

If you only use your TV for showing pre-recorded video programmes or for playing video games, then you're not required by law to own a licence. The Home Office gave an undertaking to clarify the legal situation in future advertisements.

PCB PINNING TOOL



A new hand tool has been developed for the quick and easy insertion of strip form track pins which enable double sided p.c.b.s. to be interconnected without the need for plated through holes.

The new tool feeds out the strip form track pins, exposing them one at a time so they are ready to be located in the p.c.b. hole. When the pin has been located correctly, it is broken off the strip, leaving it in place in the hole, ready for soldering. At the press of a button, the tool exposes another pin and the process is repeated in the next hole to be connected through.

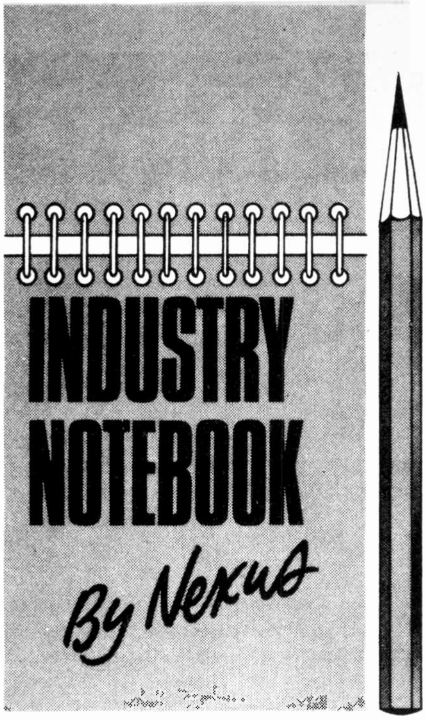
Apart from making the pin insertion process a lot quicker and easier, the new tool also ensures consistent insertion of the pin. Until now, the normal method of using the pins in strip form has been by holding the strip in the fingers. Another advantage of the new method is that the pins are kept clean during assembly prior to soldering.

The price of the tool is £25 excluding VAT and p&p, and it is available from Harwin Engineers, Fitzherbert Road, Farlington, Portsmouth, Hants. (0705 370451).

Countdown . . .

Entertainment postponed.
Welsh Amateur Mobile Rally May 10. Barry Memorial Hall. **C**
Defence Components Expo May 12–14. Metropole, Brighton. **I**
East Suffolk Wireless Revival May 24. Civil Service Sports Association, Sports Ground, Straight Road, Ipswich. **V1**
Hobby Electronics May 29–31. Bristol Exhibition Centre. **B7**
Scotelex June 2–4. Royal Highland Exhibition Hall, Ingliston, Edinburgh. **A1**
Semlab June 2–5. Grand Hall, Olympia, London. **I**
Electronic Hotel June 3–4. West Centre Hotel, Fulham, London. **Z1**
Videotext June 4. Europa Hotel, London W1. **Z1**
Transducer/Tempcon June 9–11. Wembley Conf. Centre, London. **T**
Components June 9–12. Earls Court, London. **I**
Pet Computer Show June 18–20. West Centre Hotel, London. **B8**
Compec North June 23–25. Belle Vue Hotel, Manchester. **Z1**
International Word Processing Exhibition & Conf. June 23–26. Wembley Conf. Centre, London. **Z**
BEX Salisbury June 24–25. City Hall. **K**
Leeds Electronics Show June 30–July 2. University of Leeds. **E**
Nat. Education & Training (Exhibition & Conf.) July 2–4. NEC, Birmingham. **B2**
BEX Portsmouth July 15–16. Centre Hotel. **K**
BAEC Amateur Electronics Exhibition July 18–26. The Shelter Penarth Esplanade, S. Glam. **B9**
Microcomputer Show (and seminars) July 29–31. Wembley Conf. Centre. **O**
Solar Energy Exhibition August 23–28. Brighton. **M**
Harrogate Int. Fest. of Sound August 15–18. Royal Hall Exhibition Centre & Hotels. **X**
BEX Cardiff September 3–4. Centre Hotel. **K**
Business & Light Aviation September 3–5. Cranfield Airport. **Z1**
Microprocessor Workshop September 7–8. University of Liverpool. **D**
Laboratory September 8–10. Grosvenor House, Park Lane, London. **I**
Personal Computer World Show September 10–12. Cunard Hotel, London. **M**
West of England Electronics Show September 15–17. Bristol Exhibition Centre. **Q**
Business Telecoms & Electronic Office September 23–25. Royal Lancaster Hotel, London. **O**
BEX Edinburgh September 30–October 1. Assembly Rooms. **K**
Viewdata October 6–8. Wembley Conf. Centre, London. **O**
BEX Bristol October 14–15. Exhibition Centre. **K**

C	Barry College of Further Education Radio Society. ✆ 0222 565656
D	Brownlow Hill, PO Box 147, Liverpool L69 3BS
E	Evan Steadman Communication Group, Saffron Walden. ✆ 0799 22612
I	ITF, Solihull. ✆ 021-705 6707
K	Douglas Temple Studios, Bournemouth. ✆ 0202 20533
M	Montbuild Exhibitions, London. 01-486 1951
O	Online Conferences, Northwood, Middx. ✆ 09274 28211
Q	Exhibitions For Industry Ltd., East Oxted, Surrey. ✆ 0883 34371
T	Trident, Tavistock ✆ 0822 4671
V	SDL, Dublin. ✆ 763871
X	Exhibition & Conf. Services, Harrogate. ✆ 0423 62677
Z	BETA Exhibitions, London. ✆ 01-405 6233
A1	Institute Of Electronics, 659 Oldham Road, Rochdale, Lancs. ✆ OL16 4PE
L1	London World Trade Centre, Europe House. ✆ 01-488 2400
V1	Jack Toothill, 76 Fircroft Road, Ipswich IP1 6PX.
Z1	IPC Exhibitions, Sutton, Surrey. ✆ 01-643 8040
A2	Hart Brown & Curtis, Piccadilly, London. ✆ 01-439 8556
B2	Brintex, London. ✆ 01-637 2400
B7	Modmags Ltd. ✆ 01-437 1002
B8	Baroness Internation, London. ✆ 01-734 2907
B9	British Amateur Electronics Club, Penarth. ✆ 0222 707813



Impotence

From the tremendous bickering over the economy, one fact has plainly emerged. The Chancellor, any chancellor for that matter, is virtually impotent. The best that can be hoped is to guide the economy. A chancellor cannot control it.

Even in a totalitarian state such as the USSR there are always factors beyond government control that push programmes off course. A disastrous harvest, for example, or people who prefer to drink vodka rather than work diligently.

In our own case the government, for social as well as political reasons, continued to pump massive additional resources into steel, shipbuilding, mining and the automotive industry. And this on top of failure to control the rest of the public sector expenditure, so that at midterm in the Government's life it had actually increased, although for two years critics had constantly complained of cuts.

The barely concealed sniggers by opposition parties to Mrs Thatcher's surrender to the miners' demands and other financial calls from the nationalised industries, predictably turned to howls of rage when the bills came in on budget day.

The pre-budget queue of supplicants pleading their special causes was even larger this year. In the event, nobody was satisfied and there were loud cries of complete disaster. And so it is, after every budget, except that complete disaster never comes.

Of course exaggeration is part of the stock in trade of all politicians and the popular press. Fortunately, the fact that unemployment of qualified electrical and electronics engineers has almost tripled in the past year has escaped their notice. Imagine the headlines, the parliamentary questions! But don't get scared, the statement is virtually meaningless although true. The actual figures in percentage terms are an increase, according to the recent IEE Salary Survey, from 0·3 per cent to 0·8 per cent.

The same survey shows that public sector engineers are once again pulling ahead of their private sector colleagues in salary scales. The relative increases in 1980 were 27 per cent and 19 per cent respectively. At least in our profession, if not in others, public service employees are doing very nicely thank you.

Overall, the budget is not harmful to the electronics industry and in many ways is beneficial. The reduction in MLR and the decline in international value of sterling is helpful to everybody. More exciting is the encouragement of new businesses. Most of today's great entrepreneurs in the electronics industry originated in one or two people or a small team with bright ideas starting up on their own in quite a small way.

Avionics

I often think the world would be a happier place if success was accorded the same publicity as failure. Instead of deploring our inability to build commercial ships cheaper than the Japanese or Koreans, we might spend a little time rejoicing in the success of the British avionics industry whose products sell world-wide, not least to America.

Few people realise that of the total cost of a modern military aircraft as much as 50 per cent and typically 40 per cent is in electronics. The figure is not all that much lower for civil airliners. If we add in all the ground components such as radar, instrument landing systems, and communications the immensity of the market becomes apparent and it is a market in which Britain has a first-class reputation, enjoyed ever since the pioneering days of avionics 50 years ago and never relaxed since.

Marconi, Ferranti, Smiths, Plessey and Decca are all names to conjure with in this high technology activity. Racal, apart from ground communications, has been less active in this area but will no doubt become more prominent through the re-organised Racal-Decca company.

An interesting development is the Marconi entry into the aerial platform itself as well as the airborne avionics. There is no intention of course of joining the big-time airframe manufacturers. Don't expect a Marconi successor to the Tri-Star or the 747. Marconi Avionics MACHAN remotely-piloted vehicle (RPV) is far more modest having only a 12-ft wingspan and being powered by an 18hp two-stroke engine driving a ducted pusher propeller.

The machine can carry a 33lb payload for a cruising duration at 64 knots of 2 hours, with a smaller duration at faster speeds up to a maximum in level flight of 115 knots. The airframe, powerplant and flight control system has been developed at the Cranfield Institute of Technology under sub-contract.

A payload of 33lb would not have been of much value only 10 years ago. Today it's surprising what you can pack in. The microprocessor-controlled digital autopilot is all on a single card only 6in by 4in. Seven other similar cards comprise the total electronics package including all the TV camera processing and video data links to the ground. In case you haven't guessed already, the MACHAN is a spy-in-the-sky drone for battlefield surveillance.

Incidentally, there is a touch of the old Empire in the name. MACHAN is an old Hindi word for a tree-top surveillance platform and is pronounced "Ma-shahn" with the accent on "shahn".

Leisure

The great 19th Century reformers such as Ruskin had a vision that if labourers in the factories and fields had better working conditions and especially shorter working hours, they would nobly turn to self-education and in particular devote much time to the creation of beauty and cultivation of the arts. More than a century later their hope has been achieved in respect of increased leisure time for all, but hardly in the use made of it if we are to believe, for example, that the daily attendance at Bingo sessions is six million.

Electronics, judged solely as a tool, is impartial to noble or ignoble use. I note that two recent export orders are both coupled with the human weakness of gambling. The Tote Agency in Melbourne has just upped its installation of 32-track Racal recorders to a total of 16 machines to cope with telephone bets. These expensive machines are those normally used to record all traffic information at airports. The Tote now has 464 channels of continuous recording to cope with 50,000 calls a day with exact timings to eliminate fraud.

The other order, greater in value, is for comprehensive colour TV at the Singapore Turf Club. Three Marconi cameras, video recorders and other equipment are to be used for surveillance of the races, judging by the stewards, and monitoring for the spectators. The system will also be linked by microwave to three other racecourses in Penang, Perak and Selangor. The Singapore Club is one of the oldest, founded in 1842, but is also famed as the most up-to-date in the world.

Security

Security as a business is booming as law and order becomes an increasing problem. Thorn EMI has merged into a new Security Division the formerly separate activities of fire protection and intruder detection. The Division now has annual sales of £60 million with a high content of electronics in specialised sensors. While consolidating the business at home, Thorn EMI expect to see substantial advances in overseas business.

Performance

Good bright firms prosper through good and bad times. Yes, even in vulnerable consumer electronics. Alan Sugar has pulled it off again with Amstrad turnover up 58 per cent in the last recorded half-year and, more important, profits up 51 per cent.

WIRE WRAPPING

John Lewis

LIKE all good ideas wire wrapping is simple and effective. In its basic form wire wrapping does exactly what it says. One end of a length of wire is wrapped around a terminal and the other end is wrapped round another terminal to complete the circuit. To the non believer this may seem an unreliable way of making a connection. In fact though it is a very reliable technology which is used on circuits destined for a wide variety of uses—including the very particular military sector. Its big advantage is the ease with which changes can be affected and this is a godsend to the experimenter.

The mechanics of the wire wrapped joint are that a bared wire is wrapped a number of times around a square post—typically 0·025 inches square (Fig. 1.). The actual pressure between the wire and the post can initially be as high as 100,000 lbs per sq in. though over time it may drop to 10,000 lbs per sq in. due to stretching. Even so the oxide layers are crushed or sheared and a gas tight seal is formed between the wire and the post; migration of the metals involved at the joint also takes place thus improving the electrical connection.

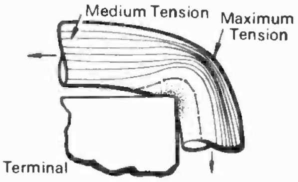


Fig. 1. The wire wrapped connection around the terminal crushes the oxide layer on both the wire and the terminal

TYPES OF WRAPS

One problem when just the bared wire was wrapped round the post was its lack of resistance to vibration (Fig. 2a.). However, by continuing the wrap to include a turn or two of the insulated portion of the wire as well this is much improved and strain relief is also provided. This type of wrap is known as a 'modified wrap' and is standard now for most applications (Fig. 2b.).

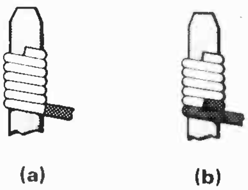


Fig. 2(a). In a standard wrap only the bare wire is wrapped around the terminal. This method is preferred with large gauge wire

Fig. 2.(b). In a modified wrap the first 1 to 1½ turns are made with the insulation wrapped around the terminal

TYPES OF TOOLS

So here we have an excellent idea but how can it be implimented by the amateur. The first thing that is required is a wrapping tool which can be either electrically or manually operated, secondly some 30 a.w.g. (0·25mm) wire, thirdly a wire stripper (though this can be an integral part of some wrapping tools) and lastly a supply of suitable i.c. sockets and terminals which have square posts long enough to accommodate at least 3 wraps.

CIRCUIT BOARDS

Obviously some form of circuit board is still required and this can be the traditional 0·1 inch stripboard provided care is taken to isolate the necessary tracks. Better though are the d.i.p. boards which have the requisite copper patterns for individual i.c.'s as well as some additional contacts, isolated from the others, together with some continuous tracks possibly on the top surface of the board as well for power and bus connections.

To build a circuit one first inserts the required number and type of sockets and solders them into place. The soldering is necessary since additional posts may be needed to be inserted in the spare holes by each socket pin should more than three connections be required to any particular i.c. pin. At this stage it helps if the pin terminals are identified on the underside of the board since it is very easy to transpose say, pin 1 and 16, when 'working upside down'. A small piece of masking tape stuck between the legs of the i.c. socket with pin numbers written on it helps to prevent such errors.

HOW TO MAKE A JOINT

To make a joint about an inch of insulation is stripped from one end of the wire (Fig. 3.). (If you are using one of the wire strippers especially designed for this application or a tool which has an integral stripper the length stripped will be predetermined so there is no need to measure.) The end of the wrapping tool has two holes in it, a large one in the centre and a smaller one on

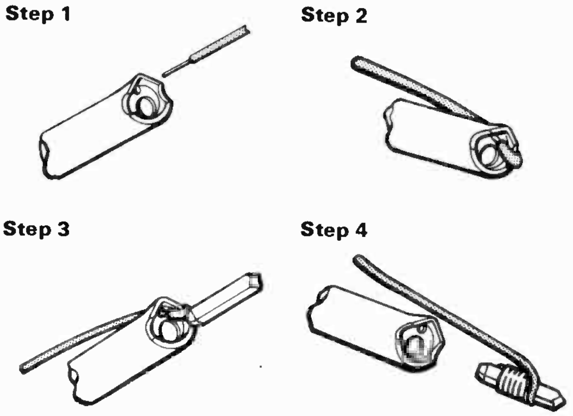
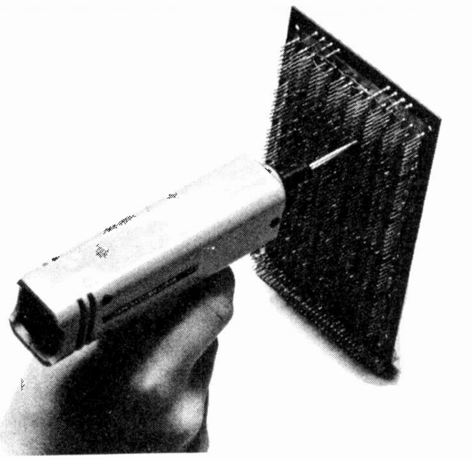


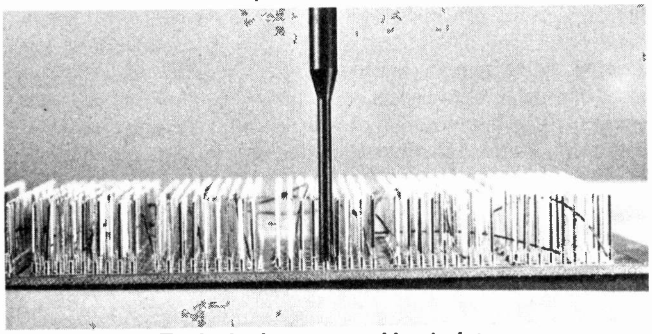
Fig. 3. Method for making a wire wrapped joint

the circumference. The bared wire is pushed into the smaller hole as far as it will go—in fact some of the insulated part will also disappear if a modified wrap is being made—and then bent at



The Hobby wrap tool from Vero Electronics has been designed specifically for the amateur market. A Ni-cad battery drives the tool and an optional plug-in charger is available. A switch on the end of the barrel enables the same bit to be used for wrapping and unwrapping

90°. The tool is then placed over the appropriate post so that it enters the larger, central hole of the tool and pushed down as far as it will go. It is then rotated clockwise until the connection is completed. If a powered tool is being used allow about 2 secs running time, if it's a manual one then it should be turned without undue pressure for approximately 10–12 turns. Take a tool off the post and the wrap is made. The turns should be laying flat and close to each other, if they are not or if they overlap then either the tool has been pulled up as it was turned or not allowed to rise as the wrap was being made.



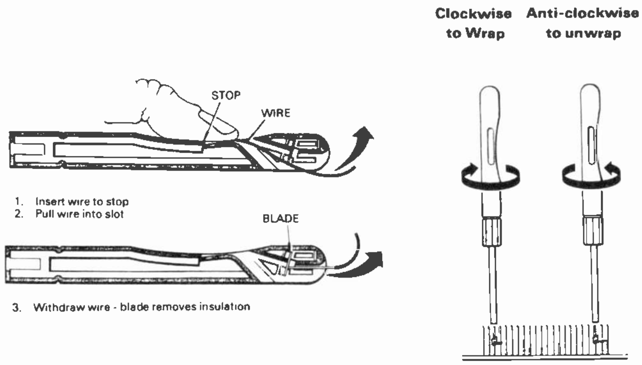
Typical wire wrapped backplate

It takes longer to describe the process than to actually do it and once a few have been done you become quite adept at it. The wire is led across to the post to which the next connection is to be made and cut so that it is about $1\frac{1}{4}$ times too long—the end is stripped and a wrap made in a similar fashion to that described above. And so on following the circuit diagram to make the various connections called for. Note that it is good practice to keep both ends of the wire at the same level otherwise it can be difficult to make changes.

UNWRAPPING

Should a change be required the joint is just unwrapped. In some cases a special unwrapping tool may be needed though most wrapping tools if turned anticlockwise do unwrap as well. So the tool is slipped over the post given a few turns anticlockwise and removed leaving the unwrapped joint ready to be taken off. It is false economy to try and use that joint again by straightening the wire and rewrapping, much better to replace it totally. If you suspect that changes will be needed once the circuit is made then leave sufficient slack in each connection so that additional wraps can be made.

A new development is a special tool using a wire which does



The Combiwrap tool from Vero Electronics is a combined wire stripper, wrapping and unwrapping tool

not require stripping. The tool has a bobbin of wire attached to it feeding down though the tool into the wrapping bit. In use the tool bit is placed over the post, the free wire end is held whilst the whole tool is rotated through 8 turns and then removed. The tool, with wire trailing is moved onto the next post and the procedure repeated. To cut the wire a button on the tool is pressed and two further turns of the tool will cut the wire at the joint. What happens is that the insulation on the wire is automatically pierced and displaced by the square corners on the post thus making a good electrical, gas tight joint.

When the wrapping is finished the connections should be checked against the circuit diagram and here the advantage of using coloured wires for different parts of the circuit becomes apparent. If all seems well the i.c.'s can be inserted into their respective sockets—the right way round—and power applied. Hopefully it will work first time, if not then fault finding and rectification is easy compared with printed circuit boards.

* *Illustrations by courtesy of Vero Electronics, Industrial Estate, Chandler's Ford, Hants.*

WEMON REVIEWED

by Dr. A.A. BERK

THE WEMON monitor, produced by *Watford Electronics*, is an overall system monitor for the UK101-Superboard family of computers. The Monitor in any machine of this kind is in constant use for such activities as interpreting keyboard data, keeping the screen formatted, allowing editing of programs, breakpoints, machine code writing etc. The revolutionary nature of WEMON is its realisation on a 2532 (4K Bytes) erasable programmable read-only memory (EPROM). These devices retail at £15-£18, normally, and WEMON costs less than £20. The reason for its requiring such a large amount of memory for all its functions lies in two or three of its advanced facilities. Firstly, full on-screen editing of BASIC programs is available—you simply move the cursor to any point on the screen containing a listing of the program, effect an insertion, change or deletion, and WEMON takes care of inserting the changes into the stored copy of your program. The second important feature is concerned with the sophisticated way in which the device controls loading and saving to tape. One of the most memory intensive parts of this function stems from the fact that WEMON's method of tape storage is fully compatible with the usual methods for 101/Superboard machines. Thus, although under WEMON it is vastly more sophisticated than normal, friends can still swop taped versions of programs with alacrity.

A third feature of some importance for the programmer, though less memory intensive than the above, is WEMON's BASIC keyword presentation facility. By this means, BASIC keywords such as FOR, POKE, etc may be called up by single keys on the keyboard. Two keystrokes are necessary, as SHIFT and CONTROL have to be pressed together first, released and followed by the key associated with the BASIC function required.

The chip containing WEMON has to be fitted into the memory space on the board, and to do this, a set of links and track cuttings must be performed on the p.c.b. before starting. These modifications are quite straightforward, and though I did not perform the modification myself, they seem to be well described in the manual.

The facilities available are described below, and have mostly been checked, during the review, on a Superboard. The chip comes in various versions, for the different machines it fits.

START UP

When the machine is switched on, the BREAK or RESET key is pressed, and a menu containing five letters appears:

M/C/W/D/U?

The machine is asking for a response from the user, and any of these letters can be typed, followed by a RETURN, to open one set of facilities available. **M** starts the machine code monitor, **C** is cold start for BASIC, **W** is warm start, **D** performs an indirect jump to a routine starting at 9800 (Hex), although this can be changed if required, and U jumps to a vector which can be defined by the user. The last two commands allow complete flexibility of use from the very beginning.

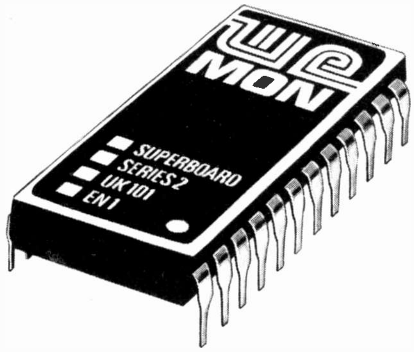
KEYBOARD

The keyboard is decoded as normal with alpha lock distinguishing between upper case teletype, and normal typewriter mode with lower case and use of SHIFT. In addition, several of the keys have special cursor control functions, and others, when used in conjunction with the CONTROL key, have command functions. See Table 1. CTRL(S) toggles between 24 and 48 characters per line with half the number of lines in the second case, CTRL (E) allows a jump to extensions to BASIC, CTRL(Q) changes to a mode whereby you can print characters on the screen corresponding to each of the cursor commands. By this means, using a PRINT statement, the cursor may be moved around the screen by your BASIC program—very useful for easy screen formatting under program control. The symbols used to signify these cursor commands are chosen to be logical—e.g., the cursor down symbol is a down arrow, etc. Table 1 also shows that cassette tape motor control is included from the keyboard to allow the tape to be rewound or forward wound without having to unplug the remote connection. CTRL(D) inserts a blank line between two BASIC lines of text to allow a new line to be written in. In addition, cursor movements are effected by LINE FEED and REPEAT, with their inverses occurring by the use of SHIFT with these keys. SHIFT RUBOUT, logically enough, produces the INSERT function in BASIC text, and SHIFT ESC (using the LEFT SHIFT) produces a screen clear.

These facilities are very useful indeed during program writing, and after a few minutes of use, it becomes very irritating to return to the old method of rewriting lines to effect changes. The only criticisms I can make are, firstly that the cursor is chosen, sensibly, to flash on and off, but the speed is rather low; and secondly, while stepping along a line, or moving up and down the screen using auto repeat, the cursor will stop flashing, and disappear. It is therefore impossible to watch the progress of the cursor on the screen to see when it has arrived at its destination.

BASIC

As mentioned above, WEMON has full screen editing, including insert both character and line. An exciting aspect of the editor is its ability to be used within a program. As explained above, characters corresponding to the editing commands may be included in PRINT statements to allow simple program formatting of the screen. By this means, a program is able to treat the screen as a "sheet of paper" around which the cursor may be moved at will to place printout easily at any position on the screen.



Another advanced feature of the monitor is its ability to extend the BASIC words which it can recognise. This is activated by CTRL(E). Before this has been performed, BASIC responds with the usual SN error if it finds a command which it does not

TABLE 1

REPEAT = Cursor Right
DELETE = Rubout
LINE FEED = Cursor Down
ESC = Home Cursor

Use of SHIFT reverses these functions, e.g. SHIFT LINEFEED = Cursor Up., and SHIFT ESC clears the screen.

CTRL(E) = Basic Extension
SHIFT RUBOUT (1E) = Insert
CTRL(X) = Cursor Left
CTRL(Z) = Cursor Up
CTRL(S) = Video Swop
CTRL(Q) = Toggle Quotes
CTRL(N) = Delete
CTRL(H) = Cursor Right
CTRL(J) = Cursor Down
CTRL(T) = Tape on/off
CTRL(D) = Open Screen
CTRL(P) = Toggle Print Flag

recognise. After CTRL(E), it performs further tests before rejecting the command. If the tests succeed, then a jump is performed to a location named EXTVEC. This is a three byte location which should contain a jump to another routine which can contain anything you wish. Some parameters are passed via the stack, and use of this function can, of course, crash the system if not set up correctly. Thus, the BASIC interpreter is no longer completely closed, any further facilities required can simply be strung on as desired.

A useful, though simple, addition to the system is use of the SPACE key to slow down a listing. Instead of flashing uncomfortably before the user's eye, a long list can be slowed down to reading speed by holding down the SPACE bar.

A printer routine is included in the monitor, but it expects a 6520 parallel I/O chip to be present at base address 8800(Hex). The command CTRL(P) toggles the print facility in and out, and every call to the normal output routine tests this flag and prints accordingly. The protocol is Centronics. Naturally, any other parallel device may be attached here if it handshakes in the Centronics manner.

The cursor symbol and flash rate are supposed to be user selectable via certain memory locations, but neither of these facilities worked on my version of the chip. I am assured that this will be rectified on the full production version, and these additions appear to be easy enough to include.

TAPE HANDLING

This is one of the areas of WEMON where it really scores very high marks. The whole problem of tape handling seems to have been cleared up by this monitor. The tape is automatically turned on and off by the program via a very simple hardware modification to the p.c.b. which includes an i.c. driver and a p.c.b. mounted relay. The RTS line of the 6850 ACIA is used to drive this facility in a very neat and easy to use manner. Once the remote connection has been plugged into the tape recorder, it does not have to be removed to rewind etc.—CTRL(T) being used from the keyboard to allow normal tape use when not required to be under program control.

Both (optional) named-files and part-SAVEs are allowed. To save a file to tape, the command: SAVE"AAAAAA is typed being followed by RETURN, opening quotes being mandatory, closing quotes are not required. The name (up to six alphanumeric characters) can be omitted (along with quotes) if no name is required for the file. At this point, a five second delay is encountered during which any tape leader is cleared, and then the message "SAVING AAAAAA" will appear followed by the command "LIST". At this point, the user may type a line-number followed by RETURN, to tell the computer where to start the listing from. Just RETURN starts the listing from the first line. The file then lists out on the screen as usual until the process is complete, when SPACE RETURN switches off the tape and clears the SAVEFLAG—which signals the computer whether or not to output to tape when a LIST is performed.

Loading from the tape is similar, with one or two extra tricks. If the opening quotes are omitted, the first character of the name is ignored in the name comparison. If a "*" is included in the name, the name comparison stops at that point. Thus:

LOAD"HELLO

will load the same file as:

LOAD"HE*

In addition, all named files encountered during a search of the tape are listed on the screen during the process, to allow the user to keep track of what is happening.

Machine code tape files are also handled with great efficiency by WEMON. It is claimed that they transfer some three times faster than normal! These files may only be handled from the machine code monitor, which is described later. S and L are used instead of SAVE and LOAD, and no quotes are necessary for file names. The form of the SAVE operation is as follows:

S AAAAAA(RETURN) XXXX-YYYY

After the RETURN, the cursor waits for the mandatory address parameters for the SAVE routine—all code from address XXXX to the location immediately preceding YYYY is thus saved to tape under the file name of AAAAAA.

LOADING of the block of data may be made to the same locations, or a different set entirely. Leading zeros are not required in the address parameters, and once again, the file name is optional.

MACHINE CODE MONITOR

The machine code monitor has one or two useful features not found on other monitors, though WEMON is much more a BASIC handler, and the features should not be expected to be wide ranging.

After RESET, if M is pressed, the machine code monitor is entered, and one of seven single letter commands is available. Unfortunately, if any other letter is pressed instead, the machine hangs up, and RESET has to be pressed to return to normal use. Each command has a set of parameters which are associated with that command's use, and if these are miss-typed in certain ways, the machine hangs again. This fragility in the software is irritating if you type fast, as mistakes are inevitable. Each command must be used, therefore, with some care as to format.

When the machine code monitor is entered, an immediate display of the registers is shown at the top of the screen, and subsequent commands, including those performing scrolls to the screen, leave this line of registers displayed at all times. The R function can be used to modify the contents of this line for various purposes. The modifications to this line are loaded into the MPU registers when the G function is used—the location to which control is transferred by G is determined by the PC value shown at the top of screen. While R is being used, the cursor steps along on the line beneath the register fields being modified. By this means, the contents are not obscured by the cursor block. The cursor may be moved back and forth at will to modify any position on the line.

M allows any set of locations to be examined and modified byte by byte. A useful display feature has been included here, whereby consecutive locations treated in this way are listed vertically down the screen rather than being confined, as with the old monitor, to a one-line display. The vertical line scrolls when it reaches the bottom of the screen, leaving the register line intact. M can also be used to search through any designated memory block for all occurrences of a particular byte. Each occurrence, with its address, is listed on the screen, and at the end the total number found is displayed.

V allows a formatted block of memory to be displayed—with scrolling if the block does not fit onto the screen. The scroll rate may be very conveniently slowed down, as for BASIC, by the use of SPACE.

B allows a block move of data in any direction. The start and end addresses of the block to be moved are given, along with the new start address for that block.

S and L have been described in the Tape Handling section above.

Breakpoints are implemented, for debugging, to allow either a branch out to the machine code monitor, or to an address specified by the user—again, maximum flexibility being the watchword.

Finally, the RS232C output of the machine may be used after the delay, and other cassette-priority routines, have been disabled by:

POKE517,255

This allows a serial system printer to be used under program control, instead of the parallel printer referred to earlier.

CONCLUSION

In addition to the above facilities, there is a very large number of subroutine entry points and functional locations included in the manual. It is fair, therefore, for the manufacturers to claim that WEMON is able to satisfy both the beginner's need for an easy to use system, and the experienced user's need for maximum flexibility and utilisation of the system offered. The version of the manual used for this review was a pre-production copy of the document, and many changes have since been incorporated; however, most of the functions are quite adequately described, and the hardware modifications well sketched.

It is inevitable that a comparison will be made between this monitor and the ever increasing number of UK101 type monitors flooding into existance. It is impressive to note that *bit for bit* this has been priced to be the cheapest monitor around; and, as it is implemented efficiently on a 4K (bytes) EPROM, it is inevitably the most sophisticated.

It was suggested that there is a user-settable location in the machine code monitor, which the machine branches to, allowing extra commands to be added, although this was not apparent in the reviewed version of the manual.

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Semiconductor UPDATE...

FEATURING CY 500 LM330

R.W. Coles

STEP THIS WAY . . .

Apply a voltage to an ordinary electric motor and it will immediately start to accelerate, remove the voltage and it will eventually slow down and stop. Suppose you want the motor to move through *exactly* 37 degrees and then stop dead. Impossible, unless you use gears and an electronic servo loop which monitors the position and speed of the output shaft and controls the applied voltage accordingly. Even in a full-blown servo of the sort used in proportional radio control systems, precise angular movement and positioning is difficult, and relies to a large extent on the skill of a human operator. The rate of acceleration is set more by the need to prevent "hunting" than by any other factor and is not normally controllable by the operator.

It was to overcome these sort of positioning and control problems that the "Stepper Motor" was developed, and since its introduction it has found application in a wide range of industrial systems, particularly those controlled by computers or microprocessors. The Stepper motor has several coils, commonly four, and these are switched on or off in a fixed pattern such that each change in the pattern causes the motor shaft to move through a clockwise or anti-clockwise step of a fixed angle determined by the motor design. Each coil is either switched on or switched off, so there is very little power dissipation in the driver circuitry and control of the pattern can be easily handled by a computer or a microprocessor. By rotating a pattern of ONEs and ZEROs, the controller can make the motor move through any number of precise angular steps, in any direction, at any speed and with precisely controlled acceleration and deceleration rates. All this is done *without* the need for a feedback servo loop, and with quite smooth operation at the higher rates.

If steppers are so marvellous, you may ask, why aren't they used universally? Well, for a start, you do need a computer-type controller, and it is only with the advent of the microprocessor that this has become an economical proposition. Secondly, they *are* becoming increasingly common in all sorts of lower cost applications. Many of the cheap printers on the market take advantage of the precise control possible with steppers and microprocessors to replace the expensive sets of cogs and levers and cams which used to do the same job.

. . . WITH THE CY 500

If you have a pet micro you can hook a few power transistors onto an output port, and, by writing a few machine code routines, you can have a stepper motor obey your commands. Full control over the motor speed, direction, acceleration, and position is certainly possible by this method, but you will spend many a happy week writing the code, and when the micro is busy stepping out, it won't be able to do anything else. A new device from a firm called Cybernetic Micro Systems can make the job much easier, and it also represents an interesting new breed of "Microprocessor components", based on standard single-chip microprocessors with programmed-in software.

The CY 500 is described as a Stored Program Stepper Motor Controller, and it comes ready programmed to perform 22 special high-level stepper motor functions such as "Set rate of stepping", "Set slope of acceleration", "Declare zero reference position", "Begin Stepping", "Wait", "Execute", "Set clockwise", "Set Anti-clockwise", etc. etc. A complete program loop using up to 18 of these commands can be loaded into the CY 500 for automatic execution, or instructions can be passed and executed one at a time. Any serious application would probably use the CY 500 as a peripheral device to assist an existing microprocessor, but for evaluation and learning purposes the CY 500 can be connected directly to a parallel ASC11 keyboard, and commands entered using single letters followed in some cases by numerical parameters. Once a command letter sequence has been entered, typing the D command will cause immediate execution.

Various control inputs and outputs are available on the CY 500 chip in addition to the 4 motor "phase" lines and the 8 bit data bus, making the CY 500 adaptable to just about any application imaginable. If only a small stepper motor is to be controlled, a single additional chip such as the Sprague ULN 2823A high voltage driver array can be used as the motor interface. Larger motors will need power transistors to handle the high current pulses. The CY 500 comes in a 40 pin package and runs from a 5 volt supply. It is available in the UK from: Data Plus Ltd., Cheltenham.

POWER MISER

Have you ever needed a 5 volt supply, for MOS or TTL circuitry perhaps, which had to be derived from batteries? If power consumption and battery size have to be minimised, this apparently simple requirement can turn out to be quite a headache!

The first thing you consider is using a 6 volt supply and a regulator—then you discover that 5 volt regulators need an input voltage of around 7·5 volts for correct operation, so you increase the battery voltage to suit. Then you realise that you will have to waste 50 per cent more power than you actually need for the logic, just to heat up a silly regulator—there must be a better way! Next, in a moment of bravado, you decide that the high efficiency of a switching regulator is what you need, only to discard this idea when you realise that it will mean going into the coil-winding business and some rather hairy design calculations, too! At this point, if you are like me, you either give in and chance running the logic at 6 volts straight from the battery (very naughty!) or you put up with the extra consumption and use an LM309 running from 7·5 or even 9 volts.

You may be pleased to know that in future you will have another, much more satisfactory, option in the form of a new voltage regulator from National Semiconductor, the LM330.

You see, the problem with the *existing* voltage regulator devices, is that they all rely on NPN transistors to do the regulating, and that means the series-pass transistor operates as an emitter follower, often a compound emitter follower, and that in turn means that the voltage at the base of the series pass element has to be well above the output voltage due to base-emitter drops. Add a bit more for the current sources used as load resistors, and you don't get much change out of 7·5 volts, especially when the regulator is cold.

Now i.c. designers are not just *perverse* in sticking doggedly to NPN emitter followers when a PNP common emitter configuration could solve the problem better, the fact is that PNP transistors are very difficult to fabricate on an i.c., and so this option has not really been available.

The LM330 is different because National have solved the problem of fabricating efficient PNP transistors on integrated circuits by using deeper diffusions to produce the so-called deep-base PNP. Using the deep-base approach National get the drop-out voltage on this 5 volt regulator down from about 2·5 volts for the NPN types to just *half a volt* for the LM330. So you can use a 6 volt battery and its terminal voltage can drop to less than 5·5 volts before the LM330 gives up! Some sacrifices have been made, because the full rated current specification is only 150 mA, a lot less than the NPN types but usually sufficient for battery applications. Protection is built in against thermal overload, reverse battery connection, input voltage transients, and even mirror image insertion of the package.

The LM330 lives in a TO 220 plastic power package, and it should be quite inexpensive when it arrives on suppliers' shelves within the next few months.

FRANK W. HYDE

COMMUNICATION CONGESTION

Commercial communication may be seriously threatened within the next decade because of lack of bands of frequencies required for domestic video and voice data slots. The two bands allowed for these purposes are the C band (6/4GHz) and the K_u band (14/12GHz). In the C band at the beginning of the year two slots only were left. At that time the FCC (Federal Communications Commission) of the USA had authorised 20 more launches, in addition to the nine in operation, between 50deg. W long. and 150deg. W long. This will exhaust the C band slots for geosynchronous orbits. On this basis there would be no further parts of the band available by the 1990's.

The National Aeronautics and Space Administration (NASA) have put forward a possible solution, though this is a long term matter. Nasa suggests that the K_a band (30/20 GHz) should be developed, using commercial satellites. They are preparing a demonstration of the system using several ground stations and with a spacecraft to be launched on the shuttle about 1987. If this is successful it will be possible to make use of the narrower band width and would allow the spacecraft to fly closer together without mutual interference. To this end experimental work is already under way to alleviate the problems by the study of multibeam antennas.

The multibeam antenna allows a number of spot frequencies in narrow beams to be used without interference. On-board switching would enable the spot beams to be interconnected so that signals could be switched from downlink to uplink in any combination. This technique is not new of course except at the frequences proposed. High power transmitters would be used in the satellites at the frequencies considered together with low noise on-board receivers. Owing to the effect of rain which restricts operation on the K_a band, the links between ground stations would be by microwave and or fibre optics.

The K_u band is fully available and it is expected that there will be sufficient slots available. It has of course the advantage that the aerials can be mounted on normal buildings in crowded areas. However, the possibility of fading due to rain would still be present. Nevertheless this is an important step in combating the band difficulties. A number of companies are engaged actively in the production of satellites and equipment undaunted by the difficulties.

ACTIVITIES OF THE USSR

During 1980 the Soviet Union launched more manned missions than in any year of their space history. The six-manned flights of 1980 also included the longest operation of astronauts so far in space. Their record will no doubt soon be surpassed by themselves. It confirms that the Russians continue to be set now on the path of space station operation. They have in fact now achieved more than double the manhours of the USA spent in space. In addition to the manned missions, automatic tankers to refuel and restock the Salyut–6 were operated. There were fewer missions in 1980 devoted to scientific activities, in favour of military projects.

In 1979, 74 military missions were known to have operated. In 1980, no less than 85 spacecraft were launched. It is understood that they continued the policy of flying two man crews for six month shifts with the addition of short period additions of crews from other parts of the world and satellite countries of the Soviet Union. There is also the possibility of guest astronauts from France participating in missions.

Salyut–6 is to be replaced by Salyut–7. This was originally planned for 1980 but the serviceability justified continued use and indeed there may be some manned activity this year. The new three man Soyus–T transport will add considerably to the versatility of these vehicles. The Russians also plan to send scientists and engineers to do active experimental work and to be free of piloting duties.

Another development is that they have demonstrated their ability to operate Soyus–T spacecraft in a way that allows the orbital modules to be left before re-entry takes place. This presents the possibility of leaving the orbital module docked with the space stations. This would necessitate the provision of more docking points. It is readily appreciated when looking at the models in the permanent space exhibition in Moscow that it is possible to extend space stations both vertically and horizontally like a Leggo construction kit.

The large antenna that was deployed in 1980 paves the way for space building and it can easily be seen that with little additional skill, the possibility of large platforms such as the proposed Satellite Power System, measured in kilometres in extent, is within the immediate future. With their development of large boosters and their already active work with a re-entry winged vehicle, they could have a space station to support ten or more crewmen on a permanent basis. All this opens up new vistas for the USSR. No doubt there will be military advantages and the new booster will enable geostationary activity to be advanced.

The lag behind missions are given here as known in late March 1981. For example, the GAIS military communications satellites, a group of four vehicles, the first of which should have been launched in 1979. The four positions planned are at 25deg. W long., 85deg. E long., 45deg. E long., and 170deg. W long. The frequency allocated for these satellites is in the 8·7GHz band. A mission that has been delayed also is the Viona communications system. These satellites consist of a group of 7 units and would provide a service similar to that of Marisat.

There seems to be a possibility of delay on another new system called Louch. It is believed that this consists of spacecraft positioned round the world to compete with the Intelsat 5 system. The frequencies of operation are said to be 11GHz downlink and 14GHz uplink. Six Molniya craft were launched during 1980 but it seems that two at least are failures. A number of other missions were flown during 1980 and many are presumably vehicles that play a dual role—that of part research with alternative military use. During 1980 all but one of the spacecraft were launched from Plesetsk.

Most projects in 1980 were increased in number compared with the same types launched in 1979. It is possible to see the pattern of the Soviet thinking by a study of the disciplines involved.

THE HALLEY COMET MISSIONS

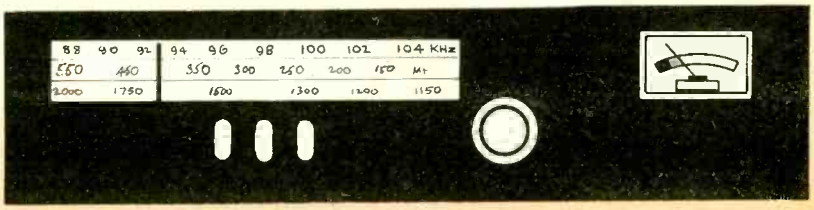
Three separate missions are to be attempted by the European Space Agency, the USSR and Japan, for a comet encounter. A meeting has been arranged to set up the necessary requirements for the pooling of the data obtained. The present plans for the encounter would mean that the Soviet comet probe would arrive shortly before the ESA spacecraft, the Giotto. Pictures taken by the Soviet vehicle could be useful for correcting the Giotto to best position perhaps even closer than the planned target distance of 1,000km. Russia has revised the strategy for the Venera unmanned mission to Venus by including a probe to be released from the Venera in mid 1985 to an encounter of the comet within a distance of 10,000 to 50,000km. Japan's project is designated "A" with no other details available at the moment.

THE SOLAR POLAR MISSION

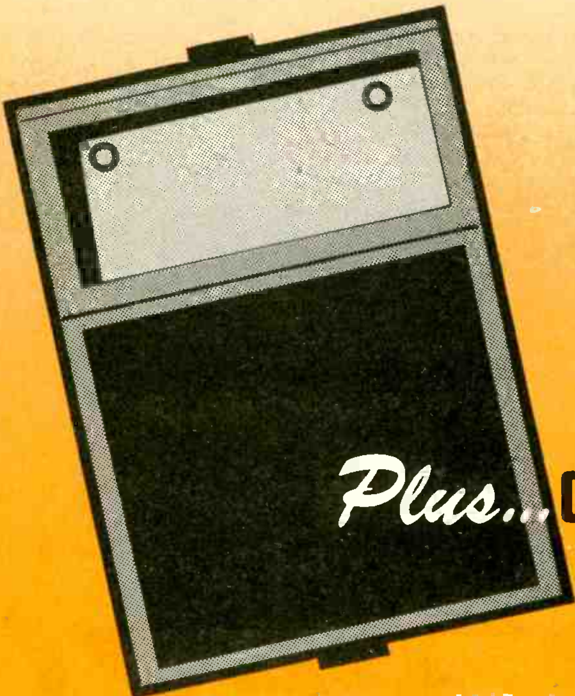
As was forecast in the last issue of *Spacewatch* there has been sharp reaction to the cut-back of programmes by the United States affecting the NASA cooperative mission with ESA. The Director General of ESA, Erik Quistgaard, has urged each member State to make the approach of protest at ambassadorial level in the first instance. The NASA/ESA memorandum of understanding covering the cooperative activities which included return flyby Jupiter secondary missions were regarded as essential. Since the agreement was signed in March 1979, a number of alterations have been made from the US side including delays because of shuttle troubles. Rather bitterly a European official said ". . . we did not expect these things to happen because of the cancelling of funding and not in this way . . . it seems that the US do not realise the importance of honouring international commitments".

NEXT MONTH...

PE QUASAR AM/FM STEREO TUNER



Our PE Quaser stereo tuner has been designed around a set of Mullard modules. It is a straightforward, easy to build unit and represents excellent value for money.



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MINITUNE

MARTIN KENT

FREE CASE PROJECT

DP400 Minitune for r.p.m., dwell, voltage and resistance testing

THE DP400 Minitune is a versatile car tester incorporating voltage, resistance, r.p.m. and dwell angle measurement ranges. Using the LE DPM200 panel meter and the special instrument case, an accurate and highly compact instrument may be easily constructed using a few additional components. The specifications listed below make the Minitune extremely useful for fault-finding in automotive electronics and for tuning an engine for better efficiency and reduced fuel consumption.

SPECIFICATION

Function	F.S.D.	Resolution	Accuracy
Voltage (d.c)	20V	10mV	0·5% ± 1 digit
	200V	100mV	0·5% ± 1 digit
Resistance	200Ω	100mΩ	0·5% ± 1 digit
	20kΩ	10Ω	0·5% ± 1 digit
R.P.M.	20,000r.p.m.	10r.p.m.	1% ± 3 digits
Dwell	90°	0·1°	2% ± 3 digits

CIRCUIT DESCRIPTION

The *PE* Microtune featured in the December 1980 issue has proven to be a very popular instrument for laboratory or automotive use and response from readers has indicated an additional need for a compact automotive-dedicated tester which may be kept in the toolbox. The recent sharp increase in the cost of petrol emphasises again the need for correct car maintenance if fuel costs are to be minimised.

The circuit diagram of the Minitune is shown in Fig. 1 where ME1 forms the 200mV full-scale meter.

Function switching is provided by S1 and range switching by S2. The voltage ranges are provided by switched outputs from the attenuator formed by R1–R4 which are metal film types for good stability. Voltage-dependant resistor R21 is included to suppress any transients appearing at the terminals by rapid clamping to low resistance.

For resistance measurement, the ratiometric method is used such that the resistance to be measured is displayed as a ratio of an internal reference resistor, providing direct display without the need for any calibration adjustment. Thermistor TH1 and transistor TR2 are included to protect the panel meter from the accidental application of high voltage to the input terminals, when measuring resistance or checking continuity. The resistance of the positive-temperature-coefficient thermistor will rapidly increase when TR1 turns on and shunts current through the thermistor, so reducing the input current to a safe value.

In order to minimise current consumption of the instrument, the r.p.m. measurement circuit incorporates a CMOS timer, IC1, configured as a monostable. The Common Pin of ME1 is established at typically 2·8V below supply positive, enabling the CMOS timer to operate using Common and supply positive as the supply connections as it will operate on supplies as low as 2V with consumption of 80µA. When a negative going pulse appears on pin 2 of IC1 a positive going pulse appears at pin 3, with duration 0·69 R14 C1. The output pulses are smoothed to a d.c. voltage by R9, R10, C5 and since the pulses are of constant duration this voltage is proportional to the input pulse rate.

The r.p.m. circuit is triggered by connecting Input LO to vehicle chassis and Input HI to the ignition coil L.T. trigger point.

For a four-stroke engine, the distributor shaft rotates at half the speed of the crankshaft and it can be shown that r.p.m. is related to the contactbreaker pulse rate by the equation:

$$\text{r.p.m.} = \frac{\text{pulse/min.} \times 2}{\text{Number of cylinders}}$$

Engine r.p.m. is therefore proportional to the pulse rate appearing at the L.T. trigger point, and accordingly the d.c. output from IC1 which is calibrated accordingly.

Pulse shaping and clamping circuitry is added to protect the CMOS input of IC1 from transients produced by the ignition coil inductance.

DWELL MEASUREMENTS

To simplify use of the Minitune, dwell measurements are made using the same connections to the vehicle as required for r.p.m. measurements. Dwell angle of a distributor is the angle through which the contact breaker cam rotates whilst the points are closed. To ensure correct combustion the dwell angle adjustment is very important and may be measured by comparing the points open time to points closed time or duty cycle.

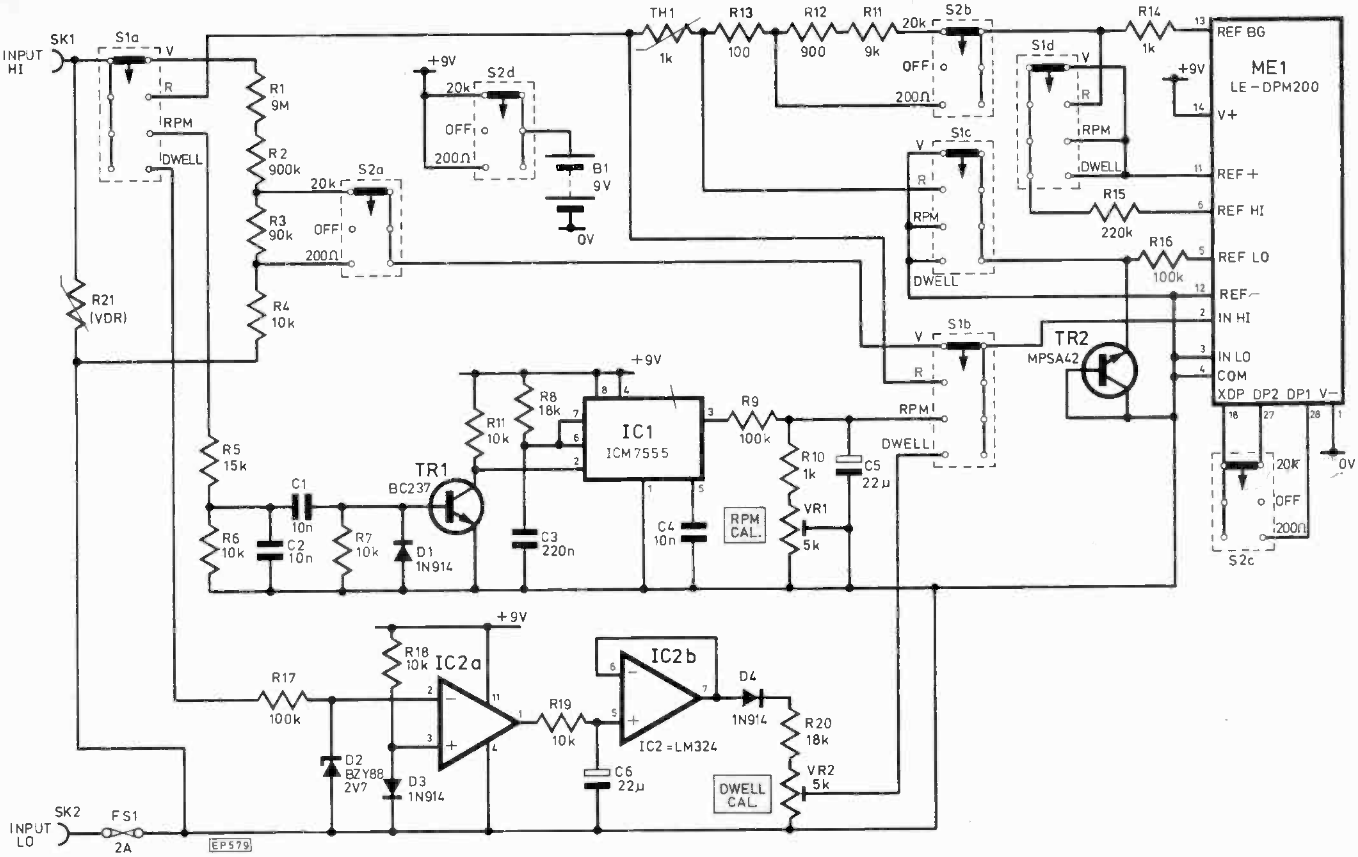

Fig. 1. Circuit of Minitune

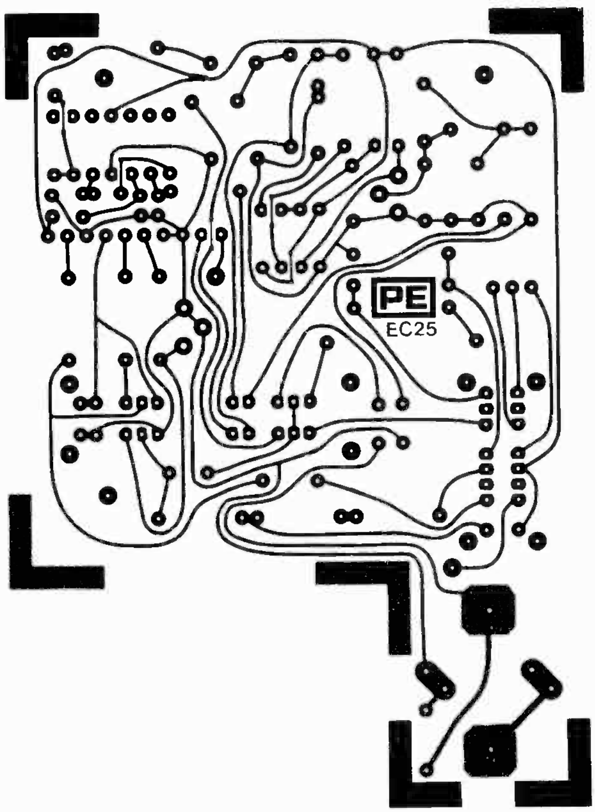

Fig. 2. Printed circuit board

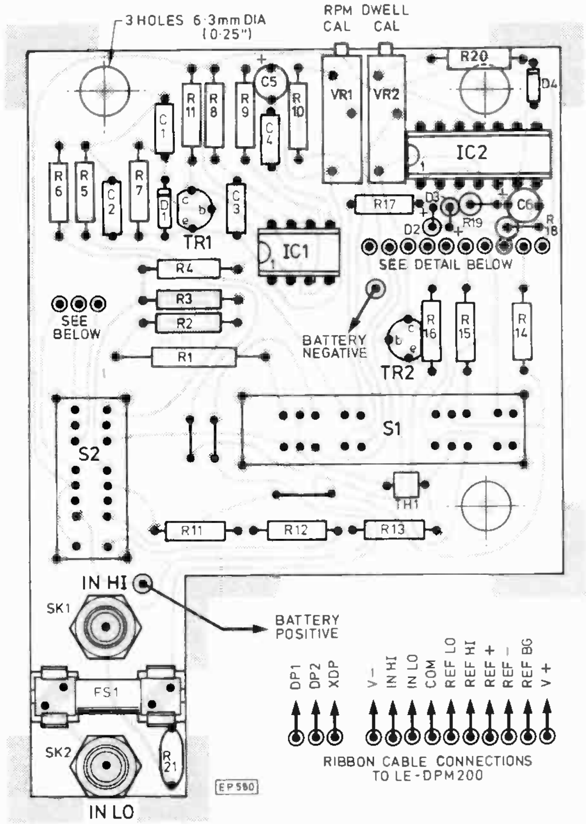

Fig. 3. Component overlay

COMPONENTS

Resistors–

R1	9M	Metal film 0·25%
R2	900k	
R4	10k	
R5	100k	Carbon film 5%
R6	10k	
R7	10k	
R8	18k	
R9	100k	
R10	1k	
R11	9k	Metal film 0·25%
R12	900	
R13	100	
R14	1k	Carbon film 5%
R15	220k	
R16	100k	
R17	100k	Carbon film 5%
R18	10k	
R19	10k	
R20	18k	
R21	400V	VDR

Variable Resistors

VR1	5k preset
VR2	5k preset

Semiconductors

D1	1N914
D2	BZY88 2V7
D3	1N914
D4	1N914
TR1–TR2	MPSA42
IC1	ICM7555 (CMOS)
IC2	LM324

Miscellaneous

S1 4 pole 4 position slide switch.
S2 3 pole 3 position slide switch.
TH1 1k PTC thermistor.
ME1 LE DPM 200 panel meter module.
Case.
P.c.b.
4 mm p.c.b. mounting terminals (2 off).
Ribbon cable.
Self M3 screws.
PP3 battery and connectors.

A kit of components (excluding the DPM200 and case) is available at £14·95 (inc. VAT and p&p) from **Lascar Electronics Ltd., Unit 1, Thomasin Road, Basildon, Essex SS13 1LH.**

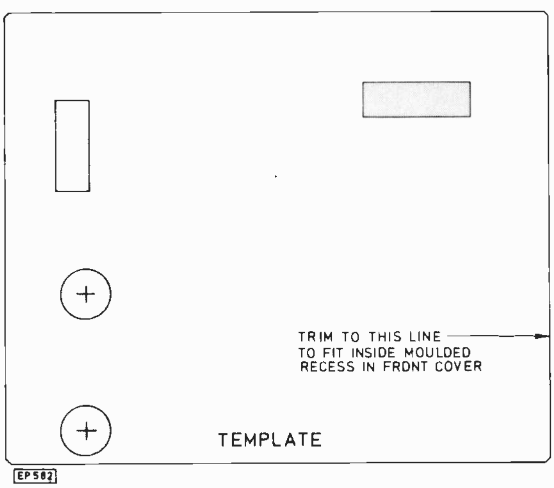

Fig. 4. Front panel template

A four cylinder engine has four distributor cam lobes spaced 90° apart which represents the maximum possible dwell angle. In practice the dwell angle is usually slightly less than two thirds the cam lobe angle.

$$\text{Dwell angle} = \text{cam lobe angle} \times \frac{100\% - \text{Duty Cycle}}{100\%}$$

The first stage of IC2 acts as a comparator with preset triggering threshold. The pulse output of IC2a is an inversion of the input pulses such that the points closed time is active "high". The pulses are averaged to produce a d.c. voltage proportional to dwell angle for input to the panel meter.

CONSTRUCTION

Construction of the Minitune is very straightforward and the component layout is shown in Fig. 2. Resistors and capacitors should be soldered in place first followed by the semiconductors and taking particular care with CMOS IC1.

Switches should be pushed down onto the p.c.b. as far as possible and checked for perpendicular positioning before soldering in place. The fuse clips and terminals should now be soldered in place.

Ribbon cable connects the panel meter to the p.c.b. and the battery connector should then be soldered in place.

TESTING AND CALIBRATION

With the instrument switched to the 20V range the display should read 0·00 and voltage measurements should not require calibration if the correct attenuator resistors have been used.

When switched to resistance ranges and the inputs open circuit the display should indicate a 1 in the leading digit with the other digits blanked which is the over-range indication. When the input terminals are shorted together, the display should read zero except on the 200 ohm range where there will be a small offset due to the fuse and switch resistance.

PULSE GENERATOR

The r.p.m. section may be calibrated using a pulse generator. Referring to the earlier equation it will be evident that a 50Hz input pulse rate corresponds to 1500 r.p.m. A low secondary output mains transformer may be used by rectifying and clipping the output. With 50Hz input VR1 should be adjusted until the panel meter reads 1·50.

To calibrate the dwell section a pulse generator with variable mark/space ratio is preferable but a 50Hz square wave source is a useful substitute. VR2 should be adjusted until the display reads 45·0 with an equal mark/space ratio input. With the input open-circuit the display should be approximately 90·0.

The Minitune is now ready for use and the p.c.b. may be screwed in place, then the panel meter located in the case and the case clipped together. The dwell and r.p.m. readings should be multiplied by two-thirds when used on six-cylinder engines and by half when used on eight-cylinder engines.

USING THE MINITUNE

The DP400 Minitune enables accurate measurements to be carried out and can be used to set the idling speed and dwell angle in accordance with manufacturers' specifications. In addition, a wide range of tests may be carried out including points, coil, air cleaner and air/fuel ratio mixture. Reference should be made to a workshop manual and/or *PE* January 1981 issue.

Note: the interior cutting details of the case are identical to that shown in the continuity meter article.

Strictly Organ

by K. Lenton-Smith

TAKE a successful business man with a passion for something quite outside his field, add some experts to develop the ideas and you have the start of something destined to prove interesting.

Frederick C. Lowrey, who died in 1955 aged 85, firmly believed that music was a 'purifying and uplifting force' and set himself the task of developing an electric instrument capable of reproducing the pipe organ as closely as possible. Although he never played the organ, he knew organ music and became thoroughly familiar with the technicalities of the instrument itself. Once he had set himself on this course there was no turning back and he never regretted the time and money spent on the process.

At the age of 16 he started up in business, selling pots and pans from a horse-drawn 'shop' and in 1894 founded Central Commercial Investment.

In the early years of this century, Lowrey had seen the Cahill organ installed in the Telharmonic Hall, New York City. The Eastern Cahill Telharmonic Company made arrangements with the telephone company to meter music to subscribers. Mark Twain was one of the first to have his home wired for organ music by telephone. The musical notes were produced by a series of alternators and, as there was no known means of electrical amplification at that time, a handset was the only method of hearing them. Unfortunately for that company, Henry P. Morgan (a leading industrialist of that era) had difficulty placing an important business call and such was his influence that he put a stop to music by telephone.

The next electrical instrument presented to the American Public was the Choralcello, originally made in Boston, Mass. In 1918, Frederick Lowrey took over its manufacture and moved the factory to Chicago. This instrument derived its tones from piano strings which were vibrated mechanically and had either one or two seven octave keyboards. Lowrey's next essay was the purchase of an organ from a Californian inventor: he had the instrument delivered by boxcar and set up in an abandoned theatre in Chicago. This organ had vertical, resonator pipes with diaphragms near their bases which were made to vibrate at given frequencies. Though smaller than a pipe organ, it proved to be too large for a home or small chapel.

During the 1930s, Lowrey continued his quest, buying patents and employing inventors, engineers and musicians. His team at Central Commercial experimented with generators of every known type — rotary magnetic, rotary electrostatic, gas discharge tubes and valves — during this decade. Their final choice was valve generators because no moving parts were involved and rich waveforms were available.

ORGANO

For the duration of the second world war, U.S. Government controls forbade the manufacture of musical instruments and purchase of electrical materials that were not essential to the war effort. Even so, Lowrey's first successful venture was the *Organo*, conceived by his associate Mr. Koehl and demonstrated at the 1941 Music Merchants Trade Show in New York by the fabulous Ethel Smith.

The Lowrey Organ Division of Central Commercial produced this instrument, which added the facilities of a single manual organ to an ordinary piano. The electronics—speaker, amplifier and generators—were housed in a single cabinet alongside the piano, an interconnecting cable carrying signals from switches under the piano keys. It was a divider organ with twelve LC master oscillators based on 12AX7 valves, each with its string of four 12AU7 bistable divider stages. The keyboard could be 'split' and vibrato applied overall. A simple tone forming system allowed the player to choose combinations of Principal, Horn and String at several volume levels.

Lowrey Organs were now well under way. Their first spinet model, the *Berkshire* was produced in 1954 and its voicing principles are still used in current models. In the following year, Frederick Lowrey died and, as the organ operation was foreign to its businesses, Central Commercial sold Lowrey Organs to the Chicago Musical Instrument Company.

Lowrey's new owners continued with the same vigour shown by the pioneer himself. 1956 saw the first spinet organ with sustain, chimes and glide—the *Lincolnwood de Luxe*. The *Holiday* and *Heritage* series of organs were initiated and in 1962 the company was first in the field with AOC. This feature—Automatic Organ Computer—will add full chords to a single note melody, according to left hand harmony. Runs of chords otherwise impossible to finger make it still a popular feature today.

In the 1960s, with Lowrey team were first in producing instruments with built-in Leslie speakers and chorus reverberation. In 1965, with the advent of more reliable silicon devices, valves were replaced by transistors. In the last decade, Golden Harp (automatic arpeggio), String and Brass Symphonizers were fitted to Lowrey models and the company was collaborating with i.c. manufacturers in designing Top Octave Synthesizers and other LSI devices.

MX1

Frederick Lowrey's dream of providing the public with convincing sounding organs would have made him proud of 1981 models, though they offer far more than organ tones. At the top of the range is the MX1, which Lowrey say almost defies description, but I will have to try just the same! This is a one man band with total realism—by means of a perfect marriage between microprocessor/computer and orchestral voicing.

'Orchestration Plus' is a feature offering the choice of twelve pre-progammed, fully orchestrated backgrounds against which to play the solo on an almost unlimited number of upper keyboard registrations. The orchestrations are Big Band, Contempo, Polka, Country, Jazz Guitar, Rock, Blue Grass, Baroque, Rhythm Guitar, Disco, Waltz and Latin. Variations can be applied: for example, Big Band is programmed to play trumpets, trombones and string bass, but saxophones can take over. The fidelity of the instrument sections is such that nothing short of the highest praise is due to Lowrey's engineers.

Eighteen digital stereo rhythm patterns are available and there are three synthesizers. The Orchestral Symphonizer is polyphonic with brass, reeds and percussive tones, all of which may be coupled down to the lower manual. The Solo Symphonizer is monophonic but can be used with other polyphonic voices, whilst the Custom Symphonizer allows the player to set up his own voicing by means of envelope and filter controls.

Orchestral Percussion provides not only the usual second and third harmonic effects but also chimes and vibraphone among its nine effects. Golden Harp arpeggiates over three octaves and may be used in conjunction with Orchestral Percussion. A string synthesiser processes cello, viola and violina and the mixture can be channelled through Sterophase Chorus Celeste for a Mantovani effect.

AOC is present and, in addition to the many tab controlled voices on each manual, Custom Flute presets allow these tones to be mixed by sliders in drawbar fashion. (It is interesting to note that Lowrey have their form of Hammond drawbar, while Hammond have their version of AOC, called 'Pro Chord'!) Magic Genie chords are fitted with the beginner in mind.

Lowrey's claim that this is the 'ultimate organ' is certainly justified at present—and it would be good to be able to write the cheque for just under £14,000 to buy it. With technology advancing rapidly, one wonders what the back room boys will come up with next!

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NEXT to temperature measurement, pH measurement is one of the most widely used in many areas of science. pH is a measure of the concentration of hydrogen ions in a solution and is effectively a measure of acidity. Absolute measurement of pH and the monitoring of its rate of change is important in chemistry experiments but pH measurement is also of importance to the food and drink industries, to aquarists to prolong the life of tropical fish and to gardeners who use lime to control soil acidity and improve plant growth.

The DP300 pH meter provides accurate measurement of pH values in the range 0 to 14pH with resolution of 0·01pH.

MEASUREMENT OF pH

The value of pH is defined as:

$$pH = \log\frac{1}{[H+]}$$

where [H+] is the hydrogen ion concentration in the solution.

Pure water at ordinary temperatures dissociates slightly into hydrogen ions and hydroxyl ions $[H_2O \rightleftharpoons H^+ + OH^-]$, the concentration of each type of ion being 10^{-7} gram-molecules per litre, the pH value of pure water will be:

$$\log\frac{1}{10^{-7}} = 7$$

This figure is therefore taken to represent neutrality on the pH scale.

If acid is added to water its hydrogen ion concentration will increase and its pH value will therefore decrease. Acidity is indicated by pH values below 7, and alkalinity is indicated by values above 7.

Acid has the effect of liberating hydrogen ions in solution and one of the traditional tests for acidity is to use litmus paper. Generally acid reacts with litmus paper to turn it red, whereas alkali turns litmus blue. For accurate measurement of pH electronic methods are universally used. A simple pH probe consists of two electrodes between which a potential difference is generated when they are immersed in the solution under test. Probes are constructed on the principle of a galvanic cell with output proportional to pH value. The output is very small and a certain amount of care is required in its measurement.

CIRCUIT DESCRIPTION

The DP300 pH meter has been designed to operate with a laboratory grade probe which will be made available to PE readers. The circuit of the instrument is shown in Fig. 1 and requires few components in addition to the LE-DPM 200 panel meter.

The pH probe is fitted with coaxial cable, to protect the electrode potential difference from r.f. pickup, and connects to the instrument via plug and socket.

Operational amplifier IC1 forms a unity-gain voltage follower which presents very high impedance of typically 10^{12} at its non-inverting input to produce negligible loading of the electrode.

Amplification is provided by VR3 and a reference voltage is adjusted by VR4 such that with zero input from the electrode a reading of 7.00 is obtained on the panel meter.

CONSTRUCTION

The p.c.b. track layout is shown in Fig. 2 and it should be noted that the p.c.b. supplied from Lascar Electronics is coated to prevent ingress of moisture which could affect accuracy.

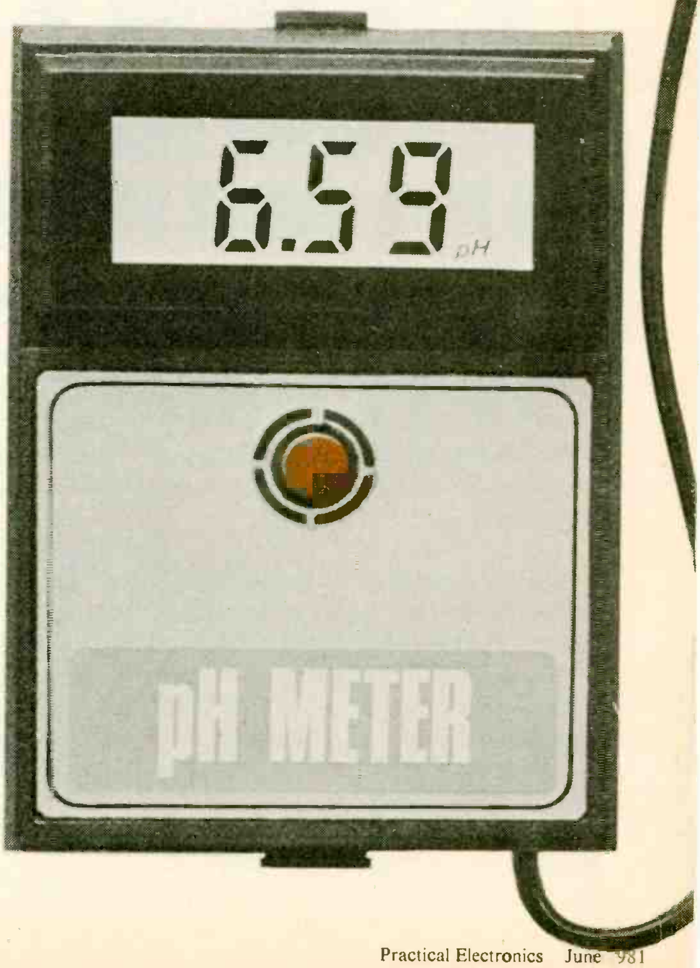
The component layout is shown in Fig. 3 and the assembly is straightforward. Link LKA should be omitted at

FREE CASE PROJECT

pH METER

THE DP300 DIGITAL PRECISION pH METER HAS A MEASUREMENT RANGE OF 0–14 pH ±0·01 pH

MARTIN KENT



** Please note the Front Cover and this photograph show the prototype pH meter.*

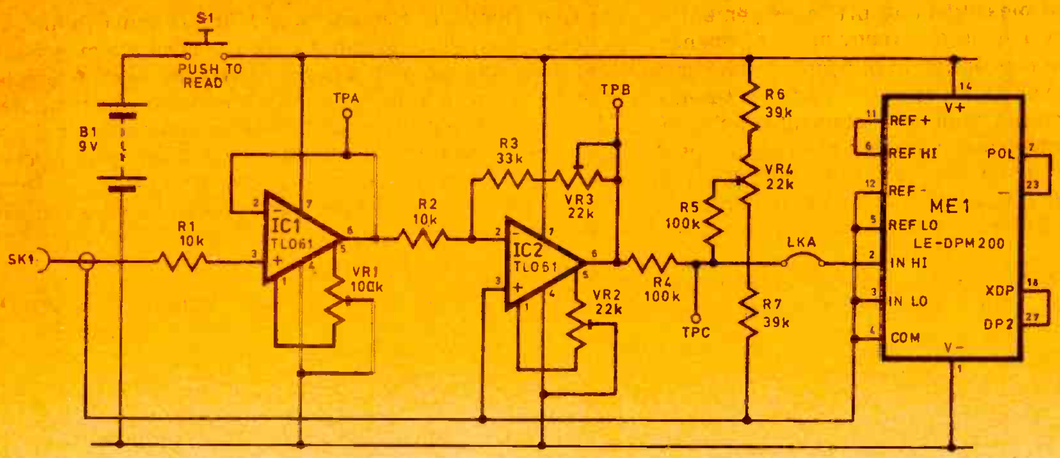


Fig. 1. Complete circuit diagram of the pH meter

this stage to ease the calibration. When all components have been soldered in place, the panel meter may be connected to the p.c.b. by the ribbon cable.

To ease the calibration of the pH meter it may be found worthwhile fixing the p.c.b. to the lower half of the case using the self-tapping screws.

CALIBRATION AND TESTING

The LE-DPM 200 is supplied tested and calibrated with 200mV, full scale and is used as a separate piece of test equipment when calibrating the pH meter to avoid the need for additional instruments.

When the p.c.b. assembly is complete, a battery should be connected to the unit and a piece of insulated wire approximately six inches long connected to the panel meter side of link LKA position on the p.c.b. The flying lead arrangement enables voltages around the p.c.b. to be monitored on the panel meter.

When the test lead is connected to the Input LO side of the coaxial socket the display should read 0.00.

Connect a shorting link to the coaxial inputs and connect the test lead to test point A. VR1 should be adjusted to zero the offset voltage produced by IC1. Now connect the test lead to test point B and zero the offset voltage of IC2.

Now connect the test lead to test point C and adjust VR4 to provide a reading of 7.00 on the panel meter.

Remove the test lead, insert link LKA on the p.c.b., remove input shorting link and connect the pH probe to the coaxial socket.

The probe is supplied with two calibration buffer powders of pH4 and pH7. The probe should be placed in buffer pH7

COMPONENTS . . .

Resistors

R1, R2	10k (2 off) carbon film 5%
R3	33k carbon film 5%
R4, R5	100k (2 off) carbon film 5%
R6, R7	39k (2 off) carbon film 5%
VR1	100k cermet multiturn preset
VR2, VR3, VR4	22k (3 off) cermet multiturn preset

Semiconductors

IC1, IC2, TL061CP (2 off)

Miscellaneous

ME1 Panel Meter LE-DPM 200 (See Special Offer)
Case
PP3 battery and connector
P.c.b.
Ribbon cable
Coaxial socket SK1
P.c.b. mounting switch
M3 self-tapping screws (4 off)

Constructor's Note

A laboratory grade pH probe with full operating instructions and pH4 and pH7 calibration powders is available at £22 (inc VAT) and a kit of components (excluding DPM 200 and Case) is available at £8·95 (inc VAT and p&p) from **Lascar Electronics Ltd, Unit 1, Thomasin Road, Basildon, Essex.**

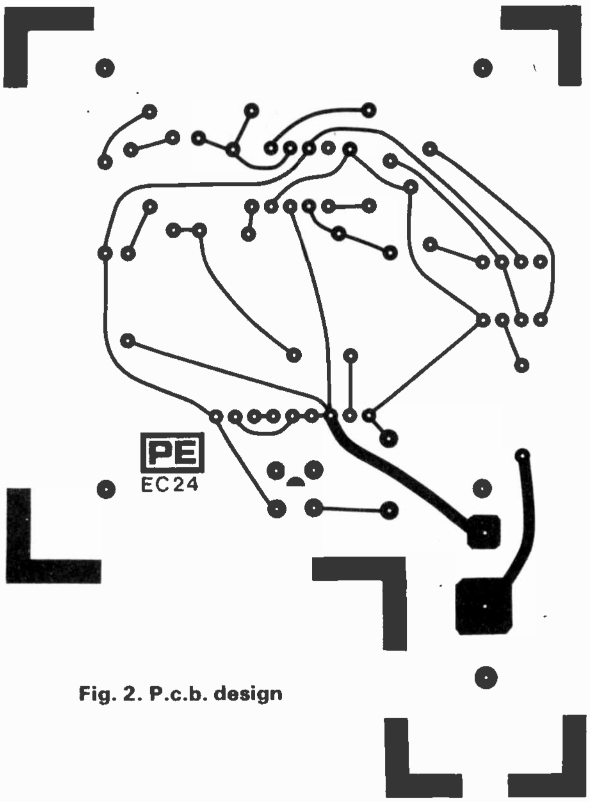


Fig. 2. P.c.b. design

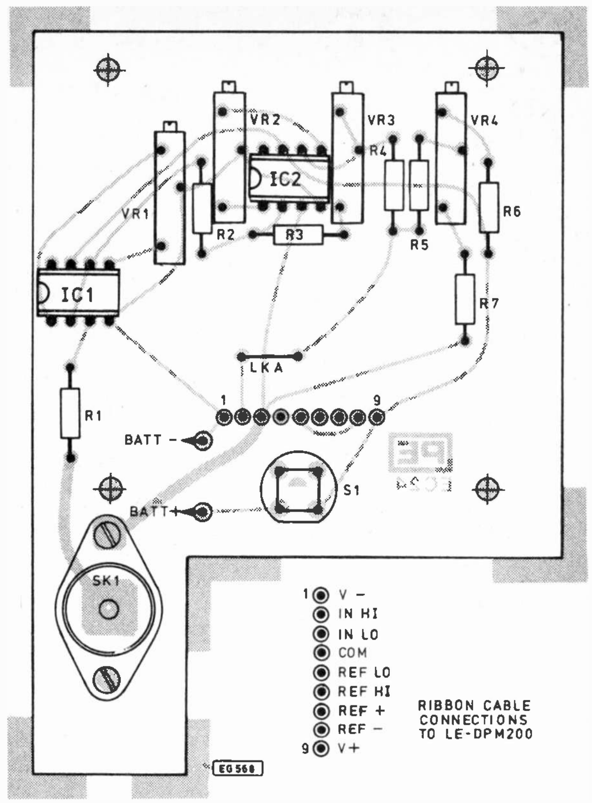


Fig. 3. Component layout

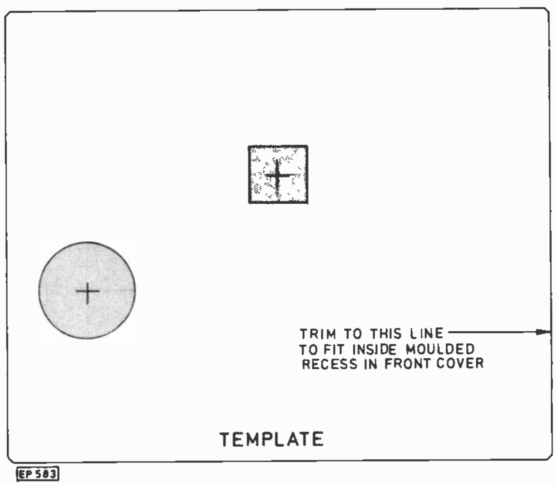
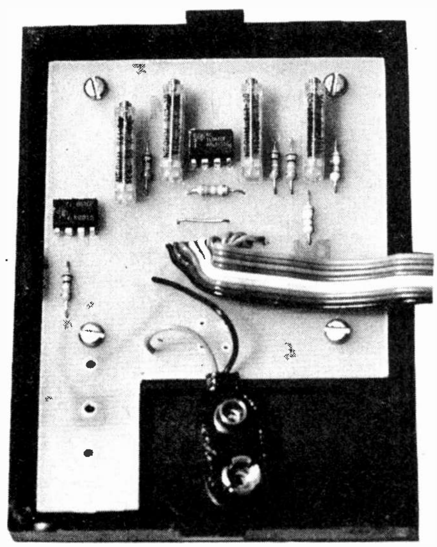
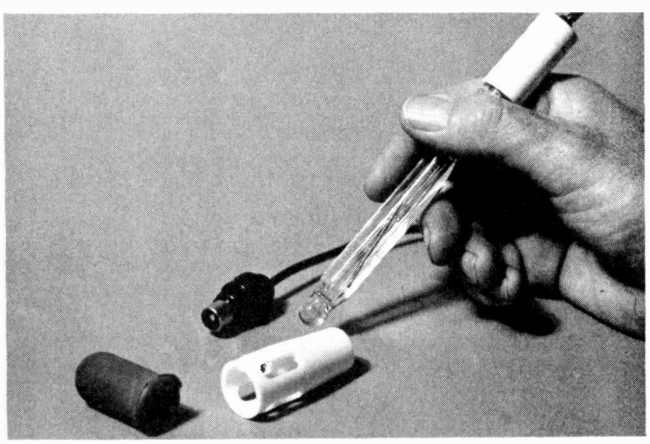


Fig. 4. Front panel template



Internal view of the pH meter



Probe assembly

solution and VR1 adjusted so that the panel meter reads 7.00. Rinse the probe in water and place it in buffer pH4 solution, adjust VR3 for a reading of 4.00. The front panel should then be drilled using the template shown in Fig. 4.

The instrument is now fully calibrated and the panel meter may be located in the top half of the case. The pH meter is ready for use for the measurement of other solutions at the same temperature and forms an ideal companion to the DP100 Thermometer.

★ The author gratefully acknowledges the assistance given by Barry James of the Aqua Chemical Co., Dover.

Readout...

A selection from our Postbag

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.

Rabbit, rabbit . . .

Sir—I simply had to put pen to paper in your defence. I feel that Mr. Bleck's criticism levelled at such a good mature-minded magazine just cannot be tolerated.

What I would like to know is: has Mr. Bleck checked all his electrical equipment for r.f. interference radiation, including his car, drill, washing machine, etc. After all, as Mr. Bleck doesn't like interference, why should his neighbours?

Mr. Bleck claims to have read so much about CB, and yet he knows so little about it. He says: "Every ten years or so it will become involved in some small way with a murder hunt . . ." Your magazine, plus all the *informed* readers will know just how many lives have been saved, and how many people have been helped by illegal CB already. Mr. Bleck also says that 99 per cent of the population is similarly disinterested. Just how naive can any person be? They say that ignorance is bliss—in Mr. Bleck's case, it is pitiful.

I have read and enjoyed your magazine for about 20 years, and have found it to be a very respectable magazine, which keeps its readers happy and informed. If Mr. Bleck had his way, it would no doubt be run on communist lines—i.e. if the Editor doesn't like it, it won't get printed.

I will go on reading your wonderful magazine even if you say things I don't agree with. Thankyou for letting me air my views, which I'm sure are shared by many other people.

R. S. Spencer,
Forest Hill.

Sir—I write in reply to Mr. Peter Bleck's letter printed in your April edition of Readout.

May I say that if "99 per cent of the population" are disinterested in Citizens Band Radio, as he so inaccurately claims, are the authorities that be (i.e. HM Government) bowing to the wishes of a one per cent minority? I doubt it.

Perhaps he should contact his local post office to help him locate the source of interference on his domestic equipment.

I would be obliged if you would print his full address, so that anyone who is interested in CB can send him a postcard to give him an idea of the support CB has. Nobody is asking him to like CB (I don't agree with foxhunting, for example)—but just to keep his childish outbursts to himself.

Ben Spencer,
Waddington.

Wonderful response

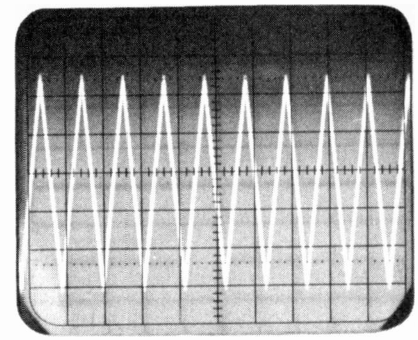
Sir—I am writing to let you know what a wonderful response I've had from an advertisement I placed in your magazine. I have been looking and hoping for a very long time that I could find someone who could build me a transistorised horn for use with my various model boats. Up until now, my search has been in vain.

Recently, I was advised to advertise in your magazine, and I'm very glad that I did—now three professional people are helping me with what I have been seeking to install in my boats.

Thankyou very much for your help and the wonderful medium that *Practical Electronics* has proved to be.

B. Clarke,
Eastbourne.

Oscilloscopes



....HOW THEY WORK

Part Three...Circuitry...by Ian Hickman

This feature is taken from the last two chapters of a new book by this well-known author. Published by Newnes Technical Books the paperback is entitled *Oscilloscopes. How to use them. How they work.*

THE circuit diagram of the trigger processing circuits, timebase and X deflection amplifier of a modern dual-trace 15MHz oscilloscope, recently introduced by Gould (formerly Advance Ltd.), is shown in Fig. 19. It is a good example of the tendency noted earlier of modern oscilloscope designs increasingly to incorporate integrated circuits while retaining discrete components for those circuit functions where they are more appropriate. The various sections of the circuit are labelled (e.g. ramp generator, X output amplifier etc.) and detailed operation is described below, as it is typical of modern oscilloscope practice.

The trigger source switches, S502 and S503, connect the required trigger signal via the trigger coupling switches, S504 and S505, to the trigger buffer amplifier formed by TR601 and TR602. S502 selects the differential CH1 signal via R313 and R314 from IC301. S503 selects the equivalent CH2 signal via R363 and R364 from IC351. Where both S502 and S503 are selected, both of the above signals are disconnected and the single-sided input from the EXT TRIG input socket SKC is selected.

When the a.c. coupling switch, S504, is out, the trigger signals are directly coupled-through, but when this switch is in, a.c. coupling is introduced via C603 and C604 (C601 on external). TR601 and TR602 form a differential buffer amplifier with the d.c. balance controlled by the trigger level control, R602. The differential output from this stage is applied to the comparator, IC602, which has positive feedback applied by R623 to form a Schmitt trigger circuit. The changeover switch, S506, reverses the output from TR601 and TR602 to determine the trigger slope.

When both S504 and S505 are "in" (a.c. and d.c. in for TV mode), the junction of R603 and C610 is connected to the −11V supply. D601 and D608 are brought into conduction, while D602 and D604 are reverse biased. This diverts the output of the trigger amplifier away from IC602 into TR605, which amplifies the positive tips of the waveform only. TR605 is prevented from saturation by feeding back the peak detected synch pulses via TR607 and TR606 to the emitter of TR605. These pulses are amplified by IC601b and applied via R617 and D603 to the Schmitt trigger, IC602. IC601a is used in conjunction with S504 and S505 to disable the sync separator when a.c or d.c. is selected.

At the fast timebase sweep speeds, S262a is open and TR603 is cut off. However at speeds of 100μs/cm and slower, R608 is connected to +11V and TR603 is switched on. This effectively grounds C609 to introduce an RC integrating time constant into the sync pulse signal path in the TV mode to separate out the frame trigger.

The square-wave trigger output from IC602 is applied (with d.c. bias of Zener diode, D605) as the clock to the D-type TTL flip-flop, IC501a. A positive-going trigger edge will clock the bistable, driving Q low. In the waiting state, Q was high (+4·5V), turning on TR261 via R507 and R262, holding the input (and hence the output) of the operational amplifier, IC261, at 0V. This timebase amplifier is connected as a direct voltage follower.

When the trigger signal sends Q of IC501 a low, the timebase clamp transistor, TR261, is turned off. Part of the constant current generated by TR264 flows through the resistor network, R272, to charge C263 at a constant rate, The resultant positive-going linear ramp voltage generated at the input of IC261 is buffered by that amplifier to generate the low-impedance ramp output.

TIMEBASE RANGE SWITCH

The timebase range switch, S262, selects the tap point on the network, R272, to vary the ramp slope in the 1, 2, 5 sequence over a range of three decades. On all fast sweep ranges TR262 is biased off, but on ramps 0·5ms/cm and slower S262c connects R263 to +11V. TR262 is turned on and C264 is effectively connected in parallel with C263 to slow the sweep rate 1000 times.

The constant current in the ramp generator is derived from the current mirror circuit formed by TR263 and TR264. The variable gain control, R269, provides an approximate 3:1 range

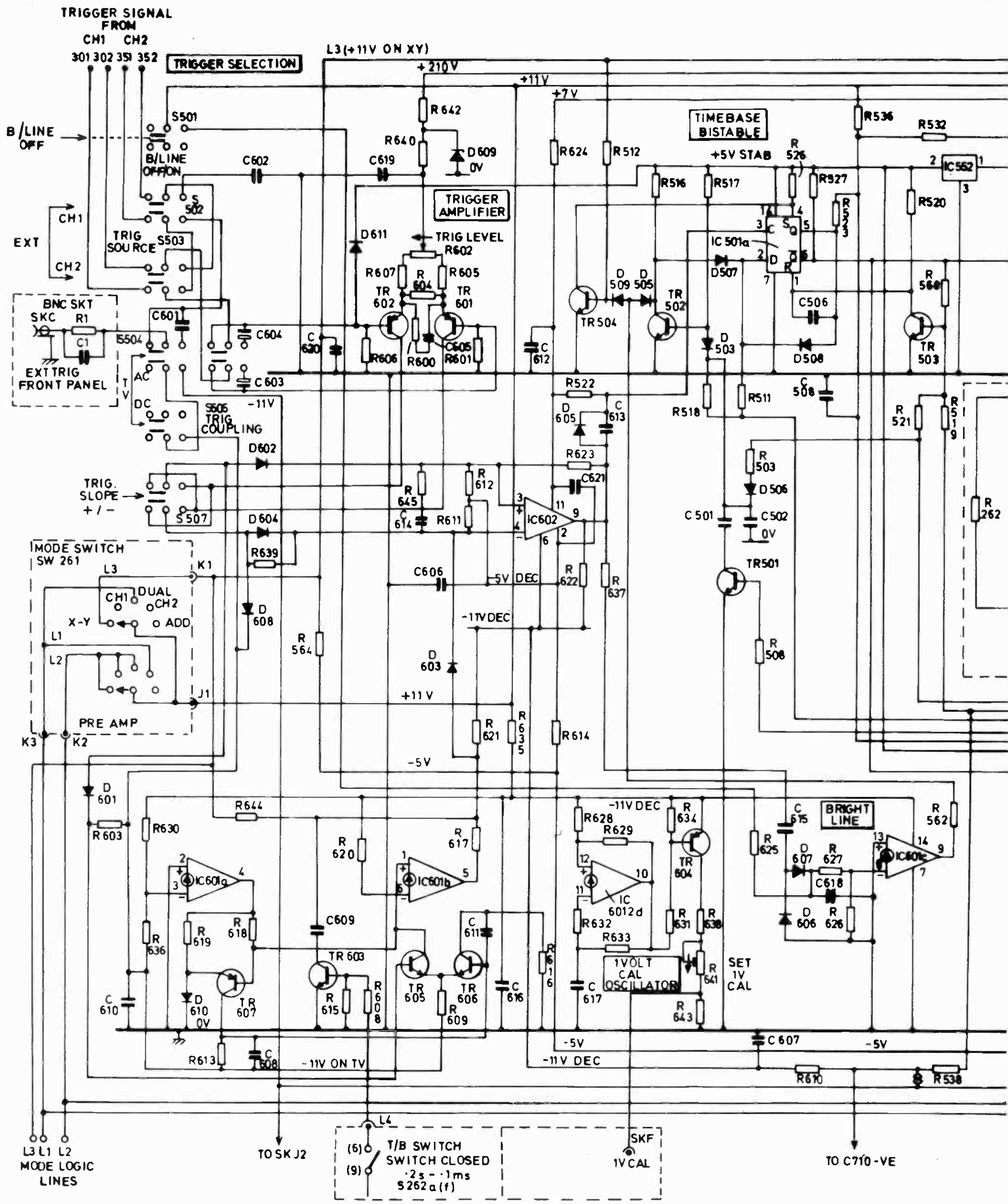
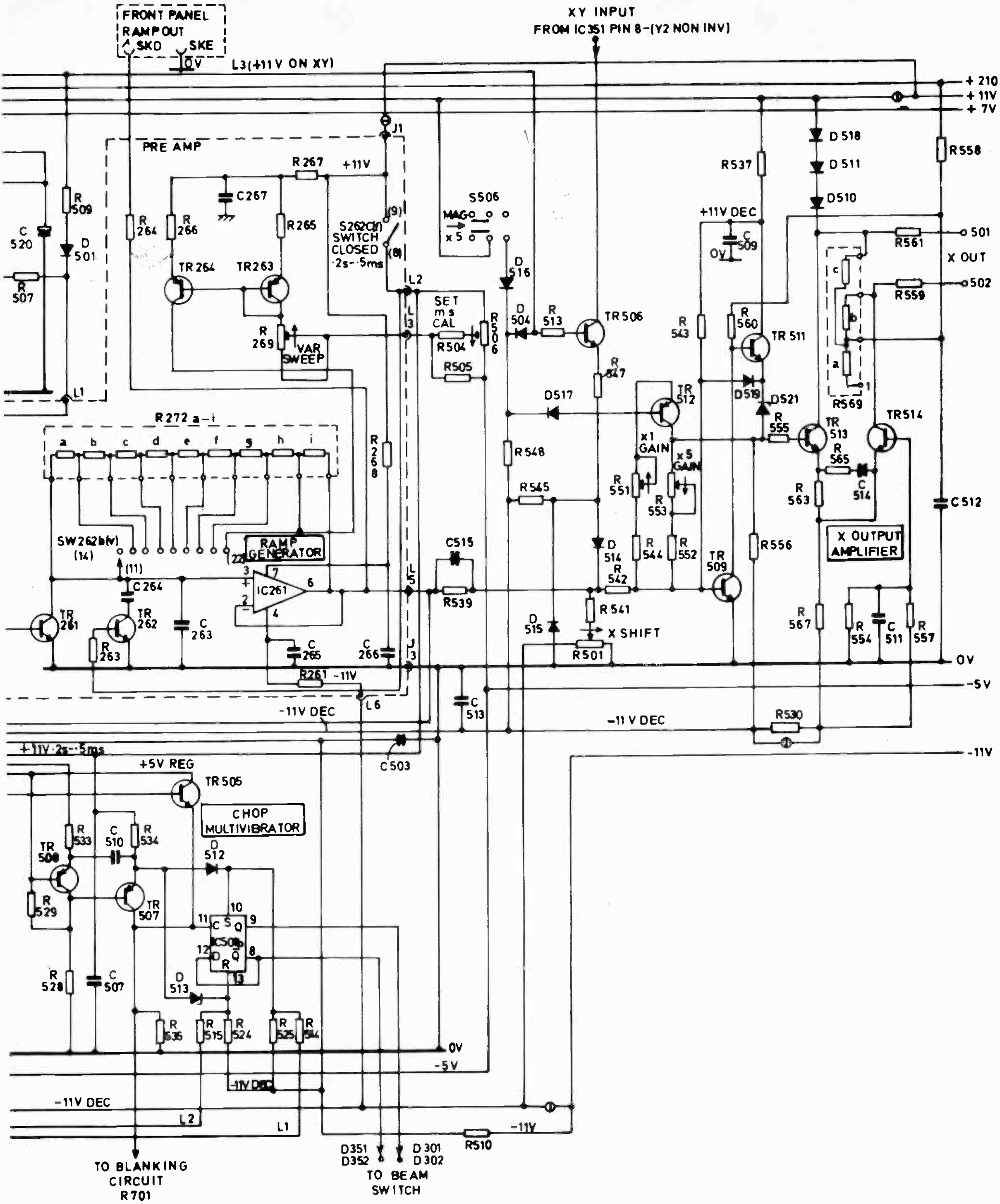


Fig. 19. X circuits of Gould OS255 oscilloscope, showing timebase generator-



trigger circuits and X-deflection amplifier *(courtesy Gould Instruments Division)* of variation in this current; R506 provides a preset calibration control on the slow sweep rates, only when S262 is closed.

When the ramp reaches its maximum level, the negative bias introduced by R521 and R519 is overcome and TR503 turns on, driving the reset input of the timebase bistable low. As the bistable switches, Q returns high, and TR261 conducts to discharge the timing capacitor(s) and the sweep is complete. However, a hold-off action takes place to inhibit trigger signals during the sweep; this remains for a short period after a sweep to ensure that the ramp potential is fully reset before the next sweep can be triggered. As the ramp goes positive, D506 conducts to charge C502, reverse biasing D503 and turning on TR502. At the end of the sweep when the timebase bistable is reset, Q goes low and the D input follows via the action of D508 and R511. The ramp output returns rapidly towards 0V, but TR502 remains in conduction for a period determined by C502 and R518. Only when TR502 turns off can R516 and D507 take the D input high for the bistable to respond to the next clock input.

Transistor TR501 acts in a way similar to TR262 (described above) to introduce additional hold-off time through C501 on the slower half of the timebase ranges.

The brightline facility causes the timebase to free-run in the absence of trigger signals. The square-wave output from the Schmitt trigger, IC602, is coupled via C615 into the peak detector diodes, D606 and D607, to generate a positive-going signal into the negative input of IC601c, driving its output negative. In the absence of such trigger signals for a period determined by C618 with R627 and R626, the output of IC601c goes positive. When TR502 turns off at the end of the hold-off period, D509 conducts to turn on TR504, driving the set output low to initiate another sweep. This free-run condition is removed as soon as IC601c detects an output from the Schmitt trigger. It can be inhibited also with a positive bias via R625 if the BRIGHTLINE OFF switch S501 is operated.

The X output amplifier is formed by the shunt feedback stage of TR509/TR511 driving single-sided into the amplifier stage, TR513 and TR514. The collector output of this stage drives the X deflection plates of the c.r.t. The gain introduced by TR509/TR511 is defined in the ×5 magnification mode by the input resistance, R539, and the feedback resistance, R552, with the preset, R553. In this mode the transistor switch, TR512, is biased off. However in normal x1 magnification mode, S507 is open and the current in R548 turns on TR512, introducing R544 with preset R551 as additional feedback to reduce the gain of the amplifier accordingly.

The X shift control, R501, introduces an additional bias input via R541 into the input of the shunt feedback amplifier.

POWER SUPPLY AND C.R.T. CIRCUITRY

The circuit diagram of the c.r.t. and power supplies section of a straightforward oscilloscope, the Scopex 4S6 is shown in Fig. 20. All the supplies are derived from a mains transformer with an untapped primary, providing operation from 210 to 250V a.c., 48–60Hz. The 6·3V secondary winding that supplies the c.r.t. heater is insulated to withstand the full −1·4kV e.h.t. voltage applied to the c.r.t. cathode/grid circuit. All the d.c. supplies are derived from a single-tapped secondary winding; as is usually the case in inexpensive scopes, they are not stabilised. This will cause the deflection sensitivity of the c.r.t. to vary with mains voltage, but the design of the Y amplifier is such that its gain varies with mains voltage in the inverse sense, maintaining the overall gain constant at the calibrated value.

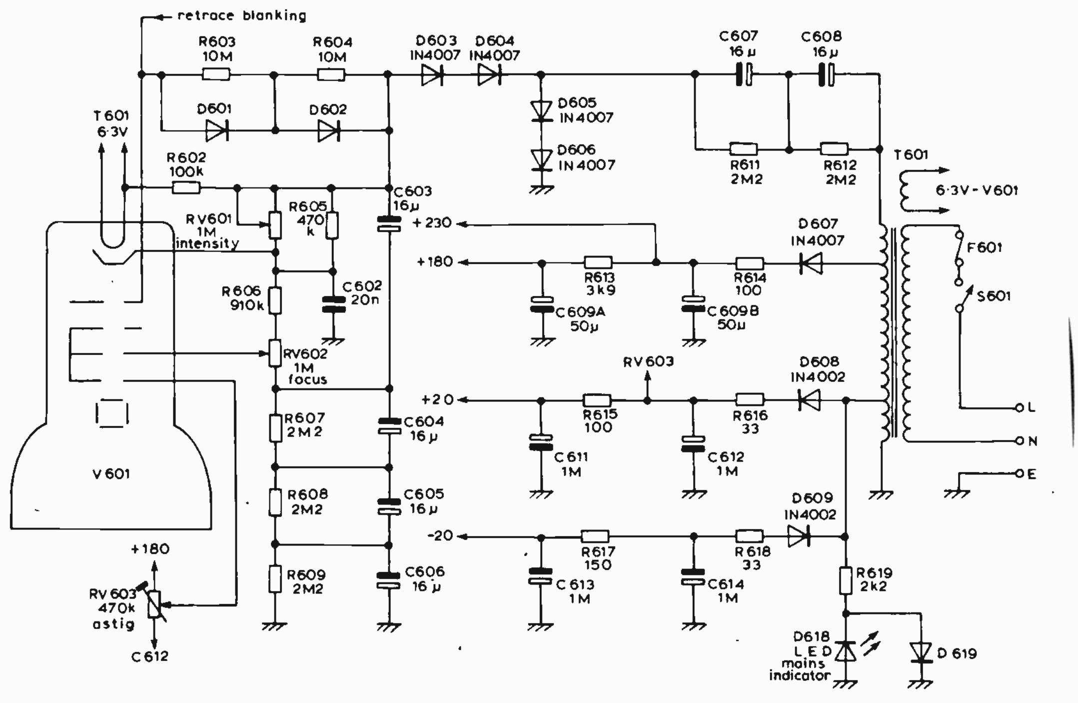


Fig. 20. Power-supply and c.r.t. circuit of Scopex 4S6 oscilloscope *(courtesy Scopex Instruments Ltd.)*

Intensity, focus and astigmatism controls are provided, the first two being mounted on the front panel. However, once set up during production test, the astigmatism control will need re-adjustment rarely if ever, so this control is a preset potentiometer mounted internally. ★

Diagrams in this series have been taken from the book and do not therefore conform with normal style for PE.

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DOS 3.3 – Operating Systems

DOS 3.3 is the handy housekeeper developed by Apple to help you take full advantage of your Disk II Floppy Disk subsystem. DOS automatically keeps track of files, saves and retrieves information on a diskette, and performs a variety of other 'housekeeping' chores. It dynamically allocates diskette space in a manner that's totally transparent to you, yet maximises diskette capacity (20% more than previous versions of DOS). DOS stands for Disk Operating System; 3.3 is the version update number.

Price	Nett	Vat	Total
	39.00	5.85	44.85
DOS 3.3 Toolkit	39.00	5.85	44.85

Double Vision 80 Column Card

Double Vision is a Video Interface designed specifically for the Apple II Plus computer with the capability of displaying 24 LINES of 80-COLUMN data on a CRT screen. With the software provided it has the capability of working with Integer BASIC, APPLESOFT BASIC and PASCAL.

Price	Nett	Vat	Total
	162.00	24.30	186.30
Software to convert to Pascal	12.00	1.80	13.80

Alf Music Synthesizer Cards

ALF music synthesizers enable you easily to create music on your Apple. Quite simply, you can slot an ALF music synthesizer card into the back of an Apple Computer and before long you will be writing and playing back your own synthesized music. Cables are supplied for connection to a stereo amplifier.

Music is entered note by note from a music sheet on to the high resolution display monitor using the games paddles (one paddle controls the type of note, the other paddle controls the position).

There are two versions of the ALF music card:

MC16: ALF music and 3 channel. This has an 8 octave range and an accuracy of over 98%. Up to 3 cards can be linked together.

MC1: ALF music card, 9 channel. A less sophisticated version with a 6 octave range.

Price	Nett	Vat	Total
ALF Music Card 9 Voice	91.00	13.65	104.65
ALF Music Card 3 Voice	114.00	17.10	131.10
Timing Mode Input Board	14.00	2.10	16.10
ALF Music Album 1 for MC16	12.00	1.80	13.80
ALF Music Album 2 for MC16	12.00	1.80	13.80
ALF Music Album 0 (Xmas) for MC16	12.00	1.80	13.80
ALF Ear Training Disc INTG MC16	28.00	4.20	32.20
ALF Ear Training Disc A/Soft MC16	28.00	4.20	32.20
ALF Process Series for MC1, MC16	28.00	4.20	32.20
ALF Music Album A for MC1	12.00	1.80	13.80
ALF Music Album B for MC1	12.00	1.80	13.80
ALF Music Album C for MC1	12.00	1.80	13.80

Apple Cards

Parallel Printer Interface

The Parallel Printer Interface Cards are available to allow the use of parallel printers with your APPLE computer.

Price	Nett	Vat	Total
Parallel	104.00	15.60	119.60
Centronics	130.00	19.50	149.50

Communications Interface Card

The Communications Interface Card is available separately to allow you to connect your APPLE to modems, CRT terminals, and other devices employing a serial RS-232C interface. The card's built-in intelligence lets you control these devices easily, in BASIC.

Price	Nett	Vat	Total
	130.00	19.50	149.50

Apple Eurocolour Card

This card has a composite video (PAL) colour output that will work with European Video Monitors. Facility for modulator to be attached to allow you to use almost any European TV by just plugging the lead from the Apple into your aerial socket. The Apple gives 16 colours in L.R. Graphics and 6 colours in H.R. Graphics.

Price	Nett	Vat	Total
	113.00	16.95	129.95
UHF Modulator	14.00	2.10	16.10

High Speed Serial Interface

The Serial Interface Card allows an APPLE computer to exchange data with computers, printers, and other devices in serial format (one bit at a time). It is intended for use (in place of the Communications Interface Card) in applications that:

—Use data rates other than 110 or 300 baud (10 or 30 char/sec)

—Involve serial printers that don't require "handshake".

Price	Nett	Vat	Total
	113.00	16.95	129.95

Hobby/Prototyping Card

Create your own APPLE interface boards with this wire-wrap card. The 2¾" x 7" double sided circuit board includes a hole pattern (on 100-mil centres) that accepts all conventional ICs and passive components. it plugs directly into an Apple expansion connector, and fits entirely within the computer case. Supplied with complete bus documentation to aid the interface designer.

Price	Nett	Vat	Total
	15.00	2.25	17.25

Books

Apple documentation is as good as you can get. Extra copies of the manuals are available for when the system has a number of users or enable prospective purchasers to fully understand the product.

	Price
Apple II Reference Manual	11.00
6502 Hardware Manual	9.00
6502 Software Manual	9.00
Apple II Basic Program Manual	6.00
Applesoft II Reference Manual	6.00
DOS 3.2 Manual	6.00
Pascal Reference Manual	8.50
Apple II Basic Tutorial Manual	6.00
Autostart ROM Manual	4.50
DOS 3.3 Manual	4.80

Note:–
There is no VAT on books
Add £1 post and packing on orders for less than £10

The Microsoft Z80 Softcard for Apple II

Plug the new Microsoft Z80 Softcard into your Apple II and start using all of the system and application software written for Z80 based computers.

Price	Nett	Vat	Total
	170.00	25.50	195.50

Other Prices

	Nett	Vat	Total
Apple Logo Ties	6.00	0.90	6.90
Applesoft Firmware Card – for integer Apples	116.00	17.40	133.40
Integer Card – for Applesoft Apples	116.00	17.40	133.40
Programmers Aid 1	27.00	4.05	31.05
Auto Start ROM Pack	38.00	5.70	43.70
Apple Juice back-up power supply	157.00	23.55	180.55
Disk Controller Card (DOS 3.2)	45.00	6.75	51.75
Apple Numeric Keypad	85.00	12.75	97.75
Vero Prototyping Board for Apple	9.95	1.49	11.44

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- Proven. There are many thousands of Apples in use doing virtually any job a computer can do. The Apple has a fabulous reputation.

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- Free delivery by Securicor.
- 30 days credit on bona fide official orders from commercial or government organisations.
- We have the resources of the Ladbroke Group behind us. We will be there when you need us most.

Microdigital supply a 48k machine for the price of a 16k machine, we supply a Black and White modulator free and give free delivery

Price	Nett	Vat	Total
Apple II Computer 48k	695.00	104.25	799.25

All Apples supplied by us are legitimately imported and are genuine 230V Europlus models.

Apple Disk II Floppy Disk Subsystem

The Apple Disk II Floppy Disk Subsystem increases the capability of your Apple Computer System through the use of flexible, or 'floppy', disks for data storage. Expanded memory capacity, greater data retrieval speed, and random access to your stored data – all of these, and more, are made available through the Disk II Subsystem. Whether you use your Apple with a Disk II in business to control inventory, or at home for household management, you'll find that it's the superior answer to your data storage needs.

The latest DOS 3.3 16 sector disk drive with controller, which replaces the old model

Price	Nett	Vat	Total
	383.00	57.45	440.45

Second disk drive uses same controller as first drive.

Price	Nett	Vat	Total
	299.00	44.85	343.85

Language System (PASCAL)

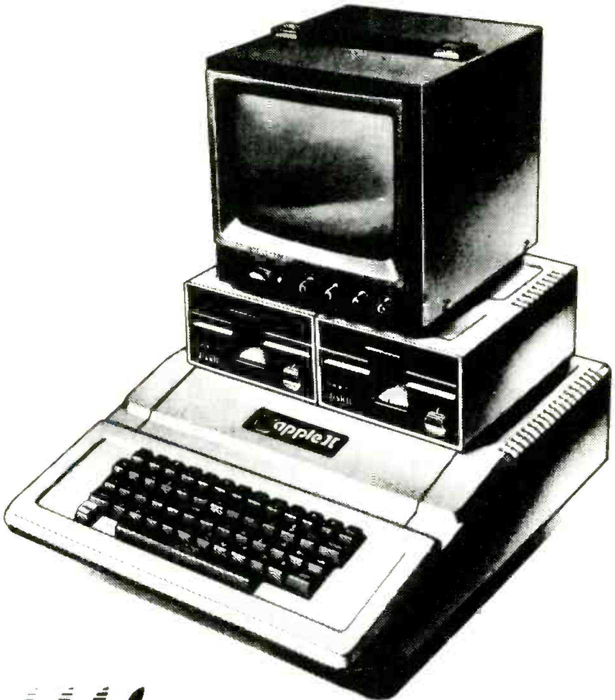
This package includes the Language Card, which allows APPLE users to take immediate advantage of the powerful PASCAL language as well as the Integer and Applesoft BASIC interpreters. The Lanuage Card's 16K bytes of RAM memory electrically replace the ROM firmware built into each APPLE. Upon start-up this RAM memory is automatically loaded from disk with the user's choice of languages then electrically protected from change.

Price	Nett	Vat	Total
	299.00	44.85	345.85

Apple Fortran

Apple FORTRAN operates in the Apple Pascal Language system offering the same comprehensive software development environment provided to our Pascal programmers. The Editor, Linker, Filer and Assembler can all be used with the Apple FORTRAN compiler, which, like Pascal, produces 'P' code.

Price	Nett	Vat	Total
	120.00	18.00	138.00



apple® computer
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Apple Pilot

Apple Pilot is a powerful, easy to use system designed to support program development for Computer-Assisted-Instruction (CAI). If you're familiar with the PILOT language, you'll quickly become proficient in developing Apple PILOT courseware – and at a fraction of the cost of most other systems.

Price	Nett	Vat	Total
	76.00	11.40	87.40

Graphics Tablet

The Graphics Tablet is an image input device that allows the user to enter pictorial information directly (by sketching or tracing).

Price	Nett	Vat	Total
	462.00	69.30	531.30

Carrying Case

The Apple is truly portable and this padded vinyl, leather look case protects your Apple in transit and makes it easier to carry.

Price	Nett	Vat	Total
	16.00	2.40	18.40
Dustcover	9.95	1.49	11.44

Silentype Printer

The Silentype allows printing of high resolution graphics at 60 dots per inch, at 40 upper/lower case characters per second and 80 characters per line. The Silentype eliminates the loading or writing of a programme to print a screen configuration, because you can dump any high-resolution screen directly to the printer.

Price	Nett	Vat	Total
	349.00	52.35	401.35
10 rolls thermal paper for Silentype	28.00	4.20	32.20
Dustcover for Silentype	9.95	1.49	11.44

Appletel

The Appletel package provides the means to bring the Apple II computer and the Prestel service together.

Price	Nett	Vat	Total
	595.00	89.25	684.25

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California Computer Systems

Model 7114A 12K ROM/PROM Module

Capable of accepting operating systems, system patches or other firmware in 12K increments of mixed ROM or PROM. This module allows you to replace your computer's firmware without physically removing the Apple II ROMs.

Price	Nett	Vat	Total
	70.00	10.50	80.50

Model 7440A Programmable Timer

Now, you can time events in four operating modes: (1) continuous, (2) single shot, (3) frequency comparison, and (4) pulse width comparison. With the Programmable Timer, you have a peripheral that can be used for anything from cooking eggs or playing games, to industrial uses all on one unit.

Price	Nett	Vat	Total
	106.00	15.90	121.90

Model 7470A 3¾ Digit BCD Analog to Digital Converter

With this module your computer will convert DC voltages to BCD numbers for monitoring and analysis. Now you can save money on your energy bills by monitoring your thermostat or use your computer as a digital voltmeter.

Price	Nett	Vat	Total
	99.00	14.85	113.85

Model 7811A Arithmetic Processor

The 7811A Arithmetic Processor is a Hardware floating point unit that will significantly improve the execution speed of your Apple II programs. Eight functions are available using the USR(X) command: ARCSIN(X), LOG10(X), PI, INVERSE(X), SINH(X), COSH(X) and TANH(X).

Price	Nett	Vat	Total
	265.00	39.75	304.75

Model 7490A IEEE Card

This card allows even more accessories such as X, Y Plotters to be interfaced with the Apple.

The 7490A General Purpose Instrument Bus Interface implements the Controller/Talker/Listener functions of the IEEE Standard 488-1978. With the 7490A GPIB interface your Apple II becomes a flexible tool for controlling large test systems or a single GPIB instrument for automated testing and measurement. When used as a talker/listener the Apple II may act as a peripheral device to another controller such as a colour graphics output device.

Price	Nett	Vat	Total
	199.00	29.85	228.85

Model 7720A Parallel Interface

With the 7720A Parallel Interface Card you will have a powerful accessory unit for the Apple II computer that can transfer data at high speed to your printer, paper tape equipment, another computer, or even control special external devices (such as low current relays, or other on/off devices through two bi-directional 8-bit buses).

Price	Nett	Vat	Total
	79.00	11.85	90.85

Model 7728A Centronics Printer

Interface Board, for Centronics-type parallel printers.

Price	Nett	Vat	Total
	79.00	11.85	90.85

Model 7424A Calendar/Clock Board

12 or 24 hour formats, adjusts Feb. to 29 days for leap years.

Price	Nett	Vat	Total
	83.00	12.45	95.45

Model 7710A Asynchronous Serial Board

For paper-tape reader, keyboard, VDU, printer, etc. Baud rates selectable from 50 to 19.2K baud.

Price	Nett	Vat	Total
	106.00	15.90	121.90

Model 7712A Synchronous Serial Board

For high-speed interface communications.

Price	Nett	Vat	Total
	119.00	17.85	136.85

Interactive Structures

D109 Digital Interface

The D109 is a single card for Apple II which provides a complete digital interface system. It can be used as a 32 line parallel interface with each line functioning as either input or output. A current drive option is available which allows output lines to sink up to 300 ma.

The system includes four independent 16-bit interval timers which can be used to count events, generate precise square waves and pulses or provide a programmable clock. By cascading timers, intervals up to 17 years may be timed. Two 8-bit shift registers are included to provide serial-to-parallel conversion on input, or parallel-to-serial conversion on output, the necessary components for construction of a serial communication link.

Price	Nett	Vat	Total
	213.00	31.95	244.95

A0-03

The A0-03 Analog Output System provides the capability to use the Apple II microcomputer to control processes common in scientific, industrial and home applications. An A0-03 output may be used for example, to adjust the brightness of a light bulb, to vary the speed of a motor, or to move a loudspeaker cone and produce sound. Anything you might consider adjusting by turning a knob can be adjusted instead by a program using the A0-03. In addition, the A0-03 operates rapidly enough to do high speed tasks such as producing good quality audio signals for computer music or speech.

Price	Nett	Vat	Total
4 Channel	180.00	27.00	207.00
8 Channel	281.00	42.15	323.15

The A102

The A102 makes the Apple II microcomputer useful in areas requiring real-time input of analog information. These include measurement of temperature, pressure, human emotions, light levels, etc. This capability is provided in a 16-channel 8-bit configuration on a simple plug-in card. The A102 opens several significant new application areas including laboratory instrumentation, industrial process control, and hands-on training.

Full engineering support is provided for the A102 by the manufacturer. Application notes are supplied to explain useful techniques and interfacing hints. Application assistance, custom interfacing and system design services are available from the factory.

Price	Nett	Vat	Total
	192.00	28.80	220.80

A1-13 Analog Input System

★ True 12 bit precision giving 204,800 : 1 or 106dB span.
★ 16 analog input channels selectable from software at speed.
★ High speed 20 microsecond conversion time.
★ 8 software selectable voltage ranges
 0 to 5V
 0 to 1V
 0 to 0.5V
 0 to 0.1V
 – 5 to + 5V
 – 1 to + 1V
 – 0.5 to + 0.5V
 – 0.1 to + 0.1V
★ Easily used from BASIC and assembly language.
★ External trigger/interrupt facility.
★ Built in precision reference.

Price	Nett	Vat	Total
	373.00	55.95	428.95

Quantity discounts available on request. 12 month guarantee/2 years on Sharp & Apple.
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Apple II

The worlds best selling computer – sophisticated and versatile to solve your problems

Mountain

Mountain Hardware, Inc.

Expansion Chassis

By popular demand! Eight more slots for your Apple. Attractive sturdy enclosure. Its own heavy duty power supply. Easy to use. Address cards in Expansion Chassis the same way as in your Apple. Only one additional command to specify in Apple or in Expansion chassis. Compatable with all Apple peripherals.

	Nett	Vat	Total
Price	362.00	54.30	416.30

MusicSystem

Digital Synthesizer with 16 oscillators. Stereo output. Polyphonic multi-voice chords and note sequences. Additive synthesis of instruments waveforms, envelopes, and amplitudes are fully programmable for each voice to create instrument definitions and music dynamics. 32Khz sample rate. Frequency resolution is 0.5 Hz steps. Graphical input of sheet music on high-resolution screen using standard music notation. print out sheet music with graphics printer. Complete software operating system. Graphical music editor using light pen (provided), game paddles, or keyboard. Pre-entered music provided for immediate playing and enjoyment. Thorough documentaion and tutorial use's manual.

	Nett	Vat	Total
Price	312.00	46.80	358.80
Spare Disk Pack	24.00	3.60	27.60
Spare Manual	11.00		11.00

Romplus (and keyboard filter)

Romplus provides six sockets that accept individually addressable 2K Eproms. Sophisticated firmware allows one or more Eproms to be used simultaneously (for programs longer than 2K).

The Keyboard Filter is one 2K Eprom that is supplied with the Romplus. Its features are:–

★ Upper and lower case characters allowed, with special graphics characters
★ A font-editor, for designing, using your own character sets (i.e. for graphics, animation and other alphabets)
★ Keyboard Macros, two key-stroke, automatic typing of multiple, user defined words or phrases, including BASIC or DOS commands
★ Ability to mix text and graphics anywhere on the page

	Nett	Vat	Total
Price	127.89	19.18	147.07

Copyrom

COPYROM may be used with your Mountain Hardware ROMPlus+ to expand your disk operating environment. Features include:

★ Current number of available sectors on any Integer BASIC or Applesoft disk
★ An improved Catalog function containing more numeric information for each file entry in decimal or hex
★ Copy the contents of an entire disk using only one disk drive
★ Operation in immediate mode or under program control
★ Print directory contents in upper/lower case to an external printer, include control characters 'hidden' in file names when displaying catalog information on the screen.

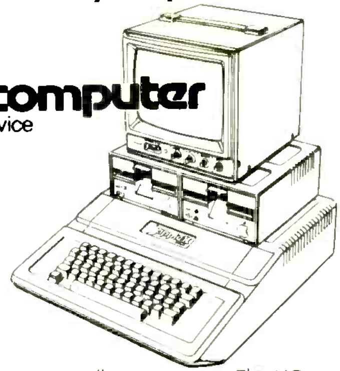
	Nett	Vat	Total
Price	30.00	4.50	34.50

Mountain Hardware Clock/Calendar Card

This plug-in card provides a 388-day calendar and clock with resolution to 1/1000 second. The clock is crystal controlled to yield 0.001% accuracy. A built-in rechargeable battery keeps the clock on time for up to four days without system power, and external batteries may be used for long periods. Interrupt capability simplifies control applications. Supplied with complete operating instructions and rechargeable battery.

	Nett	Vat	Total
Price	168.00	25.20	193.20

apple computer Sales and Service



Supertalker SD200

Input/Output Speech digitizer, permits talking programs. This I/O capability allows interactive teaching programs and speech-prompted data input formats. Use output for speech directed activities in business systems, announcements in a control-room, or sound effects in entertainment programs. Easy to use because input as well as output is under control with special software operating system.

	Nett	Vat	Total
Price	179.55	26.93	206.48

Romwriter

Hardware:

- Programs 2716 EPROMs – 5V, 2K.
- Zero insertion force socket. (ZIF). Mechanical lever opens up pin holders to drop in an EPROM.
- Complete 2716 programmed in under 2 minutes (50 msec/byte).

	Nett	Vat	Total
Price	106.05	15.91	121.96

A/D + D/A Interface

Commercial, scientific, and industrial data acquisition and control functions are now practical with Mountain Hardware's A/D + D/A. card. Superfast conversation time permits high frequency and other applications not possible with slower cards.

A/D + D/A features

- Single PC card
- 16 channels digital to analog output
- 16 channels analog to digital input
- 9us conversation time
- 8 bit resolution

	Nett	Vat	Total
Price	196.00	29.40	225.40

Heuristics

Heuristics

Heuristics Speech Link H-2000

This is an inexpensive easy-to-use voice data input device for the Apple computer. With Speechlink you can enter data with your Apple and control your Apple or equipment (peripherals) attached to it using your voice.

	Nett	Vat	Total
Price	168.00	25.20	193.20

Model 70 controller

Provides four relay contact-closure outputs on a card which plugs into an Apple II peripheral slot and which is completely controlled by POKE statements in Apple II BASIC. The unit is recommended for use with Heuristics SpeechLab and SpeechLink voice data and control input cards for the Apple II, but may be used with any Apple in any application. More than one Model 70 may be used.

	Nett	Vat	Total
Price	57.00	8.55	65.55

Heuristics Speech Lab

A voice input device consisting of microphone and interface card. The Apple may be trained to recognise a vocabulary of up to 32 words.

	Nett	Vat	Total
Price	122.00	18.30	140.30

Quantity discounts available on request. 12 month guarantee/2 years on Sharp & Apple.
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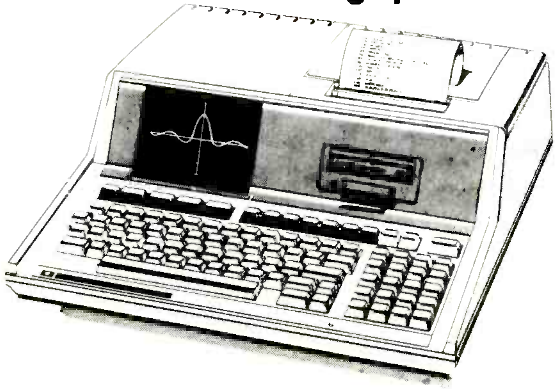
Hewlett-Packard HP-85

Hewlett-Packard brings personal computing power to the busy professional



All the computing power needed by the busy professional – processor, keyboard, video display, printer, mass storage and operating system, packed into a single unit no larger than an electric typewriter. This is the way HP-85 offers the personal computing capability, convenience, reliability and power needed by today's scientist, engineer or business professional.

Extended BASIC for power and simplicity

The enhanced BASIC language contained in the HP-85's 32K ROM provides more than 150 commands and statements that give you the power to solve problems.

Alphanumeric/graphics display simplifies operation

HP-85's video display allows you to operate in alphanumerics or graphics, then switch from one to the other.

In alphanumeric mode you can display programs, data, error messages, system commands and results. You can see 16 lines at a time or use the scrolling key to review 64 lines, up or down, from display memory.

In graphics mode, you can display graphics information separately. The 256 x 192 dot resolution screen provides clear, legible images and curved lines.

Thermal printer provides crisp hard copy and graphics

A quiet bi-directional thermal printer integrated into the HP-85 provides excellent print quality with adjustable intensity.

At a speed of two 32-character lines per second, the HP-85 printer provides fast hard copies of the graphics or alphanumeric contents of the display, outputs from programs or program listings. When displayed graphics are printed, information is oriented to allow strip-charting and continuous graphs.

Standard typewriter keyboard and numeric pad

The typewriter section of the HP-85 keyboard has a full 128-character set with the English alphabet, punctuation marks, European and Scandinavian characters, key Greek letters, mathematical operators and symbols. All characters may be underlined for emphasis to give a total of 256 characters.

High quality permanent digital storage

Magnetic tape cartridges supply the HP-85 with high quality digital storage. These high density, large capacity cartridges may be used for temporary or archival storage of data and programs.

Memory can be doubled quickly and easily

When you wish to write and run very long programs, or handle large data requirements, you can double the memory capacity of the HP-85 with an optional 16K Memory Module.

Enhancement ROMs extend the power of your HP-85

Enhancement ROMs allow you to increase the range and efficiency of your HP-85 by adding new functions and peripherals.

These enhancements are added quickly by placing a ROM module into the ROM drawer and inserting it into one of the I/O ports of the HP-85. The ROMs interface directly with the HP-85 to provide completely new commands and capabilities to complement those existing in the machine.

Matrix ROM

The HP-85 Matrix ROM provides matrix input and output, facilitates matrix mathematics with matrix operators, simple matrix manipulation, matrix inversions and linear systems solutions. It provides a powerful set of statements and functions for working with arrays – both matrices (two-dimensional arrays) and vectors (one-dimensional arrays) with more convenience, speed and accuracy than with the HP-85 alone.

Mass Storage ROM

The HP-85 Mass Storage ROM allows you to interface your HP-85 with the HP 82900 Series Flexible Disc Drives or the HP 9895A Flexible Disc drive.

Plotter/Printer ROM

The HP-85 Plotter/Printer ROM adds powerful new plotting commands and provides graphic input capability for digitizing. It enables the HP-85 to interface with Hewlett-Packard's high resolution plotters and full width line printers. It also includes several graphics enhancements.

I/O ROM

The enhanced BASIC language of the HP-85 may be enriched with straight-forward I/O commands through the HP-85 I/O ROM. Any I/O system requires program statements or subroutines ("I/O drivers") to pass data and commands among instruments. These can be complex and usually differ for each device. These language enhancements are provided by the HP-85 I/O ROM so that the programmer needs use only a few standard BASIC commands. Statements are provided to configure, control, pass data to and from, and check the status of devices in the I/O system.

Interface modules allow easy connection to peripherals

Five plug-in interface modules (HP-IB, RS-232C serial interface, GP-IO, BCD and Centronics) connect your HP-85 to a full line of peripherals for handling data file management, full-width printouts, special plotting assignments, etc.

The HP-IB Interface, for example, is the industry standard IEEE-488 Interface which allows the connection of instruments and peripherals with equal ease. It permits bi-directional, asynchronous communication with a wide variety of instruments and peripherals, up to 14 per interface. The complexity of the interfacing task is handled by the microprocessor-based interface card, so the user can concentrate on using the instrument instead of how to hook it up.

With the HP-IB, peripherals such as the HP 82900 Series Flexible Disc Drives, HP 9895A Flexible Disc Drive System, HP 2631B Impact Printer and HP 7225 Graphics Plotter can be added without difficulty. Additional devices require only an industry standard HP-IB cable. And with the appropriate enhancement ROMs, the HP-85's simplicity of operation is extended to the peripherals.

HP 7225 Graphics Plotter

Hewlett-Packard's HP 7225 Graphics Plotter is a compact and efficient unit that provides a cost-effective solution to the need for professional hard-copy graphics. It will provide publication quality plots made up of clean, continuous ink lines.

HP 2631B Impact Printer

The HP 2631B printer achieves high throughput with a print speed of 180 characters per second, bi-directional printing, suppression of leading and trailing blanks, skipping over embedded blanks and a high-speed carriage return.

Quantity discounts available on request. 12 month guarantee/2 years on Sharp & Apple. Free delivery within mainland UK on orders over £10.

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Hewlett-Packard HP-85

HP 82900 and HP 9895 Series Flexible Disc Drives

Hewlett-Packard flexible disc drives provide from 270K bytes to 4800K bytes of fast on-line storage using removable flexible discs. The 82900 Series uses 13 cm (5¼") discs, each supplying approximately 270K bytes of formatted storage. The 9895 Series uses 20 cm (8") discs, each of which supplies approximately 1200K bytes of formatted storage. The disc drives are available as dual (two disc drives) and single (one disc drive) master units and dual and single add-on units. Add-on units must be connected to a master unit which contains the control electronics.

HP-85 Application Pacs provide pre-pre-programmed solutions for a wide variety of disciplines

Information Management Pac

The Information Management Pac gives the Series 80 personal computers a data base management facility for accessing, searching and sorting data. Data base totalling and statistics are included as are report and graphics generation.

These programs speed up and simplify the creation, updating and printing of customer or mailing lists, inventory records, catalogues and other data bases.

Graphics Presentation Pac

The Graphics Presentation Pac is a versatile set of programs that lets the user make four-colour overhead projection transparencies or report copies of text, bar charts, pie charts and line charts. Management reports, customer presentations, sales seminars and so on can all benefit from graphics generated in this way

NEW!

The HP-83, the latest addition to HP's personal computer family, is identical to the HP-85 computer except that it does not have an integrated magnetic tape cartridge drive and integrated thermal printer.

Price	Nett	Vat	Total

HP-80 Series Mainframes

HP-83 Computer	1210.00	181.50	1391.50
HP-85 Computer	1750.00	262.50	2012.50
16K Memory Module	158.00	23.70	181.70
ROM Drawer	25.00	3.75	28.75

ROM's (fit into ROM drawer)

Mass storage ROM	78.00	11.70	89.70
Plotter/printer ROM	78.00	11.70	89.70
Input/output ROM	159.00	23.85	182.85
Matrix ROM	78.00	11.70	89.70
Assembler ROM	159.00	23.85	182.85

Interfaces and Accessories

HP-IB Interface	213.00	31.95	244.95
Serial Interface (RS-232)			
– with female connector	213.00	31.95	244.95
– with male connector	no charge		
– current loop, no connector	no charge		
G.P. I/O Interface	267.00	40.05	307.05
B.C.D. Interface	267.00	40.05	307.05
Centronics Interface	150.00	22.50	172.50
HP-IB Cable ½ metre	39.00	5.85	44.85
HP-IB Cable 1 metre	39.00	5.85	44.85
HP-IB Cable 2 metres	42.00	6.30	48.30
HP-IB Cable 4 metres	48.00	7.20	55.20

Plotter and Accessories

(Requires HP-IB Interface and plotter/printer ROM)

Plotter	1208.00	181.20	1389.20
Personality module	412.00	61.80	473.80
Overhead transparency kit	56.10	8.42	64.52
Digitizing sight	20.20	3.03	23.23.
Vinyl carrying case	119.24	17.89	137.13
100 sheets, English grid, (E.F.) 7 x 10in plot area	3.79	0.57	4.36
100 sheets, Metric grid, (E.F.)* 18 x 25cm plot area	3.79	0.57	4.36
50 sheets, blank, (E.F.)*	1.63	0.24	1.87
50 sheets, blank, (A4)	1.63	0.24	1.87
4 colour pen pac	3.52	0.53	4.05
5 red pens	3.52	0.53	4.05
5 blue pens	3.52	0.53	4.05
5 green pens	3.52	0.53	4.05
5 black pens	3.52	0.53	4.05
100 transparency films	11.92	1.79	13.71
Transparency solvent	2.03	0.30	2.33
Transparency pens (B,R,B,G)*	4.61	0.69	5.30
Transparency pens (B,O,B,V)*	4.61	0.69	5.30
Transparency pens, wide (B,R,B,G)*	4.61	0.69	5.30
Transparency pens, wide, (B,O,B,V)*	4.61	0.69	5.30

* E.F. English format 8.5 x 11 inches B,R,B,G, black red blue green B,O,B,V, black orange blue violet

Printer and Accessories

(Requires HP-IB Interface and plotter/printer ROM)

Printer (including 2 ribbons)	2141.00	321.15	2462.15
Printer stand	158.00	23.70	181.70
Adds paper rack	29.00	4.35	33.35
Sound/abatement cover	58.00	8.70	13.70
Wire paper basket	29.00	4.35	33.35
Printer ribbon, package of 3	33.66	5.05	38.71

Additional Accessories

Tape cartridges (pac of 5)	48.06	7.21	55.27
Thermal paper (box of 2 rolls)	18.00	2.70	20.70
Cartridges and manuals holder	6.00	0.90	6.90
HP-83/85 Carrying case	65.00	9.75	74.75
3-ring system literature binder	5.40	0.81	6.21
Dust cover	8.00	1.20	9.20

Manuals

Owners Manual	15.05
I/O ROM Manual	18.05
Pocket Guide	3.01
Plotter/Printer ROM Manual	6.02
Matrix ROM Manual	6.02
Mass Storage ROM Manual	6.02
Flexible disc operating manual	6.02
Serial installation manual	6.02
Assembler ROM Manual	11.00

Application Pacs

Basic Training	52.00	7.80	59.80
General Stats	52.00	7.80	59.80
Finance	52.00	7.80	59.80
Math	52.00	7.80	59.80
Circuit Analysis	52.00	7.80	59.80
Games	52.00	7.80	59.80
Linear Programming	52.00	7.80	59.80
Text Editing	52.00	7.80	59.80
Wave Form Analysis	52.00	7.80	59.80
Basic Stat and Data	52.00	7.80	59.80
Regression Analysis	52.00	7.80	59.80
Graphics Presentation Pac	108.00	16.20	124.20
Information Management Pac	108.00	16.20	124.20
Visicalc Plus	108.00	16.20	124.20

Flexible Disc Units

(Require HP-IB Interface and Mass Storage ROM)

Dual Master (540K bytes)	(For 5¼" disc)	1350.00	202.50	1552.50
Dual Add-On (540K bytes)	(For 5¼" disc)	1185.00	177.75	1362.50
Single Master (270K bytes)	(For 5¼" disc)	810.00	121.50	931.50
Single Add-On (270K bytes)	(For 5¼" disc)	700.00	105.00	805.00
Dual Master (2400K bytes)	(For 8" disc)	3569.00	535.35	4104.35
Dual Add-On (2400K bytes)	(For 8" disc)	3020.00	453.00	3473.00
Single Master (1200K bytes)	(For 8" disc)	2608.00	391.20	2999.20
Single Add-On (1200K bytes)	(For 8" disc)	2059.00	308.85	2367.85
Flexible disc 5¼" (Pac of 10)		42.00	6.30	48.30
Flexible disc 8" (Pac of 10)		60.19	9.03	69.22

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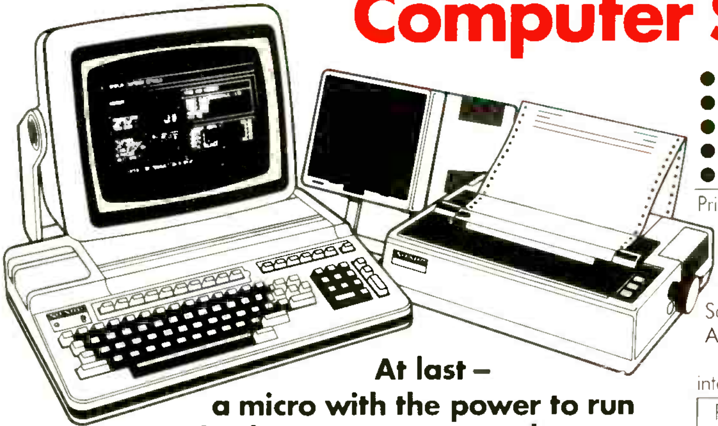

At last – a micro with the power to run a business system properly

This is the machine all the others will have to beat with a fabulous list of features

Future Enhancements

8 inch Floppy disks – 1 Megabyte capacity (available Summer 81)
RS 232C Interface – available Summer 81
General Purpose I/O Card – available Autumn 81)

Price	Nett	Vat	Total
PC3201 Computer	1500.00	225.00	1725.00
CE320C Green Video Display	250.00	37.50	287.50
CE332P Dot Matrix Printer	450.00	67.50	517.50
CE331M Twin Disk Unit	670.00	100.50	770.50
CE341M Interface for Disk Unit	125.00	18.75	143.75
Total System Cost	2995.00	449.25	3444.25

The Disk Interface can handle two twin disk drives. The 3201 can be fitted with two interface cards for a maximum of 4 twin disk units. Each twin disk unit added to the above system requires an additional cable.

Price	Nett	Vat	Total
CE350L Additional Cable	30.00	4.50	34.50

The BASIC supplied with the PC3201 is one of the best yet available and makes the writing of powerful business programs much easier. The enhanced arithmetic accuracy makes this machine also ideal for scientific applications.

Business Software

Each Business Application can be run independently of others, yet it will still offer the flexibility of operation as if the system was specially designed with your needs in mind. If you want to link one application with another, then this is simplicity itself. Invoices raised on the Invoicing System can be automatically posted to the Sales Ledger for example. As your needs grow then you can be sure there is a Business Application available to suit.

Sales Ledger System

- Up to 1600 Accounts (this is parameterisable)
- up to 5000 Transactions per month
- Balance Brought Forward System, although cash etc. can be allocated to 4 months aged debts. (When 112K RAM Sharp PC 3201 becomes available then it will be simple to convert to Open Item if required)
- Fully integrates to Sales Invoicing System
- Fully integrates to Nominal Ledger System
- All reports are range selectable on demand
- All reports can be stopped (interrupted) as and when required with no loss of data
- Press any key on the keyboard and the system will not go wrong

Reports

- Statements (Choice of formats)
- Aged Debts Listing (Choice of formats)
- Comprehensive Audit Trails including Daybook
- V.A.T. Summary Cumulative
- Control Accounts (Nominal Controls plus 94 Sales Revenue Heads)
- Non-Buying Customers
- Sales Ledger Listing/Transactions Listing
- Alphabetic Listing of Accounts
- Full screen interrogation of Account details.

Price	Nett	Vat	Total
	300.00	45.00	345.00

Purchase Ledger System

Volumes, systems procedures and reports are the same as for the Sales Ledger System, except they refer to Suppliers rather than Accounts.

There is no need for a 'Non Buying Report' and there is no integration to Sales Invoicing System.

Price	Nett	Vat	Total
	300.00	45.00	345.00

Sales Invoicing System

- 1500 Products (2000 when 112K microcomputer is available). Product Code = 6 characters.
- Access time to products less than 1½ seconds maximum.
- Free format invoices.
- Create your own products as you are constructing an invoice.
- Records all invoice line details against a comprehensive stock file including:
  - ○ Turnover ○ Cost of Sales ○ Gross Profit information
  - ○ Last Movement Dates are recorded
  - ○ Unit Gross Profit, Unit Gross Profit %, Overall Gross Profit %, Valuation of Free Stock at Selling Price, as well as at Cost Price.
- Changeable invoice format.
- A full Audit Trail.
- Takes Name and Address from Sales Ledger System when constructing an Invoice/Credit Note.
- Attractive screen layouts, and easy to follow screen 'prompts' to help end user.
- 15 lines per invoice.
- 10 V.A.T. rates.
- Invoice and Delivery Address.

Pre-printed stationery available for Sales Ledger, Purchase Ledger and Invoicing Systems.

Price	Nett	Vat	Total
	300.00	45.00	345.00

Nominal Ledger System

- 900 Nominal Codes.
- 99 Sub-Analysis Codes e.g. Monthly or Branch Accounting etc.
- 5000 Transactions.
- Batch control techniques with comprehensive verification of input.
- Full interrogation via screen.
- Complete Audit Trail.
- Selective reporting by Nominal Codes, Sub Analysis Codes and Final Accounts is available.
- Trial Balance, Profit and Loss and Balance Sheet that all balance and agree.
- Automatic V.A.T. Calculation from Gross Amount.

Price	Nett	Vat	Total
	450.00	67.50	517.50

A stock control program capable of handling up to 4,000 stock items is available free on request to systems purchasers.

Direct Generator

The Direct Generator is a suite of programs that enables a lay person to generate computer programs.

Programs can be generated for a wide range of applications e.g. Invoicing, with all the necessary file maintenance and printer output, a stock control system, mailing lists, etc.

Price	Nett	Vat	Total
CE330G Direct Generator	120.00	18.00	138.00

Quantity discounts available on request. 12 month guarantee/2 years on Sharp & Apple. Free delivery within mainland UK on orders over £10.

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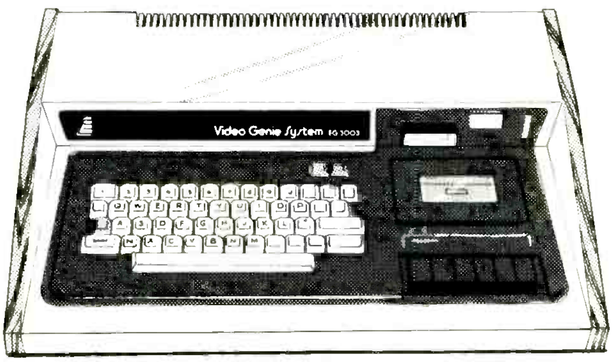
Video Genie

Amazing Value – compatible with TRS80 16K level 2



Microdigital are the hardware experts – here's why you should buy your Genie from us. ★ Low Price of £280 + VAT. ★ Each computer tested by our engineers before despatch. ★ 12 month parts and labour guarantee. ★ Free delivery within mainland U.K. ★ Bona fide official orders welcome. ★ Latest version of Genie.

The Video Genie is a complete computer system, requiring only connection to a domestic 625 line TV set to be fully operational; or if required a video monitor can be connected to provide the best quality display.

The system case contains the Central Processor Unit (CPU), 16,000 bytes RAM memory, the cassette system, a 12,000 byte operating system and BASIC interpreter in ROM, and a full size keyboard, in a stylish case, at a price that makes the Video Genie better value than some "kit" computers.

Applications

The Video Genie System has many uses in all spheres of life, the easy to use BASIC language means that programs are easily written for specific applications, and pre-recorded program tapes are available in great variety.

In a school or college the machine can be used with a large screen TV to allow a whole class to be taught at once.

Expansion

1. The EG3013 EXPANDER (expansion unit)

is designed to upgrade your VIDEO GENIE SYSTEM, from a personal computer to a powerful microcomputer system, in the most flexible and inexpensive way. All resident interfaces are fully buffered to ensure reliability.

2. Mass Storage and Fast Access

The Disk Controller Interface can handle up to 4 sets of mini-floppy disk drives (compatible types as Shugart SA-400 and Pertec FD-200).

Storage options:
i) Single side, single/double track density 35/40/77 tracks.
ii) Double side drives can also be used provided their side select signals are modified. If using double side, the Disk Interface can only handle 2 drives instead of 4.

Disk Operating System options: TRSDOS; NEWDOS; MICRODOS; VTOS.

3. Communications

The RS-232-C Interface (optional) can be connected to telephone, modem or other form of carrier to provide data communication capabilities. Besides communications, it can also be used to operate RS-232-C standard serial printers.

4. Memory Expansion

Memory capacity can be expanded from the basic 16K to 32K/48K by insertion of RAM CARD (not inclusive in the EG3013 EXPANDER package), into either one of the two remaining S-100 slots.

5. S-100 Bus Expansion

Optional S-100 Bus standard cards (such as controller cards) can be plugged into either one of the two remaining S-100 slots for further system expansion.

Prices	Nett	Vat	Total
Video Genie Computer	280.00	42.00	322.00
EG3013 Expander with RS232	215.00	32.25	247.25
EG3013 Expander without RS232	185.00	27.75	212.75
32K Memory Board S100	130.00	19.50	149.50
16K Memory Board S100	95.00	14.25	109.25
Single Disk Drive	215.00	32.25	247.25
Dual Disk Drive	410.00	61.50	471.50
2 Drive Cable	17.00	2.55	19.55
4 Drive Cable	32.00	4.80	36.80
Printer Cable	17.00	2.55	19.55
Centronics Parallel Interface			
for unexpanded Genie	33.00	4.95	37.95
Sound kit	10.00	1.50	11.50
fitting above	5.00	0.75	5.75
Lower case kit	35.00	5.25	40.25
fitting above	5.00	0.75	5.75

Books

Microdigital offer a good selection of books to help you get the best from your Genie or TRS 80. There is no VAT on books, but £1 for post and packing should be added to orders for less than £10.

Learning Level II BASIC by David Lien 10.95

This is the second excellent book by CompuSoft Publishing in California. No Genie or TRS 80 owner can afford to miss this one.

Introduction to T-Bug by D. & K. Inman 6.20

The only book which describes in detail the machine language monitor operations of the TRS 80 or Genie.

Introduction to TRS 80 Graphics by D. Inman 7.10

For some time now, graphic displays on microcomputers have been out of the reach of hobbyists because of their complexity and high cost. In this book the author will show you how, with a minimal knowledge of the BASIC computer language and your Genie or TRS 80 computer, you can create graphic displays that only a few years ago were the exclusive turf of the big computer owners. The book begins with the basics and works from line drawings through geometrics and right on up to moving figure animation and more advanced operations. A great handbook on computer graphics for microcomputer owners at all levels of experience.

Microsoft™ BASIC by Knecht 7.20

A tell it all book for Genie and TRS 80 users. It presents an introduction and tutorial on programming in MICROSOFT BASIC. The concepts presented are illustrated with examples that actually run. By starting with the simplest and most commonly used commands and then progressing onto the more complex instructions, the author illustrates how the more powerful versions of the BASIC language can save time and effort.

TRS 80 Disk and Other Mysteries 11.90

A straight-forward presentation on disk organisation and file management and hints on how to deal with some disk problems.

TRS 80 BASIC – A Self Teaching Guide by Albrecht/Inman/Zamora 5.90

A step by step guide for all Level II TRS 80 and Genie owners. Although geared towards the beginner, it contains a wealth of information for more advanced programmers.

Video Genie System Service Manual 5.00

This manual is written for servicing technicians and people who are interested in modifying the machine to suit their particular applications. Readers are assumed to have a basic background on digital electronics and microprocessors.

The easy way to programming in BASIC using the Video Genie System by John and Judy Deane 5.00

★ How to program graphics. ★ How to load and run programs. ★ 40 sample programs. ★ Full explanation of BASIC error messages. Ideal for beginners.

Quantity discounts available on request. 12 month guarantee/2 years on Sharp & Apple. Free delivery within mainland UK on orders over £10.

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Apple Software

CCA DATA MANAGEMENT (48K APPLE, Disk)

This system, developed by Personal Software, stores and retrieves information. It is very simple to learn and use, and at the same time provides real data processing capabilities for you and your Apple. Allows you to prepare and access files for your mailing list, customer lists, expense reporting, budget analysis or any report you need.

	Nett	Vat	Total
Price	75.00	11.25	86.25

DESK TOP PLANNER (48K APPLE, Disk)

A unique financial planning and forecasting system that is driven by a simple menu system. Allows you to create business models or sub-models and build up consolidated summaries if you have individual branches or cost centres.

	Nett	Vat	Total
Price	75.00	11.25	86.25

VISICALC (32K APPLE, Disk)

Visicalc provides an electronic worksheet of up to 63 columns and 254 rows.

	Nett	Vat	Total
Price	85.00	12.75	97.75

VisiList

Lists out the grid location and formulas of any VisiCalc file.

	Nett	Vat	Total
Price	10.95	1.64	12.59

Apple Plot

A useful addition to VisiCalc and Desktop/Plan systems which enables results to be plotted quickly and accurately. Multiple sets of data can be compared on the same report and displayed on the screen, in colour, or a hard copy generated for reports, files etc.

	Nett	Vat	Total
Price	37.00	5.55	42.55

Maths Sequences (Milliken)

A comprehensive software curriculum in mathematics for children age 5-10. Topics covered range from simple arithmetic through to laws of arithmetic and negative numbers. Instruction is completely individualised based on each student's needs and abilities. The programs are success orientated and allow the student to work at his own pace towards set objectives. As well as all this each student's progress is monitored thus allowing the teacher to review the progress of all students in a matter of minutes.

	Nett	Vat	Total
Price	200.00	30.00	230.00

I.F.O. – Information File Organiser

This easy-to-use Data Base Management System allows the user to quickly create a data base and then extract information from it. Extracted information can be printed out in up to 10 user defined report formats on screen or printer.

	Nett	Vat	Total
Price	105.00	15.75	120.75

Video Message

The Video Message display systems turns the Apple into an electronic bulletin board. A simple set of commands allows the user to create 'slides' containing text and colour graphics.

	Nett	Vat	Total
Price	150.00	22.50	172.50

First VISICALC, now another great for the Apple

MicroModeller is the first decision support system to run on a microcomputer. This is made possible through the powerful Apple microcomputer with the Micromodeller program. The program will seem familiar to existing users of the more popular time sharing programs, such as TABOL, FCS, PROSPER, SIMSTRAT, FORESIGHT, etc. It offers **all** the benefits of these programs at a fraction of the cost.

For more information please ring.

Price	Nett	Vat	Total
MicroModeller	425.00	63.75	488.75

The latest in Apple games

Apple Bowl

An entertaining 3-dimensional 10 pin bowling game. You control curve and speed. Requires integer basic and paddles.

	Nett	Vat	Total
Price	9.00	1.35	10.35

Apple Adventure

Surely the best adventure game available for Apple. Very hard to win, excellent graphics. Requires Applesoft Basic.

	Nett	Vat	Total
Price	21.00	3.15	24.15

Stellar Invaders

Another one in the 'Invaders' series. Realistic graphics and sound effects. You can control your base with either the keyboard or paddles. Requires Applesoft Basic.

	Nett	Vat	Total
Price	13.00	1.95	14.95

	Nett	Vat	Total
Tranquility Base	13.95	2.09	16.04
Bloody Murder Like play with knives? (Integer) Disk.	9.95	1.49	11.44
Microleage Baseball	11.95	1.79	13.74
Macro Screen Editor Cursor orientated editing tool.	19.95	2.99	22.94
Akalabeth Latest Adventure type game.	16.95	2.54	19.49
Trilogy	15.95	2.39	18.34
Tranquility Base	13.95	2.09	16.04
Head-On	13.95	2.09	16.04
Bill Budge's Space Album	20.95	3.14	24.09

NEW GAMES

An air hockey game, so fast it comes with a video synch connector.

	Nett	Vat	Total
Retroball	15.95	2.39	18.34
Alien Lander	13.95	2.09	16.04

VARIOUS

New from SIRIUS. Amazing hires graphics scroll bi-directionally.

	Nett	Vat	Total
Phantom Five	15.95	2.39	18.34

STARCRAFT (Tokyo)

The best "Invader" game we've seen bar none. We mean it!

	Nett	Vat	Total
Apple Galaxian	13.95	2.09	16.04
Galaxy Wars	13.95	2.09	16.04

Broderbund

Do you like Startrek adventures?
4 Galactic Sagas from Broderbund, provide a level of complexity and sophistication not seen before.

Galactic Empire, Trader and Revolution (3 separate disks)

	Nett	Vat	Total
Price each	13.95	2.09	16.04
Tawala's Last Redoubt	16.95	2.54	19.49

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Books

SYBEX

CP/M Handbook - R.Zaks 8.90
One of the best selling microbooks of all time, this title is useful on its own or as an addition to the Digital Research documentation.

Microprocessors - From Chips to Systems - R.Zaks 7.20
The basic text on micros for everyone with a technical or scientific background. This book teaches all the fundamentals of microprocessors step by step.

Micros - Interfacing Techniques - Zaks and Lesea 9.90
This comprehensive book introduces the basic interfacing concepts and techniques, then presents the implementation details from hardware to software.

Programming the 6502 - R. Zaks 8.70
This book is an educational text designed to teach programming, using the 6502. It does not require any prior programming knowledge, yet can be used to advantage by anyone wishing to familiarise himself with the 6502. An invaluable book for owners of the PET, Apple, Kim, etc.

Programming the Z-80 - R. Zaks 9.70
Another in the highly successful Sybex Series by Rodnay Zaks. This book combines the function of a teaching text, that Sybex do so well, with an extensive reference section. The book is much more than an introduction to the Assembly Language syntax of the Z-80.

Z-8000 Programming - R. Mateosian 9.90
Entering the field of 16-bit micros, this book fulfils a dual role as both an educational text and a reference manual, and covers machine language programming from basic concepts to advanced programming techniques.

6502 Applications Book - R. Zaks. 8.70
This book presents practical applications techniques for the 6502 ranging from a complete home alarm system to an industrial control loop for temperature control. Also includes analog to digital conversion and simple peripherals from paper-tape reader to micro printer.

6502 Games - Zaks 8.90
A book of ten games which will teach you assembly language, algorithm design and data structures in a straight-forward and enjoyable manner.

Your First Computer - R. Zaks 5.90
This book explains what a computer system is, how it works, and how to select the various components and peripheral units. Essential reading for a would-be computer user.

OTHER BOOKS

The BASIC Handbook by David Lien 10.95
This is a machine independent reference text for the BASIC compilers on most personal computers. It also shows the syntax for the new ANSI standard BASIC. It is the only book of its kind in print at present.

Illustrating Basic - a simple programming language by D. Alcock 3.25
One of the best selling books on BASIC, it's clear explanations, attention to details, style, wit and humour have won it widespread acclaim...

Practical Microcomputer Programming The 6502 - Weller 19.50
This book examines the detailed assembly level programming characteristics of the 6502 microprocessor and includes appendices giving an assembly listing of the assembly program (6502 Resident Assembler), an assembly listing of Apple 11 input/output subroutines for the assembly computers and assembly listing of the D-Bug program for Apple 11.
A very comprehensive reference book.

Advanced BASIC by J. Coan 6.80
Develops the readers expertise with BASIC through strings and files to graphing and more important mathematical functions.

The Art of Computer Programming Volume 1 - Fundamental Algorithms by Knuth 9.90
This is the first book in this world wide best selling series and thought by many as the best books of their type available. Volume 1 begins with a thorough review of the mathematical techniques used, although it does not assume mathematics above high school level in the reader. It goes on to review assembly level programming and ends with a 200 page review of information structures. The book contains numerous exercises.

The Art of Computer Programming Volume 2 - Semi-Numberical Algorithms by Knuth 16.40

The Art of Computer Programming Volume 3 - Searching and Sorting by Knuth 20.40

Using CP/M - A Self Teaching Guide - Fernandez/Ashley 5.90
CP/M is the most widely used microcomputer operating system, and this book presents a complete detailed introduction to the use of CP/M for maximum capability and efficiency -with any hardware and using any programming language.

The ZX80 Pocket Book 4.95
This is not a book for the complete beginner; it is intended for the student, who wishes to develop his or her programming skill, and for the experienced programmer who wants a concise summary of the unique characteristics of this machine.

Basic BASIC by J. Coan 6.70
One of the most widely sold text books on BASIC. The book uses over 100 example problems to illustrate the essential techniques of the language.

BASIC Computer Games by David Ahl 5.45
The first collection of games all in BASIC. Contains both a complete listing and a sample run of each game along with a descriptive write up.

BASIC Primer by Waite and Pardee 6.90
This book is exactly what it says it is - on top of this it also includes 7 appendices to help you optimise your code for speed and memory use. Finally, at the back is a reference card which you will keep in your pocket during the rest of your BASIC Programming career.

Best of Micro - Volume 1 5.45
Micro is the best known and most widely read of the specialists journals dealing with the 6502 microprocessor as used in the PET, Apple, Aim, OSI, Computhink Minimax, etc. "Best of Micro" is a bound version of the first six issues.

Best of Micro - Volume 2 6.45
This is the bound version of the second six issues of Micro up to mid 1979.

Cheap Video Cookbook by D. Lancaster 4.90
A complete guide to super low cost alphanumeric and graphic microprocessor based video displays - this book picks up where the TV Typewriter Cookbook ended.

CMOS Cookbook by D. Lancaster. 7.45
Your complete guide to the understanding and use of Complementary Metal-Oxide-Silicon integrated circuits. Gives usage rules, power supply design examples, applications, bread boarding and coverage of logic.

Computer Graphics Primer by M. Waite 8.90
Instruction in the methods of producing drawings, plans, maps and schematics on a CRT display. In 3 sections 'Perspectives', 'Basic Concepts', and 'Graphics Programming'.

Computer Programs that Work by Lee, Beech and Lee 3.90
This book contains twenty four programs in BASIC in the areas of biology, mathematics, chemistry and physics and includes simulations of real life situations and popular games.

Computerisation for the Small Business by Edward G. Cluff 2nd Edition 6.90
A layman's guide to Directors and Senior Line Management. This is a crisp, non-technical guide which covers the whole business field - computer and programming choices; data preparation; input and retrieval; financing; the secondhand market; maintenance; running costs; and security and privacy. It concludes with a collection of self-evaluation surveys for different computer applications.

Computers in Maths – D. Ahl 10.90
A fun maths book by the author of BASIC Computer Games – a huge source book of ideas for using computers to learn about mathematics.

The Howard W. Sams Crash Course in Microcomputers by L. E. Frenzel 10.60
Written in a teach yourself format with study questions, this book provides a solid background in microcomputers quickly and effectively. All aspects from fundamentals and operating systems to programming and peripherals.

How to Program Micros by W. Barden Jnr. 6.90
Explains assembly language programming of microcomputers based on the 8080, 6800 and 6502 microprocessors. Basic concepts, number systems and operations, computer operation and codes are examined.

Industrial Process Control Systems by Patrick and Fardo 8.90
Process control procedures, system concepts, components, industrial applications and study questions in a logical text book.

Introduction to Microcomputers by A. Osborne - Volume 0 The Beginners Book - A. Osborne 5.90
If you know nothing about computers this is the book to begin with. It explains what computers are and describes their components.

Introduction to Microcomputers by A. Osborne - Volume 1 Basic Concepts - A Osborne 7.90
This book describes application techniques common to all microprocessors yet specific to none. All the basic hardware and software concepts are explained simply.

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Books

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Introduction to Microcomputers by A. Osborne (September 1978 Edition) Volume 2 - Some Real Microprocessors 14.90
This 9" x 7" loose leaf format book covers every major microprocessor on the market. 4 bit to 16 bit in detail and analyses more than 20 CPUs. Includes new sections on the most recent entries into the microprocessor market. Describes support devices for use with only one microprocessor.

Introduction to Microcomputers by a Osborne - Volume 3 Some Real Support Devices - Loose Leaf 10.90
A companion volume to Volume 2. This describes the micro support devices which can be used with more than one microprocessor – including system buses.

Osborne Update Series for Volume 2 and Volume 3
6 updates to each subscription issued bi-monthly.

Volume 2 Data on:- TMS1000 MK3372/3373 Single Chip Mostek MK3886 COMBO Motorola MC6801 Single Chip Synertek SY6551 ACIA TMS9902 USART MicroNova 9940 update Intel 8086 Instruction Set Update Zilog Z8000 2900 Series Chip Slice Products. 18.90

Volume 3 Data on:- Static RAM update 2652 Multi Protocol Communications Circuit 2651 Programmable Communications Interface Introduction to Data Converters Digital to Analog Converters (8/10/12 Bit). Analog to Digital Converters (8/10/12 Bit) Am9511 Arithmetic Processor Introduction to Peripheral Controllers Keyboard Display Controllers Video Controllers Floppy Disc Controllers Motorola EXORciser Bus Heath H8 Bus RS449/422 A/423 A Standards. 18.90

Binders Custom binder for Volume 2 and Volume 3 which allows the updates to be added when issued. Volume 2 or Volume 3 must be specified when ordering. 5.75

Microcomputers for Business Applications by W. Barden Jnr. 7.10
This book will prove invaluable to a potential buyer of a business microcomputer system -helping him to select the best system for his particular needs. The micros discussed range from spin-offs of hobbyists computers to complete "turnkey" systems with customised software.

More BASIC Computer Games by David Ahl 5.45
This is the sequel to the best selling "BASIC Computer Games". 84 fascinating and entertaining games for solo or group play. All games are complete with a program listing in BASIC, a sample run and a description. Standard Microsoft BASIC is used throughout and the programs are simple to use with almost all microcomputers.

Pascal for the PET 8.95
Transam's manual for use with the Commodore Pascal disk.

PET and the IEEE 488 Bus (GPIB) by Fisher & Jensen 9.90
A book for instrument designers, scientists, programmers and hobbyists - which shows how you can have a low cost versatile system that may be interfaced to any of hundreds of electronic instruments.

PET/CMP Personal Computer Guide - Donaghue & Enger 9.95
An invaluable source of information for any PET or CBM user - giving details on BASIC programming, storing data preventative maintenance and assembly language.

The PET Revealed - Nick Hampshire (1980) 9.95

The PET Library of Sub-Routines (1980) 9.95
Invaluable aids for all Pet Owners - information packed pages about your PET -Commodore approved.

Practical Microcomputer Programming with the Z-80 by Weller 19.50
18 chapters of solid accurate programming information. Debugging techniques, interrupt modes, array and table handling, number base conversation, floating point arithmetic, programmed input/output stackpointer usage.

Practical Programs and Games in BASIC 5.70
A varied selection including Space War, Blackjack, Statistical Permutations, and many more.

Problem Solving and Structured Programming in BASIC by Koffman and Friedman 8.90
The book reflects the view that good problem solving and programming habits should be introduced at an early stage.

Programming and Interfacing the 6502 8.90
An excellent starting point for 6502 micro-computer novices, who need experience in assembly language programming or chip-level interfacing. Examples are shown using a KIM, AIM or SYM system.

Programming a Microcomputer (6502) by Foster 7.20
This book will teach you how to program a microcomputer in machine language. Although designed specifically for the 6502 microprocessor used in the Kim 1, PET and the Apple, the basic principles involved apply to all computers.

Programming in PASCAL by Grogono 6.90
This introductory language manual is an excellent start to one of the fastest growing programming languages today. The book is arranged as a tutorial containing both examples and exercises to increase reader proficiency with the language.

30 Programs for the Sinclair ZX80 (1K) - Beam Software 6.90
A host of useful programs for this best selling machine.

S-100 Bus Handbook - Bursky Dave 9.10
This book documents the bus structure used by most micro makers. Full details are given of S-100 system components.

The S-100 and Other Micro Buses by Poe and Goodwin 5.10
This book is about buses and after acquainting the reader with bus basics moves on to detail the eleven most widely used bus systems.

SARGON:A Computer Chess Program by Dan and Kathe Spracklen 9.45
Here is the computer chess program that won first place in the first chess tournament at the 1978 West Coast Computer Faire. It is written in Z-80 assembly language using the TDL macro assembler. It comes complete with block diagram and sample printouts.

Some Common BASIC Programs - Poole/Borchers 3rd 7.90
Includes 76 short programs covering financial, mathematical, statistical and general interest subjects, all of which have been tested.

The Systems Analyst by J. Attwood (Hardback) 7.45
From the initial decision whether or not to use a computer for a specific problem, to the actual installation of the completed system, the book covers the strategies, skills and techniques needed.

TTL Cookbook by D. Lancaster 7.10
Discover what transistor-transistor logic is, how it works and how to use it. Discusses practical digital applications and teaches you how to build TTL systems that entertain, test and train.

TV Typewriter Cookbook by D. Lancaster 7.20
A comprehensive guide to low cost television display of alpha-numeric and graphics data for microprocessor systems word processing, TV titling and video games.

TRS 80 Interfacing by J. A. Titus
Requiring a good understanding of Level 11 BASIC, this book describes the signals available in the TRS 80 computer and their application to the control of external devices. Experiments in the construction and use of some typical interfaces are included. Book 1 6.90
Book 2 7.90

Z-80 Assembly Language Programming 10.45

Z-80 Microprocessor Programming and Interfacing Volume 1 by Nichols and Rony 7.70
This book is the first of a two volume series on the Z-80. It covers programming at the assembly and machine language level for the Z-80. Book 2 will cover interfacing. The books are laboratory orientated texts. The strong emphasis is on learning through experiment. This book requires no background in computers.

Z-80 Programming and Interfacing Book 2 8.45

Instruction Handbook (Z-80) 3.05
This slim volume constitutes a powerful and comprehensive guide. About seven hundred instruction codes are obtainable from the basic instructions.

Z-80 Microcomputer Design Projects by W. Barden Jnr. 9.10
A solid instruction to the Z-80 microcomputer and the EZ-80 chip. Simple construction of the EZ-80 microcomputer and several applications.

Z-80 Microcomputer Handbook by W. Barden Jnr. 6.90
This book provides essential information on Z-80 technology and is organised into three sections: Hardware, software and microcomputers built around the Z-80.

Z-80 Programming for Logic Design - A. Osborne 6.25
These books describe the implementation of sequential and combinational logic using assembly language. They describe the meeting ground of the programmer and the logic designer and are written for readers in both fields.

6502 Assembly Language Programming by Leventhal 10.45
Another fine manual in the Osborne Assembly Language series to join the best selling 8080, 6800 and Z-80 books.

6502 Cookbook by R. Findley 7.70
Various component programme units given may be combined at will, and these recipes will help you to explore some of the possibilities available.

6502 Software Design by L. Scanlon (Sams) 7.90
Fundamentals of 6502 operation are explained and then extended to give a comprehensive coverage of 6502 use.

Using Forth (Manual) 13.45
This manual concentrates on the practical aspects of programming in FORTH for people who are new to this operating system and programming language.

Z-8000 Assembly Language Programming - Leventhal/Osborne/Collins 13.45
This book describes the entire Z-8000 instruction set in detail, covering all the fine points of assembly language programming.

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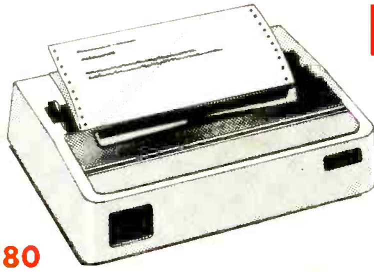
LIVERPOOL L2 0PJ
Tel 051 227 2535/6/7

Microdigital at Laskys
58 LEOPOLD STREET,
SHEFFIELD
Tel 0742 750971

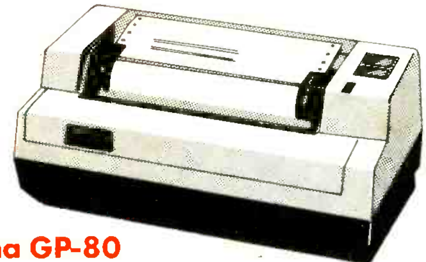
Printers



Microline 80

Now an old favourite, the MICROLINE has established itself on the market as one of the most reliable and versatile printers available. This quiet 5 x 7 dot matrix printer prints at 80cps and is capable of producing graphical output. It comes complete with 96 character set and centronics compatible interface. You can select from 40, 80 and 132 characters per line in software. The 40 character output is double-size, 80 character is at 10 cpi, 132 character is at (16.5 cpi). Now at a new low price, exceptional value.

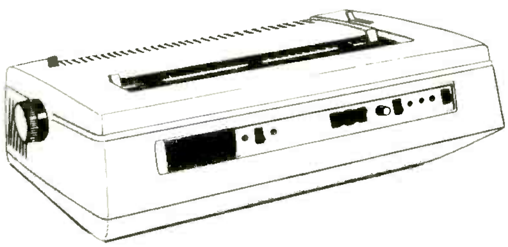
Price	Nett	Vat	Total
MICROLINE 80	345.00	51.75	396.75
Tractor Feed	45.00	6.75	51.75
RS232 Adaptor	75.00	11.25	86.25
Ribbons	2.25	0.34	2.59
PAPER (2000 sheets) 11″ x 9½″			
Pick-up Price	11.00	1.65	12.65
Delivered Price	14.00	2.10	16.10



Seikosha GP-80

At last, an economic printer for the hobbyist. This must be the lowest-cost smallest impact graphic printer in the world. Graphics, normal (12 cpi) and double-width (6 cpi) characters can be printed on the same line. Pinfeed tractor is equipped as standard. The printer prints on plain paper and has a continuous self-inking ribbon. There is a wide range of optional interface boards available. A truly remarkable dot matrix printer, it prints at 30 cps using a 5 x 7 dot matrix. A parallel interface is standard.

Price		Nett	Vat	Total
GP-80		220.00	33.00	253.00
RS232C	Interfaces:	50.00	7.50	57.50
IEE 488	"	50.00	7.50	57.50
PET	"	50.00	7.50	57.50
APPLE	"	50.00	7.50	57.50
TRS 80	"	30.00	4.50	34.50
Video Genie	"	30.00	4.50	34.50
Ribbons		4.00	0.60	4.60
PAPER (2000 sheets) 11″ x 8½″				
Pick-up Price		12.00	1.80	13.80
Delivered Price		15.00	2.25	17.25



Qume Sprint Model 545RO

An extremely high quality daisy wheel printer for the professional user. Some features are 45 characters per second print speed, asynchronous serial interface, 96 character daisy wheel, 10 or 12 characters per inch producing 132 to 158 characters per line. A plotting resolution of 5760 x 2880 points per sq. inch is available.

Price	Nett	Vat	Total
Receive only model	1750.00	262.50	2012.50

Centronics 737

80 CPS + double spacing and mono spacing 10 and 16.7 CPI, proportional spacing, 3 way paper handling, 96 character set, expanded print, right margin justification, underlining, bi-directional, centronics parallel and serial interfaces standard.

Price	Nett	Vat	Total
	395.00	59.25	454.25

Video Monitors

APH 10″ MONITOR

An economic monitor, producing a clear black and white picture.

Price	Nett	Vat	Total
APH	85.00	12.75	97.75

HITACHI 9″ MONITOR

A compact and reliable monitor, produces white on black characters.

Price	Nett	Vat	Total
VM 910	125.00	18.75	143.75

HI-RESOLUTION MONITOR (VM 906)

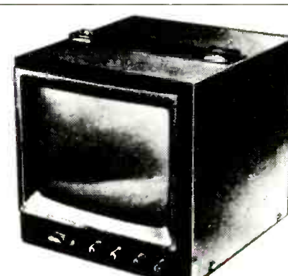
This monitor has a much finer tube than most, producing extremely clear and highly defined pictures.

Price	Nett	Vat	Total
VM 906	145.00	21.75	166.75

HITACHI 12″ MONITOR (VM 129)

This is a must for the professional user. The VM 129 is ideal for use with the 80 column displays. Provides a clear and stable picture.

Price	Nett	Vat	Total
VM 129	185.00	27.75	212.75



12″ GREEN-SCREENED MONITOR (VM 12G)

Ideal for continuous use, this monitor displays green data. A tinted perspex screen cover reduces reflections and glare. Rapidly becoming the industry standard.

Price	Nett	Vat	Total
VM 12G	162.00	24.30	186.30

CABLES FOR MONITORS

These are supplied free if purchased with a microcomputer. Otherwise:

Price	Nett	Vat	Total
Cable	3.50	0.53	4.03

Colour Monitors – please ring for details.

Quantity discounts available on request. 12 month guarantee/2 years on Sharp & Apple. Free delivery within mainland UK on orders over £10.

Mail Orders to
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QED Mains Interference Suppressors

For use when mains interference is causing your computer problems.

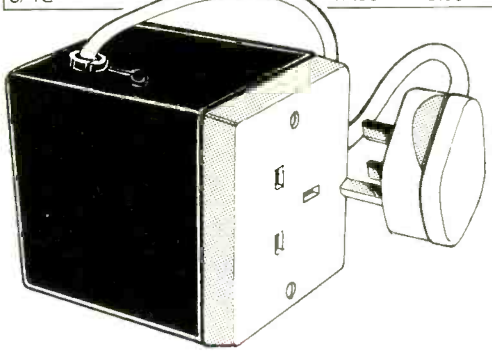
Simply plug the equipment into the suppressor and plug the suppressor into the wall socket (see specification for maximum power). Inserted in this way, most forms of mains borne interference will be cured. An alternative method of fitting, whereby the suppressor is connected to the mains circuit of the appliance causing the interference, may prove to be more effective in some cases.

Technical Specification: 6/2B

(6/4C specification in brackets)

Maximum power	:	750 watts (1500)
Maximum current	:	3 amps (6)
Operating voltage	:	up to 250 V.A.C.
Insertion loss	:	approx 55 dB's
Frequency range	:	150 kHz to 15 MHz (150 kHz to 100MHz)
Discharge time	:	less than one second

Price	Nett	Vat	Total
6/2B	12.80	1.92	14.72
6/4C	17.30	2.60	19.90



Scotch 7440 Head Cleaning Diskettes

Keeping the heads free of debris means longer lasting heads, fewer diskette replacements and fewer engineer calls. The rotating cleaning fabric in the head cleaning diskettes alternately wipes the heads with the solution and dry surface, removing contamination from the read/write heads. In half a minute the heads are clean.

The cleaning diskettes can be used with either single or double headed diskette drives. The 7440 kit is for all 5¼" minidiskette drives. The kit contains one bottle of cleaning soloution, one dispenser cap and two cleaning diskettes. Each cleaning diskette can be used for approximately 15 cleanings.

Materials and solution are completely safe, being non-flammable, non-adbrasive and will not harm metals, plastics or painted surfaces. Too little or too much cleaning solution will not affect the drive.

Price	Nett	Vat	Total
7440 kit	19.50	2.93	22.43

Cassettes

We are probably the largest supplier of microcomputer cassettes in the country and have them specially manufactured to our quality specification.

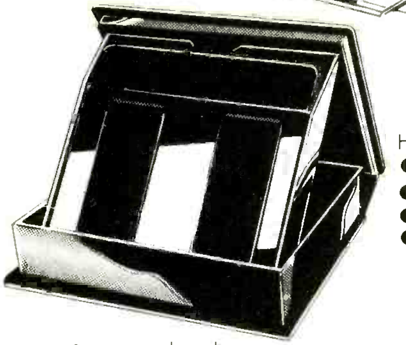
- C15 Agfa Tape
- Special Labels
- Cellophone wrapped
- Precision transport mechanism
- Leaderless
- Insert Cards
- Screw fixing case
- Proven performance

Prices	Nett	Vat	Total
one cassette	0.80	0.12	0.92
box of ten cassettes	5.20	0.78	5.98
fifty cassettes	25.00	3.75	28.75
one hundred cassettes	45.00	6.75	51.75

Guarantee

If within 12 months of purchase any of our cassettes does not give satisfactory performance send it back to Microdigital for replacement by return of post.

Disks



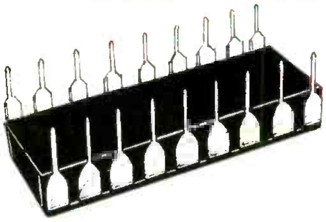
High performance Mini Floppy disks

- Anti static envelopes
- single sided, single density
- soft sectored
- labels and write protect

Prices	Nett	Vat	Total
one disk	3.00	0.45	3.45
ten disks	22.00	3.30	25.30
fifty disks	100.00	15.00	115.00
one hundred disks	180.00	27.00	207.00

Memory Chips

Guaranteed quality – Any faulty chips should be returned to us within 12 months of purchase with proof of purchase for replacement by return of post.



2114 static memory chips guaranteed to 300 nanoseconds full cycle time. Low power, suitable for Superboard Compukit, Atom ZX 80 etc. (2 chips give 1k byte of memory).

Prices No. of Chips	Unit Price	Total Price Nett	Vat	Total
2	1.80	3.60	0.54	4.14
8	1.70	13.60	2.04	15.64
24	1.60	38.40	5.76	44.16
100	1.40	140.00	21.00	161.00
500	1.30	650.00	97.50	747.50
1000	1.25	1250.00	187.50	1437.50

4116 and 2114 chips at the same price

4116 dynamic memory chips guaranteed for 200 nanoseconds full cycle time. Suitable for Apple, TRS 80, Nascom, Exidy Sorceror, Sharp MZ 80K etc (8 chips give 16k bytes of memory).

Quantity discounts available on request. 12 month guarantee/2 years on Sharp & Apple.

Free delivery within mainland UK on orders over £10.

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Microdigital Mail Order Form

MAIL TO: Microdigital Limited, Freepost, Liverpool L2 2AB.

Office Use only	Goods required	Price	
	1		
	2		
	3		
	4		
	5		
	6		
	7		
	8		
	Add £1 P & P to orders under £10		
	Total		

If you require a stereoclub application form tick this box ☐

Date:

Access: 5224 ☐☐☐☐ ☐☐☐☐ ☐☐☐☐ ☐☐☐☐

Barclaycard 4929 ☐☐☐ ☐☐☐ ☐☐☐

American Express/Diners Club/Stereo Club No. . . . .

Expiry date:

Name ____________________

Address: ____________________

____________________ Post Code __________

Tel (day) ____________________ **PE**

Lasky's Stereoclub

– the easy way to buy, from Microdigital.

For as little as £5 per month, you can join the Lasky's Stereoclub, which immediately entitles you to a credit limit of 24 times your monthly repayment, and enables you to buy **now** the microcomputer equipment that you've always wanted from Microdigital. Current Stereoclub interest rate is 2.5% monthly – equivalent to an APR of 34.5% (Rates may vary).

As a Stereoclub member we'll send you regular news and literature from Lasky's and Microdigital. Lasky's Stereoclub is probably the best thing that's happened to Microcomputers since the invention of the chip!

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Directors P.M. George, P. Klein, G.W. Ralph, A.J. Stirling, D.J. Sate, V. C. Gaffin, T. Edmundson.
Ultimate Holding Company - Ladbroke Group Limited
VAT Number:- 240 1132 31

Terms and Conditions

In addition to cash we accept, Access, Barclaycard, Stereo Club, American Express, Diners Club and cheques covered by a bankers card.
Allow one week for personal cheques to clear.
VAT in this brochure has been calculated at the rate of 15% current at the time of writing. Please allow for any changes.
Postage and carriage is offered free of charge within the United Kingdom.
All products are covered by our 1 year warranty against failure due to faulty materials or workmanship.
Official orders over £50 are welcome, with normal 30 days credit extended to bona-fide commercial and government organisations.
All prices, specifications and terms are subject to change without notice at the discretion of the management. Offers subject to availability.
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Microdigital 12 month Guarantee

Microdigital Ltd., (hereinafter called the 'company') warrants the products it sells against defects in material and workmanship for a period of one year from the date of purchase, two years for Apple and Sharp products.
During the warranty period, the company will repair (or at its own option, replace) at no charge, components that prove defective. This is provided the product is returned, shipping prepaid, or by person, to 25 Brunswick Street, Liverpool 2, L2 0PJ, stating when it was bought and enclosing proof of purchase.
This warranty does not apply if, in the opinion of the company, the product has been damaged by accident, misuse, misapplication or, in the case of a kit, bad construction.

NEW Quantity Discounts

These are available on orders for 5 or more units (Hardware Only). Write in with your exact requirements and we will quote by return of post.

Opening Hours

Shop – 9 till 5.30 Mon – Sat.
closed Bank Holidays.
Mail Order – 9 till 5 Mon – Fri.

Ansaphone Service

24 Hour – 7 Day
Ansaphone Service
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Prices correct at time of going to press.

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SAXON FOR ALL YOUR DISCO/P.A. NEEDS

STEREO DISCO SYSTEMS

100-600W COMPLETE WITH LIGHT SHOW

ABSOLUTELY COMPLETE

FEATURES:
- ★ MIC/TAPE INPUTS
- ★ CROSSFADE
- ★ SLAVE OUTPUT
- ★ FULL MONITORING/CUE LIGHT
- ★ WIDE RANGE BASS/TREBLE
- ★ FOUR CHANNEL SOUNDLIGHT

PLUS!! BUILT IN LIGHT DISPLAY – 2 YEAR WARRANTY
ONLY 20% DEPOSIT – TYPICAL APR 36%

STANDARD CENTAUR 100W	£345	Dep. only £69
SUPER CENTAUR 200W	£425	Dep. only £85
GXL CENTAUR 200W	£545	Dep. only £109
CUSTOM CENTAUR 400/600W	£945	Dep. only £189


GXL CENTAUR

SEE OUR CATALOGUE for other exciting combinations of consoles and loudspeakers – **ONLY £1** – INCLUDES £30 WORTH FREE VOUCHERS – over 3000 systems now in use. Please telephone for details of carriage charges – area decides cost.

P.A. GEAR

A FULL RANGE OF EQUIPMENT TO SUIT YOUR GROUP/PUB/CLUB ETC.

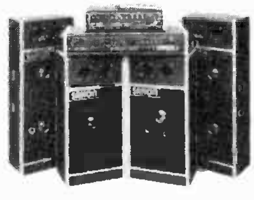
AP100 £72 carr. £2.50
4 mixed inputs plus bass/treble master controls – 100W output.

AP200 £119 carr. £3.50
6 mixed inputs on 3 channels – 3 sets bass/treble plus master plus presence 200W output plus slave output.

1×12 P.A. CAB £79 carr. £4
12" 100W driver plus twin piezo horns – 100W handling

2×12 P.A. CAB £116 carr. £5
2×12" units plus twin piezos 200W RMS handling.

20% DEPOSIT TERMS AVAILABLE (See below)



LIGHTING EQUIPMENT

PLUTO P140 projector C/W wheel £57.50 carr. £1.50
PLUTO P250 projector C/W wheel £94.90 carr. £1.50
PLUTO P500 projector C/W cassette £115 carr. £2.50

FULL RANGE OF WHEELS, ADD ON ATTACHMENTS ETC IN OUR CATALOGUE

- ★ 22' Rope Light £39.50. ★ Rope Controller with Sound/Lite £19.75. ★ The pair only £55
- ★ 4 CH Sound/Lite sequencer plus dimmers £55 ★ 3 CH Sound/Lite £39.50
- ★ PLUTO Rhythmatic Super Rope Light Controller 4kW For/Rev/Auto functions £69.50
- ★ DJ ELECTRONICS 10 way chaser 32 programmes plus Sound/Lite plus Auto Bargain Price £149
- ★ DJ ELECTRONICS Auto Zoner 64 programme matrix unit. Similar to PE STARSPINNER £225

Carr. on all lighting controllers 90p.

Lightomation Freeze Flasher Strobe £64.75 carr. £1.50
Lightomation Super Freeze Flasher Strobe £99.75 carr. £1.50
Bulgin Plug/Socket 8 way £4.25 carr. 50p

Saxon Light Boxes. Match consoles & loudspeakers.
4 way 800 watt £55 carr. £4
3 way 600 watt £45 carr. £4
5 metre Multiway Lighting Lead £12.50 carr. £1
Boxes include lamps

LOUDSPEAKER CABINETS

THE AMAZING PDF BIN £125 carr. £5.00
(illustrated opposite) 100W reflex CAB with twin horns – Very efficient and very loud and low distortion due to the cabinet design – Ideal for Discos.

WE HAVE A COMPLETE RANGE OF LOUDSPEAKERS IN CABINETS **FROM £30** – CALL IN AND SEE OR PHONE FOR DETAILS.

DRIVE UNITS

12" 100W SAXON DRIVER 4/8/16 ohm £24.50 carr. £1.50

★ Piezo Horns £5.45 carr. 40p ★ 12" Fane Crescendo 100W £55 carr. £1.50 ★ 15" Fane Crescendo £69 carr. £2.50 ★ 12" 50W Saxon Driver £19.50 carr. £1.50 ★ 12" 600 mans pro. 12 80W £29 carr. £1.50 ★ 15" Baker £47.50 carr. £2.50 ★ Fane J104 50W horn £15.50 carr. 50p ★ Fane 18" 150W Crescendo – FEW ONLY AT £89.50 carr. £3.

FIRST CLASS CONSTRUCTIONAL PROJECTS – GLASS FIBRE PCB – FULL INSTRUCTIONS

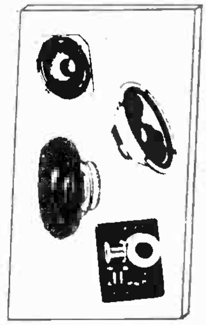
LIGHTING KITS

Carr. on all kits 90p.

LK 1 £9.90	3cm 300W/ch 1V-100V input
LK 2 £17.90	3 channel 3kW zero voltage switched fully automatic level control 200mV-100V input.
LK 3 £9.80	2kW slider dimmer suitable for Pubs, Clubs etc. C/W face plate – suppressed – 15A triac.
LK 4 £17.90	4 channel 4kW sound-lite sequencer with for./rev./auto functions. Ideal for rope lights or spot banks.
LK 5 £11.50	4 channel rope light controller with sound-lite – Handles up to 20 ropes.
LK 6 £7.50	2 channel domestic automatic controller with built-in microphone – runs 4 or 6 bulbs.

Cases to suit kits £3.50
100W spots (state colour) £1.50
Coloured pigmy lamps 65p
Rope lights 22' £39.50

UNREPEATABLE HI-FI BARGAIN 3 WAY LOUDSPEAKER KIT C/W BAFFLE (pre-cut)

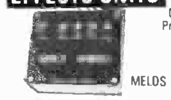


Comprises:
- ★ 25Hz-30KHz response
- ★ 6½" linen surround bass unit
- ★ 5" mid-range unit
- ★ 3" tweeter
- ★ 3 way crossover, fixing screws and baffle
- ★ 20 watts handling capability – 8 ohm system

Full instructions provided
Must be heard to be believed!!

£10.50 or 2 for £20
Carr. £1.25 per kit.

EFFECTS UNITS



'SAXON SMASH' Connect between mic amp. – Press button for Alien Voice effect. £9.75

'SAXON KLAXON' 4 siren effects for the price of 2 US Police UK Police Hawaii 5-0 Destroyer £19.75

'SAXON SIREN' Single siren – State which required – US, UK or Hawaii Police or Destroyer £9.75

MELOS MC350 Echo Chamber £77.50 carr. £2.50 MELOS DE1 Digital Echo £89.90 carr. £2.50

ACCESSORIES

Carr. on accessories £1.50 unless otherwise stated

★ Disco Stand P&N Style	£26.75 carr. £2.50	★ Transformer to suit	£3.50
★ Stereo Headphones	£7.50	★ 12" Goose Neck	£5.65
★ Flexilites	£5.50	★ 6m Curly Lead	£2.45
★ Floor Mic. Stand	£12.90	★ 5m L/Speaker Lead	£2.45
★ Boom Arm	£8.95	★ Goose Neck Base	£2.70
★ Desk Stand	£4.50	★ DJ Electronic Jingle Machines reduced to £95 with 16 Jingles – **SNIP!**	

MIXER KITS

BUILD YOUR OWN DISCO!!

MONO DISCO MIXER £19.75
STEREO DISCO MIXER £29.75
EACH MIXER FEATURES:

★ Twin deck controls + Crossfade ★ Tape inputs ★ Mic input with Bass/Treble ★ Autofade circuitry & controls ★ Wide range tone controls ★ Ample monitor power front panel to suit £3.50 – Supply for mains operation £7.50.

CABINET & KIT FITTINGS

- ★ ICI 'Hide' Vynide 50" wide £4.75/m
- ★ Kick Proof Grille 50" wide £4.75/m
- ★ ICI 'Vox' Vynide 50" wide £4.75/m
- ★ Aluminium Cabinet Trim 35p/St.
- ★ Blue or Black insert for Ali Trim 7p/St.

★ Plastic corners 20p	★ Metal corners 30p	★ Recess plates 20p	★ Pocket handle 50p
★ Strap handle 70p	★ H/duty strap £1.75	★ Mono jack plug 30p	★ Stereo jack plug 45p
★ IEC mains lead £1.20	★ IEC chassis plug 50p	★ Ventilation grille 60p	★ Mono/stereo jack skt 35p
★ Heavy duty foot 20p	★ L.S. cable 20p/m	★ 6 way cable 75p/m	★ Screened lead 20p/m

Carr. 50p min plus 5p in the £.

SPECIAL OFFER – LIMITED QUANTITY – DJ ELECTRONICS

'SUPREME' LIGHT UNIT

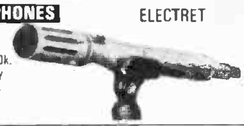
★ 3 channel 3kW ★ Individual bass/mid/treble ★ Variable speed sequences
★ Additional effects of flowlight and override ★ Fully guaranteed.
Originally sold at **£89** we have a few of these great units at **ONLY £49.**
SEE THIS MARVELLOUS UNIT AT OUR SHOWROOM

CREDIT TERMS AVAILABLE ON ORDERS OVER £100

20% deposit – Ring Sue on (01) 689 7826 and ask for a written quotation.
12-24 months to pay – typical APR 36%
or
INTEREST FREE OVER 3 MONTHS
(Discount vouchers invalid on interest free deals)

MICROPHONES

ELECTRET



EM506
600 ohm/50k.
Top quality Disco mic.
£24.30

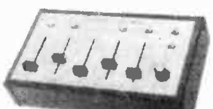
ELECTRET

DI501
600Ω/50k.
Rugged. Value for money.
£23.80

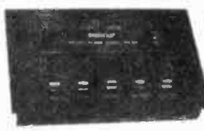
MIXERS

MX 680
- ★ 5 channels, 2 phono, 2 tape, 1 mic.
- ★ Headphone monitor
- ★ All slider controls

£49.50
carr. £1.50



STEREO



STEREO

SM500 5 channel Disco Mixer
- ★ Magnetic cartridge inputs (2)
- ★ Mike plus 2 tape inputs
- ★ Twin VU meters plus record output
- ★ Switched headphone monitor
- ★ Mains powered

£54.50 plus carr. £1.50

AMPLIFIER KITS

Well proven kits for a range of quality amplifier modules from 30W-240W.
- ★ Full short/open circuit proof
- ★ 4 or 8 ohm operation
- ★ High sensitivity – 240mV (–10dB)
- ★ 20Hz-30KHz response
- ★ Complete with heatsink and sockets
- ★ Match most mixer/preamps inc. our own make

BEAT THESE PRICES!!

240W AK1 £19.75 carr. 90p
POWER SUPPLY PK1 £14 carr. £1.50

120W AK2 £12.75 carr. 70p
POWER SUPPLY PK2 £9.90 carr. £1

60W AK3 £7.90 carr. 70p
POWER SUPPLY PK3 £6.90 carr. 90p

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Semiconductor Curve Tracer

D. MANDELZWEIG

THE Transistor Curve Tracer was designed as an add-on unit for a dual-trace oscilloscope. N.p.n. and p.n.p. transistor I.c. versus Vce (as a function of Ib) are displayed, as well as diode and Zener diode curves. Iceo and Iceo Reverse can also be displayed as a function of Vceo. See full specification opposite. The prototype, using readily available components, costs approximately £30 to build, and when compared to a commercially available curve tracer, costing about 22 times that price, was found to be within 3% accurate, which is the basic accuracy of smaller dual trace oscilloscopes.

BASIC OPERATION

Refer to Fig 1. A ramp voltage is applied to the collector of the transistor to be tested, via a current sensing resistor Rc. The voltage across the transistor (Vce) is sensed via the X channel of the oscilloscope. A stepped current from a current source is applied to the base and the voltage across the transistor is ramped once for every current value. The actual current flowing in the transistor, Ic, is sensed as a voltage across Rc by the Y channel of the scope. Thus Ic is displayed as a function of Vce for different base currents. Iceo is displayed similarly, with a different value of Rc and with the base drive disconnected. The Diode curves are also similarly displayed, except that a bipolar signal is applied, so that If and Ir or Zener diode curves can be displayed.

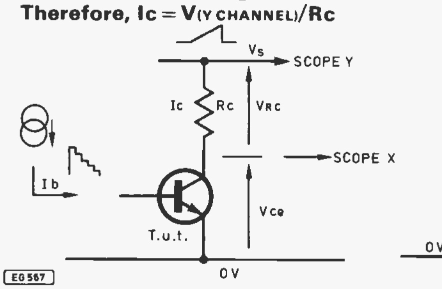
BLOCK DIAGRAM

A block diagram is shown in Fig 2. This diagram shows the sub-sections of the unit, and the main components used in the sub-sections. With the aid of this diagram, and the circuit diagram. Fig 3. the circuit description can easily be followed.

CIRCUIT DESCRIPTION

The circuit functions as follows: IC9 and IC10 form the clock running at approximately 1kHz and a ramp generator respectively. CMOS 555 timers are used to reduce switching transients, which otherwise appear on the scope trace. These i.c.s have their own 12V supply, which was found necessary to prevent the transients affecting the trace. IC7a and TR7 buffer the ramp, and form a power amplifier for the ramp waveform. VR1 must be adjusted for maximum ramp and minimum space between ramps without affecting the ramp. VR2 must be adjusted for a peak of 12·5V at the emitter of TR7. This positive going ramp is split into 3 paths. One goes to relay contact 2 for use on n.p.n. transistors. The second path is to IC7b which inverts the waveform and feeds it to IC8a and TR8. These form a power amplifier for the inverted ramp to drive p.n.p. transistors via relay contact 2. VR3 must be adjusted for a negative peak of −12·5V at TR8 emitter. The third path goes to IC8b which is a level shifter/amplifier. The resultant waveform is used to test diodes. VR4 must be adjusted so that the 25V base- to-peak ramp waveform is centred about 0V.

Fig. 1. As shown, scope Y channel measures Vcc + VRC. Y channel should measure VRC to get Ic. Thus, IC6b has been included in the circuit to subtract Vce from Vs to give a true VRC. Therefore, Ic = V(Y CHANNEL)/Rc



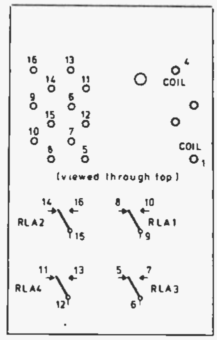
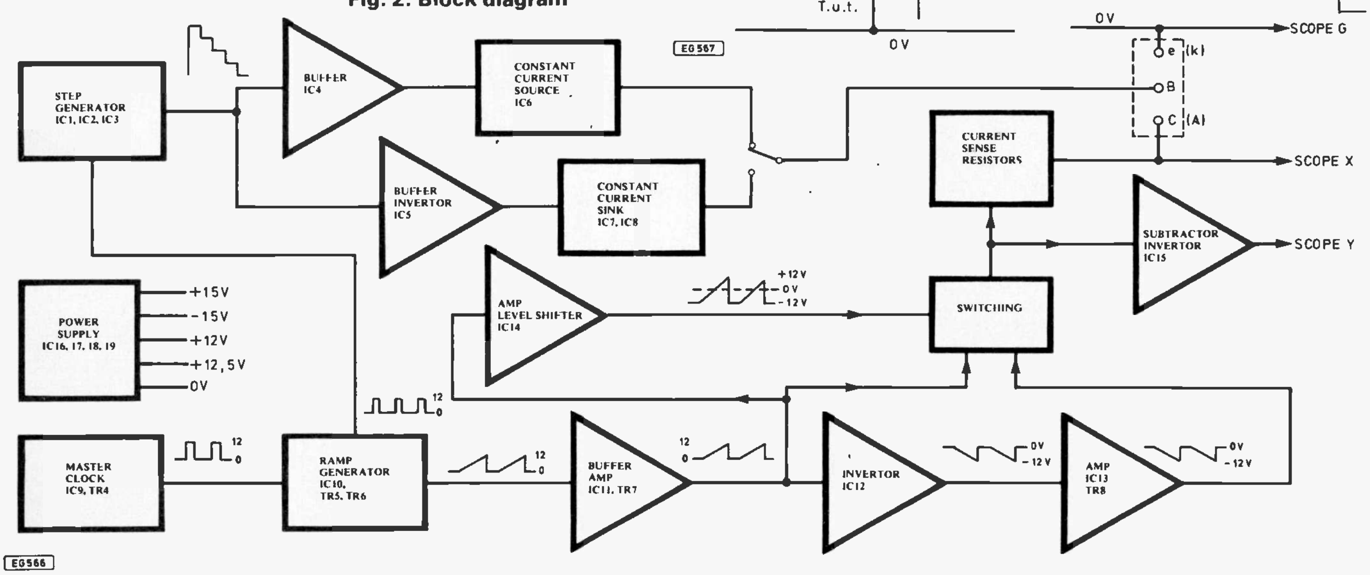
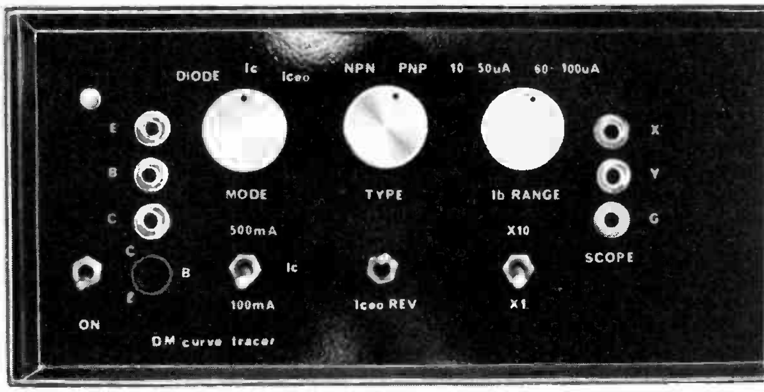


Fig. 2. Block diagram





SPECIFICATION

Modes:	n.p.n. and p.n.p. transistor Ic versus Vce curves. Iceo and Iceo Reverse for n.p.n. and p.n.p. Diodes and Zener Diode curves.
Transistor base currents:	4 ranges of 5 constant values each.
Ic current limit:	100mA and 500mA selectable.
Max. Vce:	12V
Diode current limit:	24mA
Largest Zener diode that can be tested:	8V2

The output of IC10 (pin 3) is inverted by TR5, and the positive going pulses are used to clock IC3, which is a divide-by-eight counter divider. The Q5 output (pin 4) is used to reset the counter, so that it only counts to five. These five decoded outputs are used to control the transmission gates IC1 and IC2 so that each gate closes in turn, continually repeating the process. R1 to R11 and S5 form a precision divider chain, allowing voltage steps of 1V between 7·5V and 11·5V (with S5 in the position shown) and between 2·5V and 6·5V (with S5 in the other position) to be

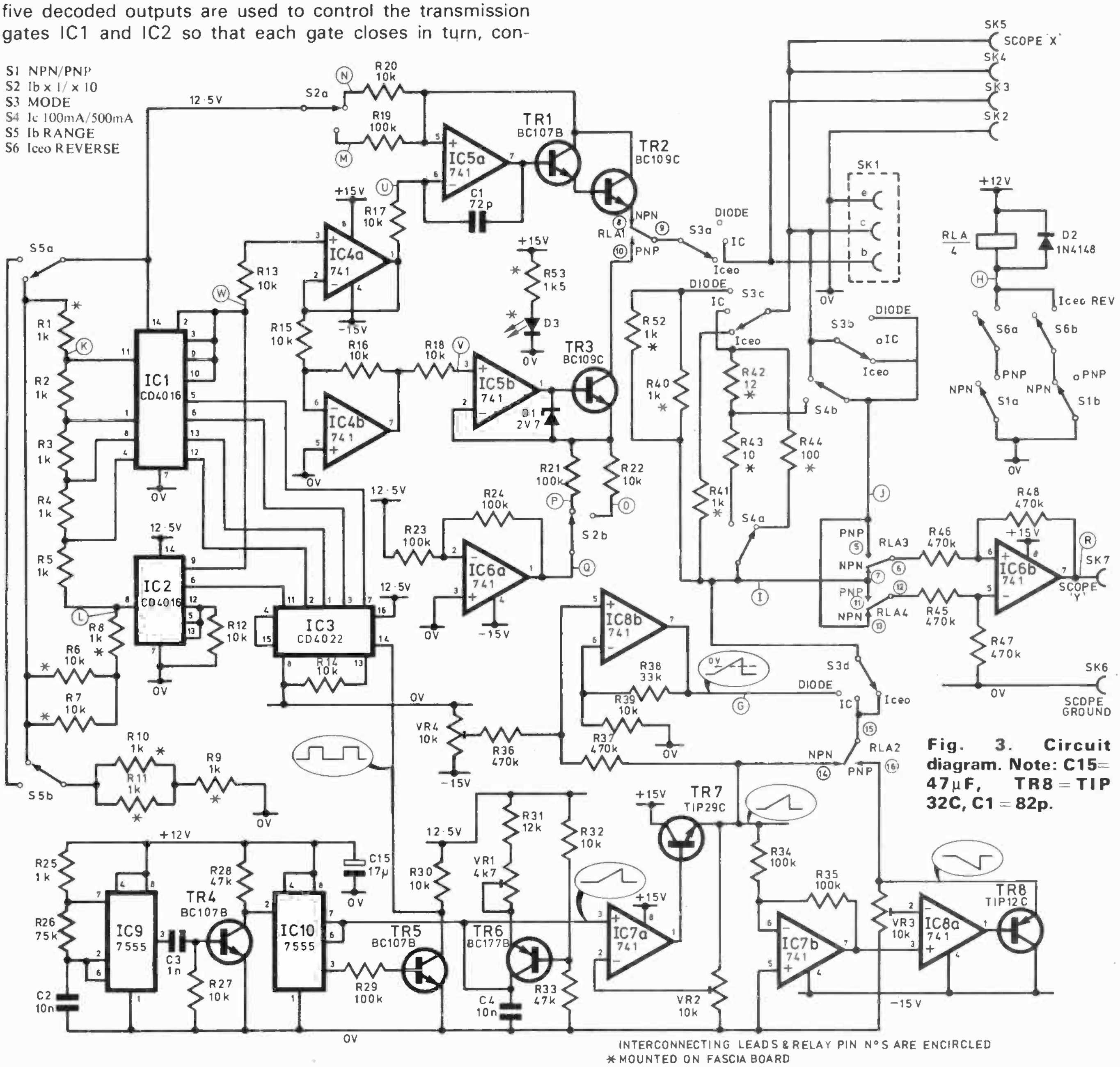


Fig. 3. Circuit diagram. Note: C15 = 47μF, TR8 = TIP 32C, C1 = 82p.

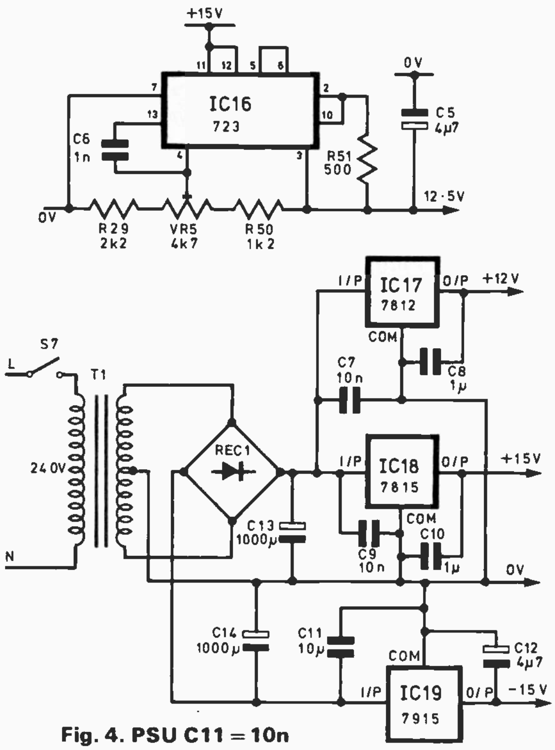


Fig. 4. PSU C11 = 10n

applied to the respective transmission gate inputs. The output of the gates are summed together, and the result of the sequentially closing gates (controlled by IC3) is a precise stepped waveform either 7·5V to 11·5V in 1 volt steps or 2·5V to 6·5V depending on S5. S5 is the base current range switch. In the position shown, it selects the 10μA to 50μA range (in steps of 10μA) and in the other position it selects 60μA to 100μA (also in steps of 10μA).

This stepped waveform is buffered by IC4a to avoid loading of the divider chain, and is fed to IC4b and IC5a. IC4b inverts the waveform and feeds it to IC5b. IC5a and IC5b with their associated components form a precision programmable constant current source and constant current sink respectively. The output currents are dependant on the input voltage and the values of R19/R20 and R21/R22. Here S2 is used to select one of two resistors in the current source and sink respectively, and is used as a base current multiplier. In the position shown, the base current range is as mentioned above, and in the alternate position, the range is multiplied by 10, i.e. 100μA—500μA and 600μA—1mA, again depending on S5. The resultant stepped constant currents are chosen by relay contact 1 (the source for n.p.n. transistor, and the sink for a p.n.p. transistor) and is fed via S3a to the base of the transistor under test (TUT).

The power supply looks more complicated than may be thought necessary, but as mentioned above, it is not so. Three 3-terminal voltage regulators supply voltages as shown, and a 723 voltage regulator, adjusted via VR5 to a precise 12·5V, supplies current to the current source/sink and their associated components.

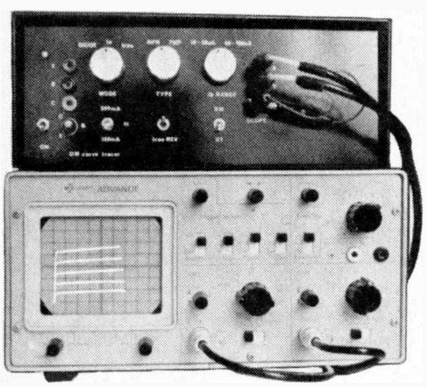
CONSTRUCTION

Although other methods of construction may be used, it is strongly advised that the unit is constructed using the p.c.b. layouts presented here. This will ease construction and make for a neater finish.

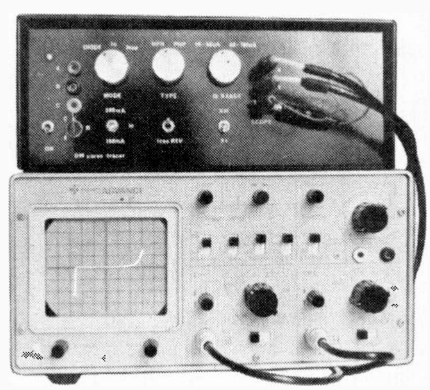
P.c.b. mounting switches may be obtained for all switches except S7, due to the different lengths of the switches, however, the following method of construction is adopted.

First solder a 3cm length of tinned copper wire to each tag of each switch except S7. Once this has been done, the case front panel must be drilled out as shown in Fig. 11. Fit the switches temporarily to the panel, and then fit the wire leads into the corresponding holes in the front panel p.c.b. Align the p.c.b. as close to the switches as possible, remembering to leave room for direct connections to S7, and for the Banana sockets. With the p.c.b. in this position, solder all the wires to the p.c.b. The p.c.b. and switch assembly can then be removed, and construction of the p.c.b. can be completed, leaving l.e.d. D3 and the connections for the Banana sockets and transistor socket for later.

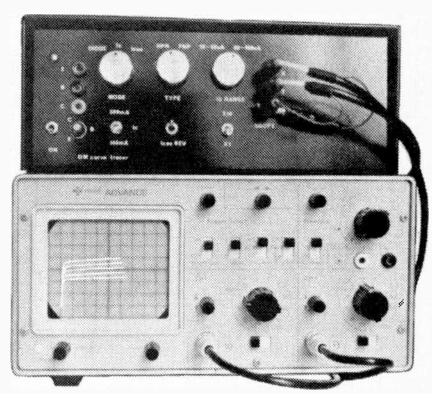
The PSU can be constructed next, and when completed, can be checked for correct operation. Before connecting a.c. to the board, check that all the capacitors are in the correct way round. If all is well, set VR5 for 12·5V on pin 3 of IC16, remove power, and continue construction of the main circuit. As usual start with the passive components and links, then solder in the transistors, and finally the i.c.'s. The prototype use i.c. sockets, and this practise is strongly recommended. Be careful when handling the CMOS i.c.'s as they are easily damaged. Finally fit the relay into its socket, and check the board carefully for solder splashes, and for correct orientation of the i.c.'s transistors, diodes and C15.



NPN transistor: At four horizontal positions, we have 4 × 2V = 8V. Second curve, i.e. Ib = 20μA, we have 1·7 vertical divisions, at 0·2V per div. which gives 0·34V. Therefore, Ic = 0·34/R44 = 0·34/100 = 3·4mA. Therefore hfe = 3·4mA/20μA = 170.



4V7 Zener diode. Forward voltage = 0·6 × 1 = 600mV (at point when current begins flowing). Reverse breakdown: 4V at initially, 5V at a reverse current of 1·4 div. × 5V/div. over 500Ω = 14mA.



NPN transistor. 60μA to 100μA base current range.

Using stranded hook-up wire, preferably of different colours to aid checking, connect up the main p.c.b. and the front panel p.c.b., and solder lengths of wire to the boards for later connection to the PSU board. Leave enough wire between the main p.c.b. and the front panel p.c.b. to allow easy access to the main p.c.b. without having to remove the front panel p.c.b. at a later stage, if this becomes necessary.

SETTING UP AND CHECKING OUT

Once construction is completed, and the p.c.b. and wiring has been carefully checked, the unit can be set up and functionally checked. An oscilloscope and a meter will be required. First turn all the presets to mid-position, and switch S1 to n.p.n. S2 to Ib x1, S3 to Ic, S4 to 100mA and S5 to 10–50uA. Turn on the power, and check the outputs of IC18

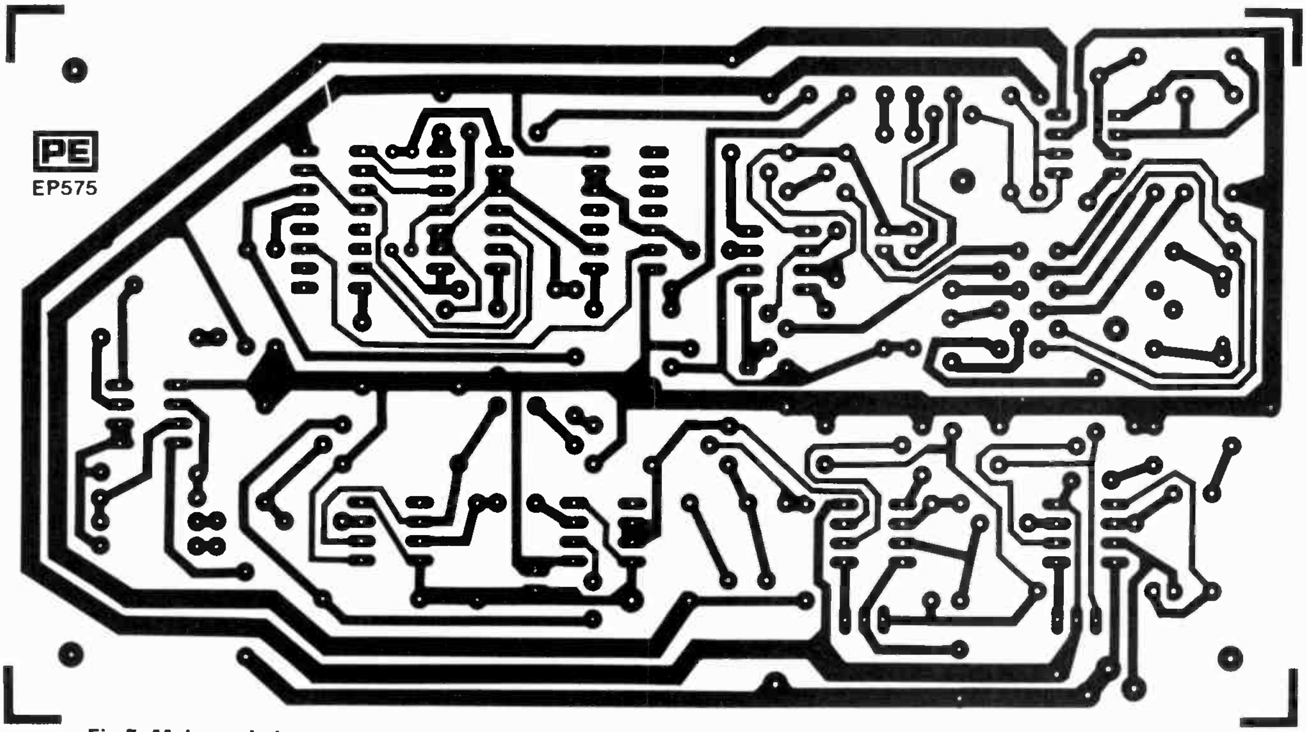
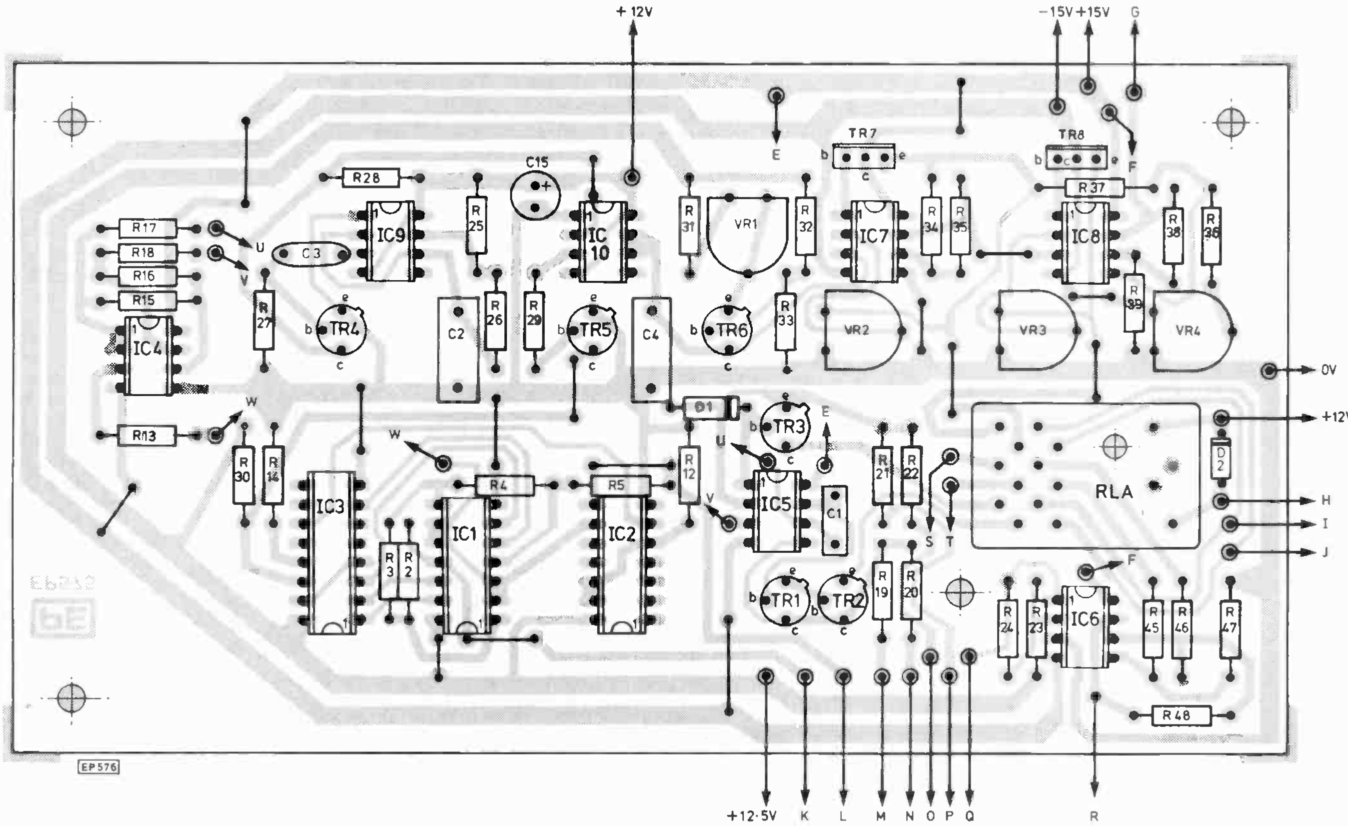


Fig 5. Main p.c.b. layout



and IC19. The voltage should be +15 and −15 volts respectively. Now adjust VR5 so that the voltage at pin 3 of IC16 is +12·5V exactly. Check that the voltage at the output of IC17 is +12V. With the oscilloscope connected to pin 7 of IC10 adjust VR1 so that the ramp part of the waveform is a maximum, without the point becoming flattened. Turning VR1 too far will indicated the above condition. Now adjust VR2 so that the base-to-peak value of the ramp measured at the emitter of TR7 is +12V. Adjust VR3 for a negative ramp of −12V at the emitter of TR8. Adjust VR4 so that a ramp waveform with a base-to-peak value of about 25V appears at pin 6 of IC8b, centred at 0V. Check that a stepped waveform is available at pin 3 of IC1. Finally, if S6 is depressed, the relay contacts should pick up.

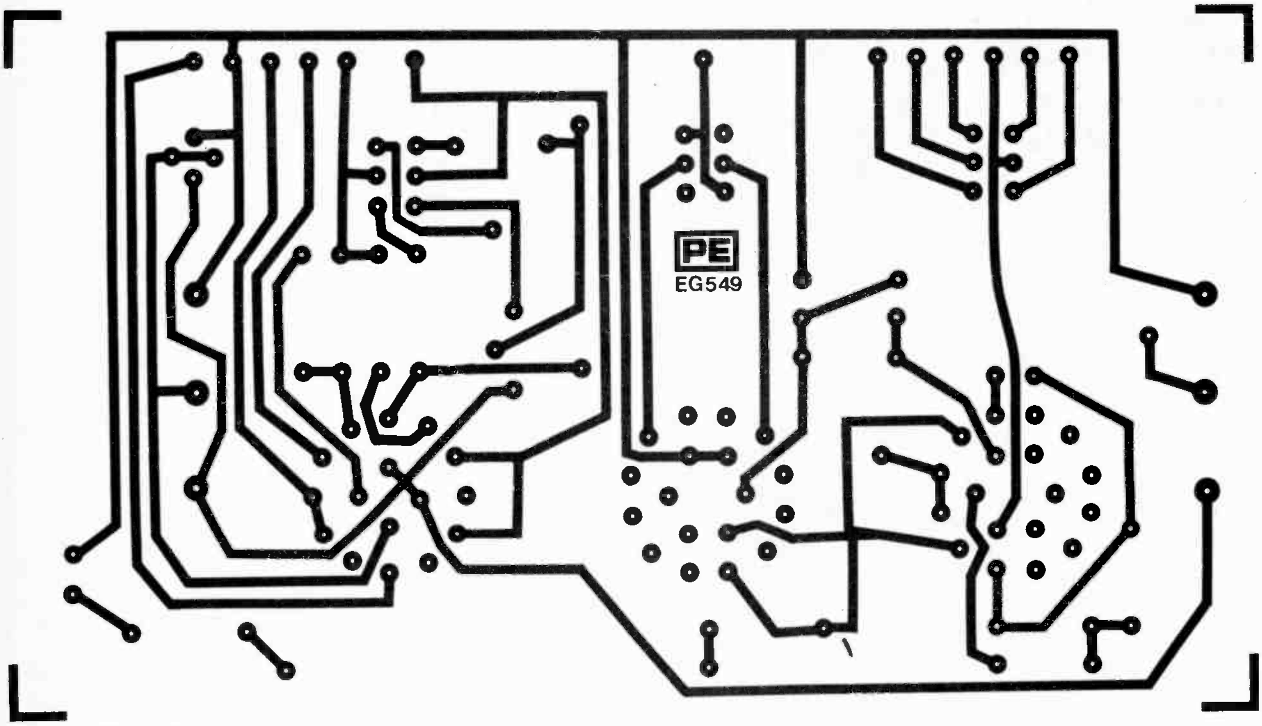


Fig. 7. Fascia p.c.b. layout

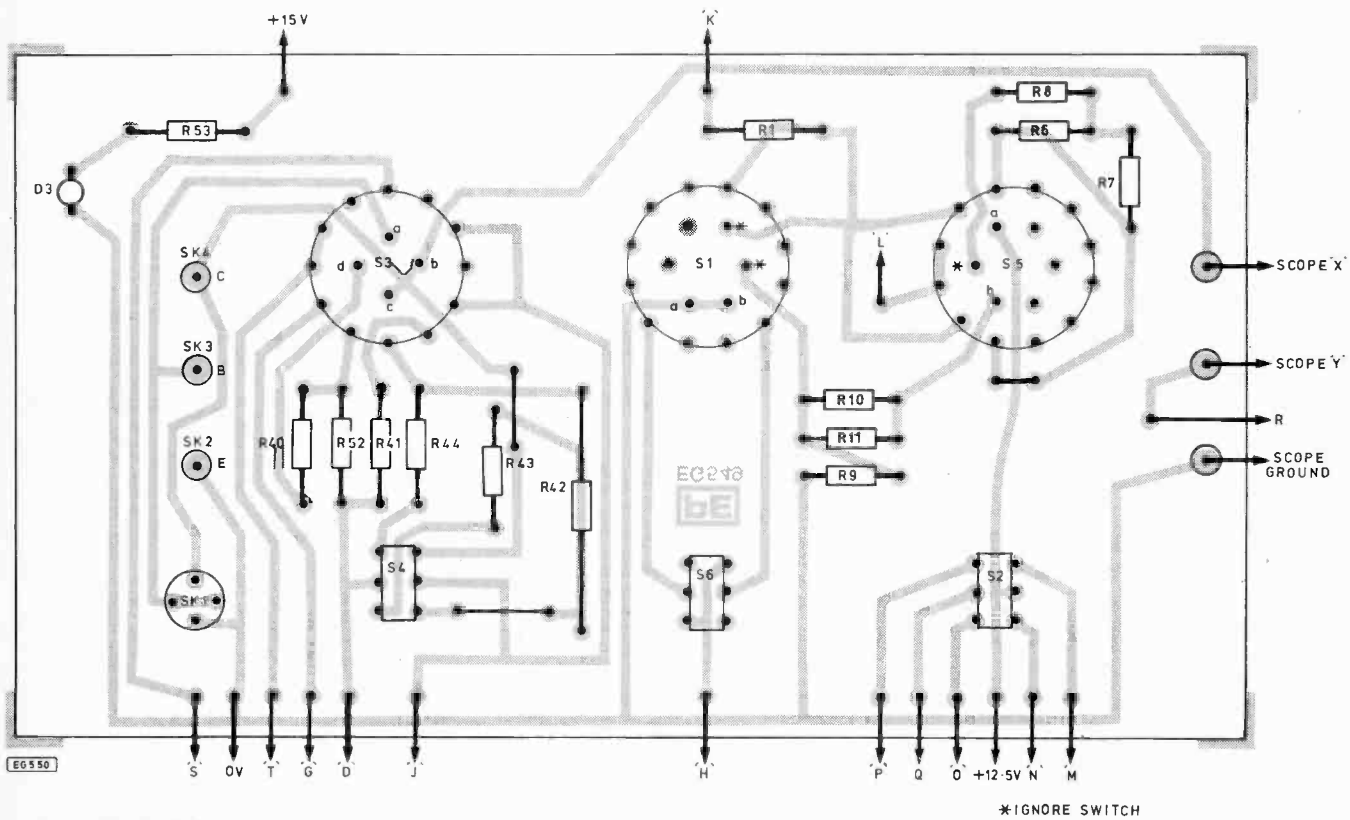


Fig. 8. Fascia p.c.b. component overlay

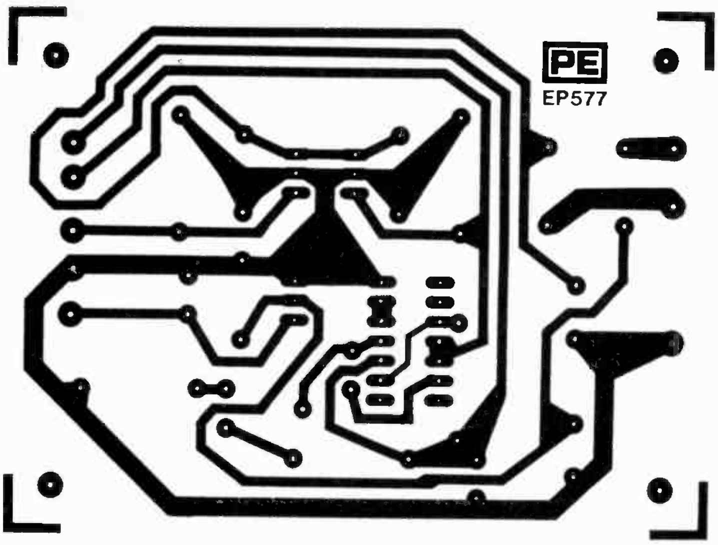
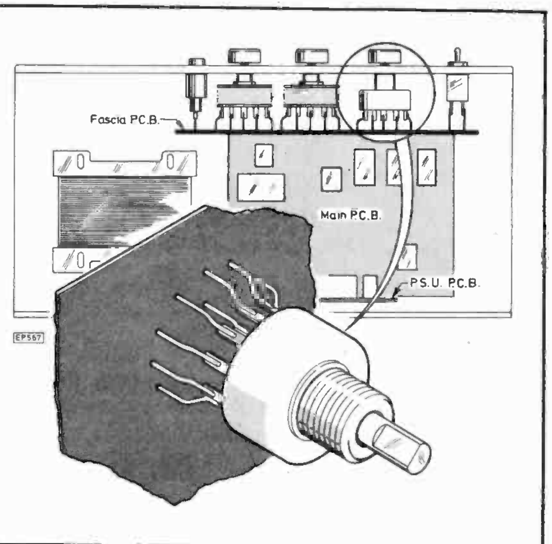


Fig. 9. PSU p.c.b. layout



The fascia p.c.b. obviates the need for tricky front panel wiring. Solder lengths of tinned copper wire to each tag of the front panel switches, then insert these switches into the p.c.b. and solder. The fascia p.c.b. is fastened solely by these connections. It is worth noting that insertion of the rotary switches into this board will be made easier if wires to the less accessible centre pins are left longer.

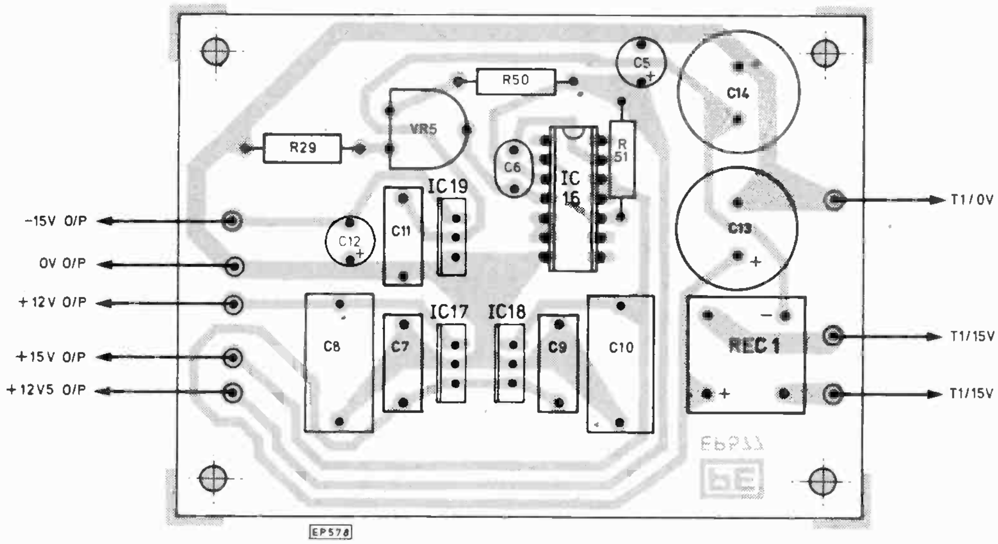


Fig. 10. PSU component overlay

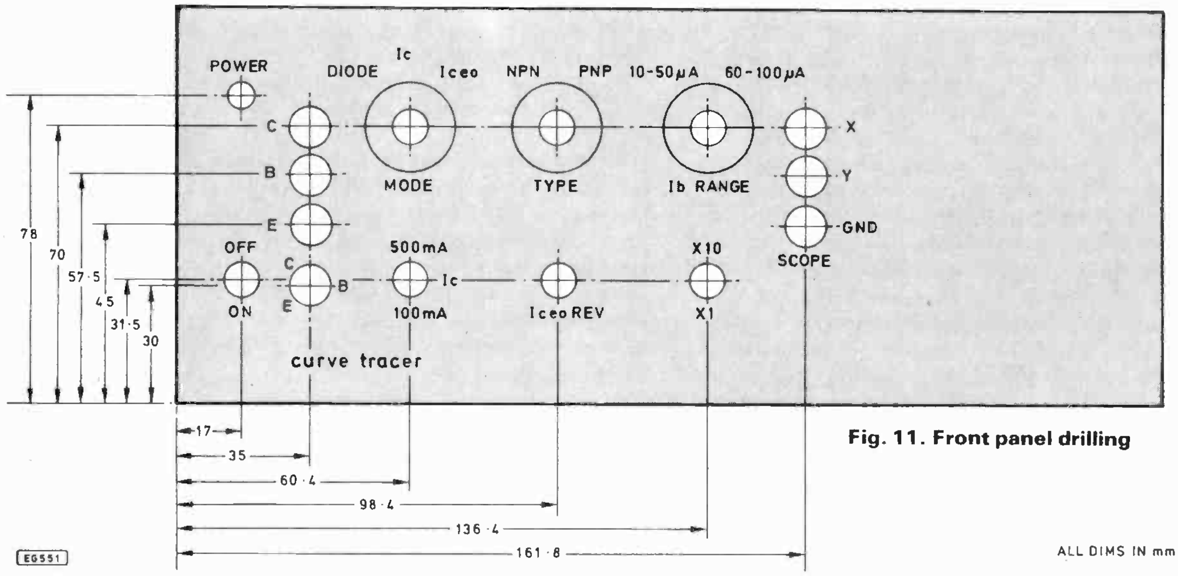


Fig. 11. Front panel drilling

ALL DIMS IN mm

COMPONENTS . . .

Resistors

R1–R5, R8–R11, R40, R41, R52	1k ¼W 2% (12 off)
R25	1k ¼W 5%
R6, R7, R15, R16, R20, R22, R39	10k ¼W 2% (7 off)
R12, R13, R14, R17, R18, R27, R30, R32	10k ¼W 5% (8 off)
R19, R21, R23, R24, R34, R35	100k ¼W 2% (6 off)
R29	100k ¼W 5%
R26	75k ¼W 5%
R28, R33	47k ¼W 5% (2 off)
R31	12k ¼W 5%
R36, R37, R45, R46, R47, R48	470k ¼W 2% (6 off)
R38	33k ¼W 2%
R42	12 2W 5%
R43	10 ½W 2%
R44	100 ½W 2%
R49	2k2 ¼W 2%
R50	1k2 ¼W 5%
R51	560m ½W 5%
VR1, VR5	4k7 min. horiz. preset (2 off)
VR2, VR3, VR4	10k min. horiz. preset (3 off)
R53	1k5 ½W 5%

Capacitors

C1	82p
C2, C4, C7, C9, C11	10n (4 off)
C3, C6	1n (2 off)
C5, C12	4µ7 tant. 25V (2 off)
C8, C10	1µ (Siemens) (2 off)
C13, C14	1000µ/25V (2 off)

Transistors

TR1, TR4, TR5	BC107B (3 off)
TR2, TR3	BC109C (2 off)
TR6	BC177B
TR7	TIP29C
TR8	TIP32C

Diodes

D1	2V7 Zener
D2	IN4148
REC1	2A 200V stack
D3	Red l.e.d.

Ic's

IC1, IC2	CD4016 CMOS quad switch (2 off)
IC3	CD4022 CMOS counter
IC4–IC8	µA 1458 DUAL 741's (5 off)
IC9, IC10	7555 CMOS timers (2 off)
IC16	µA 723 voltage regulator
IC17	µA 78M12UC +12V 500mA
IC18	µA 7815UC + 15V 1A
IC19	µA 7915UC −15V 1A

Switches

S2, S4	DPDT (2 off)
S3	4P3W rotary
S6	DPDT biased
S7	SPDT
S1, S5	6P2W (2 off)

Relay

12V coil resistance	1k, 4 C/O contacts +base

Transformer

15–0–15V	1 amp secondary

PLEASE NOTE

If difficulty is experienced in making the system operate reliably, it may be necessary to alter the Main p.c.b. so that R30–R32 are powered from +12V and not +12·5V. Link IC10 pin 8 across to top of R31 on p.c.b. and cut the main 12·5V track between top of R30 and IC3 pin 16, i.e. break just to left of IC3.

Also note that a link is required on Fascia p.c.b. to join the bottom end of R40 to bottom end of R52. S2a in Fig. 3 is shown at rest in wrong position, i.e. should point to R19.

BASE CURRENT VALUES

SWITCH POSITIONS	NO. OF STEPS	RANGE	STEP SIZE
S1 10–50µA, S2 × 1	5	10–50µA	10µA
S1 60–100µA, S2 × 1	5	60–100µA	10µA
S1 10–50µA, S2 × 10	5	100–500µA	100µA
S1 60–100µA, S2 × 10	5	600µA–1mA	100µA

USING THE UNIT

Connect the unit to an oscilloscope, set to X–Y mode. Connect the component to be tested via the socket or flying leads. Set the mode switch to the desired mode. If testing transistors, select the type, base current range, and the maximum allowable collector current for the type of transistor in use. Remember that Ic = hfe x Ib, so that the settings of switches S2 and S4 will be dependent on the transistor type. If the transistor data is completely unknown, always start with the lowest values of Ib and S4 set to 100mA. Adjust the X and Y inputs of the scope to give a suitable trace.

Label the front panel with Letraset as shown in the photographs (note that the collector and emitter 'C' and 'E' markings on the prototypes are incorrect for the Banana sockets—they have been swapped around. From the top it should read CBE). Fit S7, the l.e.d. D3, and the Banana sockets to the case. Glue the transistor socket to the case with an epoxy glue. Now fit the p.c.b. switch assembly into the case; tighten the switch retaining nuts, and bolt the main p.c.b. to the base of the case using spacers. Use tinned copper wire to connect the sockets and the l.e.d. to the p.c.b. Mount the transformer, the p.s.u. p.c.b. and complete all interconnections. Once the complete unit has been carefully checked for wiring errors, a functional check and setting up can be carried out.

When testing a transistor for hfe (mode switch in Ic position), 5 curves will be displayed. These correspond to set values of Ib, depending on the position of S2 and S5. Table 1 gives the possible combinations. The only thing that must be remembered is the values of R43 and R44 depending on the position of S4. Thus, to calculate the gain of a transistor at any Vce with a set of base current, divide the Y voltage reading by the value of the resistor selected, and then divide by Ib. The diode currents and transistor leakage currents are found similarly by dividing the Y voltage reading on the scope by the selected resistor (500Ω for DIODES and 1k for leakage currents, Iceo).

The accuracy of the unit is dependent on the resistors marked as 2 per cent in the parts list. Ideally 1 per cent resistors should be used, but these seem hard to come by. A way to get round this is to buy a few more 2 per cent resistors than that required and then select by measurement those that have the closest value to the required value. R1 to R11, R19 to R22 are of particular importance, and it is also important that R45=R46=R47=R48 as close as possible. ★

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Positive Impedance Converters

A.B. BRADSHAW

MANY electronic experimenters are deterred from embarking on work involving the winding of low frequency inductors by the cost of pot cores and the obvious chore of winding many turns. This is a pity as a large area of interesting activity is denied them.

With the circuits about to be described this may now be remedied. Low pass, high pass, band pass and equaliser filters can be constructed using the positive impedance converter (PIC) to simulate the inductors (Fig. 1).

The upper frequency of this useful circuit is governed by the response of the op amps used, but the 741 will take care of the a.f. range.

The signal to noise ratio of the simulated inductance may not be as good as a wound compoinent, but in the majority of applications this is not important, and could in any case be preceded by a low noise preamp for low noise filter applications.

The PIC is realised physically using two separate 8 pin d.i.l. 741 op amps, three resistors, one capacitor, a setting resistor (R_O). Using a balanced supply to the op amps $\pm 12V$, the setting resistor R_O can be referenced to ground, in later arrangements an unbalanced configuration can be used. (See Fig. 2.)

It will be observed that 'looking into' port 1 an inductance is seen, the value of inductance we require is obtained by selecting the appropriate value for R_O the setting resistor. Q values of 300 are obtainable with this arrangement.

Here $L=KR_O$ where K is called the conversion factor and

$$K=\frac{C\,R_1\,R_3}{R_2}$$

With perfect op amps this would give

$$K=\frac{0{\cdot}01 \times 10^{-6} \times 270 \times 10 \times 10^3}{5{\cdot}6 \times 10^3}=4{\cdot}82 \times 10^{-6}$$

But due to imperfect op amps and worst case component tolerances, there is usually an error which can be determined by a test set-up.

SETTING UP A PIC

Wire up the circuit on a small piece of Veroboard. Use a stable a.f. generator with an accurate dial, or use a frequency counter on its output. An output indicator having a high impedance input, or an oscilloscope with a 10X probe will be needed. Connect up as in Fig. 3. The resistors R_A R_B are to load down the output impedance of the generator (this is in series with C_O and L). Let $R_B=100$ and $R_A=1k$.

For a first run set C_O to be 10n, use two 5,000p silver mica 1% capacitors in parallel. Set the generator to 1kHz accurately, and turn its output level to maximum. Use a variable resistor of 500k for R_O. Connect up the high impedance monitor or scope. Vary the potentiometer until a very sharp peak is obtained on the scope. The inductance of the PIC is now at series resonance with C_O. Its inductance can be calculated from the expression:

$$\omega^2=\frac{1}{LC_O} \qquad \omega=2\pi f$$

In the example f=1kHz C_O=·01µF giving

$$L=\frac{1}{0{\cdot}01 \times 10^{-6} \times 4\pi^2 \times 10^6}=\frac{10^2}{4\pi^2}=2{\cdot}533\text{henries}$$

The next step is accurately to measure the set value of R_O.

A technique when setting up is to decrease the value of R_O below resonance and replace the potentiometer with a fixed value, say 10% lower, and use a lower value of pot (perhaps 20k); if this procedure is continued then the circuit can be brought to resonance and R_O' will be known with good accuracy.

Having found the value of R_O', the conversion factor can now be determined from:

$$L=KR_O' \text{ so that } K=\frac{L}{R_O'}$$

Having now wired up the PIC circuit and arranged the test set-up, the value of K is calculated, we can now write:

$$L=KR_O$$

At this point it is worth while to substitute various accurately known fixed resistors for R_O. Calculate then measure the resonant frequency. This will give some practice in using the set-up arrangement.

When attempts are made to simulate inductors embedded in, say, a filter network, we have to consider three situations:

Grounded Inductors

Note that with a $\pm 12V$ supply with centre at ground potential, the resistor R_O is returned to ground, this is to give the op amps an input bias reference (Fig. 4).

If a single +24V rail is used with the op amps, an artificial centre point of +12V must be provided. This can be a low resistance resistive divider chain or a Zener diode +12V rail and R_O will be returned to this point with a.c. decoupling.

Balanced Inductors

A balanced inductor is simulated as in Fig. 5. It will be observed that two PICs are needed for this one inductor, this uneconomical situation only occurs in simple filters, as will be shown in the next situation.

Here we find a snag, it is not possible in the balanced case to feed d.c. to the inductor and its simulating PICs, if the inductor is capacitively isolated. We can get around this by reconfiguring the filter as in Fig. 6.

Combined Inductors

This last case is shown in Fig. 7.

A surprise is in store here, for L1 and L2 can be simulated with two PICs only.

L1 is simulated by PIC1 $-R_{01}$ $-$PIC2

L2 is simulated by PIC2 $-R_{02}$

In effect PIC2 is shared between L1 and L2. Balanced d.c. supplies are shown for simplicity.

For many filters, if we know the component values we now have enough information to employ PICs for the inductors.

In the test set-up individual 741 op amps were advocated

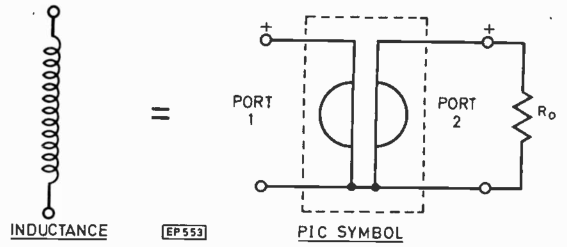


Fig. 1. PIC symbol for an inductor

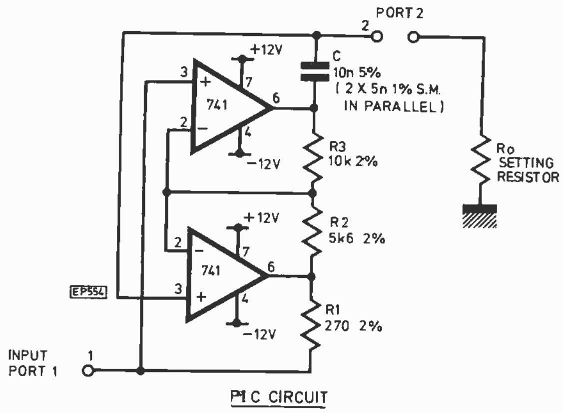


Fig. 2. Physical realisation of a PIC

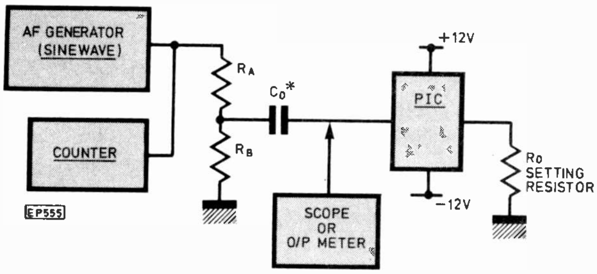
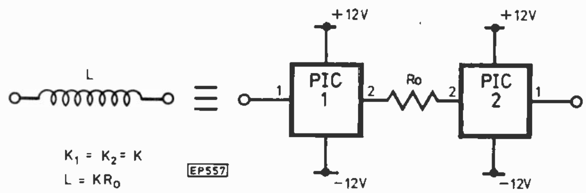


Fig. 3. Test set up for PIC



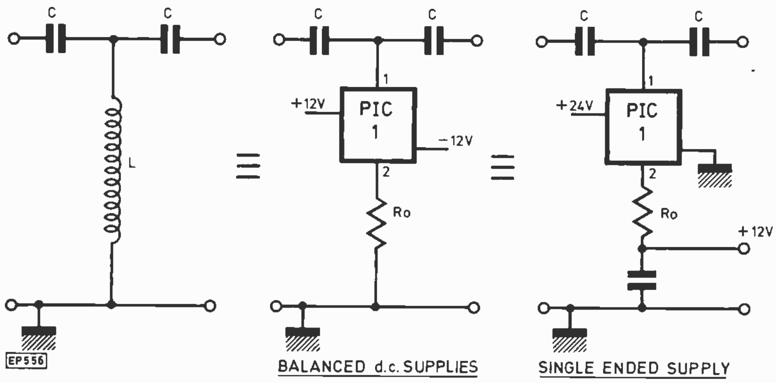
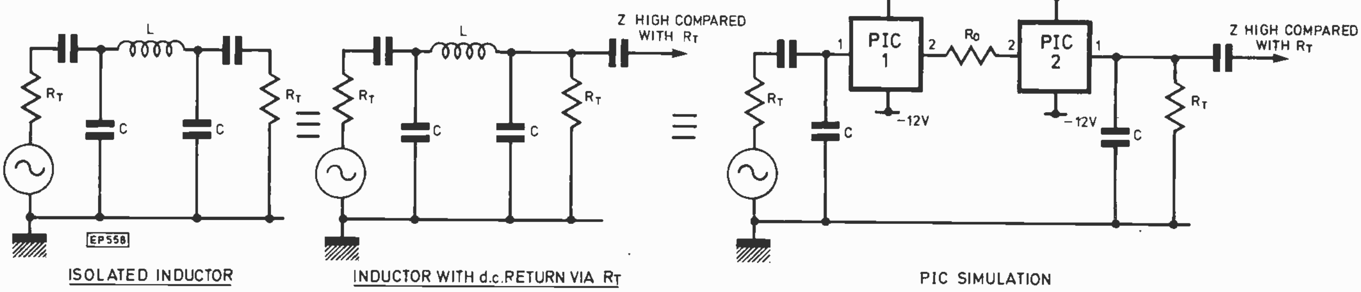


Fig. 5. (above) balanced inductor and its simulation

Fig. 4. (left) grounded inductor and its simulation



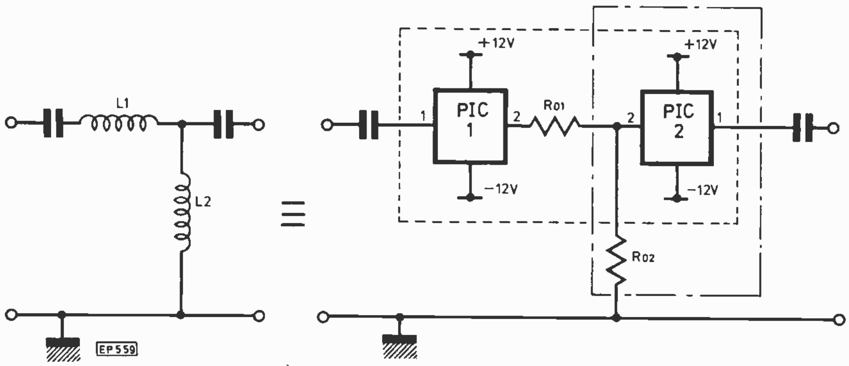


Fig. 6. (above) balanced and isolated inductor showing how to feed d.c. (via R_T) to the simulating PIC

Fig. 7. (left) combined inductors and their simulation

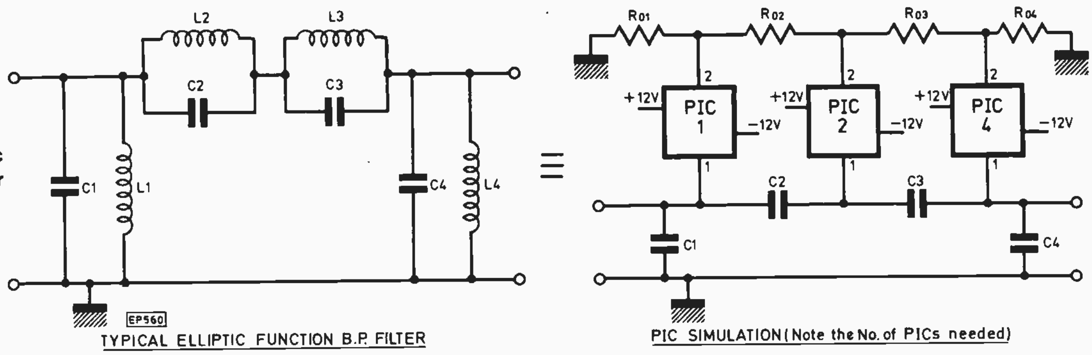


Fig. 8. Typical elliptic function bandpass filter with PIC simulation

but if the MC1458CP1 is used with ± 6 volt supply it will give a $K=5{\cdot}0 \times 10^{-6}$ and will cut the package count by a factor of 2.

In Fig. 8 a typical elliptic function bandpass filter with its PIC equivalent is shown.

BANDPASS DESIGN

The idea here is to define the shape of the bandpass response that is required. To do this, we need to know the bandwidth ratios.

This "shape" requirement is now compared to the data in the low pass tables, and one line of data is selected for best fit.

The selected low pass filter is called the "low pass prototype" (LP_p). See Fig. 9 for details of bandwidth ratios. The next step is to transform this selected low pass prototype into a bandpass filter.

If we consider that the LP_p is resonated at $\omega_0=1$ for band centre, we can choose reciprocal values for the resonating pairs of reactances. Hence reciprocal values of capacitance are added in series with the inductors. Reciprocal values of inductance are added in parallel with the capacitors.

This completes the LP_p to bandpass transformation. See Fig. 10.

If the "Q" values are correct, **the bandpass filter has the same bandwidth at any attenuation as the low pass prototype.** The middle section of this bandpass filter looks rather untidy (and inconvenient). A transformation is performed on this in Fig. 11.

The network now looks much more manageable. The final step is to transform by scaling to the operating impedance and frequency.

THE "Q" CONDITION

Nothing has been said so far about the element "Q". When we select a LP prototype, it will meet the requirements using a definite branch "Q"; this is an important number and is known as "Q_p".

We modify the LP network by adding other elements, some in series and some in parallel to form the bandpass filter. The series elements have "Q" values which increase with frequency, the parallel elements have the reverse law, when scaled up in frequency.

To achieve the "Q" requirements in the final bandpass response, definite relationships exist between the "Q" values in the transposition stages.

$$Q_b=Q_c \times Q_p$$

Where Q_p=prototype low pass "Q"

Q_b=branch "Q" of bandpass filter

Q_c="Q" of the desired bandpass response.

By using PICs and good quality capacitors, the branch "Qs" can be made high, and can thus be lowered by adding loss resistors if needed.

For medium and narrow % bandwidth designs, "Q" values larger than necessary are not often a problem, and usually sharpen up the corners.

The stopband attenuation is only slightly affected by the size of the "Q" values.

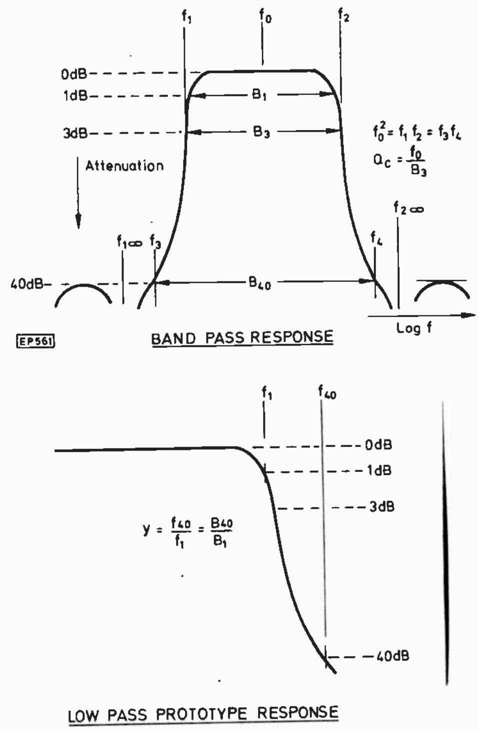


Fig. 9. Showing relationship between bandpass and lowpass response

WORKED EXAMPLE 1

Using table A4–3

The following data is read.

A_s=40dB

ω_s=3·542

C_1=0·988

C_2=0·0570

L_2=1·081

C_3=0·988

ω_2=4·027

This is a single section, take f_0 centre frequency 1350Hz, "R" to be 220.

This network is converted to bandpass. Firstly normalising to $\omega_0=1$, this enables us to write reciprocals for the resonating components.

We next transform the middle section.

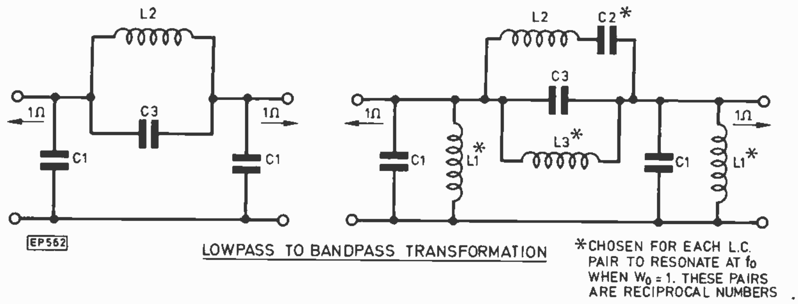


Fig. 10. The lowpass to bandpass transformation

Fig. 11. (below) the middle section of the bandpass filter is transformed. The five equations on the left show the working through

(1) let $x = \dfrac{L}{K}$

(2) let $\alpha = 1 + \dfrac{1}{2x}$

(3) let $\beta = \sqrt{\alpha^2 - 1}$

(4) let $\gamma = \alpha + \beta$

(5) let $L_0 = \dfrac{1}{\gamma + 1}$

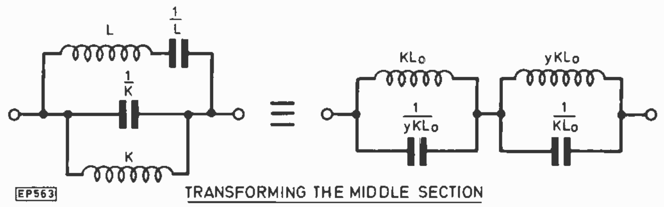
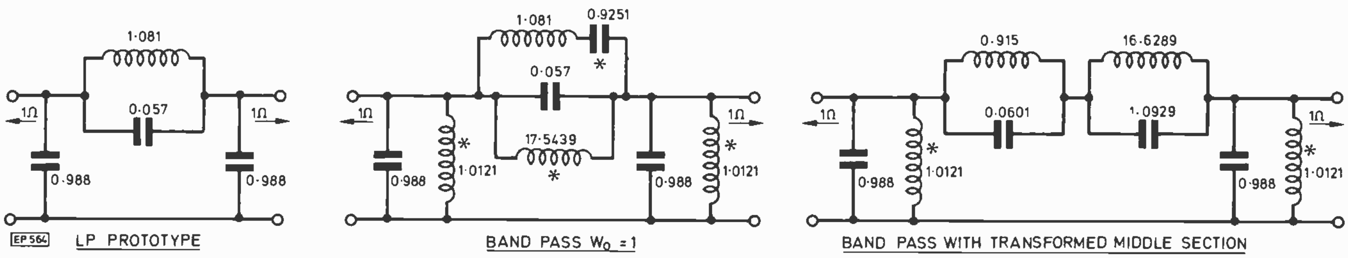


Fig. 12. (below) the worked transformation



When performing these step calculations, the display on many calculators rounds up the contents of the registers, so use the storage register and carry the process to the end; this should avoid any small errors which can occur at this stage.

The values of y and L_O are used in the transformation to give

$KL_O = 0{\cdot}9150$

$YKL_O = 16{\cdot}6289$

$\dfrac{1}{KL_O} = 1{\cdot}0929$

$\dfrac{1}{YKL_O} = 0{\cdot}0601$

as in Fig. 12.

We now have to scale up to $f_O = 1350$Hz and the operating impedance of 220.

From $A = \dfrac{R}{2\pi f} = \dfrac{220}{2\pi \times 1350}$ (inductance multiplier)

and

$B = \dfrac{1}{2\pi fR} = \dfrac{1}{2\pi \times 1350 \times 220}$ (capacitance multiplier)

Giving $A = 0{\cdot}0259$H

$B = 0{\cdot}53587\mu$

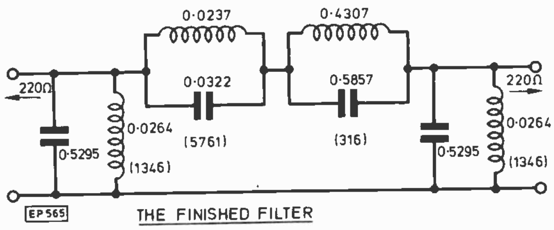


Fig. 13. (above) the finished filter and (right) the bandpass response when used as a sideband filter for single sideband reception. The send level is 0dBm

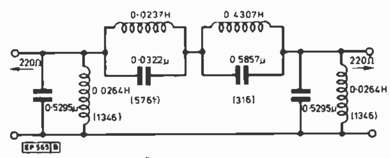
Multiply through by these multipliers to give the values shown in Fig. 13.

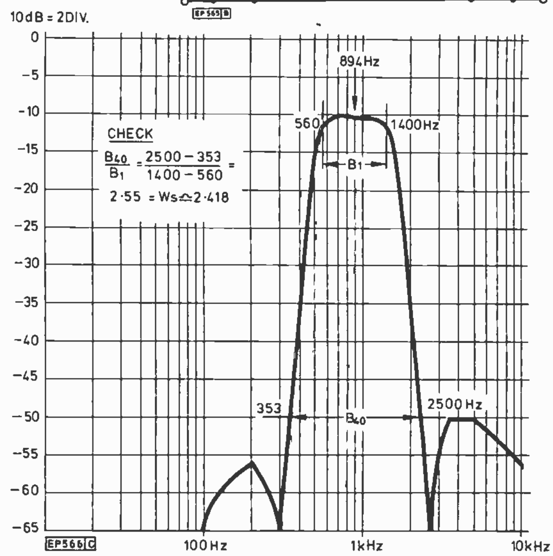
This network can now be made up. A word of caution is needed here. Set up the three PICs to have the same conversion factor (I used 5000p 1% and 10k 1%).

If necessary, to get the conversion factors equal, trim the values of R_3 or R_2.

I used MC1458 op amps with ±12V.

The conversion factors trimmed to be $K = \dfrac{5{\cdot}7155}{10^6}$





I selected the capacitors by tuning, using one of the PICs, and the setting resistors were 2%.

WORKED EXAMPLE 2

For simplicity we again use a single section. Attenuation in stop band 40dB. Band centre 894Hz. Terminating resistance 330.

From the charts we select

$A_s=40\text{dB}$
$\omega_s=2{\cdot}418$
$C_1=1{\cdot}910$ — Table A4—1, 1dB ripple
$C_2=0{\cdot}145$
$L_2=0{\cdot}905$
$C_3=1{\cdot}910$
$\omega_2=2{\cdot}762$

For 40dB this data gives steepest cut. Calculate the reciprocals for the LP to BP at $\omega_O=1$

$L_1=0{\cdot}5236$
$C_2=1{\cdot}1050$
$L_3=6{\cdot}8966$

Proceed to transform the middle section as in the first example to give

$$Y=9{\cdot}5155$$
$$L_O=0{\cdot}0951$$
$$KL_O=0{\cdot}6559$$
$$YKL_O=6{\cdot}2407$$
$$\frac{1}{YKL_O}=0{\cdot}1602$$
$$\frac{1}{KL_O}=1{\cdot}5247$$

At this stage we have the bandpass filter prior to scaling. See Fig. 14.

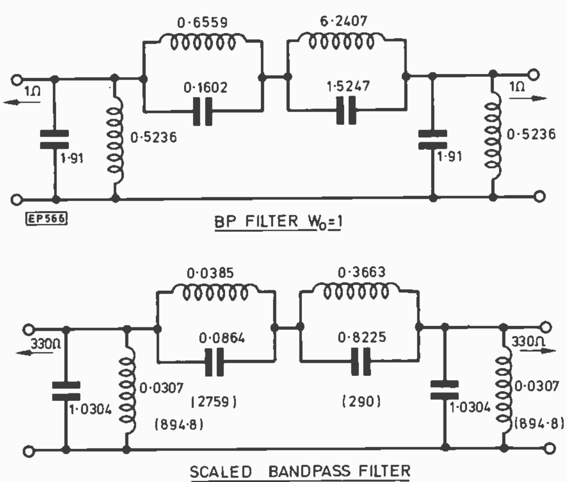


Fig. 14. (above) bandpass filter prior to scaling and (below) final filter

Scale to 330 and $f_O=894\text{Hz}$ using the scaling factors as below.

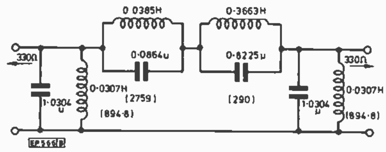
$$A=\frac{R}{2\pi f}=\frac{330}{2\pi\times 894}=0{\cdot}0587 \text{ (inductance multiplier "h")}$$

$$B=\frac{1}{2\pi fR}=\frac{1}{2\pi\times 894\times 330}=0{\cdot}53947 \text{ (capacitance multiplier "}\mu\text{")}$$

Final filter is shown in Fig. 14.

As in the first example, set up the three PICs. Set their conversion factors to be exactly the same. Trim R_2 or R_3 to achieve this condition.

Select the capacitors by either bridging them, or resonating with an accurately set up PIC.



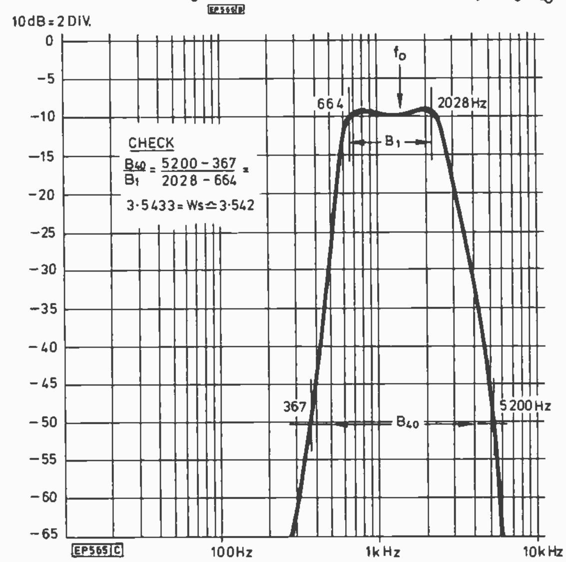


Fig. 15. Response of the final filter. Compare the bandwidth ratio (B_{40}/B_1) with the figure ω_s in the prototype

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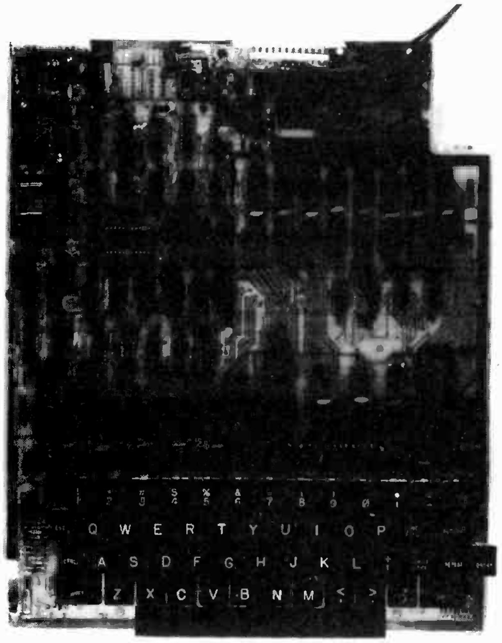

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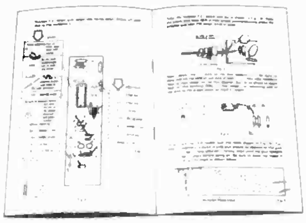

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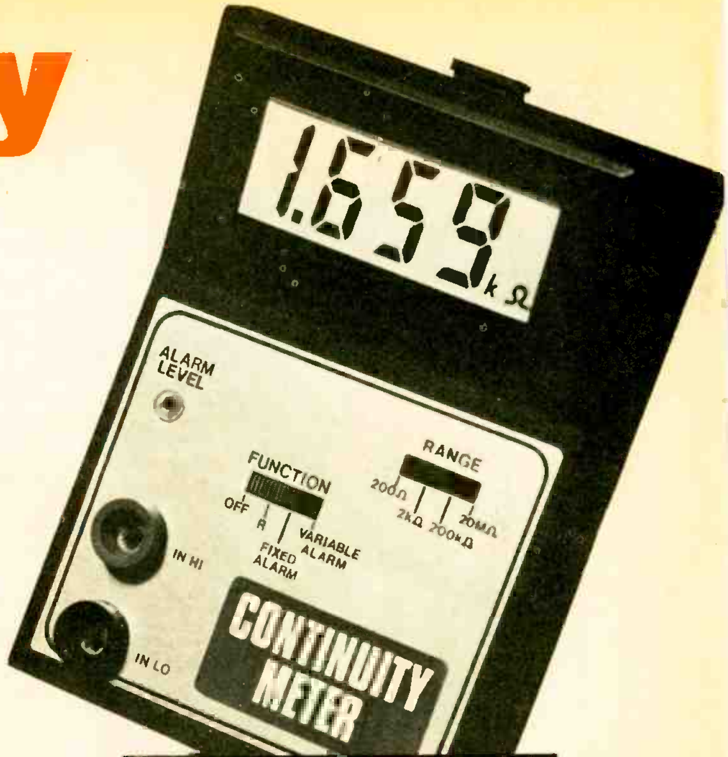


FREE CASE PROJECT

THE present trend in electronics is for equipment to incorporate more functions in a gradually reducing space. This is a good policy until the equipment malfunctions and then the small space can add other problems. The DP500 Continuity Meter is intended to speed fault finding on crowded p.c. boards or complex cable looms.

The LE DPM200 panel meter is used to give four resistance measurement ranges providing accurate indication between 0·1Ω and 20MΩ. A low-power piezo-ceramic alarm is included to produce an audible output when the measured resistance falls below a preset level. Using the audible output, resistance may be assessed without the need to look at the display, leaving the operator to give full attention to the circuit under test. When a fault condition is found, the resistance may be measured accurately on the display. The threshold detection principle may be easily adapted for use in other instruments.

SPECIFICATION

Function	f.s.d.	Resolution	Accuracy
Resistance	200Ω	0·1Ω	0·5%
	2kΩ	1Ω	0·5%
	200kΩ	100Ω	0·5%
	20MΩ	10kΩ	0·5%

Fixed Threshold: alarm sounds when applied resistance is less than 0·5% of range.
Adjustable Threshold: alarm sounds when applied resistance is less than threshold which may be set anywhere within the range.

CIRCUIT DESCRIPTION

The Continuity Meter circuit diagram is shown in Fig. 1. Ratiometric resistance measurement is employed which eliminates the need for calibration by comparing the applied resistor to metal film reference resistors R1-R6.

$$\text{Display} = 1000\ \frac{\text{R unknown}}{\text{R reference}}$$

Protection against voltage being applied to the input of the panel meter is provided by R10 and TR2. In the presence of applied voltage TR1 turns on and shunts current through the PTC thermistor which increases in value to reduce the input current to a safe level.

Resistance measurement may be combined with an alarm output triggered when the input resistance falls below either a fixed or variable threshold.

The piezo-ceramic alarm specified produces large audible outputs even at low operating voltage and current consumption is very small. The alarm is triggered by IC1 which compares the applied voltage on pin 3 against the threshold voltage on pin 2. During normal resistance measurement the voltage developed across the external resistor will be in the range 0–200mV and this is applied to the non-inverting input of IC1. This input has extremely high input impedance of typically $10^{12}\Omega$ such that loading of the input voltage will be negligible and accuracy of measurement will not be impaired. A comparator is essentially an operational amplifier operated in open-loop mode with high gain and the basic configuration is shown in Fig. 2.

The output of the comparator has two output states:

$V_{in} > V_{th}$ then output is high
$V_{in} < V_{th}$ then output is low

The LE DPM 200 panel meter has a very accurate 100mV reference voltage available between REF+ and REF–. Resistors R10–R12 form a potential divider across the reference voltage to form an extremely stable 10mV threshold for IC1 when the instrument is switched to fixed threshold mode. The 10mV figure represents a 0·5% level of the 200mV full scale, which is equivalent to 1Ω on the 200Ω range, 10Ω on the 2kΩ range etc. The alarm will be triggered when the input falls below the level set by the range switch S2.

To provide increased flexibility of operation, a further position on the function switch enables the alarm to be generated when the input falls below an adjustable threshold. The bandgap reference voltage of typically 1·2V is available between REF BG and REF– on the LE DPM200.

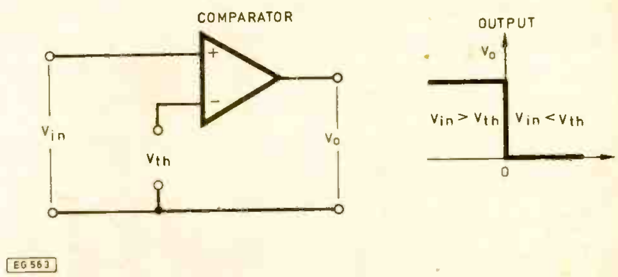
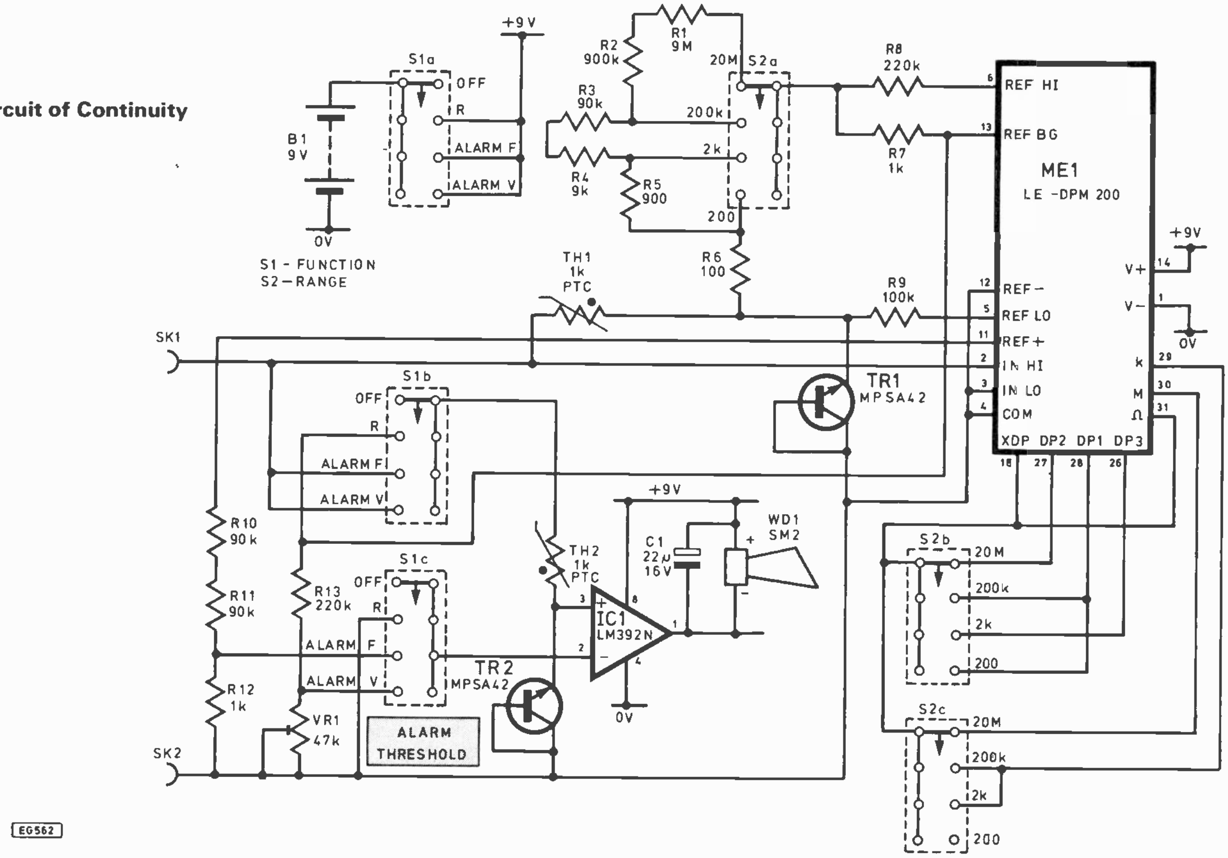


Fig. 2. Comparator action

Fig. 1. Circuit of Continuity Meter



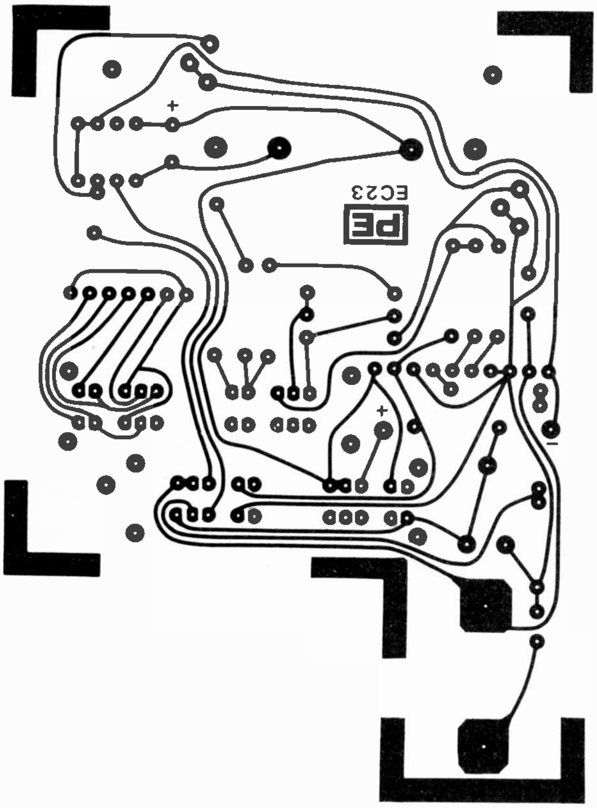


Fig. 3. Printed circuit board

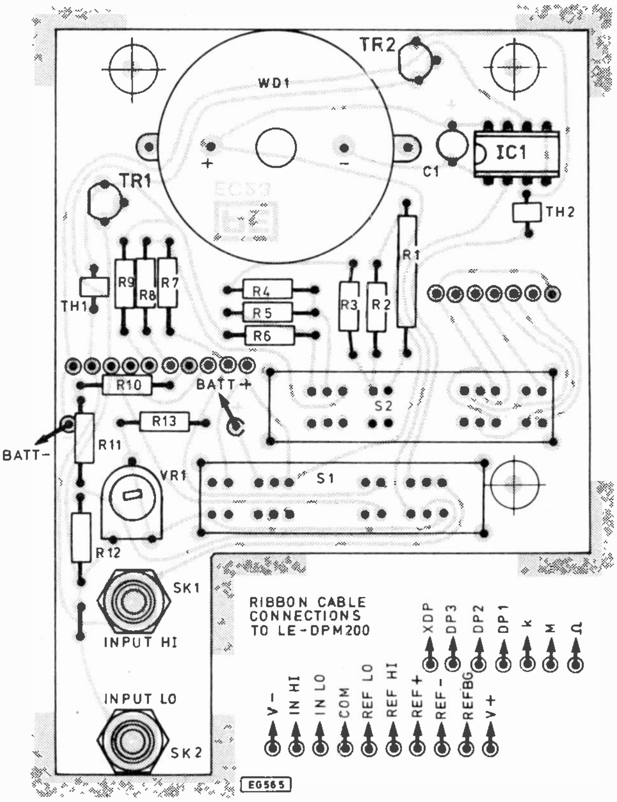


Fig. 4. Component overlay

COMPONENTS . . .

Resistors

R1	9M	metal film 0·25%
R2	900k	
R3	90k	
R4	9k	
R5	900	
R6	100	
R7	1k	carbon film 5%
R8	220k	
R9	100k	
R10	90k	metal film 0·25%
R11	9k	
R12	1k	
R13	220k	carbon film 5%

Variable Resistors

VR1 47k

Capacitor

C1 22M 16V tant. bead

Semiconductors

IC1	LM392N
TR1	MPSA42
TR2	MPSA42

Panel Meter

ME1 LE DPM200 (see special offer)

Thermistor

TH1	PTC	1k
TH2	PTC	1k

Miscellaneous

Instrument case
P.c.b.
Slide switches 4-pole 4-way (2)
Piezo-ceramic alarm SM2
Battery connector
Input terminals, p.c. mounting (2)
Ribbon cable
Self-tapping screws M3 (3)

A kit of components (excluding the DPM200 and case) is available at £12.95 inc. VAT from **Lascar Electronics Ltd., Unit 1, Thomasin Road, Basildon, Essex.**

Resistors R13 and VR1 attenuate the reference and VR1 provides an adjustable threshold for IC1. The higher bandgap reference voltage is used to provide adjustment over the full scale of 0–200mV. The variable resistor may be adjusted when the instrument is in use such that the resistance threshold level may be altered to suit the circuits being tested.

The threshold detection techniques employed in the instrument could be used in most instruments using the LE DPM200 as the 0–200mV input to the DPM is a standard feature.

Switch S2b selects the appropriate decimal point on the display and S2c selects the correct resistance units on the display of either ohms, kilohms or megohms according to the selected range.

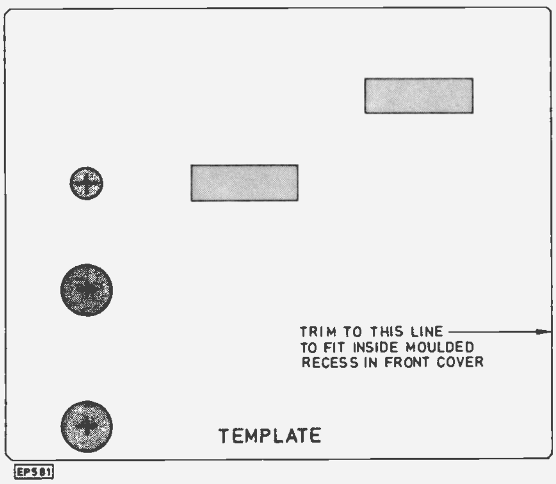


Fig. 5. Front panel template

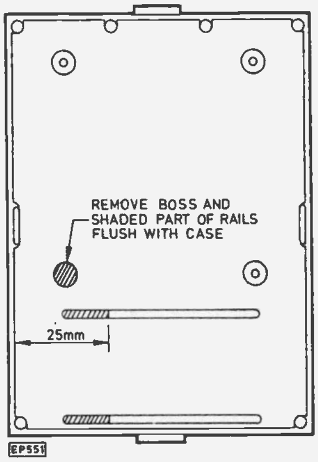
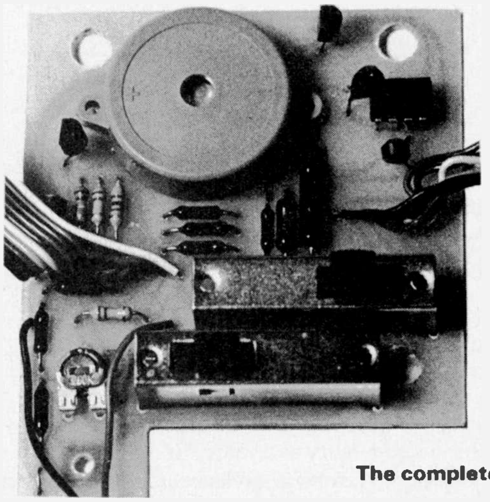


Fig. 6. Interior case cutting details



The completed board

CONSTRUCTION

The few components required for the Continuity Meter simplify construction which should be commenced with the resistors, then semiconductors. Position the switches and check that they are perpendicular to the p.c.b. before soldering. The input terminals, alarm unit and battery connector should then be fitted and the panel meter connected to the p.c.b. by the ribbon cable.

Connect the battery and with the function switch set to resistance measurement the display should indicate a 1 in the leading digit with other digits suppressed on each range. This is the overrange indication.

Switch to Fixed Threshold and when the input terminals are shorted the alarm should be triggered. Triggering of the alarm at the fixed and variable threshold levels may be tested with various resistors if desired.

When testing is complete, the p.c.b. may be secured in the case using three self-tapping screws and when the panel meter is located in the case lid the case may be clipped together. ★

Interfacing COMPUKIT

Part 6 D. E. Graham

THIS month we shall be looking at applications of the 6522 Versatile Interface Adaptor.

6522 VERSATILE INTERFACE ADAPTOR.

The third section of the Analogue Board consists of a 6522 Versatile Interface Adaptor. This is an extremely useful 16 register device, providing two programmable 8 bit input/output ports with handshaking and interrupt control, two 16 bit timers, and a serial input/output port. Fig 6.1 gives its schematic diagram.

Because of the complexity of this chip, we are forced to be highly selective in the treatment of it here, and have chosen to concentrate on the use of its timing and counting registers. In this context we will explore a number of practical applications including a signal generator, a digital frequency meter, a digital capacitance meter, and a real time clock.

For a treatment of aspects of the 6522 not covered here, the reader is referred to the bibliography at the end of the article.

6522 INTERFACE

Fig. 6.2 gives the circuit of the 6522 section of the Analogue Board. The device is selected by the $\overline{BL2}$ line from the Decoding Module, giving it a base address of 61344 decimal. All external connections to the 6522 are made via the 16 pin d.i.l. sockets SK4 and SK5 on the Analogue Board (see Fig. 6.3 for pin connections). These have been made similar to those of SK3 and SK4 of the Decoding Module for the purposes of interchangeability.

The 6522 is a much more demanding device to interface than the 6821 PIA; and the timing and state of the chip select, Ø2 and R/W signals and ground connections are much more critical. For this reason, as suggested earlier, leads between the Analogue Board and the Decoding Module should be kept to a few inches in length. It is also necessary to enhance the earthing between the 6522 and IC2 on the Decoding Module, and between the UK101 earth track close to its expansion socket and the 6522. This is accomplished by soldering two leads as indicated in Fig. 6.4. For the same reason a 1n capacitor (C18) not provided for in the published p.c.b. design, but included in the kit supplied by *Technomatic Ltd.*, must be taken from the 6522 chip select line (pin 23) to ground (or Vcc). This is most easily accomplished by soldering the capacitor between pins 23 and 24 of the 6522 on the underside of the board. This capacitor has the effect of delaying the chip select pulse sufficiently to coincide with the arrival of the slightly misshapen and overworked Ø2 and R/W signals.

TESTING THE 6522

After checking the supply to the socket of IC1, the 6522 should be inserted, and the program listed in Table 6.1 run. This displays the states of the 6522's sixteen registers. Even after a Reset, these should contain a variety of data. If all registers read the same, then the chip is not interfacing correctly, and checks should be made on pins 1, 20, and 22-38 of IC1 for a faulty connection or short circuit, either on the Analogue Board itself, or in the connections to the Decoding Module.

Once the registers appear to read correctly, data may be written to them using the program of Table 6.1. After displaying a readout of each of the 6522's registers, the program requests a register number, and data to be entered in it. And after performing the writing operation, will display the new states of all registers. When using this program in initial tests, it should be remembered that by no means all of the 6522's registers can be directly written to. To test the operation of the 6522 for both Read *and* Write operations, a convenient pair of registers to use is 2 and 3. These should each accept any integer from 0 to 255, and the program should display the value entered, on subsequent readout.

This is also an appropriate point to test the Reset function. Pressing the Reset button on the Decoding Module should reset certain (but not all) of the 6522's registers. As a test, it should be found that registers 2 and 3 are set to zero by this operation. Because of the complexity of the VIA it is advisible to reset it in this way before carrying out any of the experiments below using the two parallel ports or the timers; although as mentioned earlier, the Decoding Module Reset line is automatically activated at power-on.

USE OF THE PARALLEL PORTS

The 6522 has a pair of 8 bit input/output ports very similar to those of the 6821 PIA, though because of its extra provision of registers it is much easier to configure than the latter. Table 6.2 gives the configuration of the 6522's sixteen registers. From this it may be seen that registers 0 and 1 are the data registers for ports B and A respectively; note the reversal of order here. Registers 2 and 3 (the Data Direction Registers) determine whether each bit of port B and Port A Data Registers are set for input or output. This is very similar to the functioning of the 6821's Data Direction Registers.

To set port B for output on all 8 bits, the value 255 should be placed in register 2. This may be accomplished either by executing the command POKE 61346, 255, or by using the program in Table 6.1 to enter the data manually. In either case this should set the port B data pins (ie pins 9-16 of SK5) to zero volts. To output data through the port, that data should then be written to register 0 (at 61344). Thus for example the two commands:

```
POKE 61346, 255
POKE 61344, 15
```

will cause an output on port B of 15; or in other words, pins 16, 15, 14 and 13 of SK5 will read a one (about 4·5 volts), while pins 12, 11, 10 and 9 will read a zero (a few tens of millivolts). The configuration of port A follows a similar pattern, with the Data Register (register 1) at 61345, and the Data Direction Register (register 3) at 61347.

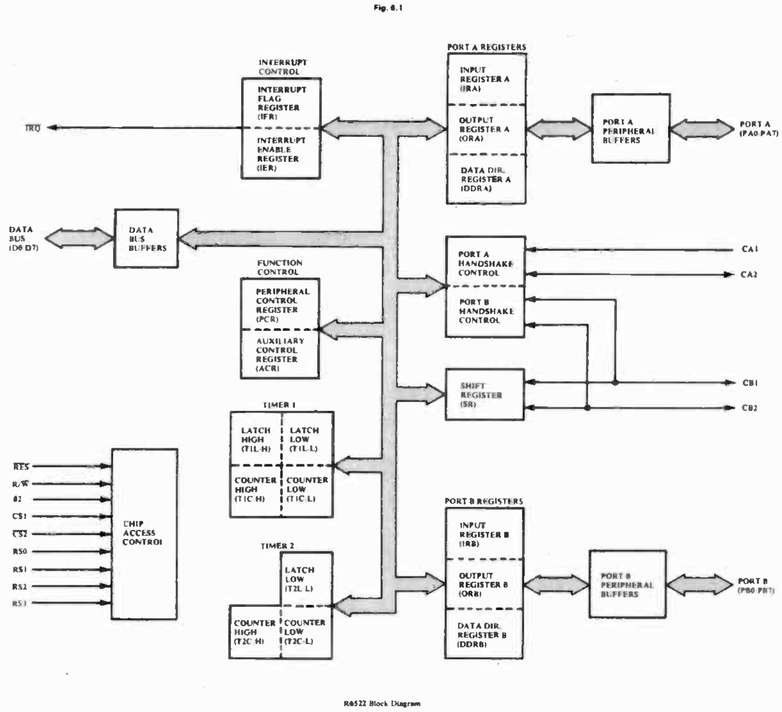


Fig. 6.1. 6522 Block diagram

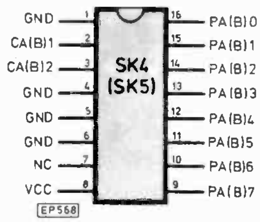
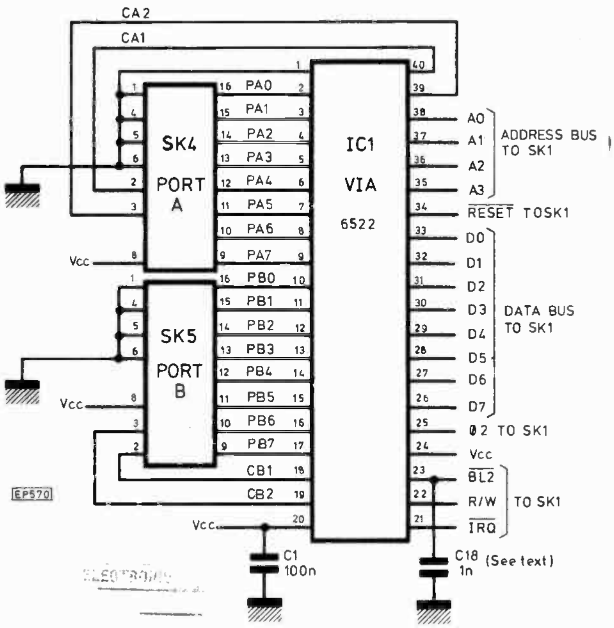


Fig. 6.3. Pin-outs of SK4 and SK5 of Analogue Board. SK4 carries Port A of VIA, SK5, Port B

Fig. 6.2. 6522 section of the Analogue Board



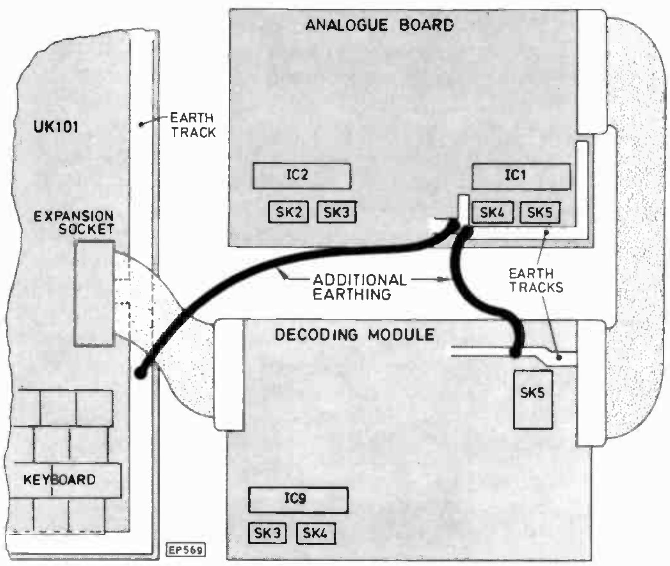


Fig. 6.4. Additional earthing leads to Analogue Board

Table 6.1. 6522 handling program

```
80 REM INTRFACING UK101 PROGRAM 12
85 REM 6522 HANDLING PROGRAM
90 DIMA$(15)
95 P=61344
100 FORA=0TO15
110 READA$(A)
120 NEXT
130 PRINT
140 FORA=0TO15STEP2
145 PRINTTAB(9)CHR$(140);
150 PRINTTAB(10)A;TAB(15)A$(A);
160 PRINTTAB(20)PEEK(P+A);TAB(25);CHR$(140);
170 PRINTTAB(26)A+1;TAB(31)A$(A+1);
180 PRINTTAB(36)PEEK(P+A+1);
185 PRINTTAB(41)CHR$(140)
190 NEXT
200 PRINT
250 INPUT" REGISTER";R
255 IFR>15THEN130
260 INPUT" DATA";D
270 POKEP+R,D
280 GOTO130
300 DATADRB,DRA,DDB,DDA,T1L,T1H,T1L,T1H
310 DATAT2L,T2H,SR ,ACR,PCR,IFR,IER,DRA
```

Table 6.2. The 6522's registers

Register Number	Address (Decimal)	Register Function	Nemonic
0	61344	Port B Data Register	DRA
1	61345	Port A Data Register	DRB
2	61346	Port B Data Direction Register	DDA
3	61347	Port A Data Direction Register	DDB
4	61348	Timer T1 Low Order Byte	TIL
5	61349	Timer T1 High Order Byte	TIH
6	61350	Timer T1 Low Order Byte	TIL
7	61351	Timer T1 High Order Byte	TIH
8	61352	Timer T2 Low Order Byte	T2L
9	61353	Timer T2 High Order Byte	T2H
10	61354	Shift Register	SR
11	61355	Auxiliary Control Register	ACR
12	61356	Peripheral Control Register	PCR
13	61357	Interrupt Flag Register	IFR
14	61358	Interrupt Enable Register	IER
15	61359	Port A Data Register	DRA

Data input on each port is configured by setting the corresponding bits in the Data Direction Register to zero. Thus the commands:

POKE 61347, 0
PRINT PEEK (61345)

will print the value of the data at port A. This will of course be a decimal representation of the binary states of the 8 input lines at pins 16-9 of SK4.

The 6522 does offer one extra facility over the 6821 PIA in the input mode: it may be configured to latch data in response to level changes in the peripheral control lines CA1 and CB1; and for details of how this is accomplished the reader is referred to the 6522 data sheets.

Since the pin connections to SK4 and SK5 of the Analogue Board have been made similar to those serving the PIA on the Decoding Module, devices such as the Joystick Control Box described in parts 2 and 5 of the series may be plugged directly into either of the 6522 ports if desired. In order to run the Joystick from port B of the 6522, for example, the Joystick header should be plugged into SK5 of the Analogue Board, and the Joystick program of Table 3.4 of Part 3 may be run with the following alterations:

130 P=61344
150 POKE P+2, 0
160 Deleted

THE 6522's TIMERS

The 6522 contains two 16 bit counters which may be used for timing and/or counting operations. The two counters, usually referred to as T1 and T2 are somewhat different in operation, and each may be used in a number of different modes. Mode selection is carried out by setting the appropriate bits in the Auxillary Control Register and the Interrupt Enable Register. See Table 6.3.

Timer T1 will only count at the Ø2 clock rate, and may therefore only be used in timing operations. At the end of each count it may be variously conditioned to cause an interrupt and/or to switch the polarity on PB7 (data line 7 of port B of the VIA, accessed through pin 9 of SK5). This counter may also be configured either in a one-shot mode, in which case only a single interrupt, or a single change in polarity occurs on PB7; or it may be configured in the free running mode, in which case a continuous series of interrupts may be produced, and a continuous square wave train of predetermined frequency may be output at PB7.

Timer T2 can be conditioned to count either at the Ø2 rate, or to count the pulses appearing on PB6 (data line 6 of port B of the VIA, accessed through pin 10 of SK5). When a predetermined number of pulses from either source has been counted, T2 can cause an interrupt to signal this event. Timer T2 may also be conditioned to produce clock pulses for the 6522's shift register, though there is not the space here to discuss this latter feature.

The precise operation of the two counters is best understood with reference to specific applications. Timer T2 is the least complex of the two, and we will look at this first.

EVENT COUNTER

Since T2 is able to count incoming pulses on PB6, it may be used as a simple event counter. Only one bit (bit 5) of the Auxilliary Control Register controls the operation of T2. When it is at zero, T2 counts at the Ø2 rate. Setting it to one on the other hand causes it to count pulses on PB6. For an event counter therefore, the value 32 should be loaded into the ACR (register 11 at 61355), so as to give a one at bit 5. For initial tests this may be done manually with the program of Table 6.1. It now remains to set the counter operating. This is accomplished by loading data into T2's latches. The latches are a pair of 8 bit registers that may be loaded by writing data to registers 8 and 9 of the VIA. For the purposes of the event counter it is probably easiest to write 255 into each of these. This may be done using the manual entry program. Writing 255 into register 8 will have no apparent effect, but when register 9 is written to, the data in the two latches will automatically be loaded into the counting registers of T2, and the count started. Reading registers 8

		FUNCTION OF EACH BIT							
Register	Nemonic	7	6	5	4	3	2	1	0
11	ACR	T1 Control		T2 Control	Shift Register Control			Port B Latch Enable	Port A Latch Enable
12	PCR	CB2 Control			CB1 Control	CA2 Control			CA1 Control
13	IFR	IRQ	T1	T2	CB1	CB2	Shift Register	CA1	CA2
14	IER	Interrupt Control	T1	T2	CB1	CB2	Shift Register	CA1	CA2

Table 6.3. Function of Auxiliary Control, Peripheral Control, Interrupt Flag, and Interrupt Enable Registers of the 6522

and 9 has the effect of reading the value of the ongoing count, and with no signal on PB6, this should continue to be 255 for each register.

To use the event counter to count switch closures, a debouncing circuit is essential. Fig. 6.5 gives a suitable circuit using an NE555 in the monostable mode. It is supplied by a 5 volt line from SK5. Each time that the push button is closed T2's counting registers will decrement by one.

By using the program in Table 6.4, setting up the event counter on T2 may be streamlined a little. This loads the ACR with 32, and places 255 into registers 8 and 9, and then continuously monitors their contents. If any change is detected, it prints out the new contents, suitably deducted from 65535, so as to effect a count up rather than down. If no pulses are present, a single zero will be printed. Such a counter may of course be used with any device producing a useable voltage transition, such as a photocell or Geiger counter for example, though in both cases the signals would need to be suitably conditioned before application to PB6. In the case of an l.d.r. light sensor, a single transistor amplifier driving pin 2 of the NE555 monostable of Fig 6.5 should prove to be adequate.

A SIMPLE FREQUENCY COUNTER

Similar principles may be used to create a simple frequency counter. Table 6.5 gives a program which achieves this. The signal to be measured is applied to PB6, and the number of pulses occurring during a one second interval is counted, so giving the frequency in Hz. The counting period is determined by the assigned value of T in line 105. By trimming this value, accuracies of up to about 0·1% should be possible, which will be sufficient for many applications.

The frequency under test is calculated in line 180 of the program from the data in the counting registers of T2; and then the subroutine at line 2000 is entered. This POKEs the value of N (the frequency measured) directly on to the screen at a location assigned in line 2200. The subroutine is then re-entered at line 2220 to POKE up the units of measurement. In this case these are Hz only, but in a later program the same routine is used to provide an auto-ranging readout. The routine at 2000 is quite portable, and may be used for POKEing to the screen any assigned variable, or if entered at 2220 will POKE up any assigned string variable. For use on the Superboard, it should only be necessary to alter the value of S, the screen address, in line 2200.

The test signal (applied to PB6) should be a t.t.l. compatible pulse train of frequency from a few Hz up to about 65 kHz. For greater precision at low frequencies a longer waiting loop could obviously be employed; while for higher frequencies a shorter waiting loop could be used, but accuracy would be likely to decline as a result. In any case the maximum useable frequency is determined by the 6522's timing characteristics, which require pulses on PB6 to be at least 2 µs in duration, and of 2 µs separation. For frequencies above 250 kHz therefore, a prescalar should be used. Also it should be noted that if it is required to use this counter arrangement for measuring sine rather than square waveforms, some form of input conditioning will be required to square the waveform, such as a high gain amplifier.

DIGITAL CAPACITANCE METER

The frequency counting facilities provided in the case above may be conveniently employed to produce a digital capacitance meter. This uses an NE555 timer i.c. in the astable mode to generate a frequency dependent on the unknown capacitor. The output of the 555 is fed to PB6 of the 6522, and is counted for one second intervals by timer T2.

Fig. 6.6 gives the circuit of the tester, which may be built on a small piece of Veroboard, and is powered by the 5 volt supply available at SK5, which also carries the PB6 line.

The output frequency of the 555 in this circuit is determined by the expression $F = 0{\cdot}7/(R \times C1)$, where C1 is the value of the capacitor under test. The program for the tester employs this fomula to print out the value of C1 in nanofarads. It allows for any value of R to be used, and requests the value employed to be entered at the outset; although once a value (or series of values) has been decided upon, it may be easiest to write it into the program.

Fig. 6.5. NE555 monostable debounce circuit for use with event counter

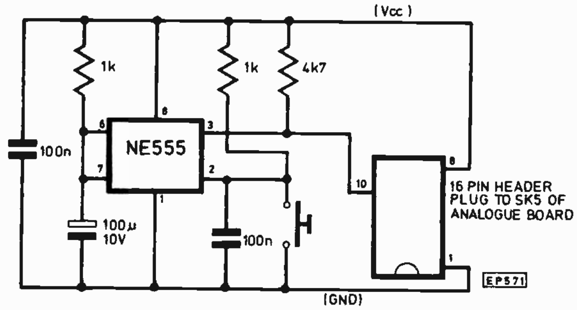
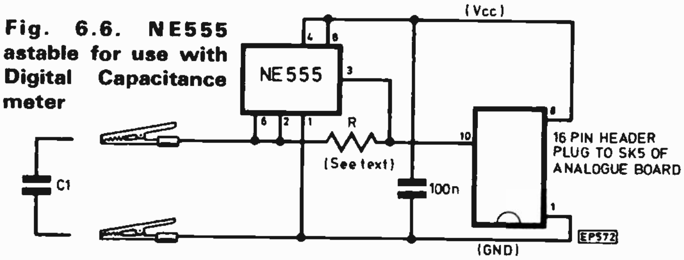


Fig. 6.6. NE555 astable for use with Digital Capacitance meter




```
70 REM INTERFACING UK101 PROGRAM 13
80 REM 6522 EVENT COUNTER
90 REM COUNTS PULSES ON PB6
95 FORZ=1TO16:PRINT:NEXT
96 PRINT,"6522 EVENT COUNTER"
98 PRINT:PRINT:PRINT:PRINT
100 P=61344
110 POKEP+11,255
120 POKEP+8,255
130 POKEP+9,255
140 Y1=Y:Z1=Z
150 Y=PEEK(P+8)
160 Z=PEEK(P+9)
170 IF(Y=Y1)AND(Z=Z1)THEN150
180 PRINT,65535-Y-256*Z
200 GOTO140
```

Table 6.4. Event counter program

```
80 REM INTERFACING UK101 PROGRAM 14
90 REM SIMPLE FREQUENCY COUNTER USING 6522
95 REM SQUARE WAVE INPUT ON PB6
96 FORZ=1TO16:PRINT:NEXT
97 PRINT,"SIMPLE FREQUENCY COUNTER"
98 PRINTTAB(11)"('P' PRINTS - SPACE BAR EXITS)"
99 PRINT:PRINT:PRINT:PRINT:PRINT
100 P=61344
105 T=1110
110 POKEP+11,255
120 POKEP+8,255
130 POKEP+9,255
140 FORQ=0TOT:NEXT
150 Y=PEEK(P+8)
160 Z=PEEK(P+9)
180 N=65535-Y-256*Z
200 GOSUB2000
220 S=S+10
230 N$="HZ"
240 GOSUB2220
250 GOSUB3000
300 GOTO110
2000 REM
2200 S=54110
2210 N$=STR$(N)
2220 L=LEN(N$)
2240 FORM=1TOL
2250 POKES+M,ASC(MID$(N$,M,1))
2260 NEXT
2265 IFPEEK(S+M)=32THEN2280
2270 POKES+M,32:M=M+1:GOTO2265
2280 RETURN
3000 REM
3020 POKE530,1
3030 POKE57088,253
3040 IFPEEK(57088)=239THENPOKE530,0:END
3050 IFPEEK(57088)=253THENPRINT:PRINT
3060 POKE530,0
3080 RETURN
```

Table 6.5. Simple frequency counter program

The circuit appears to give best results with R = 1mΩ (giving a range from about 100p to about 100n, or R = 100k (giving a range from about 500p to 1m). Using lower values of R (eg 10k or 1k) to extend the range to higher values of capacitor unfortunately corrupts the mark to space ratio of the output, causing a false reading—although it might be possible to compensate for this somewhat in calculating the capacitor value. Another way to extend the range would be to use a longer waiting loop. A ten second loop, achieved by setting T to about 10000 in line 105, would extend the range at the high end by a factor of 10.

TIMER T1

Timer T1 is a slightly more complex device than T2, and makes use of four count and latch registers, where T2 uses only two. It also differs significantly in being able to count only at the Ø2 rate, but is able to toggle PB7 each time a count is completed. Thus while T2 can be conveniently conditioned to *count* pulses on an external line (ie PB6), T1 can *produce* an external square wave output; and in fact by wiring PB6 and PB7 together (and taking a 1kO load resistor to earth) counters T1 and T2 could be cascaded to give a 32 bit counter. As with timer T2, we will use specific examples to illustrate its operation.

PRECISION FREQUENCY GENERATOR

With minimal conditioning operations T1 may be set up to produce a square wave output on PB7 (pin 9 of SK5) of frequency between 10Hz and 250kHz.

T1's counting mode is determined by bits 6 and 7 of the Auxilliary Control Register. See Table 6.7. With bit 6 at one, the counter operates in the free running mode, while a zero will put it in the one-shot mode. Bit 7 determines whether there will be an output on PB7 (bit 7 = 1) or not (bit 7 = 0). Incidentally when PB6 or PB7 are selected for use with T2 or T1 this takes precedence over their use as input/output data channels for port B.

From Table 6.7 it may be seen that placing a one at bits 6 and 7 of the ACR conditions T1 for continuous output on PB7. This is arranged in such a way that the output of PB7 is inverted at the end of each count.

It only remains to place the required values for the count in T1's latch registers. These are written to at registers 4 (low order byte) and 5 (high order byte); and as with T2, writing the high order byte automatically causes the two values to be loaded into the counter, and counting to begin. When T1's counting registers reach zero, the polarity on PB7 is inverted, and the contents of the two latch registers again loaded into the counters, and so on.

This operation may be set up using the manual entry program of Table 6.1. As a test, place 192 into register 11 (setting bits 6 and 7 of the ACR), followed by 2 into register 4, and 0 into register 5. This should produce a square wave output on PB7 of period 8 μs.

The length of the period is given by the expression' T = 2(256A + B + 2) μs; where A is the high order byte, and B the low order. The initial multiplication factor of 2 arises because of the toggling of the output effectively dividing the frequency by 2, and the additional 2 in the expression is associated with the time taken to load the counters etc.

It should be noted here that because of the configuration of the 6522's registers, the latches of timer T1 are *written to* at registers 4 and 5, but are *read* at 6 and 7. Data entered in register 4 actually appears on reading register 6, and similarly for 5 and 7. Reading registers 4 and 5 gives the current value of the count in progress. In the author's experience register 4 is particularly sensitive to good earthing of the 6522 and to good timing of chip select, Ø2and R/W, and it is advisable to check that data written into register 4

```
60 REM INTERFACING UK101 PROGRAM 15
70 REM 6522 DIGITAL CAPACITANCE METER
80 PRINT"   DIGITAL CAPACITANCE METER"
85 PRINT"   USING NE555 DRIVING PB6 OF VIA"
86 PRINT:PRINT
90 INPUT"  R IN KILOHMS";R
100 P=61344
105 T=1110
110 POKEP+11,255
120 POKEP+8,255
130 ROKEP+9,255
140 FORQ=0TOT:NEXT
150 Y=PEEK(P+8)
160 Z=PEEK(P+9)
180 HZ=65535-Y-256*Z
190 IFHZ<3THENPRINT"OUT OF RANGE":GOTO110
195 IFHZ<10THENPRINT,"LOW PRECISION RESULT"
200 C=700/(HZ*R)
210 C=1000*C
230 Q=4
240 IFINT(C/10^Q)<1THENQ=Q-1:GOTO240
250 C=INT(.5+C/10^(Q-1))*10^(Q-1)
260 PRINT,C;
270 PRINTTAB(22);"NANOFARADS"
300 GOTO110
```

Table 6.6. Digital capacitance meter program

Table 6.7. Functions of bits 6 and 7 of 6522 Auxiliary Control Register

bit 7	bit 6	Mode
0	0	T1 one-shot mode—Generate a single time out interrupt each time T1 is loaded. Output to PB7 disable
0	1	T1 free-running mode—Generate continuous interrupts. Output to PB7 disabled
1	0	T1 one-shot mode—Generate a single time out interrupt and an output on PB7 each time T1 is loaded
1	1	T1 free-running mode—Generate continuous interrupts and toggle output on PB7

does actually appear at register 6. As a test, try for example the values 0 then 1. If these fail to write in correctly, a check should be made that C18 is in place, and that the extra earth connections described earlier are properly made—some experimentation may be required here.

Using the 6522 to toggle the output on PB7 allows the implementation of very precise frequency generation; although of course only frequencies corresponding to integral numbers of counts may be generated, and ultimately the accuracy is limited by that of the UK101's 8 MHz crystal, which on the author's machine was about 1 part in 3000.

The program listed in Table 6.8 implements the signal generator. It first requests a frequency, and then outputs the nearest frequency available (rounding down), and at the same time prints out the exact frequency actually produced (within the limits imposed by the 8 mHz crystal). It will be noted when using this program that at the high end of the scale, at 100 or 200 kHz, the choice available is somewhat limited. In fact one can either have a 4, 6, or 8 μs time period. At lower frequencies, much greater choice is available, and in the 1 kHz region for example, the frequency may be adjusted in steps of about 2 Hz.

FREQUENCY COUNTER USING T1 AND T2

One of the limitations to the accuracy of the frequency counter described earlier is the timing loop used to produce the one second delay during which the signal to be measured is counted. A more precise way to implement such a delay for higher frequencies is to use timer T1 in the one shot mode. T2 could then be made to count pulses on PB6 for the duration of T1's count. Stopping the count on T2 at the moment when T1 times out may be accomplished using a pair of NAND gates as shown in Fig. 6.7. The first gate (i.c. 1a) is used to invert the output of PB7 since this goes low rather than high during the count period. The signal to be tested is applied to the second gate (i.c. 1b) with the result that an output to PB6 is produced only during the counting time of T1.

```
80 REM INTERFACING UK101 PROGRAM 16
90 REM PRECISION SQUARE WAVE GENERATOR
95 REM USING 6522 VIA
100 P=61344
110 POKEP+11,192
115 PRINT:PRINT:PRINT:PRINT
120 PRINT:PRINT:PRINT,"PRECISION SQUARE WAVE"
130 PRINT,"GENERATOR - O/P ON PB7 OF VIA"
135 PRINT:PRINT:PRINT
140 PRINT:PRINT"  FREQ REQUIRED (10 - 250000 HZ)"
145 INPUTF
150 IFF>=10ANDF<=250000THEN180
160 PRINT:PRINT"   OUT OF RANGE - ENTER AGAIN"
170 GOTO140
180 N=(500000/F)-2
190 N1=INT(N/256)
200 N2=INT(N-256*N1)
205 N3=256*N1+N2
210 F1=500000/(N3+2)
215 PRINT:PRINT"  EXACT FREQ GENERATED =";
220 PRINTF1;" HZ"
225 PRINTTAB(20);"OR ";
230 PRINT1000/F1;" M SEC"
240 POKEP+4,N2
250 POKEP+5,N1
300 GOTO140
```

Table 6.8. T1 frequency generator program

A t.t.l. wave train is then applied at point X, and the program in Table 6.9 run. This puts the value 160 into register 11 of the VIA, setting bits 7 and 5 high, and conditioning T2 for input on PB6, and T1 for the one-shot mode with output on PB7. T2 and T1 are then both loaded with the value 65535 (by placing 255 into both low and high order bytes), so setting in motion both counters. After a wait, the program POKEs the input signal frequency to the screen with auto-ranging units, then repeats the sequence.

As with the frequency counter described earlier, signals must be below 250kHz, and be t.t.l. compatible. And again a prescalar may be used to extend the upper limit. As a simple example Fig. 6.8 shows a 7490 configured as a divide by ten counter which effectively extends the range up to about 2 mHz. The accuracy of this frequency counter (±20 Hz) is determined by the relatively short period (about 1/20 sec) during which the sample is taken. The only way around this with this method is to use software to extend the counting period to several count cycles of T1.

THE USE OF INTERRUPTS

One obvious application of the 6522 VIA in the personal computer context is the implementation of a real time clock. There are many ways of achieving this. About the simplest would be to set either T1 or T2 counting down at the Ø2 rate, and inspect its count registers periodically, calculating the time accordingly. Such a procedure however will tie up the CPU rather more than is necessary, rendering the simultaneous running of other programs difficult if accurate timekeeping is to be achieved.

An alternative approach which does not suffer from this drawback is to use the 6502's interrupt facilities. An interrupt provides a way of drawing the CPU's attention to a particular situation at the instant that it occurs, without the CPU having to waste time in waiting loops, perpetually examining the state of various registers for a given occurrence.

The 6502 has two interrupt lines: the $\overline{\text{NMI}}$ or non-maskable interrupt, and the maskable $\overline{\text{IRQ}}$ line. When either of these is taken low by some external device, the CPU will shelve what it is doing and start the execution of a separate set of routines. When it has completed these it will return to where it left off, and continue until further interrupts are sensed. In the case of the maskable interrupt, the CPU will only take notice of the $\overline{\text{IRQ}}$ line going low if the interrupt mask flag in the 6502's own status register is not set (ie at zero). This is not the case with NMI, which cannot be masked in this way, and is acted upon as soon as the CPU has completed the instruction that it was engaged upon when NMI was taken low.

Interrupt facilities provided by the $\overline{\text{IRQ}}$ line may be used in a number of ways. As an example, they might be used to signal to the CPU that new data had arrived at a particular

```
80 REM INTERFACING UK101 PROGRAM 17
90 REM FREQUENCY COUNTER USING T1 + T2
91 FORZ=1TO16:PRINT:NEXT
92 PRINT,"T1 T2 FREQUENCY COUNTER"
94 PRINTTAB(11)"('P' PRINTS - SPACE BAR EXITS)"
95 PRINTTAB(15)"  ACCURACY +/- 20 HZ  "
96 PRINT:PRINT:PRINT:PRINT:PRINT
100 P=61344
120 POKEP+11,160
130 L2=255
140 L1=255
150 GOSUB4000
1000 F=(256*C1+C2)/(256*L1+L2+1.5)
1010 N=INT(F*100000+.5)/100
1020 N1=0:IFN<1THENN=1000*N:N1=1
1040 GOSUB2000
1050 S=S+10
1060 N$="KHZ":IFN1=1THENN$=" HZ"
1070 GOSUB2220
1080 GOSUB3000
1090 GOTO100
2000 REM
2200 S=54110
2210 N$=STR$(N)
2220 L=LEN(N$)
2240 FORM=1TOL
2250 POKES+M,ASC(MID$(N$,M,1))
2260 NEXT
2265 IFPEEK(S+M)=32THEN2280
2270 POKES+M,32:M=M+1:GOTO2265
2280 RETURN
3000 REM
3020 POKE530,1
3030 POKE57088,253
3040 IFPEEK(57088)=239THENPOKE530,0:END
3050 IFPEEK(57088)=253THENPRINT:PRINT
3060 POKE530,0
3080 RETURN
4000 REM
4100 POKEP+8,255
4110 POKEP+9,255
4120 POKEP+4,L2
4130 POKEP+5,L1
4142 FORZ=1TO1000:NEXT
4150 C1=255-PEEK(P+9)
4160 C2=255-PEEK(P+8)
4200 RETURN
```

Table 6.9. T1–T2 frequency counter program

Fig. 6.7. Nand gates used in T1–T2 frequency counter

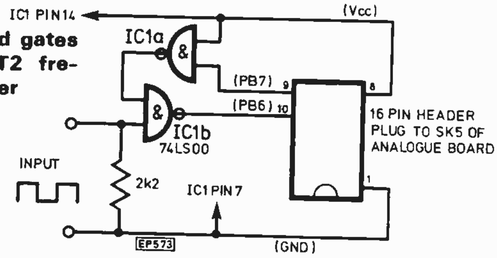
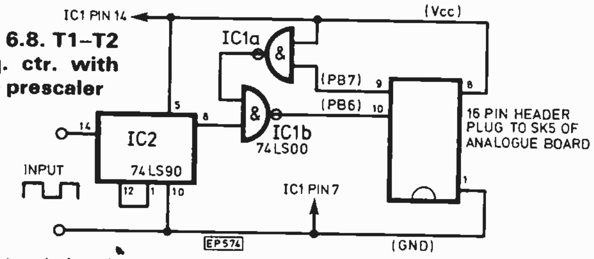


Fig. 6.8. T1–T2 freq. ctr. with ÷10 prescaler



port, and should be read in at the earliest convenience. Alternatively they might be used in the implementation of what is called an interrupt driven clock. Essentially this uses a counter to pull the $\overline{\text{IRQ}}$ line low at regular intervals, say 20 times every second. The interrupt routine can then count the number of times this occurs, and store the number of elapsed seconds, minutes and hours in RAM, returning to the main program when this has been done. Because interrupt handling routines are written in machine code, their execution times are usually very short. In the case of the interrupt-driven clock the CPU will only spend a few microseconds every 50 ms on timekeeping activities, so that this can provide a very efficient way of implementing a clock function on a microcomputer system.

Next month we will give a program which achieves this using the 6522 on the Analogue Board. But for now we will take a look at the general principles involved in using the IRQ interrupt on the UK101.

A SIMPLE INTERRUPT ROUTINE

As a simple illustrative example we will consider an interrupt program which just increments a given memory location when an IRQ interrupt occurs. And to keep the hardware very simple, we will take the $\overline{\text{IRQ}}$ line low with a push button connected between $\overline{\text{IRQ}}$ and ground (pins 1 and 8 of the UK101 expansion socket).

Interrupts can only be handled using machine code since there are no appropriate Basic commands, and in any case for interrupt servicing, speed of operation is usually of the essence. The central part of an interrupt program is the so-called interrupt service routine, to which the CPU is directed every time the $\overline{\text{IRQ}}$ line is brought low. This must first of all save the contents of the 6502's operating registers by pushing them on to the stack. The 6502 automatically saves its program counter and status register in this way, so that it is only necessary to include instructions for saving the Accumulator and X and Y registers; and even this is only necessary if their contents will be disturbed by the main body of the interrupt service routine.

In this case the main body of the routine will simply increment a given memory location. And when this is complete, the interrupt routine must restore the contents of the 6502's operating registers and finally execute a return to the program on which it was engaged prior to interrupt.

Table 6.10 gives a listing of an interrupt service routine which performs these functions. It is located at 0230 hex, and will cause the data stored at 022F hex to be incremented each time an interrupt is sensed.

Table 6.10. Disassembler listing of simple interrupt service routine

0230 48	PHA
0231 8A	TXA
0232 48	PHA
0233 EE2FO2	INC $022F
0236 68	PLA
0237 AA	TAX
0238 68	PLA
0239 40	RTI

The first command PHA pushes the contents of the accumulator on to the stack. Next the contents of the X register are transferred to the accumulator, and are themselves pushed on to the stack for later retrieval. In this particular example these three commands are not in fact necessary, since the main body of the interrupt service routine does not use either the accumulator or the X register, and so their contents do not need to be protected in this way. The instructions are included here to illustrate the principle involved; and if the Y register is to be used in the service routine, then its contents should also be preserved in the same way.

The next command, INC 022F, increments the contents of 022F, while the three which follow, PLA, TAX and PLA, restore the contents of the X register and then the accumulator. Note that there is an effective reversal of order here, since the stack works on a first-in last-out basis. The final command, RTI, causes a return to the main program.

Before this interrupt service routine can be used, the UK101's interrupt system must be initialised in two ways. Firstly the 6502's IRQ mask must be cleared. This is performed by executing the instruction CLI. In the example we will do this by setting up a two instruction subroutine at 0228 hex. This involves placing 58 hex (CLI) at 0228, and 60 hex. (RTS) at 0229. We can then jump to this subroutine to clear the interrupt mask. Clearing the mask in this way must be carried out as a subroutine of the main program, since using a systems Reset on the UK101 to get back into Basic, automatically resets the IRQ mask again. This is why taking the IRQ line low has no effect during the normal running of Basic or machine code programs—IRQ is masked.

The second part of the initialisation procedure involves the UK101's IRQ vector. This is a location in RAM (01CO hex, 448 dec) to which the CPU jumps when it accepts an IRQ request. We must load this location with an instruction that directs it to the interrupt service routine described above, which is located at 0230 hex. To do this, locations 01CO, 01C1 and 01C2 are loaded with 4C, 30 and 02 hex respectively, representing the instruction jump (JMP) to 0230.

We are now in a position to test the IRQ interrupt. To do this, the data in Table 6.11 should be entered at the locations indicated, using the UK101 Monitor. This effectively enters the CLI subroutine, the interrupt jump instruction at the IRQ vector, and the main interrupt service routine described above. When these are in, the BASIC program in Table 6.12 should be run. Lines 120-160 of this use the USR(X) call to clear the interrupt mask. The program then prints out a running count together with the contents of location 022F hex. It will be seen that this latter changes after the $\overline{\text{IRQ}}$ line has been brought low using the push button. It will of course not simply increment by one, since during the finite time that the button is pressed, the CPU will complete many cycles through the interrupt service routine. It will also be noted that during the time that the button is pressed, the BASIC program will pause, resuming operation when it is released.

In more usual interrupt applications, the interrupt would be initiated by a device such as a 6821 or 6522 which can be instructed to take the $\overline{\text{IRQ}}$ line high again as soon as the CPU acknowledges the interrupt. This prevents the CPU getting involved in an endless loop of interrupts, and at the same time clears the way for fresh interrupt requests. This is the case with the interrupt driven clock to be described in the next issue.

Table 6.11. Table of data for IRQ interrupt test

Address	Data	Function
01CO	4C	Replace Jump Instruction at IRQ Vector
01C1	30	
01C2	02	
0228	58	Clear Interrupt Flag
0229	60	
0230	48	Interrupt Service Routine
0231	8A	
0232	48	
0233	EE	
0234	2F	
0235	02	
0236	68	
0237	AA	
0238	68	
0239	40	

```
80 REM INTERFACING UK101 PROGRAM 18
90 REM BASIC PROGRAM FOR USE WITH
92 REM MACHINE CODE ROUTINES TO TEST
94 REM UK101 IRQ INTERRUPT
100 FORA=1TO16:PRINT:NEXT
105 PRINT,"IRQ TEST PROGRAM"
106 PRINT,"FOR USE WITH MACHINE CODE"
107 PRINT,"PROGRAM"
108 PRINT:PRINT"IF UK101 HANGS UP, CHECK MACHINE CODE"
120 POKE11,40
130 POKE12,2
160 X=USR(X)
162 PRINT"   IRQ MASK NOW DISABLED"
163 PRINT:PRINT
165 PRINT,"COUNT";"      022F"
166 PRINT
170 PRINT,B;"       ";PEEK(559)
180 B=B+1
190 FORC=1TO500:NEXT
200 GOTO170
```

Table 6.12. Basic program for interrupt test

NEXT MONTH, as well as the interrupt driven clock, we will cover analogue to digital conversion, and discuss applications of the 8 channel A/D converter on the UK101 Analogue Board.

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MICRO-BUS

Compiled by DJD.

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

GAMES are the main topic in this month's *Micro-Bus;* three games are presented, in BASIC for the Acorn Atom. The final topic shows how to obtain a continuously-changing display on the ZX80.

THREE GAMES

The three games programs contain a large number of abbreviations to keep them compact, and those not familiar with the Atom may therefore find them difficult to follow. The following list of abbreviations will be helpful in understanding them:

F.	FOR
G.	GOTO
GOS.	GOSUB
IN.	INPUT
N.	NEXT
P.	PRINT
R.	RND
R.	RETURN
T.	TOP

The lower-case letters, after line numbers, are used as labels referenced by the GOTO or GOSUB statements.

SKI RUN

The first program, devised by *Tim Dobson* of Cambridge, simulates a ski run down a hill of random trees, with the aim of reaching a hut at the bottom of the slope. The skier is represented by a + sign, and the hut as a white block: see Fig. 1.

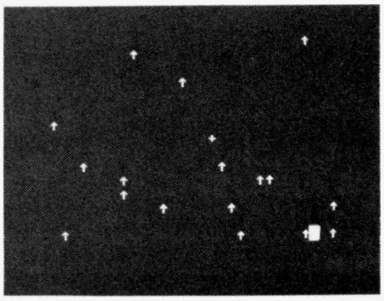


Fig. 1. Display for the Ski-run game; the skier, shown as a '+', attempts to reach the white hut.

The game starts by asking you to enter the speed, and this can be in the range 0 (fast) to 500 (slow). Then the slope is displayed, and after a short delay the skier starts down the hill. The CTRL and SHIFT keys cause the skier to go left or right respectively, in order to avoid the trees. If the skier collides with a tree you fail, and if he reaches the bottom of the screen safely, but misses the hut, he starts again at the top. If, however, he succeeds in reaching the hut, he can attempt a second run with more trees on the hillside.

PROGRAM OPERATION

The program, shown in Fig. 2, works by poking symbols directly to the Atom's screen memory. The variable S, contains the address of the start of the screen; a statement such as:

S?P=30

pokes 30 into the Pth. screen location. First the program puts 15 trees at random places on the screen (line 25), and puts the skier at address R with a blank below him (line 30). Lines 40 to 100 then move the skier down the screen, testing for the CTRL and SHIFT keys, until he hits the hut or a tree. The expression ?#B001 gives a value of 191 if the CTRL key is pressed, and 127 if the SHIFT key is pressed. The old position of the skier is replaced by a blank (line 90), with a test to start again if the skier has reached the bottom, and the skier's new position is put in (line 100). Finally, there is a delay depending on K, the skill level.

Fig. 2. Ski-Run game, in BASIC, runs on an Acorn Atom.

```
  5 P.$12"ski"$#80"run"'
 10 @=3;S=#8000;V=32
 20aIN."SPEED(0-500)"K;U=15
 25xCLEAR0;F.T=1TOU;P=R.&511;S?P=30;N.
 30hR=S+39;?R=43;R?V=V
 35 S?477=127;F.T=1TO7000;N.
 40bP=R;IF?#B001=191R=R-1;G.c
 50 IF?#B001=127R=R+1;G.c
 60 R=R+V
 70cIF?R=30G.e
 80 IF?R=127G.f
 90 ?P=V;IFR>#81FFG.h
100 ?R=43;F.Y=1TOK;N.;G.b
110e?P=V;?R=158;P.$30"BAD LUCK"
115 P."-YOU CRASHED ON"U" TREES";G.g
120f?P=V;?#81BD=33;P.$30"WELL DONE !"'
130 P."YOU MADE IT WITH"U" TREES"'
135 P."NOW TRY"U+2" TREES"';U=U+2
140 F.I=1TO7000;N.;G.x
150gIN."ANOTHER GAME "$T.;IF?T.<>78G.a
160 E.
```

SNAKE

The second game tests your reactions and manual dexterity, and was written by *Chris Cant* of Edinburgh. It shows a snake moving around on the screen whose direction of movement can be changed by the keys: W (up), A (left), D (right), and Z (down). Digits appear at random on the screen, and if the snake collides with one of these its length increases by the value of the digit; see Fig. 3. The point of the game is to increase the length of the snake without allowing it to collide with itself.

The program, Fig. 4, includes a section of assembler, for the 6502, which scans the keyboard and detects whether the keys W, A, D, or Z have been pressed. If a key-press is detected the routine stores the corresponding symbol, ↑, <, >, or U, in memory location G (line 180). Initially, a snake consisting of a single > (code #3E) is set up moving from left to right across the screen (lines 300 to 330). The main program loop, lines 520 to 720, is then repeated for each move of the snake, until a collision occurs. Variables H and T contain the addresses of the head and tail of the snake, and array D contains offsets to move the snake in the four directions. The head is first moved (line 520), and the square it moves to is tested to make sure that it is not part of the snake (lines 525 and 527). The square is also tested to see if it contained a digit. If so, the score, W, is increased by the digit's value, and the tail of the snake is held still for this number of moves (line 536); the effect is to increase the length of the snake by the digit's value. Otherwise, the tail of the head is moved (lines 615 and 630).

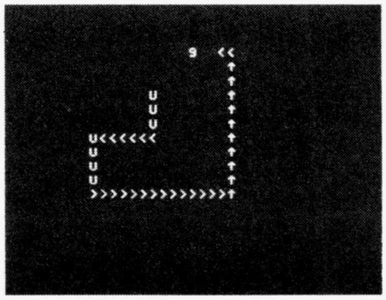


Fig. 3. The snake, about to swallow a digit and increase its length.

The program then checks the keyboard by linking to the machine-code scan routine, LLO (lines 640 and 670). Variables O and F are used as counters to determine how long the digits remain on the screen, and time until another one appears (lines 700 to 740). A random digit is poked to the screen in lines 760 to 790.

SNAKE STRATEGY

The snake coils around on the screen, so that if it moves off the top of the screen it will reappear at the bottom. Since the screen contains only 16 lines, it is very dangerous to travel vertically, and you are apt to bump into your own tail. Therefore, the best strategy is to move horizontally most of the time, only moving vertically for short periods to swallow digits. If you score more than about 40, congratulate yourself on excellent co-ordination!

Fig. 4. Snake game for the Acorn Atom. The assembler routine reads the keyboard; the BASIC section moves the snake.

```
  5 REM SNAKE
 10 DIMC4,G6,K6,LL3,D4
 20 C!1=#151E3E3C;P.$21
 30 D!1=#4000211F
 40 G!1=#DFF700DF
 50 G?5=0;G?6=#F7
 60 K!1=#1E3E0015
 70 K?5=0;K?6=#3C
100 REM assembler routine
120 F.I=1TO2;DIMP(-1)
130[:LL0 LDY @10
140 :LL1 LDX @6
150 :LL2 STX #B000
160      LDA #B001
170      CMP G,X
172      BNE LL3
176      LDA K,X
180      STA G
190 :LL3 DEX
200      BNE LL2
210      DEY
220      BNE LL1
230      STY #B000
240      RTS
250];N.I
300 B=#8000;W=5;P.$6;CLEAR0
320 ?#8022=#3E;H=#0022;T=H;J=2;@=32
330 O=0;F=13;S=5;Y=#40;Z=#1FF
520 DO H=(H+D?J-@)&Z
525 WAIT;Q=?(H+B)
527 IFQ=21ORQ=30ORQ=60ORQ=62G.e
530 IFQ<>Y E=Q-#30;W=W+E;S=S+E;O=0;F=1
533 I=0;WAIT;?(H+B)=C?J
536 IFS<>1 S=S-1;G.a
600 WAIT;E=?(T+B)
610jI=I+1;IFC?I<>E G.j
615 WAIT;?(T+B)=Y
630 T=(T+D?I-@)&Z
640a?G=2;LINKLL0;IF?G=2 G.s
670 WAIT;?(H+B)=?G;J=0
690mJ=J+1;IFC?J<>?G G.m
700sO=O-1;F=F-1;IFO<>0 G.t
720 ?(P+B)=Y;F=RND&#1F+2;U.0
740tIFF<>0 U.0
760uP=RND&#1FF;IF?(P+B)<>#40 G.u
780 N=(?8%9)+1;O=ABS(?9&#1F)+15-N
790 ?(P+B)=#30+N;U.0
800e@=0;P.W" SCORED."
850 IN.'"ANOTHER GAME"$G;IF?G=CH"Y" G.20
900 P.'"CAN'T STAND THE PACE, EH?"''
999 END
```

LAS VEGAS CRAPS

The third game simulates the excitement of playing the dice game Craps at Las Vegas. It was written by *Alex van Someren* of Windsor, and it uses the Atom's low-resolution graphics to plot the two dice; see Fig. 5.

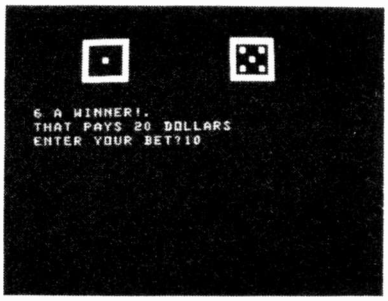


Fig. 5. Dice display for the Craps game.

PROGRAM OPERATION

The program for the Craps game is shown in Fig. 6. The program first asks you to make a bet. It then throws the dice, and you can watch your money increase or disappear depending on your luck.

The program uses a subroutine, r, to throw the dice and plot them on the screen, and this could be incorporated into many other games. P and Q are the numbers on each dice, and S is their sum. Routine q, lines 380 to 450, plots a dice at the current graphics-cursor position, and is called twice by subroutine r. Lines 100 to 200 form a jump table for the 11 different possible totals, 2 to 12, on the two dice.

Fig. 6. Craps game, in BASIC, for an Acorn Atom.

```
  5 P.$12"LAS VEGAS CRAPS..."'
  6 P."==================="'
 10 DIM A(3);R=0
 15 @=0
 40 P."PLEASE BET 0 TO END THE GAME:"''
 50 P."2,3,12 ARE LOSERS; 4,5,6,8,9,10 ARE POINTS."
 60 P.''
 70 IN."ENTER YOUR BET"F;IF F=0 G.e
 80 P."HERE ARE YOUR DICE"';GOS.r
 85 X=S;P.$30'''''
 90 G.((S*10)+80)
100 G.t
110 G.t
120 G.p
130 G.p
140 G.p
150 G.w
160 G.p
170 G.p
180 G.p
190 G.w
200 G.t
210wP.S" A NATURAL:"'"YOU WIN "F" DOLLARS"'
215 G.a
220tP.S" CRAPS:"'"YOU LOSE "F" DOLLARS"'
230 F=-F
240aR=R+F
250 G.70
260pP.S" A POINT: I WILL ROLL AGAIN"'
270 LI.#FFE3;GOS.r;P.$30'''''
275 IF S=7 G.t
280 IF S=X G.300
290 P.S" NO POINT: I WILL ROLL AGAIN";G.270
300 P.S" A WINNER!."'"THAT PAYS "2*F" DOLLARS"'
310 F=2*F;G.a
320rP=ABS(R.%6)+1
330 Q=ABS(R.%6)+1
340 S=P+Q
345 CLEAR0
350 O=P;MOVE10,38;GOS.q
360 O=Q;MOVE40,38;GOS.q
370 R.
380qPLOT1,8,0;PLOT1,0,8
390 PLOT1,-8,0;PLOT1,0,-8
395 G.((O*5)+400)
405 PLOT9,4,4;PLOT8,-4,-4;R.
410 PLOT9,2,2;PLOT9,4,4;PLOT8,-6,-6;R.
415 GOS.405;G.410
418 PLOT9,2,6;PLOT9,4,-4;PLOT8,-6,-2;R.
420 GOS.418;G.410
425 GOS.415;G.418
430 PLOT9,2,4;PLOT9,4,0;PLOT8,-6,-4;G.420
450 PLOT9,4,4;PLOT8,-4,-4;R.
460eIFR>0P."YOU NOW HAVE $"R;E.
465 IFR<0P."YOU ARE UNDER $"-R;E.
470 P."YOU CAME OUT AT $0";E.
```

When you are tired of tossing you can enter 0 for your bet, and see how you have fared overall.

CONTINUOUS DISPLAY FOR ZX80

The following program gives a continuously-updated display of the time on a ZX80; the same technique could be used to provide displays for games, simulations, or analysis programs. The program was submitted by *Mr. Duggins* of Birmingham, and what follows is based on his letter.

"Usually on the ZX80 information cannot be displayed on the screen unless the program is waiting for input from an INPUT statement, or has executed a STOP statement; this is because the display is software driven, and program execution cannot be maintained at the same time. To overcome this problem it was necessary to discover how the display operates."

DISPLAY ROUTINE

"The display routine is also the input routine, and is between addresses 013C and 01B5 (hex). The only useful part is a small subroutine at 01B0 (hex) which actually starts the display. A call to this routine generates one frame, down to the 24th display line. A second call to the routine must be made to finish the TV frame, and a vertical sync pulse must then be output to the TV. The duration of this pulse should be about 1ms, and the idea of the program is to use this time, once every 250 frames or 5 seconds, to update the display. The updating of the display actually takes slightly longer than 1ms, so there is an inevitable slight flicker.

DIGITAL CLOCK

"The digital clock program of Fig. 7 illustrates how to drive the display. The time is shown continuously, and is updated once every 5 seconds. It is accurate to about 2 minutes per day, but as the program stands there is no provision for a reset to 1 o'clock after 12 o'clock. The machine-code routine is entered by typing 'GO TO 250' and entering the codes shown in Fig. 8. Then set S, the seconds, M, the minutes, and H, the hours, to a convenient time using direct LET commands, type 'GO TO 10', and when the preset time is reached press NEWLINE to start the clock.

Fig. 7. Digital clock program for the ZX80 uses a machine-code routine to give a continuous display.

```
 10 LET K=USR(17191)
 20 CLS
 30 LET S=S+5
 40 IF S=60 THEN GO TO 100
 50 FOR U=1 TO 2
 60 NEXT U
 70 IF M<10 THEN PRINT "TIME",H
;":0";M;":";S
 75 IF M>9 THEN PRINT "TIME",H;
":";M;":";S
 80 LET K=USR(17232)
 90 GO TO 20
100 LET S=0
110 LET M=M+1
120 IF M=60 THEN GO TO 200
130 GO TO 70
200 LET M=0
210 LET H=H+1
220 GO TO 70
250 FOR A=17191 TO 17243
260 INPUT I
270 POKE A,I
280 NEXT A
```

The BASIC part of the program is quite straightforward, except for the two USR calls. The first call, to address 17191, makes sure that there will be enough NEWLINE characters in the display file: from then on the machine-code is entered at 17232. The FOR . . . NEXT loop in lines 50–60 is used as a delay so that the TV is at the beginning of a frame, and the output from the ZX80 is therefore in sync with the TV; without this, the flicker is severe while the TV achieves sync.

MACHINE-CODE

The machine-code routine is shown as a decimal dump in Fig. 8. The display time depends on the byte at location 17201; in this case it is 250 frames. If more than 20 characters are to be printed by the routine, the byte at address 17196 should be increased by 1 for every extra character printed. With the program as it stands the machine code cannot be saved on cassette, but it only takes a few minutes to enter.

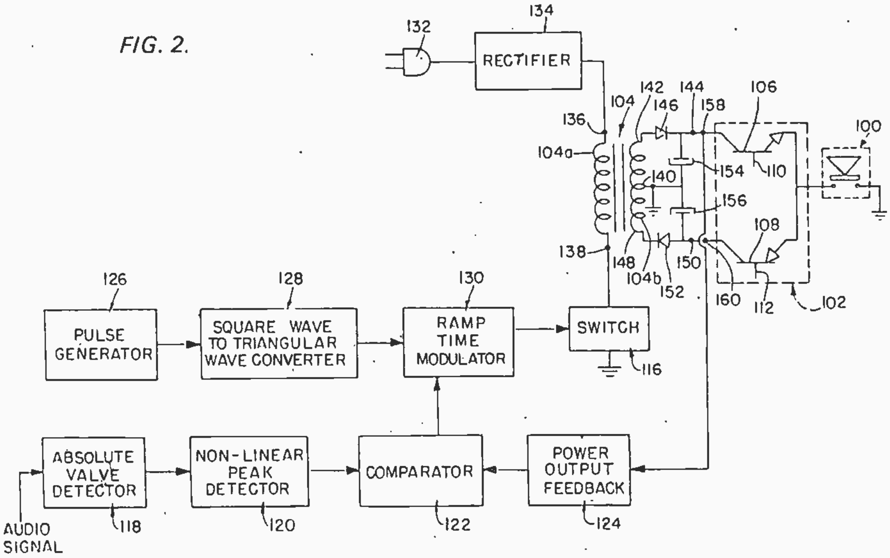
Fig. 8. Machine code display routine, in decimal, for the ZX80.

```
DECIMAL DUMP:
17191: 237  91  12  64   6  50 205 200   5  46
17201: 250 229  62 237   1  56  25  42  12  64
17211: 203 252 205 176   1  43  62 232  14  55
17221:   4 205 176   1 219 254 225  45  32   5
17231: 201 211 255  24 220   6  90  16 254 211
17241: 255  24 214
```

PATENTS REVIEW...

Copies of Patents can be obtained from: the Patent Office Sales, St. Mary Cray, Orpington, Kent. Price £1·45 each.

FIG. 2.



AMP RE-VAMP

Arguably the most radical re-think in amplifier design since the switch from valves to transistors is patented by Robert Carver in International PCT application WO 80/01023. The Carver M400 power amplifier is already on sale in the USA and is now starting to attract attention in the UK. A cube, 7in in size and weighing less than 9lb, it can deliver a total of 500 watts of audio power and costs only 350 dollars. Yamaha of Japan produced a similar design and has now taken a licence under the Carver patent.

Another PCT patent from Robert Carver from the USA (WO 80/02219) gives details of the hitherto secret "sonic holography" circuitry that is built into the Carver pre-amplifier. This will be dealt with in a future issue. Copies of both patents can be referred to, free of charge, in the Science Reference Library attached to the British Patent Office, Southampton Buildings, Chancery Lane. Copies of the patents may be purchased, but *beware.* Because the applications are not routine British cases (they were filed from the USA under the World Patent Cooperation Treaty), the normal British flat-fee purchase price does not apply. Each patent is well over 100 pages in length and full copies can cost nearly £20 each!

The Carver power amplifier achieves high efficiency and low cost, small size and light weight by the clever combination of several techniques, some known and some apparently new. In a conventional high power amplifier the mains transformer accounts for much of the size, cost and weight. To reduce the weight by reducing the winding, also reduces inductance and thereby increases idling current which wastes power as heat. Carver uses a small transformer and switches the primary in and out of circuit so that it draws just sufficient power for the programme being reproduced. *Figure 2* shows a simplified circuit in which transformer 104 is of low inductance and weighs 1/40th the weight of the transformer of a conventional power amplifier of comparable power rating. When a voltage is applied across primary 104a, the current reaches a pre-set maximum of around 20 amps within a few microseconds. Switch 116 then opens to leave energy stored in the transformer windings as a collapsing magnetic field. This stored magnetic energy is analogous to the electrical energy stored in the capacitors of a conventional amplifier. Switch 116 opens and closes at high frequency, e.g. 20 kHz, and the time for which the switch remains open during each 50 micro-second cycle is controlled by tracking the audio signal as it is amplified at 102 for reproduction by speaker 100. Comparator 122 compares the audio signals arriving via detectors 118, 120 with a feedback signal at 124, while switch 116 is controlled by pulses from generator 126.

In this way the current pulses passing through primary 104a are ramped up to maximum amperage as the load requirement increases. Full power is achieved in about 200 micro-seconds. Thanks to this fast response time, the storage capacitors 154, 156 can be kept small and inexpensive.

Figure 5 shows a more sophisticated system with the secondary of transformer 500 tapped to provide a stepped positive and negative voltage output. Control of stepping is by SCR 508 which in turn is controlled by the audio input signal. So as the audio input amplitude increases the SCR conducts for long periods and at higher voltage level. Diodes D511–521 keep capacitors 542–550 charged at preset levels by current flowing through the transformer secondary.

FIG. 5.

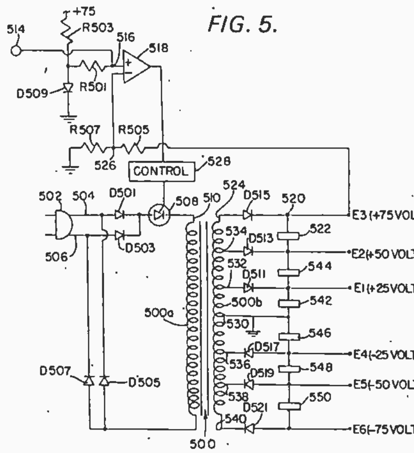


Figure 11 shows an amplifier 1100 designed to utilise such a stepped voltage power supply. NPN transistors Q1101, 1103 and 1105 amplify positive portions of the input signal; PNP transistors Q1107, 1109 and 1111 amplify the negative portions. Switches 1126, 1130, 1138 and 1140 control the conduction state of their associated transistors. When the signal voltage comes within a few volts of the 25 volt level, the first switch 1126 sends current to the base electrode 1124 of transistor Q1103. When the signal voltage comes close to 50 volts, the second switch 1130 makes transistor Q1105 conductive. In this way Q1101 takes power from the 25 volt line E1, Q1103 receives power

FIG. 11.

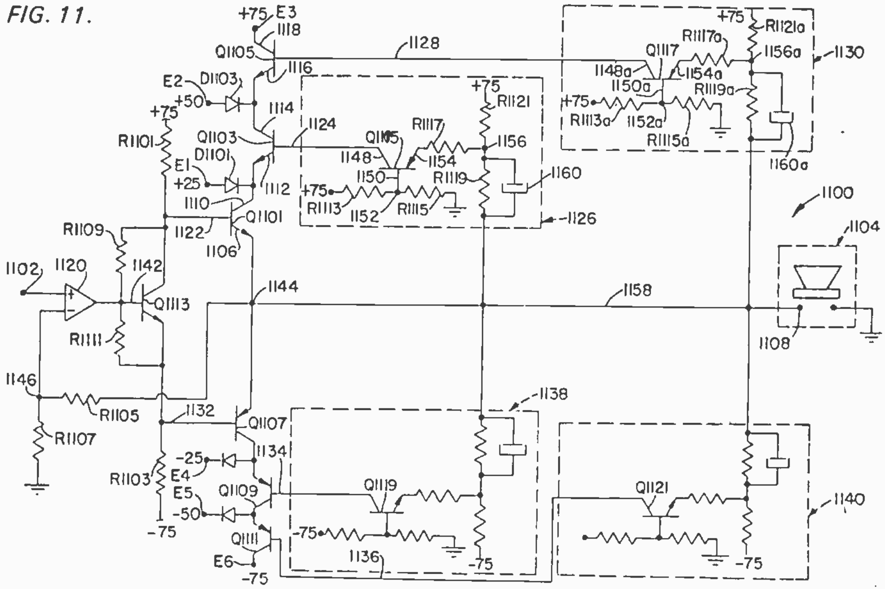
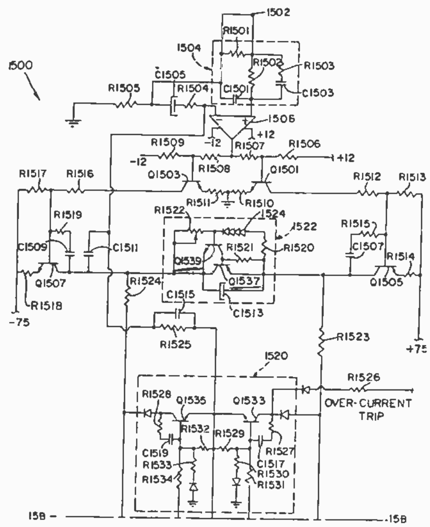


FIG. 15A.

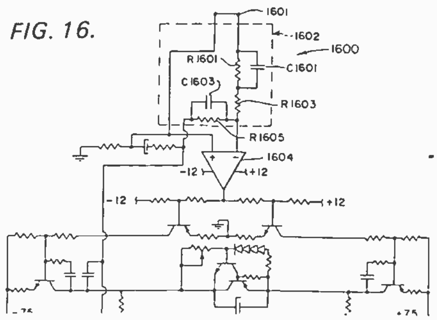


from the 50 volt line E2 and Q1105 takes power from 75 volt line E3. Voltage drop across the transistors is minimised and efficiency maximised.

Yet another feature of the Carver design is shown in *Figure 15A*. Crossover distortion is minimised by transistors Q1537, 1539, with diodes 1524, resistors R1520, 1521 and capacitor C1513. Together these form a bias network which keeps transistors Q1509 and Q1511 on the verge of conduction. Onset of audio input causes the transistors to conduct immediately without discontinuity of the audio output waveform.

Finally *Figure 16* shows another essential link in the Carver chain. One channel of the amplifier includes a network for shifting the phase of the incoming audio signal by 180°. Carver says that statistical analysis

FIG. 16.



of stereo programme material has shown that for most of the time the information in the left and right channels is similar and in phase. As a result conventional amplifiers place a heavy burden on one side of the power supply while leaving the other side idle. By inverting the phase of one channel, and thereafter processing the two channels in out-of-phase relationship, there is a marked gain in efficiency. Both positive and negative excursions of the power supply during each power cycle are fully employed. The inverter network of Figure 16 consists of capacitors C1601, 1603 and resistors R1601, 1603 and 1605 to drive the inverting terminals of operational amplifier 1604. Preferred values for the network components are listed towards the end of the book-sized patent document.

First reports suggest that the Carver amplifier works well. But r.f. interference created by the rapid duty cycle switching may prove a problem in the UK, where radiation regulations are very strict.

Readout...

A selection from our Postbag

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.

Frustration with Integration . . .

Sir—With reference to R. W. Coles introduction to the SG 1547 Power Supervisor in Semiconductor Update, March 1981 issue, I think a very interesting subject has been intentionally or unintentionally touched on. This being the design of discrete power supplies, or for that matter the design of anything discrete. Everything that is said in the first paragraph is very true, and the satisfaction gained from designing a piece of electronic apparatus and sorting out its problems must be likened to the latest "in thing" of computing and debugging programs.

However the crux of the matter is, as R. W. Coles says, why bother designing PSUs etc, when there are available a plethora of i.c.s which can do the job—but where is the satisfaction! Who, if anyone, would design for their own purposes discrete monostables, counters, op-amps etc. With such a range of i.c.s available, the average constructor has got to a stage where it's easier to select an i.c. rather than build it discretely, to see how it works and check on his own design theory, rather than accept a "black box" attitude.

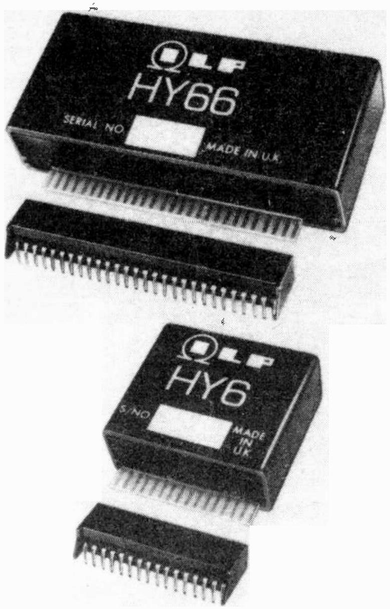
Personally I have thought that since the 1970s that many constructors have moved away from the design table and have, rightly or wrongly, selected an i.c. for the job. This results in frustration when there is a problem to be tackled and there isn't an i.c. suitable for that task. Like, for example, low supply voltage applications and low voltage dropout regulators in high quality audio.

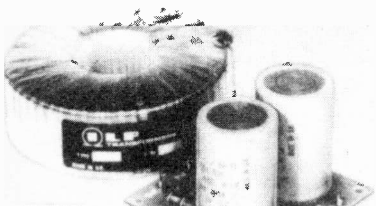
Of course there is the other side of the coin—integration has opened up very interesting areas for the constructor which 10 years ago just would not have been considered. So while i.c.s have enhanced the constructors techniques, I think in some ways there has been a step in the wrong direction, away from designing at the discrete level. This situation could be helped with more articles in *PE* on design principles and concepts.

Geoffrey Pike,
Co. Antrim.

Point taken. Mr Pike, though there are other factors which we have to bear in mind when considering a project for publication. Cost, degree of constructional difficulty and the performance of the end product rank high on our list of priorities. This does mean as you pointed out that a large number of our projects are based around i.c.s. However, judging by the letters we receive, a good proportion of our readers DO know what goes on inside the "black boxes".

Our forthcoming series on Digital Design will help others to get to grips with the subject.—Ed.





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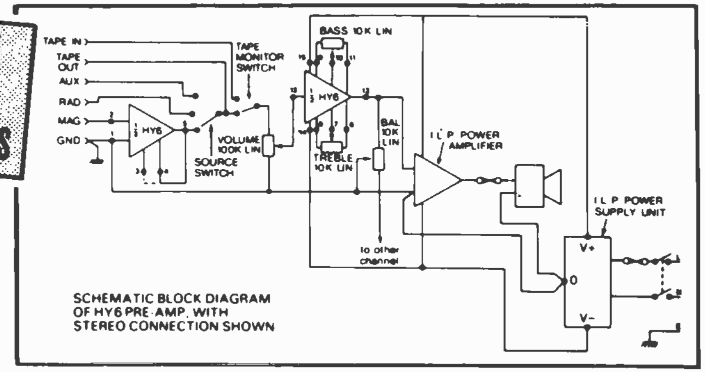

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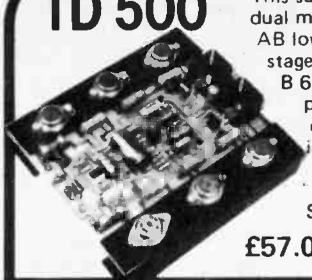

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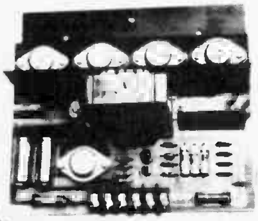

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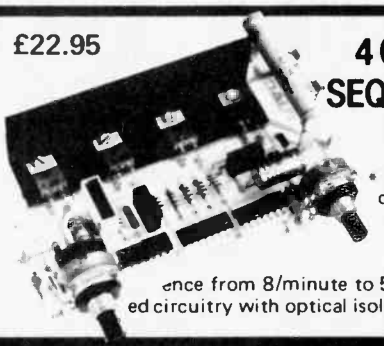

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213	1	0.50	**2.32**	0.70
71	2	1	**2.51**	0.90
18	4	2	**3.24**	1.43
68	3	1.5	**3.15**	1.43
85	5	2.5	**5.52**	1.43
70	6	3	**6.26**	1.43
108	8	4	**7.36**	1.73
72	10	5	**8.05**	1.65
116	12	6	**8.57**	1.90
17	16	8	**10.53**	2.05
115	20	10	**13.69**	2.05
187	30	15	**17.62**	2.45
232	40	20	**25.16**	3.50
226	60	30	**35.35**	4.00

15/30V RANGE PRI 220/240V
SEC: 0V 12V 15V 0V 5V 9V 15V
VOLTS AVAILABLE 3 → 15 — 0 — 15

TYPE	amps 15v	amps 30v	price £	p-p £
112	1	0.50	**2.47**	0.95
79	2	1.0	**3.16**	0.95
3	4	2	**5.64**	1.43
20	6	3	**6.59**	1.73
21	8	4	**7.80**	1.73
51	10	5	**9.68**	1.90
117	12	6	**10.97**	2.05
88	16	8	**14.65**	2.20
89	20	10	**16.93**	2.35
90	24	12	**18.84**	2.55
91	30	15	**21.56**	2.65
92	40	20	**30.08**	3.50

25/50V RANGE PRI 120/220/240V
SEC: 0V 20V 25V 0V 8V 15V 25V
VOLTS OUT 5 → 25 — 0 — 25

TYPE	amps 25v	amps 50v	price £	p-p £
102	1	0.50	**2.88**	1.43
103	2	1.0	**3.60**	1.43
104	4	2	**7.04**	1.73
105	6	3	**8.33**	1.90
106	8	4	**11.18**	1.90
107	12	6	**14.79**	2.20
118	16	8	**20.49**	2.55
119	20	10	**24.52**	2.55
109	24	12	**29.39**	3.50

30/60V RANGE PRI 120/220/240V
SEC: 0V 24V 30V 0V 10V 18V 30V
VOLTS 6 → 30 — 0 — 30

TYPE	amps 30v	amps 60v	price £	p-p £
124	1	0.5	**2.92**	1.43
126	2	1	**5.78**	1.43
127	4	2	**7.13**	1.73
125	6	3	**10.73**	1.90
123	8	4	**12.28**	2.20
40	10	5	**15.55**	2.20
120	12	6	**17.72**	2.35
121	16	8	**25.09**	2.65
122	20	10	**29.07**	4.00
189	24	12	**33.51**	4.60

48/96V RANGE PRI 120/220/240V
SEC: 0V 36V 48V 0V 36V 48V
VOLTS 12 → 48 — 0 — 48

TYPE	amps 48v	amps 96v	price £	p-p £
430	1	0.5	**4.14**	1.43
431	2	1	**7.22**	1.73
432	4	2	**11.87**	2.05
433	6	3	**14.47**	2.20
434	8	4	**18.43**	2.45
435	10	5	**26.16**	2.65
436	12	6	**32.75**	4.00
437	16	6	**35.77**	4.60

AUTOTRANSFORMERS 240/220—115V
65VA — 10KVA
0V 115V 220V 240V

TYPE	va	price £	p-p £
25	65	**3.82**	1.10
64	80	**4.40**	1.10
4	150	**5.64**	1.43
69	250	**7.13**	1.73
53	350	**8.97**	1.90
67	500	**11.09**	2.20
83	750	**12.42**	2.20
84	1000	**16.88**	2.65
95	2KVA	**31.26**	4.00
73	3	**61.27**	4.75
57	5	**87.42**	6.60
101	10	**159.45**	13.00

CASED AUTOTRANSFORMERS
240V LEAD IN 115V 2PIN SOCKET OUT

TYPE	va	price £	p-p £
56W	20	**5.52**	0.58
64W	80	**7.63**	1.43
4W	150	**9.63**	1.73
69W	250	**11.98**	1.90
67W	500	**18.67**	2.20
84W	1000	**26.90**	2.65
95W	2000	**48.45**	7.00
73W	3000	**69.18**	8.00

LINE ADJUSTMENT AUTOTRANSFORMERS
0 200 210 220 230 240 250

TYPE	va	price £	p-p £
415C	50	**2.13**	0.58
416C	100	**3.13**	1.10
417C	200	**3.65**	1.43
418F	350	**5.63**	1.43
419F	500	**6.13**	1.73
420E	750	**7.60**	1.90
421F	1000	**10.55**	2.05

MAINS ISOLATORS (SAFETY SCREEN)
PRI 120/220/240V SEC 60V 55V 0V 55V 60V 60V 55V 0V 55V 60V

TYPE	va	price £	p-p £
149F	60	**7.35**	1.73
150F	100	**8.61**	1.73
151F	200	**12.15**	2.05
152F	250	**14.75**	2.20
153F	350	**18.22**	2.55
154F	500	**22.70**	2.65
155F	750	**32.08**	7.00
156F	1000	**41.26**	7.00

MAINS ISOLATORS (SAFETY SCREEN)
PRI 380/415/440V SEC 60V 55V 0V 55V 60V 60V 55V 0V 55V 60V

TYPE	va	price £	p-p £
243F	60	**7.35**	1.43
244F	100	**8.61**	1.73
245F	200	**12.15**	2.05
246F	250	**14.75**	2.20
247F	350	**18.22**	2.55
248F	500	**27.70**	2.65
249F	750	**32.08**	7.00
250F	1000	**41.26**	8.00

TYPE	va	price £	p-p £
277PI	750	**34.96**	5.50
279PI	1500	**50.60**	7.00
280PI	2250	**68.26**	7.00

MAINS ADAPTORS
13 amp plug in type. Reversible spider jack lead.

TYPE	va	mA	price	p-p
100	6-7.5-9v	250	**3.85**	0.58
	Regulated			
101	6-7.5-9v	300	**4.70**	0.58

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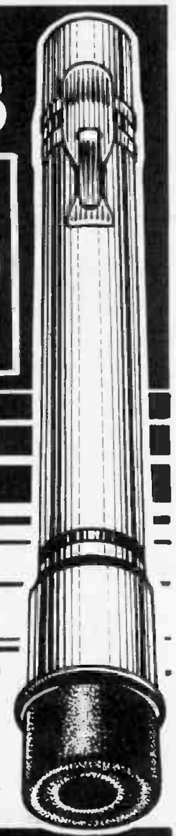

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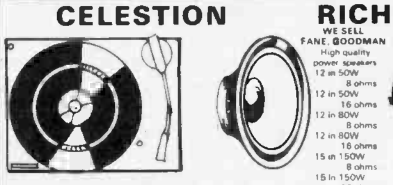

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.001	to	.015/400v	£0.08
.0067	to	.027/250v	£0.08
.033	to	.1/250v	£0.10
0.15/250	£0.12		
0.22/250	£0.14		
0.1/100	£0.12	0.15/100	£0.13
0.22/100	£0.45	33/100	£0.20
0.47/100	£0.26	0.68/100	£0.34

SIEMENS LAYER B32561 10mm

.01 – .022/400v			£0.08
.033/400v	£0.09	.047/400v	£0.10
.022/250v	£0.08	.047/250v	£0.09
.068/250v	£0.10	.1/250v	£0.13
.22/250v	£0.16	.47/250v	£0.26
.22/100v	£0.16	.47/100v	£0.25
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4.7/100	13	22/40	16
10/63	16	22/63	18
10/100	16	22/100	20
47/25	16	47/40	19
47/63	20	47/100	24
100/25	20	100/40	19
100/63	21	100/100	44
220/16	19	220/25	22
220/40	24	220/63	45
220/100	67	470/16	23
470/40	47	470/63	72
470/100	1.16	1000/16	45
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LF 13741H	2.70	SAA 5010	7.11
* LM 301 8	0.26	SAA 5012	7.11
LM 308N	0.48	SAA 5020	5.33
LM 348	0.90	SAA 5030	8.26
* LM 380 N14	0.50	SAA 5040	15.14
LM 383	1.56	SAA 5050	8.51
* LM 386N	0.75	SAS 560	1.60
LM 389N	0.92	SAS 570	1.60
LM 340T5	0.50	SAS 580	1.80
LM 710-14	0.42	SAS 590	1.80
LM 723 CH	0.60	* SFF 96800A	6.25
LM 723 C14	0.40	SFF 96810A	4.28
LM 741 C14	0.58	SFF 96821A	5.19
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LM 1303	1.00	* SN 76228	1.00
LM 1458	0.40	* SN 76116	1.25
LM 1801	2.04	* SN 76666	0.70
LM 1871	1.95	* TAA 263	1.00
LM 1872	1.95	TAA 521	0.75
* LM 3900	0.50	TAA 621	2.49
LM 3909	0.67	TAA 700	1.50
* LM 3914	2.20	TAD 100	1.55
* LM 3915	2.20	TBA 120	0.75
LM 4250	1.42	TBA 500	0.45
NE 531	0.95	TBA 550	3.50
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NE 544	1.60	* TBA 810S	1.00
* NE 555	0.21	TBA 920	2.75
* NE 556	0.73	* TBA 990Q	2.65
NE 558	3.12	TCA 270S	3.15
NE 562	3.12	TDA 2540	3.85
NE 565	1.05	TDA 2611	1.58
NE 566	1.53	* TLO 81CP	0.32
NE 567	1.10	* TLO 82CP	0.56
NE 570	3.50	* TLO 84CN	1.00

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			p/p
Digital Multimeter	PDM35	£34.50	£0.60
" "	DM235	£52.50	£1.30
" "	DM350	£72.50	£1.30
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2N 697	.10	AD 161	.25	BC 184L	.05	BF 195	.10
2N 914	.10	AF 106	.10	BC 212A	.05	BF 196	.10
2N 929	.05	AF 109	.10	BC 213B	.05	BF 199	.05
2N 3133	.10	AF 126	.10	BC 213L	.05	BSY 28	.10
2N 3566	.50	BC 115	.05	BC 214	.05	MJE 371	.30
2N 3638	.05	BC 118	.05	BC 214B	.05	MPSA 05	.05
2N 3642	.10	BC 154	.10	BC 214L	.05	ZTX 500	.05
2N 3708	.05	BC 157A	.05	BC 238B	.05	AA 119	.05
2N 3711	.05	BC 157B	.05	BC 239C	.05	BA 102	.05
2N 3794	.05	BC 158	.05	BC 251B	.05	BA 142	.05
2N 3771	.75	BC 159	.05	BC 253	.08	BA 144	.05
2N 3905	.08	BC 167B	.05	BC 308B	.08	BA 154	.05
2N 3962	.10	BC 168B	.05	BC 350	.05	BA 316	.05
2N 4286	.05	BC 169B	.05	BC 347	.05	BA 317	.05
2N 4400	.05	BC 170B	.05	BC 414	.05	BA 318	.05
2N 5220	.05	BC 171B	.05	BC 415A	.05	BAW 49	.05
2N 5222	.10	BC 172	.06	BC 416A	.05	BAX 13	.05
AC 126	.15	BC 172C	.06	BC 517	.12	BAY 93	.02
AC 127	.15	BC 173	.05	BCY 71	.05	BB 105B	.10
AC 132	.05	BC 174B	.05	BCY 72	.09	BY 126	.14
AC 152	.15	BC 178B	.14	BD 138	.10	CV 7641	.05
AC 188	.15	BC 182A	.05	BF 161	.08	GEX 23A	.03
AC 188K	.15	BC 183	.05	BF 177	.05	ITT 44	.05
AC 187K	.15	BC 183B	.06	BF 180	.08	ITT 921	.05
ACY 22	.05	BC 183L	.05	BF 181	.05	OA 47	.10
ACY 30	.05	BC 183 LA	.05	BF 194	.05	OA 90	.05

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20V. 2.2, 10. 15V. 22uF	ea. 20p
6.3V. 47uF	ea. 20p
Potientiometers	
Carbon with DP switch	
log. 4K7, 10K, 1M	ea. 35p
less switch, lin 220K	ea. 15p
Dual gang 47K lin	35p
1M log/anti-log, 2M2 log	ea. 15p
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lin: 47K, 100K, 220K	ea. 20p
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Presets, std. size PR15	
300R vert., 4K7 horiz.	ea. 6p
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5K, 15K, 50K	ea. 60p
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Resistors UPM033	per 100 50p
1K3, 9K1 only	
Resistors UPM075 5%	per 100 50p
5R1, 9R1, 330, 1K1, 1K5, 5K6, 16K, 22K, 56K, 240K, 910K, 3M9	
Resistors 1W wirewound	ea. 7p
0R27, 0R39, 0R82, 1R5, 1R8, 2R2	
Resistors 3 W & 7W wirewound	ea. 7p
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TAA865A op-amp, 70mA	30p
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3.9, 4.3, 7.5, 9.1, 15V	ea. 4p
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3mm: 8, 16, 20mm	50p
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2.5" vert. cap clips	8p
Centre-zero edge meters 100uA	£1.70
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Square lamps 12mm 6V red, amber or clear	ea. 25p
28V red, amber or clear	ea. 32p
CELLS MN1500 22p.,	MN2400 22p
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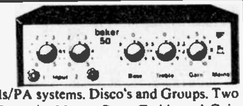

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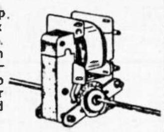

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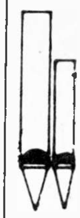

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LM318N	200p
LM324N	55p
LM339N	70p
LM348N	95p
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LM380N	90p
LM381N	★140p
LM382N	130p
LM1310N	140p
LM1458N	45p
LM3900N	55p
LM3909N	75p
MC1496P	80p
NE531	150p
NE555	26p
NE556	50p
NE566	160p
SN76023N	170p
SN76115AN	100p
TBA641B	250p
TBA800	90p
TBA810S	110p
ZN414	100p
ZN1034E	220p

DIODES

OA47	8p
OA91	7p
OA200	5p
OA202	6p
1N916	4p
1N4148	4p
1N4001//2	4p
1N4003	5p
1N4004/5	6p
1N4006/7	8p
1N5400	11p
1N5401	12p
1N5402	13p
1N5404	14p

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W02M	18p
W06M	20p
1A/50V	20p
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1A/400V	28p
1A/600V	29p
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2A/100V	32p
3A/100V	60p
3A/600V	75p

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4001B	17p
4002	16p
4006B	90p
4007	16p
4008	85p
4009	42p
4010	50p
4011B	20p
4012	25p
4013B	45p
4014/5B	80p
4016	44p
4017	75p
4018	85p
4019	50p
4020B	100p
4021/2	95p
4023	25p
4024B	55p
4025	20p
4027	50p
4028	85p
4029	100p
4030	55p
4035	110p
4041	85p
4042	80p
4043/4	95p
4047	105p
4048	60p
4049	40p
4050B	50p
4066	55p
4068/9	25p
4070B/1	30p
4072/3	25p
4081/2	28p
4086	80p
4510	99p
4511B	100p
4516/8	105p
4520/8	105p

TTL

7400/1	16p
7402/3	16p
7404/5	16p
7406	35p
7407	35p
7408	20p
7409	20p
7410	16p
7411/2	22p
7413	30p
7414	44p
7416	30p
7417	28p
7420	15p
7421	40p
7422	26p
7427	33p
7428	40p
7430	18p
7432	30p
7433	38p
7437	35p
7438	32p
7440	18p
7441	70p
7442	60p
7443	115p
7444	110p
7445	105p
7446	100p
7447A	75p
7448	75p
7450	16p
7451/3	16p
7454	16p
7460	16p
7470	35p
7472	30p
7473	33p
7474	33p
7475	40p
7476	33p
7480	50p
7485	140p
7486	35p
7490	33p
7491	85p
7492/3	45p
7494	85p
7495	75p
7496	66p
7497	200p
74100	130p
74105	60p
74107	35p
74109	60p
74110	55p
74118	90p
74121	35p
74122	50p
74123	65p
74125/6	52p
74132	65p
74141/5	75p
74150	130p
74151	70p
74153	70p
74154	120p
74155	80p
74156	80p
74157	75p
74160	100p
74161	99p
74162/3	99p
74164/5	120p
74166	120p
74173	110p
74174/5	95p
74176/7	90p
74180	90p
74181	170p
74182	90p
74190	120p
74191	120p
74192/3	100p
74194	100p
74195	80p
74196	99p
74197	80p
74198	150p
74199	160p

TRANSISTORS

AC126/7	22p
AC128	20p
AC153	25p
AC176	22p
AC187/8	22p
AC187K	30p
AD149	40p
AD161/2	28p
AF114	30p
AF124	60p
AF125/6	35p
AF127	35p
BC107/8	10p
BC109	10p
BC140	20p
BC142/3	30p
BC147/8	10p
BC149	10p
BC157/8	12p
BC159	12p
BC167	14p
BC171	10p
BC173	8p
BC177/8	16p
BC179	16p
BC182	10p
BC182L	★8p
BC183B	10p
BC184	10p
BC186	25p
BC187	15p
BC207/9	13p
BC212	10p
BC212L	★8p
BC213L	10p
BC214	10p
BC214L	★8p
BC238	18p
BC261B	23p
BC301/3	32p
BC328	17p
BC461	40p
BC477	35p
BC478	20p
BC479	23p
BC547/8	12p
BC549	12p
BC557/8	14p
BC559	14p
BCY70	18p
BCYY71/2	18p
BD115	35p
BD121/3	50p
BD124	50p
BD131/2	40p
BD135 to BD140	40p
BF179	19p
BF180	34p
BF181	8p
BF183	34p
BF184/5	25p
BF194/5	12p
BF196/7	12p
BF198	10p
BF200	23p
BF224B	14p
BF244B	★22p
BF258	28p
BF259	40p
BFR39	30p
BFR40	20p
BFR79	32p
BFR80	20p
BFX29	25p
BFX84	25p
BFX85/6	20p
BFX87/8	25p
BFY50/1	20p
BFY52	22p
BRY39	50p
BSX19	12p
BSX20	22p
BU205	200p
BU208	210p
MJ2955	110p
MJE340	52p
MJE3055	80p
MPF102	45p
MPF104/5	40p
MPF106	45p
OC28/35	50p
TIP29	40p
TIP29B	42p
TIP30	40p
TIP30B	42p
TIP31	30p
TIP31A	31p
TIP32	40p
TIP33	65p
TIP33C	70p
TIP34A	75p
TIP35B	200p
TIP36A	200p
TIP36B	210p
TIP41A	60p
TIP42A	60p
TIP2955	70p
TIP3055	★30p
ZTX107/8	12p
ZTX109	12p
ZTX300/1	14p
ZTX302/3	18p
ZTX304	23p
ZTX500/1	15p
ZTX502	20p
ZTX504	24p
2N696/7	20p
2N698	20p
2N706	14p
2N914	20p
2N918	35p
2N1302/3	35p
2N1304	35p
2N1306	30p
2N1308	35p
2N1613	25p
2N1711	13p
2N1893	25p
2N2217	18p
2N2219	23p
2N2222A	23p
2N2369	17p
2N2484	25p
2N2646	46p
2N2904/5	21p
2N2906/7	21p
2N2926G	10p
2N3053	20p
2N3054	30p
2N3055	45p
2N3442	140p
2N3702 to 2N3711	11p
2N3772	★70p
2N3773	250p
2N3819	21p
2N3820	40p
2N3823	70p
2N3866	65p
2N3903/4	15p
2N3906	15p
2N4037	45p
2N4058	10p
2N4059	10p
2N4060	10p
2N4061	10p
2N5458	40p
2N5459	40p
2N6027	30p
3N128	100p

4001B 15p	4069A 18p	7493 26p	ZD5V6 5p	CA3090AQ 1.90p	TRIAC	PRESETS 4.5p	W005 16p	500uF/30V 7p	MINIMUM
4007A 13p	7420 13p	OA91 5.5p	BF244C 16p	SN76115AN 70p	30A/600V 70p	FND500 55p	W06 19p	640uF/16V 4p	25 PIECES
4011B 16p	7447A 45p	1N4005 4.5p	BFY50 15p	7812UC 50p	THYRISTOR	Red LED 10p	S01 23p	1500uF/40V 25p	EACH
4016A 28p	7473 16p	1N4007 6p	TIP31A 22p	Toggle Sw	4A/300V 16p	Grn LED 11p	33uF/40V 4p	MANY	POSTAGE
4017A 45p	7490 23p	1N5404 10p	TIP3055 30p	3A/250V 28p	8A/400V 50p	Yel LED 11p	160uF/25V 4p	MORE	70p

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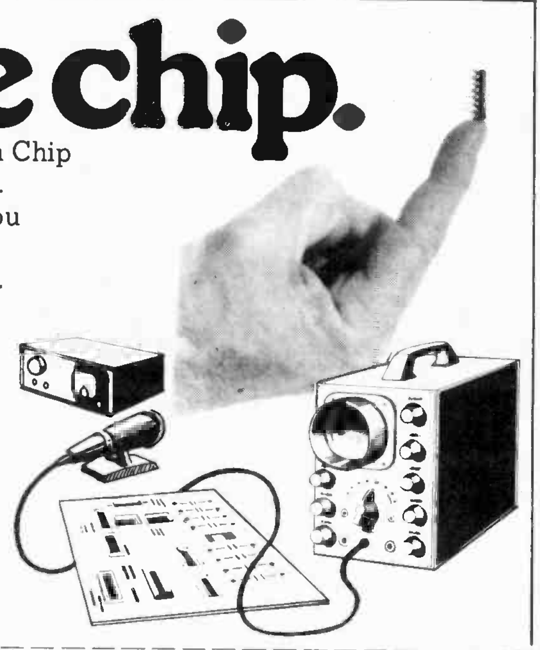

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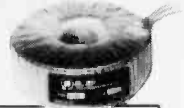

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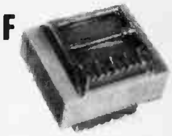

TYPE	SERIES No.	SECONDARY RMS Volts	Current	PRICE
30VA 70x30mm 0.45 Kg	1X010	6+6	2.50	**£4.48** +0.87p P/P +0.80p VAT
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	1X012	12+12	1.25	
	1X013	15+15	1.00	
	1X014	18+18	0.83	
	1X015	22+22	0.68	
	1X016	25+25	0.60	
	1X017	30+30	0.50	
50VA 80x35mm 0.9 Kg	2X010	6+6	4.16	**£4.93** +£1.10 P/P +0.90p VAT
	2X011	9+9	2.77	
	2X012	12+12	2.08	
	2X013	15+15	1.66	
	2X014	18+18	1.38	
	2X015	22+22	1.13	
	2X016	25+25	1.00	
	2X017	30+30	0.83	
	2X028	110	0.45	
	2X029	220	0.22	
	2X030	240	0.20	
80VA 90x30mm 1 Kg	3X010	6+6	6.64	**£5.47** +£1.43 P/P +£1.04 VAT
	3X011	9+9	4.44	
	3X012	12+12	3.33	
	3X013	15+15	2.66	
	3X014	18+18	2.22	
	3X015	22+22	1.81	
	3X016	25+25	1.60	
	3X017	30+30	1.33	
	3X028	110	0.72	
	3X029	220	0.36	
	3X030	240	0.33	
120VA 90x40mm 1.2 Kg	4X010	6+6	10.00	**£6.38** +£1.43 P/P +£1.17 VAT
	4X011	9+9	6.66	
	4X012	12+12	5.00	
	4X013	15+15	4.00	
	4X014	18+18	3.33	
	4X015	22+22	2.72	
	4X016	25+25	2.40	
	4X017	30+30	2.00	
	4X028	110	1.09	
	4X029	220	0.54	
	4X030	240	0.50	

TYPE	SERIES No.	SECONDARY RMS Volts	Current	PRICE
160VA 110x40mm 1.8 Kg	5X012	12+12	6.66	**£8.44** +£1.43 P/P +£1.48 VAT
	5X013	15+15	5.33	
	5X014	18+18	4.44	
	5X015	22+22	3.63	
	5X016	25+25	3.20	
	5X017	30+30	2.66	
	5X018	35+35	2.28	
	5X028	110	1.45	
	5X029	220	0.72	
	5X030	240	0.66	
225VA 110x45mm 2.2 Kg	6X014	18+18	6.25	**£10.06** +£1.73 P/P +£1.77 VAT
	6X015	22+22	5.11	
	6X016	25+25	4.50	
	6X017	30+30	3.75	
	6X018	35+35	3.21	
	6X026	40+40	2.81	
	6X028	110	2.04	
	6X029	220	1.02	
	6X030	240	0.93	
300VA 110x50mm 2.6 Kg	7X016	25+25	6.00	**£11.66** +£1.73 P/P +£2.01 VAT
	7X017	30+30	5.00	
	7X018	35+35	4.28	
	7X026	40+40	3.75	
	7X025	45+45	3.33	
	7X028	110	2.72	
	7X029	220	1.36	
	7X030	240	1.25	
500VA 140x60mm 4 Kg	8X017	30+30	8.33	**£15.53** +£2.05 P/P +£2.64
	8X018	35+35	7.14	
	8X026	40+40	6.25	
	8X025	45+45	5.55	
	8X033	50+50	5.00	
	8X028	110	4.54	
	8X029	220	2.27	
	8X030	240	2.08	

TYPE	SERIES No.	SECONDARY RMS Volts	Current	PRICE
3VA	P2401	3+3	0.50	**0.92p** +24p P/P +17p VAT
	P2402	4.5+4.5	0.33	
	P2403	6+6	0.25	
	P2404	7.5+7.5	0.20	
	P2405	9+9	0.17	
	P2406	12+12	0.12	
	P2407	15+15	0.10	
	P2409	20+20	0.07	
6VA	P3401	3+3	1.00	**£1.91** +£30p P/P +33p VAT
	P3402	4.5+4.5	0.67	
	P3403	6+6	0.50	
	P3404	7.5+7.5	0.40	
	P3405	9+9	0.33	
	P3406	12+12	0.25	
	P3407	15+15	0.20	
	P3408	17.5+17.5	0.17	
	P3409	20+20	0.15	
	P3410	25+25	0.12	
12VA	P4401	3+3	2.00	**£2.09** +58p P/P +40p VAT
	P4402	4.5+4.5	1.33	
	P4403	6+6	1.00	
	P4404	7.5+7.5	0.80	
	P4405	9+9	0.66	
	P4406	12+12	0.50	
	P4407	15+15	0.40	
	P4408	17.5+17.5	0.34	
	P4409	20+20	0.30	
	P4410	25+25	0.24	

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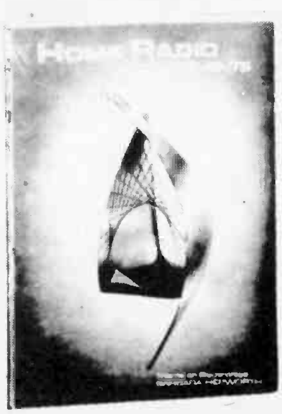

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3 Amp, 5 Volts, Ready-built £18
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2112-4	300p
2114 (25ons)	560p
2114 (45ons)	450p
4027	375p
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4116	300p
5101	400p
6810	350p

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Z80A	850p

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2708	400p
2716	£6

CRYSTALS

32.768KHz	250p
100KHz	300p
1.00MHz	320p
1.8432MHz	325p
2.00MHz	325p
2.476MHz	325p
3.2768MHz	300p
3.6864MHz	325p
4.00MHz	290p
4.1943MHz	300p
4.4336MHz	125p
5.00MHz	325p
6.00MHz	300p
6.144MHz	300p
8.00MHz	300p
8.867MHz	300p
10.00MHz	310p
10.70MHz	300p
16.00MHz	350p
18.00MHz	300p
18.432MHz	350p
19.968MHz	390p
27.145MHz	325p
38.6667MHz	350p

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AY 3 1015P	400p
AY 5 1013A	400p
IM6402	450p

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RO-3-2513LC	650p
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KEYBOARD ENCODER

AY-5 2376	£7

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3245	450p
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6850	300p
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6875	600p
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8228	525p
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8253	1000p
8255	450p
8257	900p
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16 pin	40p	22 pin	65p	40 pin	100p

SUBMINIATURE SWITCHES

TOGGLE	
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SPDT	58p
DPDT	60p
DPDT (Centre off)	85p
Push to make	15p
break	25p
*SLIDE DPDT	18p
*ROCKER SPST	28p
*WAFER	
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4P/3W	45p
2P/6W	45p

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6845	£16
6847	£9.50
5027	£15

UK101: INTERFACING COMPUKIT
(Current PE)

HARDWARE:

Decoding Module Kit	£27.50 + VAT
Display Board Kit	£9.50 + VAT
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The analogue Board kit includes D/A Converter, 8 Channel A/D Converter, AY-3-8910 Prog. Sound Generator, 6522 VIA giving timing and counting functions plus extra 16 bit port.

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★ SPECIALS ★

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