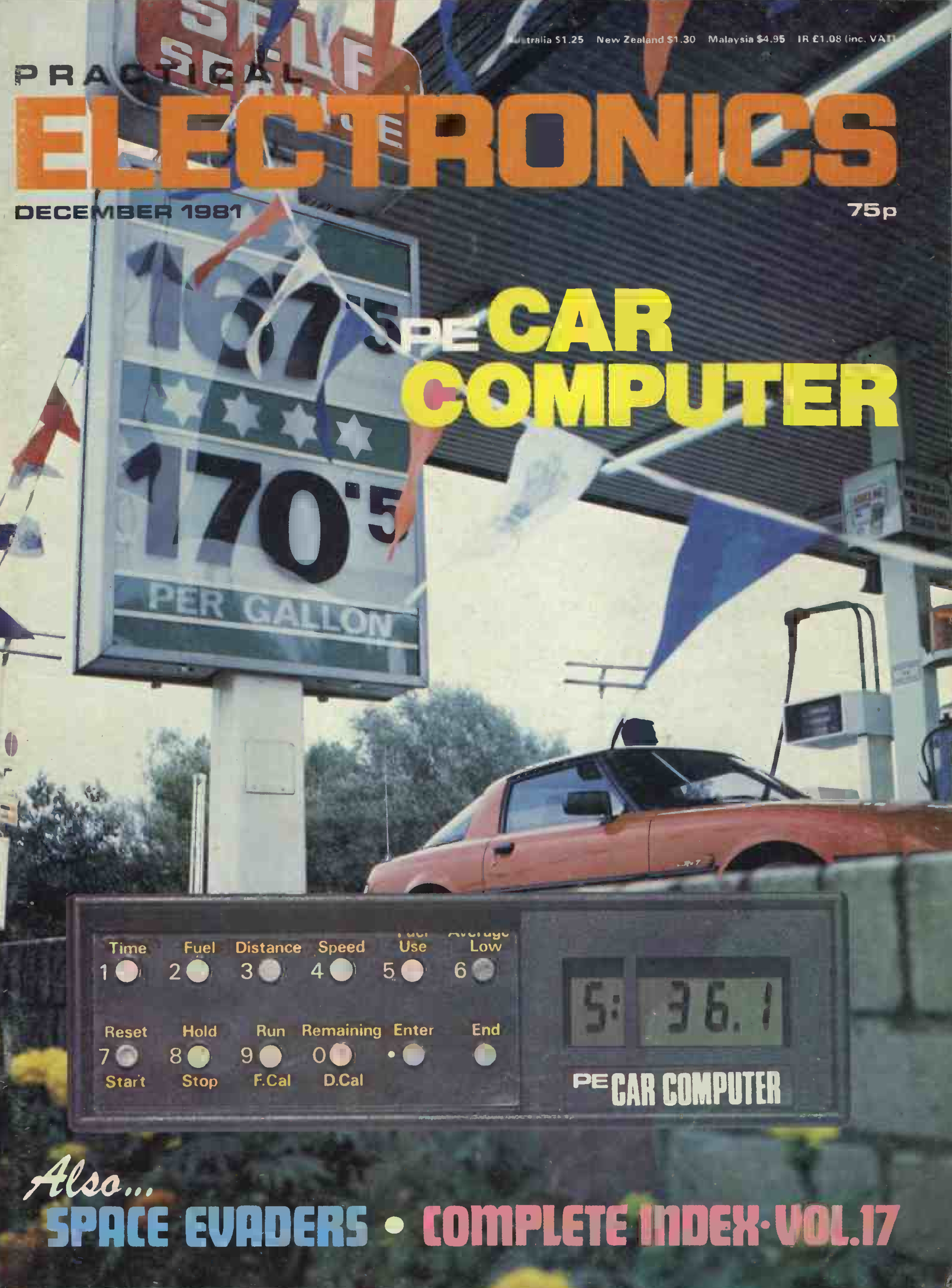
Australia $1.25 New Zealand $1.30 Malaysia $4.95 IR £1.08 (inc. VAT)

PRACTICAL
ELECTRONICS

DECEMBER 1981

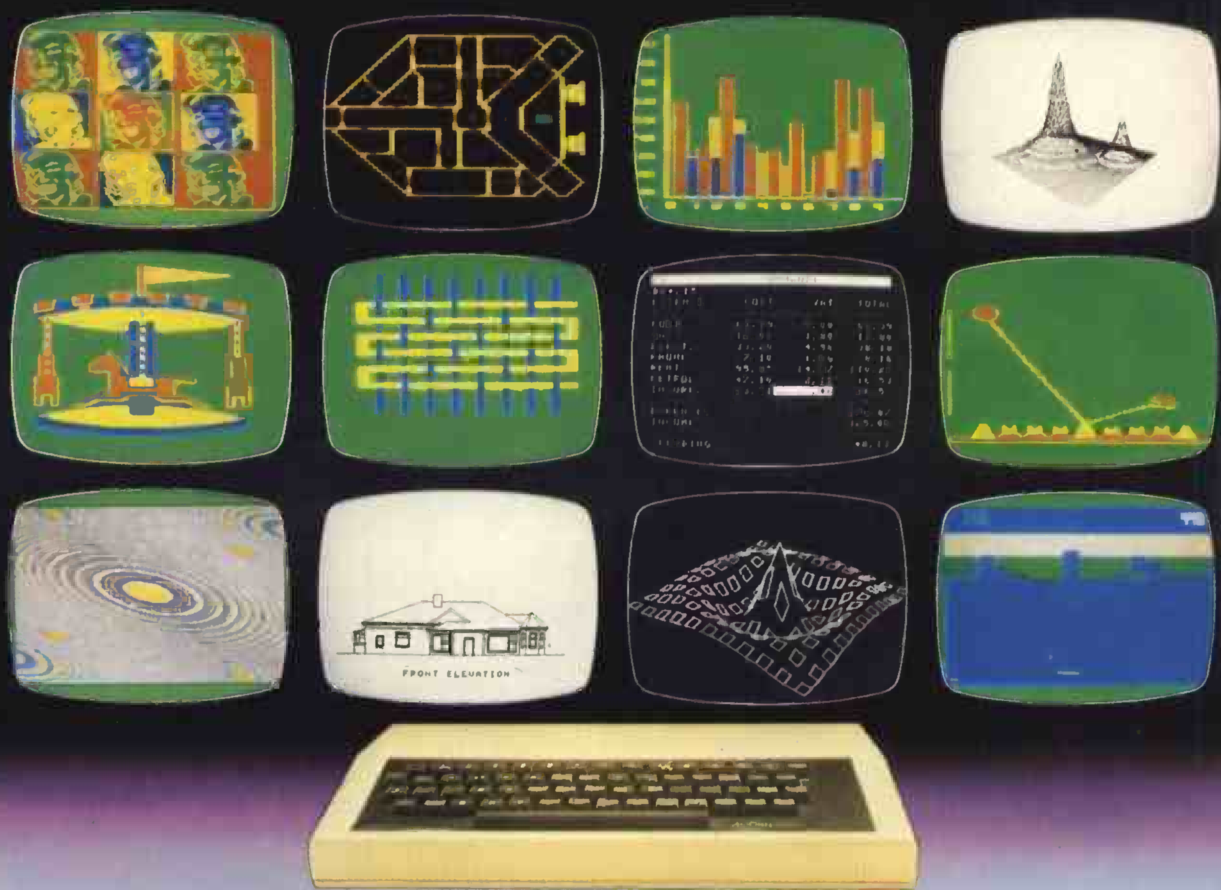
75p

PE CAR COMPUTER



Also...

SPACE EVADERS • COMPLETE INDEX·VOL.17



CHOOSE ATOM POWER

At work or play – everything you need in a personal computer

The Atom is a machine to be used. Every day, day after day. It's a full function machine – check the specification against others. It's rugged, easy to operate built to last and features a full-size typewriter keyboard.

Just look at some of the features!

● More hardware support than any other microcomputer ● Superfast BASIC – can be updated to BBC BASIC if required
● High resolution and comprehensive graphics ideal for games programmers and players* ● Integral printer connection*
● Software available for games, education, maths, graphs, business, word processing, etc.
● Other languages: Pascal, FORTH, LISP
● I/O port for control of external devices
● Built-in loudspeaker ● Cassette interface
● Full service/repair facility ● Users club

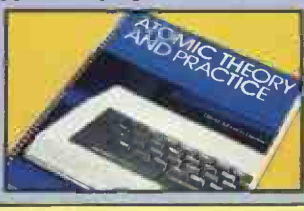
* Expanded version only

Optional Extras

● Network facility with Econet
● Disk ● PAL UHF colour encoder
● Add-on cards include 32K memory, analogue to digital, viewdata VDU, disk controller, daisywheel printer, plus many, many more! ● Power supply

FREE MANUAL

The Atom's highly acclaimed manual comes free with every Atom and leaves nothing out. In just a while you'll be completely at ease with your new machine! Within hours you'll be writing your own programs.



Computer stores are stocking Atoms – there's a list below, but if you have any problems getting hold of one just fill in the coupon and we'll rush one to you within 28 days. If the machine isn't all you expected, or all we've told you, just return it within 14 days for a full refund.

MOM, Aberdeen 22863. Broadway Elect, Bedford 213639. Owl Computers, Bishops Stortford, 52682. Eltec Services, Bradford 491371. Gamer, Brighton 698424. Electronic Information Systems, Bristol 774564. Cambridge Comp Store, Cambridge 65334. Cardiff Micros, Cardiff 373072. Bellard Elect. Chester 380123. Emprise, Colchester 865926. Silicon Centre, Edinburgh 332 5277. Esco Computing, Glasgow 204 1811. Control Universal, Harlow 31604. Unitron Elect, Haslington. Castle Elect, Hastings 437875. Currys Micro Systems, High Wycombe. Customised Electronics, Leeds 792332. D.A. Computers Leicester 708402. Micro-digital, Liverpool 236 0707. Barrie Elect, London 488 3316. Eurocalc London 729 4555. Microage London 959 7119. Sinclair Equip. Int (Export) London 235 9649. Off Records, SW12, 674 1205. Technomatic, NW10 452 1500. NSC Comp Shops, Manchester 832 2269. Customised Electronics, Middlesborough 247727. Compshop, New Barnet 441 2922. H.C.C.S., Newcastle. 821924. Newcastle Comp Services, Newcastle 615325. Anglia Comp Centre, Norwich 29652. Leasalink Viewdata, Nottingham 396976. R.D.S. Electrical Portsmouth 812478. Computers for All, Romford 751906. Intelligent Artefacts, Royston, Arrington 689. Computer Facilities Scunthorpe. Datron Micro Centre Sheffield 585490. Superior Systems, Sheffield 77824. Q-TEC Systems, Stevenage 65385. 3D Computers, Surbiton (01) 337 4317. Abacus Micro Comp, Tonbridge, Paddock Wood 3861. Northern Comp, Warrington 601683. Compass Design Wigan Standish 426252.

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More and more schools are buying Atoms. More and more children will learn on an Atom. You can give them that extra familiarity with an Atom in the home.

ACORN COMPUTER
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When you order your Atom we will include full details of all software packs and the optional hardware.

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I enclose a cheque/postal order for £. . . . .

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Barclaycard No . . . .

Signature . . . .

Name (please print). . . . .

Address . . . .

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Telephone Number . . . .

Registered No. 1403810 VAT No. 215 400 220

Quantity	Item	Item price inc. VAT + P&P	Totals
	Atom Kit 8K ROM+ 2K RAM	@ £140 00	
	Atom Assembled 8K ROM+ 2K RAM	@ £174 50	
	Atom Assembled 12K ROM+ 12K RAM	@ £289 50	
	Power Supply	@ £ 10 20	
		TOTAL	

PRACTICAL
ELECTRONICS
VOLUME 17 No. 12 DECEMBER 1981

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

OUR JANUARY ISSUE WILL BE ON SALE FRIDAY, 11 DECEMBER 1981
(for details of contents see page 37)

HOW TO SUCCEED IN THE ELECTRONICS BUSINESS:

Available at your newsagent or direct for 60p p&p inc

INVEST 60p AND MAKE £2.40 net profit

Buy Ambit's new concise component catalogue and get £1 vouchers. Use them for a £1 discount per £10 spent. But even without this, you will still find WR&E offers the low prices, fast service and technical support facility second to none.

Here are some examples from the current issue:

I.C. SOCKETS

A range of high quality, low cost, low profile DIL sockets ideally suited for both the OEM and hobbyist. All types feature double sided phospher bronze contacts, tin-plated for low contact resistance.

8 x 0.3"	12p	22 x 0.3"	20p
14 x 0.3"	13p	22 x 0.4"	20p
16 x 0.3"	13p	24 x 0.6"	22p
18 x 0.3"	18p	28 x 0.6"	25p
20 x 0.3"	19p	40 x 0.6"	35p
20 x 0.4"	19p	42 x 0.6"	38p

DISCRETES

BC237	8p	BC556	12p		
BC238	8p	BC550	12p	2SK168	35p
ZTX238	9p	BC560	12p	J310	69p
BC239	8p	BC639	22p	J176	65p
BC307	8p	BC640	23p	40823	65p
BC308	8p	2SC1775A	22p	3SK45	49p
BC309	8p	2SA872A	18p	3SK51	54p
BC413	10p	2SD666A	30p	3SK60	58p
BC414	11p	2SB646A	30p	3SK88	99p
BC415	10p	2SD668A	30p	MEM680	75p
BC416	11p	2SB648A	40p	BF960	99p
BC546	12p	BF256	38p	BF961	70p
		2SK55	28p	BF963	99p

VOLTAGE REGULATORS

78XX1A TO-220 pos	0.58
79XX1A TO-220 neg	0.60
78G 1A TO-220 adj pos	1.10
78G 1A TO-3 adj pos	3.95
78H5A TO-3 5v pos	4.25
78H5A TO-3 12v pos	5.45
78HG5A TO-3 adj pos	7.45
79HG5A TO-3 adj neg	7.45
LM317.5A adj pos	1.30
LM337.5A adj neg	1.75
78S401.5A adj pos sw reg	1.20

XTALS

1MHz	3.00
3.2768MHz	2.00
4MHz	1.70
4.194MHz	1.70
4.43MHz	1.25
5MHz	2.00
6.5536MHz	2.00
7MHz	2.00
8MHz	2.00
9MHz	2.00
10MHz	2.00
11MHz	2.00

Prices shown exclude VAT. Postage 50p per order (UK). ACCESS/ BARCLAYCARD may be used with written or telephone orders - official MA details on application, and a special prize for those who read our ads carefully - a free 4 or 8MHz crystal filter with every CPU IC you buy - just clip out the paragraph and attach it to your order. E&OE.

CMOS

4000	0.13	4077	0.18	4705	4.24
4001	0.13	4078	0.18	4706	4.50
4002	0.13	4081	0.18	4720	4.00
4007	0.15	4082	0.18	4723	0.95
4008	0.70	4093	0.41	4724	0.95
4008AE	0.80	4099	0.93	4725	2.24
4009	0.30	4175	0.90	40014	0.54
4010	0.30	4502	0.79	40085	0.99
4011AE	0.24	4503	0.48	40098	0.54
4011	0.15	4506	0.63	40106	0.69
4013	0.32	4507	0.38	40160	0.68
4015	0.64	4508	1.95	40161	0.69
4016	0.30	4510	0.66	40162	0.69
4017	0.45	4511	0.66	40163	0.69
4019	0.38	4512	0.70	40174	0.69
4020	0.58	4514	1.45	40175	0.69
4021	0.68	4515	1.45	40192	0.75
4022	0.64	4516	0.75	40193	0.75
4023	0.15	4518	0.40	40194	0.69
4024	0.45	4520	0.75	40195	0.69
4025	0.15	4521	1.60		
4026	1.05	4522	0.89		
4027	0.50	4527	0.89		
4028	0.50	4528	0.78		
4029	0.75	4529	0.89		
4030	0.35	4531	0.85		
4035	0.75	4532	1.20		
4040	0.68	4534	5.30		
4042	0.58	4536	3.00		
4043	0.65	4538	0.97		
4043AE	0.93	4539	0.89		
4044	0.64	4543	1.05		
4046	0.69	4549	3.50		
4047	0.69	4553	3.20		
4049	0.30	4554	1.30		
4050	0.30	4555	0.48		
4051	0.65	4556	0.53		
4052	0.65	4557	2.30		
4053	0.65	4558	0.89		
4054	1.30	4559	3.80		
4055	1.30	4560	1.75		
4056	1.30	4561	2.18		
4059	5.75	4562	0.89		
4060	0.88	4566	3.80		
4063	1.15	4568	1.45		
4066	0.34	4569	1.50		
4067	4.30	4572	1.95		
4068	0.18	4580	3.25		
4069AE	0.18	4581	1.50		
4070	0.18	4582	1.65		
4071	0.18	4583	0.80		
4072	0.18	4584	0.45		
4073	0.18	4585	0.45		
4075	0.18	4702	4.50		
4076	0.60	4703	4.48		
		4704	4.24		

TTL N

7400N	0.10	7447N	0.62	74153N	0.55	74366N	0.85
7401N	0.10	7448N	0.56	74154N	0.55	74367N	0.85
7402N	0.20	7450	0.14	74155N	0.55	74368N	0.85
7403N	0.11	7451N	0.14	74156N	0.55	74390N	1.85
7404N	0.12	7453N	0.14	74157N	0.55	74393N	1.85
7405N	0.12	7454N	0.14	74159N	1.90	74490N	1.85
7406N	0.22	7460N	0.14	74160N	0.55		
7407N	0.22	7470N	0.28	74161N	0.55		
7408N	0.15	7472N	0.27	74162N	0.55		
7409N	0.15	7473N	0.28	74163N	0.55		
7410N	0.12	7474N	0.28	74164N	0.55		
7411N	0.18	7475N	0.35	74165N	0.55		
7412N	0.19	7476N	0.30	74166N	0.70		
7413N	0.27	7480N	0.26	74167N	1.25		
7414N	0.51	7481N	0.20	74170N	1.25		
7416N	0.27	7482N	0.75	74173N	1.10		
7417N	0.27	7485N	0.75	74174N	0.75		
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7421N	0.28	7489N	1.05	74176N	0.75		
7423N	0.22	7490N	0.30	74177N	0.75		
7425N	0.22	7491N	0.55	74178N	0.90		
7426N	0.22	7492N	0.35	74179N	1.35		
7427N	0.22	7493N	0.35	74180N	0.75		
7430N	0.13	7494N	0.70	74181N	1.22		
7432N	0.23	7495N	0.60	74182N	0.70		
7437N	0.22	7496N	0.45	74184N	1.20		
7438N	0.22	7497N	1.40	74185N	1.20		
7440N	0.14	74100	1.10	74188N	3.00		
7441N	0.54	74104	0.62	74190N	0.55		
7442N	0.42	74105	0.62	74191N	0.55		
7443N	0.62	74107	0.26	74192N	0.55		
7444N	0.62	74109N	0.35	74193N	0.55		
7445N	0.62	74110N	0.54	74194N	0.55		
7446N	0.62	74111N	0.68	74195N	0.55		
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		74122N	0.34	74247N	1.51		
		74123N	0.40	74248N	1.89		
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		74126N	0.40	74251N	1.05		
		74128N	0.65	74265N	0.66		
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		74136N	0.65	74278N	2.49		
		74141N	0.45	74279N	0.89		
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		74144N	2.50	74285N	3.50		
		74145N	0.75	74290N	1.00		
		74147N	1.50	74293N	1.05		
		74148N	1.09	74297N	2.36		
		74150N	0.79	74298N	1.85		
		74151N	0.56	74365N	[illegible]		

74LSN

74LS00N	0.11	74LS109N	0.25	74LS248N	1.35
74LS01N	0.11	74LS112N	0.25	74LS249N	1.35
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74LS03N	0.12	74LS114N	0.25	74LS253N	0.46
74LS04N	0.14	74LS122N	0.40	74LS257N	0.55
74LS05N	0.14	74LS123N	0.55	74LS258N	0.39
74LS08N	0.14	74LS124N	1.80	74LS259N	0.39
74LS09N	0.14	74LS125N	0.29	74LS260N	0.70
74LS10N	0.13	74LS126N	0.29	74LS266N	0.24
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74LS28N	0.19	74LS156N	0.38	74LS366N	0.35
74LS30N	0.13	74LS157N	0.33	74LS367N	0.35
74LS32N	0.14	74LS158N	0.33	74LS368N	0.35
74LS33N	0.16	74LS160N	0.40	74LS373N	0.78
74LS37N	0.15	74LS161N	0.40	74LS374N	0.78
74LS38N	0.16	74LS162N	0.40	74LS375N	1.15
74LS40N	0.13	74LS163N	0.40	74LS377N	1.99
74LS42N	0.33	74LS164N	0.46	74LS378N	1.40
74LS47N	0.39	74LS165N	1.20	74LS379N	2.15
74LS48N	0.65	74LS166N	0.80	74LS384N	2.50
74LS49N	0.59	74LS168N	0.85	74LS385N	4.20
74LS51N	0.14	74LS169N	0.85	74LS386N	0.29
74LS54N	0.15	74LS170N	1.40	74LS390N	0.68
74LS55N	0.15	74LS173N	0.70	74LS393N	0.61
74LS73N	0.21	74LS174N	0.55	74LS395N	2.10
74LS74N	0.18	74LS175N	0.55	74LS396N	1.99
74LS75N	0.28	74LS181N	1.20	74LS398N	2.75
74LS76N	0.19	74LS183N	1.75	74LS399N	2.30
74LS78N	0.24	74LS189N	1.28	74LS445N	1.40
74LS83N	0.50	74LS190N	0.56	74LS447N	1.95
74LS85N	0.70	74LS191N	0.56	74LS490N	1.10
74LS86N	0.18	74LS192N	0.56	74LS668N	1.05
74LS90N	0.32	74LS193N	0.59	74LS669N	1.05
74LS91N	0.70	74LS194N	0.39	74LS670N	1.70
74LS92N	0.34	74LS195N	0.39		
74LS93N	0.34	74LS196N	0.55		
74LS95N	0.44	74LS197N	0.65		
74LS96N	1.20	74LS200N	3.45		
74LS107N	0.25	74LS202N	3.45		
		74LS221N	0.60		
		74LS240N	0.99		
		74LS241N	0.99		
		74LS242N	1.65		
		74LS243N	1.65		
		74LS244N	0.83		
		74LS245N	1.50		
		74LS247N	1.35		

RAM

2102	1.70
2112	3.40
2114/2	1.49
4027	5.78
4116/2	1.59
4116/3	1.49
4864P	12.50
6116P-3	12.50
6116P-4	11.25
8264	12.50

74CXX

74C00	0.20	74C161	0.80
74C02	0.20	74C162	0.80
74C04	0.20	74C163	0.80
74C08	0.20	74C164	0.80
74C10	0.20	74C165	0.84
74C14	0.55	74C173	0.72
74C20	0.20	74C174	0.72
74C30	0.20	74C175	0.72
74C32	0.20	74C192	0.80
74C42	0.80	74C193	0.80
74C48	1.03	74C195	0.80
74C73	0.50	74C200	4.52
74C74	0.50	74C221	1.06
74C76	0.48	74C901	0.38
74C83	0.98	74C902	0.38
74C85	0.98	74C903	0.38
74C86	0.26	74C904	0.38
74C89	2.68	74C905	5.64
74C90	0.80	74C906	0.38
74C93	0.80	74C907	0.38
74C95	0.94	74C908	0.84
74C107	0.48	74C909	1.52
74C151	1.52	74C910	3.62
74C154	2.26	74C914	0.86
74C157	1.52	74C918	0.98
74C160	0.80	74C925	4.32
		74C926	4.32
		74C927	4.32

Processors 8080 series

8080AFC/2	3.11
8212	1.70
8214	3.50
8216	1.41
8224	1.85
8251	4.26
8255	3.97

6800/6809

6800P	3.75
68A00	4.25
68B00	4.75
6802	5.55
6809	15.00
6810	1.75
68A10	1.85
68B10	2.04
6820	1.95
6821	1.75
68A21	2.10
68B21	2.34
6840	4.25
68A40	4.55
68B40	4.75
6850	1.75
68B50	2.17
6852	2.47
68A52	2.75
68B52	2.95
68488	5.25

Z80 series

Z80A	4.99
Z80ADRT	7.50
Z80APIO	4.10
Z80ASIO/1	14.00
Z80ASIO/2	14.00
Z80ASIO/9	14.00
Z80CTC	4.00
Z80ACTC	4.50
Z8001	65.00

PROM

2708	2.00
2716	3.55
2532	8.50
2732	8.50

AMBIT international

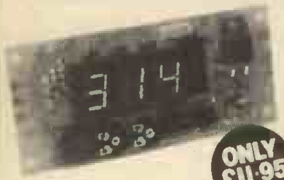
TELEPHONE (STD 0277) 230909 TELEX 995194 AMBIT G POSTCODE CM14 4SG

200 North Service Road, Brentwood, Essex

EXCITING OFFERS!

DIGITAL VOLTMETER MODULE

Fully built & tested



- Positive and negative voltages with an FSD of 999mV which is easily extended.
- Requires only single supply 7 - 12V.
- High overall accuracy ± 0.1% + 1 digit.
- Large bright 0.43" (11mm) LED displays.
- Supplied with full data and applications information.

Using this fully built and calibrated module as a basis now means that you can easily build a wide range of accurate equipment such as multimeters, thermometers, battery indicators, etc. etc. at a fraction of the cost of ready-made equipment. Full details are supplied with each module showing how to easily extend the voltage range and measure current, resistance and temperature. Fully guaranteed, the unit has been supplied to electricity authorities, Government departments, universities, the P.O. and many companies.

Temperature Measurement £2.15+VAT

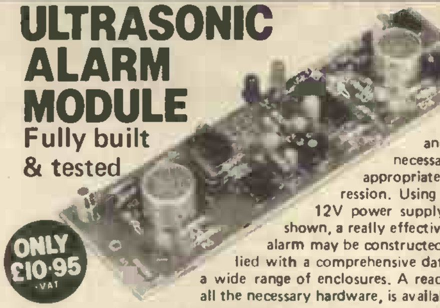
An easily constructed kit using an I.C. probe providing a linear output of 10mV/°C over the temperature range from -10°C to +100°C. The unit is ideal for use in conjunction with the above DVM module providing an accurate digital thermometer suitable for a wide range of applications.

Power Supply £4.95 +VAT

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

ULTRASONIC ALARM MODULE

Fully built & tested



Range adjustable from 5' - 25'

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

Power Supply & Relay Unit £3.95 +VAT

Incorporating a stabilised 12V supply and a s.p.c.o. relay with 3A contacts, this unit is designed to operate in conjunction with the above ultrasonic unit. Fully built and tested, its compact size makes it ideal for constructing the smallest of units.

Hardware Kit £3.95+VAT

A suitable ready drilled case together with the various mounting pillars, nuts and bolts, and including a mains switch and 2mm sockets designed to house the ultrasonic alarm module, together with its associated power supply. This hardware kit provides an ideal solution for assembling the economical alarm system. Size 153mm x 120mm x 45mm

In addition to the above a wide range of competitively priced electronic components is stocked. Please telephone your specific requirements.

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GB 3-octave **£16.76,** 4-octave **£21.93,** 5-octave **£27.45**

SYNTHESISER INTERFACE
Allows external inputs such as guitars, microphones etc., to be processed by synthesiser circuits.
Kit order code = **SET-81 £8.40**

TRANSIENT GENERATOR
An ADSR envelope shaper without VCA, and additionally providing repeat triggering enabling a synthesiser to be programmed for mandolin and banjo effects etc.
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Suitable for use with most electric guitars, organs and other similar instruments. Includes speed, depth & by-pass controls.
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Produces 84 switch-selectable frequency-accurate tones with LED monitor displaying beat-note adjustments.
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A simple octave frequency comparitor for use with synthesisers where the full versatility of Kit 46 is not needed.
Kit order code = **SET-69 £14.83**

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For automatically reducing music volume during disco talk-over.
Kit order code = **SET-30 £8.93**

VOICE SCRAMBLER
Enables a 'garbled' version of a spoken message to be recorded or transmitted. Decoding of message is achieved using the same unit or an identical second model. Requires a 12V PSU at about 30mA.
Kit order code = **SET-117 £20.37**

WAVEFORM CONVERTER
Converts saw-tooth waveform into sinewave, mark-space sawtooth, regular triangle, or squarewave with variable mark-space. Ideally one should be used with each synthesiser oscillator.
Kit order code = **SET-67 £20.34**

WAVEFORM GENERATOR
Provides sine, square and triangular wave outputs variable between 1Hz & 100KHz up to 10V P-P.
Kit order code = **SET-112 £21.58**

WIND & RAIN EFFECTS
As the name says!
Kit order code = **SET-28 £10.55**

PHOTOCOPIES
Unless otherwise stated all sets include photocopies of the original texts as published, but they may also be bought separately as follows –

TXT100	.80	TXT66. JUN	.77
TXT101	.70	TXT66. MAR	.77
TXT102	.75	TXT66. MAY	.58
TXT104	.95	TXT66. NOV	.86
TXT105	.75	TXT66. OCT	.77
TXT106	.75	TXT66. SEP	1.15
TXT107	.75	TXT67	.10
TXT108	.65	TXT69	.68
TXT109	.65	TXT70	.77
TXT110	.50	TXT75	.48
TXT112. POP	1.80	TXT76. DEC	.78
TXT115. POP	1.80	TXT76. NOV	.78
TXT116	.65	TXT79	.88
TXT117	.50	TXT81	.20
TXT118	.65	TXT83	.67
TXT119	1.15	TXT85. DEC	.97
TXT120	.75	TXT85. FEB	.88
TXT25	.38	TXT85. JAN	.97
TXT28	.38	TXT85. JAN	.97
TXT30	.38	TXT86. APR	1.07
TXT38	.40	TXT86. MAR	.97
TXT38. SND	1.50	TXT87	.48
TXT42	.38	TXT88	.78
TXT46	1.07	TXT89	.88
TXT56	.78	TXT90. OCT	.75
TXT57	.88	TXT90. SEP	.95
TXT58	.68	TXT91	.65
TXT63	.68	TXT93	1.80
TXT66. APR	.86	TXT96	.20
TXT66. DEC	.77	TXT97	.85
TXT66. FEB	.77	TXT98	.30
TXT66. JAN	.67	TXT99	.50

RHYTHM GENERATORS
Two different kits – the control units are designed around the M252 and M253 rhythm-gen chips which produce pre-programmed switch-selectable rhythms driving 10 effects instrument generators feeding into a mixer.
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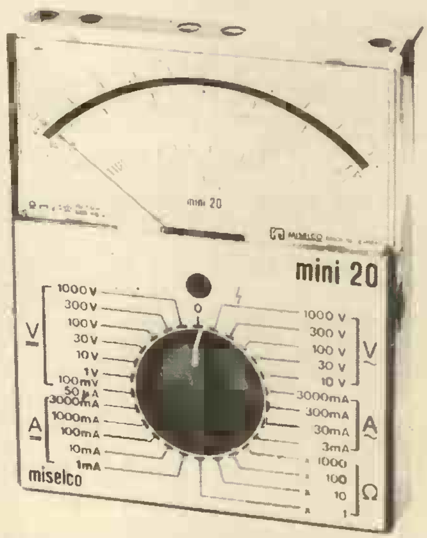

The Mini 20 is an ideal instrument for the constructor.

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Accuracy: 2%d.c. & resistance, 3% a.c.
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(Project described in Practical Electronics, Sept issue onwards)

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This offer price includes rechargeable batteries, mic., aerial, mains lead and 2 channels.
Extra channels £2.25 each + 50p P.P. + VAT
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AF (internal speaker) ½ Watt
Modulation: FM: freq. 27.6MHz-28MHz (CB Band) (excellent speech quality)
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Fully protected against bad aerial connection.

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30 VOLT RANGE (Split Sec)
Sec Voltages available 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30V or 12V-0-12V or 15V-0-15V.

Ref.	Amps 30V	Amps 15V	Price	P&P
112	·5	1	2.90	1.00
79	1	2	3.93	1.00
3	2	4	6.35	1.20
20	3	6	7.39	1.44
21	4	8	8.79	1.60
51	5	10	10.86	1.60
117	6	12	12.29	1.72
88	8	16	16.45	1.96
89	10	20	18.98	1.84
90	12	24	21.09	O.A.
91	15	30	24.18	O.A.
92	20	40	32.40	O.A.

50 VOLT RANGE (Split Sec) Pri 120/240V
Sec Voltages available 5, 7, 8, 10, 13, 15, 17, 20, 33, 40 or 20V-0-20V or 25V-0-25V.

Ref.	Amps 50V	Amps 25V	Price	P&P
102	.5	1	3.75	1.20
103	1	2	4.57	1.20
104	2	4	7.88	1.44
105	3	6	9.42	1.60
106	4	8	12.82	1.72
107	6	12	16.37	1.84
118	8	16	22.29	2.20
119	10	20	27.48	O.A.
109	12	24	32.88	O.A.

MAINS ISOLATORS (SCREENED)
Pri 0-120: 0-100-120V (120, 220, 240V) Sec 0-CT-120V twice.

Ref	VA	Price	P & F
*07	20	4·84	1.20
149	60	7·37	1.20
150	100	8·38	1.44
151	200	12·28	1.72
152	250	14·61	2.04
154	500	22·52	2.20
155	750	32·03	O.A.
156	1000	40·92	O.A.
157	1500	56·52	O.A.
158	2000	67·99	O.A.
159	3000	95·33	O.A.

*Pri 0-240V Sec 115 or 240V only. State sec volts required

CASED AUTO TRANSFORMERS
240V cable in 115V USA flat pin outlets

VA	Price	P & P	Ref
20	6·55	0.95	56W
75	8·50	1.20	64W
150	11·00	1.44	4W
250	13·39	1.44	69W
500	20·13	2.04	67W
1000	30.67	2.20	84W
2000	54.97	O.A.	95W

60 VOLT RANGE (Split Sec)
Pri 120/240V. Voltages available 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 or 24V-0-24V or 30V-0-30V.

Ref	Amps 60V	Amps 30V	Price	P&P
124	·5	1	4.27	1.20
126	1	2	6.50	1.20
127	2	4	8.36	1.60
125	3	6	12.10	1.72
123	4	8	13.77	1.96
40	5	10	17.42	1.84
120	6	12	19.87	2.04
121	8	16	27.92	O.A.
122	10	20	32.51	O.A.
189	12	24	37.47	O.A.

12 OR 24V OR 12-0-12V
Pri 220-240 volts

Ref	Amps 12V	Amps 24V	Price	P&P
111	0 5	0 25	2·42	0.95
213	1 0	0 5	2·90	1.00
71	2	1	3·86	1.00
18	4	2	4·46	1.20
85	0 5	2 5	6·16	1.20
70	6	3	6·99	1.20
108	8	4	8·16	1.44
72	10	5	8·93	1.60
116	12	6	9·89	1.60
17	16	8	11·79	1.72
115	20	10	15.87	1.84
187	30	15	19.72	2.04
226	60	30	40.41	O.A.

SCREENED MINIATURES

Ref	mA	Volts	£	P&P
238	200	3-0-3	2·83	0.50
212	1A, 1A	0-6, 0-6	3·14	1.00
13	100	9-0-9	2·35	0.50
235	330, 330	0-9, 0-9	2·19	0.60
207	500, 500	0-8-9, 0-8-9	3·05	0.95
208	1A, 1A	0-8-9, 0-8-9	3·88	1.20
236	200, 200	0-15, 0-15	2·19	0.60
214	300, 300	0-20, 0-20	3·08	1.00
221	700 (DC)	20-12-0-12-20	3·75	1.00
206	1A, 1A	0-15-20 (x2)	5.09	1.20
203	500, 500	0-15-27 (x2)	4.39	1.20
204	1A, 1A	0-15-27 (x2)	6.84	1.20
239	50	12-0-12	2·88	0.50
234	500	6-0-6	2·19	0·44

Send 20p stamps for Catalogue. Prices correct 21/4/81.

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Voltages available: 105, 115, 190, 200, 210, 220, 230, 240, for step up and step down.

Ref.	VA (Watts)	£	P&P
113*	15	2.73	1.00
64	80	4.41	1.20
4	150	5.89	1.20
53	350	10.00	1.44
67	500	12.09	1.84
84	1000	20.64	2.20
93	1500	25.61	O.A.
95	2000	38.31	O.A.
73	3000	65.13	O.A.
80S	4000	84.55	O.A.
57S	5000	98.45	O.A.

*0, 115, 220, 240.

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Clean mains to computers/peripherals
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15V CT Range (7.5V-0-7.5V)

Ref			P & P
171	500 mA	2·30	0.60
172	1A	3·26	1.00
173	2A	3·95	1.00
174	3A	4·13	1.20
175	4A*	6·30	1.20

96/48/36V RANGE
Pri 0-120/240V
Sec 2 windings 0-36-48V to give 36-0-36V or 48-0-48V or 72V or 96V.

Amps 72v/96v	Amps 36v/48v	Ref.	Price	P&P
1	2	431	8.12	1.44
2	4	432	13.35	1.22
3	6	433	16.17	1.96
4	8	434	20.65	2.04
5	10	435	29.30	2.20
6	12	436	36.69	O.A.
8	16	437	40.03	O.A.

Split Bobbin Type. Sec Voltages available 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30V, or 12-0-12V or 15-0-15V. 1 amp (09) £2.06 + 98p. PP 2 amp (10) £4.11 £1.10p PP + VAT.

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43mm · 43mm		82mm · 78mm	
0 50μA	6·20	0 50μA	7·37
0 500μA	6·20	0 500μA	7·37
0 1mA	6·20	0 1mA	7·37
0 30V	6·20	0 30V	7·37

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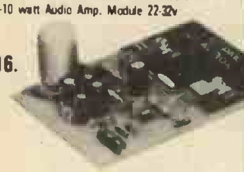
AUDIO AMPLIFIERS

5-10 watts (RMS)

AL20 5 watt Audio Amp Module 22-30v supply £3.57

AL30A 7-10 watt Audio Amp. Module 22-32v supply

£4.16.



AUDIO AMPLIFIERS

15-25-35 watts (RMS)

AL60 15-25 watt Audio Amp Module 30-50v supply £5.15.

AL80 35 watt Audio Amp Module £8.07

AUDIO AMPLIFIER

Audio Amplifier, 50W R.M.S., with integral heat sink and short circuit protection.

Introduced to fulfill the demand for a fully protected power amp., capable fo driving high quality speaker systems at up to 50w with distortion levels below .05%. Ideal for domestic use. Discos, P.A., systems, electronic organs, etc. The generously rated components ensure continuous operation at high output levels. AL120 50 watt Audio Amp Module 50-70v supply

£13.14.

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A power amplifier providing an output of up to 125w RMS, into a 4 ohm load. Four 115w transistors in the output stage makes it extremely rugged while damage from incorrect or short circuit loads is prevented by a four transistor protection circuit. For use in many applications such as disco units, sound re-inforcement systems, background music players etc.

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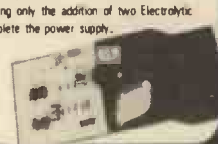

STEREO PRE-AMPLIFIERS

PA12 Supply voltage 22-32v input sensitivity 300mv Suit: AL10/AL20/AL30 £8.55. PA100 Supply voltage 30-55v inputs. Tape Tuner Mag P.U. Suit: AL60/AL80 £17.65. PA200 Supply voltage 35-70v inputs. Tape Tuner Mag P.U. Suit: AL80/AL120/AL250 £18.24.

The PA200 is basically our popular PA100, modifications being made to make it compatible with the higher output amplifiers i.e. AL120 & AL250. The unit boasts six push button selectors giving a choice of 3 inputs, 2 filters, for both high and low frequencies and a stereo or mono button, all combining to give a top quality stereo pre-amplifier and tone control.

COMPLETE AUDIO CHASSIS

STEREO 30 Complete 7 watt per channel Stereo amp board – includes amps, pre-amp, power supply, front panel knobs etc – requires 2039 Transformer £19.08.

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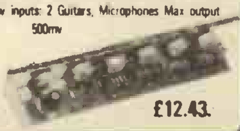
Enjoy the quality of a magnetic cartridge with your ceramic equipment using the MPA30 which is a quality pre-amp. enabling magnetic cartridges to be used where facilities exist for ceramic cartridges only. With a DIN input socket & full, easy to follow instructions. MPA30 Stereo Mag Cartridge, Pre-amp. – input 3.5mv Output 100mv £3.27.

MONO PRE-AMPLIFIERS

MM100 suitable for disco mixer. MM100G suitable for guitar pre-amp mixer.

The MM100 and MM100G mono pre-amplifiers are compatible with the AL60, AL80, AL120 and AL250 power amplifiers and their associated power supplies.

MM100 Supply voltage 40-65v inputs. Tape Mag P.U. Microphone Max output 500mv £12.43. MM100G Supply voltage 40-65v inputs: 2 Guitars, Microphones Max output 500mv



£12.43.

GE100 MKII

10 Channel Monographic Equaliser.

Only 155mm x 65mm x 50mm including the 10 x 10K 45mm slider potentiometers and knobs which are mounted on a board above the circuitry. In the range of 31Hz to 16KHz you can cut and boost ±12dB with the 10 sliders, each with frequency marked on the circuit board. The GE100 uses include mixers, P.A. systems and discos. It will also improve the sound reproduction of your existing audio equipment. Power supply for GE100 old SG30. Together with Transformer no: 2043.

GE100 MKII 10 Channel mono-graphic Equaliser with sliders & Knobs £20.00.

PUSH BUTTON STEREO FM TUNER

Fitted with Phase locked loop decoder

S453 Provides instant programme selection at the touch of a button ensuring accurate tuning of 4 pre-selected stations, any of which may be altered as often as you choose, simply by changing the settings of the preset controls. Features include FET input stage, Vari-cap diode tuning.

£19.00.

Transformers are not included with power supplies SPM120 Range also require reservoir and output capacitors

TRANSFORMERS

2034 1.7 amp 35v suit SPM80 £4.90. 2035 2 amp 55v £6.65. 2036 750mA 17v Suit PS12 £2.85. 2040 1.5 amp 0-45v-55v Suit SPM120/45 SPM120/55v £6.45. 2041 2 amp 0-55v-65v Suit SPM120/55 SPM120/65v £8.46. 2039 1 amp 0-20v Suit Stereo 30 £3.50. 2043 150mA 15-0-15v Suit SG30 £1.60.

ACCESSORIES

139 Teak Cabinet Suit Stereo 30 320 x 235 x 81mm £7.00. 140 Teak Cabinet Suit STA15 425 x 290 x 95mm £9.50. FP100 Front Panel for PA100 & PA200 £1.80. BP100 Back Panel for PA100 & PA200 £1.80. GE100FP Front Panel for one GE100MKII £1.75. TC60 Kit of Parts including Teak Cabinet chassis, sockets & knobs etc (to house STA15 Amplifier) £17.50. PS250 Consists – 1 capacitor & 4 diodes for constructing unstabilised power supply for AL250 to 125 watts £2.90.

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SIREN ALARM MODULE

American Police type screamer powered from any 12 volt supply into 4 or 8 ohm speaker. Ideal for car burglar alarm, freezer break down and other security purposes. BP124 5 watt 12v max – Siren Alarm Module £3.85.

BI-KITS

STA5 5 watts per channel Stereo Amplifier Kit consisting of 2 x AL20 amplifiers 1 x PA12 pre-amplifier 1 x PS12 power supply 1 x 2036 transformer and necessary wiring diagram £19.52. STA10 10 watts per channel Stereo Amplifier Kit consisting of 2 x AL30 amplifiers 1 x PA12 pre-amplifier 1 x PS12 power supply 1 x 2036 transformer and necessary wiring diagrams £20.63. STA15 15 watts per channel Stereo Amplifier Kit consisting of 2 x AL60 amplifiers 1 x PA100 pre-amplifier 1 x SPM80 power supply 1 x 2034 transformer 2 x coupling capacitors for 8 ohms 470 mfd 50v and necessary wiring diagrams £38.76. STA25 25 watts per channel Stereo Amplifier Kit consisting of 2 x AL60 amplifiers 1 x PA100 pre-amplifier 1 x SPM120/45 power supply 1 x 2040 transformer 2 x coupling capacitors for 8 ohms 470 mfd 45v 1 x reservoir capacitor 2200 mfd 100v and necessary wiring diagram £45.76. STA35 35 watts per channel Stereo Amplifier Kit consisting of 2 x AL80 amplifiers 1 x SPM120/55 power supply 1 x PA200 pre-amplifier 1 x 2035 transformer 2 x coupling capacitors 470 mfd at 50v for 8 ohms 1 x reservoir capacitor 2200 mfd 100v and necessary wiring diagram £45.76.

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Sinclair ZX81 Personal Comp
the heart of a system that grows with you.

1980 saw a genuine breakthrough – the Sinclair ZX80, world's first complete personal computer for under £100. Not surprisingly, over 50,000 were sold.

In March 1981, the Sinclair lead increased dramatically. For just £69.95 the Sinclair ZX81 offers even more advanced facilities at an even lower price. Initially, even we were surprised by the demand – over 50,000 in the first 3 months!

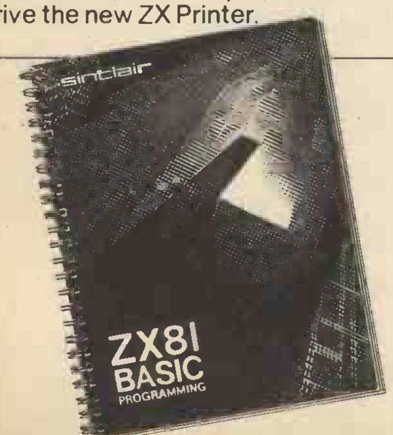
Today, the Sinclair ZX81 is the heart of a computer system. You can add 16-times more memory with the ZX RAM pack. The ZX Printer offers an unbeatable combination of performance and price. And the ZX Software library is growing every day.

Lower price: higher capability

With the ZX81, it's still very 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, *and* to drive the new ZX Printer.



New BASIC manual

Every ZX81 comes with a comprehensive, specially-written manual – a complete course in BASIC programming, from first principles to complex programs.

Kit: £49.95

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!

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.
- Advanced 4-chip design: micro-processor, ROM, RAM, plus master chip – unique, custom-built chip replacing 18 ZX80 chips.

Built: £69.95

Kit or built – it's up to you!

You'll be surprised 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.

ter-

Available now-the ZX Printer for only £49.95

Designed exclusively for use with the ZX81 (and ZX80 with 8K BASIC ROM), the printer offers full alpha-numerics *and* highly sophisticated graphics.

A special feature is COPY, which prints out exactly what is on the whole TV screen without the need for further intructions.

At last you can have a hard copy of your program listings – particularly useful when writing or editing programs.

And of course you can print out your results for permanent records or sending to a friend.

Printing speed is 50 characters per second, with 32 characters per line and 9 lines per vertical inch.

The ZX Printer connects to the rear of your computer – using a stackable connector so you *can* plug in a RAM pack as well. A roll of paper (65 ft long x 4 in wide) is supplied, along with full instructions.

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.

With the RAM pack, you can also run some of the more sophisticated ZX Software – the Business & Household management systems for example.

How to order your ZX81

BY PHONE – Access, Barclaycard or Trustcard 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, Barclaycard or Trustcard.
EITHER WAY – please allow up to 28 days for delivery. And there's a 14-day money-back option. 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.	18	**49.95**	
	Sinclair ZX Printer.	27	**49.95**	
	8K BASIC ROM to fit ZX80.	17	**19.95**	
	Post and Packing.			2.95

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sinclair ZX81

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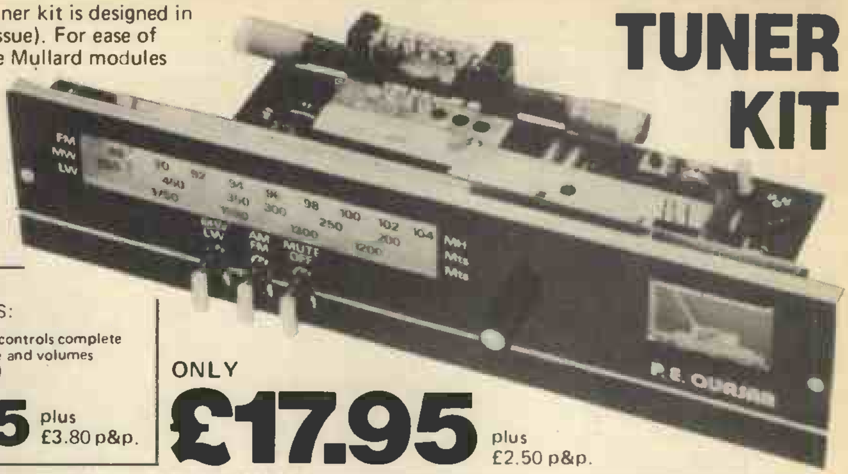
NEW

PRACTICAL ELECTRONICS - STEREO TUNER KIT

This easy to build 3 band stereo AM/FM tuner kit is designed in conjunction with Practical Electronics (July issue). For ease of construction and alignment it incorporates three Mullard modules and an I.C. IF. System.

FEATURES: VHF, MW, LW Bands, interstation muting and AFC on VHF. Tuning meter. Two back printed PCB's. Ready made chassis and scale. Aerial: AM - ferrite rod, FM - 75 or 300 ohms. Stabilised power supply with 'C' core mains transformer. All components supplied are to P.E. strict specification. Front scale size 10½"x 2½" approx. Complete with diagrams and instructions.

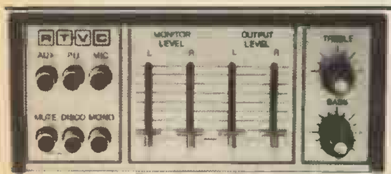


ONLY **£17.95** plus £2.50 p&p.

SPECIAL OFFER! TUNER KIT PLUS:

- Matching I.C. 10+10 Stereo Power amplifier kit (usually £3.95 + £1.15 p&p)
- Mullard LP1183 built preamp. suitable for ceramic and auxiliary inputs (usually £1.95 + 70p p&p)
- Matching power supply kit with transformer (usually £3.00 + £1.95 p&p)
- Matching set of 4 slider controls complete with knobs for bass, treble and volumes (usually £1.70 + 80p p&p)

£21.95 plus £3.80 p&p.



STEREO AMPLIFIER KIT

- Featuring latest SGS/ATES TDA 2006 10 watt output IC's with in-built thermal and short circuit protection.
- Mullard Stereo Preamplifier Module.
- Attractive black vinyl finish cabinet, 9"x8¼"x3¾"(approx)
- 10+10 Stereo converts to a 20 watt Disco amplifier.

To complete you just supply connecting wire and solder. Features include din input sockets for ceramic cartridge, microphone, tape or tuner. Outputs - tape, speakers and headphones. By the press of a button it transforms into a 20 watt mono disco amplifier with twin deck mixing. The kit incorporates a Mullard LP1183 pre-amp module, plus power amp assembly kit and mains power supply. Also features 4 slider level controls, rotary bass and treble controls and 6 push button switches. Silver finish fascia with matching knobs and contrasting cabinet. Instructions available, price 50p. Supplied FREE with the kit.

£14.95 Plus £2.90 p&p.

SPECIFICATIONS:	Suitable for 4 to 8 ohm speakers.
Frequency response	40Hz - 20KHz.
Input sensitivity	P.U. 150mV. Aux. 200mV. Mic. 1.5mV.
Tone controls	Bass ±12db @ 60Hz Treble ±12db @ 10KHz
Distortion	0.1% typically @ 8 watts
Mains supply	220 - 250 volts 50Hz.

STEREO MAGNETIC PRE-AMP CONVERSION KIT Includes FREE Magnetic cartridge with diamond styli. All components including p.c.b. to convert your ceramic input on the 10+10 to magnetic. Only available with 10+10 amp. £2.00 includes p&p.

8" SPEAKER KIT Two 8" twin cone domestic speakers. £4.75 per stereo pair plus £1.70 p&p. when purchased with amplifier. Available separately £6.75 plus £1.70 p&p.

PRACTICAL ELECTRONICS CAR RADIO KIT SERIES II

2 WAVE BAND MW -- LW

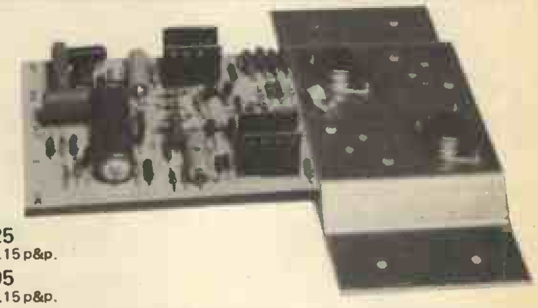
- Easy to build
- 5 push button tuning
- Modern design
- 6 watt output
- Ready etched and punched PCB
- Incorporates suppression circuits.

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

£10.50 Plus £2.00 p&p.

Suitable stainless steel fully retractable aerial (locking) and speaker (6"x 4"app.). available as a kit complete. £1.95/pack. Plus £1.15 p&p.

HIGH POWER AMPLIFIER MODULES



READY BUILT OR IN KIT FORM

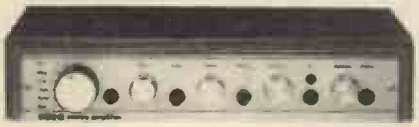
	KIT	BUILT
125 WATT MODEL	£10.50 Plus £1.15 p&p	£14.25 Plus £1.15 p&p.
200 WATT MODEL	£14.95 Plus £1.15 p&p	£18.95 Plus £1.15 p&p.

SPECIFICATIONS:	125 W Model	200 W Model
Max. output power (RMS)	125 watts	200 watts
Operating voltage (DC)	50 - 80 max.	70 - 95 max.
Loads	4 - 16 ohms	4 - 16 ohms
Frequency response measured @ 100 watts	25Hz - 20KHz	25Hz - 20KHz
Sensitivity for 100 watts	400mV @ 47K	400mV @ 47K
Typical T.H.D. @ 50 watts, 4 ohms	0.1%	0.1%
Dimensions (both models)	205 x 90 and 190 x 36mm.	

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

ACCESSORIES:

Suitable LS coupling electrolytic for 125W model	£1.00 plus 25p p&p.
Suitable LS coupling electrolytic for 200W model	£1.25 plus 25p p&p.
Suitable mains power supply unit for 125W model	£7.50 plus £3.15 p&p.
Suitable Twin transformer power supply for 200W model	£13.95 plus £4.00 p&p.



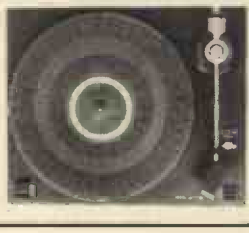
30+30 WATT STEREO AMPLIFIER

Viscount IV unit in teak simulate cabinet, silver finished rotary controls and pushbuttons with matching fascia, mains indicator and stereo jack socket. Functions switch for mic magnetic and crystal pickups, tape and auxiliary. Rear panel features fuse holder. DIN speaker and input socket 30+30 watts RMS, 60+60 watts peak. For use with 4 to 8 ohm speakers. Size 14¾"x10" approx. **BUILT AND TESTED.**

£32.90 Plus £3.80 p&p.

PHILIPS BELT DRIVE RECORD PLAYER DECK GC037 (Size: 15¼"x 12¼"approx.)

HiFi record player deck, 2 speed, damped cueing, auto shut-off, belt drive with floating sub chassis to minimise acoustic feedback. Complete with GP401 stereo magnetic cartridge



LIMITED STOCK.

UNBEATABLE OFFER AT **£27.50** COMPLETE Plus £3.16 p&p.

MONO MIXER AMPLIFIERS

50 WATT Six individually mixed inputs for two pick ups (Cer. or Mag.), two moving coil microphones and two auxiliary for tape, tuner, organs, etc. Eight slider controls - six for level and two for master bass and treble, four extra treble controls for mic and aux inputs. Size: 13¼"x6½"x3¾"app. Power output 50 watts R.M.S. (continuous) for use with 4 to 8 ohm speakers. Attractive black vinyl case with matching fascia and knobs. Ready to use.

£39.95 Plus £3.70 p&p.

100 WATT Brushed Aluminium fascia and rotary controls. Size: approx. 14"x4"x10¾".

Five vertical slider controls, master volume, tape level, mic level, deck level, PLUS INTERDECK FADER for perfect graduated change from record deck No. 1 to No. 2, or vice versa. Pre fade level controls (PFL) lets YOU hear the next disc before fading it in. VU meter monitors output. 100w RMS output (200w peak).

£76.00 Plus £4.60 p&p.

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PE VOLUME 17 No. 12 DECEMBER 1981

THE CB INDUSTRY

By the time this is published the UK will have its very own CB band. It is, of course, quite impossible for us to foresee just how things will turn out and just how useful the band will be. What is perhaps significent at this time is the lack of British made rigs. Although manufacturers are expecting to sell many tens of thousands of rigs each, before Christmas, almost without exception all the 27MHz rigs will be imported. The exception is of course our own *PE Ranger 27FM* designed for PE by Mike Tooley and David Whitfield and for which Autumn Products (Modus Systems) are the appointed kit supplier; Autumn are now also manufacturing PE Rangers.

There are a number of obvious reasons why British manufacturers are unable to build competitively priced rigs in the UK but one restriction, that is not so well known outside the industry, is that import duty has to be paid on components but is not levied on complete equipment. However, it is very pleasing to note that at least two UK manufacturers are proposing to make rigs for the 934MHz band. This shows that UK companies can be competitive on products where the market is smaller and where the retail unit cost is higher, giving more flexibility on profit margins.

Some of the bigger companies are claiming that they will totally dominate the UK CB market but we doubt that this will happen within the first year, if ever. There are many manufacturers investing large amounts and none of them will be prepared to back out quickly.

QUALITY

What we must also wait and see is the technical quality of the products. Because it was first, and a kit, the PE Ranger has attracted much attention on its ability to meet the Home Office specification and of course our designers have been fully aware of this; hence the additional information in the article this month. What we will soon know is just how much attention manufacturers have paid to ensuring all their rigs meet the Home Office performance specification.

We also await with interest the fate of those who continue to use illegal a.m. or a.m./f.m. CB rigs; it is rumoured that the radio regulatory department are planning to clamp down heavily on illegal use. This would seem sensible as they have been avoiding the protests on interference by advising injured parties that everything will change when the legal system is introduced; it certainly won't unless they prevent the continued use of a.m. equipment.

NEWS

No doubt many readers will be looking for their first rig, be it for 27 or 934MHz; with this in mind we are putting together a four page guide to available legal rigs, which will be published as a pull-out next month. Once again this does not mean PE will be going over to CB, but the new rigs are news and we hope the pull-out will interest most readers.

As we mentioned in *News and Market Place* last month, the PE Ranger was shown on TV and the *PE Bandbox* has also attracted media interest, being put through its paces for many radio programmes by the designer Alan Boothman.

Mike Kenward

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Technical Queries

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.

Subscriptions

Copies of PE are available by post, inland or overseas, for £13·00 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

BBC: 'far from disappointed'

Following our headline in the October issue of News and Market Place concerning the BBC disappointment over the response to their Electronics and Microelectronics School Radio Course we were very pleased to hear from Mr Arthur Vialls, the producer of School Broadcasting Radio.

Mr Vialls tells us that since our headline the response has been overwhelming with the teachers' notes (supplied on the basis of one set per applicant) now in their third reprint and to date 2500 copies have been dispatched. This means that the penetration into the secondary school market has been between 30 and 40 per cent.

Orders for the kits which accompany the programmes are now coming in at the rate of 60 a day and with the film strips also having to be reprinted it would appear that many schools have taken up the challenge.

Full details of how to obtain the kits and film strips are included in the teachers' notes which are available from Electronics and Microelectronics BBC School Radio, 1 Portland Place, London W1A 1AA on receipt of a s.a.e. with a 20p stamp.

ULTIMATE TIMER...

The CT5000 from TK Electronics is a timer kit which has 18 programmable time sets and 4 independent 2A mains outputs with zero voltage switching.

The 12hr 0·5in display will give day of the week, a.m./p.m. and output status indication. A battery back-up facility saves stored programmes and continues time keeping during power failures.

The unit is programmed by a 20 function keypad which includes programme verification button.

The timer kit is priced at £45·00 plus VAT and is available from TK Electronics, 11 Boston Road, London W7 3SJ (01-579 9794).

SOLAR CAMERA

The Ricoh camera company have recently announced the XR-S Solar powered camera which utilises two solar panels containing 20 solar cells mounted on each side of the pentaprism housing. These solar cells extend the life of a 31V silver oxide battery developed by Ricoh, for an estimated five years.

When first shown at Photokina '80, it was questioned as to whether it would need to be exposed to sunlight to charge the camera's battery, however, it can be effectively charged under white light as well as sunlight and if the light level is too low for the solar cells to operate the battery will work for up to four hours when fully charged.

CHEAP TWEET!

Any reader who is planning to build a pair of speaker units or update old speakers will be interested to learn that RT-VC are offering Goodmans soft-dome tweeters (shown below) at a very competitive price. The tweeters can be used in systems handling up to 40 watts and are priced at £3·50 each plus £1·75 p&p, or £5·95 per pair plus £2·40 p&p. Filter components are included in the prices. RT-VC, 21b High Street, Acton, London W3 6NG.

POINTS ARISING . . .

INGENUITY UNLIMITED (Nov. '81)

In the circuit diagram of the 0-99s photographic timer, the centre tap of the mains transformer is shown connected to the positive supply rail. It should be connected to the negative.

HOROLOGICUM (Oct. '81)

There is an error in Table 1, the MM5309 pin-outs. The pin-out functions of 15–28 should be reversed. I.e. Pin 15—Positive Supply and Pin 28—Display Enable.

Also, on page 22, column 2, 4th line from bottom should read: 1MHz instead of 1·03MHz.

MICROPROMPT (July '81)

Line 60 in Noel Caffrey's "HECDEC" program should read: S$ = MID$ (A$, I, 1) etc.,

MARKET PLACE

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

Briefly...

Bernard Babani, publishers of technical books on most subjects in the field of electronics inform us that their 1982 catalogue is now available. The 32 page catalogue lists books for both beginners and those with a wide knowledge of the subject. It is available free to readers who send a large s.a.e. to: Bernard Babani (Publishing) Ltd,, The Grampians, Shepherds Bush Road, London W6 7NF. (01-603 2581).

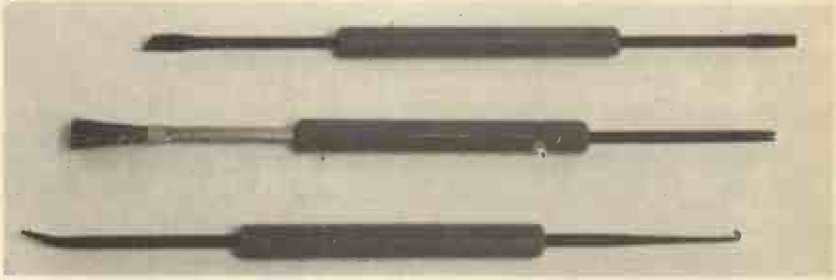
● ● ● ●

The business of A. Marshall (London) Ltd. at 40 Cricklewood Broadway, London NW2 has now changed hands and will be trading in the future as Cricklewood Electronics Ltd. Customers are invited to phone 01-452 0161 for details of stock and prices as a catalogue has yet to be printed. A. Marshall continue to trade from Kingsgate House and Edgware Road.

● ● ● ●

The latest 64 page Bi-Pak catalogue is now available from Bi-Pak Semiconductors, The Maltings, 63A High Street, Ware, Herts., on receipt of £1·00 including p&p.

PCB SERVICE AIDS



New from Tele-Production Tools are six aids specially designed for use on printed circuit boards. The set comprises three double ended tools which includes a stainless steel brush for removing resin and oxidization etc. from p.c.b.s, a fork for forming component leads and wire wrapping, a knife for cutting tracks and a scraper for cleaning leads. Also included is a hook for removing components after de-soldering and a reamer for opening p.c.b. holes.

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A product sheet with prices is available on request. L&B Electronic, 45 Wortley Road, West Croydon, Surrey. Tel: 01-689 4138.

Countdown...

Please check dates before setting out, as we cannot *guarantee* the accuracy of the information presented below.

IFSEC (Fire & Sec.) Nov. 17–19. RDS Dublin. **V**
Compec Nov. 17–20. Olympia London. **Z1**
BEX Plymouth Nov. 18–19. Holiday Inn. **K**
Intron Nov. 24–26. RDS Dublin. **V**
Continuous events at Nat. Micro & Elect. Centre. L1

1982

IDEA (Domestic appliances) Jan. 12–14. Birmingham. **B6**
OEM Assemblies Feb. 2–4. Royal Hort. Halls London. **T**
BEX Bristol Feb. 3–4. **K**
BEX Bournemouth Feb. 17–18. **K**
Microsystems Feb. 24–26. West Centre Hotel London. **Z1**
Seminex Mar. 29–Apr. 2. Imperial College London. **H1**

B6 Andry Montgomery Ltd. ✆ 01-486 1951
E Evan Steadman, Saffron Walden ✆ 0799 22612
H1 Seminex Ltd., Tunbridge Wells ✆ 0892 39664
K Douglas Temple, Bournemouth ✆ 0202 20533
L1 World Trade Centre ✆ 01-488 2400
T Trident, Tavistock ✆ 0822 4671
V SDL ✆ Dublin 763871
Z1 IPC Exhibitions, Sutton ✆ 01-643 8040

INDUSTRY NOTEBOOK

By Nexus

Pioneers

Viewed in the context of the general economic climate, electronics has enjoyed a remarkable year. But 1981 also saw the passing of two pioneers who in different ways furthered the growth of the industry.

P. A. G. H. Voigt did as much as any one man could to popularise the concept of high-fidelity sound reproduction in the 1930s. The Voigt corner horn loudspeaker system was an outstanding achievement and was not only uncanny in its sound realism but had remarkable acoustic efficiency. So much so that at a Radiolympia exhibition of the period, when each exhibitor was allowed 100 milliwatts of audio from a central amplifier, the sound volume from Paul Voigt's exhibit was so markedly louder that neighbouring stands complained he must be cheating. In fact for domestic use only three watts, obtained from a single triode output valve, was more than enough to deafen the listener.

Of course the Voigt corner horn would hardly do in today's small box-like rooms. It was designed in and for a more spacious age. The speaker itself was a massive unit with a huge electromagnet which was powered from the a.c. supply. And there was a heavy concrete block at the base of the horn unit. He also developed a moving coil pick-up, probably the first ever, which gave us, even with those old 78r.p.m. discs, a glimpse of future fidelity yet to come.

Paul Voigt emigrated to Canada in 1950 where he died earlier this year at the age of 80. He started his career in audio in 1922 and retired in 1970.

Dr Trevor Lloyd Wadley, a South African scientist and inventor, died in Natal at the early age of 61. It was he who came to England in the early 1950s canvassing a new idea for a very stable communications receiver. He visited all the major companies and was told it was too complicated to manufacture. Scraping the bottom of the barrel he was introduced to a tiny company, almost a back-street concern, who not only showed interest but bought the licence to manufacture. The company was Racal Engineering and the end result was the world-beating RA 17 communications receiver incorporating the principle of the Wadley-Loop drift-cancelling circuit.

The rest is history. The RA 17 was the breakthrough for the company which we now know as the Racal Electronics Group. But Dr Wadley did more than help put Racal on the ladder to success. He also invented the Tellurometer, a radio-based distance measuring system for survey work. Unlike the Wadley Loop which has now been superseded by frequency synthesis, the Tellurometer is still in production and has earned a great deal of money over the years for Plessey, the British licensee.

Wadley and Voigt both left their mark in the history of electronics. Their passing, one in South Africa, the other in Canada, reminds us that electronics as an applied science knows no boundaries and grows inexorably through cross-fertilisation of brilliant minds.

Neston

Nothing more clearly showed up the chaotic structural state of British trade unionism than the establishment of Marconi's new factory at Neston. Looking at industries like printing and automobile manufacture in which a multiplicity of separate, often competing, unions are involved, with consequent demarcation disputes and frequent walk-outs, it seems sensible to have all workers in a plant in a common union.

In the case of Neston, which manufactures torpedoes calling for a variety of engineering disciplines, the workers could not agree that any single existing union could adequately represent the totality of the workforce.

So, by popular vote, there will be no union at all. Instead a works council of workers and management.

This simple, almost obvious, solution has been described as a new shop-floor industrial revolution. Or is it plain common sense opting for concord rather than discord? This happened before Marconi was awarded, subject to price negotiations, the contract for the heavyweight torpedo for the Royal Navy said to be worth £500 million.

Mercifully, the electronics industry has always escaped the worst excesses of industrial relations. Of course it has every advantage. Continued growth generates none of the bitterness of workers in stagnating or declining industries. A forced redundancy in electronics is not automatic relegation to the 'scrap heap'. Unlike static industries such as ship building or mining it is not geographically limited and mobility is accepted as natural by the ambitious either through promotion within a company or change of employer.

In short, there is none of the rigidity of the older industries. And there are almost daily start-ups by small entrepreneurial teams, fired by enthusiasm and who constantly refresh the industry while, at the same time, the pace of technological advance maintains interest and presents ever-new challenges. The industrial climate of electronics enjoying rude health encourages constructive co-operation towards further success and this contagious enthusiasm appears to work at all levels.

Expansion

1982 already looks a bumper year for expansion. Plessey, whose first quarter results suggest £100 million pretax profit in the year ahead, are to build a new Telecommunications Engineering Centre on their site at Edge Lane, Liverpool. Six storeys high, it will accommodate 700 engineering personnel and will cost £2·5 million. The production plant is also to receive investment in redesign and new equipment to fit it to changing technology. All this confirms Plessey commitment to Merseyside. As a quid pro quo the workforce of some 4,000 is being asked to accept what Plessey describes as 'major changes in working practices and productivity'.

Then there's Mitel who, before their 100,000sq. ft plant at Caldicot, South Wales, was completed, have already decided to triple the size and could be employing 2,000 people by the end of next year. Mitel will be making ICs and thick film microcircuits as well as assembling PABX microprocessor controlled telephone exchanges one of which, re-engineered to UK standards, is being promoted by British Telecom under the name Regent.

Systime, making microcomputers on a site on the outskirts of Leeds, has a planned £46 million investment which initially should create some 450 jobs with further phases over three years taking the total up to a possible 1,000.

These investments top up Motorola's £60m, NEC's £40 million and H-P's £12 million mentioned in this column last month. Not a bad score in just two months and reflecting confidence in the future.

Exports, too, remain lively. Marconi Marine, in a depressed shipping market, are to provide all the communications equipment for eight deep sea cargo vessels for Pakistan being built at the Gdansk yards in Poland. And Thorn Consumer Electronics has won a £2 million order for Ferguson TX colour TV kits for assembly in Greece. Cable & Wireless has also been active in Greece, winning a £4 million contract for communications equipment.

The defence market continues buoyant both at home and overseas. Thus we note an order for £2·5 million worth of electronic warfare equipment from the Argentine Navy for Racal-Decca Defence Systems, while sister company Racal-Decca Marine Radar has contracted for £0·5 million worth of radar to the Swedish Navy. And Racal-Decca Survey has a £5 million order from the Royal Navy for electronic positioning systems for mine-hunting operations.

In avionics, companies such as Plessey, Ferranti and Smiths should have a good share in the big British Aerospace/McDonnell Douglas deal for the Anglo-US AV-8B advanced Harrier jump-jet which in total could top £1 billion over five years. Good news, too, from British Aerospace in its first year of de-nationalisation achieving record turnover and profits.

SPACE EVADERS

Tom Gaskell B.A.(HONS)ELEC.ENG.

THE problem with many small self-contained electronic games is that they are too easily beaten, or their interest and entertainment value seems to diminish rather rapidly after an initial enthusiasm! Computer based games gain in sophistication, but are often too large, complex or expensive to be a realistic proposition. However, in between these two extremes comes SPACE EVADERS! Simple enough to be built with standard CMOS logic devices in a small portable case, but difficult and frustrating enough when played to keep you occupied for hours.

As in the case of many other 'Space games', EVADERS is a battle between alien and human, the latter using missiles to defend himself against the former. The alien flies along from left to right, over and over again, dipping downwards towards the missile base on each pass. The missile is launched initially from a position very close to the alien's path. After launching, the missile moves slowly upwards with a 'bleep' noise. If it hits the alien, there is an explosion sound effect, and the missile jumps back one position, i.e. one step further away from the alien. 'Hitting' is achieved by having the missile arrive in the way of the alien's flight path just as the alien gets there. If the missile misses, it returns to its previous starting position. Gradually, as more and more hits are scored on the alien, the missile moves further away from the alien's path until a successful hit from the most distant missile base wins the game; the alien stops dead and a dull drone can be heard. The number of missiles fired is counted and displayed on a numerical readout in order that scores can be readily compared.

DIFFICULTIES!

On every fourth pass of the alien over the missile base it drops a bomb (which makes a 'dull bleep' sound) on the missile. This terminates any missile attack that is currently under way, and moves the missile one position back towards the alien flight path, i.e. away from that final winning position! The alien and missile speeds are independently adjustable; the missile normally travels fairly slowly, so the game becomes more difficult the further its starting position is from the alien. As if that wasn't enough, the really nasty part of the game, and the reason why it's a space EVADER, is that the alien doesn't fly at a constant rate, but at random! There is a subtle amount of speeding up and slowing down (even stopping dead sometimes) from the normal set speed. Hence the 'frustration' aspect of the game, because just as a missile is right on course for him, he can jump past it, or even stop in his tracks, and it misses again!

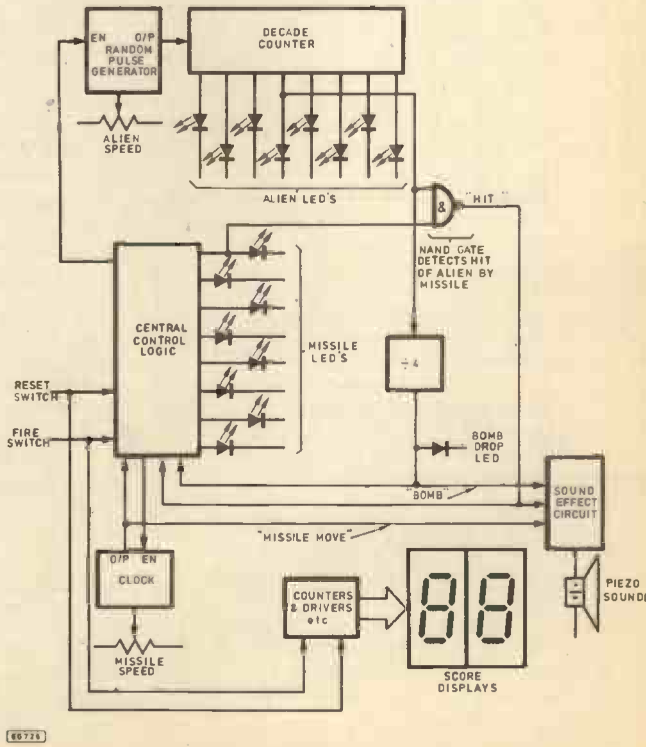

Fig. 1. Block diagram

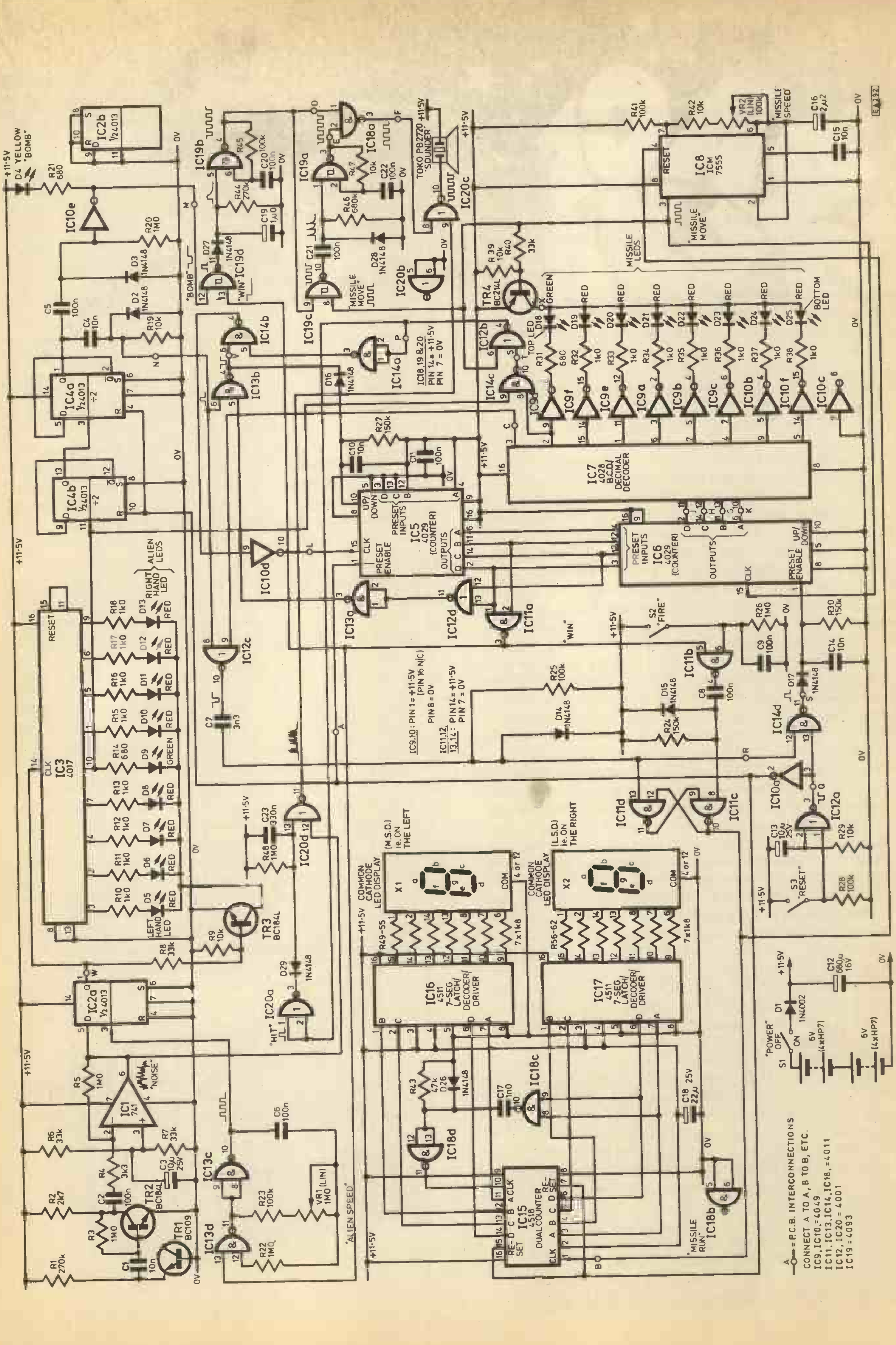

Fig. 2. Complete circuit diagram

Two 7-segment l.e.d. displays show the score, with the alien and missiles being indicated by discrete l.e.d.s; mostly red, but with the centre alien and top missile l.e.d.s being green. (These are the ones that must be lit together at the same time to score a hit.) The design principles for this project have or will be covered in our Digital Design Techniques series, so for greater detail on the design of the circuitry refer to these articles. However, we can look now at the design of the circuit in fairly general terms, with the assistance of the block diagram shown in Fig. 1 and the circuit diagram shown in Fig. 2.

CIRCUIT DESCRIPTION

The circuitry can be divided up into three different areas: the control circuit, the scoring circuit, and the sound effects circuit. Let's start by considering the control circuit, as this comprises the main part of the project.

The alien's path is indicated by a row of l.e.d.s, D5 to D13, which are lit sequentially by IC3, a decade counter which is connected to reset itself at the end of each sequence. Hence, the l.e.d.s give the impression of a continuously moving light. The common cathodes of the l.e.d.s are taken to 0 volts via TR3, which is turned on and off by the clock input signal to IC3. Each l.e.d. is turned on for a short period, then off again, and then a short time elapses before the next l.e.d. lights, giving the impression of the alien 'jumping along'.

TR1, TR2 and IC1 form a random noise generator, fully described in this month's Digital Design Techniques. The random noise signal feeds the 'D' input of D-type flip-flop IC2a, which is clocked by the very low frequency oscillator formed by IC13c and IC13d. At every positive clock transition the logic state of the random noise signal is fed to the Q output, and depending on its state the Q output may, or may not, change state. Because the Q output clocks IC3, this gives the pseudo-randomness to the alien l.e.d. movement. Some control of the alien's speed can be given by VR1 (setting the oscillator frequency), since this determines the rate at which the random noise is sampled.

The illumination of the missile l.e.d.s is considerably more complicated than of the alien's! Basically, they are controlled by IC6, an up/down presettable binary counter, which has its binary outputs decoded into decimal by IC7, and then uses the inverter drivers of IC9 and IC10 to sink current from, and illuminate, the l.e.d.s. IC6 is clocked by IC8 a 7555 CMOS timer connected as a very low frequency oscillator, with frequency controlled by VR2. At each clock pulse of IC8, the counter IC6 (which is hard wired to always count DOWN) counts down by one, and hence illuminates the l.e.d.s in the sequence, one at a time. Note that the highest count corresponds to D25, i.e. the lowest l.e.d. in the missile chain. So, as the counter counts down, the missile appears to move upwards towards the alien l.e.d.s. TR4 gates the l.e.d.s on and off in a similar way to TR3 and the alien l.e.d.s. This not only gives the impression of jumping of the l.e.d., but also (more importantly) makes it much more difficult to hit the alien!

The alien is 'hit' when output pin 10 of IC3 (the alien's green l.e.d.) is at logic 1 at the same time as D18 is lit (the missile's green l.e.d.). This condition is detected by IC14c, the output of which is then enabled by IC12b from IC8; this ensures that the alien can only be hit when the missile l.e.d. is actually illuminated. The output of IC12b is inverted, then passes through IC14b and is inverted again by IC10d (we'll look at the action of IC14b pin 6 later), which provides the clock to IC5, another presettable up/down counter. IC5 is used to determine the starting position for the missile which, of course, advances by one for every alien hit, but decreases by one for every bomb dropped. For the moment let's assume that the up/down control pin 10 is at logic 1 (i.e. count up) and hence as soon as an alien is hit, IC5 counts up by one. The outputs of IC5 feed into the preset inputs of IC6, and the IC6 ouputs are forced to this preset condition when the missile 'run' is completed; IC7 pin 3 (the last decoded output of IC6) goes to logic 1, which feeds via IC12c to the pulse deriving network of C7, D14 and R25, then via IC14d to the pulse stretching network of D17, C14 and R30, and then to the preset enable pin 1 of IC6. So, when the missile has finished moving towards the alien, it moves to a position determined by IC5. For every alien hit the IC5 count increases by one, so each time the missile hits the alien it jumps back one position before starting its next run.

A missile is fired at the alien by pressing S2, a simple push-to-make switch, contact de-bounced by R26 and C9. This logic signal passes to the pulse deriving network of R24, D15 and C8 via IC11b, and then to the cross-coupled latch (or 'bistable') formed by IC11c and IC11d. This causes IC11c pin 10 to go to logic 1, forcing IC8 pin 4 (the reset pin) to go high, which enables IC8 and allows the missile to start 'moving'. As mentioned above, at the end of the missile's run IC7 pin 3 goes to logic 1 which then passes via IC12c to the pulse deriving network of C7, D14 and R25. This causes the latch to be set into the opposite state, i.e. IC11 pin 10 goes to logic 0, which resets IC8 and stops the missile from moving forwards towards the alien.

THE BOMB

At every fourth pass of the alien over the missile base it drops the bomb. IC3 pin 10 is the output which is at logic 1 when the alien is in its central position, so this is passed through IC4b and IC4a, both connected as divide-by-two circuits. Hence, pin 1 of IC4a goes to logic 1 for every four output pulses from IC3 pin 10. C5, D3 and R20 form a pulse deriving network to illuminate the bomb l.e.d., D4, via IC10e and R21. C4, R19 and D2 form a similar network with a much shorter time period, the pulse from which passes to IC12c and IC13b. Via IC12c it stops the missile and presets IC6 in exactly the same way as IC7 pin 3 going to logic 1 does. Via IC13b it passes to IC14b, IC10d and then to the clock of IC5 in the same way as a 'hit signal' does. Also, it causes the up/down control to IC5 (pin 10) to go to logic 0 via the pulse stretching network of D16, C10 and R27. Since the pulse derived by C4, R19 and D2 is much shorter in duration than the pulse stretched period of D16, C10 and R27, the up/down control is still at logic 0 (count down) when the clock input goes back to logic 1, so IC5 counts DOWN by one, moving the missile one position nearer the alien because of the preset enable pulse applied to IC6. Note that these timing delays have to be introduced between the up/down control and the clock to avoid hazards being

COMPONENTS . . .

Resistors

R1, R44	270k (2 off)
R2	2k7
R3, R5, R20, R22, R26, R48	1M0 (6 off)
R4	3k3
R6, R7, R8, R40	33k (4 off)
R9, R19, R29, R39, R42, R47	10k (6 off)
R10, R11, R12, R13, R15, R16, R17, R18, R32, R33, R34, R35, R36, R37, R38	1k0 (15 off)
R14, R21, R31	680 (3 off)
R23, R25, R28, R41, R45	100k (5 off)
R24, R27, R30	150k (3 off)
R43	47k
R46	680k
R49, R50, R51, R52, R53, R54, R55, R56, R57, R58, R59, R60, R61, R62	1k8 (14 off)

All resistors $\frac{1}{3}$ or $\frac{1}{4}$ watt 5% carbon

Potentiometers

VR1	1M0 lin
VR2	100k lin

Capacitors

C1, C4, C10, C14, C15	10n polyester (5 off)
C2, C5, C6, C8, C9, C20, C21, C22	100n polyester (8 off)
C3, C13	10µ 25V electrolytic (2 off)
C7	3n3 ceramic
C11	100n 30V disc ceramic
C12	680µ 16V electrolytic
C16	2µ2 35V tantalum bead
C17	1n ceramic
C18	22µ 25V electrolytic
C19	1µ 35V tantalum bead
C23	330n polyester

Semiconductors

D1	1N4002
D2, D3, D14, D15, D16, D17, D26, D27, D28, D29	1N4148 (10 off)
D4	yellow l.e.d. (0·125in)
D5, D6, D7, D8, D10, D11, D12, D13, D19, D20, D21, D22, D23, D24, D25	red l.e.d. (0·125in) (15 off)
D9, D18	green l.e.d. (0·125in) (2 off)
Displays X1, X2	common cathode red l.e.d. 7-segment display (2 off) 0·3in Maplin type 4 (FR38R)
TR1	BC109
TR2, TR3	BC184L (2 off)
TR4	BC214L
IC1	741 (8 pin)
IC2, IC4	4013 CMOS dual D-type flip-flop (2 off)
IC3	4017 CMOS decade counter
IC5, IC6	4029 CMOS presettable binaryup/downcounter(2 off)
IC7	4028 CMOS BCD to decimal decoder
IC8	ICM 7555 CMOS timer
IC9, IC10	4049 CMOS HEX inverter/ buffer (2 off)
IC11, IC13, IC14, IC18	4011 CMOS quad NAND gate (4 off)
IC12, IC20	4001 CMOS quad NOR gate (2 off)
IC15	4518 CMOS dual BCD counter
IC16, IC17	4511 CMOS 7-segment latch/ decoder/driver (2 off)
IC19	4093 CMOS quad Schmitt NAND gate

Miscellaneous

1 off TOKO PB 2720 PIEZO SOUNDER (available from AMBIT)
1 off each p.c.b.
S1—Double pole miniature toggle switch
S2, S3—Momentary pushbutton switches (2 off)
2 off battery holders with connecting leads (each 4 × HPT)
1 off Global Specialties 'DESIGN MATE' case DMC—1
1 piece of red tinted gelatine or perspex (see text)
2 off suitable knobs for the two potentiometers, mounting pillars, screws, etc., for the p.c.b.s.
(6BA threaded pillars are suggested)
Sticky fixers.

created; this was covered extensively in this month's Digital Design Techniques article.

If the missile is already at the nearest starting position it can get to the alien (D19 is lit) then we don't want to move it at all when a bomb is dropped. IC12d detects this condition, which corresponds to a binary count of 0011. The output of IC12d is inverted, and then disables IC13b, preventing any counting down of IC5.

WINNING AND RESETTING

When you've finally moved the missile to its bottom l.e.d. position, D25, and then subsequently hit the alien from this position, the game is won. The output of IC5 becomes binary number 1010, which is detected by IC11a. The output of IC11a disables the "FIRE" switch S2 via IC11b and stops the alien by disabling the oscillator formed by IC13d and IC13c.

Power-on reset is provided by C13, R29 and IC12a. Manual reset, via S3, can also be applied in the same way. The reset pulse out of IC12a pin 3 is inverted by IC10a and used to reset the two flip-flops of IC4, and to preset enable IC5, the preset inputs of which are connected to give a binary count of 0011; this corresponds to the missile l.e.d. D19 being lit, and is the starting condition for the game. The reset pulse also passes through IC14d and the pulse stretching network, then to the preset enable pin of IC6, and hence the whole system is set up to start a new game.

SCORING

The scoring circuit comprises the two 7-segment displays, IC15, IC16, IC17, IC18c and IC18d. IC15 is a dual BCD counter, with asynchronous cascading between the two halves being arranged by detecting the 1001 output of the first counter (i.e. the number 9) with IC18c, then when this count changes to 1010, pin 10 of IC18c goes back to logic 1, so via the pulse deriving network of C17, D26 and R43 and inverter IC18d, this is used to clock the second counter which is arranged to trigger a negative edge. IC16 and IC17 are 7-segment latch/decoder/drivers, although in this application the latching facility is not used. The BCD inputs are

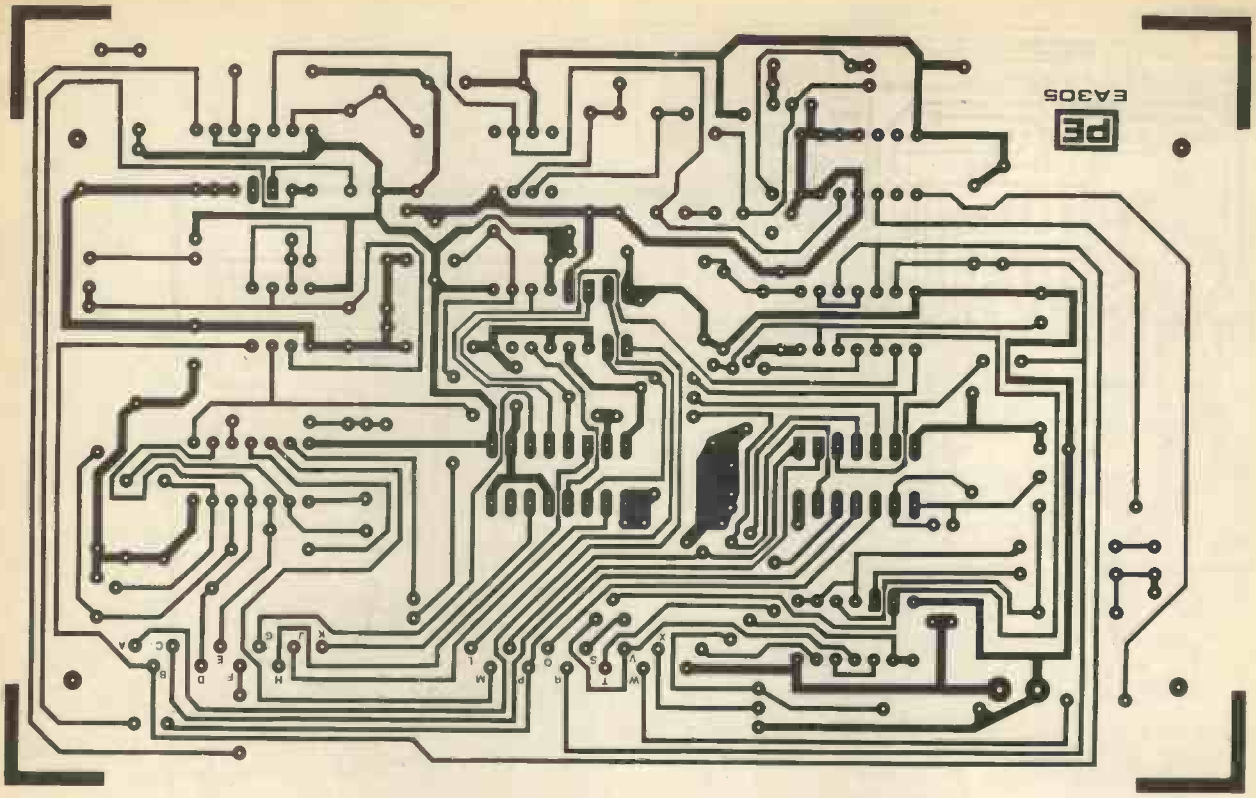

Fig. 3. P.c.b. design

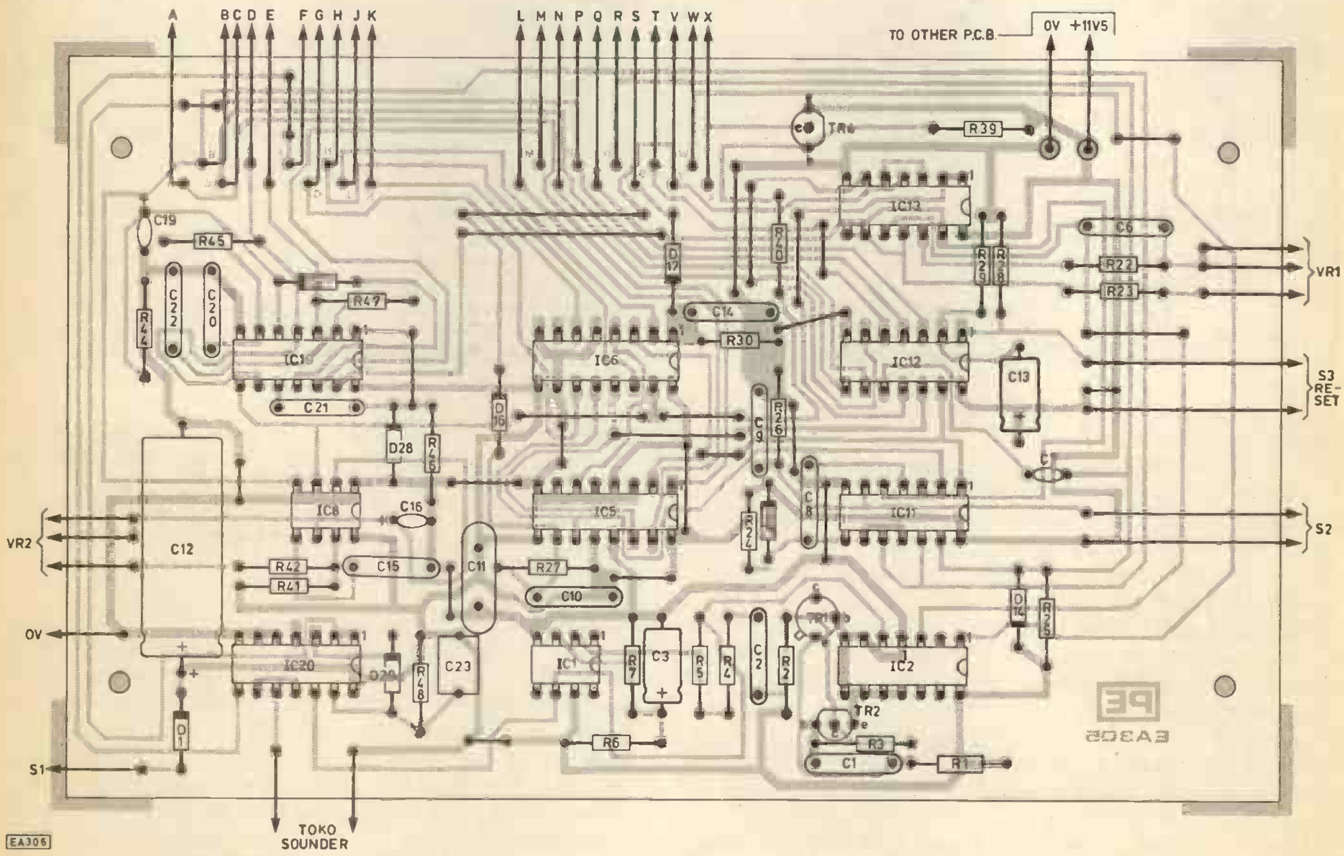

Fig. 4. Component layout

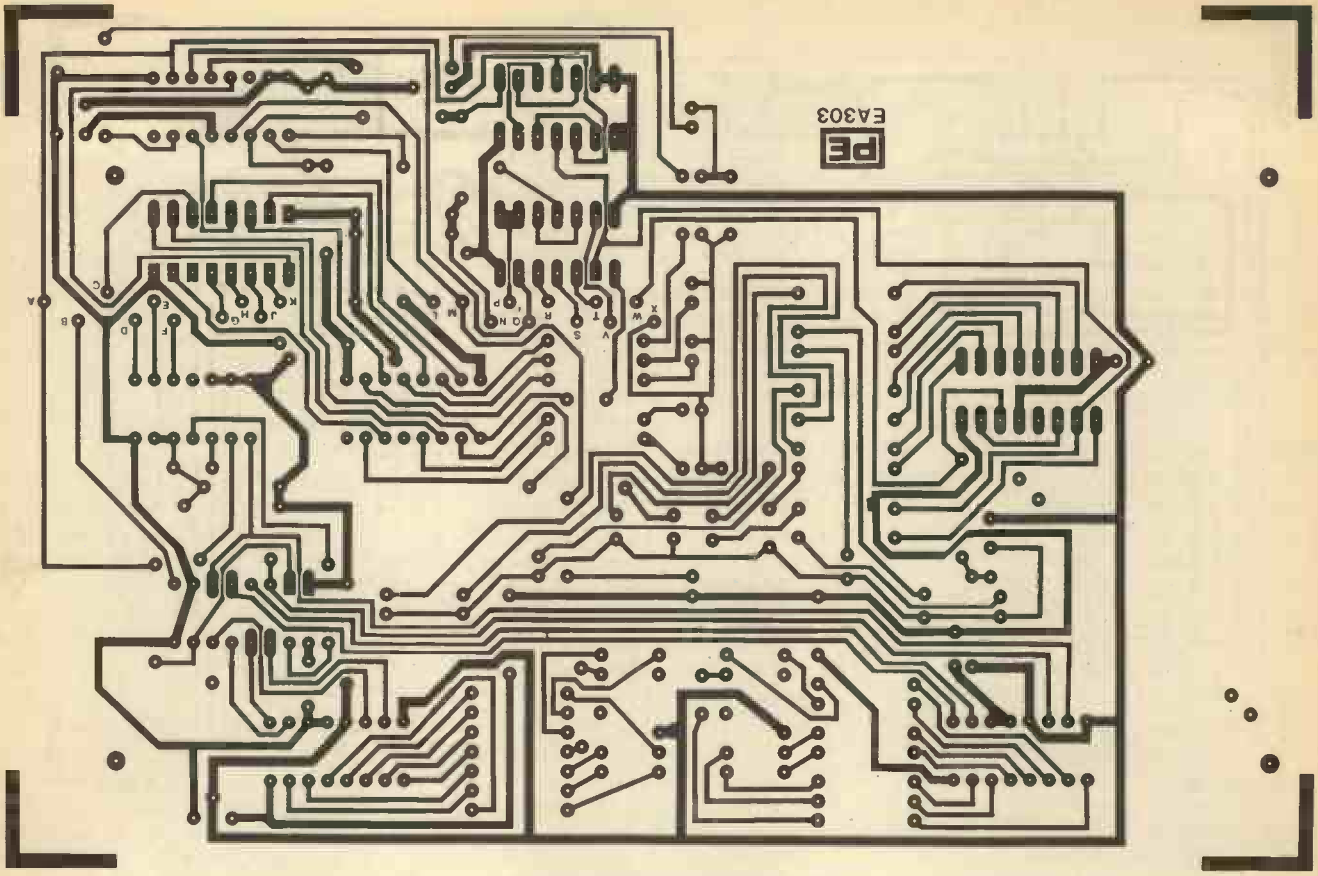

Fig. 5. P.c.b. design

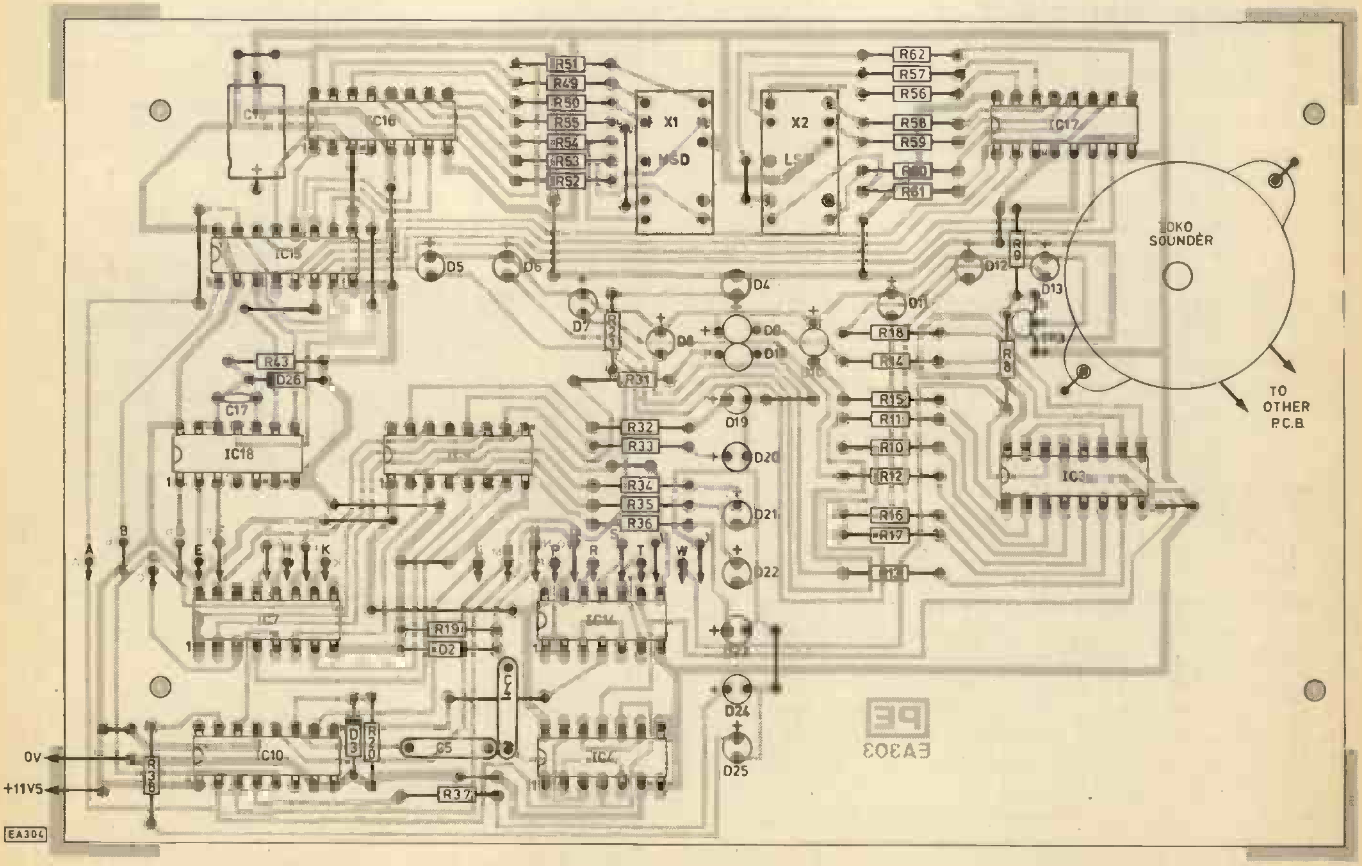

Fig. 6. Component layout

converted to 7-segment output codes (on pins 9 to 15) which drive the displays via current limiting resistors. The two counters are reset by the control circuit's reset pulse, and the first counter is clocked by the output of the latch formed by IC11c and IC11d. (Because of the latching action this point is completely bounce free; the output of IC11b pin 4 would not be as bounce free, and could give false counting, so was not used even though it might seem to be a more likely point to take the scoring from.)

SOUND EFFECTS

The raucous noises generated by this game can all be blamed on the TOKO sounder used! This is a cheap piezo loudspeaker which can be driven directly from a CMOS gate (it has a very high impedance) yet gives relatively high sound levels. The alien hit explosion sound is generated by gating on the noise output of IC1 by the 'hit signal' pulse stretched by D29, R48 and C23. (IC20a is included to prevent any problems caused by feeding the 'hit signal' directly into the pulse stretching network.)

Every movement of the missile is indicated by deriving a short pulse from the output of IC8 using the network of C21, D28 and R46 (and via IC19c), and using this to gate on and off a medium frequency audio oscillator formed by IC19a, R47 and C22. This gives out a short 'squeak' for each missile movement. The circuit is disabled, though, whenever the bomb is dropped or an overall win occurs, to allow these other sounds to take precedence, via IC19c pin 9.

The bomb and overall win sounds are both the same low frequency audio tone generated by IC19b, with R45 and C20. The oscillator is gated on and off via a pulse stretcher circuit formed by D27, C19 and R44. In the case of a bomb dropping only a short tone is heard, but in the case of an overall win the tone is continuous until the game is reset or switched off. IC18a and IC20c serve merely to combine the various effects and feed them to the sounder.

Finally, D1 provides protection against incorrect connection of the batteries, and C11, C12 and C18 decouple the power supplies to help stop transients from affecting circuit operation. Note that a high battery voltage is needed for the unit (12 volts) in order that a satisfactory noise voltage can be obtained from the reverse biasing of the TR1 junction. Although a 9 volt battery could be used, it would require special selection of TR1 to find a transistor with a particularly high noise voltage. If preferred, a simple mains power supply could be added, either squeezed directly into the unit or as a separate 'battery eliminator'. Part 2 of the Digital Design Techniques series (September '81) showed a suitable circuit; any voltage from 12 to 15 volts will work very well indeed. Whatever power supply is being used, make sure that it never exceeds 15 volts under any circumstances, or change C12 to a 25 volt type and make sure that the supply never exceeds 18 volts.

CONSTRUCTION

The components should be soldered to the p.c.b.s as shown in Figs. 4 and 6. Leave the integrated circuits until last, don't touch their pins with your hands, and use an earthed soldering iron. The l.e.d.s and displays sit well up off the p.c.b. surface, not flat down, and should be adjusted in height off the board to suit the spacers and fixings used. The displays will be visible through a 'window' in the case, and the l.e.d.s will fit directly through holes in the front panel. The piezo sounder should be fixed to its p.c.b. using short wire links fixed through its mounting holes. (Flying leads connect it to the other p.c.b.)

The two p.c.b.s should be wired together using ribbon cable, jumper strip, or just discrete wire links as preferred. Join point A to A, B to B etc. The battery holder connectors, potentiometers, and switches can also be wired up at this point using adequate lengths of flexible stranded wire. (A spare pin on the power switch S1 can be used to anchor this joint between the two battery holder connector wires.) The case should be drilled to take the switches, pots, mounting pillars for the p.c.b., the l.e.d.s and a rectangular cutout should be made to allow viewing of the 'score' displays. This cutout should have a piece of red tinted plastic or perspex glued behind it to improve visibility and contrast of the 7-segment displays. Note that the l.e.d. holes must be ACCURATELY drilled to match the positioning of the l.e.d.s on the p.c.b.; it is easy to damage l.e.d.s by too much bending of their legs, so be careful!

Lettering and symbols should then be applied to the case. The p.c.b.s, joined together and with pillars fitted, should be offered up to the case, screwed in, and the switches and pots added. The battery holders should be fixed to a suitable position in the case using 'sticky fixers'.

The SPACE EVADERS game is now finished. If it seems that the noise source is not operational (no logic level changes at IC2a pin 5) try changing TR1, or lowering the value of R4 to 1k0, and make sure that the supply voltage is as high as it is supposed to be. If no l.e.d.s come on at all, it is possible that they've all been inserted into the p.c.b. the wrong way round, so check this before proceeding. To test the action of the game, it is usually best to set the alien speed to minimum, and the missile speed to the maximum.

There are many potential changes, modifications, and variations possible on the basic theme of this game. Naturally the more complex it becomes, the more likely it is that a dedicated microprocessor would prove easier to use than discrete logic. However, at the level shown it is fairly easy and economical to build, and the alien seems to be sufficiently difficult to beat that even die-hard enthusiasts of 'that other' alien space game find it an absorbing deviation!

Multimeter OFFER

KIT £19·95

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The DP2010 is a development of the DP200 Multimeter (featured in PE May 1981) aimed at giving reasonable specification at remarkable value for money. The instrument is available ready-assembled and calibrated, or in kit form for home assembly. All parts (except PP3 battery and test leads) are supplied including clear assembly and calibration details. The DP2010 features 6 functions and 21 measurement ranges, with a high contrast 12·5mm l.c.d. readout for extended battery life.

SPECIFICATION

FUNCTIONS: **Volts** (d.c.) 1mV–500V, 4 ranges; accuracy 1% ±1 digit. **Current** (d.c.) 1μA–1000mA, 4 ranges; accuracy 1% ±1 digit—5% ±1 digit @ 1000mA. **Volts** (a.c.) 1mV–500V, 4 ranges; accuracy 2% ±5 digit. **Current** (a.c.) 1μA–1000mA, 4 ranges; accuracy 2% ±5 digit—7% ±5 digit @ 1000mA. **Resistance** 1R–2000k, 4 ranges; accuracy 1% ±1 digit. **Diode Test** 2V range; accuracy 1% ±1 digit. DISPLAY: 12·5 l.c.d. INPUT IMPEDANCE: 10MΩ. BATTERY TYPE: PP3, 2mA typical consumption. POLARITY INDICATION: Automatic. LOW BATTERY INDICATION: Automatic. OVERRANGE INDICATION "1" at most significant digit with other digits suppressed. INPUT TERMINALS: Standard 4mm.

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PE Car Computer...

P. MacFarlane — Part 1

THIS computer (shown actual size below) is able to provide the following digital information in either imperial or metric units.

Current or average speed and m.p.g., distance travelled, remaining distance possible on fuel left, average speed needed for remaining distance to meet an arrival time, acceleration and deceleration times between any two preset speeds, fuel used during acceleration, average m.p.g. during acceleration, distance covered including standard distance times and fuel used and provides instant and average fuel costs.

MODES OF OPERATION

There are three basic modes of operation:

Indicating mode. This is used to display such things as current or average speed, or distance travelled.

Remainder mode. The unit can perform simple calculations such as remaining distance, remaining distance possible on the amount of fuel left, average speed required for the remainder of a journey in order to arrive in the time allowed, and so on.

Start-stop or programmed mode. This is used for acceleration timing and the like.

There is also provision to drive a combination lock ignition cut out which will be described later.

INDICATING MODE

To cause the unit to display one of the functions listed above the buttons 1 to 5, simply press that button. 'Time' is 'elapsed time' not time of day, the latter would require the unit to be on power even with the car engine off. This will read out in hours and minutes up to 19 hours 59 minutes and in decimal hours for longer times. The other functions read over three ranges depending on the value. 'Fuel Use' is either miles per gallon or litres per 100 kilometres.

Pressing 'Average/Low' causes the unit to read average rather than instantaneous values if the function selected is 'Speed' or 'Fuel Use', and to read 1000 times the value if the function is 'Fuel' or 'Distance'. When the function selected is 'Time', the unit reads in minutes and seconds or seconds and tenths. The main use for the low operation is for reading the low values obtained during start-stop operation. To indicate low or average, a colon shows by the 'function' digit.

'Reset' sets the time, fuel and distance stores to zero and introduces the averages.

'Hold' causes the total and instantaneous stores to be held at their current values and an 'H' to show in the function digit. It is still possible to change functions using keys 1 to 6 so the conditions at the moment the 'Hold' button was pressed can be examined. 'Run' cancels 'Hold' and returns to normal operation.

REMAINDER MODE

The 'Remaining' key can be used to calculate values based on previously entered information as follows.

'Remaining' followed by 'Time', 'Fuel' or 'Distance' causes the value digits to read the entered quantity minus the measured quantity. If a further key 1 to 3 is pressed, the digits show the value of the first function based on the remaining second and the ratio of the two. For example, pressing 'Remaining', 'Fuel', 'Distance' gives the amount of fuel required for the remaining distance assuming the same average fuel use. 'Remaining', 'Distance', 'Fuel' is the distance possible with the remaining fuel and so on. The function digit always shows the units of the value digits. There are nine such remaining calculations possible.

'Remaining', 'Speed' calculates remaining distance divided by remaining time, which is the average speed now required to complete the distance in the time allowed. Similarly with remaining fuel use.

To revert to normal use, press 'End' followed by the function now required, or the function twice. The unit will perform the equivalent of pressing the 'End' button eight seconds after the last button was pressed, unless in the hold condition.

The quantities required for a journey are entered into the unit by pressing 'Enter', followed by the key for the function to be entered (1 to 3), followed by the number, followed by 'End'. Thus to enter $25\frac{1}{2}$ miles, press 'Enter', 'Distance', 2, 5, ., 5, 'End'. The 'End' is needed to indicate that a subsequent key is not a number, but see previously about automatic 'End'.

Numbers entered this way are not affected by 'Reset' or changes in the totalising stores, so if the same journey is to be done, the numbers need not be re-entered. To examine a number press 'Enter', followed by the key for the quantity to be examined. The previously entered number will now appear in the result digits and can be modified as before using the number digits, or left the same by pressing 'End'.

START-STOP MODE

The unit can be programmed to reset its stores when the display reads a certain number and to go to the hold condition at another number. Either number can be zero in which case the unit will not reset until the display reads just above zero or will not hold until the display becomes zero.

To enter the number the unit is required to reset at, press 'Enter', 'Start' (same as 'Reset'), followed by the number, followed by 'End'. Similarly the stop number can be entered using 'Stop' ('Hold'). 'Enter', 'Stop' sets a start-stop request flag in the unit, but the start-stop mode does not become active until 'Run' is pressed, indicated by a 'P' in the function digit. During start-stop operation the sample rate for instantaneous values is increased up to eight times per second.

Suppose it is required to test the acceleration of the car from 0 to 50 miles per hour, the sequence is as follows. Press 'Enter', 'Start', 0, 'End', 'Enter', 'Stop', 5, 0, 'End'. The unit is then set to read 'Speed', the car driven to where the test is to be carried out, stopped (for long enough for the display to go to zero), then 'Run' pressed. As soon as the car starts moving the total stores will be reset to zero, and when the speed exceeds 50 miles per hour, the unit will go to the hold condition. Press 'Time', 'Low' to see the acceleration time, 'Fuel', 'Low' the amount of fuel used and so on. 'Speed' shows the speed at which the unit stopped, which will be just over 50. 'Speed', 'Average' the average speed, and so on.

This is a very good way to tune a car as the best compromise between performance and economy can be found quite quickly. The setting for ignition timing that gives the best performance also gives best economy, and up to a point the richer the mixture the better the performance at the expense of economy and vice-versa.

It is possible to start and stop on any function, thus a standing $\frac{1}{4}$ mile test can be done starting at zero and stopping at ·25, reading 'Distance' (or stopping at 250 reading 'Distance' and 'Low'). Make sure though that 'Reset' is pressed before 'Run' when stationary. If starting and stopping on a time, this time must be expressed in decimal hours.

Pressing 'Reset' when in the start-stop mode will start the unit without waiting for the start condition. Similarly the unit can be stopped early by pressing 'Hold'. Going to the hold condition, manually or automatically, clears the start-stop mode. To repeat a test using the same figures press 'Enter', 'Stop, 'End, 'Run'.

The start number can be greater than the stop number, used, for example, for braking tests. The display must be reading more than the start number when the 'Run' button is pressed, and obviously the wheels must not skid.

It is interesting to repeat the distance tests accelerating both fiercely and gently, work out the difference in time taken and the difference in cost of fuel used, to obtain cost/time and compare that with how much you feel your time is worth to you.

'F.Cal' and 'D.Cal' are used for calibrating the unit for metric or imperial use.

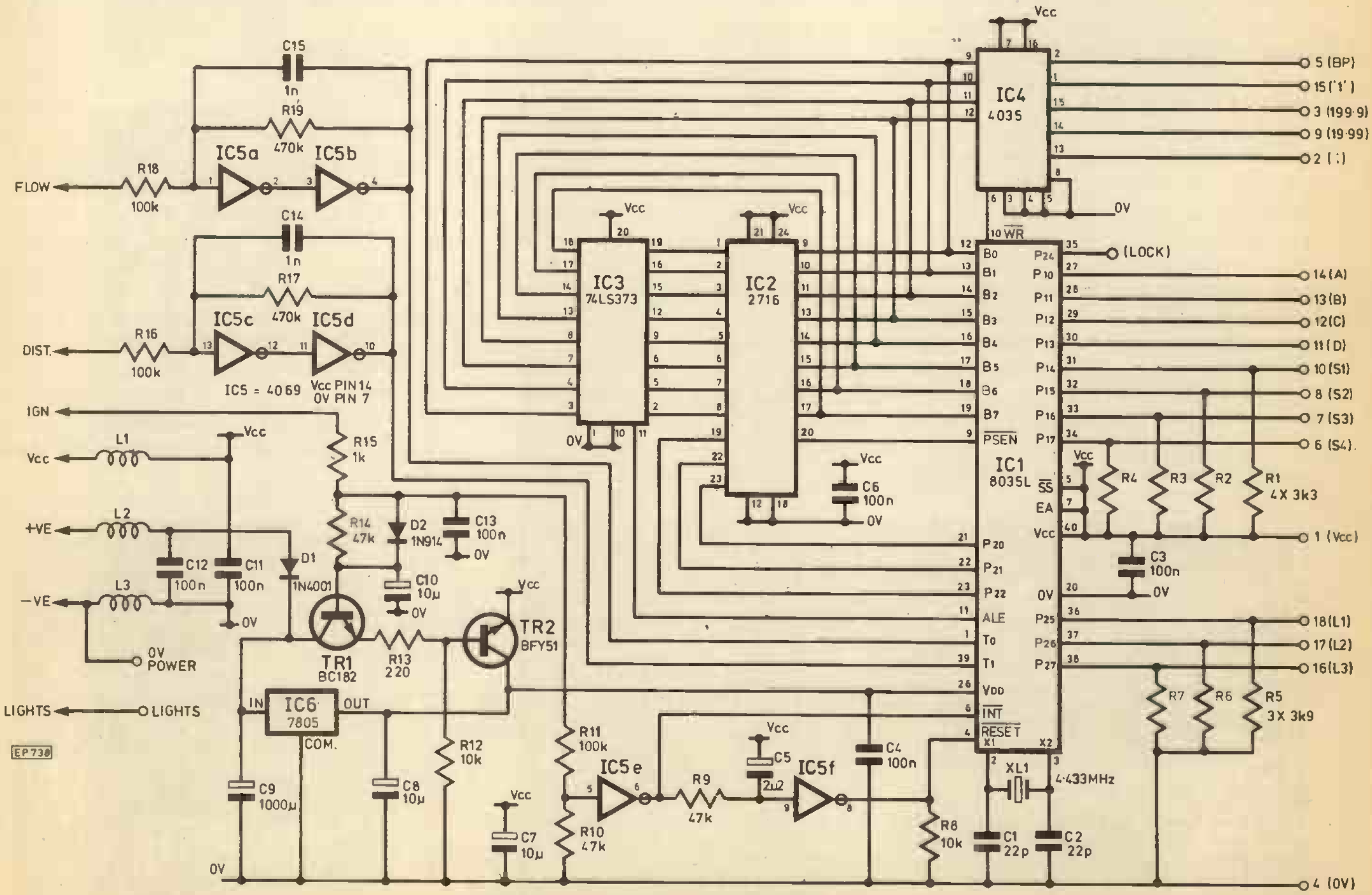


Fig. 1. Circuit diagram of main board

MAIN BOARD

The circuit for this is based around a 8035L microprocessor with a 2716 program store (Fig. 1). A 74LS373, IC3 is used to latch low order program store addresses for the ROM which on the 8035L are multiplexed with the data bus. B0 to B3 are also latched under the control of the $\overline{WR}$ signal in IC4, a 4035. This has exclusive OR outputs for driving the l.c.d. direct.

The digit outputs for the display are in BCD form on lines ABCD, multiplexed under the control of strobes S1 to S4. The strobes also drive the keyboard, organised as a 3 x 4 matrix, the sense lines being L1 to L3. Pull up resistors on the strobes are necessary because the 8035L port lines have a high impedance (50k) pull up on both inputs and outputs. Without the resistors there would be insufficient current to drive the keyboard lines.

The 8035L has an internal 64 x 8 data RAM which is used for holding the various quantities which must not be lost when the ignition is switched off. V_{dd} line drives only this RAM and is connected directly to the 5 volt regulator, IC6. This regulator is powered from the car battery directly. The rest of the circuit is powered via TR2 which is only on when the ignition switch is on.

IC5 pins 9 and 8 and 5 and 6 ensure that a $\overline{RESET}$ signal is applied to IC1 when the power is applied or removed. Pin 6 of IC1 is used to sense when power is about to fail.

The remainder of IC5 is organised as two Schmitt triggers for the inputs from the sensors. C14 and C15 ensure that there is maximum noise immunity when a threshold has just been crossed.

DISPLAY BOARD

The display board circuit is shown in Fig. 2. Here the 7211A is a 4 digit l.c.d. driver and is fed with the multiplexed data ABCD and the strobes directly. The l.c.d. decimal points, results digits '1' and function colon are driven directly from the 4035.

The keyboard is organised as a 3 x 4 matrix but is laid out on the board as 2 x 6. It is also driven one strobe early because the lines L1 to L3 are sampled at the end of a strobe when the internal strobe information is for the next strobe.

There are two bulbs for backlighting the display on this board.

The basic microcomputer comprises IC1, IC2 and IC3, and could be used to drive other display/keyboard arrangements, and with a different power supply/input arrangement.

POWER SUPPLY AND INPUT

Pin 26 of IC1 must be supplied with 5 ± 0·5 volts continuously to retain the information in the RAM, at a current of about 10 mA. When power is being applied or removed, pin 4 of IC1 ($\overline{RESET}$) should be low and preferably when power is about to be removed pin 6 ($\overline{INT}$) should be high. This puts the processor in a known state, and ensures that power will not fail half way through an addition for example.

The flow pulses are applied to pin 1 and the distance pulses to pin 39, IC1. A 4·433619MHz crystal is needed as in Fig. 1 for the timebase for the correct timing.

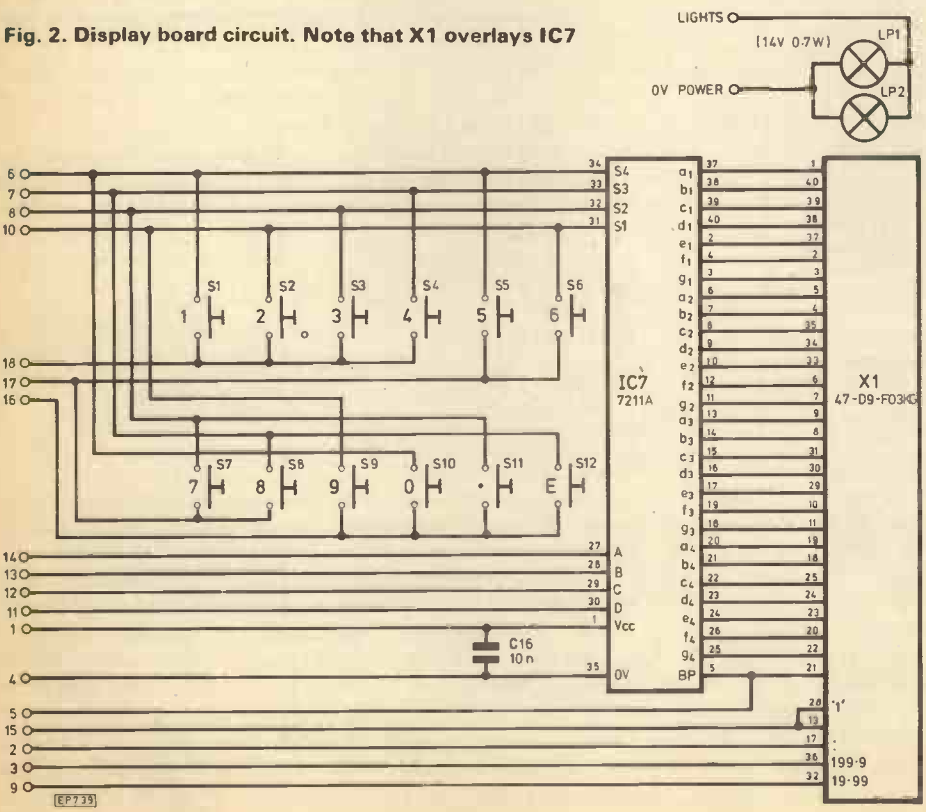
KEYBOARD/DISPLAY

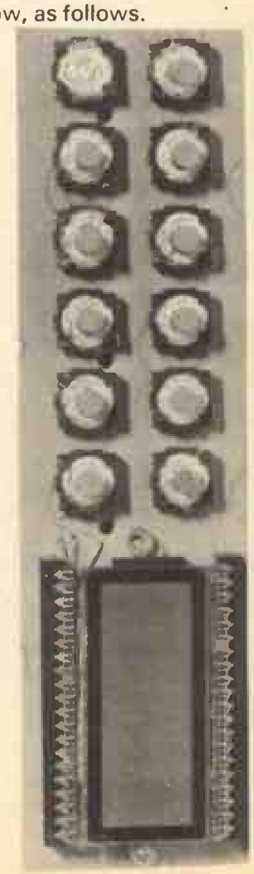
The keyboard is matrix driven between strobe lines S1 to S4 and keyboard input lines L1 to L3. Note that the strobe lines are only capable of sourcing about 100μA without pull up resistors.

In order to get correct letter outputs on the function digits a code 'B' type decoder is needed for lines ABCD. There is a small amount of interdigit blanking on the strobe lines which will prevent ghosting when multiplex driving l.e.d. or fluorescent displays, but which may not be sufficient when driving gas discharge displays. Strobe S1 is high when lines ABCD have information for the least significant digit, through to strobe S4, high for the function digit.

Other output information is present on lines B0 to B7 when pin 10 of IC1 ($\overline{WR}$) is low, as follows.

Fig. 2. Display board circuit. Note that X1 overlays IC7





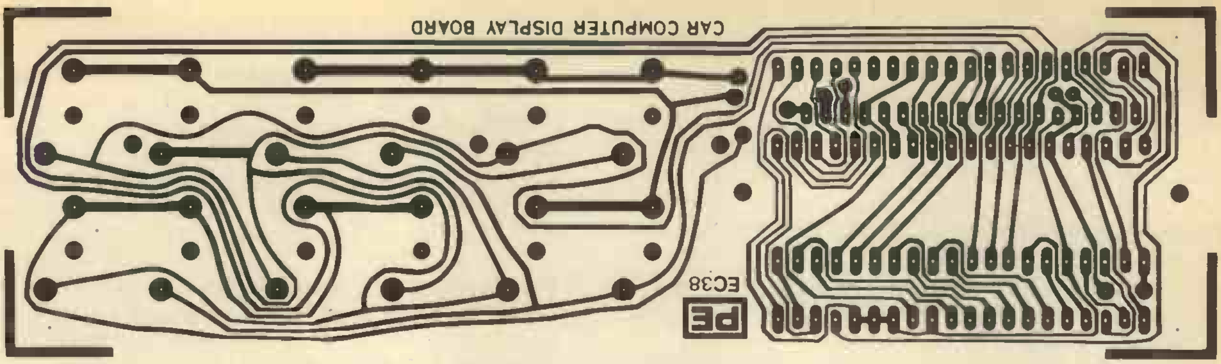


Fig. 3. P.c.b. design for the display and keyboard

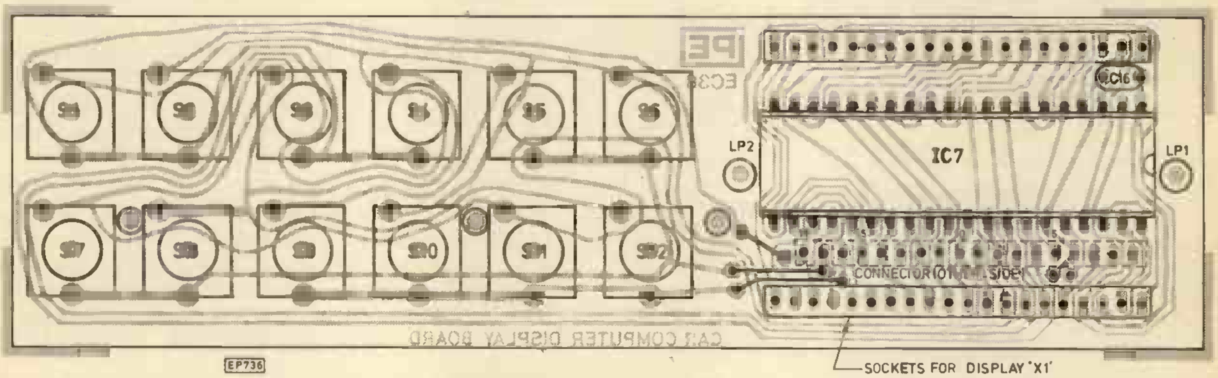


Fig. 4. Component layout

B0	Most significant '1' digit on display
B1	199·9 decimal point
B2	19·99 decimal point
B3	Low/Average flag
B4	Remainder flag
B5 } B6 }	Start-stop information
B7	Start-stop direction

These are active low. The start-stop direction flag is low if the start number is greater than the stop number.

Bits B5 and B6 operate as follows.

B5 = 1, B6 = 1	Not programmed mode.
B5 = 0, B6 = 1	Start-stop request—'Enter', 'Stop' pressed, but not 'Run' yet.
B5 = 0, B6 = 0	Start-stop active—'Run' pressed from start-stop request.
B5 = 1, B6 = 0	Started—unit has performed reset, display value is between start number and stop number.

FLOW SENSOR

The unit requires approximately 20,000 pulses per litre of fuel. The flow range in a motor car can be from 1 to 50 litres per hour, and it is difficult to make a flow sensor to handle this range. There are problems too with pulsations in the flow.

The recommended sensor has been designed specifically for this application and should be accurate to within 2 per cent. It uses a small helical turbine running in precision bearings, which is rotated by the flow, the rotation being sensed optically. It is mounted together with its pulse reducing valve in the fuel line between the fuel pump and the carburettor. **This sensor cannot be used with fuel injection or diesel engines.**

DISTANCE SENSOR

The unit needs one pulse every 200mm or so, a sensor giving one pulse per revolution of the prop shaft could be used, or one giving 4 pulses per revolution of a half shaft. The recommended sensor fits into the speedometer cable giving 6 pulses per revolution. This is because of the difficulty of making a universal fitting for a drive shaft sensor, and one fitting on the end of a speedometer cable could necessitate a tight bend in the cable.

There are at least six different end formats for speedometer cables as well, but I have only come across two different inner cable sizes so far, both of which the sensor will accommodate. To fit it requires that the outer cable be cut at some point. A slotted disc inside the sensor rotates with the inner cable, the rotation being sensed optically.

HOUSING

In order to keep the outside dimensions of the unit as small as possible and to give a professional appearance to the finished unit, a custom box has been designed.

CONSTRUCTION

The p.c. board layout for the display and keyboard is shown in Fig. 3. Fig. 4 shows the component layout, the display is mounted above IC7, in the soldercon connectors.

Fit the three wire links first, then the switches, making sure that they are close against the board. Now fit IC7 as in Fig. 4, again pressed close to the board, and without a socket. Cut the bottom row of legs of this i.c. close to the board. Fit and solder the capacitor C16 and the soldercon sockets for the display. Break off the backing strip from the sockets. A small piece of white paper about 25mm/1in square stuck to the middle of IC7 will improve the appearance of the display when back lit. Press the display into the sockets so that the front of it is 11mm from the front of the board. Fit and solder the connecting wires **on the copper side of the board.** These can be 40mm/1½in lengths of 10/0·1 wire, or a 40mm length of 18 way 0·1in pitch ribbon cable.

Figs. 5 and 6 show the printed circuit layouts for the main board. Fit a through pin in all top side pads and solder both sides. The position of the components is shown in Fig. 7; it is recommended that IC1 and IC2 be mounted in sockets. Solder in the sockets, but do not fit IC1 or IC2 yet.

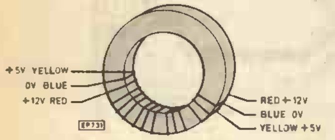


Fig. 8. Coils L1 to L3 consist of five turns each of kynar wire

L1 to L3 consists of five turns each of three lengths of ·25mm kynar wire wound around the ferrite core as shown in Fig. 8. The core is held onto the board using a cable tie.

Fit IC6 and its heatsink (Fig. 9) last, an M3 × 8mm bolt holding them to the board, with the nut and washer on the component side. Fit the crystal (as far as the wires permit) lying over IC1.

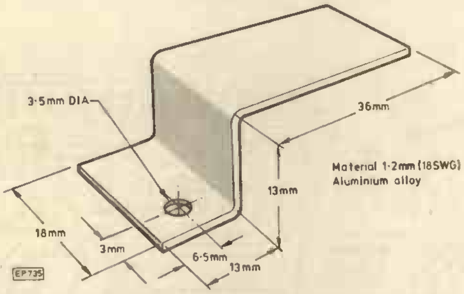


Fig. 9. Heatsink for IC6. It is only shown in outline in Fig. 7

Join the two boards together, again soldering the connecting wires to the copper side of the board. The wires connect without crossing over. Fit the seven wires for the power and sensors, thread through the sleeving, and if the unit is to be mounted above the car dashboard, i.e. with the sloping part of the box at the top, thread the cable through the big hole in the board. Fit a cable tie approximately 75mm/3in from the board.

The two bulbs are fitted through the holes in the display board, from the component side, making sure that the metal parts of them are not touching the metal bar passing through IC7, and held in place with adhesive (e.g. 'Superglue'). Connect these to the main board with a twisted pair of wires kept away from the main components.

TESTING

Apply power between the −ve and +ve wires (black and red on board), 9 to 15 volts, and check that there is 5 volts ± ·25 between 0 volts (heatsink) and pin 26 of IC1 socket. Now connect IGN (yellow) to the +ve supply and check that there is 5 volts between 0 volts and pin 40 IC1 socket. Remove the power, wait a minute or so for the capacitors to discharge and plug in IC1 and IC2.

Apply power between −ve and +ve/IGN again, press the 'End' button (bottom right) on the keyboard, the 'Run' button, then some of the buttons 1 to 5 on the keyboard top row and check that the function (leftmost) digit of the display shows the key number 1 to 5.

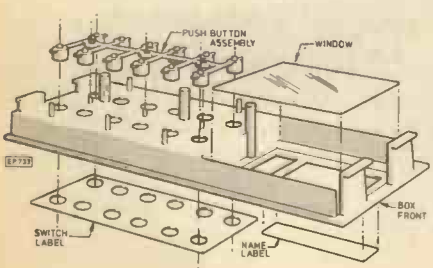


Fig. 10. Box/front assembly

MAIN ASSEMBLY

Refer to Fig. 10 for the positioning of the various components that make up the box front. Remove the backing paper from the switch label and fit it to the box front, making sure that the holes line up and that it is the right way up. Use the two plastic sprues from the box mouldings through button 6 and 7 holes to align the label, and once pressed down do not attempt to move it. Fit the name label similarly.

The transparent window is fitted to the inside of the box front using polystyrene cement or 'Superglue'. Do not get adhesive on the visible part of the window, it does not come off! Fit the switch button assembly over its studs and melt the studs down to hold it in place.

Thread the cable from the main p.c.b. through the hole in the back of the box cover and pull through, sliding the p.c.b. along the appropriate set of runners. These will grip the board fairly tightly. Press the board home, making sure that the board engages the slots at the back of the box cover, and that the capacitor C9 is not pulled from the board by the edge of the box.

Locate the holes in the display p.c.b. over the long studs in the box front, and tucking the connecting wires under the main p.c.b., hook the keyboard side lugs on the box front into the slots in the cover. Press the display side lugs inwards to fit into the cover and press the front into the cover so that the lugs snap home.

COMPONENTS

Resistors

R1–R4	3k3 (4 off)	R11, R16, R18	100k (3 off)
R5–R7	3k9 (3 off)	R13	220
R8, R12	10k (2 off)	R15	1k
R9, R10, R14	47k (3 off)	R17, R19	470k (2 off)

All resistors ¼W 5% carbon film

Capacitors

C1, C2	22p ceramic (2 off)
C16	10n ceramic
C5	2µ2 electrolytic 16V
C7, C8, C10	10µ electrolytic 16V (3 off)
C9	1000µ electrolytic 16V
C3, C4, C6, C11, C12, C13	100n ceramic (6 off)
C14, C15	1n ceramic (2 off)

Semiconductors

D1	1N4001	IC3	SN74LS373
D2	1N914	IC4	4035
TR1	BC182	IC5	4069
TR2	BFY51	IC6	7805
IC1	8035L	IC7	7211A
IC2	2716		

Miscellaneous

L1-L3 3 × 5 turns on T68–40 core, XL1 4·433619MHz crystal, S1 to S12 AKS switch (12 off), X1 47–D9–F03KG display, LP1–LP2 14V 0·7W LES bulbs (2 off), 40 pin DIL socket, 24 pin DIL socket, soldercon pins (40 off), heatsink, p.c.b.s, through pins (34 off), wire, cables etc., plastic box kit, speed sensor, flow sensor and valve, connector block, cable ties, various 'plumbing' parts as required.

A complete kit of parts is available from **Pimac Systems Ltd., 20 Bloomfield Road, Birmingham B13 9BY.** Price £89.50 which includes VAT plus postage and packing.

Next Month: Fitting the flow and speed sensors. Installation, calibration and a description of the program controlling the computer.

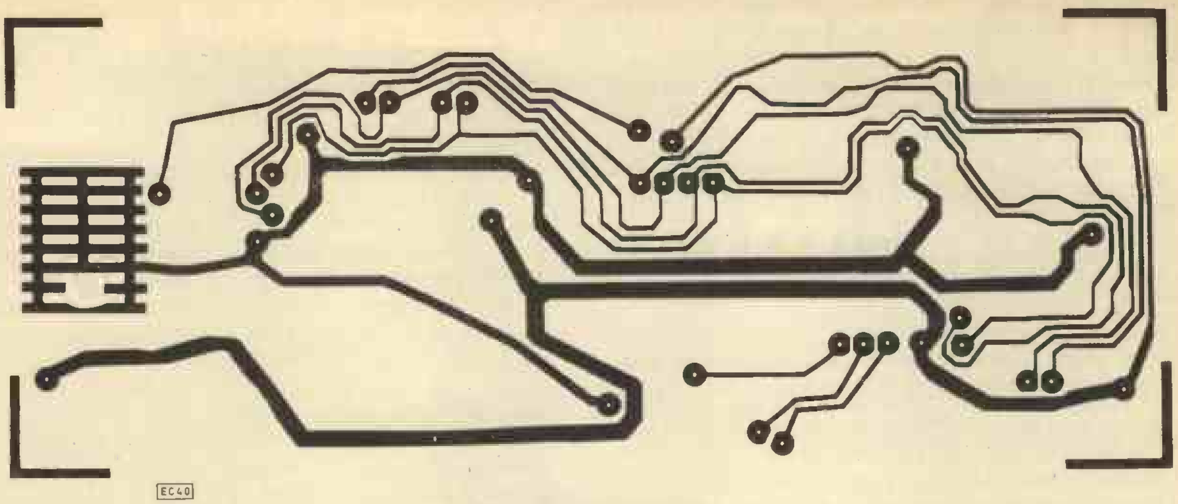


Fig. 5. Topside of p.c.b.

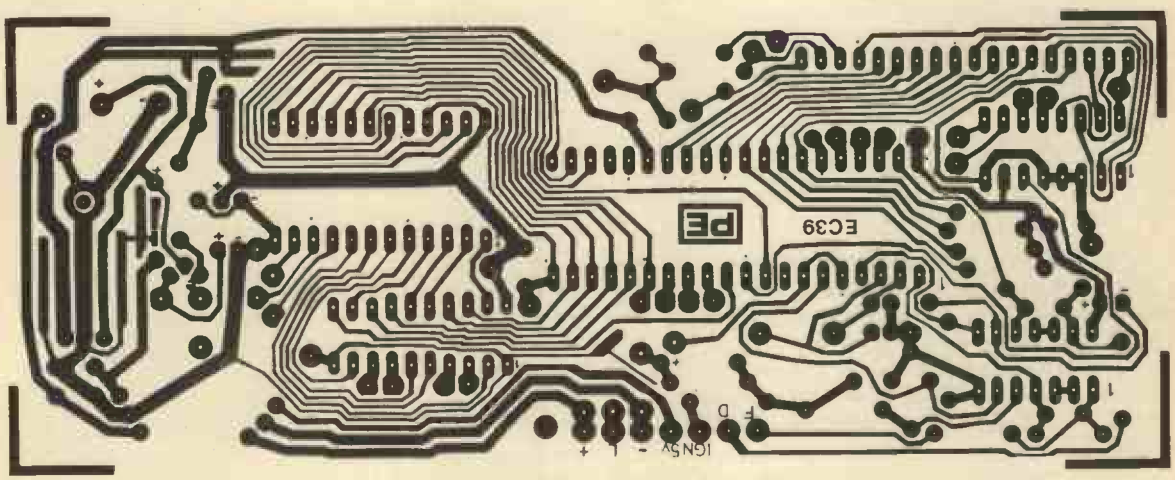


Fig. 6. Underside of p.c.b.

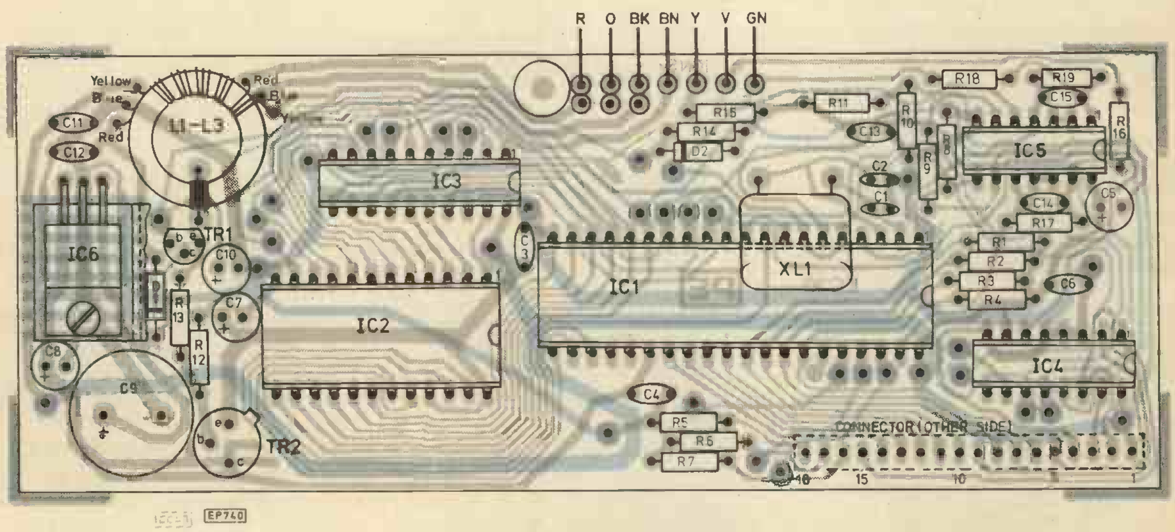


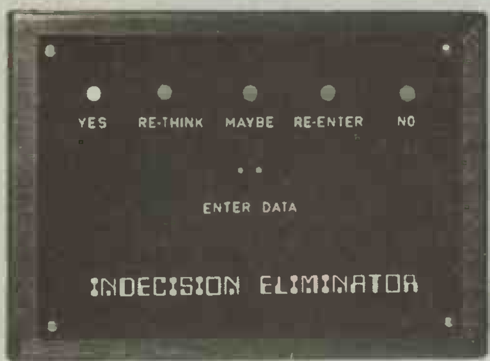
Fig. 7. Component overlay

NEXT MONTH

TV Camera

With video recorders now in widespread use many people have the most expensive item required to produce home video tapes; this black and white camera provides the outstanding unit at a realistic price. Since it can be supplied with power via the coax link it is also well suited to remote monitoring/security applications.

It will connect directly to any standard u.h.f. TV set or video recorder.



INDECISION ELIMINATOR

We would like to tell you that our Indecision Eliminator is used by many heads of Government—we would like to tell you that but we can't—yet! We think this executive toy will catch on though, so why not build one?

Plus... 4 Page Pull-out

WHAT CB? Guide to Legal Rigs

With CB now legal we thought it would be a good idea to let you know just what rigs are available so we have collected details and photos of every legal rig we can find, for both 27MHz and 934MHz, and put them all in this pull-out guide.

PE RANGER 27FM CB BASE STATION Part 1

PRACTICAL

ELECTRONICS

JANUARY ISSUE ON SALE FRIDAY DECEMBER 11th

Digital Design Techniques...

Tom Gaskell B.A.(HONS) ELEC.ENG.

Part 5 Advanced Sequential Circuits

LAST month we looked at the principles of flip-flops, dividing, counting and sequencing. This month we shall take the principles further and look at more complex devices and more sophisticated circuitry.

SHIFT REGISTERS

A 'register' is the term used for a collection of flip-flops, often with associated gates, which can be used to store and 'move around' combinations of logic 0's and logic 1's. They are used extensively in calculators, computers and microprocessors where each piece of binary information (logic 0 or logic 1) is known as a 'BIT' (which stands for BInary Digit). Hence, a piece of circuitry consisting of 8 flip-flops, and capable of giving eight logic outputs, might be called an 8 bit register.

The most basic form of register is known as a 'shift register'; it has a clock input, a data input and a data output, with logic 0's and 1's being 'shifted' through the flip-flops of the register, one position per clock pulse, from the input to the output pin. A basic 4 bit shift register based on D-type

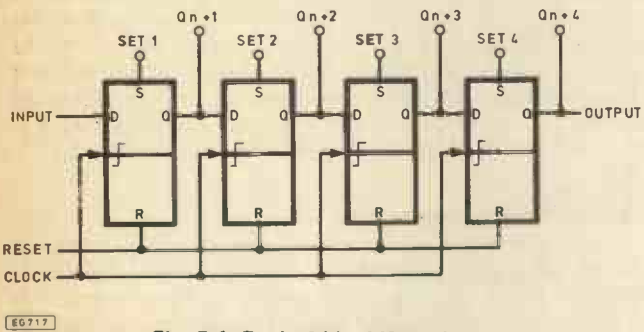


Fig. 5.1. Basic 4 bit shift register

flip-flops is shown in Fig. 5.1. Whatever the logic state of the input, after one clock pulse point Qn+1 will be at that state, then after 2 clock pulses Qn+2 will be at that state, after 3 clock pulses Qn+3 will be at that state, then after 4 clock pulses the output (Qn+4) will be at that state; the logic state of the input is being 'shifted' along the register. Hence, whatever the state of the input, the output will go to that state 4 clock pulses later. By changing the logic state of the input prior to each clock pulse, the 'contents' of the register can be adjusted at will. Note that the flip-flops must be edge triggered, otherwise input changes would be transferred directly to the output whenever the clock was at logic 1.

Fig. 5.1 represents a 'Serial In-Serial Out' device; 'data' is represented by a series of logic changes at the input, one per clock pulse and emerges as a series of logic changes at the output 4 clock cycles later. This format of register is abbreviated to SISO. It may be more convenient to us, however, to 'fill up' the register as required with 1's and 0's, then to look at the points Qn+1, Qn+2, Qn+3, and Qn+4 simultaneously. These give us a parallel set of data, because although the 1's and 0's were loaded into the register one at a time, they can be fed out of the register simultaneously. This is now a Serial In-Parallel Out register, or a SIPO.

Taking the concept even further, it is possible to use the 'set' inputs of the flip-flops to 'preset' a certain number of 1's and 0's into the register simultaneously; applying clock pulses would then shift the 1's and 0's out of the register output pin one by one. It doesn't require a lot of imagination to see that this is a PISO: Parallel In-Serial Out. The parallel outputs Qn+1, Qn+2, Qn+3 and Qn+4 can also be used in this instance, of course, in which case the device acts as a 4 bit or 'Quad' latch. For consistency we can refer to this as a PIPO register: Parallel In-Parallel Out.

Other far more complex registers are available which are often used in calculator and computer circuitry. For example, the First In-Last Out register, in which the first bit coming out of the register is the last bit that went in and vice-versa. The more usual type of course is a 'FIFO': first in, first out. Many shift registers are of considerable length (i.e. many bits); up to 1024 is typical of the larger types. (These, for obvious reasons, are only available in SISO form.) More generally available types such as the CMOS 4006 have several stages of shift register in them, mostly SISO but with several parallel 'tappings'. Mention should also be made of the CMOS 4035. This is a 4 bit serial or parallel in, serial or parallel out device of great versatility and low cost, and can perform many complex functions. One of its most notable features is that the first stage is a JK flip-flop, with the K input inverted. Hence, all the input functions of a JK flip-flop can be utilised, or the J and K inputs can be connected together and it will behave as a normal D-type device.

COMPLEX COUNTERS

Last month we looked at basic counters, both decade and binary. There are, of course, much more advanced types of counter, with many extra facilities and functions. Many have decoding logic provided to count in special codes; often these are used to count and directly drive numerical displays such as the '7-segment' l.e.d. displays used in the Disco Hat project last month, or 'liquid crystal' displays. (We'll look at the 7-segment code next month.) Others have built-in latches, oscillators (less the capacitors and resistors) or even two independent counters in the same i.c. package. The 4018 is a presettable divide-by-N counter, and is in essence a cross between a shift register and a counter. It is a five stage counter, with counting stages that can be preset by parallel logic inputs, often known as 'JAM' inputs. The first counter stage has a 'data' input, which can be fed from any of the outputs, via combinational gates if necessary, to set the values of 'N'. By this means, the output counts up to 'N', then starts again from zero as a continuous process, with no 'glitches' or transients that might be produced when using a simple self-resetting circuit.

Finally, probably the most useful counter in the CMOS range is the 4029; a presettable 4 stage up/down counter. Presetting occurs in parallel, in a similar way to the 4018 mentioned above, and from this preset value the 4029 can count upwards or downwards, and in one of two possible codes, binary or BCD (binary coded decimal), which we shall be looking at later in the series. Two of these counters are used in the project this month, so a greater understanding of the workings of this i.c. will be possible now. There are, of course, even more complex counters than these; a frequency counter instrument, for example, is often based on a single i.c. for the majority of its functions, but these are far more specialised in use and are usually fairly expensive when compared with the normal 4000 series of CMOS i.c.'s and most TTL series.

SYNCHRONOUS/ASYNCHRONOUS OPERATION

The term 'synchronous' means that changes in a device or circuit occur at the same time as the clock pulse. Asynchronous is the opposite of this; changes in the circuit can occur at any time, not necessarily related to the state of the clock. In the case of the 4029 up/down counter, for example, the preset 'JAM' inputs can be fed into the counter asynchronously, it doesn't matter what state the clock is in — the moment that the 'preset enable' pin is taken to logic 1, the counter outputs immediately change to these new preset states.

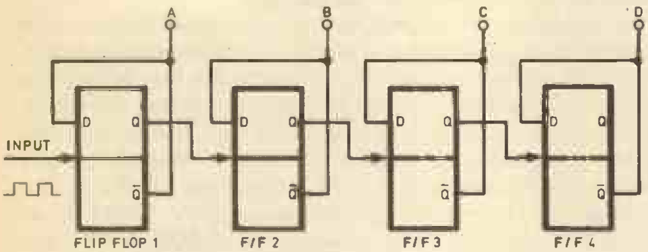


Fig. 5.2. Cascaded divide by two circuit

To see how this affects the design and the use of counters, let us look at the basic binary counter, as discussed last month. In Fig. 5.2, when the clock input goes to logic 1 it causes flip-flop 1 to change state. The change of state of this flip-flop then clocks flip-flop 2. Due to propagation delays, there is a finite time interval between the counter clock input changing, and the clock input of flip-flop 2 changing. When the state of the whole counter is such that the 'D' output state changes, this change takes place a considerable time after the counter clock input edge occurs: flip-flop 1 changes, which causes flip-flop 2 to change, which in turn causes flip-flop 3 to change, finally causing flip-flop 4 to change. These changes seem to 'ripple' through the counter and since output 'D' changes some time after 'A' changes and hence is not synchronous with the clock, this counter is known as a ripple or asynchronous counter. Although the delay is very short (normally less than 1µs) it does result in invalid information being present at the counter output for a short while, which potentially could be latched into registers or other devices and result in serious mis-operation of the system. We'll look in greater depth at this type of error a little later on.

To avoid this ripple effect it is necessary to change the state of all flip-flops simultaneously rather than in sequence. Fig. 5.3 shows a simple synchronous counter. You will remember that if the J and K inputs of a flip-flop are both held at logic 0, no change in the output state occurs when the clock goes to logic 1. If J and K are both at logic 1, the outputs reverse state when the clock goes to logic 1. Hence, flip-flop 1 always reverses state; it is a simple divide-by-two circuit. Assuming that the other outputs start from an initial zero condition, then if the state of output A is 1 before a clock pulse occurs, flip-flop 2 will change state as soon as the clock pulse occurs, in turn changing output B. When both A and B are 1 before a clock pulse, i.e. binary count 0011, then as soon as the clock pulse occurs, flip-flop 3 changes state, so output C goes to logic 1; but, A and B also both change state (they go back to logic 0) so the count becomes 0100, and so on.

The extra complexity and greater cost of synchronous counters is not always needed although both asynchronous and synchronous devices are readily available in both CMOS and TTL families. Practically the only operational disadvantage of synchronous circuits is that they tend to be less tolerant of slowly changing or noisy clock inputs. In a ripple counter all flip-flop clocks are derived successively from the previous flip-flop, and this relatively slow propagation of changes ensures that the correct logic changes all occur in the correct order, whereas in the synchronous counter a very slow or noisy clock edge may cause some flip-flops in the device to be clocked before others, (due to manufacturing tolerances in the CMOS threshold points) and this could lead to incorrect operation. Hence, it is important to ensure fast clean clock edges when driving synchronous circuitry.

CASCADING COUNTERS

The use of synchronous or asynchronous circuit designs should also be considered when cascading counters. 'Cascading' is the term used to describe the joining together of two or more counters to make a much larger counter in total. This can sometimes be as simple as taking the last output of one counter and feeding it into the clock input of another counter, but is considerably complicated when up/down counters are involved. Often, these i.c.'s have 'carry out' and 'carry in' pins, to permit easy cascading.

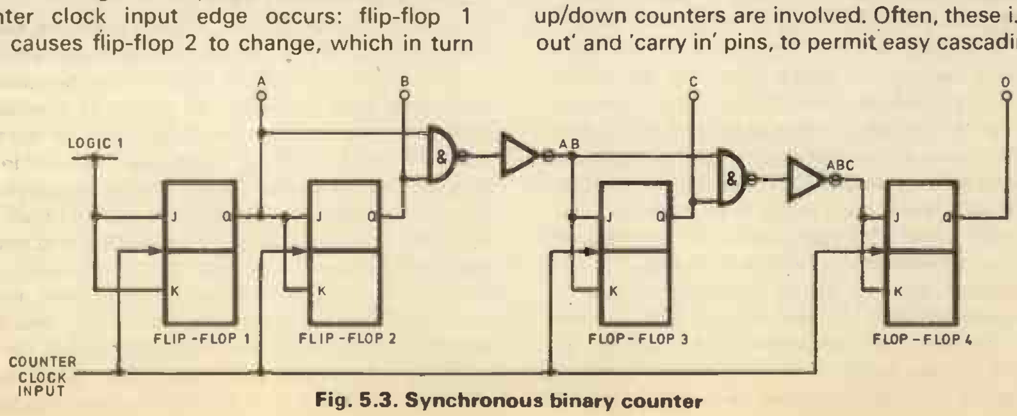


Fig. 5.3. Synchronous binary counter

Once again, data sheets and books should be consulted for detailed applications of counters including asynchronous and synchronous cascading where appropriate: there are far too many different possibilities and circuits to go into here. The discussion of synchronous versus asynchronous working, and the potential errors introduced into logic systems, leads us naturally on to look at the whole aspect of errors in sequential logic circuitry, these errors being collectively known as 'hazards'.

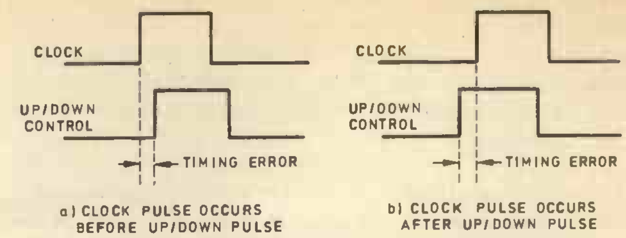


Fig. 5.4. Race hazards in an up/down counter

HAZARDS

Due to manufacturing variations and tolerances and to physical limits on the speed of propagation of electric signals, various delays and timing differences are always present in logic circuitry. Outputs of gates change a finite time after the input has changed; counter or latch outputs do not all change simultaneously, etc. We can classify the effects and types of errors in circuit operation due to these timing differences. A 'hazard' is an incorrect or invalid state of a logic output and a 'race' is the time difference between the changes of various outputs within the circuitry; hence, some races cause hazards.

'Transient Hazards' are caused by, and occur for the duration of, the delay between the input of a circuit changing and its output changing. The error in the circuit operation is only present during this propagation delay period, and hence it is a short duration, or transient effect. However, if this transient hazard results in a permanent error in the following circuitry's state (a flip-flop is reset, for example, when it should not have been) then the error is termed a 'Static Hazard'. Timing differences between supposedly simultaneously changing outputs of a circuit are known as 'races'; the output changes of a ripple counter are a good example of a race, because, as already discussed, output changes do not occur simultaneously, but in succession. If a race gives rise to a permanent error (i.e. a static hazard) in the state of the following circuitry, then it is known as a 'Critical Race'. Any other types of hazard all fall under the overall category heading of 'Race Hazards'.

There are forms of mathematics which can be used to describe and manipulate the design of sequential circuits, using similar (but more complex) types of 'maps' to those used in 'Boolean Algebra' as discussed in Part 1 of this series. Unfortunately, they are very complicated indeed and far too involved for us to look at even briefly. These mathematical techniques have procedures for removing all the above mentioned hazards or at worse reducing them to transient effects only, but to avoid going deeply into the mathematics we shall have to be content with a rather more intuitive, common sense approach to the problem.

TYPICAL PROBLEMS

Hazards are typically caused by trying to have too many sequential circuit elements fed from the same single logic change. A frequently seen design error is to have the same control used to reset a flip-flop (or counter) as is used to latch the output of that flip-flop (or counter); in this case, correct operation of the circuit is obviously dependent on the latch being operated before the device is reset, not the other way round. Similar problems can be encountered with up/down counters; see Fig. 5.4. If the up/down control is at logic 1 when the clock input goes to 1, the device counts up; if the up/down is at logic 0 when the clock input goes to 1, it counts down. If the same pulse is used for both the up/down control and the clock, then depending on which delays in the i.c. are greater, the counter could count down as shown in Fig. 5.4a or up as in Fig. 5.4b. In practice it is usually found that the circuit will sometimes count up and sometimes down. The effects are unpredictable. Note also that these delays (and hence the timing errors) can be both internal to the i.c. and external to it in the control logic and other surrounding circuitry.

Another often seen design error is to have the input to a flip-flop or other sequential i.c., dependent on the output of the same i.c., often via an indirect path of combinational gates. In some instances this is allowable; self re-setting of counters, for example, and divide-by-two circuits as discussed last month. However, it is frequently the cause of race hazards, and should be avoided in most cases. Finally, be aware that some counters, shift registers, etc., give out short transients on their outputs when in the process of being reset. Although these are only transient hazards, they could become static if the following circuitry is not carefully designed to allow for this effect. This is not usually a problem, as most devices do not exhibit this fault, but it is worth bearing in mind. TTL seems worse than CMOS in this respect.

THE ELIMINATION OF HAZARDS

Generally speaking, the best way to design out hazards is to ensure that only one change in a logic signal path happens at a time, or, if several supposedly simultaneous and related changes occur, to arrange that the following circuitry is not dependent on receiving all its inputs at exactly the same time. Often, extra gates or sequential devices have to be added to isolate or avoid potential hazard situations.

There are several techniques employed to space apart 'events', or critical logic changes, in time. Fixed time delays can be added to the relevant parts of the circuitry using monostable timer i.c.s or simple resistor/capacitor networks as already discussed in this series. The time delays necessary are usually very short indeed, so small values of capacitor and large values of resistor can be used (usually a few hundred picofarads and a few hundred kilohms) which places negligible loading on the outputs of CMOS logic, causing no 'glitch' or transient problems. In fairly simple circuits, sufficient time delay can be added by passing the offending logic signal through a few spare gates in series, acting as inverters or buffers as required. The propagation delay of most CMOS gates is between 20 and 100ns and this is often sufficient to compensate for a slight timing error elsewhere. The addition of gates in the signal path is the technique usually employed within i.c.s to correct for time delay errors and races, and remove potential hazards. In fact, the only way in which some flip-flops, counters, and shift registers can actually work at all is by utilising propagation delays. In the basic binary counter shown in Fig. 5.2, the circuit action is based on there being a finite propagation delay between each flip-flop's D input state being clocked in, and that flip-flop's Q and $\overline{Q}$ outputs changing. If this delay did not occur, the $\overline{Q}$ output could never be used to feed back to the D input; the device would just sit in an indeterminate state. The synchronous counter, Fig. 5.3, is similarly dependent on propagation delays for its correct operation.

It may be possible to avoid hazards by using both edges of a pulse, instead of just one edge, often necessitating the inversion of the edge of the incorrect polarity. Hence, one event may be caused to occur by the 0 to 1 transition, and the other event by the 1 to 0 transition, spacing them apart by the width of the clock pulse, in a similar way to the two pulses derived in the "PE Pulser" described earlier in the series. Beware, though, that it is often bad practice to use edges for implementing several functions simultaneously, because (as mentioned in the case of synchronous counters) different logic inputs can trigger at different points on the waveform edge. In these instances it is wise to keep the edge as fast and 'clean' (i.e. noise free) as possible.

If a number of events must be made to happen in a fixed sequence, it may be necessary to add some form of sequencer to control them. For example, a shift register or decimal counter could be used, with each parallel output connected to the relevant circuit to be controlled. Finally, one should remember that most transient hazards are only a few nanoseconds long, which is often too short to trigger logic probes.

RANDOM PULSE GENERATION

We've been concerned until now with the removal of noise, transients, and other spurious effects from our logic circuitry. There are, however, situations which actually require this type of logic change: random number generators! These are often used in statistical work, for testing purposes, or more usually in games and gambling machines!

In its simplest form, the generator can be a very fast running oscillator (10 or 100kHz typically) gated on and off by a pushbutton switch, and feeding a counter, as shown in Fig. 5.5. The frequency should be selected such that many complete counter cycles occur in 0·1 seconds. By this means, there is no way in which the person pressing the button can pre-judge the value of the counter output. However, if a second oscillator is being used to gate the first on and off, patterns of output numbers will be seen to occur after a time. A 'pseudo-random' number sequence can be generated by feeding the counter from a clocked shift register with various combinations of gates taking parallel outputs of the register and feeding them back, suitably combined, into the serial input. This technique will still cause repeats of patterns, although it can take many thousands of counts before any repetitions are obvious. Finally, a 'pure' noise source can be used, such as the amplified noise generated by the reverse biasing of a transistor junction.

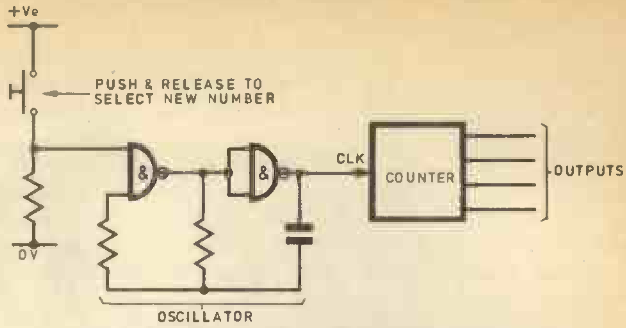
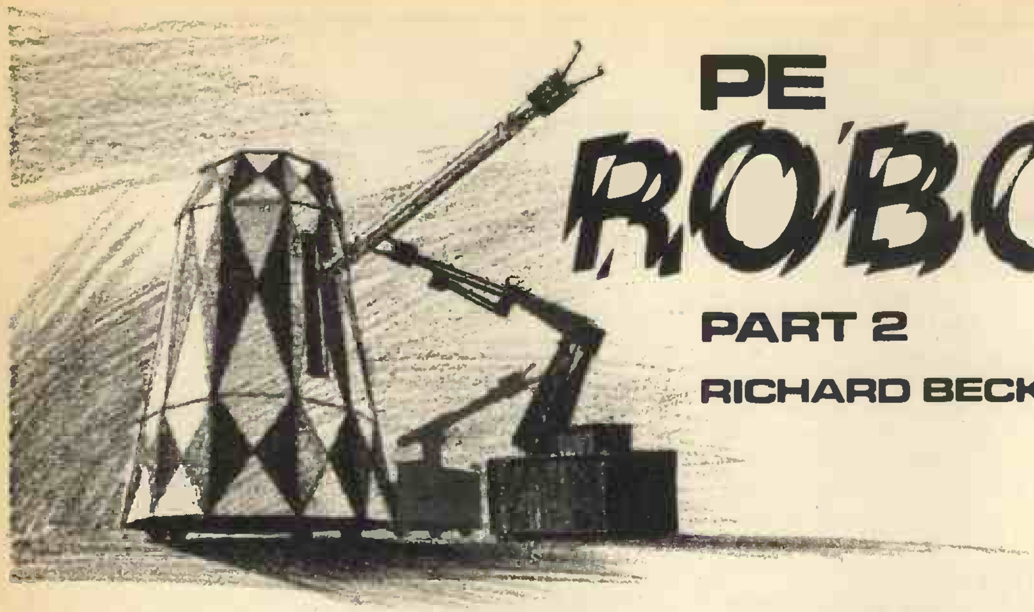


Fig. 5.5. Simple random number generator

Our project this month is Space Evaders on page 22.

NEXT MONTH

Next month we cover Numerical Systems — the various codes and arithmetic used in digital electronics, and the driving of numerical displays.



PE ROBOTS

PART 2

RICHARD BECKER · TIM ORR

ALTHOUGH the Genesis series of hydraulically powered robots can be controlled by a simple bank of push-button switches energising solenoid operated valves, it is necessary to use an electronic control system with feedback to take full advantage of the power and the versatility of these machines. Feedback of positional information is a feature included in these machines, which, although essential for reliable repeatability, is absent in the majority of all other low cost machines, severely restricting their use as emulators of the mainstream industrial robots. The block diagram of the microprocessor based control system is shown in Fig. 2.1.

MICROPROCESSOR UNIT

The heart of the system is the microprocessor unit which performs the task of overseeing the complete system and issuing control signals in response to arm positional data, programmed-in commands, commands from the control box or information from an external computer. With its CMOS memory it stores the positions of the arm and by using servo techniques will instruct the robot to repeat the sequence of tasks programmed in. Each of the arm and joint positions is defined by an 8 bit word giving a resolution of 1 part in 256 (0·4%). Data is transferred to and from the interface board by 8 bits in parallel whilst data is received from the control box serially, permitting the use of a simple infra-red link to be used for controlling the Genesis M101 mobile machine. In the interests of standardisation, interfacing with an external computer is via an RS232C serial interface with a range of baud rates between 300 and 9600. Although this facility is included, an external computer is by no means necessary as the system's own processor and operating system provides all the functions normally required.

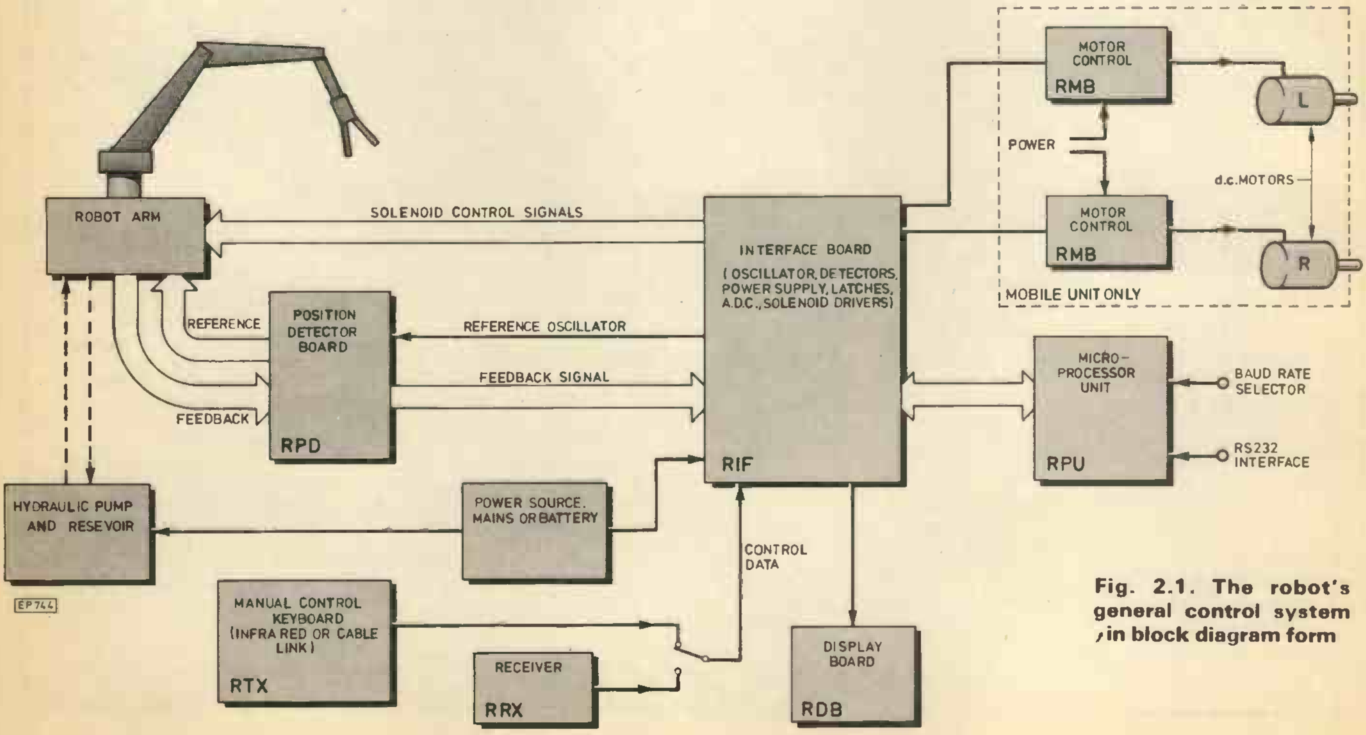


Fig. 2.1. The robot's general control system in block diagram form

COMPONENTS . . .

INTERFACE BOARD

Resistors

R1	47
R2	1k
R3, R4, R7, R9, R12,	10k (5 off)
R5, R8, R10, R11, R21	100k (5 off)
R6	110k
R13	15k
R14	100
R15, R18	220 (2 off)
R16	2Ω2
R17	2k2
R19	2k7
R20	1k2
R22	10
R23, R24	4k7 (2 off)
R25	4Ω7
R26	330
R27	1Ω5 2 Watt
R28	18k
R29	47k
R30 A-E	10k 1% (5 off)
R31 A-E	20k 1% (5 off)
R32, R33 A-E	100k 1% (10 off)
R34 A-E	68k (5 off)
R35, R36 A-E	47k (10 off)
R37 A-E	24k (5 off)
R38, R39, R42, R43 A-E	100k (20 off)
R40 A-E	390k (5 off)
R41 A-E	150k (5 off)
R44 A-E	22k (5 off)
R45	1 2W

All resistors $\frac{1}{4}$W 5% unless otherwise stated

Potentiometers

VR1 A-E	470k preset (5 off)
VR2 A-E	100k preset (5 off)

Capacitors

C1, C2	15n (2 off)
C3, C4, C11, C29, C30, C36	10µ/16V tant. (6 off)
C6	470µ/10V elect.
C7	220n Siemens B32560
C8	2200µ/10V elect.
C9	100n
C10	100n
C5, C12–14, C20	100µ/16V elect. (5 off)
C15–18	1µ/16V tant. (4 off)
C19, C21, C22	4700µ/16V elect. (3 off)
C23–27	47n/50V disc cer. (5 off)
C28	470p Piher ceramic
C31	470n/35V
C32–35	680p Piher ceramic (4 off)
C37 A-E	47n B32560 (5 off)
C38–41 A-E	15µ B32560 (20 off)
C42, C43 A-E	33n B32560 (10 off)

Transistors and Diodes

D1	1V2 Zener BAND GAP
D2	2V7 BZY 88
D3	10V BZY 88
D4	5V6 BZY 88
D5, D7, D8A-E, D9A-E	1N4148 (12 off)
D6	1N4002
TR1	BFY 51 (or 2N699)
TR2	BC182L

Integrated Circuits

IC1	74LS123
IC2	74LS132
IC3	74LS00
IC4	74LS175
IC5, IC7 a-e	LM324N (6 off)
IC6	LM383
IC8	ICL 7660 CPA
IC9, IC10	7805 (1 Amp TO220) (2 off)
IC11–14	ULN2003 (4 off)
IC15–19	74LS373 (5 off)
IC20	ADC 0804
IC21	4051 B

Miscellaneous

Printed circuit board RIFb
S1 SPST switch
Link-through 0·84mm dia. (approx. 200 off)
TV5 heatsink
1·25 QY heatsink (drilled for two TO220)
TB1 4-way screw terminal
PL2–PL6, PL8 10-way Molex p.c. pins (6 off)
PL7, PL9, PL10 5-way Molex p.c. pins (3 off)
SIP1, SIP2 SIP 1k networks (2 off)
SIP3 SIP 4k7 network
20-pin i.c. sockets (6 off)
16-pin i.c. sockets (3 off)
14-pin i.c. sockets (8 off)
8-pin i.c. socket
20mm p.c. mounting fuse holder
20mm 1·5A fuse

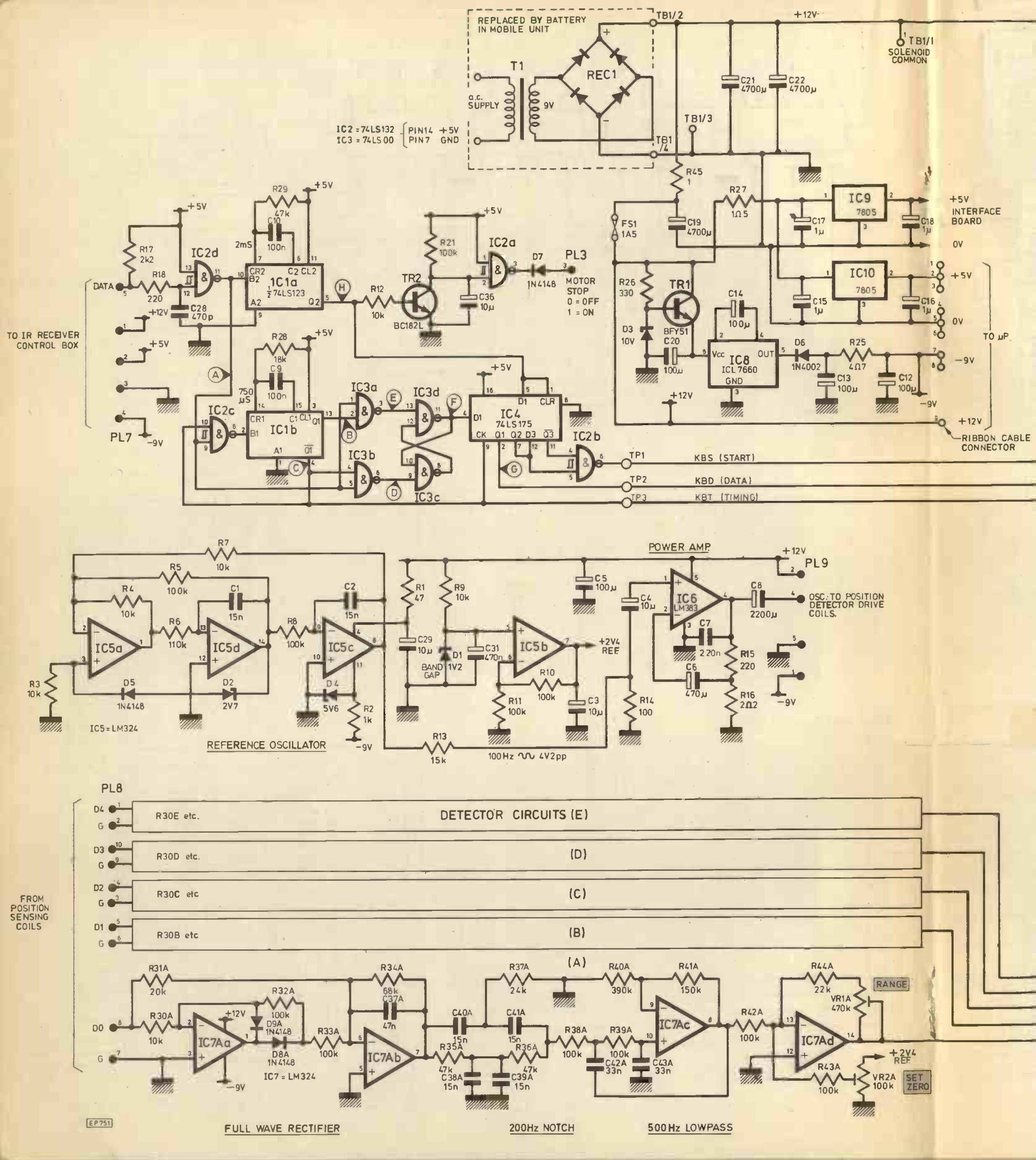
Constructor's Note

Complete kit of parts for this project can be obtained from Powertran Cybernetics, Portway Industrial Estate, Andover, Hants SP10 3WN. ✆ Andover (0264) 64455.

Prices are as follows . . .

Genesis M101 4 axis model (excluding wheel base)	*£295.00*
Genesis M101 5 axis model (excluding wheel base)	*£345.00*
Genesis M101 wheel base	*£79.00*
Genesis P101 4 axis model	*£450.00*
Genesis P101 6 axis model	*£545.00*
Genesis S101 4 axis model	*£355.00*
Genesis S101 5 axis model	*£405.00*
Position detector coil set for M101, S101 4 axis models	*£15.00*
Position detector coil set for M101, S101 5 axis models	*£19.00*
Position detector coil set for P101 4 axis model	*£15.00*
Position detector coil set for P101 6 axis model	*£24.00*
Position detector board for M101, S101 4, 5 axis models	*£6.50*
Position detector board for P101 4, 6 axis models	*£7.50*
Motor drive board for M101 wheel base (2 required per machine)	*£11.50*
Control electronics for M101 (microprocessor board, interface board, display board and mounting bracket)	*£135.00*
Processor box for S101, P101 (microprocessor board, interface board, display board, power supply, interface cables, conduit, cabinet)	*£175.00*
Parts for RS232C interface (fits on microprocessor board)	*£14.50*
Hand held controller box for M101 (includes infra red transmitter and rechargeable battery)	*£47.00*
Hand held controller box for S101	*£33.00*
Hand held controller box for P101	*£33.50*

All prices subject to 15% V.A.T.


REPLACED BY BATTERY IN MOBILE UNIT
a.c. SUPPLY
T1
9V
REC1
TB1/2
TB1/3
TB1/4
TB1/1 SOLENOID COMMON
+12V
C21 4700µ
C22 4700µ
IC2 = 74LS132
IC3 = 74LS00
PIN14 +5V
PIN7 GND
R45 1
FS1 1A5
C19 4700µ
R27 1Ω5
IC9 7805
C17 1µ
C18 1µ
+5V INTERFACE BOARD
0V
IC10 7805
C15 1µ
C16 1µ
+5V
0V
TO µP
-9V
+12V
RIBBON CABLE CONNECTOR
R26 330
TR1 BFY51
D3 10V
C20 100µ
C14 100µ
IC8 ICL7660
Vcc
OUT
GND
D6 1N4002
R25 4Ω7
C13 100µ
C12 100µ
R29 47k
C10 100n
2mS
IC1a ½ 74LS123
R17 2k2
R18 220
IC2d
DATA
C28 470p
TO IR RECEIVER CONTROL BOX
PL7
R21 100k
TR2 BC182L
R12 10k
C36 10µ
IC2a
D7 1N4148
PL3
MOTOR STOP 0 = OFF 1 = ON
R28 18k
C9 100n
750 µS
IC1b
IC2c
IC3a
IC3b
IC3c
IC3d
IC4 74LS175
IC2b
TP1 KBS (START)
TP2 KBD (DATA)
TP3 KBT (TIMING)
R7 10k
R5 100k
R4 10k
C1 15n
R6 110k
R8 100k
C2 15n
IC5a
IC5d
IC5c
R3 10k
D5 1N4148
D2 2V7
D4 5V6
R2 1k
IC5 = LM324
REFERENCE OSCILLATOR
R1 47
R9 10k
C29 10µ
D1 1V2 BAND GAP
C31 470n
IC5b
+2V4 REF
R10 100k
R11 100k
C3 10µ
R13 15k
100Hz 4V2pp
POWER AMP
C5 100µ
C4 10µ
IC6 LM383
C8 2200µ
PL9
OSC. TO POSITION DETECTOR DRIVE COILS.
C7 220n
C6 470µ
R14 100
R15 220
R16 2Ω2
PL8
DETECTOR CIRCUITS (E)
R30E etc.
R30D etc.
(D)
R30C etc
(C)
R30B etc
(B)
(A)
FROM POSITION SENSING COILS
R31A 20k
R30A 10k
IC7Aa
R32A 100k
D9A 1N4148
D8A 1N4148
R33A 100k
IC7 = LM324
R34A 68k
C37A 47n
IC7Ab
C40A 15n
R35A 47k
C38A 15n
R37A 24k
C41A 15n
R36A 47k
C39A 15n
R38A 100k
R39A 100k
C42A 33n
C43A 33n
R40A 390k
R41A 150k
IC7Ac
R42A 100k
R44A 22k
VR1A 470k
RANGE
IC7Ad
R43A 100k
VR2A 100k
SET ZERO
EP751
FULL WAVE RECTIFIER
200Hz NOTCH
500Hz LOWPASS

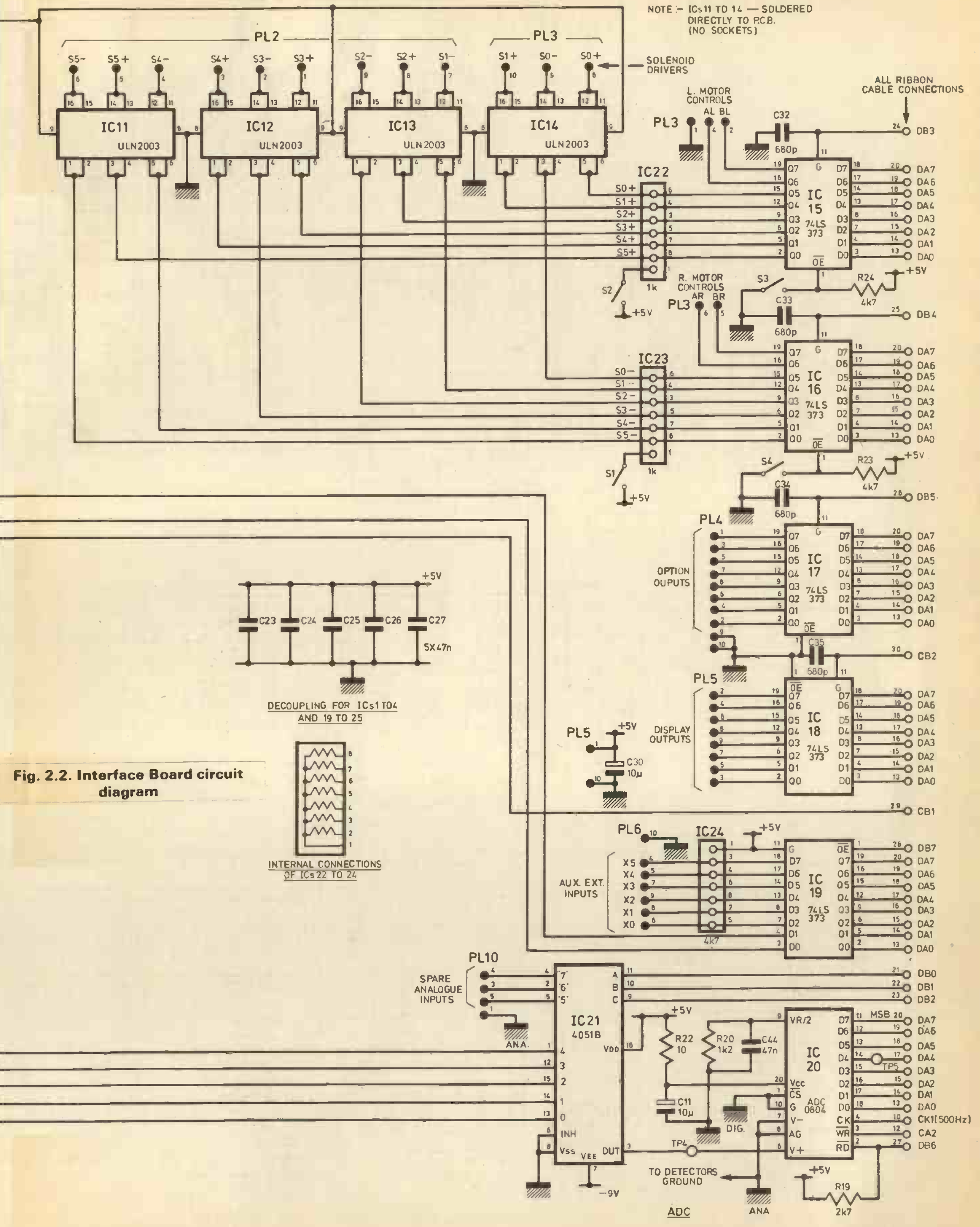


Fig. 2.2. Interface Board circuit diagram

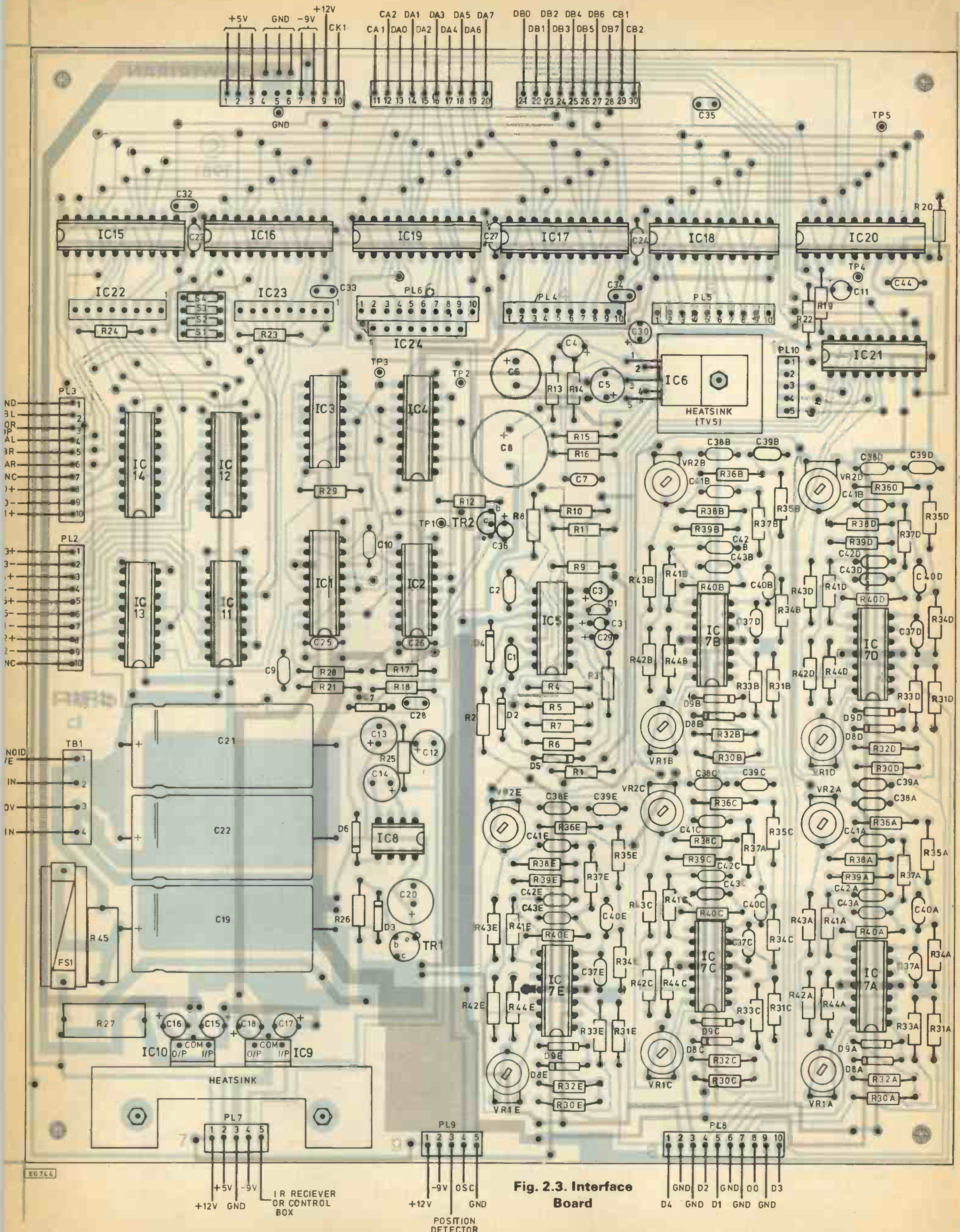


Fig. 2.3. Interface Board

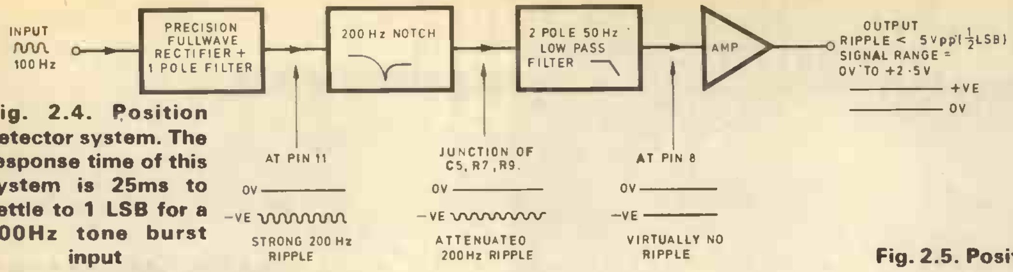
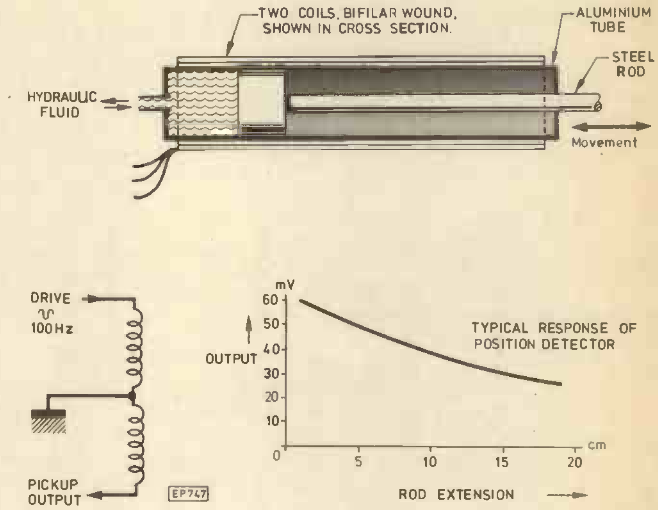


Fig. 2.4. Position detector system. The response time of this system is 25ms to settle to 1 LSB for a 100Hz tone burst input

Fig. 2.5. Position detector



INTERFACE BOARD

This board produces the power supply rails for all the electronic units; it also generates a precision reference sinewave for the position detector units. It detects the position feedback data and converts it to a d.c. voltage which is then multiplexed into an ADC. This then delivers its data to the microprocessor. All data into and out of the microprocessor is held in latches on this board. The solenoid valves are driven by Darlington power drivers which are themselves driven by the latched data. This board together with the microprocessor board fits on the rotating platform of the M101, but for the bench mounting S101 and P101 there is a separate cabinet which encloses the pair of them.

CIRCUIT OPERATION

Refer to interface board (Figs. 2.2 & 2.3). The power supply is relatively simple. Most of the electronics runs from +5V which is obtained from two regulators IC13 and IC14. The positive unregulated rail is used to power op. amps. and some other devices, and is nominally +10 to +12V. A negative rail is needed to power the op. amps. and so a d.c. to d.c. converter is used (IC12). This delivers −7 to −9V at about 40mA. This is quite a low current and so it is necessary to use low power op. amps. (LM324 quad devices).

Latches IC19 to IC23 latch data into and out of the microprocessor section. Latches IC19 and IC20 send data to the Darlington drivers which drive the solenoid valves (Fig. 2.6). The solenoids need 600mA of current drive and so two drivers are paralleled to provide enough drive. Because of the high current, i.c. sockets are not used for these drivers. The ULN2003 also has internal protection diodes to prevent damage from back-e.m.f.s from the solenoids. The latches can be turned on and off (tri-state outputs) so that the solenoid drivers can be manually tested, i.e. tested without the microprocessor.

The position detectors use a magnetic coupling principle (Fig. 2.5) which avoids any electrical contacts on moving parts. Two coils are wound on a tube that fits on the outside of the non-ferrous hydraulic cylinder. A sine wave is fed to the drive coil and it is detected on the pickup coil. The size of the pickup signal depends on the magnetic coupling between the coils, which is dependent upon the position of the steel actuator rod (see graph). The pickup signal is attenuated by about 30dB relative to the drive signal and changes by about 6dB at the operating frequency of 100Hz. Fast response in the system is ensured by the carefully designed detector electronics which has a very short settling time.

The reference oscillator is a state variable filter with positive feedback (IC5). A low distortion sinewave (total harmonic distortion of about 1%) is fed into a power amplifier (IC6), which is used to drive the position detector coils. The position detector electronics consist of a precision full-wave rectifer, a notch filter and a lowpass filter, see Fig. 2.4. Half. wave rectification can be seen at the junction of D2/R3. Full-wave rectification occurs by mixing this signal with the original. The smoothed full wave rectified signal has a strong

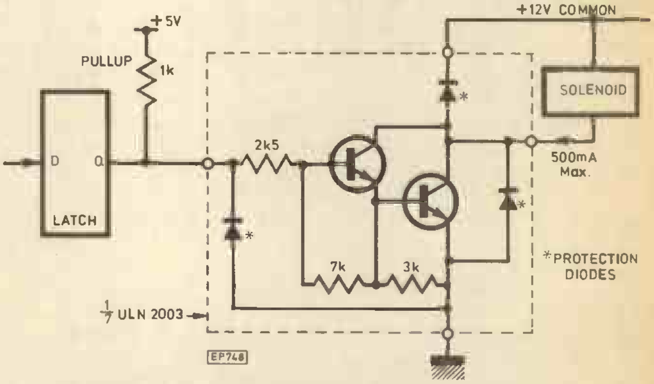


Fig. 2.6. Darlington drivers for solenoids

200Hz component and theoretically no 100Hz component. The 200Hz component is attenuated by the notch filter and it is then further filtered by a 50Hz lowpass filter. The last stage of the detector is a variable gain stage with a variable d.c. offset. The output voltage should be 0V with the actuator extended, and +2·5V with it retracted. There are 5 detector circuits on the interface board, although only 4 are used on the M101 and S101 robots, i.e. one for each movement except the gripper where there is little advantage in knowing how *open* its fingers are. The five detector output voltages are multiplexed (IC25) into the micro-processor controlled ADC (Analog to Digital Converter), IC24. Conversion time is about 20 microseconds. IC1, 2, 3, 4 are used to detect the incoming data from the manual control unit which will be discussed in a future part.

NEXT MONTH: Display and Motor boards, plus mobile wheel base.

Semiconductor UPDATE...

FEATURING LM1894 ICL7663 Z800

R. W. Coles

NOISES OFF

The trouble with noise reduction systems like Dolby is that audio signals have to be encoded before transmission or recording for the technique to work. The principle employed relies on the pre-emphasis of high frequency sounds before recording, and the de-emphasis of those portions of the audio spectrum during replay. Troublesome noise sources introduced during the recording and replay phase such as tape "hiss" are *not* boosted during pre-emphasis but *are* attenuated during de-emphasis with the result that the high frequency noise "floor" is dropped by up to 10dB for the Dolby B system. All this is fine if signals are properly encoded by means of pre-emphasis before reproduction, but it cannot help at all in the case of un-encoded signals such as most radio broadcasts, records, and old tape recordings.

A new technique called Dynamic Noise Reduction (DNR), while probably not replacing Dolby where it can be most effectively employed, in cassette systems for example, offers the major advantage of being completely independent of any sort of pre-emphasis or encoding and therefore usable with any kind of audio source—even old 78 records! This technique relies on the phenomenon of auditory masking exploited by the use of signal controlled bandwidth reduction in the replay or receiving equipment only.

Taking advantage of the fact that aggregate noise output is proportional to the bandwidth of the system, DNR acts to reduce bandwidth or frequency response when only low audio signal levels are present, while increasing it to the maximum possible during louder passages. While the signal level is high, then no noise reduction takes place in the DNR circuitry, but the human ear can happily take care of these situations unaided thanks to the auditory masking of the lower level high frequency noise components during loud passages.

Electronically, the audio signal is fed through a low-pass filter with a variable cut-off frequency which is "tuned" dynamically by the incoming signal level. To ensure a well balanced response, it is necessary to pass the incoming signal through a high-pass filter with a 6dB per octave slope and a −3dB point at about 6kHz before using this to generate the filter control signal. This ensures that a loud low frequency signal opens up the bandwidth less than a loud high frequency signal.

National Semiconductor have produced one chip that does the whole job, coded LM1894. It contains two variable low-pass filter sections (for stereo applications), a summing amplifier to combine the two input signal channels, and a detector and voltage to current converter to drive the filters. All you need in addition to the LM1894 and its 14 pin plastic package are a few resistors and capacitors, and maybe a 19kHz filter coil if the circuit must handle stereo broadcast signals.

(At the time of going to press, the LM1894 is not available, as National are considering the introduction of a licensing system, similar to that presently being operated by Dolby.—*Ed.*)

CMOS REGS

Those Intersil whizz-kids who showed us that CMOS wasn't just a logic technology have done it again. Their latest CMOS chip is going to be very useful in very many applications, in fact now that I have seen the spec. I can't help wondering how we managed to get by without it all these years!

On offer are their ICL7663 and 7664 voltage regulators, but these regulators are unique in: a) being made in CMOS, and b) having a standby current consumption of just 4 microamps—maximum! The new chips are ideal for battery powered instruments that need stable supply rails, and they can handle supply currents from only 1 microamp to a respectable 40 milliamps over a voltage range adjustable from 1·6 to 16 volts with an input-output voltage differential of only 50 millivolts.

You can even use these babies as switches to save even more precious juice during your system's idle moments, a simple logic command is all you need to use them as an on/off switch, just like on those fancy l.c.d. calculators which turn themselves off when you ignore them for long enough.

The ICL7663 handles positive voltages and the 7664 negative voltages, and in their 8 pin mini-dip packages they will only set you back a pound or two, a bargain if ever I saw one!

CORPORAL ZILOG?

You may remember me mentioning the "Captain Zilog" comic strip character and his heroic deeds among the index registers of the Z8000 sixteen bit microprocessor. Well the 16 bit race is now old hat, and Zilog seem to have retired their hero on full pay. Not that he was a complete success, because it now seems that the Intel 8086 and the Motorola 68000 are selling rather better than the Z8000, probably because Intel were first and Motorola have (arguably) the better chip.

Another possible reason for the lack-lustre sales performance of the Z8000, despite the tremendous success of the eight bit Z80, could be the lack of an "in between" processor to bridge the gap from eight to full sixteen bit performance. Intel have their 8088 which is really an 8086 inside working with a multiplexed eight bit bus outside to keep system costs low, and Motorola have the 6809 which is rather like a souped up 6800 with a lot of internal sixteen bit operations which the earlier 6800 lacked.

Now Zilog are not an outfit to let the grass grow under their feet, and to meet the challenge they are about to introduce a new device which could prove more popular than either the 8088 or the 6809 since it will build directly on their acknowledged success with the Z80. The new chip will be known as the Z800 (surprise surprise!) and it will offer complete code compatibility with the Z80 so that system upgrade will be possible without rewriting software, something which neither of the competitors can claim. Despite its ability to run Z80 programs, the Z80 is a true 16 bit machine internally with a very advanced performance which will allow even old Z80 stuff to run three to five times faster, with even better results available when new programs are written to take full advantage of the 16 bit architecture and new opcodes.

The Z800 will also be available in two basic versions. The first of these uses a non-multiplexed eight bit bus compatible with existing Z80 systems which offers a very simple performance increase to established Z80 users. When users are ready for yet more power, they can switch to the second version which has an 8088 type multiplexed bus to make better use of its sixteen bit architecture. After that gentle rise in capability, Z800 users are expected to find the switch to full Z8000 sixteen bit designs a painless procedure!

All this is interesting of course, but all I am waiting for is the new comic—featuring *Corporal* Zilog no doubt!

WESTERN SUPPLIER

In last October's Semiconductor Update, one of the featured devices was the WD55 from Western Digital. I mentioned that it was available in this country from Jee Distribution of Hayes, Middlesex. Now I am informed that Jee do not stock the WD55, but it is available from Pronto Electronic Systems of Ilford, who are distributors for Western Digital.

Step-by-step fully illustrated assembly and fitting instructions are included together with circuit descriptions. Highest quality components are used throughout.

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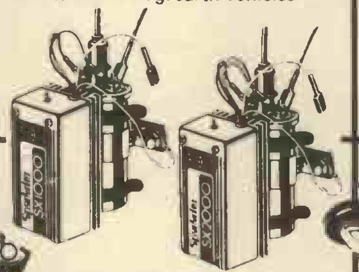

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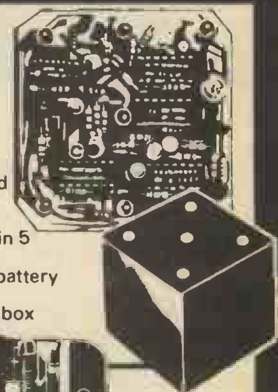

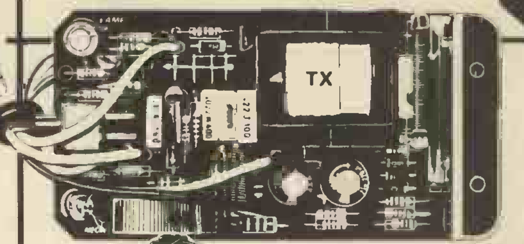

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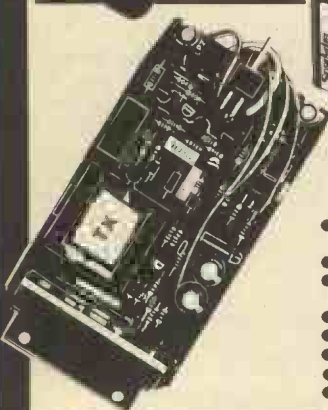

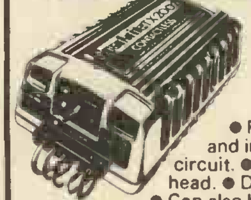

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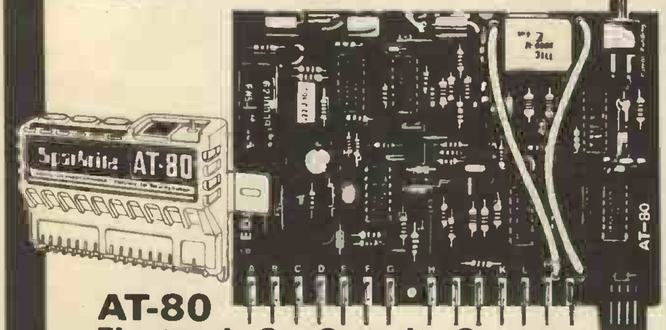

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FRANK W. HYDE

THE SECOND SHUTTLE MISSION

After the first and historic mission of the spacecraft Columbia there was widespread excitement, and relief that the mission had achieved its object. Naturally there was the enthusiastic reaction and speculation that there would be an immediate turnround programme for a second mission. However, after the first inspections and examination of various items of a physical nature, some of the data concerning the aerodynamics, coupled with the new programme for the second and perhaps vital trial, more time has been needed before orders to proceed were forthcoming. By the time you read this, history will have determined the way in which the programme will proceed after the second mission.

The sophistication of the electronics involved in space programmes is extensive and much of the practice is well known to those familiar with the art. Perhaps in some ways many people have become somewhat blasé about the whole business. Yet those engaged directly or indirectly with the space programme are still very conscious of the implications for the future. The public generally have come to regard even Columbia as a secondary matter to pop stars and football. While many of those close to the matter do regard such an attitude as heresy, the fact is that the very attitude is in a way complimentary. The main theme of any activity seems to contain a large element of gladiatorial stimulus. The fact that space activities are commonplace and do not have great disasters, takes from the matter the excitement required. It is significant perhaps that this really is an admission that modern technology *is* reliable.

The second mission of Columbia, with USAF Colonel Joe H. Engle and Navy Captain Richard H. Truly, will be carrying out an extensive survey of the many unknowns which became evident in the first flight. There were some unusual events noted on the first mission with regard to aerodynamics. The two Astronauts have been preparing certain planned manoeuvres by using the Singer Link simulator. These relate to some complicated supersonic and hypersonic techniques for re-entry plans. The data obtained will provide information about the vehicle's centre of gravity, angles of attack and flight stability and performance required by the differing characteristics of the various payloads. It is clear already that an important point in re-entry is manual control. Both Astronauts will be very busy on this trip for there are 19 groups of manoeuvres to be made. Some of them allow intervals of only 20 seconds between sequences.

On the first mission the vehicle was quite stable. Bank reversals were manually flown at Mach 5 and Mach 2·8 but did not use manual control; apart from that, until reaching an altitude of 35,000 ft no manual control was exercised. One of the reasons for this was that at Mach 5 and Mach 2·8 there were stability questions in those two areas. Mission 2 will operate manual control slightly differently. The Mach 5 and Mach 2·8 manoeuvres will be flown automatically because they were found to be stable in practice. However the initial bank manoeuvre will be initiated somewhere about Mach 24 to 25 with manual control and reach up to 80° bank at an altitude of 260,000 ft. In this area more precise control can be maintained manually than could be achieved by automatic control. It was in fact at this point on Mission 1 that a roll oscillation that exceeded the expected sideslip occurred.

The importance of the simulator in the whole scheme of vehicle control is exemplified in the remarks made by the first of the Shuttle crews. Both Young and Crippen have already made reference to the fact by such remarks which indicated that actual experience of re-entry was helped enormously by the time spent with the simulator. It is here perhaps that tribute should be paid to such men as Major Steven R. Nagel of the USAF who specialises in shuttle re-entry issues. During re-entry the incoming data is mainly from dynamic pressure and velocity. Dynamic pressure is most active above velocities of Mach 22 at an altitude about 238,000 ft. Below this the velocity is the more useful parameter from which to initiate the next manoeuvres. Great use is made of 'cue' cards in much the same way that aerobatic teams operate. With the Shuttle the cues relate for example to the dynamic pressure or the velocity at which to initiate action and a minimum level of control system propellant below which any manoeuvre would not be continued. There will be a time at re-entry when communications after the radio black-out period will be kept to a minimum. This is to allow the astronauts maximum concentration at about Mach 10.

THE NEW INDUSTRIALISATION

The success of the first Shuttle mission and the soon to be realised hopes of the second, is already accelerating the vanguard of *new* things and the rapid development of those begun. Robotics has an important part to play here. The success of the USSR in their unmanned automatic missions to embryo space stations gives new impetus to the extension of man's peaceful pursuits in recovering the fruits of the Earth and its environs. The reduction of certain activities required in any task has been established for more than a century. Now though the mechanical precision is still very much required, it is the control which needs the most attention. There is an opinion among a large group who consider that all things should be done by remote operation. The argument usually is that this reduces mortality. Some reason quite well and plausibly. There is good reason to suspect *fear* is a motivation for some of this. Perhaps it will be possible to be free from this naïve approach when the forecasting aids such as simulators, which can give real time information leaving practically nothing to chance, are used. Though in some instances continuing communication in real time becomes difficult when extensive journeys from the Earth are undertaken, nevertheless this has been shown with the Voyagers to be surmountable.

In the specific instance Marshall Space Flight Center in Alabama have tasks which are being examined by the Massachusetts Institute of Technology under a one year contract to investigate systems of robotics for working in outer space. When work is required to be done in geostationary orbits or others at high altitudes protection for astronauts would have to be extensive. This is due to the high level of radiation and also the conditions of magnetic fields holding charged particles inimical to the biological machine—*man*. The robotic units would of course be immune. It is to be hoped that the robots of film fame have finally disappeared when these matters are discussed and a great deal of engineering skill will not be squandered in making man in his own image. Indeed one robotic unit with which the writer is associated puts all three of the parameters (seeing, feeling and hearing) into one box manipulator. It is perhaps pertinent to point out here that there is always a revival of the 'making machines think' approach. It is on some occasions perhaps worth while asking why people approach the subject from the wrong end, that is thinking of emulation instead of analysing the problem in its reality. The designing of *Automatics* (as the writer would prefer to call them) has been around for a long time and many people do not seem to realise that these form quite a large part of the engineering scene. It is only the advent of some of the new requirements that focuses attention and ideas run riot. Also it has to be remembered that these highly sophisticated units would be in many cases directed at a particular task. If one encountered a space unit not of the kind for which the 'robot' was designed, it would be useless.

This leads to another important point: standardisation. It will be necessary for the builders of new satellites to adopt some common agreement as to configuration. This does not necessarily mean overall but rather the standard units could be those which have a finite lifetime and could have a configuration which was standard including fixing with a homing signal to which it could call the repair unit. This would apply to much of the operating equipment including the replacement of manoeuvring propellants etc.

Whatever may be the progress in this area the final and human way will be to *take a look see*! Nothing in the foreseeable future will take the adventure from the human temperament.

PE BAND-BOX

PART 2 A.J.BOOTHMAN

THIS month the principles and construction of the peripheral system which operates in conjunction with the Microcontroller will be described.

The Band-Box provides a full trio backing of musicians in a single unit and may be programmed by the vocal or instrumental soloist to give automatic accompaniment for some 50 to 100 tunes dependent on the complexity of each score.

THE MICROCONTROLLER

Fig. 3 shows the track layout and component overlay for the p.c.b. and it is advisable to closely inspect this before proceeding, particularly ensuring that bridges are not present between any of the tracks.

The first operation is to insert the track linking pins from the front of the board. Track pins are easily pushed into the holes and broken off from the stick, using a metal implement e.g. screwdriver, the pins can be pushed home with the thumb and then soldered on top of the board. Note that some of the pins are positioned underneath i.c. sockets so that it is essential they are inserted first.

All i.c.s should be mounted in sockets which can be soldered to the board in the same operation as the resistors. In order to avoid confusion later it should be noted that all i.c. sockets have some indication to fix the position of pin 1 and this should be followed at this stage to ensure that orientation of the i.c.s is not confused at a later date. IC1 has pin 1 to the bottom of the board, IC2 to the right, IC3-7 to the left. Memories IC8-11 have pin 1 to the top, IC12-15 to the bottom, monitor IC16 is to the top whilst the spare EPROM position is to the bottom. At this stage the larger components should be soldered to the board. Some difficulty may be experienced in soldering with a 1mm bit on the larger components and a $\frac{3}{32}$in bit may be necessary.

A further inspection of all tracks and connections should be made after assembly of the board including meter checks on adjacent tracks to detect shorts, and then the i.c.s can be inserted into the sockets. IC9, 10, 11, 13, 14, and 15 should be omitted until the complete Band-Box has been tested since they are unnecessary until the first five pages of the score store have been used and there is no point in risking damage to them unnecessarily. When any i.c.s are inserted care should be taken to ensure that all pins correctly enter the socket and do not bend under the integrated circuit. Apart from checking for track shorts and missing solder connections this is the third most common cause of malfunction in high density i.c. based systems.

SYSTEM BOARD

The majority of the electronic hardware, apart from the Microcontroller, is mounted on a single p.c.b. which will be referred to as the system board. A second board contains the displays and a number of keyswitches. The circuitry is best understood if it is split into four parts, music generation, input controls, display and keypads, and the power supply.

MUSIC GENERATION

Before describing the music generation circuitry the method used to generate the audio tones is illustrated in Fig. 4. A set of waveforms is stored in the monitor memory in a similar manner to that shown in Fig. 4(a). In the illustration a complete cycle is divided into sixteen parts and values between 0 and 15 given to approximate the amplitude of the waveform in a stepped manner. In the Band-Box the chord instrument waveforms are split into 64 segments and the bass into 128 segments, both using amplitude values between 0 and 63; however, for diagrammatic simplicity sixteen segments are used in the illustration without change to the principles involved.

In order to produce a sound from the sequence of stored values it is necessary to convert each number into an analog voltage which is achieved using a digital to analog converter (DAC), and provided that an interval of time is allowed to lapse between the moment at which each value is converted by the DAC a stepped waveform will appear at the DAC output. Consequently a method of changing the fundamental frequency of the waveform is apparent by changing the interval of time between samples which if reduced will result in an increase in frequency.

This assumes that each and every stored value requires to be read at varying time intervals, but it is also possible to use a fixed time interval and either skip some values to increase frequency or read some values more than once to reduce frequency. The Band-Box uses this second principle and has a set of increment figures stored in the monitor which accurately correspond to the required amount of movement through the memory, after each fixed time interval, which will produce the required range of fundamental frequencies.

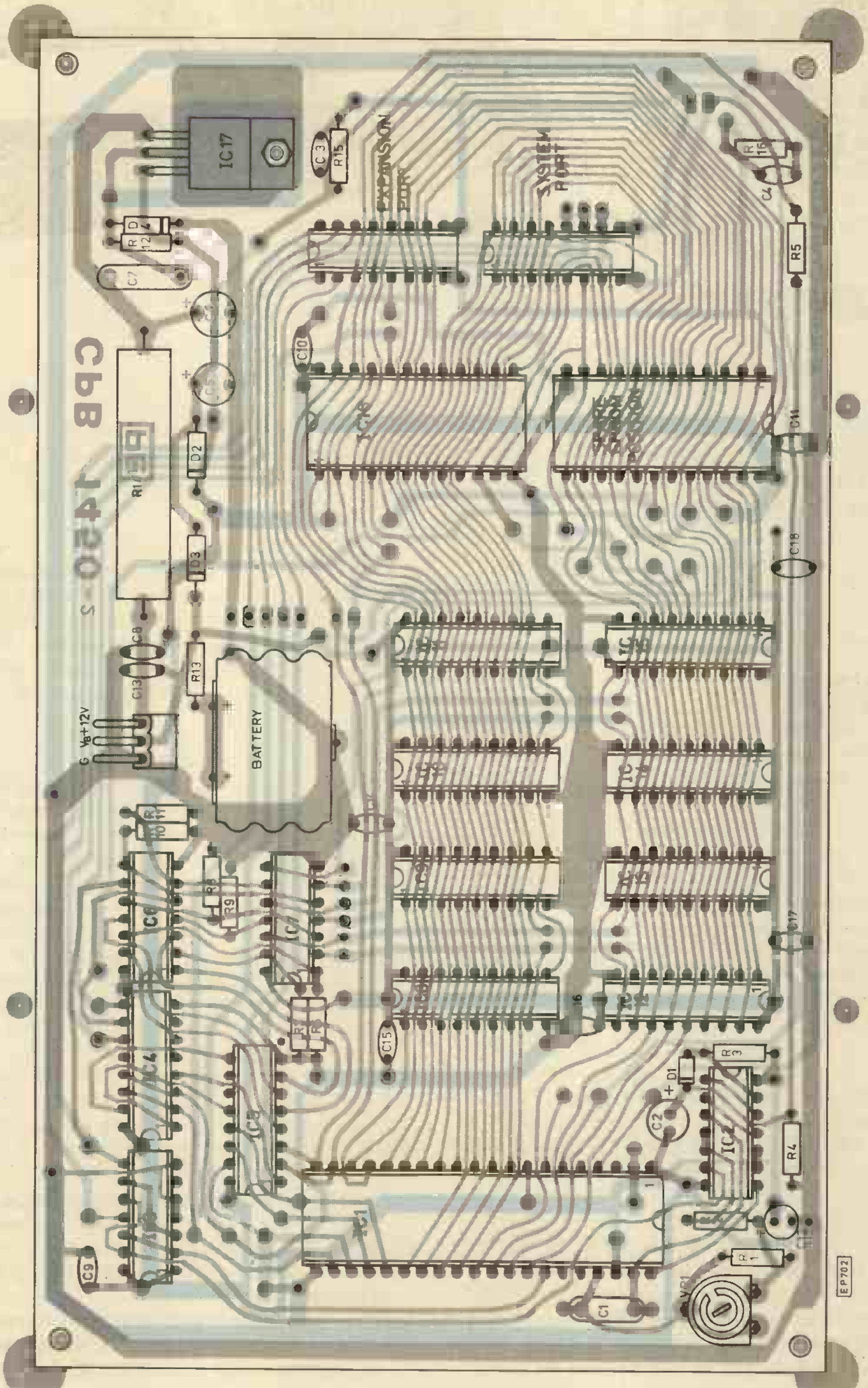

Fig. 3. Track layout and component overlay for the double-side Microcontroller

The effect of different increments is shown in Figs. 4(b-d). Whereas in Fig. 4(a) the X-axis simply represents the memory positions in which the sixteen numbers are stored (0–15), Figs. 4(b-d) are shown in real time at intervals of 0·2ms which roughly corresponds to that used in the Band-Box. The microprocessor is programmed to accumulate one relevant increment per time interval so that for an increment of 0·67 it will count 0, 0·67, 1·33, 2·0 etc., and it looks at the value stored in the memory position given by dropping the following fraction—i.e. position 0, 0, 1, 2 etc. As shown in Fig. 4(b), 24 time intervals are required to complete a cycle using an increment of 0·67, such that the overall period with an 0·2ms interval is 4·8ms, giving a frequency of 208·33Hz. An increment of 1·0 is shown in Fig. 4(c) and since it causes longer jumps through the memory the higher frequency of 312·5Hz results. Fig. 4(d) shows an octave increase in frequency to 416·67Hz due to the corresponding doubling of the increment to 1·33.

Very accurate tuning can be realised using this technique, a factor which has considerable importance in the Band-Box application where the four note combinations used for the chord instrument, which must have high relative accuracy, are produced by programming the microprocessor to separately accumulate increments corresponding to each of the four notes and then add the four waveforms internally to give a composite waveform at the output of the DAC. It will be noticed that the example waveforms shown in Fig. 4 are not of simple sine, square, or triangular variety, but are in fact computed from elements of the fundamental plus overtones at factors of 2, 2·75, 3, 4 and 5·4, a freedom in waveform construction not easily available by conventional synthesizer techniques.

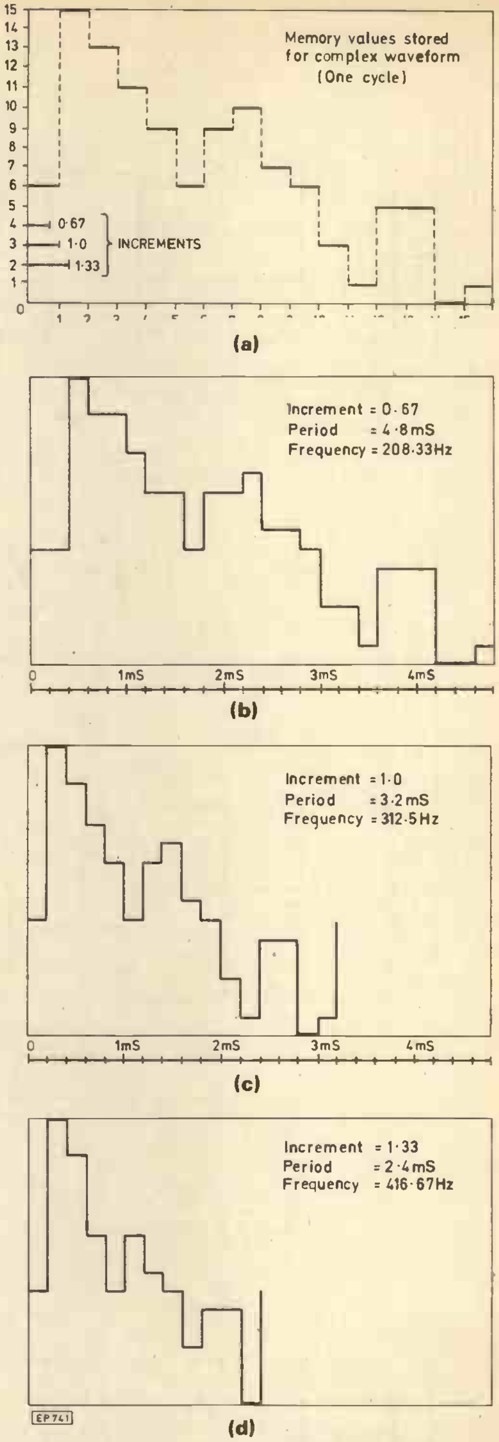

Fig. 4. Music generation principles

MUSIC FROM THE MEMORY

In Part 1 the score store was described in that it contains numbers corresponding to the next action required of the Band-Box. Most instructions give the chord required plus its duration, and when detected by the micro it converts half the number to represent a particular type of chord the notes of which are tabled in the monitor. To cope with the adjustable playback key and movements in chord group which will have occurred during composition, the micro transposes the notes (frequency) of the chord and then checks the monitor for the increments corresponding to each chord note plus the increments corresponding to four bass notes one of which will be playing at a particular time. The increments are translated into waveforms as described above and thus is music produced.

MUSIC GENERATION CIRCUITS

The complete circuitry for music generation is shown in Fig. 5. The bass waveform first appears at the output of IC22d and is produced by DAC IC20. At intervals of 0·2ms a binary number between 0 and 63 is taken from the data bus into the latches which comprise Output Port 1. The moment at which the number is placed in the latches is determined by the 0·5µs positive chip select pulse CS1 produced by the decoding circuits which operate on the address and write signals generated by the micro. The number remains on the outputs of the port after the chip select pulse is over, and is converted by IC20 to a corresponding analog voltage level.

BASS ENVELOPES

It will be noted that 0 to 63 uses the bottom six lines of the data bus (D0–D5) leaving D6 and D7 spare. D6 is normally at logic zero except when a pulse is required to switch off the Master Rhythm in the auto-stop mode which occurs after a 'Fine' instruction is found in the score store. D7 is used to provide a positive pulse to trigger the two bass envelope circuits, one of which is selected by S1b at any particular moment. The micro is programmed to count clock pulses received from the Master Rhythm and convert them into musical beats. Depending on the bass figure selected on the appropriate control a bass envelope trigger pulse will appear on pin 19 of IC18, be shaped by the following resistor/capacitor networks, buffered by IC22c, and presented at the DAC control pin 14. The output at pin 4 is modulated from zero by the envelope input at pin 14 and is buffered by IC22d.

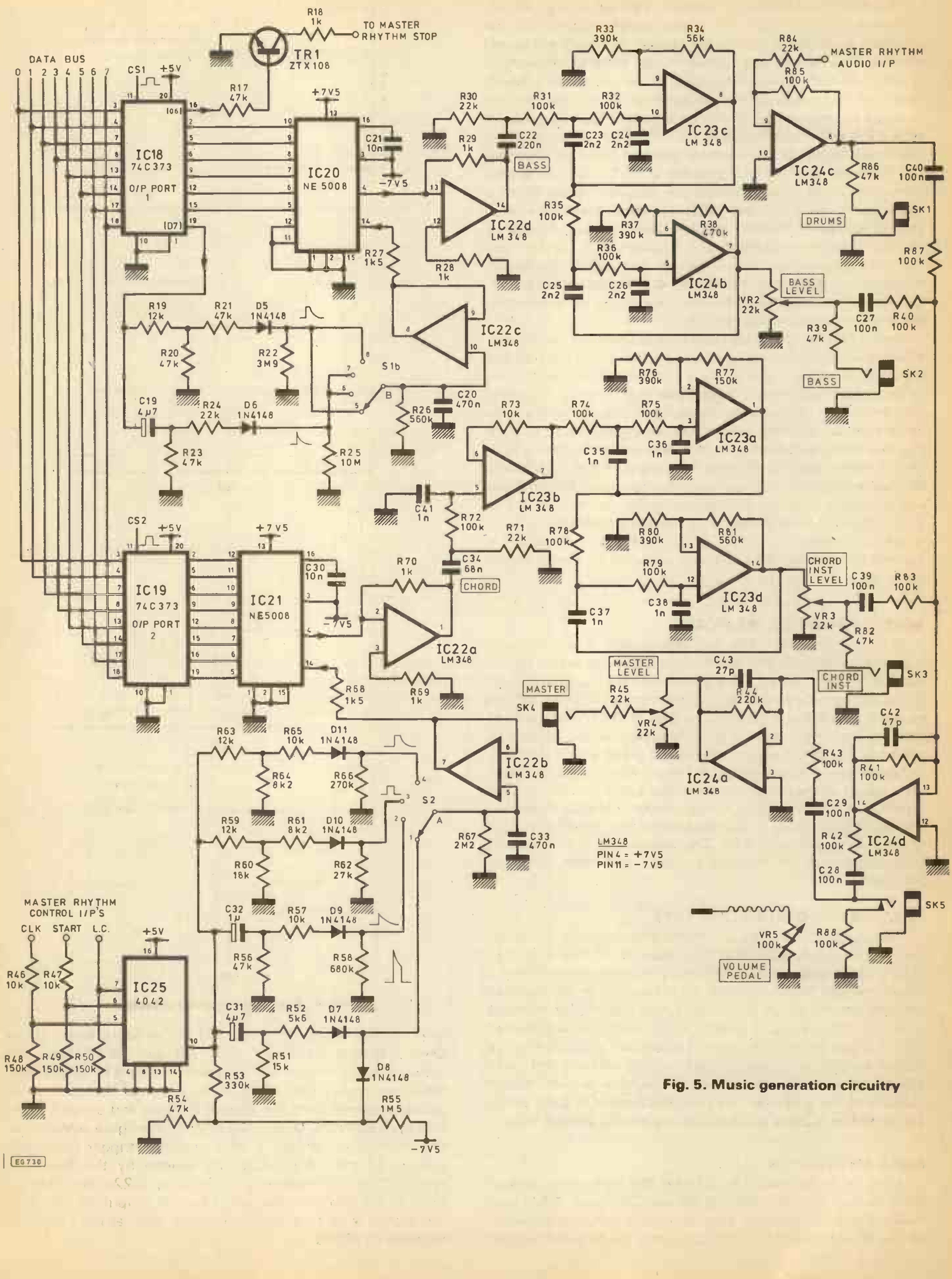

Fig. 5. Music generation circuitry

LOW PASS FILTERS

The waveform at the output of IC22d contains 0·2ms steps, as shown earlier, corresponding to a frequency of 5kHz. IC23c and IC24b comprise a four pole low pass filter with a 24dB per octave roll off and cut off frequency of 700Hz to remove the steps from the bass waveform.

CHORD INSTRUMENT WAVEFORM

Four notes are summed inside the micro to produce the chord instrument waveform which first appears at the output of IC22a. The operation is similar to the bass generator except that all eight data lines are used to give numbers between 0 and 252 (4×63) at the latched outputs of Output Port 2. The filter comprising IC23b, 23a and 23d is of five pole type with a cut off of 1·6kHz and roll off of 30dB per octave. The higher quality filter is necessary since the fundamental and harmonic frequency range of the chord instrument more nearly approach the theoretical limit of $\frac{1}{2}$ the sampling frequency which is placed on sample waveform generation techniques.

CHORD INSTRUMENT ENVELOPES

Master Rhythm inputs are shown entering pins 5, 6 and 7 of IC25 which generates the envelope trigger at its output pin 10. When pin 6 is held at zero by an off condition in the Master Rhythm, pin 10 is also held at zero. When the Master Rhythm is playing the "Start" signal rises to +5 volts, and for each positive clock pulse on pin 5 of IC25 the output takes up the state of pin 7 at that moment, latching the state until the next clock pulse occurs. Pin 7 is connected to the Master Rhythm control line which previously operated the long cymbal circuit and now becomes the programmable rhythmic pattern for the chord instrument. Due to the latching action of IC25 a continuous program of play pulses from the Master Rhythm will result in an uninterrupted high output at pin 10 which can give a sustained organ type output for example. However, the envelope trigger will drop when a programmed rest appears at pin 7 giving a large number of possible rhythmic permutations which may be stored in the Master Rhythm.

Four chord instrument envelope shapers are present on the board. In position one a percussive attack is followed by a damper action when pin 10 of IC25 drops to zero, whilst in position two the damper circuit is omitted. Positions three and four give sustained envelopes with different rates of attack and decay.

MIXER AND PREAMPS

IC24c amplifies the output from the Master Rhythm before entering the mixer IC24d together with the bass and chord instruments. A volume pedal fits between IC24d and IC24a which is the final preamplifier giving a mixed signal in phase with the individual instrument outputs.

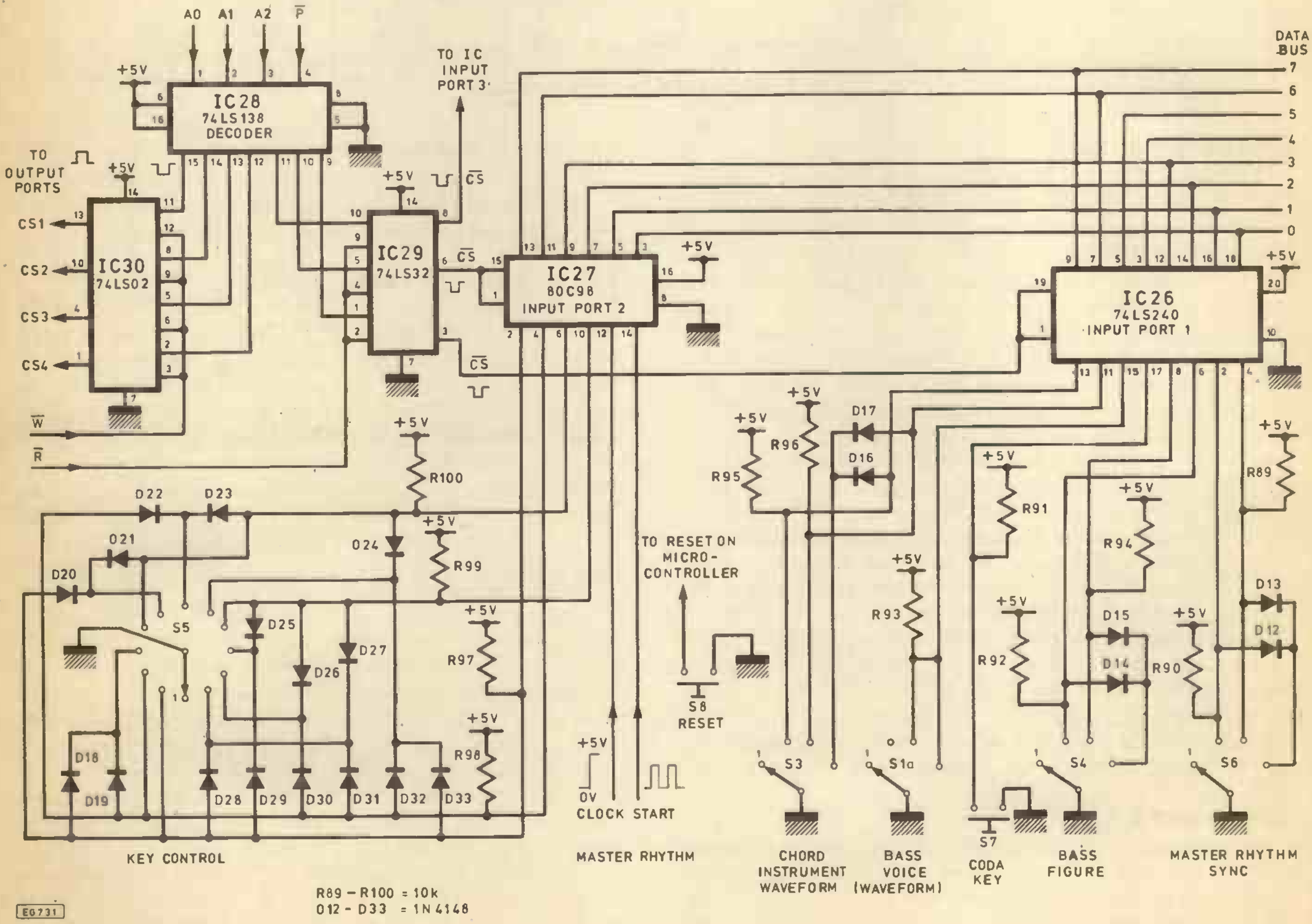

Fig. 6. Input control circuits for Band-box

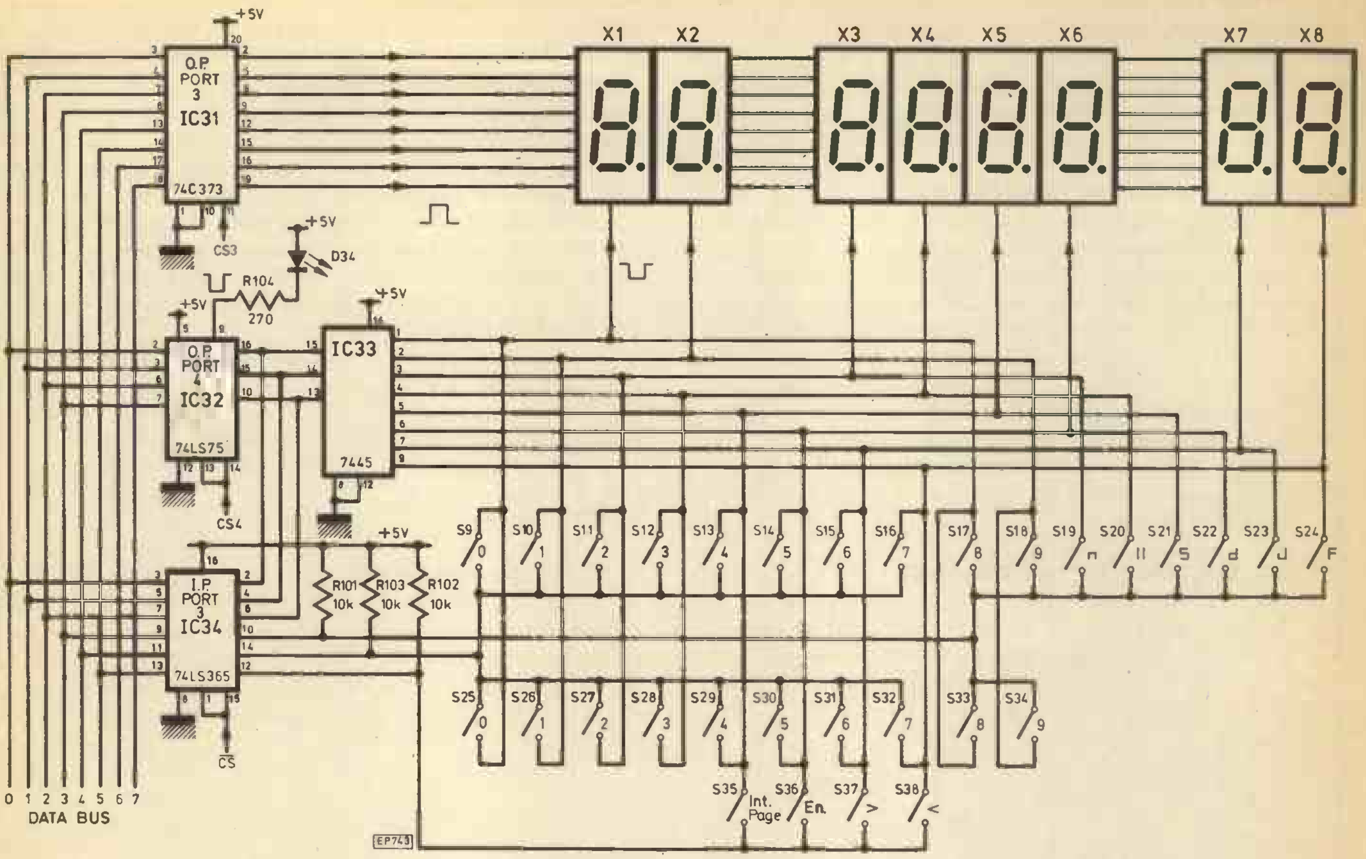

Fig. 7. Display and keyswitch circuits

INPUT CONTROLS

The input controls cover the multi-position rotary switches and the full circuitry is given in Fig. 6. As shown last month a four position switch can be represented by numbers 0,1,2,3. Referring to S6 in Fig. 6, resistors R89 and R90 hold the two inputs to IC26 at +5 volts when the switch is in position 1. IC26 is an inverter used as an input port so that when it receives an 0·5µs chip select pulse from the decoding circuits it puts the complement of the binary number seen at its inputs onto the data bus. Thus in positions 1,2,3 and 4 the binary numbers 00,01,10 and 11 are put onto bits D1 and D0 of the data bus respectively.

Considering S4 it will place similar binary numbers onto bits D3 and D2, which in decimal terms are equivalent to 0, 4,8 and 12. The remaining switches on Input Port 1 act in a similar manner on data lines D4–D7 equivalent to higher decimal numbers and it can be seen that a single number between 0 and 255 can represent the sum of a unique combination of positions for all switches on the Port.

The chip select pins 1 and 19 on IC26 are normally at +5 volts but the micro is programmed by the monitor to pulse them to ground for 0·5µs every 0·2ms to pass the number corresponding to the switches onto the data bus. The Band-Box program in the monitor determines what procedures to carry out based on the switch position combination.

INPUT PORT 2

This port passes the information relating to the playback key onto the data bus in the same manner as above and it will be noticed that data lines D4 and D5 are not used. D6 and D7 enable the micro to look at the Master Rhythm. Pin 12 rises to +5 volts when the Master Rhythm is running which after inversion sends a zero to the Microcontroller. The Master Rhythm clock pulse is being checked every 0·2ms by the input port and the micro is programmed to detect each rising edge through D7 and use this for the purpose of timing chord duration and bass trigger.

CHIP SELECT PULSES

A total of seven ports are involved in the Band-Box system, three are inputs to and four are outputs from the Microcontroller and each is selected at the appropriate moment by a chip select pulse generated by IC28–30. A combination of A0, A1, A2 and $\bar{P}$ decides which port is required using the decoder IC28, and the 0·5µs period of selection is determined by $\bar{R}$ or $\overline{W}$ gated with the negative outputs of IC28. OR gates in IC29 and NOR gates in IC30 ensure that input ports receive negative chip select pulses and output ports receive positive chip select pulses.

DISPLAY AND KEYING

A common circuit handles both the eight segment l.e.d. displays and the two sets of input keyswitches. This part of the system is inoperative whilst music is being generated but is used for playback score selection and composition. The system is multiplexed which means that the eight displays are each scanned in turn for approximately 1ms and the micro puts the information required for a particular display into the output port latches of IC31 for the period concerned. The monitor contains a set of codes which are converted to messages on the displays (Fig. 7).

The Output Port 4 comprising IC32 has three input lines to produce a sequence of eight numbers 0 to 7 which are decoded from their binary form by IC33, the outputs of which fall to zero as selected. The display segments which require to be lit at a particular moment receive a positive

COMPONENTS . . .

SYSTEM BOARD/DISPLAY BOARD

Resistors

R17	47k	R59	12k
R18	1k0	R60	18k
R19	12k	R61	8k2
R20–21	47k	R62	27k
R22	3M9	R63	12k
R23	47k	R64	8k2
R24	22k	R65	10k
R25	10M	R66	270k
R26	560k	R67	2M2
R27	1k5	R68	1k5
R28–29	1k0	R69–70	1k0
R30	22k	R71	22k
R31–32	100k*	R72	100k*
R33	390k*	R73	10k
R34	56k*	R74–75	100k*
R35–36	100k*	R76	390k*
R37	390k*	R77	150k*
R38	470k*	R78–79	100k*
R39	47k	R80	390k*
R40–43	100k	R81	560k*
R44	220k	R82	47k
R45	22k	R83	100k
R46–47	10k	R84	22k
R48–50	150k	R85	100k
R51	15k	R86	47k
R52	5k6	R87–88	100k
R53	330k	R89–103	10k
R54	47k	R104	270
R55	1M5	R105	1k0
R56	47k	R106–107	180
R57	10k	R108	10, 7W
R58	680k		

All resistors 0·25W 5% carbon film except * which are 2%

Capacitors

C19	4µ7 35V elect.
C20	0·47µ
C21	10n ceramic
C22	0·22µ polyester
C23–26	2n2 ± 2%
C27–29	0·1µ polyester
C30	10n ceramic
C31	4µ7 35V elect.
C32	1µ0 63V elect.
C33	0·47µ
C34	68n polyester
C35–38	1n0 ± 2%
C39–40	0·1µ polyester
C41	1n0 ± 2%
C42	47p ceramic
C43	27p ceramic
C44	4k7µ 16V elect.
C45	470µ 16V elect.
C46–49	47n ceramic

Semiconductors

D5–33	1N4148
D34	l.e.d.
D35–42	1N4002
D43	l.e.d.
D44–45	7V5 Zener 400mW
TR1	ZTX108
IC18–19	74C373
IC20–21	NE5008
IC22–24	LM348
IC25	4042
IC26	74LS240
IC27	80C98
IC28	74LS138
IC29	74LS32
IC30	74LS02
IC31	74C373
IC32	74LS75
IC33	7445
IC34	74LS365
IC35	LM340–5

Miscellaneous

VR2–4	22k log
VR5	100k log
S1	3 pole 4 way rotary
S2–4	1 pole 4 way rotary
S5	1 pole 12 way rotary
S6	1 pole 4 way rotary
S7–38	D6 keyswitches + 16 key caps
S39	Mains 2 pole
T1	Mains transformer 2 × 9V, 20VA
FS1	315mA slow blow
Displays	8 × DL-500
SK1–4	Mono jack unswitched
SK5	Mono jack switched
24 pin D.I.L. sockets	2
40 pin D.I.L. socket	1
Track pins	250
14 pin D.I.L. sockets	5
16 pin D.I.L. sockets	9
20 pin D.I.L. sockets	4

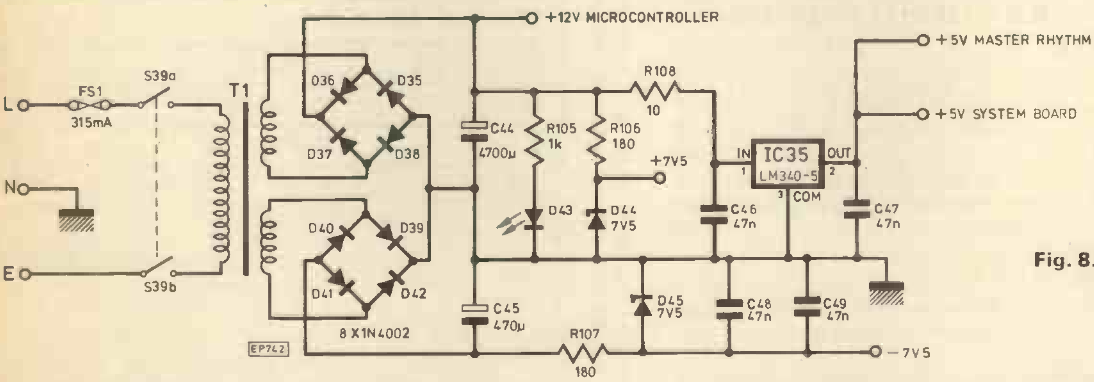

Fig. 8. Power supply

voltage from IC31 and the current in the segments is self-limited by the voltage drop across this integrated circuit.

IC34 decodes keying activity in parallel with the display operation in that data lines D0, D1 and D2 are connected to the latched outputs of IC32 which indicate which display and key column (0–7) is currently being accessed, and depression of a key in this column will pull the voltage down on either pin 14, 10 or 12 depending on which key group is being used (0–7), (8–F.), or (Int. Page, En, >, or <). Keys 0–9 appear twice in parallel to give operator convenience. The key group selected is transmitted on data lines D3, 4 and 5 to the micro which is programmed to note when a key is pressed and take the necessary action.

Data line D3 on IC32 is controlled by the micro to give a negative pulse on each beat to flash the l.e.d.

POWER SUPPLIES

A mains transformer is mounted in the base of the Band-Box and the remainder of the circuitry as shown in Fig. 8 is integrated into the system board. An unregulated supply of approximately +12 volts feeds the microcontroller and Zener diodes are used to obtain ±7V5 for the audio circuits. The remainder of the system operates on +5 volts from the regulator IC35.

Next Month: Construction of the system and display boards together with details of assembly and memory map.

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PE RANGER 27FM CB PART FOUR

MICHAEL TOOLEY B.A.
DAVID WHITFIELD M.A. M.Sc

CONSTRUCTORS who own or have access to more sophisticated test gear may wish to carry out additional tests on the Ranger in order to confirm that it is operating in accordance with the design specification. The most useful items of equipment are summarised in the list below. It is not, however, expected that all of these items will be to hand and the actual measurements carried out by individual constructors will obviously be limited by the available test gear. For this reason the measurements will not be described in detail and only a brief outline of each will be given.

(i) A digital frequency meter which can provide a direct readout to 30MHz with a resolution of 1kHz or better. Alternatively a low frequency DFM and pre-scaler can be employed. See Fig. 4.1.

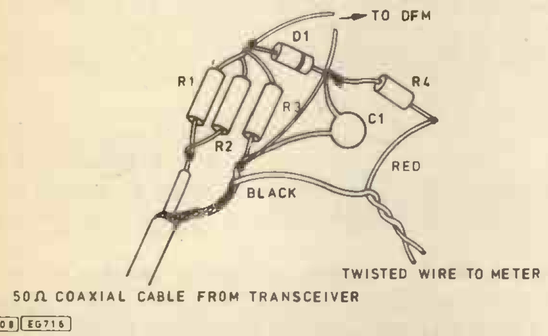


Fig. 4.1. Transmitter Frequency adjustment using a DFM

Connect the DFM across the 10Ω resistor of the 50Ω load. This should produce an RF level of approx. 1V r.m.s. Operate the PTT switch on the microphone and adjust L1 to give the exact channel frequency required. Note that the reading on the output indicator will be slightly reduced when the DFM is connected.

(ii) An r.f. power meter with an internal load of 50Ω. Alternatively a combined power/SWR meter may be used together with a separate 50Ω load; the 50Ω load/indicator is quite suitable. See Fig. 4.2.

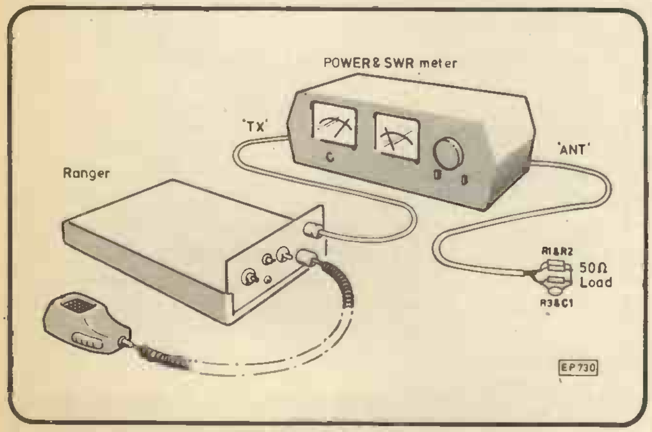


Fig. 4.2. Measurement of r.f. output power

Connect the Power and SWR Meter as shown above. Operate the PTT. Measure the SWR (follow the instructions supplied with the meter) and check that it is less than 1·25:1. Then measure the r.f. power. Note that, with most combined power and SWR meters, the power meter is a voltage sensing device and it is only accurate for a low value of SWR (ie: less than 1·25:1). If necessary make slight adjustments to VC1 and VC2 for maximum power output.

(iii) A stable and accurately calibrated r.f. signal generator with a 50Ω attenuated output. The generator should preferably also have an FM facility rather than the more usual AM. See Fig. 4.3.

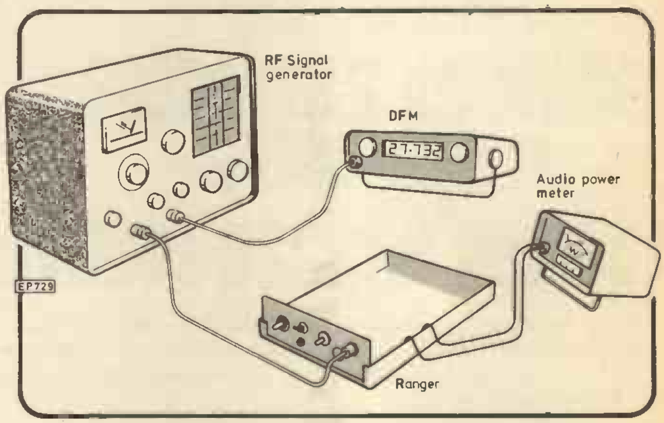


Fig. 4.3. Measurement of receiver sensitivity

Switch 'on' the signal generator and allow it to stabilise. Accurately set the output frequency to the channel in use with the aid of the DFM. Switch the internal modulation 'off' and adjust L104/5 so that the signal appears in the centre of the receiver passband. Switch off the squelch and progressively reduce the output of the generator and adjust L100/1, L102/3 and L106 for maximum quieting (reduction in background noise). Switch the modulation 'on' and adjust L108 for best audio quality.

Disconnect the r.f. generator and terminate the aerial socket with the 50Ω load. Connect the audio power meter in place of the internal loudspeaker and adjust the volume control to produce an output power of 100mW. Reconnect the generator and adjust its output level (using the attenuator) so that the output power meter reads 10mW. The output voltage from the generator is the receiver sensitivity for 10dB quieting.

(iv) An accurate and sensitive absorption wavemeter covering a frequency range of at least 27MHz to 150MHz. Alternatively an r.f. field strength meter covering the same range may be used.

Position the transceiver in the vertical plane and connect the helical aerial. Operate the PTT and hold the wavemeter in close proximity to the aerial. Check that a strong output is obtained at 27MHz and no other output is obtained at any other frequency. Particular frequencies to check are those that are harmonically related to the output, ie: 55MHz,

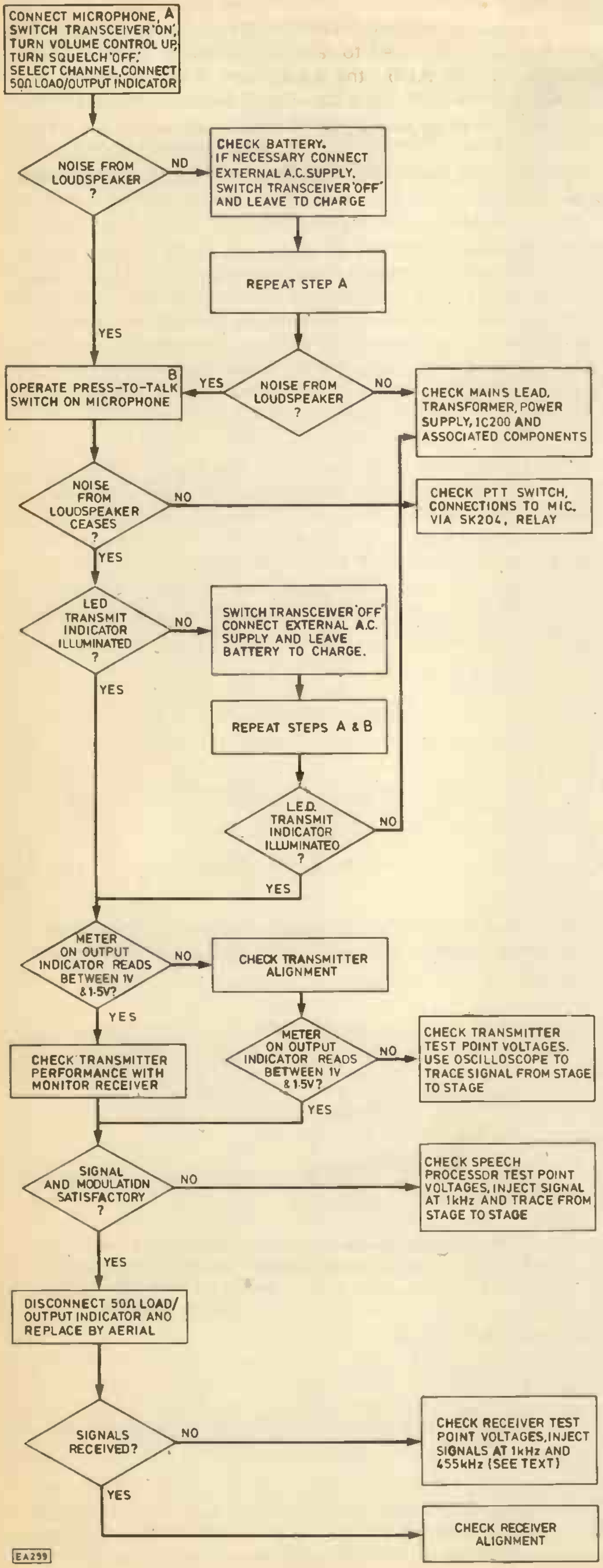


Fig. 4.4. Fault finding flowchart

83MHz, 111MHz, and 138MHz. With a very sensitive instrument (and particularly in the case of a field strength meter when used in place of the wavemeter) it may be possible to detect the presence of harmonics; however, their relative level should be very much less than that of the 27MHz output.

(v) An FM deviation meter suitable for use at 27MHz. (An a.f. generator will also be needed for deviation measurements).

(vi) An r.f. spectrum analyser covering the range 9MHz to 1GHz.

The last two items are unlikely to be found in any other than the better equipped r.f. laboratories but they are included for the sake of completeness. Where such devices are available it is highly probable that constructors will already have the expertise required to use them and therefore instructions for carrying out measurements with these instruments are not given.

FAULT FINDING

By now most constructors will have completed the wiring and assembly of the Ranger and this would appear to be an appropriate moment to introduce the topic of fault finding. As with any piece of complex electronic equipment, a logical approach to fault tracing is required. The basic tools required for fault finding are a d.c. multi-range meter, an a.f./r.f. signal generator, and an oscilloscope. The last two items are useful but fortunately they are not always required. Indeed, it is generally possible to find even the most complex fault using no more than a basic multimeter and a lot of patience!

The first step is to ascertain the general area of the fault, i.e: transmitter, receiver, power supply, control circuitry. Then sub-divide the area you have identified into its constituent parts; oscillator, multiplier, driver and power amplifier, for example. Comparison of the test voltages with the actual circuit voltages can usually throw some immediate light on the subject and, having satisfied yourself that the d.c. supplies are correct the next step is to follow the signal through from stage to stage. When fault tracing on the transmitter it is important to note that most of the stages are operated under class C conditions and the d.c. voltages will vary widely with the level of r.f. Fortunately comparison between driven and non-driven conditions can be very easily made by simply switching the channel selector to a spare channel. This will provide an immediate indication as to whether, or not, r.f. is present in the stage concerned.

In the receiver section things are not quite so simple and it is unlikely that constructors will be able to glean a great deal of information from test voltages in, for example, the i.f. amplifier stage—unless they are lucky enough to have the internal circuit of IC100! This is where a signal generator can be useful. A 455kHz signal can be injected directly into IC100 (pin 3) and this will help decide whether the fault is in the front-end or i.f. stages of the receiver. Similarly an a.f. signal, at say 1kHz, can be injected across the volume control and this will provide some indication of whether the fault is in the i.f. or audio stage. To help with the initial stages of fault tracing, a flow chart has been provided in order to determine the area of any possible fault condition, see Fig. 4.4.

VOLTAGE TABLE

Test voltages were measured under the following conditions:

(i) 240V a.c. mains supply connected via SK201

(ii) 50Ω load/output indicator connected (see Alignment section).

(iii) VR2 adjusted for 500mW output (see Alignment section).

Test voltages were measured using a 20kΩ/volt multi-range meter.

TEST POINT	TRANSMIT	RECEIVE
a	2·1	0
b	0·8	0
c	1·1	0
d	9·0	0
e	0	6·0
f	0	5·7
g	0	14·5
h	11·5	0
i	5·7	0
j	5·7	0
k	9·3	0
load output	1·2	0
"ext d.c." socket SK203	12·3	15·5

RF VOLTAGE TABLE

Transmit	SK200	5V
	TR1 emitter	1·9V
	TR1 collector	2·0V
	TR2 collector	5·0V
	TR3 collector	9·0V
	TR4 collector	19·5V
Receive	TR102 drain	1·0V

All voltages measured using external a.c. supply and 50Ω load/output indicator. Voltages are r.m.s. readings using a valve voltmeter and diode probe.

AERIALS

The aerial system used with any transceiver is a crucial factor in determining its overall performance both on transmit and on receive. The best possible aerial system should always be employed and money spent on improving aerials and feeders is always well invested.

Users should not expect too much from the Ranger when it is operated as a hand-held unit in conjunction with its matching helical aerial. This is due not only to the relatively low output power but also to the inefficiency of a miniature aerial system operating with a very inadequate earth plane. The result is a working range which is very much less than that which could be obtained with, say, a well sited full-size base station aerial system. A further point worth noting when using the helical aerial is that a significant amount of the r.f. energy radiated will be absorbed by the body of the user! For best results the transceiver should be held with the helical aerial in the vertical plane as high as possible and well away from the user. If a car roof, filing cabinet, water tank, or similar metal structure is available this can be used most effectively as a means of improving the efficiency of the aerial system. Simply place the transceiver upright as near as possible to the centre of its improvised ground plane and operate as far away from the transceiver as the microphone lead will allow.

The type of aerial used in any particular base station situation will depend on several factors, the most significant of which are the available space and, when dealing with omni-directional vertically polarised aerials, the maximum height attainable. Whenever possible the Ranger should be used with a properly designed base station aerial rather than depend on its helical aerial which will certainly give disappointing results when used indoors. The most obvious choice of aerial will probably be a derivative of the vertical monopole. This is a very simple aerial consisting of a single radiating element and a ground plane to provide a reflected image of the monopole. The aerial performs in a manner similar to that of a free-space dipole and has basically similar radiation patterns modified, somewhat, by the effect of the imperfect ground plane. The major problem is that, with a discontinuous ground plane, an appreciable amount of radiation is directed upwards away from the surface of the earth and not concentrated in the most useful direction which is, of course, at right angles to the element. Typical radiation patterns for perfect and imperfect ground plane monopole aerials are shown in Figs. 4.5a and b and it is clear from these that the quality of the ground plane has a major effect on the performance of the aerial system. For this, and other reasons, there has been a move to free-space aerials, such as the vertical dipole, "J-antenna", and "Slim-Jim". All of these aerials operate without the need for a ground plane but they are generally a little more difficult to construct and adjust. Whatever type of aerial is selected most proprietary CB aerials will work well with the Ranger provided, of course, that the manufacturer's assembly and installation instructions are carefully followed.

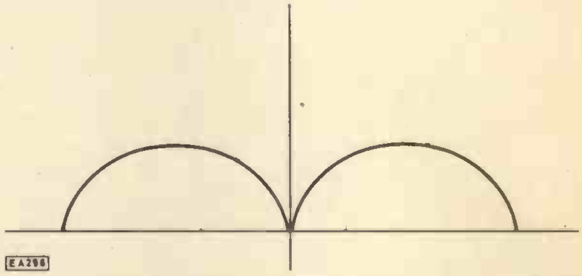


Fig. 4.5a. Vertical plane radiation pattern of a vertical quarter wave monopole aerial mounted above a perfect ground plane

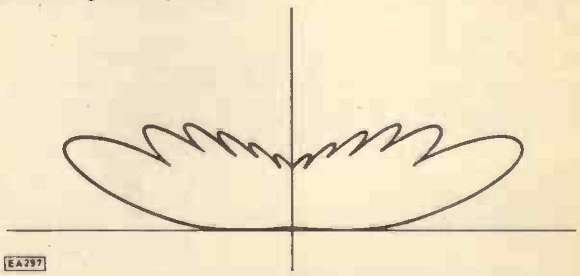


Fig. 4.5b. Vertical plane radiation pattern of a vertical quarter wave monopole aerial mounted above an imperfect ground plane

FEEDERS AND SWR

Coaxial feeders having a nominal impedance of 50Ω should be used for connecting the Ranger to an aerial system (do not use 75Ω TV aerial downlead!). Ideally the feeder used should be a "low-loss" type. However, where only a short length of feeder is used (say less than 20') the power lost in "standard" cables will be quite insignificant. The power lost depends on two factors; the type and quality of tt cable used and its length. A 25' length of UR-43, for example, will have a loss of approximately 0·5dB, doubling the length to 50' increases the loss to 1dB. In the first case approximately 10 per cent of the power is wasted in the cable and 90 per cent arrives at the aerial (assuming, of course, that it is perfectly matched). In the second case approximately 20 per cent is lost in the cable and 80 per cent reaches the aerial. In practical terms this would make very little difference to the radiated signal. In general the feeder loss should not be allowed to exceed about 2dB since, at this point, only 63 per cent of the power appears at the aerial. The relationship between feeder loss and per cent power arriving at a perfectly matched aerial is shown in the table.

The characteristics of some commonly available coaxial cables are given in the table. Note that inferior cables of unknown origin and sometimes described as "UR-43 type" etc, should always be avoided as their performance is generally not as good as the cable which they purport to be!

A great deal of nonsense is often heard (and read!) concerning the topic of SWR (standing wave ratio). Far too many existing CB operators place too much emphasis on obtaining the lowest possible SWR from their aerial systems. Much of this effort is wasted since, in practical terms, an SWR of less than 2:1 is quite adequate and only represents an additional power loss of 0·2dB when present in, for example, a cable offering a matched loss of 1dB (ie: the total loss due to both feeder loss and SWR loss will only be 1·2dB). Furthermore a low SWR is not conclusive proof that an aerial is working efficiently. In fact a very low value of SWR can easily be obtained by using grossly inefficient aerial connected at the end of a very long length of lossy feeder!

In general, an SWR of 2:1 is nothing at all to worry about, 1·5:1 is good, and better than 1·3:1 is excellent. High values of SWR, say greater than 2:1 do not necessarily imply that an aerial system is poor. The solution is to add an aerial matching device in order to tune out the reactance associated with a non-resonant aerial and mismatched feeder. Aerial matching or tuning units are readily available as standard CB accessories however there is little point in purchasing one unless your SWR is greater than 2:1.

One final point worth mentioning is that, unlike some other CB transceivers, the power amplifier stage on the Ranger will tolerate excessively high values of SWR indefinitely. This means that, in the unfortunate event of your aerial dropping-off or the feeder becoming short circuited, the Ranger will just sit and take it.

FEEDER LOSS (dB)	PER CENT POWER AT PERFECTLY MATCHED AERIAL	PER CENT POWER WASTED IN FEEDER
0	100	0
0·5	90	10
1·0	80	20
2·0	63	37
3·0	50	50
6·0	25	75
α	0	100

CABLE NUMBER	IMPEDANCE (Ω)	OVERALL DIAM. (INCH)	INNER CONDUCTOR (INCH)	CAPACITANCE PER FOOT (pF)	APPROX. ATTENUATION PER 100' at 27MHz (dB)
UR 43	52	0·195	1/0·032	29	2·2
UR 67	50	0·405	7/0·029	30	1
UR 76	51	0·195	19/0·0066	29	2·6

MODIFICATIONS

As a result of detailed tests and measurements made on a number of PE Ranger transceivers the following information has become available:

1. It is sometimes possible to set up the transmitter such that the level of spurious radiation is above the permitted level at particular frequencies. In order to substantially reduce the possibility of these harmonics being generated, the following changes to the original circuit must be made.

a) Replace R6 (100 ohms) by a 10μH inductor; the type used for L6 is suitable.
b) Add a 100pF disc ceramic capacitor between the primary winding terminals of L4. This is most conveniently soldered directly to the coil on the underside of the p.c.b.
c) Replace C13 by a shorting link.
d) Add a 15pF disc ceramic capacitor in parallel with L6, soldered on the underside of the p.c.b.
e) Reduce the value of R10 from 27Ω to 10Ω.

2. An improved filter response will be obtained from the original low pass filter design if the mutual coupling between the input and output coils is reduced by the addition of a tinplate screen between these coils. The screen should be earthed, and may even be extended to enclose the whole filter unit. A recommended alternative filter design, with improved stopband attenuation but slightly higher insertion loss (1–2dB max), is shown in Fig. 4.6a and b. This may be fabricated on the original filter p.c.b. with only slight changes (2 holes and 2 trackbreaks).

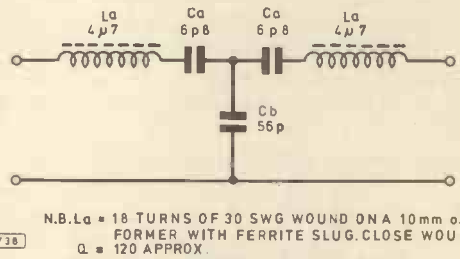


Fig. 4.6a. Modified filter design

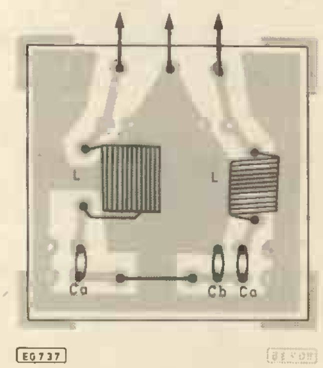


Fig. 4.6b. Modified board design

3. If more output power is required from the transmitter, 2N2219 transistors may be used for TR3 and TR4. (You will have to make slight re-adjustments to L4/5 and L7/8 to compensate for the change.) The 2N2219 has a larger value of current gain and this will usually increase the output to 1W or so. Note that this modification will reduce the battery life (normally 2–3 hours of continuous operation).

4. If instability in the audio amplifier is observed this can easily be cured by the addition of a 1nF ceramic capacitor wired under the p.c.b. between pins 1 and 2 of IC101. To check whether instability is present move the loudspeaker connecting wires and listen to the noise produced by the loudspeaker. If there is a change in the noise produced as and when you move the connections or when they are touched this usually indicates high frequency instability in the audio stage and the signal produced may interact with the i.f./r.f. amplifier stages.

5. To improve front-end selectivity, image rejection, and simplify alignment the values of C121 and C122 should be changed to 22pF. It will then be harder to mis-align the r.f. tuned circuits.

6. For final alignment of the two r.f. tuned circuits, L100/101 and L102/103, it is recommended that all-plastic or all-nylon trimming tools are used. Tools fitted with phosphor bronze blades will de-tune the inductors whilst an adjustment is made. This is quite important if you want to get the "last ounce" of performance from your Ranger!

7. When aligning the receiver of the Ranger without the aid of test equipment it is important to note that, at present and until the new system comes into operation, signals likely to be heard will be AM and SSB and these will usually be off-frequency. These signals will sound very distorted and will certainly not be readable—they will at least give an indication that the receiver is functioning. Final adjustment of the r.f. tuned circuits should therefore be left until a proper FM signal is available.

8. There have been a number of cases where spurious output has been generated as a result of feedback by direct radiation of r.f. energy from the co-ax link (between the p.c.b. and the aerial socket) to the transmitter chain. It is essential that the front panel should exhibit a low impedance r.f. path to the earth plane on the p.c.b. A series tuned circuit is recommended for inclusion between the co-ax cable and the aerial socket, mounted immediately behind the aerial socket.

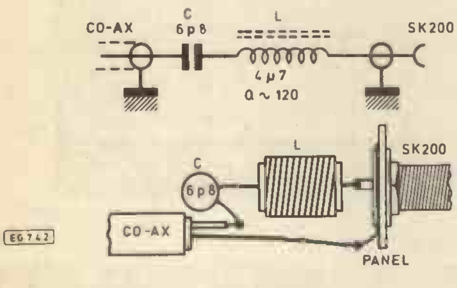


Fig. 4.7. Series tuned circuit

9. It is important that early issue p.c.b.s from Modus Systems are checked to ensure that the solder resist has been removed from around the slider pin of VR2 prior to soldering. Failure to do this will limit the maximum available output power to less than 5mW.

10. Should a 'chattering' squelch (i.e. where the squelch appears to open and close erratically in the absence of any discernible signal) be encountered, it is recommended that C102 be increased to 4·7μF, or even 10μF.

11. When tuning up the receiver, it is recommended that a matched 50Ω impedance be maintained. The receiver front end may show some sign of instability if not correctly terminated.

12. It is recommended that the exposed terminals of SK201 be protected with insulated sleeving.

13. A good earth bond between the front panel and the p.c.b. ground plane is essential. In some cases it has been found necessary to use a short length of braid to connect the body of SK204 to the earth tag on SK200. A short length of braid should also be fitted from the earth tag of SK200 to the can of L104.

14. Should the squelch appear to be non-operational, it is well worth checking the polarity and marking of D102 with an ohm meter; there have been cases where the polarity of the diodes has been incorrectly marked on the body of the diode.

15. Low profile d.i.l. sockets (N.B. no other type) have been found suitable for use with all of the i.c.s in the Ranger.

16. When mounting the NiCad batteries (B200 and B201) on the p.c.b., it is advisable to ensure that they are firmly seated; track damage may occur (especially in transit) if the tags are not pushed fully through the board. Similar considerations apply to the mains transformer, T200.

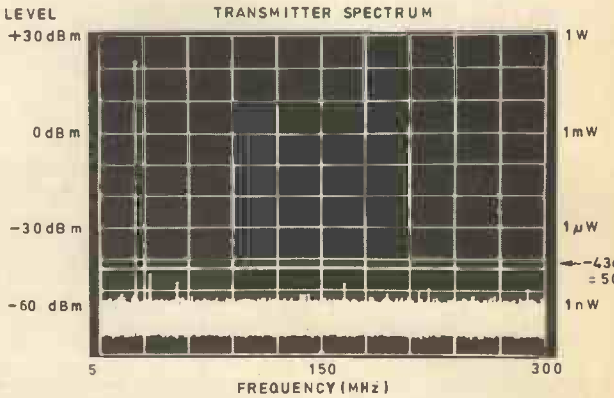
17. Apparent instability and lack of sensitivity in the receiver can be attributed to relatively high values of local oscillator injections in some sets. This can be cured by wiring a resistor of between 33Ω and 180Ω under the p.c.b. directly to the pins of L105. The value should not be so low as to stop the oscillator functioning and 100Ω makes a good starting point.

A further improvement may also be gained by wiring a 47kΩ resistor under the p.c.b. between pin 1 of IC100 and 0V. This increases the range of the local oscillator input swing.

After including the above mods (filter, series trap, R6, R10, C13, 2 extra capacitors) the alignment of the transmitter continues from step 17 as follows: using the load output indicator, adjust in the following sequence and repeat until *maximum* output is achieved: core in the series trap, cores in the filter, VC2, L8, VC1, L4, and L2.

TEST RESULTS

The following test results have been produced from a kit-built sample of the PE Ranger 27FM, which has been carefully aligned using techniques outlined in the series of articles. The set in question incorporated all of the suggested modifications in this part of the series, and was run from a mains supply.



RECEIVER SPURIOUS EMISSIONS

The maximum amplitude of emission from the receiver was measured as −48dBm into 50Ω; this is a power level of 15·8nW.

RECEIVER SENSITIVITY

The measured usable sensitivity of the receiver on Channel 9 using 1kHz tone modulation and ±2·5kHz deviation was 0·43μV. The measured sensitivity at 10dB signal-to-noise ratio was 0·80μV. All measurements made in a constant 50Ω environment.

TRANSMITTER SPECTRUM ANALYSIS

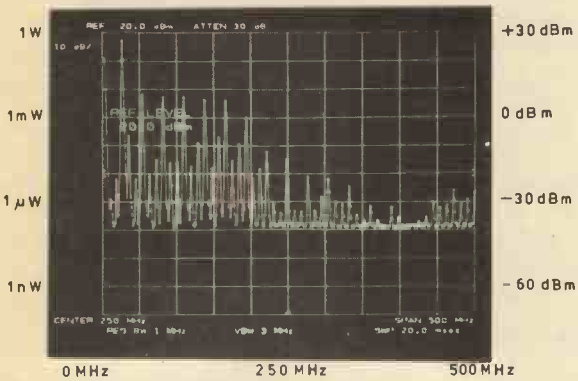
The detailed transmitter spectrum is shown for a Ranger transmitter which is fitted with the improved filter, the series trap in the co-ax link between p.c.b. and SK200, and has R6 and R10 replaced as described earlier.

The Home Office specification calls for the levels of spurious emissions to be as follows:

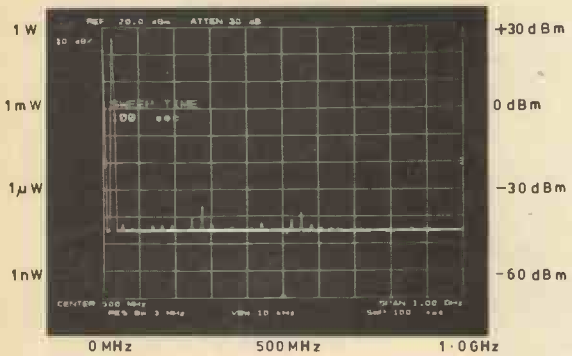
0 to 80MHz	below 250nW	(−36dBm)
80 to 85MHz	below 50nW	(−43dBm)
85 to 87·5MHz	below 250nW	(−36dBm)
87·5 to 104MHz	below 50nW	(−43dBm)
104 to 108MHz	below 250nW	(−36dBm)
108 to 118MHz	below 50nW	(−43dBm)
118 to 135MHz	below 250nW	(−36dBm)
135 to 136MHz	below 50nW	(−43dBm)
136 to 174MHz	below 250nW	(−36dBm)
174 to 230MHz	below 50nW	(−43dBm)
230 to 470MHz	below 250nW	(−36dBm)
470 to 862MHz	below 50nW	(−43dBm)
862MHz upwards	below 250nW	(−36dBm)

The traces below show the importance of correct alignment. The first trace (A) is without a filter, and the second (B) is with the transmitter above.

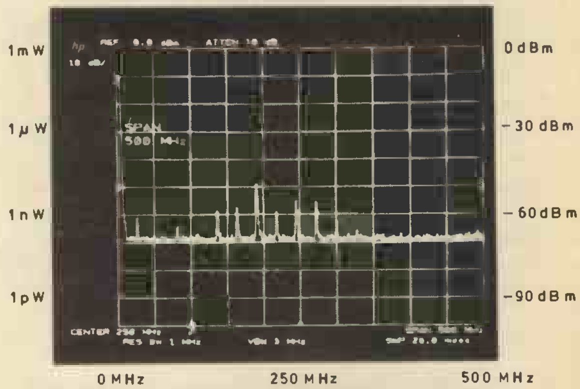
The results for a spectrum analysis of the Ranger receiver are shown below (C). The Home Office specification calls for a maximum allowable level of emission from the receiver of below 20nW (−47dBm) at any frequency. The Ranger receiver meets this specification. The tested sample is shown without modifications; the performance above 30MHz is improved when the series tuned circuit is added. A detailed examination of the local oscillator spectrum is shown (level = −63·6dBm or 0·5nW) in trace (D).



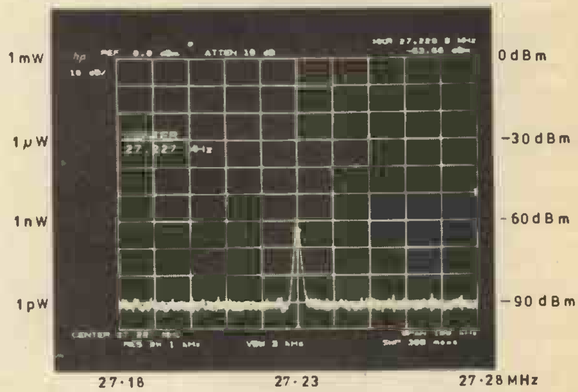
A



B

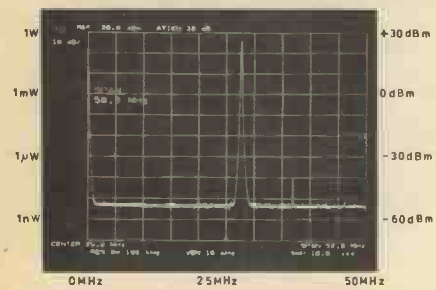


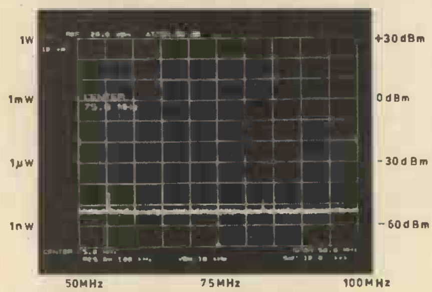
C

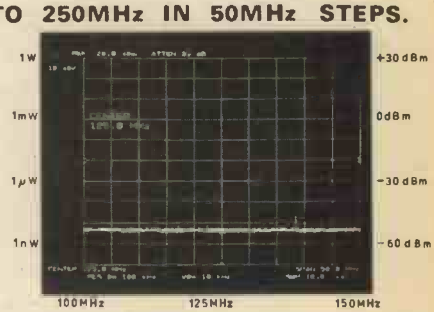


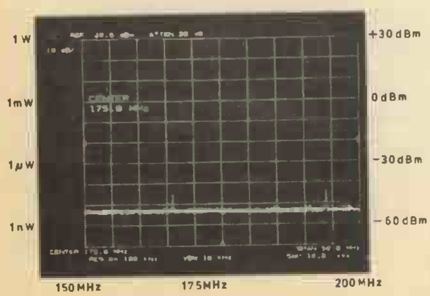
D

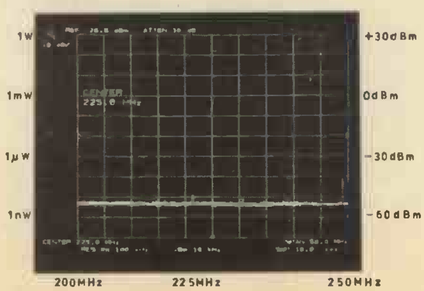
DETAILED TRANSMITTER SPECTRUM ANALYSIS — D.C. TO 250MHz IN 50MHz STEPS.











PLEASE NOTE

Will constructors please note that CB licences are now available from any Post Office for an annual fee of £10·00.

NEXT MONTH

The base mobile adaptor has been developed to complement the basic ranger transceiver, whilst retaining all of the original features.

MICRO PROMPT

The hardware and software exchange point for PE computer projects

M/C TO BASIC CONVERTER

Sir—I expect that all UK101 owners know how to put a decimal m/c program into HEX simply by using the READ, DATA and POKE commands in BASIC. But how do you convert a HEX m/c program into the above BASIC thus not needing checksum loaders etc.?

One slow way is to PEEK all the m/c program when in BASIC and enter the bytes into a program of DATA statements by hand, not much fun for a 200 byte program! Alternatively, you could write a program that would write its own BASIC lines into the memory, like Tony Walsh's "Graph Plot" (PE January 1981).

A far simpler way to achieve this would be to make use of the fact that everything printed on the screen of the UK101 when in Save mode also goes on to tape. The enclosed program writes a BASIC program to store anything stored anywhere in the memory as DATA using only the print command.

The program starts at line 49999 so as not to overlap any program already in the computer. To start it just type "Run 50000".

Description:

Line 49999: prevents any other program running accidentally into it.

50040–50110: data entry from keyboard and validity checking.

50200: present memory address (decimal).

50240–50250: converts byte at present address to string of decimal value and remove preceding space caused by STR$. Increments character count on line being printed.

50260: checks if line full, if not then 50330.

50270–50320: starts new line, sets L to next line No. and sets character count for new line to zero.

50330: checks if sufficient line numbers left to complete program.

50340: prints data byte in D$ onto tape with preceding comma.

50360–50390: prints BASIC routine to poke data back in when loaded.

50400: resets Save flag and gives a small tape delay before instructing for the tape to be stopped.

Variables:

S & F	*First and last memory addresses to be recorded.*
L & IN	*Starting line number and line increment.*
M & D$	*Present memory address and string of decimal data value at M.*

```
0 RUN 50000
1 : M/C TO BASIC 'DATA' STATEMENT PROGRAM
2 : WRITTEN BY A.W.H BRUCE 13-4-1981
3 :
4 : TO OPERATE TYPE 'RUN 50000'
5 :
6 : AUTHOR'S ADDRESS:-
7 :                   10 NORTHEND, WARLEY
8 :                   BRENTWOOD,ESSEX .
9 :
10 : ACTUAL LISTING FOR PRINT: 49999 TO 50440.
11 :----------------------------------------
49999 PRINT:PRINT"Error...program over run.":PRINT:STOP
50000 PRINTCHR$(12):FORI=1TO16:PRINT:NEXT:REM --CLS--
50010 PRINT"MEMORY DATA RECORDING PROGRAM"
50020 PRINT"=============================":PRINT
50030 PRINT"Written by A.W.H Bruce.":PRINT
50040 REM -- GET LOCATION & LINE INFO. --
50050 INPUT"Memory address, start";S
50060 PRINTTAB(15);:INPUT"finish";F
50070 IFF<SORF>65535ORS<0THENRUN50000
50080 PRINT:INPUT"Start line number";L
50090 L=INT(L):IFL<0ORL>63997THEN50080
50100 PRINTTAB(8);:INPUT"Increment";IN
50110 IN=INT(ABS(IN)):IFIN=0ORIN>300THEN50100
50120 REM -- RECORD MEM.DATA AS BASIC 'DATA' --
50130 PRINT:FORI=1TO29:PRINT"=";:NEXT:PRINT:PRINT
50140 PRINT"Push 'PLAY' & 'RECORD' on tape and hit any key."
50150 POKE11,0:POKE12,253:X=USR(X)
50160 FORX=1TO3000:NEXT:REM --- TAPE DELAY ---
50170 POKE15,72:POKE517,1:PRINT:PRINT
50180 REM -- SET COUNT HIGH TO CAUSE NEW LINE --
50190 LL=90
50200 FORM=STOF
50210 REM-- CONVERT BYTE TO STRING & REMOVE --
50220 REM-- PRECEEDING SPACE CAUSED BY STR$.--
50230 D$=STR$(PEEK(M)):DL=LEN(D$)-1
50240 D$=RIGHT$(D$,DL):LL=LL+DL+1
50250 REM -- NEW LINE? --
50260 IFLL<60THEN50330
50270 PRINT
50280 REM -- START NEW LINE --
50290 PRINTL;"DATA ";D$;
50300 REM -- NEW LINE No., LINE LENGTH TO 0 --
50310 L=L+IN:LL=0
50320 GOTO50350
50330 IFL+IN*2>63999THENPRINT:PRINT"ERROR..line too big.":GOTO50410
50340 PRINT",";D$;
50350 NEXT:PRINT
50360 REM -- DATA FINISHED & NOW TO POKE IT --
50370 PRINTL;"FOR I =";S;"TO";F
50380 PRINTL+IN;"READ J:POKE I,J:NEXT I"
50390 PRINT:PRINT"POKE515,0:LIST-";L+IN
50400 REM -- TIME DELAY & TURN OFF TAPE --
50410 FORI=1TO2000:NEXT:POKE517,0
50420 PRINT:FORI=1TO31:PRINT"=";:NEXT:PRINT
50430 PRINT" Recording finished, stop tape.":PRINT
50440 END
OK
```

DL & LL	*Length of D$ and No. of characters on line.*

NOTE
Line 50260 should read:
IFLL<56 etc. . .

A. W. H. Bruce,
Brentwood,
Essex.

UN-NEW!

Here is a short machine-code program (38 bytes) for the UK101 which may come in useful. It will restore "lost" programs. By "lost" I mean programs which have been inadvertently NEWed. It must be entered as a m/c program since entering it as data statements will destroy the "lost" program pointers in basic.

It is relocatable and uses two subroutines in ROM. Once entered, it must be executed immediately after the NEW command, i.e. before any new line numbers are entered.

```
A0 04        LDY &04
C8       L1;INY
B1 79        LDA (79), Y
D0 FB        BNE L1        ; find end of
C8           INY           ; first line
C8           INY
8C 01 03     STY 0301
A5 7A        LDA 7A
8D 02 03     STA 0302
A9 FF        LDA &FF
85 12        STA 12
20 32 A4     JSR A432      ; find end of
86 7A        STX 7A        ; program
A5 AA        LDA AA
20 6D A4     JSR A46D      ; reset pointers
A9 03        LDA &03
85 7A        STA 7A
4C 74 A2     JMP A274      ; warm start
```

Stuart Smith,
Dumbarton.

MULTIPLE USER CALLS

Sir—If you wish to link more than one machine code routine to UK101 Basic, the restriction of a single 'USR' function can be a drawback. By POKING into locations 11 and 12 you can of course change the USR address but this leads to lengthy BASIC lines which don't make for easy reading. For example it's difficult to see that

POKE 11,227:POKE 12,168:X=USR(Y)

is calling the routine at 43235 decimal.

When the USR call is made from BASIC as above, the value of Y is placed into the floating accumulator at $ AC to $ B0. It seems logical therefore to try to use this route to allow multiple USR calls with the address of the routine as the argument.

The technique is to vector USR calls to a machine code patch containing the following:

JSR $B408	Convert floating accumulator contents to integer at $11, $12
JMP (11)	Branch to routine whose address is in $11, $12

Including the following lines of BASIC in a program will set this patch up at $0228 and link subsequent USR calls to it.

FOR I=565 TO 570 : READ X : POKE I, X : NEXT
DATA 32, 8, 180, 108, 17, 0 : POKE 11, 53 : POKE 12, 2

The patch used here is compatible with the original monitor, and the new monitor as well as CEGMON.

The calling routine mentioned above now reduces to:

X=USR (43235)

This saves memory, is more readable and the omission of the two POKEs also speeds up the calling procedure considerably. Enterprising EPROM programmers could fit the patch into the New Monitor or CEGMON by stealing some of the ROM used for message storage.

P. Beckett,
Blackpool.

QUICK TIP

A short routine to print superscripts as required in A^2 etc.

Example:

140 AC=32
150 ?:? "ACCELERATION="; AC ; "FEET/SEC"; :
POKE 54157 + POS (I), 50:?

How about an article on programming techniques with tips like this one and wider aspects such as how the interpreter works. For example, is it faster to put DATA statements early in the programme, or after the READ statement?

S. Jeans,
Cardiff.

FULL RENUMBER

Sir—Here is a full-function BASIC Renumberer program for the UK101 in reply to Mr. I. Pawson of Leicester (PE November 1980).

This program renumbers, with the same steps as the original, lines and statements GOTO, GOSUB, THEN, ONI GOTO and ONI GOSUB if they are in positions it is necessary to change, anywhere in the program.

The renumbering is successful in GOTO'S, THEN'S etc., even with new numbers having more or less digits than the old ones. If there is no space to enter the full number (in the case of a number having more digits), the program enters the most significant digits of the new number and reminds you to REWRITE line n. So, when writing BASIC programs it is better to leave one or two spaces in GOTO'S, THEN'S etc., before or after the number.

After renumbering, the lines remain at the same memory locations as before. Suppose you have a program with lines 100, 110, 120, 130.

CASE 1 Renumber from 100 to 110 starting at 80; The new sequence of lines will be 80, 90, 120, 130.

CASE 2 Renumber from 120 to 130 starting at 400; The new sequence of lines will be 100, 110, 400, 410.

CASE 3 Renumber from 110 to 120 starting at 400; The new sequence of lines will be 100, 400, 410, 130. The new program will not work. You must SAVE it in a spare cassette and LOAD back to COMPUKIT. The new sequence will become 100, 130, 400, 410.

```
44400 REM *** FULL-FUNCTION
      RENUMBERER FOR UK101
44405 REM **** A. GALLOPOULOS
      — GREECE ****
44410 INPUT "RENUMBER OLD
      LINES FROM"; X
44415 INPUT "THROUGH TO"; Y
44420 INPUT "AS NEW LINE
      NUMBERS FROM"; Z
44425 A = 768 : S = Z - X
44430 A = A + 1 : L = PEEK (A+2)+
      PEEK (A+3) * 256
44435 IF L = > 44400 THEN 44475
44440 IF L < X OR L > Y THEN
      M = L : GOTO 44455
44445 M = L+S : POKE A + 2,
      M - INT(M/256) * 256
44450 POKE A + 3, INT (M/256):
      PRINT L, M
44455 A = A + 4
44460 C = PEEK(A) : IF C = 0 THEN
      44430
44465 IF C = 136 OR C = 140 OR
      C = 160 THEN 44500
44470 A = A + 1 : GOTO 44460
44475 PRINT "RENUMBERING
      COMPLETED" : END
44500 E$ = "" : B = A
44505 B = B + 1 : C = PEEK (B)
44510 IF C > 64 THEN A = A + 1:
      GOTO 44460
44515 IF C = 0 OR C = 44 OR C = 58
      THEN 44525
44520 E$ = E$ + CHR$(C) : GOTO
      44505
44525 K = VAL(E$) : W = B - A :
      A = A - 1
44530 IF K < X OR K > Y THEN 44555
44535 E$ = STR$ (K + S) : FOR J = 2
      TO W
44540 IF J < = LEN(E$) THEN 44550
44545 POKE A + J, 32:NEXT:GOTO
      44555
44550 V = ASC (MID$(E$, J, 1)) :
      POKE A + J, V : NEXT
44552 IF LEN (E$) > W THEN PRINT
      "REWRITE LINE"; M
44555 A = B : IF C = 44 THEN 44500
44560 GOTO 44460
```

Antonios Gallopoulos,
Greece.

CASSETTE FILE HANDLING

Sir—The basic UK101 has no built-in data file handling capability. The data file program published in your "Micro Prompt" of April 1980 suffers from the disadvantage that a program change is required to change:—

a) the name of the file;
b) the number of characters allowed in the file name;
c) the number of data "words" stored in the file.

Also, the pause period in line 10 is running while the operator is actually reading the instruction and starting the tape. There is, therefore, no tape run-up time before the instruction "HIT ANY KEY" is given. The following modification of your program overcomes these limitations.

```
 5 INPUT"NAME THE FILE";F$
10 INPUT"HOW MANY ITEMS OF
   DATA";N
15 FOR A=0 TO N-1: PRINT"EN-
   TER ITEM" A+1;:INPUTW$(A):
   NEXT:PRINT:PRINT
20 PRINT"WIND TAPE TO RE-
   QUIRED POSITION & SET TO
   RECORD":PRINT:PRINT
25 PRINT"HAVE YOU STARTED
   THE TAPE?":PRINT:PRINT
27 INPUT"IF SO, ANSWER 'Y' ";-
   Q$:IF Q$<>"Y" THEN 25
30 PRINT:PRINT"WAIT . . .";:FOR
   A=1TO 8000:NEXT:PRINT"HIT
   ANY KEY"
35 POKE 11,0:POKE 12,253:X=USR
   (X):SAVE
40 PRINT F$:PRINT N
45 FOR A=0 TO N-1:PRINT
   W$(A):NEXT:PRINT
50 POKE517,0
55 PRINT"' "F$"' FILE IS NOW ON
   TAPE"
60 END
```

The program to retrieve the file from tape follows.

```
120 INPUT"WHICH FILE DO YOU
    REQUIRE";F$:PRINT
125 PRINT"WIND TAPE TO FILE
    POSITION, SWITCH TO"
130 PRINT"REPLAY & HIT ANY
    KEY IMMEDIATELY."
135 POKE 11,0:POKE 12,253:X=
    USR(X):LOAD
140 INPUT T$
145 IF RIGHT$(T$,LEN(F$))=F$
    THEN 155
150 GOTO 140
155 INPUT N
160 FOR A=0 TO N-1:INPUT
    W$(A):NEXT
165 POKE515,0 : PRINT : PRINT :
    PRINT
170 PRINT F$:PRINT:FOR A=0 TO
    N-1:PRINTW$(A):NEXT
175 END
```

Since the W$(A) array has not been dimensioned, the maximum number of data "words" is 11. This is in any case the maximum number that will be displayed together at line 170.

D. R. Smith
Coventry

LIKE V

Sir—This short program for the UK101 allows the programmer to view the contents of a tape without loading it into memory, a similar facility to the V command in the extended monitor.

The program is in BASIC, and uses a machine code routine as follows:

```
0222 20 80 FE      JSR FE80
0225 8D 29 02      STA 0229
0228 60            RTS
0229—character store
```

The FE80 is the address to a subroutine, that inputs a ASCII character from cassette, and stores the value in the accumulator. After re-entry, the value in A is stored at 0229, and the program returns to BASIC and prints out the character.

```
10 FOR A=546 TO 552
20 READ B:POKE A,B:NEXT
30 DATA 32,128,254,141,41,2,96
40 POKE 11,34:POKE 12,2:X=USR(X)
50 V=PEEK(553):PRINTCHR$(V):
60 GOTO 40
```

Hans Palm,
Sweden.

CEGMON TRACE HELP

Sir—I noticed R. J. Newman's snags with "Trace". Having used it under CEGMON I can only suggest either (1) the "Trace" cannot be loaded at 546 as the window handler resides there; I relocated mine to 672 ($02A0 hex), and (2) the control-C vector is mentioned twice in the program, being $FB94 under CEGMON.

I have found the PE "Trace" one of the most useful utilities published. I hope this is helpful.

Robin H. Tracey,
Coventry.

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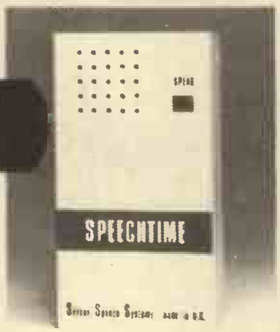

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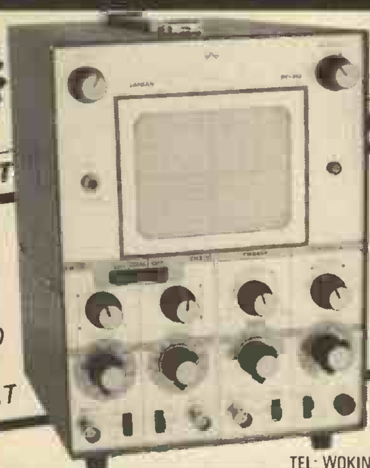

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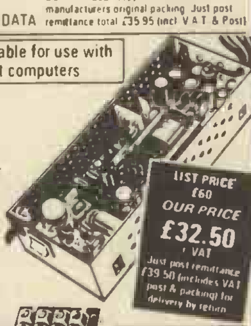

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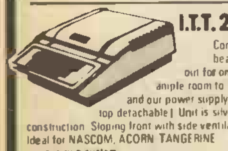

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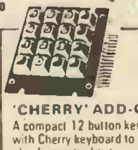

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	7X018	35 + 35	4 28		
	7X026	40 + 40	3 75		
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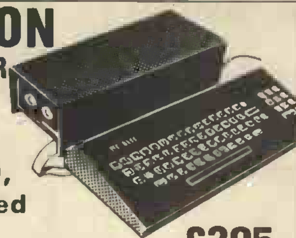

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6502 based microcomputer VDU alpha numeric display. Powerful monitor TANBUG 8K RAM 32 parallel I/O lines 2 TTL serial I/O lines. Four 16 Bit counter timers. Cassette interface. Data bus buffering. Memory mapping contol 71 key ASCII Keyboard, including numeric keypad. Includes power supply. Also includes the first "10K MICROSOFT BASIC" available in the U.K. All the usual BASIC commands.

FULL MANUALS: MICROTAN, TANEX, BASIC, X BUG
All £5.00 each

TANRAM

AVAILABLE NOW TANRAM - 40K Bytes on one board! Single board of bulk memory offering 7K Static RAM (2114), and 32K Dynamic RAM (4116). Onboard refresh is totally transparent to CPU operation and is unaffected by normal DMA's. TANRAM fully expands the available address space of the 6502 microprocessor. MICROTAN, TANEX and TANRAM together provide 16K RAM, 48K RAM, and 1K I/O - that's a lot of memory and a lot of I/O! Built and tested. TANRAM ASSEMBLED

40K RAM CARD with 16K DYNAMIC RAM £76 +VAT
CONTENTS: High quality plated thru hole printed circuit board, solder resist and silk screened component identification. Full complement of I.C sockets for maximum expansion. 64 way D.I.N. edge connector. 1K RAM (2114) Data bus buffering. TANRAM users manual

EXTRA RAM:
1K STATIC (2114) £2.95 each 16K DYNAMIC (4116) £1 50 each.

MEMORIES

EXPAND YOUR SYSTEM WITH OUR TANGERINE APPROVED CHIPS.
Discounts 10% for 4, 15% for 8, 20% for 16.

2102 1K x 1 Static RAM	80p	IM 6402 UART	£4.50
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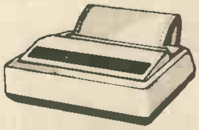

SHEIKOSHA **£199** + V.A.T.
Model 730 **£350** + V A T
Model 737 **£395** + V.A.T.

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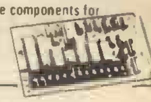
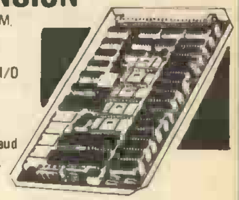
TANEX £43.00

Minimum Config Kit.
CONTENTS + V A T £6 45, total £49 45
High quality plated thru hole printed circuit board, solder resist and silk screened component identification. I.C. sockets for maximum expansion. 64 Way D.I.N. edge connector. 1K RAM, cassette interface, 16 parallel I/O lines, a T.T.L. serial I/O port, two 16 bit counter timers, data bus buffering, memory mapping, logic and discrete components for maximum expansion. TANEX users manual.
TANEX (Minimum configuration) Assembled
£53.00 + V.A.T. £7 95, total £60 95.



TANEX EXPANSION



Expanded, TANEX offers: 7K RAM, locations for 4K EPROM (2716), locations for 10K extended MICROSOFT BASIC, 32 parallel I/O lines, two TTL serial I/O ports, a third serial I/O port with RS232/20mA loop, full modem control and 16 programmable baud rates, four 16 bit counter timers, cassette interface, data bus buffering, and memory mapping.

EXPANDED TANEX KIT (Excludes ROM, XBUG and BASIC)
£89.70 + V A T £13.46, total £103.16.
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AS YOU CAN SEE THE PRICES OF OUR EXPANSION COMPONENTS ARE VERY, VERY COMPETITIVE!

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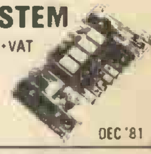

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DOUBLE SIDED DOUBLE DENSITY DRIVE
£215.00 +VAT
CP/M DISK OPERATING SYSTEM
Available January **£80** +VAT

DEC '81

71 KEY ASCII KEYBOARD £69.95+ INCL.

NO EXTRAS NEEDED.
Uses gold crosspoint keys. Includes numeric keypad and ribbon cable. Available as fully assembled and tested.
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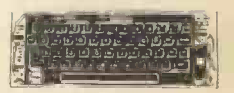
PROFESSIONAL ASCII KEYBOARDS Ideal for Tangerine



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- 52 key 7 bit ASCII coded
- Positive strobe +5V-12V
- ASCII characters
- Parallel output with strobe
- Power light on control
- Chip by General Instrument (G.I.) TTL output
- Superbly made
- Size 13 x 5.5 x 1.5 ins
- Black keys with white ledgens
- Escape shift return & reset keys
- Control repeat & bell
- Complete with DATA

ADD-ON KEYPAD

A compact 12 button keypad suitable for use with above keyboard to extend its functions plus four extra keys. Supplied brand new with with data. A non-encoded single mode keyboard

LIST PRICE £22.00
OUR PRICE **£7.95** + VAT

PLUS MANY NEW EXCITING PRODUCTS IN DEVELOPMENT AUTOMATICALLY AVAILABLE FROM US WHEN RELEASED BY TANGERINE LTD
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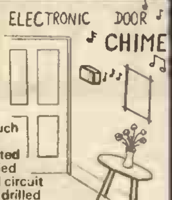
Fed up with your old doorbell? This KIT should cheer you up! Our latest kit gives you a pleasing three note harmonically related tone sequence (NOT a microprocessor controlled buzz) at a touch of a button. Based on a new integrated circuit, this KIT is supplied complete with a printed circuit board, loudspeaker and drilled box and requires only a 9V battery and a push-button, which you've probably already got. It may also be switched by logic in such applications as car alarms, clocks, toys, PA systems, etc. The unit produces a 150mW output and draws less than 1uA from a PP3 battery, when the tone ceases. Supplied complete with circuit and assembly instructions.



IDEAL PROJECT FOR BEGINNERS

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SOFTY 2

Plug SOFTY 2 into the EPROM socket of your favourite micro (Z80, 6800, 8035, etc.) prototype system, which will also contain input/output lines, RAM, keyboard; displays, etc. SOFTY 2 will operate as the ROM in your system but enable you to write data into any location, observe the memory contents on any black & white TV and store the program on a cassette recorder if required. Various editing facilities are also available to permit bytes or blocks of code to be changed, inserted, deleted, shifted, etc. enabling the programme to be developed and run on the host computer. When the program has been "debugged", SOFTY 2 may be used to turn it into an EPROM (2716 or 2732). Plug the Eprom into its socket and you have a dedicated microprocessor system.

You can also use it as an EPROM programmer and to copy EPROMs from a master or to/from tape.

The SOFTY 2 is housed in a black ABS case and comes complete with main supply, cable with 24-pin d.i.l. plug for connecting to your prototype system, and television lead. Fully built and tested.

£169 + VAT. Send SAE for further details.

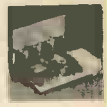
Also available is the new Z80 ASSEMBLER/MICRO CONTROLLER – MENTA. £115 + VAT

DISCO LIGHTING KITS

Each unit has 4 channels (rated at 1KW at 240V per channel) which switch lamps to provide sequencing effects, controlled manually or by an optional opto isolated audio input.

DL1000K
This kit features a bi-direcitonal sequence, speed of sequence and frequency of direction change being variable by means of potentiometers. Incorporates master dimming control. **£14.60**

DLZ1000K
A lower cost version of the above, featuring undirectional channel sequence with speed variable by means of a preset pot. Outputs switched only at mains zero crossing points to reduce radio interference to minimum. **£8.00**



Optional Opto Input
DLA1 60p

NOT JUST ANOTHER CLOCK

NEW

but a PROGRAMMABLE TIMER KIT which can run your central heating, burglar alarm, lighting, taperecorder/radio and lots more. Designed to control four mains outputs independently, switching these on and off on selected days and times in a seven day cycle.

Features include:

★ 0.5" LED 12 hr. display.
★ Day of week, am/pm and output status indicators.
★ Zero Voltage Switching Outputs.
★ 50/60Hz mains operation.
★ Battery backup saves stored programmes and continues time keeping during power failures. (Battery not supplied).
★ Display blanking during power failure to conserve battery power.
★ 18 programme time sets.
★ Powerful "Everyday" function enabling output to switch everyday but use only one time set.
★ Useful "sleep" function – turns on output for one hour.
★ Direct switch control enabling output to be turned on immediately or after a specified time interval.
★ 20 function keypad for programme entry.
★ Programme verification at the touch of a button.

To control your central heating, for example, (including different switching times at weekends), just connect it to your system, programme it, set it and forget it. The clock will do the rest. There has never been a clock capable of so much at this price. CT5000K Timer Kit (includes all components, assembly and programming instructions, and an attractive black case)

£45.00

DVM/THERMOMETER KIT

NEW DESIGN

Based on the ICL7126 (a low power version of the ICL7106 chip) and a 3½ digit liquid crystal display, this kit will form the basis of a digital multimeter (only a few additional resistors and switches are required – details supplied), or a sensitive digital thermometer (–50°C to +150°C) reading to 0·1°C. The basic kit has a sensitivity of 200mV for a full scale reading, automatic polarity indication and an ultra low power requirement – giving a 2 year typical battery life from a standard 9V PP3 when used 8 hours a day, 7 days a week.

£15.50 + VAT

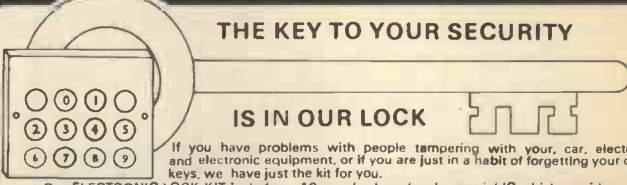
IF YOU CAN'T (REMOTE) CONTROL YOURSELF . . .

Remote control systems in magazines tend to be quite complex, requiring many difficult to get components and a well equipped lab to set them up. If this has put you off making your own system we have just the kits for you. Using infra-red, these KITS range from simple on/off controllers to coded transmitter/receivers with 16 on/off outputs or three analogue outputs for controlling TV or hi-fi systems, the kits are easy to build and simple to set up – and they are extremely versatile so you can use them for controlling anything from garage doors to room lighting just by adding the required output circuits, i.e. relays, triacs, etc.

If you can design your own system, we stock a wide range of remote control components at very competitive prices.

To help you decide, we have compiled a booklet on remote control, containing circuits, hints, data sheets and details of our remote control kits and components. So DON'T control yourself – send us 30p and an S.A.E. for your copy TODAY.

THE KEY TO YOUR SECURITY IS IN OUR LOCK



If you have problems with people tampering with your car, electrical and electronic equipment, or if you are just in a habit of forgetting your door keys, we have just the kit for you.

Our ELECTRONIC LOCK KIT includes a 10-way keyboard and a special IC which provides a 750mA output to drive a solenoid or relay (not supplied) when four keys are depressed in the correct sequence. This gives over 5,000 possible combinations! The sequence is pre-wired and may be easily changed by means of a small plug and socket. A "SAVE" function is also available enabling the open code to be stored (especially useful in a car when it is left in a garage for servicing as the open code need not be disclosed). Size: 7×6×3 cms. Power Consumption is 40uA at 5V to 15V d.c.

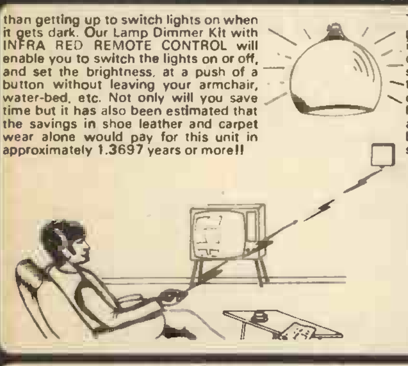
At only £10.50 + VAT, it will make a smaller hole in your pocket than a bunch of keys!

LOCK I.C.s	
LS7220 with SAVE memory	£2.75
LS7225 with latched and momentary outputs and a tamper output	£2.60
Electric Lock Mechanism	£12.50

Suitable for use with existing door locks and above electronic lock kit.

YOU MUST HAVE BETTER THINGS TO DO

than getting up to switch lights on when it gets dark. Our Lamp Dimmer Kit with INFRA RED REMOTE CONTROL will enable you to switch the lights on or off, and set the brightness, at a push of a button without leaving your armchair, water-bed, etc. Not only will you save time but it has also been estimated that the savings in shoe leather and carpet wear alone would pay for this unit in approximately 1.3697 years or more!!

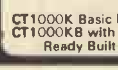


This unit has, of course, considerable practical uses, especially for the old, infirm and disabled. It works like a conventional dimmer, enabling you to switch the lights on or off, or to dim them to whatever brightness you require, by touch or remotely using the hand-held infra red transmitter. When assembled, it fits into a plaster depth box to replace your conventional switch or dimmer with no rewiring.

TDR300K Dimmer Kit £14.30 and MK6 Transmitter Kit £4.20. We also still sell our highly popular TD300K Touch Dimmer Kit at £7.00 and the LD300K rotary controlled Dimmer Kit at only £3.50 (plus VAT to above prices).

All kits contain all necessary components and full assembly instructions. You only need a soldering iron, cutters and a few hours.

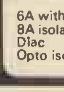
24 HOUR CLOCK/APPLIANCE TIMER KIT



Switches any appliance up to 1KW on and off at preset times once per day. Kit contains: AY-5-1230 IC, 0.5" LED display, mains supply, display drivers, switches, LEDs, triac, PCBs & full instructions.

CT1000K Basic Kit	£14.90
CT1000KB with white box (56/131×71mm)	£17.40
Ready Built £22.50	

TRIACS



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8A TIC226D	58p
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16A TIC246D	96p
25A TIC263D	190p
6A with trigger Q4006LT	80p
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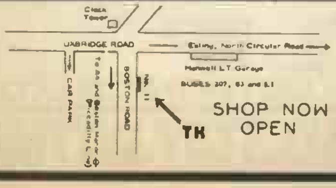
Diac	18p
Opto isolated triac MOC3020 0.6A/400V	110p



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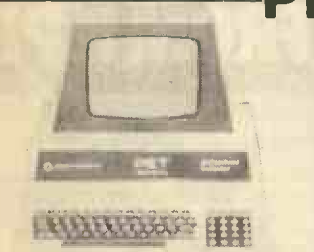

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NEW:NEW:NEW

32K DYNAMIC MEMORY BOARD KIT
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PIO and EPROM PROGRAMMER KIT
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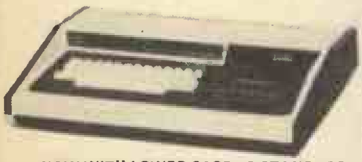
VIC 20

VIDEO GENIE



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Utilises Z80, 12K level II Basic, Integral Cassette Deck, UHF O/P, 16K RAM, all TRS80 features. Simply plugs into monitor or UHF TV. With V.U. Meter.

NOW WITH LOWER CASE AS STANDARD

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VIC 20

Colours
24 total. 8 for characters, 8 for border, 16 for screen mixed as you wish. Basic colours on program keys are black, white, red, blue, light blue, green, yellow, and purple.
Sound
3 Tone Generator for music
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Each Generator gives 3 octaves.
Reproduction is through tv speaker.
Character/Line Display
22 Characters by 23 lines
64 ASCII characters, pet-type graphic character set.
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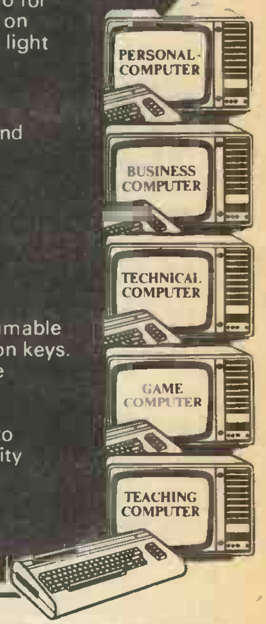
DIN typewriter keyboard with 8 programmable function possibilities via 4 special function keys. Colours are directly addressable from the keyboard.
Peripherals/Accessories
VIC Datacassette with special interface to guarantee high reliability read/write quality (PET/CBM compatible).

PRICE ONLY £165
CASSETTE DECK £34.95
with free programmes



APPLE

APPLE II PLUS

48K Machines	£595.00
Disk Drive with Controller	£349.00
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Colour Card	£69.00
Graphics Tablet	£425.00
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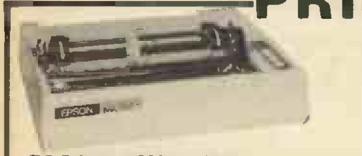
Typical Business Starter System. Apple 48K, 2 Discs, Monitor and Printer only. **£1,785.**

Apple II plus

PRINTERS



EPSON MX80 £359
Dot-matrix printer with Pet graphics interface. Centronics parallel and serial. Pet and Apple compatible. True bidirectional, 80 cps.
EPSON MX80 FT/1 £399
Dual single sheet friction and tractor, 9 wire head, true descenders.

Interfaces and Cables for APPLE II, PET, TRS80, RS 232, UK101, SHARP SUPERBOARD All Available
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An FT/1 with high resolution graphics.
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Friction and tractor feed, high resolution graphics, wide carriage 15½".
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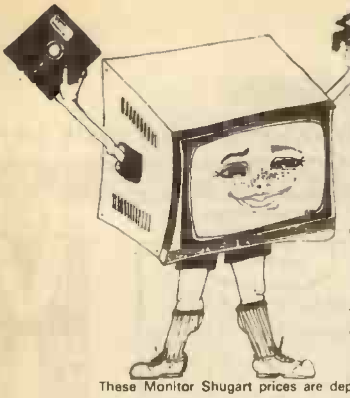
Please add VAT 15% to all prices. Postage on computers, monitors, printers and cassette decks charged at cost, all other items. P&P 30p. Place your order using your Access or Barclaycard (Min. tel order £5). Export enquiries welcome. Official orders welcome.



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TYPICALLY
9" Crofton Monitors

P4 White	£64.97
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No case, No Power Supply

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Model No.	Module	What it does	Current required	Price inc VAT	Price ex VAT
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HY 77	Stereo VU meter driver	Programmable gain/LED overload driver.	20 mA	£10.64	£9.25

For easy mounting we recommend:
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*All modules are encapsulated and include clip-on edge connectors. All operate from ±15V minimum to ±30V maximum, needing dropper resistors for higher voltages. HY67 can be used only with the PSU 30 power supply unit. Modules HY6 to HY13 measure 45 × 20 × 40mm HY66 to HY77 measure 90 × 20 × 40mm.

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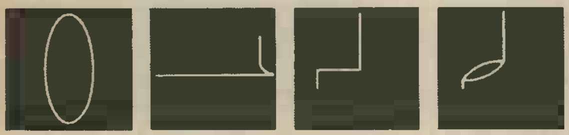

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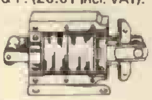
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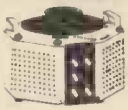

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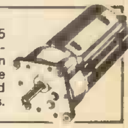
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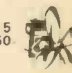
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