

PRACTICAL

ELECTRONICS

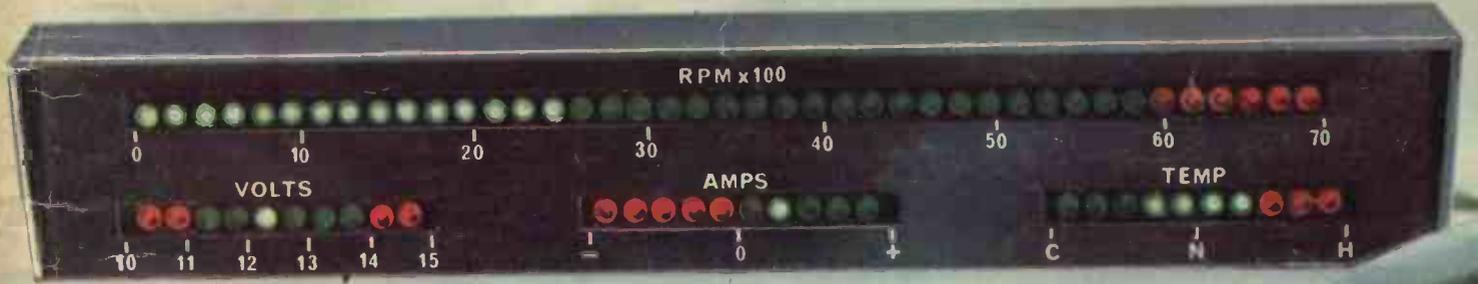
OCTOBER 1978

50p



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TOOL**

SOLID STATE INSTRUMENTS



No.1 Battery Voltage Indicator



Also...

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AS SEEN IN
P.E. AUGUST, SEPTEMBER
OCTOBER 1979

EUROPE'S FASTEST SELLING ONE BOARD COMPUTER —
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COMPUKIT UK101

SAMPLE TAPE
WITH EXTENDED
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The CompuKit UK101 has everything a one board 'superboard' should have.

- * Uses ultra-powerful 6502 microprocessor.
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- * 48 chars by 16 lines — 1K memory mapped video system providing high speed access to screen display enabling animated games and graphs.
- * Extensive 256 character set which includes full upper and lower case alphanumerics. Greek symbols for mathematical constants and numerous graphic characters enabling you to form almost any shape you desire anywhere on the screen.
- * Video output and UHF Highgrade modulator (8Mz Bandwidth) which connects direct to the aerial socket of your T.V. Channel 36 UHF
- * Fully stabilised 5V power supply including transformer on board.
- * Standard KANSAS city tape interface providing high reliability program storage — use on any standard domestic tape or cassette recorder
- * 4K user RAM expandable to 8K on board £49 extra.
- * 40 line expansion interface socket on board for attachment of extender card containing 24K RAM and disk controller. (Ohio Scientific compatible).
- * 6502 machine code accessible through powerful 2K machine code monitor on board.
- * High quality thru plated P.C.B. with all I.C.'s mounted on sockets.
- * Professional 52 Key keyboard in 3 colours — software polled meaning that all debouncing and key decoding done in software.



*8K Microsoft Basic means conversion to and from Pet, Apple and Sorcerer easy. Many compatible programs already in print.
SPECIAL CHARACTERS
@ Erases line being typed, then provides carriage return, line feed.
Erases last character typed.
CR Carriage Return — must be at the end of each line.
: Separates statements on a line.
CONTROL/C Execution or printing of a list is interrupted at the end of a line.
"BREAK IN LINE XXXX" is printed, indicating line number of next statement to be executed or printed.
CONTROL/O No outputs occur until return made to command mode. If an Input statement is encountered, either another CONTROL/O is typed, or an error occurs.
? Equivalent to PRINT

Simple Soldering due to clear and concise instructions compiled by Dr. A.A. Berk, BSc.PhD

NO EXTRAS NEEDED JUST HIT 'RETURN' AND GO.

Build, understand, and program your own computer for only a small outlay.

KIT ONLY **£219** + VAT including RF Modulator & Power supply. Absolutely no extras.

Available ready assembled and tested, ready to go for **£269** + VAT

COMMANDS
CONT LIST NEW NULL RUN
STATEMENTS
CLEAR DATA DEF DIM END FOR
GOTO GOSUB IF GOTO IF THEN INPUT LET
NEXT ON GOTO ON GOSUB POKE PRINT REAC
REM RESTORE RETURN STOP
EXPRESSIONS
OPERATORS
+ . / . ↑ NOT . AND . OR . > < . <> . >= <= RANGE 10³² to 10⁺³²
VARIABLES
A.B.C. . Z and two letter variables
The above can all be subscripted when used in an array. String variables use above names plus S.e.g A\$

FUNCTIONS
ABS(X) ATN(X) COS(X) EXP(X)
LOG(X) PEEK(I) POS(I) RND(X)
SPC(I) SQR(X) TAB(I) TAN(X)
FRE(X) INT(X)
SGN(X) SIN(X)
USR(I)
STRING FUNCTIONS
ASC(X\$) CHR\$(I) FRE(X\$) LEFT\$(X\$,I)
RIGHT\$(X\$,I) STR\$(X)
LEN(X\$) MID\$(X\$,I,J)
VAL(X\$)

EXTRAS AVAILABLE SOON

COLOUR ADD-ON enables you to choose your foreground and background colour anywhere on the screen. Flash any character on the screen at will. Full documentation and parts in kit form.

AD-A-RAM EXTENDER CARD provides up to 32K Dynamic RAM Expansion, 8 Eprom sockets for 2708's or 2716's. Parallel Port (centronics compatible) and an RS232C serial port.

WIN YOURSELF AN ANADEX DP8000 LINE PRINTER

There's never enough good software around. That's why COMPUKIT LTD. are sponsoring a software contest. There are 2 categories:

- 1) Business and Education
- 2) Fun and Games

One lineprinter will be awarded to the winner of each category.

Send or bring along to the address shown below the following:

- 1) The program on cassette in the format used by the COMPUKIT UK101
- 2) Any documentation that you have for the program (source listing not necessary)
- 3) This coupon signed by you accepting the rules and conditions of the competition.

RULES:

- 1) Entries, including documentation, must be printed by computer or typed double spaced, with your name on every page.
 - 2) Send or bring your entries to the address shown below.
 - 3) Entries must be received by midnight on 29/2/80, any received after this time are void.
- Winners will be notified by post before 31/3/80.
- 4) You warrant by your signature that all programs and documentation material included is entirely your own creation, and that no rights to it have been given or sold to any other party, and you agree to allow COMPUKIT LTD. to use, publish, distribute, modify, and edit it as it sees fit.

- 5) All entries become the property of COMPUKIT LTD. No entries will be returned nor any questions answered regarding individual entries.
- 6) Judging will be by a selected panel chosen by, and including representatives of COMPUKIT LTD. Judges may assign programs to any of the categories as they see fit. Decision of the judges is final.
- 7) Employees of COMPUKIT LTD, its dealers, distributors, advertising agencies and media are not eligible to enter.

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Address _____

I agree to abide by the above mentioned rules.

Signature _____

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PRACTICAL ELECTRONICS

VOLUME 15 No. 10 OCTOBER 1979

CONSTRUCTIONAL PROJECTS

SOLID STATE INSTRUMENTS <i>by Michael Tooley B.A. and David Whitfield B.A., M.Sc.</i>	
Battery Voltage Indicator—1. <i>First of a series</i>	24
DIGITAL TEMPERATURE CONTROLLER <i>by D. Coutts and P. McAllister</i>	32
V.L.F. RECEIVER <i>by C. R. Francis B.Sc.</i>	
Listen to Sferics, Tweeps and Whistlers	42
6 CHANNEL MIXER—2 <i>by S. R. W. Grainger and C. R. Harding</i>	
Wiring and final setting up	50
COMPUKIT UK101—Part 3 <i>by A. A. Berk B.Sc., Ph. D.</i>	
Error codes, program recording and playback, running BASIC	56

GENERAL FEATURES

SEMICONDUCTOR UPDATE <i>by R. W. Coles</i>	
A look at some recently released devices—MM74C911/7, ICL 7611	23
INGENUITY UNLIMITED	
Freezer Temperature Alarm—Digital Servo Amplifier—Fridge/Freezer Thermostat—Sequential Light Chaser—Motion Detector	37
MICROBUS <i>by D.J.D.</i>	
A bi-monthly focus on micro's for the home constructor	67
SCHMITT TRIGGER CIRCUITS <i>by D. F. Bowers B.Sc.</i>	72

NEWS AND COMMENT

EDITORIAL	17
MARKET PLACE	
New products	18
Chicago Consumer Electronics Show	20
INDUSTRY NOTEBOOK <i>by Nexus</i>	
What's happening inside industry	22
Using the I.C. Removal Tool	30
NEWS BRIEFS	
Electronic Club at Margate—On Course—Automatic Fare Collection	30
SPACEWATCH <i>by Frank W. Hyde</i>	
More about Jupiter, Interesting Io, Galilean Satellites	48
PATENTS REVIEW	
Class A Transistor Amplifier	54
COUNTDOWN	62
CB IN THE UK <i>by Dr. Mark Sawicki</i>	66
READOUT	
A selection of readers' letters	70

OUR NOVEMBER ISSUE WILL BE ON SALE FRIDAY, 12 OCTOBER, 1979
(for details of contents see page 65)

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WATFORD ELECTRONICS

(Continued from opposite side)

DIODES	BRIDGE RECTIFIERS	SPEAKERS	ZENERS
AA119 15	1A/50V 20	8Ω 0.3W 74	Rng. 2V7 39V
AA129 25	1A/100V 22	2.5x3" 74	400mW 9p
AA130 25	1A/200V 22	4.0x2.5" 78	400mW 9p
AA15 15	1A/200V 25	6.0x2.5" 74	Rng. 3V3-33V
BA100 10	1A/400V 29	8Ω 0.5W 74	1 3W 15p
BY100 24	1A/600V 34	7x4" 250	
BY126 12	2A/50V 35	8Ω 3W 160	
BY127 12	2A/100V 44	6"x4" 160	
CRO33 167	2A/200V 46		
OA9 75	2A/400V 53	ALUM. BOXES	
OA47 12	2A/600V 62	3x2x1" 54	
OA70 12	4A/200V 75	2 1/2 x 5 x 1 1/2 72	
OA79 12	4A/400V 79	4x2x1 1/2 72	
OA81 15	4A/800V 120	4x2 1/2 x 1 1/2 85	
OA85 12	6A/100V 73	4x2 1/2 x 2 72	
OA90 6	6A/200V 78	5x4x2 98	
OA91 6	6A/400V 85	6x4x2 108	
OA95 8	6A/800V 85	6x5x2 145	
OA200 9	VM18 DIL 40	8x6x3 185	
OA202 8		10x7x3 210	
IN914 4		12x5x3 215	
IN916 5		12x8x3 265	
IN400/2 5			
IN4003 6			
IN4004/5 6			
IN4006/7 7			
IS44 4			
3A/100V 18			
3A/400V 20			
3A/600V 27			
3A/1000V 30			
SCR's			
Thyristors			
0.6A/200V 30			
0.8A/30V 28			
0.8A/100V 30			
0.8A/200V 35			
1A/600V 70			
5A/300V 35			
5A/600V 43			
8A/300V 48			
8A/600V 85			
12A/300V 59			
12A/600V 92			
15A/700V 150			
15A/100V 95			
15A/200V 105			
15A/400V 160			
15A/800V 295			
TIC44 22			
TIC45 28			
TN4444 140			
	DIAC		
	ST2 20		

OPTO ELECTRONICS

LEDS Plus. Clip	OPTO Isolators
TIL209 Red 125" 13	TL111/2 48
TIL211 Grn 125" 18	TL117 110
TIL212 Yellow 22	
TIL32 Infra Red 58	
0.2" Red TIL220 15	
0.2" Yellow, 19	
Grn, Amber 18	
Square LEDES 48	
OP71 120	
ORP12 63	
ZNS5777 45	
	7 Segment Displays
	LS400 265
	TL1307 675
	TIL312 & 313-3" 106
	TIL321 5" C.Anod 115
	TIL322 5" C.th 115
	DL704 3" C.Cth 99
	DL707 3" C.Anod 99
	DL74 7.5" An 180
	FND357 120
	MAN3640 165
	XAN351 3" Green 180
	Liquid Crystal Display
	3 1/2 digit 875p; 4 digit 975p
	VEROBOARD
	Pitch 0-1 0-15 0-15
	(copper clad) 31p 24p
	(plain) 31p 24p
	2 1/2 x 3 1/2 46p 39p
	2 1/2 x 5 1/2 56p 50p
	3 1/2 x 3 1/2 55p 50p
	3 1/2 x 5 1/2 62p 67p
	3 1/2 x 7 1/2 218p 180p
	4 1/2 x 7 1/2 280p 20p
	Pt of 36 pins 20p
	Spot face cutter 85p
	Pin insertion tool 120p
	VERO WIRING PEN Spool
	Spare Wire (Spool 80p); Combs 7p ea.
	FERRIC CHLORIDE
	1 lb bag Anhydrous 70p + 35p P&P
	DALO ETCH RESIST
	Pen + Spare tip 75p
	COPPER CLAD BOARDS
	Fibre Single-sided Double-sided SRBP
	6" x 6" 75p 90p 80p
	6" x 12" 130p 175p
	SOLDERCON PINS
	100 pins 50p; 500 pins 200p

VOLTAGE REGULATORS

1A TO3 +ve -ve	5V 7805 145p 7905 220p	12V 7812 145p 7912 220p	15V 7815 145p	18V 7818 145p	1A TO20 Plastic Casing	5V 7805 65p 7905 75p	12V 7812 65p 7912 75p	15V 7815 65p 7915 75p	18V 7818 65p 7918 75p	24V 7824 65p 7924 75p	100mA TO92 Plastic Casing	5V 78L05 30p 79L05 65p	6V 78L62 30p	8V 78L82 30p	12V 78L12 30p 79L12 65p	15V 78L15 30p 79L15 65p
CA3085 95	LM323K 625	LM300H 170	LM325N 240	LM305H 140	LM326N 240	LM309K 135	LM327N 270	LM317K 350	LM723 39							
SWITCHES	TOGGLE 2A 250V	SPST 28	DPST 34	1A DPDT 14	1A DPDT C/OFF 15	4 pole 2-way 13	4 pole 2-way 24	PUSH BUTTON	SP changeover	SPST on off 54	SPST biased 85	DPDT 6 tags 70	DPDT C/OFF 79	DPDT Biased 115	3 pole C/OFF 150	
SLIDE 250V	SPST 28	DPST 34	1A DPDT 14	1A DPDT C/OFF 15	4 pole 2-way 13	4 pole 2-way 24	SP changeover	SPST on off 54	SPST biased 85	DPDT 6 tags 70	DPDT C/OFF 79	DPDT Biased 115	3 pole C/OFF 150			
ROCKER: (white) 5A 250V SP change-over centre off	30	ROCKER: Lights red when on. Chrome Bezel, 3A 250V, SPST	52	ROTARY: "Make-A-Switch" Make your own multiway Switch. Adjustable Stop Shafting Assembly. Accommodates up to 6 Wafers	75	Mains Switch DPST to fit	34	Break Before Make Wafers, 1 pole/12 way, 2p/6 way, 3p/4 way, 4p/3 way, 6p/2 way	47	Spacer and Screen	5	ROTARY: (Adjustable Stop)	1 pole/2 to 12 way, 2p/2 to 6 way, 3 pole/2 to 4 way, 4 pole/2 to 3 way	41	ROTARY: Mains 250V AC, 4 Amp	45

OHIO SUPERBOARD II Only £188.00 ex stock

Yes, we are now selling this single board microcomputer at only £188.00. Due to the recent devaluation of US Dollar against £ Sterling, we have been able to purchase a limited number of Superboards at lower price. Naturally, we wish to pass this price advantage on to our customers. Buy now to avoid disappointment should Mrs. Thatcher & Co. decide to devalue the pound. Superboard II is supplied fully assembled and tested. Requires +5V at 3A and a Video Monitor or TV with RF Converter to be up and running. (Data sheet supplied. We can also supply the RF Converter and Power Supply in kit form or ready-built). 8k Microsoft BASIC IN ROM. 4k Static RAM on BOARD expandable to 8k. Full 53 Key Keyboard with Upper/Lower Case & user programmability and a lot more. See it for yourself. Continuous demonstration on at our retail shop. Specially designed case for Superboard available at £25.00.

CRYSTALS	6 5536MHz 200p	100kHz 385p	7.680MHz 323p	455kHz 385p	9.375MHz 323p	1MHz 323p	10MHz 323p	1.008MHz 323p	10.7MHz 323p	1.80MHz 385p	12MHz 392p	1.832MHz 362p	14.318118M 300p	1.6MHz 395p	18MHz 323p	3.2768MHz 323p	18.432M 33p	4MHz 290p	20MHz 362p	4.032MHz 323p	27.648MHz 350p	4.433619M 135p	48MHz 323p	5 0MHz 355p	100MHz 300p								
VDU BOARD	Thompson SFKEX 68364-1-1, ready built 7 tested £69.00.	UHF Modulator 250p.	Wide Bandwidth Special for Computer 470p.	Full Ascii KEYBOARD Model 756	Low cost, ready-built, tested & Guaranteed. Full technical details supplied. Only £49.75.	KEYPADS	4x4 matrix, push button read switches assembly. Extremely reliable. Only 450p.	DIL SOCKETS (TEXAS)	Low profile	8 pin 10p	14 pin 12p	16 pin 13p	18 pin 16p	20 pin 22p	22 pin 25p	24 pin 36p	28 pin 39p	36 pin 50p	40 pin 50p	DIL PLUGS (Headers)	14 PIN 35p	16 PIN 39p	EDGE CONNECTORS	double type	2 x 10 way 85p	2 x 15 way 99p	2 x 18 way 115p	2 x 22 way 130p	2 x 25 way 149p	2 x 30 way 170p	2 x 35 way 194p	2 x 40 way 210p	2 x 43 way 232p
TRANSFORMERS (mains Prim. 220-240V)	6.0-6V 100mA; 9.0-9V 75mA; 12.0-12V 75mA 95p	8VA type: 6V-5A 6V-5A; 9V-4A 9V-4A; 12V-3A 12V-3A; 15V-2.5A 15V-2.5A 195p	12VA: 4.5-1.3A 4.5V-1.3A; 6V-1.2A 6V-1.2A 12V-1.5A 12V-1.5A 220p (20p p&p)	24VA: 6V-1.5A 6V-1.5A; 9V-1.2A 9V-1.2A; 12V-1A 12V-1A; 15-8A 15-8A; 20V-6A 20V-6A 290p (45p p&p)	50VA: 6V-4A 6V-4A; 9V-2.5A 9V-2.5A; 12V-2A 12V-2A; 15V-1.5A 15V-1.5A; 20V-1.2A 20V-1.2A; 25V-1A 25V-1A; 30V-8A 30V-8A 350p (50p p&p)	100VA: 12V-4A 12V-4A; 15V-3A 15V-3A; 20V-2.5A 20V-2.5A; 30V-1.5A 30V-1.5A; 40V-1.25A 40V-1.25A; 50V-1A 50V-1A 650p (60p p&p)	(N.B. P&P charge to be added above our normal postal charge.)																										

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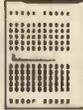
EXPERIMENTOR BREADBOARDS

FROM 

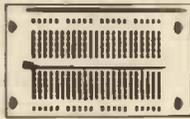
No soldering modular breadboards, simply plug components in and out of letter number identified nickel-silver contact holes. Start small and simply snap-lock boards together to build breadboard of any size.

All EXP Breadboards have two bus-bars as an integral part of the board, if you need more than 2 buses simply snap on 4 more bus-bars with the aid of an EXP.4B.

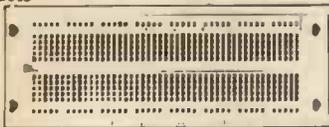
EXP.325. The ideal breadboard for 1 chip circuits. Accepts 8, 14, 16 and up to 22 pin IC's.



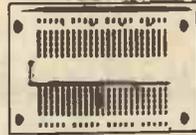
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- 1945 Iron coated bit 1/8" for 1943 £0.53
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- 1949 Iron coated bit 3/32" for 1948 £0.53
- 1950 Iron coated bit 1/8" for 1948 £0.53
- 1951 Iron coated bit 3/16" for 1948 £0.53
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- 1932 Iron coated bit 1/8" for 1931 £0.57
- 1933 Iron coated bit 2/16" for 1931 £0.57
- 1934 Iron coated bit 3/32" for 1931 £0.57
- 1953 SK1 soldering Kit - contains 15 watt soldering iron with 3/16" bit plus two spare bits, a reel of solder, heat-sink and a booklet 'How to Solder' £6.38
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- 1724 Model MLX as X25 iron but 12 volts £5.29

DIODES

Type	Price	Type	Price	Type	Price	Type	Price
AA110	£0.09	BY100	£0.25	BY211	£0.52	OA90	£0.11
AA120	£0.09	BY101	£0.25	BY212	£0.46	OA91	£0.11
AA129	£0.09	BY105	£0.25	BY213	£	OA95	£0.11
AA300	£0.10	BY114	£0.25	BY216	£0.47	OA182	£0.15
AAZ13	£0.17	BY124	£0.25	BY217	£0.41	OA200	£0.09
BA100	£0.11	BY126	£0.17	BY218	£0.41	OA202	£0.09
BA102	£0.37	BY127	£0.18	BY219	£0.41	SD10	£0.07
BA148	£0.17	BY128	£0.18	OA5	£0.07	SD19	£0.07
BA154	£0.14	BY130	£0.19	OA10	£0.69	IN34	£0.08
BA195	£0.16	BY133	£0.24	OA47	£0.09	IN34A	£0.08
BA173	£0.17	BY164	£0.58	OA70	£0.09	IN914	£0.07
BB104	£0.17	BY176	£0.86	OA79	£0.11	IN916	£0.07
BAX13	£0.08	BY206	£0.34	OA81	£0.11	IN4148	£0.07
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INSTRUMENT CASES in two sections vinyl covered top and sides, aluminium bottom, front and back.

No.	Length	Width	Height	Price
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No.	Length	Width	Height	Price
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161	4in	2 1/2in	1 1/2in	£0.85
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163	4in	2 1/2in	2in	£0.87
164	3in	2in	1in	£0.60
165	7in	5in	2 1/2in	£1.43
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No.	Length	Width	Height	Price			
169	2 1/2in	5 1/2in	2 1/2in	12in	3 1/2in	8in	£5.45
168	2 1/2in	7 1/2in	4in	16in	4 1/2in	11in	£8.21

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No.	Length	Width	Height	Price
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16220	40 mixed 1/2w 100kohms-820kohms	£0.69

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16162	24-3 of each value 470pf 560pf 680pf 1000pf 1500pf 2200pf 3300pf	£0.69
16163	24-3 of each value 470pf 680pf 01uf 015uf 022uf 033uf 047uf	£0.69

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uA7824 TO220	£0.85
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uA7912 TO220	£0.92
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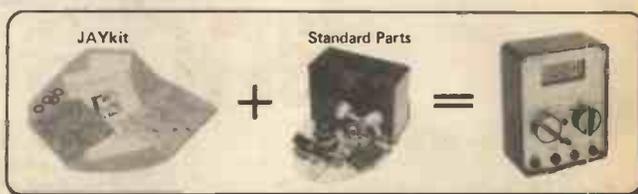
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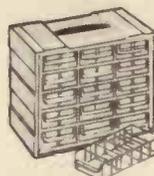
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Mono C/W
Front panel **£10.92**
Stereo C/W
Front panel **£15.81**

Power supply to suit **£10.92**

send for full details.

SOUND-TO-LIGHT UNITS

3 CHANNEL - 3kW **£33.92**
 Operates from 1W upwards
 Boss/middle/treble/master controls + £1 corr complete
Module only **£22.71**
Panel **£3.39**

4 CHANNEL - 4 kW SOUNDLIGHT SEQUENCER (illus) **£46.57**
 Dimmer on each channel
 Automatic sound light level
 Logic circuitry throughout
Module only **£30.76** Panel **£3.39**

MOTOROLA PIEZO HORNS £5.46 YES!!

FUZZ LIGHTS Red, Blue, Yellow, Green **£26.22**

HEAVY DUTY SPOT BANKS - MATCHES LOUDSPEAKERS
3 way 600W **£40.82** 4 way 800W **£47.72**

100W SPOTS
Red - Blue - Amber - Green **£1.72**

CABINET FITTINGS
ICI Vynide 50" wide **£4.02m**
Kick-res grille 50" wide **£4.02m**
Netlon kick proof 24" wide **£4.02m**
Corners/feet-recess plates 17p
Recess handle 52p
Bar handles **£2.87**
Jack plugs/sockets 29p

LOUDSPEAKER CABINETS - COMPLETE WITH LEADS

- Fitted with 100W 17,000 Gauss drivers
- Rugged cabinets with aluminium trim - black vynide etc
- Lifetime guarantee on main drive unit

Standard 100W 1 x 12 (48 x 41 x 24) **£50.60**

Large 100W 1 x 12 (65 x 48 x 24) **£62.67**

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P.A. 2 x 12 200W (100 x 38 x 24) **£119.60**

Disco 2 x 12 200W (80 x 63 x 24) **£103.50**

PDF reflex bin (80 x 40 x 41) **£115.00**

PDF100 Reflex Bin - Twin Horns - Integrated Slave Amplifier - Accepts mono or stereo signals

- Use with all types of mixer
- Pan and volume controls
- Send for details **£155.25** Deposit **£31.25**

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MANCHESTER DISCO CENTRE, 237 DEANS GATE, MANCHESTER CALLERS ONLY - (061) 832 8772 - COMPLETE UNITS ONLY

KITS FOR SYNTHESISERS, SOUND EFFECTS



COMPONENTS SETS include all necessary resistors, capacitors, semiconductors, potentiometers and transformers. Hardware such as cases, sockets, knobs, keyboards, etc. are not included but most of these may be bought separately. Fuller details of kits, PCBs and parts are shown in our lists.

LAYOUT DIAGRAMS are supplied free with all PCBs unless "as published".

PHONOSONICS

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

P.E. 128-NOTE PROGRAMMABLE SEQUENCER

Enables a voltage controlled synthesiser to automatically play pre-programmed tunes of up to 32 pitches and 128 notes long. Programs are keyboard initiated and note length and rhythmic pattern are externally variable.

Set of basic component kits	KIT 76-5	£28.92
Set of PCBs & layout charts	KIT 76-6	£5.66
Set of text photocopies		£1.36

P.E. 16-NOTE PROGRAMMABLE SEQUENCER

Sequences of up to 16 notes may be programmed by the use of external panel controls and fed into most voltage controlled synthesisers.

Set of basic component kits	KIT 86-3	£22.90
Set of PCBs	KIT 86-4	£5.09
Set text photocopies		£1.84

P.E. STRING ENSEMBLE

A multivoiced string instrument synthesiser.

Set of basic component kits	KIT 77-6	£68.70
Set of PCBs & layout charts	KIT 77-7	£24.19

P.E. JOANNA PLUS ORGAN VOICING

A modified version of the P.E. 5-octave piano that retains all the original facilities and also includes switchable organ voicing circuitry.

Set of basic component kits	KIT 71-5	£89.87
Set of PCBs & layout charts	KIT 71-6	£29.51
"Sound Design" booklet		£1.00

ELEKTOR ELECTRONIC PIANO

A touch-sensitive multiple-voicing piano using the latest integrated circuit techniques for the keying and envelope shaping, and virtually eliminating "bee-hive" noise hitherto inherent in previous electronic pianos.

5-octave set of basic components	KIT 80-6	£100.84
5-octave set of PCBs (as published)	KIT 80-7	£26.02
Additional 3-octave extension basic parts	KIT 80-5	£40.98
Additional 3-octave set of PCBs (as published)	KIT 80-8	£9.45
Set of text photocopies		£1.81

P.E. MINISONIC MK2 SYNTHESISER

A portable mains operated miniature sound synthesiser with keyboard circuits. Although having slightly fewer facilities than the large Formant and P.E. synthesisers the functions offered by this design give it great scope and versatility.

Set of basic component kits (excl. KBD R's & tuning pots - see list for options available)	KIT 38-23	£67.05
Set of PCBs (incl. layout charts)	KIT 38-24	£9.87
"Sound Design" booklet		£1.00

P.E. SYNTHESISER

The well acclaimed and highly versatile large scale mains operated synthesiser. Other circuits in our lists may be used with it to good advantage.

Main Unit basic component kits	KIT 23-27	£86.99
Main Unit set of PCBs & layout charts	KIT 23-28	£14.52
Keyboard Unit basic component kits	KIT 23-29	£82.07
Keyboard Unit set of PCBs & layout charts	KIT 23-30	£8.42
Main Unit set of text photocopies		£5.91
Keyboard Unit set of text photocopies		£2.30

ELEKTOR FORMANT SYNTHESISER

A very sophisticated synthesiser for the advanced constructor who puts performance before price.

Set of basic component kits	KIT 66-12	£193.68
Set of PCBs (as published)	KIT 66-13	£53.92
Set of text photocopies		£7.83

P.E. GUITAR EFFECTS PEDAL

Modulates the attack, decay and filter characteristics of a signal from most audio sources, producing 8 different switchable effects that can be further modified by manual controls.

Basic parts with foot switches	KIT 42-1	£8.45
Basic parts with panel switches	KIT 42-2	£5.55
PCB & layout chart	PCB 43A	£1.57
Text photocopy		28p

ELEKTOR DIGITAL REVERB UNIT

A very advanced unit using sophisticated i.c. techniques instead of mechanical spring lines. The basic delay range of 24 to 90mS can be extended up to 450mS using the extension unit. Further delays can be obtained using more extensions.

Main unit basic component kit	KIT 78-1	£49.99
Main unit PCB (as published)	PCB 9913	£3.69
Extension unit basic component kit	KIT 78-2	£47.69
Extension unit PCB (as published)	PCB 788	£1.16
Text photocopy		

ELEKTOR ANALOGUE REVERB UNIT

Using i.c.s instead of spring-lines the main unit has a maximum delay of up to 100mS, and the additional set extends this up to 200mS. May be used in either mono or stereo mode.

Main unit basic component set	KIT 83-1	£29.49
Additional Delay basic components	KIT 83-2	£20.07
PCB (as publ.) to hold both kits	PCB 9973	£4.31
Text photocopy		

P.E. GUITAR MULTIPROCESSOR

An extremely versatile sound processing unit capable of producing, for example, flanging, vibrato, reverb, fuzz and tremolo as well as other fascinating sounds. May be used with most electronic instruments.

Set of basic component kits	KIT 85-3	£43.75
Set of PCBs & layout charts	KIT 85-4	£10.62
Set of text photocopies		£2.52

P.E. PHASER

An automatically controlled 6-stage phasing unit with integral oscillator.

Set of basic components, incl. PCB & chart	KIT 88-1	£10.14
Text photocopy		68p

ELEKTOR PHASING & VIBRATO UNIT

Includes manual and automatic control over the rate of phasing & vibrato, and has been slightly modified to also include a 2-input mixer stage.

Set of basic components	KIT 70-1	£19.11
PCB & layout chart	PCB 70A	£2.56
Text photocopy		67p

P.E. PHASING UNIT

A simple but effective manually controlled phasing unit.

Set of basic components incl. PCB & chart	KIT 25-1	£3.52
Text photocopy		28p

PHASING CONTROL UNIT

For use with Phasing Kit 25 to automatically control rate of phasing.

Set of basic components incl. PCB & chart	KIT 36-1	£5.21
Text photocopy		10p

P.E. SWITCHED TONE TREBLE BOOST

Provides switched selection of 4 preset tonal responses.

Set of basic components, PCB & chart	KIT 89-1	£3.82
Text photocopy		78p

P.E. TREBLE BOOST UNIT

A simple treble boost unit with manual control of depth.

Set of basic components, PCB & chart	KIT 53-1	£2.76
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ELEKTOR RESONANCE FILTER

Allows a synthesiser to produce a more realistic simulation of natural musical instruments.

Set of basic components	KIT 82-1	£16.61
PCB (as published)	PCB 9951	£3.29
Text photocopy		

P.E. GUITAR OVERDRIVE

Sophisticated versatile fuzz unit including variable controls affecting the fuzz quality whilst retaining the attack and decay, and also providing filtering. Can be used with other electronic instruments.

Set of basic components	KIT 56-1	£7.57
PCB & layout chart	PCB 56A	£1.78
Text photocopy		68p

P.E. FUZZ UNIT

A simple fuzz unit. Slightly modified from the original.

Set of basic components, PCB & chart	KIT 65-1	£2.25
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TREMOLO UNIT

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

Set of basic components, PCB & chart	KIT 54-1	£3.23
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GUITAR FREQUENCY DOUBLER

A slightly modified and extended version of the P.E. unit.

Set of basic components, PCB & chart	KIT 74-1	£4.97
Text photocopy		39p

P.E. GUITAR SUSTAIN

Maintains the natural attack whilst extending note duration.

Basic components, foot switches, PCB & chart	KIT 75-1	£5.64
Basic components, panel switches, PCB & chart	KIT 75-2	£4.08
Text photocopy		38p

P.E. WAH-WAH UNIT

Can be controlled manually or by integral automatic control.

Set of basic components, PCB & chart	KIT 51-1	£3.99
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P.E. AUTO-WAH UNIT

Automatically Wah or Swell sounds with each note played.

Basic components, foot switches, PCB & chart	KIT 58-1	£8.43
Basic components, panel switches, PCB & chart	KIT 58-2	£5.31
Text photocopy		58p

ELEKTOR WAVEFORM CONVERTOR

Converts a saw-tooth waveform into sinewave, mark-space saw-tooth, regular triangle, or square-wave with variable mark-space ratio.

Basic components, PCB & chart, but excl. sw's.	KIT 67-1	£9.24
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P.E. VOLTAGE CONTROLLED FILTER

Extracted from P.E. Minisonic project.

Set of basic components, PCB & chart	KIT 65-1	£7.88
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P.E. RING MODULATOR

Extracted from P.E. Minisonic project.

Set of basic components, PCB & chart	KIT 59-1	£6.05
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ELEKTOR RING MODULATOR

Compatible with the Formant & most other synthesisers.

Set of basic components	KIT 87-1	£4.66
PCB (as published)	PCB 79040	£1.74
Text photocopy		38p

10% DISCOUNT VOUCHER (PE 70)

TERMS: Goods in current adverts & lists over £50 goods value (excl P&P & VAT). Correctly coded, C.W.O., U.K. orders only. This voucher must accompany order. Valid until end of month on cover of P.E.

ADD: POST & HANDLING

U.K. orders: Keyboards add £2.30 each. Other goods: Under £5 add 25p, under £20 add 50p, over £20 add 75p. Recommended insurance against postal mishaps: add 50p for cover up to £50, £1 for £100 cover, etc., pro-rata. N.B. Eire, C.I., B.F.P.O. and other countries are subject to higher export postage rates.

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EXPORT ORDERS ARE WELCOME but to avoid delay we advise you to see our list for postage rates. All payments must be cash-with-order, in Sterling by International Money Order or through an English Bank. To obtain list - Europe send 20p, other countries send 50p.

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AND OTHER PROJECTS

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

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

OVERSEAS enquiries for list: Europe—send 20p; other countries—send 50p.



KIMBER-ALLEN KEYBOARDS AND CONTACTS

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

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

CONTACT ASSEMBLIES (gold-clad wire) — 1 required for each KBD note:

Type GJ — SPCO 26½p ea. Type GA — 1 pr of contacts, normally open 24p ea. Type GB — 2 pr N/O 28½p ea. Type GC — 3 pr N/O 37½p ea. Type GE — 4 pr N/O 46½p ea. Type GH — 5 pr N/O 58½p ea. Type 4PS — 3 pr N/O plus SPCO 57p ea.

P.E. NOISE GENERATOR

Extracted from the P.E. Minisonic.

Set of basic components,
PCB & chart

KIT 60-1 £4.00

WIND & RAIN EFFECTS UNIT

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

Set of basic components,
PCB & chart

KIT 28-1 £4.68

Text photocopy 28p

P.E. ENVELOPE SHAPER WITHOUT VCA

Provides full manual control over attack, decay, sustain and release functions, and is for use with an existing VCA.

Set of basic components,
PCB & chart

KIT 44-1 £5.24

Text photocopy 49p

P.E. ENVELOPE SHAPER WITH VCA

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

Set of basic components,
PCB & chart

KIT 50-1 £7.34

Text photocopy 58p

P.E. GENERATOR

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

Set of basic components

KIT 63-1 £5.13

PCB & layout chart

PCB 63A £2.00

Text photocopy 58p

P.E. EXTERNAL-INPUT SYNTHESISER-INTERFACE

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

Set of basic components,
PCB & chart

KIT 81-1 £3.23

P.E. TUNING FORK

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

Set of basic components,
PCB & chart

KIT 46-1 £16.42

Power Supply components,
PCB & chart

KIT 46-2 £6.90

Text photocopy 97p

P.E. TUNING INDICATOR

A simple 4-octave frequency comparator for use with synthesisers and other instruments where the full versatility of KIT 46 is not required.

Set of basic components,
PCB & chart, but excl. sw.

KIT 69-1 £8.19

Text photocopy 58p

P.E. DYNAMIC RANGE LIMITER

Preset to automatically control sound output levels.

Set of basic components,
PCB & chart

KIT 62-1 £5.03

P.E. CONSTANT-DISPLAY FREQUENCY COUNTER

A 5-digit counter for 1Hz to 55KHz with 1Hz sampling rate. Readout does not count visibly or flicker due to blanking.

Set of basic components

KIT 79-1 £26.45

PCB (as published)

PCB 79A £3.33

Text photocopy 78p

INTEGRATED CIRCUITS

301	48p
318	220p
320-15	195p
323	562p
324	87p
341-15	87p
356	101p
709	48p
723	81p
726	1005p
741	24p
748	57p
4001	15½p
4007	17½p
4011	17½p
4013	34p
4016	33p
4017	54p
4024	46½p
4046	96p
4049	37½p
4066	40½p
4069	18p
4081	16½p
4136	126p
AM2833	396p
AY-1-0212	617p
AY-1-1320	636p
AY-1-6721/6	188p
CA3046	71p
CA3080	63p
CA3084	209p
FX209	729p
M252	680p
MC3340	150p
MCM6810	670p
RC4195	117p
SA01024	1762p
SG3402	262p
TD1A1022	582p
TL074	120p
KR2207	420p
2N425	375p
7400	20p
7402	20p
7404	18p
7413	31p
7420	15p
7447	72p
7472	22½p
7473	37½p
7474	31½p
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PHONOSONICS

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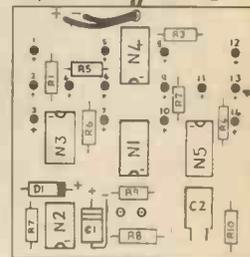
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Sound-light, 3 channel x 1000W. Zero mains voltage switching, high sensitivity, high input impedance, excellent separation.

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Light sequencer, 4 chan. x 1000W. Suedo-random, zero switching.

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Light dimmer, 3 chan. x 1000W. Stage lighting from full off to full on.

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25W, RMS 4Ω
10Hz-50kHz
T.H.D. 0.1% 90dB S/N

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PREAMPLIFIERS

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LBPA2. 4 channel gen. purpose mixer £13.50

LBPA3. Stereo disco with mic. £22.00

— LB250 —

250W R.M.S. 4Ω
10Hz-20kHz
T.H.D. 0.3% 110dB S/N

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— LB100 —

100W R.M.S. 4Ω
10Hz-25kHz
T.H.D. 0.4% 80dB S/N

£15.70

POWER SUPPLIES

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LB100PS£12.20

LB250PS£21.20

All above prices include VAT. Please add 50p p/packing. Quantity/trade discounts, up to 33% available. Export enquiries welcome. SAE for further info.

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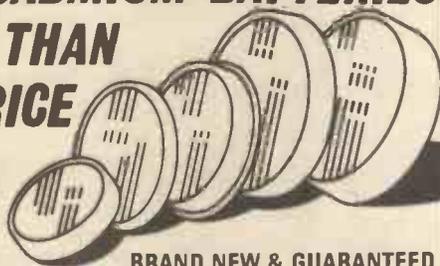
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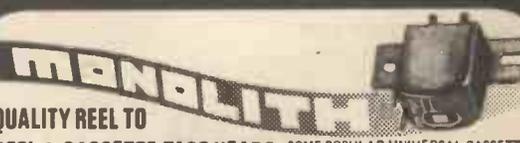


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3 Ch. 6 Spots	£78.95	£63.95	£59.95	£56.95
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4 Ch. 8 Spots	£89.95	£76.95	£67.95	£62.95
4 Ch. 16 Spots	£117.95	£102.95	£96.95	£90.95

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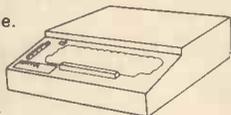
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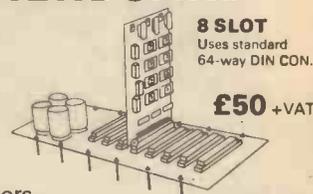


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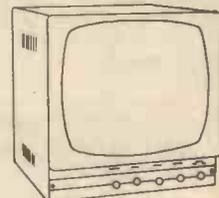
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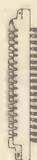
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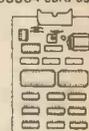
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L4-1 Listing listing of 1k monitor 2k tly basic £4.20
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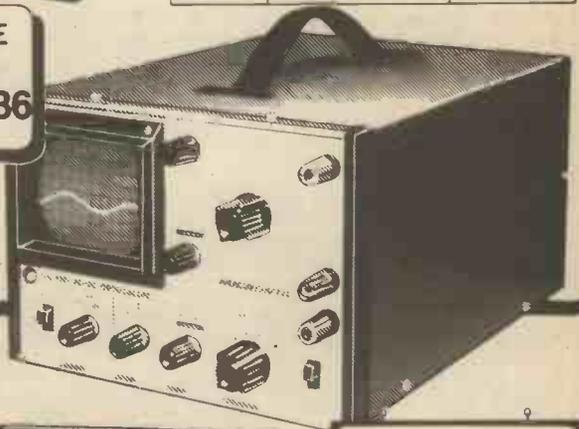


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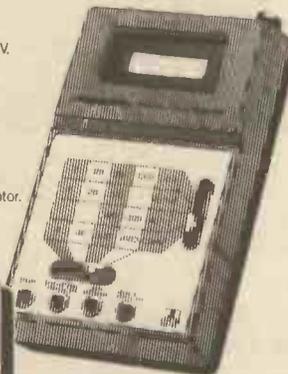


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MORE-MORE-MORE

EXACTLY a year ago we published an editorial similar to this one. The ways of the world are dictating the position and it is sad to realise that these editorials are probably going to be recurring at even shorter intervals in the future.

What is it all about? We are asking you to spend another 5p on P.E. next month—doesn't sound much does it and perhaps it won't worry you, but our view is that in these inflationary days every extra 5p must be fully considered. We have not put the price up just for the hell of it, we need you and we want you to keep buying P.E.—that's why we take a lot of care to try to bring you the best mag. on the market—and that we believe, is why we have a total sales figure that is higher than any other British hobby electronics magazine and that is an unqualified fact.

We have been under pressure on the price front for some time as the cost of paper in particular has risen dramatically yet again. Our costs have now risen by just under 20 per cent and we must reluctantly pass some of this on.

At this stage we have increased the price by 10 per cent but just how long we can hold it remains to be seen. If we use the standard argument 10 per cent in a year is less than the rate of inflation, but of course it is another 5p and adds to all the others, as we know.

Since our paper is shipped from Scandinavia and our issues are distributed by road, the cost of oil plays an important part and, with a forecast of £2 a gallon for petrol next year, we do not see P.E. staying at 55p. All we can say is that we will do our best.

VALUE

We hope we can give you good value for money—this issue is fatter than usual and carries a free gift. By designing and making these tools ourselves in very large quantities (108,000 in fact) we can get the price right down and give you a useful tool that is worth about 60p—that's what an equivalent would cost you.

Next month we will also be presenting a Marshall's catalogue free with each issue sold in Britain and that again is worth 50p. The catalogue is larger than previous ones from Marshall's,

carries a full colour cover, shows reductions in price on almost all their top 500 lines and contains some prepaid order forms—at least the price of some things continues to go down!

Marshall's are also the first British component suppliers to be offering a budget account available through their four retail shops and making use of a Marshall's credit card. This card can also be used in any other store that is a member of RETRA. Quite an innovation in our market and it will certainly help spread the cost of one of our larger projects or of test gear etc.

What else are we planning? Well we have some excellent projects in the pipeline but you will have to wait and see just what they are, we are also working on special offers which should save you some of that cash we have been discussing. One exclusive offer on an incredible new Seiko watch should produce a saving of about £45 and, with luck, we will bring you the offer in time for Christmas! That sort of saving should buy P.E. for a good few years on its own.

Mike Kenward

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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 are usually available from advertisers; where we anticipate supply difficulties a source will be suggested.

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

Market Place

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

by
Alan Turpin

RING THEIR B.E.L.

Well worth an S.A.E. is the catalogue of Barrie Electronics Ltd. (B.E.L.), particularly for reference to their range of transformers, the nine pages of which cover the following categories:—Auto, Battery Charger, Cased Auto, Equipment, Filament, Ignition and Inverter, Miniature, New Range, Output, Safety Isolating, Valve, 12V, 24V, 30V, 50V, 60V, Specials.

Barrie Electronics Ltd., 3 The Minories, London EC3N 1BJ (01-488 3316).

STOCK O' SCHOTTKY

A new company holding substantial stocks of those increasingly hard to find LS devices has just launched itself on the hobbyist market. Romane Electronics are based in Sale, Cheshire and are advertising a good range of LS devices at very competitive prices.

They say that customer orders will be dealt with in strict rotation so get in quick or the bigger buyers may be topping up supplies from this source.

Romane Electronics, 64 Newlyn Drive, Sale, Cheshire M33 3LE (061-962 2606).

CODESPEED CATALOGUE

Most of their components are full specification devices but Codespeed also offer untested packs in varying degrees of guarantee of satisfaction. So if you are a bit of a gambler you could chance your shirt in the following way; "4/5 digit displays in manufacturer's support frames, header and tie bars to be cut, four for a £1"; "n.p.n. transistors, designated F107, spec. unknown, 10 for 70p"; "Op. amps., 20 assorted, £1"; "Factory reject calculators, £2.50 each"; "Two min. relays, 25p"; "15 logic i.c.s £1"; "30 mixed i.c.s £1".

S.A.E. to Codespeed Electronics, Box 23 34 Seaford Road, Copnor, Portsmouth PO3 5BJ.

and
David Shortland

WHEN QUADS ARE WELCOME

Siliconix has given birth to a quad VMOS power FET device in a standard 14 lead d.i.l. package.

The VQ1000 contains four independently accessible high speed VMOS FETs each with a maximum switching capability of 60V and 0.5A continuous or 1A pulsed. For higher power applications the FETs can be externally paralleled to load share.



Switching times are typically as low as 5ns and uses suggested are TTL/CMOS logic to high power interfacing, i.e.d. digit strobe drivers, high speed line drivers, stepping motors, peripheral controls, solenoids, etc. Switching capabilities comparable with bipolar transistors can be achieved without the many disadvantages such as secondary breakdown, thermal runaway, low gain, low speed due to minority carriers, and current hogging when used in parallel.

Each FET is Zener protected and overall power dissipation for the plastic or ceramic package is limited to 1.75W at 25°C.

Siliconix Ltd., Morriston, Swansea SA6 6NE (0792 74681).

BIO CLOCK

Much has been said and published on the usefulness and results of biorhythms; we are told that Japanese insurance companies even advise clients not to drive on certain days because they are critical "switching" days in the biorhythm curves. Whether you take notice of biorhythms or not, it is quite interesting to check results against the predictions for each day—a bit like reading your horoscope! We will refrain from passing any opinions on how much reliance anyone should place on biorhythms, what interests us is a biorhythm clock that is now available.



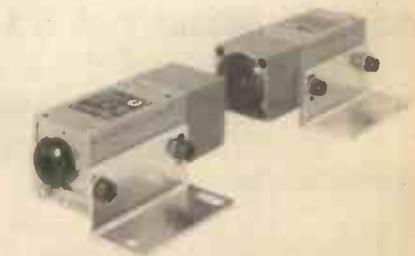
The clock provides three readouts which are colour coded to correspond to a graph showing the rhythm curves for physical, emotional and intellectual capacities. It is thus easy to check where on each curve an individual lies each day—the clock can only be set to one birth date so is normally only usable by one person. Initial setting of the clock involves a calculation of the days one has lived for and divisions of this total to set each readout. This is however a once only operation, provided the unit is not unplugged—or until the next power cut!

In use we found the displays were a little dim but since it is only normal to read the clock once a day this is hardly a problem.

The clock is available in kit form from Maclin-Zand, Unit 10, 1st Floor, East Block, 38 Mount Pleasant, London WC1X 0AP (01-837 1165).

30 METRE AUTO-SWITCH

This photoelectric switch has an operating range of 30 metres. The infra red i.e.d. light source ensures long operating life and high immunity to ambient light. Transmitter and receiver are compact units measuring only 90.5 x 40 x 40mm.



Available in operating voltages from 12V d.c. with a voltage output, or 24V d.c. with a power output capable of switching up to 200mA. 110/240V a.c. operation is also available.

IMO Precision Controls Ltd., 349 Edgware Road, London W2 1BS (01-723 2231).

4½ DIGIT L.E.D. METERS

Lascar Electronics have introduced two new 4½ digit panel meters priced from under £40. They are fitted with high efficiency 0-43in red l.e.d. displays and are available with f.s.d.s of 2V or 200mV.



Accuracy is guaranteed to ± 1 count over the entire range, giving a resolution of up to $10\mu\text{V}$. Auto-polarity, auto-zero, b.c.d. outputs, digital hold and programmable decimal points are standard features.

Six auxiliary inputs/outputs are available for interfacing to UARTS, microprocessors or other complex circuitry.

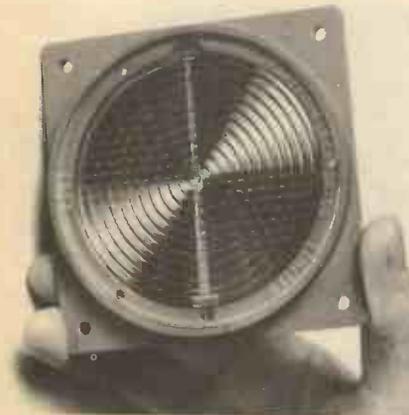
Also available is a panel mounting bezel with a red circularly polarised filter. A mains power supply option is also offered.

Lascar Electronics Ltd., Unit 1, Thomasin Road, Burnt Mills, Basildon, Essex SS13 1LH (0268 727383).

SOLAR CELL

Ferranti have developed a silicon solar cell specifically for educational use, but maybe hobbyists will find a use for it too.

The cell, designated the ESC3 series, is 3in in diameter and is capable of producing 0.9A at 0.5V under good sunlight conditions. Physical protection is provided by a tough moulded case and by a Fresnel lens which also acts as a light collector.



Power take off is from metal pins on the rear of the case. Accidental short circuiting of the output will not damage the cell, and any number of cells can be arranged in series/parallel combinations to provide increased output values.

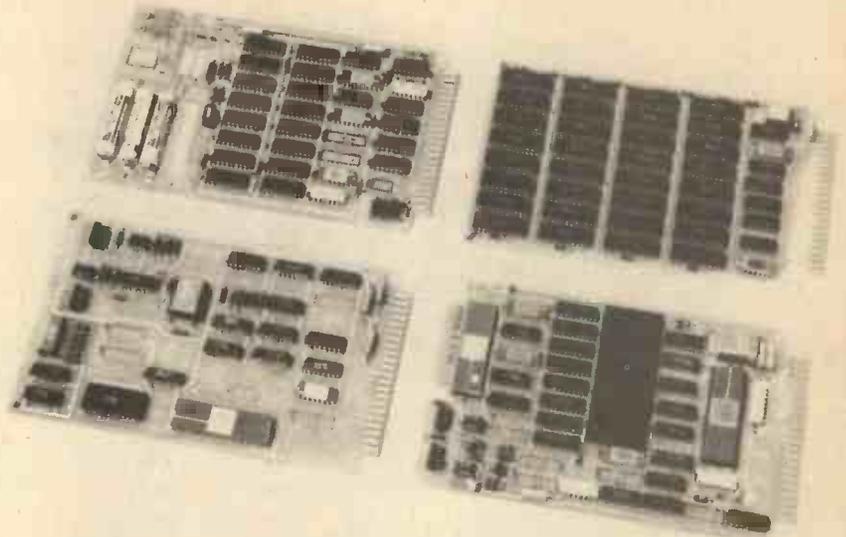
How many of these would you need to bolt on your bonnet to power all the car instruments in our new series?

Ferranti Electronics Limited, Fields New Road, Chadderton, Oldham, Lancs OL9 8NP (061-624 0515).

RCA SINGLES

Not to be left out of the single board race RCA Solid State has introduced a family of single board microcomputer systems based on the CDP1802 COSMAC microprocessor. The family consists of two single board microcomputers with differing memory capacities, a range of add-on memory boards and expansion modules, 5-card and 25-card chassis/backplane units, a milliwatt power supply, and two prototyping systems. All Microboard modules are compatible with existing RCA COSMAC Development Systems. Each module measures 4.5 x 7.5in. (114 x 191mm), and any module works in any location on the backplane. Software development can commence as soon as the modules are plugged in.

The use of CMOS means that power consumption is measured in milliwatts, and a complete system can be powered from nickel-cadmium batteries. Alternatively, the ability of the CMOS circuitry to operate over a wide voltage range allows low-cost power supplies with extended regulation limits to be used. Also there is excellent immunity to electrical noise.



Each of the computers contains a CDP1802 microprocessor, crystal-controlled clock, read/write memory, parallel input/output ports, serial communications interface, 'power-on' reset, expansion interface, and sockets for user-selected ROMs. The two computers are designated CDP18S601 (4Kbyte RAM; sockets for 4/8Kbyte ROM/PROM) and CDP18S603 (1Kbyte RAM; sockets for 4/8Kbyte ROM/PROM).

Memory modules include 4Kbyte, 8Kbyte and 16Kbyte RAM boards, 4Kbyte and 8Kbyte RAM boards with battery backup, and an 8/16Kbyte ROM/PROM board. Other expansion modules available on Microboards are a UART interface, a combination memory-input/output module, digital/analogue and analogue/digital convertors, and a control and display module.

The two Microboard prototyping systems available from RCA each contain a Microboard computer together with a control/display module, a 5-card chassis in a protective case, a power convertor, a breadboard for prototyping, cables and connectors, utility software, and technical literature.

RCA Solid State-Europe, Sunbury-on-Thames, Middlesex TW16 7HW (093-27 85511).



MAINS STABILISERS

Of particular interest to our overseas readers are these mains voltage stabilisers. Regulation of two per cent is achieved on the ferro resonant range; VA ratings, 175, 250, 500, 1000 or 2000. The other models which make up the full range of 21 are thyristor controlled buck and boost transformers. Also available are three models of cutout, one of which is an OEM version. Trade enquiries are welcomed world wide.

Galatrek, Scotland Street, Llanrwst, Gwynedd LL26 0A1, North Wales, Great Britain. Telephone (0492 640311). Telex 617114.

FUNCTION GENERATOR

This function generator can produce square, triangular or sine waves over a frequency range of 1Hz–100kHz, and incorporates an electronic sweep facility which gives a sweep range of up to 100 : 1 from an a.c. signal.

The instrument has five overlapping frequency ranges with pushbutton selection and a vernier frequency dial to give an accuracy within ± 5 per cent dial setting.

In addition to the normal high and low-level outputs for sine, triangular and square waveforms, a separate TTL square-wave output is provided which will drive ten TTL loads with rise and fall times of less than 25ns.

Sine, square and triangular waveform outputs are variable over a range of more than 40dB. The high-level output is rated at 0.1–10V (peak-to-peak) into an open circuit, and 0.005–5V (peak-to-peak) into a 600 Ω load. A separate low-level output, 40dB down from the high-level output, is rated at 1–100mV into an open circuit and 0.5–50mV into a 600 Ω load.



The variable d.c. offset amplitude control, once set, holds the output signal to within ± 0.5 dB over the entire frequency range.

Distortion on the sinusoidal waveform is less than two per cent, and linearity error of the triangular waveform is within one per cent. The standard square wave has rise and fall times of less than 100ns and a time symmetry error within ± 2 per cent.

The voltage-controlled sweep oscillator can be zero-referenced from any frequency setting, and the sweep input can be within the range ± 10 V.

Price of the Model 2001 is £75 plus VAT.

Continental Specialties Corporation, Shire Hill Ind. Est., Saffron Walden, Essex CB11 3AQ (0799 23101).

HAND HELD DMM

A new $3\frac{1}{2}$ digit multimeter has been introduced by Lascar Electronics. It is claimed to combine the accuracy of a digital instrument with the low cost of an analogue type.

The LMM-200 has a basic accuracy of 0.5 per cent, a 200 hour battery life and 0.5in. l.c.d. read-out. The display also indicates when the battery has only 20 hours life left.



The instrument has 15 different ranges and can resolve voltage to 0.1mV, current to 0.1 μ A and resistance to 0.1 Ω . Auto-polarity and auto-zero are standard. Inputs are via 4mm terminals and are protected against overloads and transients.

Housed in a black ABS case, the instrument is £34.95 and is supplied with a battery, instructions for use and a 2-year warranty. Suitable test leads are also available.

Lascar Electronics Ltd., Unit 1, Thomasin Road, Burnt Mills, Basildon, Essex SS13 1LH (0268 727383).



CHICAGO CONSUMER ELECTRONICS SHOW

VERA LIVES

Do you remember VERA, the BBC's Video Electronic Recording Apparatus? VERA's passion was the rapid consumption of yards of magnetic tape to record her signals. Tape pass speeds for video and audio dropped dramatically after VERA's debut and she went into early retirement.

It appears now that VERA's style of working may be the new vogue, for Toshiba were showing a cartridge recorder with a tape speed



This Harmonizer, for recording studios, can change the pitch of a signal by three octaves (one up, two down); has two outputs, each with 400ms of delay; a frequency response of 15kHz and a signal to noise ratio of 96dB. It is also capable of flanging, repeat, random delay, and reverse effect. Price is \$2,400 Eventide Clockworks Inc., 265 West 54th Street, New York, N.Y. 10019. Telephone (212-581 9290).

of six metres per second. The tape is in a loop of 100 metres, and 220 longitudinal tracks store the recording. It takes only 17 seconds to make one circuit of the loop but 17 x 220 gives just over one hour of recording time. Seventeen seconds is also the access time to any part of the loop.

The half-inch wide tape, on a non-revolving fixed reel cartridge, is pulled from the centre of the reel, and driven by a direct drive capstan

motor near the centre of the reel. The head, near the capstan, moves vertically across the 220 tracking positions, powered by a stepping motor.

Apart from domestic TV recording Toshiba are expecting this system to be valuable where rapid random access to digital information is required (20ms to access track in use, 4.4s to range all tracks). Just the device to bolt on to a home computer. The simplified mechanism

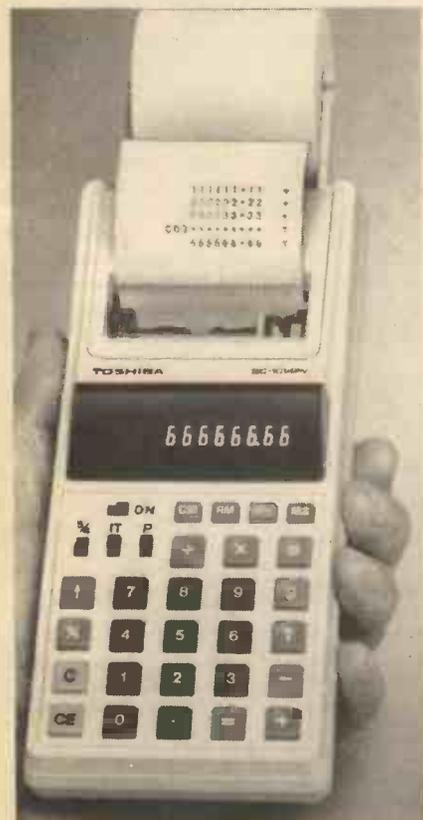


eliminates about two thirds of the mechanical parts used in other video recording systems. The prototype LVR (Longitudinal Video Recorder) shown at Chicago was NTSC compatible, to EIA standard. Weight of the unit is a readily portable 17-6lbs.

Consumer Electronics Division, Toshiba America Inc., 280 Park Avenue, New York, N.Y. 10017.

HAND HELD PRINTER

Toshiba have brought out a 10 digit cordless printing calculator with: memory, per cent, constant, and item counter. The model shown has a Digitron display and there is also an l.c.d. version with floating decimal.



The machines print at two lines per second. The model shown has a suggested price of \$90 which includes a Ni Cad battery and an a.c. adapter. The l.c.d. version (\$100) has a Ni Cad pack as an optional extra.

Business Equipment Division, Toshiba America Inc., 280 Park Avenue, New York, N.Y. 10017.

WHISTLE STOP

The Whistle Switch is a sonic receiver which plugs into a mains outlet and can switch on or off any mains device up to 300W. It is activated at up to 50ft by a hand held remote control which emits a barely audible whistle.

If you can't get in to Bloomingdale's or Macy's with your \$25 there was a project in the June issue of PE which had a similar capability although not the same range.

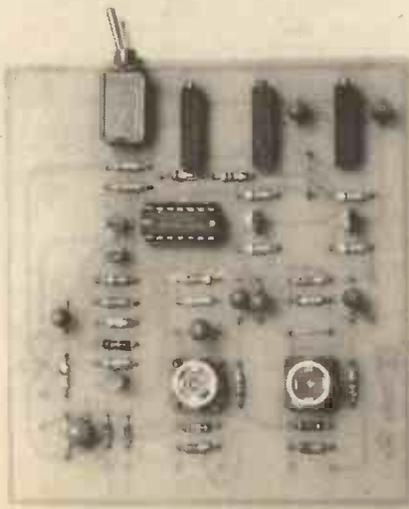


Universal Controls Corporation, Suite 868, Kirkeby Center, 10889 Wilshire Boulevard, Los Angeles, California 90024. Telephone (213 477 4509).

MORE HEADROOM

Dolby have developed and are making available their HX (Headroom Extension) system for incorporation in their present B-type systems.

The HX module (prototype shown) "automatically and continuously varies the record bias level and record equalisation to optimise both, in response to changes in the recorded level and high-frequency content". It permits recording at 10kHz and above at a level 10 or more dB higher than is currently possible, while at low and middle frequencies perfor-



mance is optimised for minimal distortion, modulation noise and drop-out effects. The HX system works with any tape formulation (for which a recorder is nominally set up).

The technology is available to all Dolby licencees for inclusion in cassette recorders with Dolby B-type noise reduction, without further royalty or licensing charges. The parts required for the new system add about a third to the manufacturing cost of the Dolby circuits within a recorder.

Dolby Laboratories, 731 Sansome Street, San Francisco, CA 94111. Telephone (415-392 0300); Telex 34409.

Dolby Laboratories, 346 Clapham Road, London SW9 9AP. Telephone (01-720) 1111. Telex 919109.

MAGIC MIKE

No not our editor, although he does seem to have been on the button as far as CB goes (see August editorial and recent reports of Home Office announcements in the daily press). Magic Mike is, according to the manufacturers, the first cordless CB mike. The mike can be installed without any modification to the existing CB rig, and is powered by a nine volt battery. Effective range is three metres, allowing back-seat CB-ing.

The system operates on VHF and receiver and transmitter are certified in compliance with FCC rules and regulations.

Autoalert Inc., 4488 Spring Valley Road, Suite #102, Dallas, Texas, 75240. Telephone (214-233 0187).

PET ANALYSER

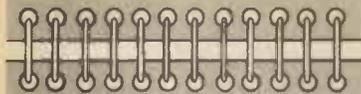
If you have a PET computer and a spare \$600 you can have yourself a Real Time Third Octave Spectrum Analyser. The analyser divides the audio spectrum from 20Hz to 20kHz into 31 third-octave bands and displays them on the PET screen.



The manufacturers suggest that the plug in board can be used for measuring sound and noise levels, for optimising the equalisation of a hi-fi or public address system, for checking the frequency response of audio components, and for speech and sound pattern recognition.

Of course the PET can be used to store, recall and compare data. Programs to access the analyser are written in BASIC and three are provided with the unit.

Eventide Clockworks Inc., 265 West 54th Street, New York, N.Y. 10019. Telephone (212-581 9290).



INDUSTRY NOTEBOOK

By Nexus



Energy

Recently the popular rave topic has been chips. Every aspect has been talked out—technical, industrial, economic and social consequences. It went on for months and seemed like years. But at least the prices of chips were expected to fall and fall.

Now the rave topic is something which keeps going up in price—energy. And as with doom-laden prophecies on the chip, so they say, we are doomed by the energy crisis.

You might imagine there was a world shortage. Not so. Our earth came from the sun. And so does all its energy, whether ripening the corn today or stored up as a fossil fuel from way back. And the sun is still out there shining away and our earth is still collecting energy in the same old way and, very slowly, a few new ones too.

The crisis, if there is one, is not a shortage of total energy available but, with oil particularly, its price structure and geographical distribution. It's amazing that the Middle East, with its distinguished history in the mathematical sciences, took so long to work out the simple economic equation of supply and demand. Equally amazing that an area closely associated with hashish (an Arabic word) and its consequences, should so tardily recognise that the industrial West was so completely hooked on oil-guzzling that withdrawal from the drug would be unthinkable. So, with the customers hooked and the aid of a revolution in Iran, not to mention a price-fixing ring (OPEC), the going rate is what the market will stand.

Good and Bad News

Although bad news for us all in general, the crisis is good news for the electronics industry. British companies have prospered well over the North Sea exploration and production phases of development and in other oil-producing areas as well. Marconi, for example, has just picked up yet another troposcatter contract, this time worth

£750,000, for communications with Shell's Fulmar platform, a link 280km from the Post Office base station at Fraserburgh. But as well as big business in communications, companies have been supplying electronic survey and navigational equipment, instrumentation and industrial control gear.

Now even more business is in prospect because many of the less promising oil fields not worth touching at \$10 a barrel are beginning to look attractive at a going rate of over \$20 a barrel. More platforms, more drilling, more pipelines, more and more electronics.

But the industry will also score from conservation and alternative energy. In conservation, microprocessor control will 'fine-tune' temperature and other systems far better than old fashioned thermostats. Gains in efficiency measured in single percentage points, even one per cent, are significant for big energy-intensive enterprises. Self-adaptive energy saving systems, mini or microcomputer based will be big business in the 80s.

For alternative energy sources there is a choice of solar, wind, falling water, wave and tidal power, biomass (organic matter of biological origin) and the way-out prospect of tapping the enormous heat concentrations in tropical oceans. The trouble with most of these is that they are intermittent and the collecting mechanism is seldom conveniently situated near the point of use, at least for large generation.

Nonetheless, all the techniques are being vigorously pursued, with thermal technologies, particularly direct and indirect solar energy, as favourites. In the direct form, in which solar heat collectors are attached to rooftops, electronics will be there for system management.

Solar Cells

In the indirect form, using photovoltaics typified by the silicon solar cell, electricity is generated by sunlight falling on a panel of cells. The mass market here is for the cells themselves and there is much development work going on to get production costs down to a level where systems are competitive in price with conventional power from a national grid.

In looking at systems, costs have to be measured which include the cost of delivering power to the point of use. Thus, although initially expensive, a solar cell array on the top of a mountain and used to power a navigational beacon can already score over a conventional supply involving miles of cable and supports to get the power there. In fact there are hundreds, if not thousands, of such installations already in use. Intermittency of output is not a problem when the solar energy is used to charge a battery. A panel four feet square will, with present technology, deliver 8.5A at 28V.

The attack on costs of solar cells is on two fronts. One is to reduce manufacturing costs of high efficiency devices using expensive materials, the other to make present low efficiency devices using cheap materials more efficient.

In the first case, according to a recent report from RCA, attempts are being made

to cut costs on crystal growth, slicing and encapsulation for high performance devices. In the second, completely new materials are being studied, notably amorphous silicon, which has electrical and optical properties quite different from crystalline silicon. It has better sunlight collecting properties and can be deposited readily with only a little material as thin film on cheap substrates. The only snag is that conversion efficiency is, at present only 6 per cent compared with a minimum target of 10 per cent, preferably 15 per cent, to make amorphous silicon competitive. The twin attack could result in the two technologies drawing together in cost per watt output which is the decisive factor.

The immediate attraction of the solar cell is that photovoltaics is a technology already established, in contrast, for example, to harnessing wave or tide power which is still experimental. And semiconductor manufacturers are already conversant with the manufacturing processes. For low power local use, the solar cell will become big business in the next decade.

Wind Power

The other local energy technology about which we know quite a lot is wind power, and since cheap rural electricity finished off the windmill we have learnt a lot more about aerodynamic design. Before cheap electrical power was piped nation-wide, the United States had some six million windmills, nearly all used for pumping water. The new name is wind energy converters and it is a fair guess that we shall see a lot more installed in the year ahead. Conversion efficiency is high, 35 per cent has been achieved, and examples delivering 200kW of power are already operating. Although still an intermittent source, depending on wind force, the wind energy converter has the advantage that it will keep turning during the hours of darkness. A belt-and-braces solution would be a hybrid wind and solar cell structure when one or other, sometimes both, would be working.

Large wind energy converters capable of delivering two megawatts are being built in the United States. These will be used for feeding into the big supply networks. At local level, small on-site units which could be mass produced will deliver a kilowatt or so.

It only needs another couple of hikes in world oil prices to make these cranky ideas look completely realistic and the obvious thing to do. The big electricity suppliers don't like the prospect of having their customers switching to home-brew power, but the anti-pollution brigade will love it because sun power and wind power produce no effluent. Nonetheless it seems quite certain that although the pattern might change we shall still need and have huge generating stations, oil fired, coal fired and nuclear, for many years to come.

Moreover, we shall still use petrol in cars. Petrol is stored energy in portable form and there is no comparable storage medium—83 gm of petrol contains a kilowatt hour of energy compared with 55kg weight of lead-acid batteries to store the same amount.

Semiconductor UPDATE...

FEATURING MM 74C911/2/7 ICL 7611

R.W. Coles

DISPLAY COMBO

The cheapest way to display numeric data is to use seven segment l.e.d.s in a multiplexed drive scheme. Static l.e.d. drive circuits require a decoder for each digit, and that gets expensive when more than three or four digits are required. In a multiplexed scheme only one display digit is turned on at any given instant, but the scanning, or multiplexing, rate is made sufficiently high that to the human eye, all display digits appear to be "on" simultaneously.

In a multiplexed display scheme only one decoder is required for the whole system, because it too is multiplexed with its input, and therefore output, data changing in synchronism with the digit strobes which are used to enable each l.e.d. in turn.

Most familiar systems such as watches, clocks, calculators and digital multimeters, employ display multiplexing because it is more economic and because it uses fewer pins on an LSI chip (seven segment lines and N digit strobes as compared with 7N lines for a static scheme), but for homebrew systems a multiplexed display may seem a bit of a problem at first.

You'll need a decoder of course, something like the 7447 would do nicely, and you can use TTL for most of the other bits and pieces too. These include a multiplex clock oscillator, a digit counter and decoder or a shift register, and a method for multiplexing the data into the seven segment decoder, such as a recirculating shift register or some tri-state gates if that data is already latched in parallel.

To drive the digit lines you may need some discrete transistors, because in a multiplexed system the display currents are N times greater for the same effective brightness as can be obtained with an N digit static system.

THINK TWICE

Hmmm! enough to make you think twice about the "economies" of multiplexing, isn't it? Well, not to worry, because National have spotted the problem and built up some very nifty multiplexed display subsystems and put the whole mess on to a single CMOS chip.

The new devices are called display controllers, and there's one to suit every system. Typical of the family is the **MM 74C912**, which is intended for use in eight segment (that's seven plus a decimal point), six digit decimal displays. You give it your data in parallel four bit b.c.d. form, by addressing one of the six latch registers in turn via the three address lines and the chip enable. It does all the rest.

The on chip oscillator drives the digit multiplexer which generates one of six digit strobes while gating the correct latch contents to the decoder (actually at 16 x 7 ROM). The ROM outputs are buffered to drive the segment lines directly, at least for the smaller l.e.d.s.

Another family member, the **74C917**, does all that the 74C912 does, but its decoder ROM is programmed to do the full hexadecimal character set of 0-9 and A-F, instead of just 0-9. The **74C911** does away with the decoder altogether but allows you to store data a byte at a time. This could

be data that's already been decoded, by a microprocessor say, or it could be followed by an external decoder for a full alphanumeric dot matrix or "Union-Jack" type display.

The 74C911 drives four digits, but devices can be used together for more digits or a wider word. These devices are especially useful when used to relieve a microprocessor of the display driving chore, but no doubt they will find many applications in non-micro systems, where their single five volt supply and compact 28 pin packages will make them excellent replacements for steam TTL!

MICRO-AMPS

Last month I dealt with the amazing CAZ-AMPS from Intersil, but those CMOS wizards have tricks up their sleeves, like the incredible **ICL 7611** family for example.

If you have ever balked at the prospect of having to provide plus and minus 15 volt supplies for a solitary 741 op-amp, then the ICL 7611 devices could be for you, because they will run from plus and minus half a volt! You don't have to go that far though. This super-low-power operational amplifier family will run at up to plus and minus eight volts, or you can use a single supply like a 1½ volt pen cell or a five volt logic supply.

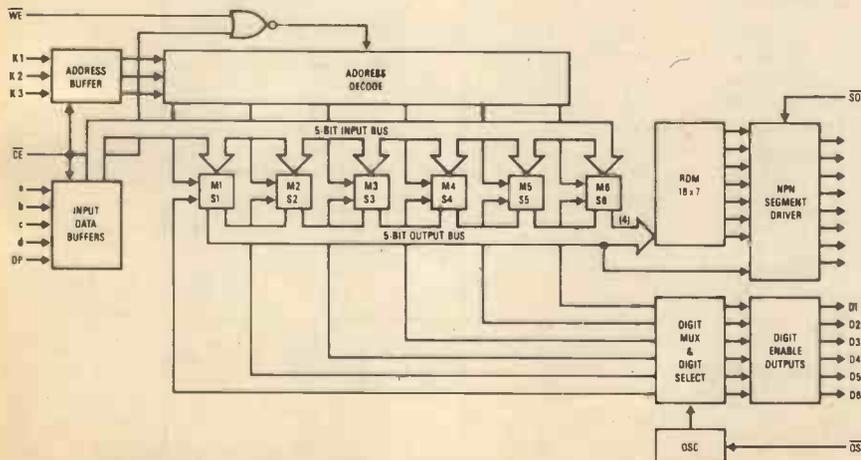
Don't worry about running the pen-cell flat either. Many of the family have a current programming pin which allows you to set quiescent bias current to between 10 microamps and one milliamp. Even at one milliamp that pen cell will last a long time, and at that current you get almost 1.5MHz of bandwidth! Regardless of bias current, you can expect 100dBs of open loop gain, 90dBs of CMRR, an input offset voltage of three millivolts and a one pico amp input bias current.

You can have these devices in all sorts of shapes and sizes—singles, duals, quads—internally or externally compensated, and some with unique features like plus and minus 200 volt input protection. And all at very low prices (less than £1.00 for a single device).

You can now gain the benefits of operational amplifier circuitry in just about any kind of battery powered gadget you care to think of; no more messing with discrete transistors or converted CMOS logic gates!

National Semiconductor, 19 Goldington Road, Bedford MK40 3LF. (0234 211262)

Intersil Inc., 8 Tessa Road, Richfield Trad. Est., Reading RG1 8NS. (0734 595011)



Internal circuitry of National MM 74C917

SOLID STATE

No.1 • Battery Voltage Indicator

THE shape of vehicle instrument displays will undergo radical change in the next decade, or so we are constantly assured. A recent *PE* article gave an insight into some of the changes we can expect to see on the dashboard. At present, however, most of these predictions belong to the realms of publicity for such dreams as the Aston Martin Lagonda; the province of the lucky few! The real question for the amateur constructor is how to take advantage of the technological revolution in vehicle instrumentation without indulging in the seemingly obligatory multi-million pound development programme.

This is the first in a series of articles which will describe a range of solid state instruments for motor vehicle applications which involve no moving parts, make use of readily available inexpensive components, and which are easily added to any vehicle with a 12 volt electrical system. The instruments may alternatively be constructed as self-contained test units.

VEHICLE INSTRUMENTATION DESIGN

The purpose of vehicle instrumentation is to provide the driver with an indication of the current state of the vehicle in a form which is easily and quickly understood. In practice, this usually means some form of visual indication.

To make use of the solid state display requires that the information to be displayed is available as an electrical signal. In many cases, therefore, the quantity to be displayed must first be converted to an electrical signal, and often further processed, before it is suitable for display. Fig. 1 shows the overall block schematic of such an instrument. In some cases, blocks 1 and/or 2 may not be required owing to the nature of the variable being measured. The requirements of a solid state vehicle instrument are given below.

- (1) Transducer to convert from the physical variable (e.g. temperature) to an electrical signal (e.g. voltage).
- (2) Signal processing unit to convert the output of the transducer (which could be a low-level pulsating voltage) into a suitable level.
- (3) Driver and reference level to translate the processed level into appropriate commands to the display.
- (4) Display unit to provide a physical display of the measured physical variable.

The design should give good rejection to supply fluctuations, which are of a considerable level in motor vehicles.

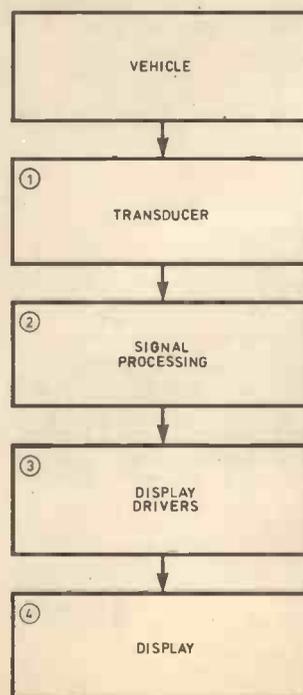
INSTRUMENT DISPLAYS

Over the last decade, the seven-segment display device in its various forms has become almost synonymous with the advances in measurement technology. Such numeric displays are well suited to the many applications where a precise indication of the measured parameter is required.

But there are many situations where such precision is unnecessary, even confusing. This is especially true in the situation where a number attached to a particular measurement has no immediate significance to the user. For example, the number "35" in the FUEL window of the dashboard requires an appreciation that the units are litres, and the user must perform some mental arithmetic in order to learn that the tank is, in fact, about one-quarter full. Rather better assimilation would result from a display which presents information to the user on a related proportional scale. Such a trend is currently apparent in the move towards electronic watches with analogue (dial and pointers) display, and away from the original digital display, despite the unquestioned 'precision' of the 6 digits.

One approach to the problem of a low-cost analogue type solid state display is to make use of a linear array of light emitting diodes. The diodes may be arranged in a straight line or in a circular arc, to suit the particular application. A single l.e.d. may be lit at one time to give the effect of a moving pointer, or the l.e.d.s may be accumulatively illuminated to give a bar graph display. In the "Dot" mode, the individual l.e.d.s may be coloured appropriately to represent safe and unsafe regions of operation according to the variable being measured.

Fig. 1. Flow diagram of a vehicle instrument display



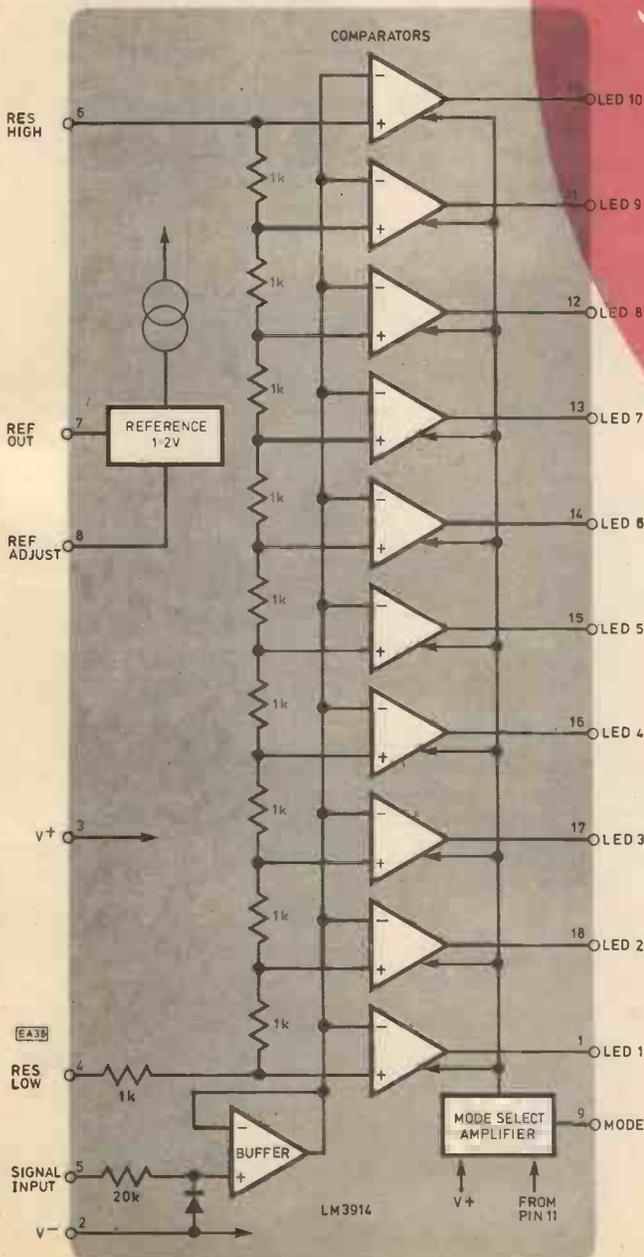
EA37

INSTRUMENTS

Michael Tooley B.A.

David Whitfield B.A. M.Sc.

Fig. 2. LM3914 block diagram



A series of articles
on vehicle projects
using the LM3914

DISPLAY MODULE

There is now a wide range of integrated circuits designed specifically for use in automotive applications. One device in particular is the *National Semiconductor* LM3914 Dot/Bar Display Driver. The LM3914 is a monolithic i.c. that senses analogue voltage levels and drives 10 l.e.d.s, providing a linear analogue display. A single pin changes the display from moving dot to a bar graph. Current drive to the l.e.d.s is regulated and programmable, eliminating the need for current-determining resistors. The circuit, shown in outline in Fig. 2, contains its own adjustable reference, and accurate 10-step voltage divider. The low-bias-current input buffer accepts signals down to ground, or V^- , yet requires no protection against inputs of 35V above or below ground. The buffer drives 10 individual comparators referenced to the precision divider, allowing the indication non-linearity to be held typically between one and two per cent. The flexible design of the LM3914 allows many devices to be "chained" to form displays of 20 to over 100 segments. Both ends of the divider chain are externally accessible so that two drivers may be used in a centre-zero meter. When in Dot mode, there is a small amount of "fade" (about 1mV) between adjacent segments to ensure that at no time will *all* l.e.d.s be off.

The use of the LM3914 allows a basic circuit building block to be designed which represents units 3 and 4 in Fig. 1, and which may be used in the whole range of instruments to be described in this series of articles. The block diagram in Fig. 3 shows the features of the basic 10-bar display module. Full-scale indication is achieved with an input of +5 volts, and the display may be set to either Dot or Bar graph mode. In the design of this basic module, consideration must be given to the range of possible supply voltages, and the attendant problem of power dissipation. In Bar graph mode, with +15 volt supply and an input of +5 volts, the power dissipation involved in the i.c. and l.e.d. supply regulator will be 120mW for each milliampere of individual l.e.d. current. Also to be considered are the decoupling requirements to prevent oscillations in applications where long leads are used. The circuit diagram of the 0-5 volt Dot or Bar graph display module suitable for use with supplies of 7-15 volts is shown in Fig. 4.

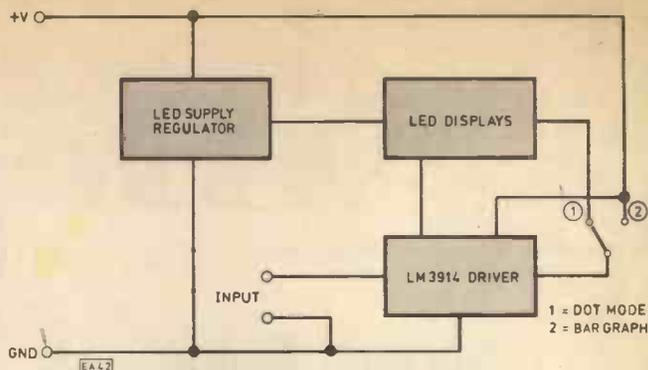


Fig. 3. Block diagram of basic 10-l.e.d. display

BATTERY CONDITION INDICATOR

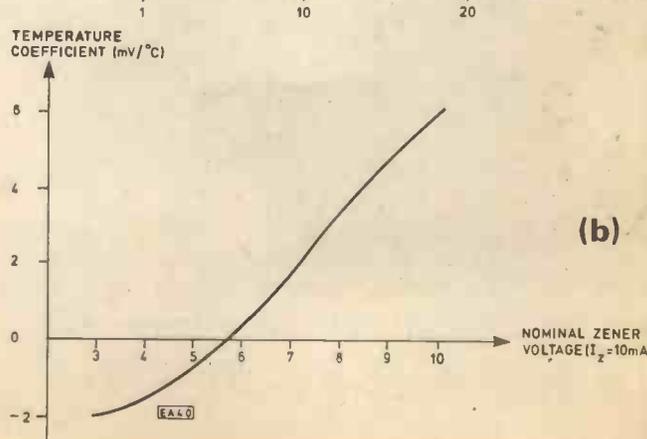
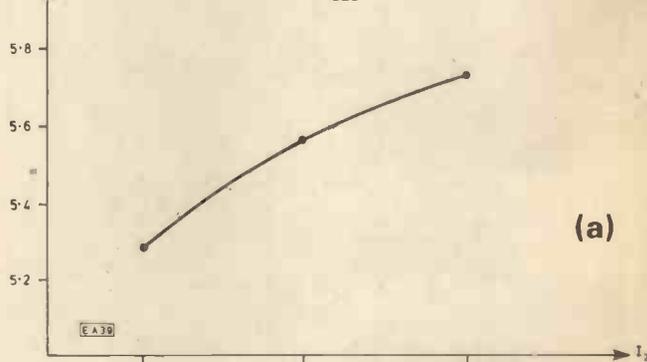
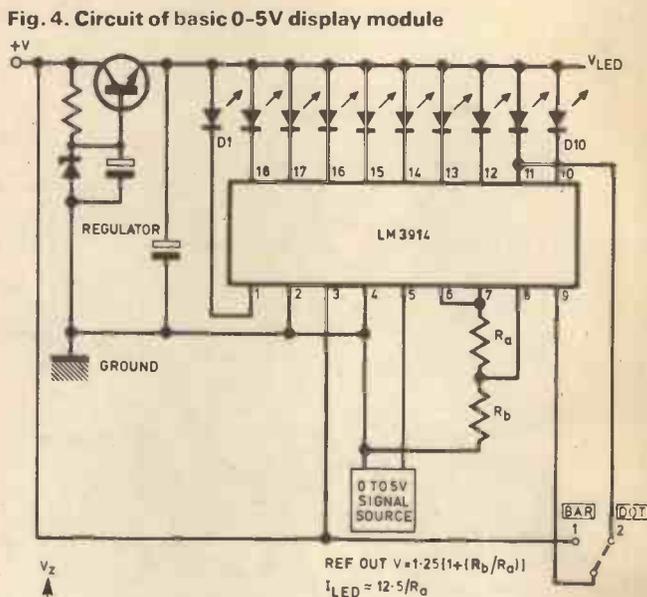
A measure of the general condition of a motor vehicle battery may be obtained by measuring the terminal voltage under operational conditions. The nominal open-circuit terminal voltage of the conventional 6-cell lead/acid accumulator is 13.2 volts. This value falls under load, especially as the internal resistances of the cells rise due to physical deterioration; and the voltage rises when the cells are on charge. At no time, however, will the terminal voltage fall much below 10 volts, and the voltage regulator should ensure that the terminal voltage does not rise much above 15 volts when charging. For these reasons, a battery condition indicator need only have a display range of approximately 10 to 15 volts.

The transducer requirement is therefore to convert a voltage in the range 10-15 volts into a signal of range 0-5 volts, to be compatible with the display module described earlier. A Zener diode has characteristics ideally suited to this problem. The reverse characteristics of these diodes of Zener voltage above 6 volts are illustrated in Fig. 5 (three graphs). The nominal Zener voltage is usually given at a reverse current of 10mA. The Zener voltage may be increased by the use of a forward-biased conventional diode placed in series with the reverse-biased Zener. This also has the effect of reducing the overall temperature coefficient of the diode combination. The method of generating a zero-referred signal for driving the display unit (i.e. the signal processing unit number 2) in this application is shown in Fig. 6.

The overall circuit of the battery condition indicator is shown in Fig. 7 and it closely follows the block diagram of Fig. 1. The battery voltage is actually measured from the supply to the instrument, which is fully protected against reverse polarity. Using the circuit values given, the first l.e.d. will light at a supply voltage of 9.8 volts, and the tenth l.e.d. will light at a supply voltage of 15.2 volts.

CONSTRUCTION

The detailed construction of the battery condition indicator is a matter which is very much influenced by the preferences of the individual constructor. Two particular constructional examples will be described in some detail, but these are intended only as illustrations of the wide range of practical implementations which are possible. Individual constructors may wish to make different use of the range of displays currently available. There is, for example, a linear array of 12 matched l.e.d.s available in a 24-pin d.i.l. package for those wishing to produce a miniaturised display; such units may be cascaded using additional drivers.



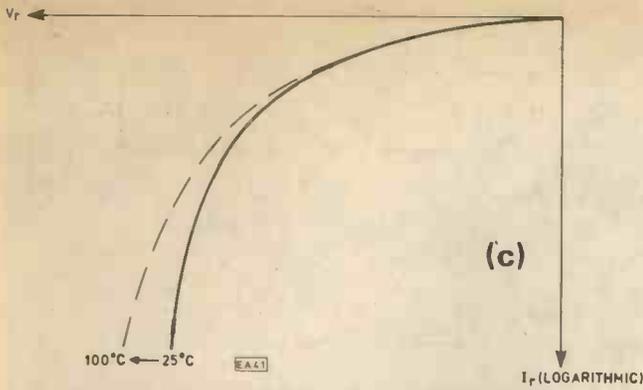


Fig. 5 (above and opposite). Graphs showing reverse characteristics of Zener diodes. (a) Voltage vs. bias current for BZY88 C5V6. (b) Temperature coefficient vs. voltage at I const. (c) Voltage vs. bias current and temp.

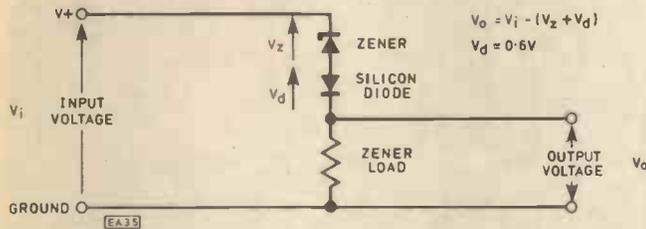


Fig. 6. Zero-referred signal circuit

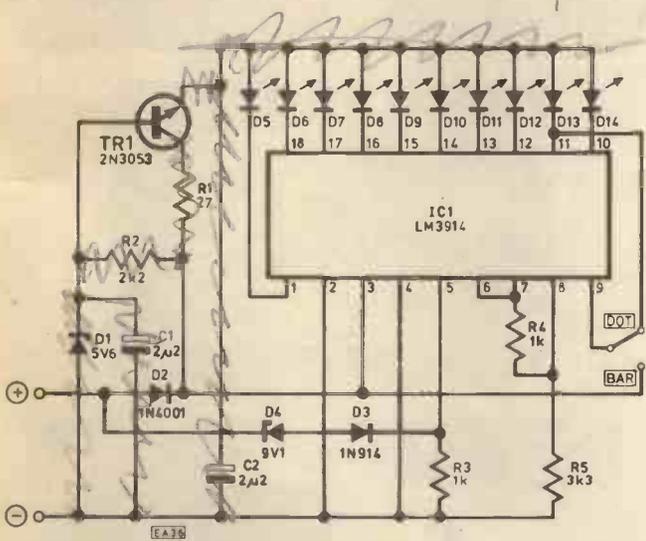
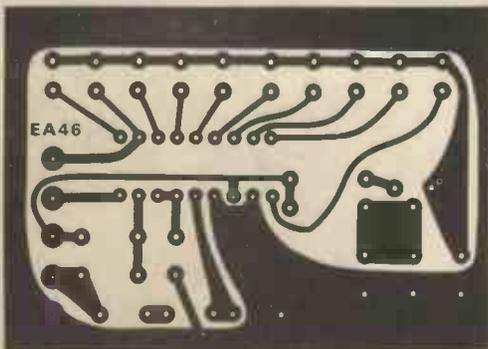


Fig. 7. Full circuit diagram of the Voltage Indicator



One area of decision at the construction stage is in the mode of display. For a Bar graph display, it seems reasonable to make use of 10 l.e.d.s of the same colour. In Dot mode, however, it is possible to colour-code the individual l.e.d.s to give an indication of satisfactory and unsatisfactory conditions e.g. red for the first three and last two l.e.d.s, and green for the remainder.

Fig. 8 shows the printed circuit track pattern for use in a dashboard instrument mounted in a rectangular moulded "instrument pod". The component layout, shown in Fig. 9, is designed to accommodate 10 standard 5mm diameter l.e.d.s in a straight line. The wire link is shown set up for Dot mode display, and the l.e.d.s are colour-coded as described above. The power supply connections are brought out to two small sockets on the back of the unit; the measurement of battery condition also uses this supply. The p.c.b. should be mounted on spacers to bring the l.e.d.s up level with the back of the front panel window. This front panel cut-out is approximately 56mm long x 5mm high.

The power supply for the instrument should be taken from a low impedance line via the vehicle ignition switch. In use, the instrument has been found to display in the green zone (except when starting!) for batteries and charging systems in good condition.

An alternative arrangement is to build the battery condition indicator as an item of test equipment. For this application a Bar graph display seems more appropriate, though it remains a matter of individual choice. The circuit is the same as before, but in this case the prototype used a piece of 0.1 inch veroboard 60 x 40mm mounted in an all-plastic case measuring 100 x 50 x 25mm. This case is a comfortable size for hand-held operation. The l.e.d.s this time are TIL209 red subminiature types, and are mounted across the short side of the case on a 0.1 inch pitch. A convenient component layout is given in Fig. 10. The l.e.d.s are mounted using the full length of the leads, and the circuit board is secured to the base of the case—an arrangement which brings the active elements up level with the lid of the case. The cutout should be approximately 26 x 3mm. The power supply connections are brought out to flying leads and terminated in crocodile clips; these may then be attached directly across the battery terminals or any other point of interest. The individual illumination voltages for the l.e.d.s may be measured and marked on the case. Typical calibration is given in Table 1. The calibration is determined by the characteristics of D3 and D4, and the accuracy of R4 and R5.

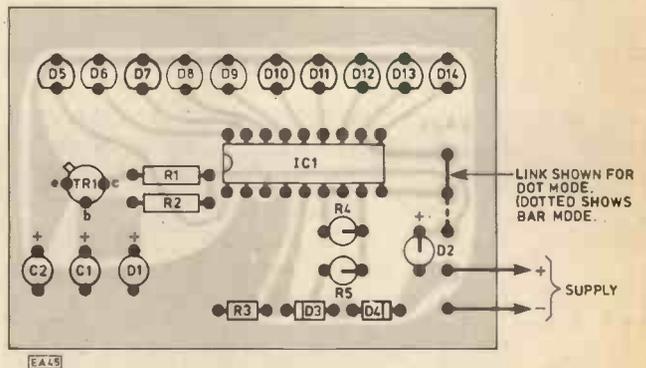


Fig. 9 (above). Component layout of p.c.b. version of Battery Voltage Indicator

Fig. 8 (left). Printed circuit layout (actual size)

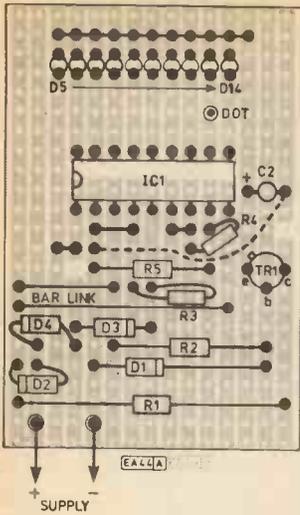
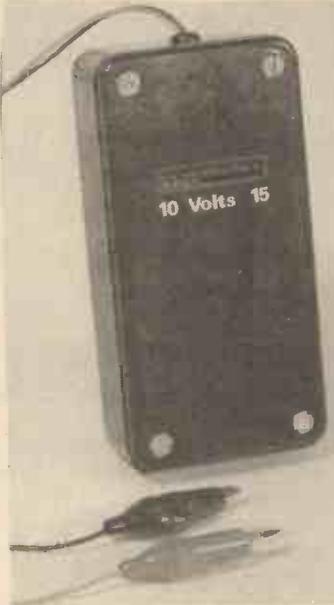


Fig. 10. Alternative Component layout using stripboard (21 track cuts)



COMPONENTS . . .

Resistors

R1	27Ω	½W	5%
R2	2k2		
R3	1k		
R4	1k		
R5	3k3		

All resistors ½W 5% unless otherwise stated.

Capacitors

C1	2μ2	10V
C2	2μ2	25V

Semiconductors

D1	BZY88C5V8
D2	1N4001 or similar
D3	1N914 or similar
D4	BZY88C9V1
D5-14	10 off l.e.d.s to constructor's requirements
TR1	2N3053/BFY50 or similar
IC1	LM3914

Miscellaneous

- Case
- Printed Circuit Board (or Veroboard)

CONSTRUCTOR'S NOTE

Printed circuit boards, etc., are available from Howard Associates, 59, Oatlands Avenue, Weybridge, Surrey KT13 9SU. S.a.e. for details.

VARIATION OF DISPLAY BRIGHTNESS

The basic display module (Fig. 7) is designed to run the l.e.d.s at a nominal current of 12.5mA each when illuminated. The authors have found this to be a useful compromise value, appropriate to a wide variety of l.e.d. sizes and colours in a range of varied applications. There will, however, be many instances where the requirement of the individual constructor is not satisfied by this compromise value. This section is intended to describe how the basic circuit in Fig. 7 may be modified to suit the application.

The internal reference source develops a nominal 1.25V between the REF OUT (pin 7) and REF ADJ (pin 8) terminals. The current drawn out of the REF OUT terminal determines the l.e.d. current and approximately 10 times this current will be drawn through each illuminated l.e.d. The l.e.d. current will be relatively constant despite supply voltage and temperature fluctuations.

Table 1: L.e.d. illumination voltages in two circuit arrangements.

L.e.d. number	Illumination Supply Voltage	
	D3=short circuit D=BZY88C9V1	D3=1N914 D4=BZY88C9V1
5	9.3	9.8
6	9.9	10.45
7	10.5	11.1
8	11.1	11.7
9	11.7	12.25
10	12.25	12.85
11	12.85	13.45
12	13.35	14.05
13	13.85	14.6
14	14.55	15.2



In the circuit of Fig. 7 the l.e.d. current is:

$$I_{LED} = 12.5/R4$$

The full-scale indication value is:

$$V_{FSI} = 1.25 (1 + R5/R4)$$

The adjustment of the l.e.d. current programming resistor R4 will thus affect the full-scale indication voltage, and must be compensated by a corresponding change to R5. A table of suitable values for R4 and R5 for different l.e.d. currents is given in Table 2. Values of R4 and R5 are nearest preferred values, and R5 may need to be trimmed to give the required full-scale indication (see later). An alternative arrangement using variable resistors is shown in Fig. 11. The adjustment procedure is as follows. Connect the instrument to a variable d.c. supply and adjust VR1 to give the required l.e.d. brightness. Now adjust the supply to give 5.0V at pin 5, and vary VR2 such that D14 is just illuminated. Adjustment is

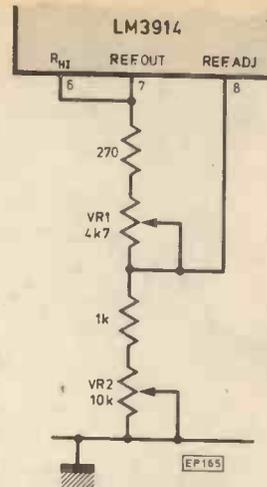


Fig. 11. Variation of l.e.d. brightness

Table 2: Values of R4 and R5 for differing l.e.d. currents.

L.e.d. current	R4(Ω)	R5(Ω)
1.2	10k	33k
2.7	4k7	15k
5.7	2k2	6k8
12	1k	3k3
17	750	2k2
22	560	1k8
27	470	1k5
32	390	1k2

now complete. In applications where an l.e.d. current in excess of 12mA is required, the maximum allowable regulator power dissipation will be exceeded for a fully-illuminated bar display. In such cases it is recommended that the discrete regulator (TR1, R1, R2, D1 and C1) is replaced with an i.c. 5V regulator mounted on a small heatsink. In dot mode the power consumption should not be a problem, as the maximum dissipation will be only 10 per cent of the bar mode display. The LM3914 has a maximum dissipation of 660mW. ★

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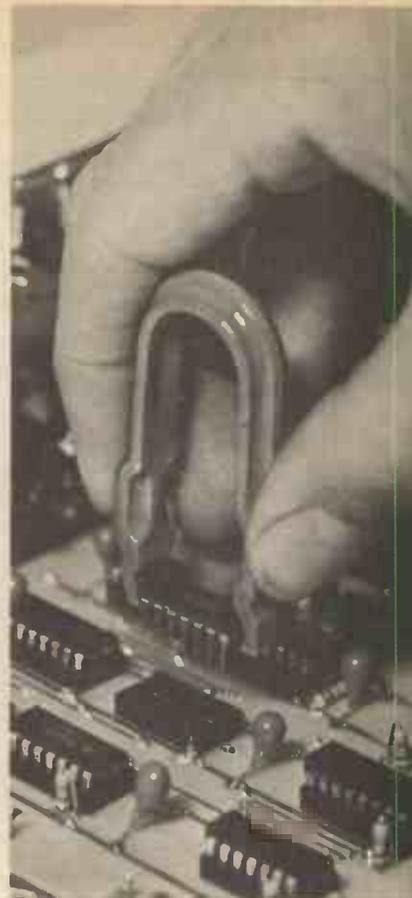
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News Briefs

ELECTRONICS CLUB AT MARGATE

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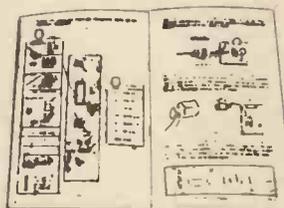
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DIGITAL TEMPERATURE CONTROLLER

D. COUTTS & P. MCALLISTER

TO date there have been many circuits produced to measure temperature and display it, either in analog form, or, more recently, in digital form using seven segment displays. Temperature control on the other hand has been left largely to the mechanical bimetallic strip. This suffers from restricted control range on one hand and coarse setting on the other. Even electronic systems using pots to set the temperature suffer from similar problems. However, a new chip from G.I. Microelectronics has been designed to combine the functions of digital temperature display and measurement with accurate control over wide range using digital switches (BCD encoded) to set up the desired temperature.

This project describes a system, using this chip, suitable for use in photography, home brewing, aquariums or even just simple room heating.

CONTROLLER DESCRIPTION

Externally the controller has the following format. All controls and the display are mounted on the front panel. The desired temperature is set up on the two digit BCD switch. The four seven segment leds are used as follows:

1. The left hand digit displays a C when the cooler is switched on and a minus sign (segment g) when the temperature is negative.
2. Two centre digits show the actual temperature from 0 to 90°C. The right hand digit displays an H when the heater is on.

Mounted on the back panel are two mains outlets, one to which a heater may be connected, and the other a cooler; an outlet for the temperature sensor, which consists of four diodes, and the mains inlet and three fuse holders.

DRIVE CIRCUIT

The relay drive circuit is necessary only because the chip cannot sink enough current to operate the relay. In the heater circuit, TR3 sinks the relay current while TR4 inverts the signal from the chip to drive TR3. Diodes D1 and D2 are necessary to protect TR1 and TR3 from the back e.m.f. generated by the relay coils when they turn off. Switches S1 and S2 are to enable either the heater or cooler to be manually turned on. Diodes D3, D4, D5, and D6 allow the on position of either S1 or S2 to over-ride the control signals from the chip. Thus if the cooler is on and then the heater is switched on using the manual switch (S2) the cooler will go off, and stay off (unless S1 is also turned on) until S2 is switched off again (Fig. 2).

CONTROLLER CIRCUIT

The controller circuit is best described by giving a brief description of the function of the circuitry to each pin out (Fig. 1).

Pins 21-27 drive the units digit, while pins 29-35 drive the tens digit. Pin 40 drives the sign indicator. Pin 17 drives the cooler relay circuit, and pin 18 the heater relay circuit.

Pins 14, 15 and 16 form the bridge network which does the temperature measurement and sensing. Before describing this further a few words about the use of a diode as a temperature sensor.

The voltage drop across a diode when current flows through it in the forward direction depends on the magnitude of the current and its temperature, so that to achieve a voltage across the diode varying only with temperature a constant current is put through it. Note that the value of this



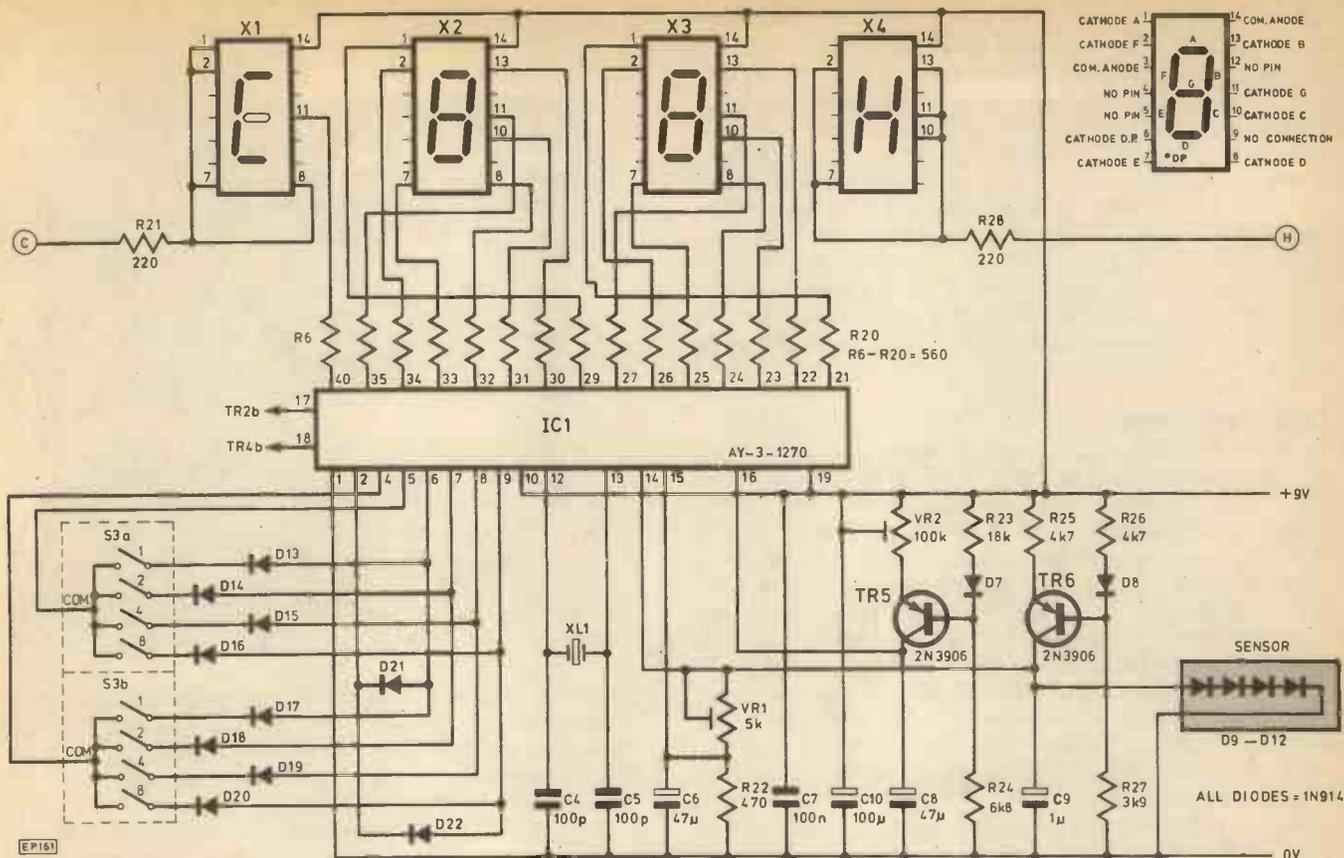


Fig. 1. Circuit of controller

current is chosen so that the diode is well passed the knee of its turn on characteristic, but not so high that a significant amount of self heating occurs. Under the above conditions the voltage across the diode varies approximately linearly by about 2mV/°C. To operate correctly the chip requires a change at its input of at least 5mV/°C hence it was decided to use four diodes in series to ensure sufficient voltage change.

R25, R26, R27, D8 and TR6 form the constant current source driving the diode sensor network, D9 to D12; the junction of TR6 and D9 providing the temperature dependant voltage to the input pin 14 of IC1. Pin 15 is connected to

a reference voltage, provided by VR1 and R22. This is adjusted to give the same voltage out as the sensor network at 0°C. Pin 16 is connected to a linear ramp, generated by the constant current source VR2, R23, R24, D7 and TR5 charging capacitor C8. IC1 measures the time that the ramp takes to travel between the voltage at pin 14 and the voltage at pin 15. Since these voltages are the same at 0°C, and the voltage on pin 15 varies linearly with temperature; time is also proportional to temperature. Suitable adjustment of VR2 enables the display reading to represent °C. If the voltage on pin 15 is less than that on pin 14, the minus sign comes on.

COMPONENTS . . .

Semiconductors

TR1-TR4	BC337 (4 off)
TR5-TR6	2N3906 (2 off)
IC1	AY-3-1270 (Marshall's)
IC2	7805 (with heatsink)
D1-D2	1N4004
D3-D22	1N914
D23	BZY88-3.9V Zener
REC1	1A bridge rectifier

Capacitors

C1	1,000µ	25V
C2-C3	100n	30V disc ceramic
C4-C5	100p	30V disc ceramic
C6	47µ	16V tantalum
C7	100n	30V disc tantalum
C8	47µ	16V tantalum
C9	1µ	16V tantalum
C10	100µ	16V tantalum

Switches

S1-S2	SPST 250V, 10A rocker (2 off)
S3	2 decade thumbwheel edge switch

Relays

RLA, RLB	12V, 205Ω two pole changeover (contacts 5A, 250V) (2 off)
----------	---

Displays

X1-X4	0.3in, 7 segment green l.e.d.s (common anode) (4 off) Bezel to suit 4 displays
-------	---

Potentiometers

VR1	5k 20 turn trimmer
VR2	100k 20 turn trimmer

Miscellaneous

XL1	560 kHz ceramic resonator
SK1, SK2	205 x 140 x 75mm case (Marshall's) 3 way sockets (2 off)

Resistors

R1	560
R2-R5	6k8 (5 off)
R6-R20	560 (15 off)
R21	220
R22	470
R23	18k
R24	6k8
R25-R26	4k7
R27	3k9
R28	220
All ¼W 10% carbon	

OSCILLATOR

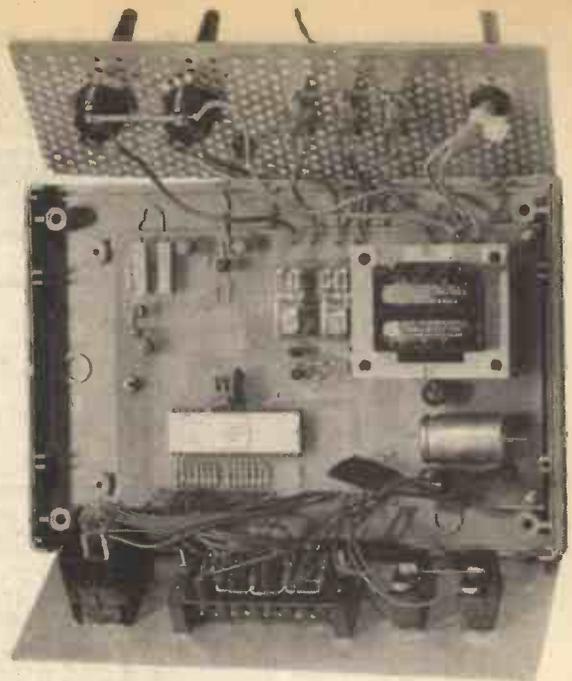
XL1, C4 and C5 form the oscillator circuit. (XL1 is a ceramic resonator). The diode matrix connected to pins 4-9 determine the actual temperature to which the temperature is controlled. Diode D22 selects l.e.d. drive mode (if this diode is left out, the chip produces a.c. output signals for driving l.c.d.s). Diode D21 sets the controller output hysteresis to 2°C. In other words, when the desired temperature equals the displayed (actual) temperature, the heater (or cooler) will go off. The heater will not come on again until the temperature has dropped by 2°C. Likewise the cooler will not come on unless the temperature rises by two degrees. This prevents excessive switching on and off of the relays.

CONSTRUCTION

Mount and secure the panel components to the box. Note that to simplify wiring to the front panel, diodes D13-D20 are mounted on the back of their respective BCD switches, on the terminals marked 1, 2, 4, and 8. Now make and drill the p.c.b. and base of the box so that it may be easily mounted after the components are inserted. It is a good idea to hold the p.c.b. in position on the box while drilling to ensure perfect alignment of the holes. Now mount the remaining components on the p.c.b. as illustrated in Fig. 3.

The wiring to the front panel should now be carried out. The connections to be made are shown in Fig. 4. Note, that in order to accommodate the heatsink, which must be flattened in order to fit in, the terminals on S1 and S2 require shortening.

When wiring the back panel it is essential to keep in mind the electrical rating of the components being used to ensure they can safely handle the current and voltage of the appliance being controlled. First make sure the mains flex is rated to carry the current the heater/cooler requires. The live should go straight to the three fuses. FS1 then supplies the transformer; FS2 and FS3 each go to one set of relay contacts. The relay contacts are rated at 5A, 250V each. Since there are two contacts in each relay, used in parallel



in this circuit, each relay may switch 10A. Inductive loads, such as motors, cause faster contact wear hence these should be limited to appliances with a rating of about 1A. With resistive loads, such as heaters, the full 10A rating may be used.

It is also unlikely that the p.c.b. track will carry such large current, hence it should be reinforced by soldering thick copper or tinned mains wire along the length of the current carrying tracks to and from the relay contacts. The outlet sockets take their neutral and earth straight from the mains input and their live from the relay switch. The sockets suggested are rated at 250V 1.5A. If this is insufficient use higher rated sockets, or alternatively wire the appliance permanently to the appropriate relay.

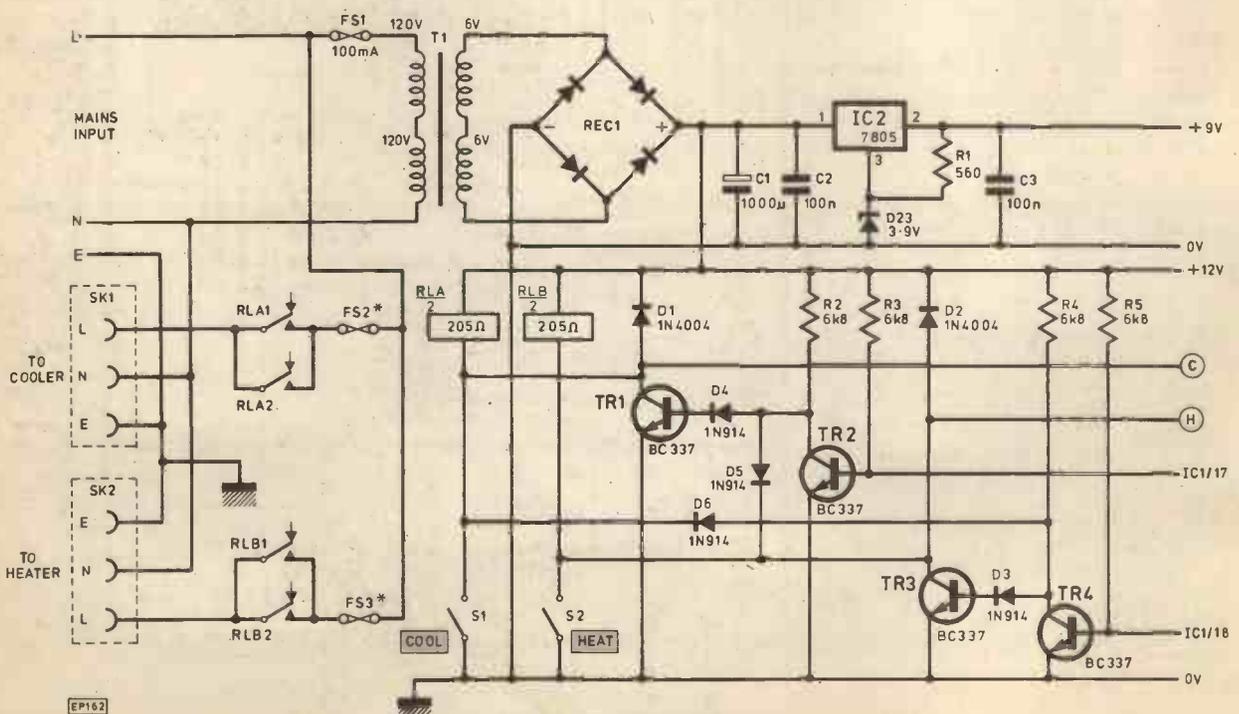
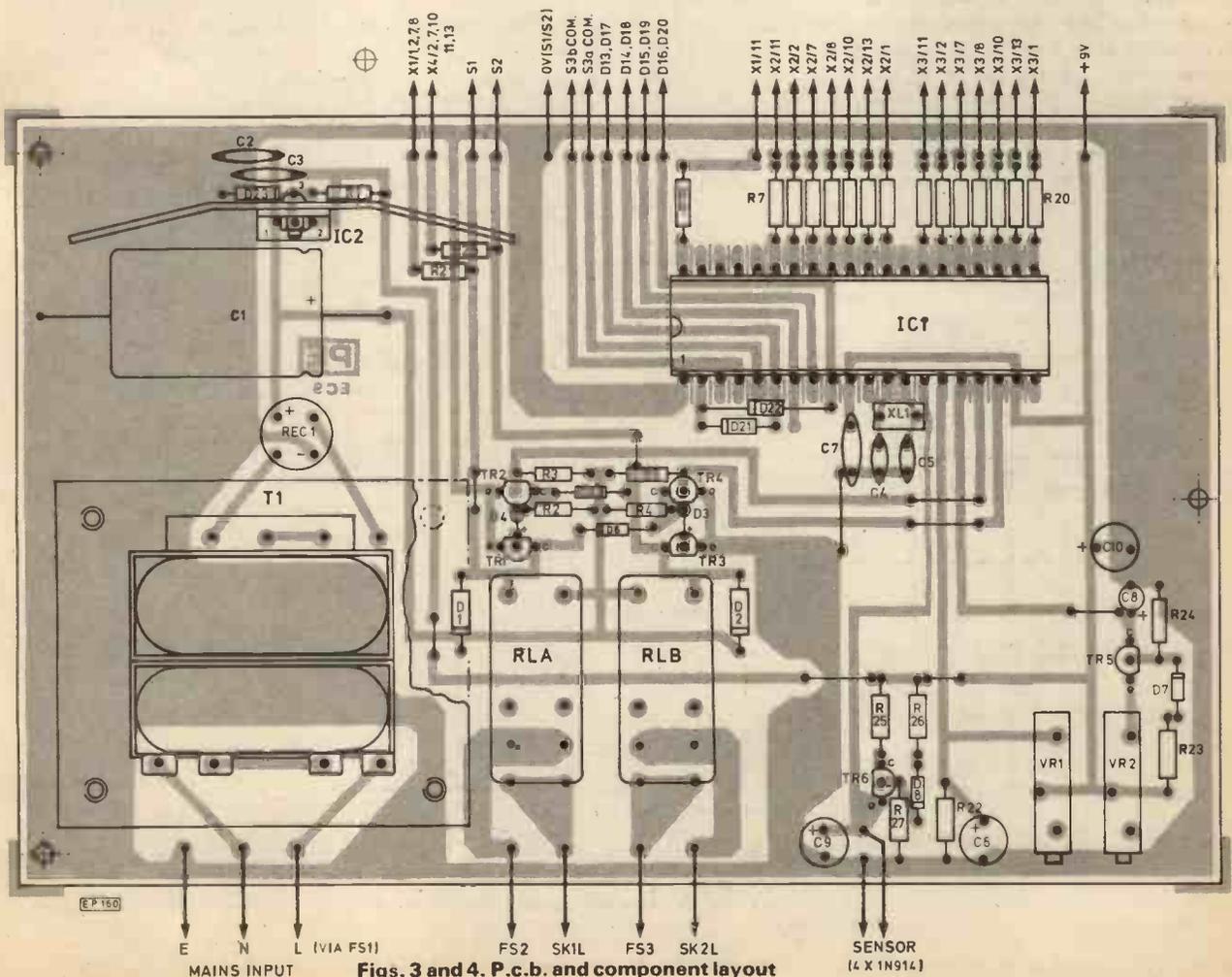
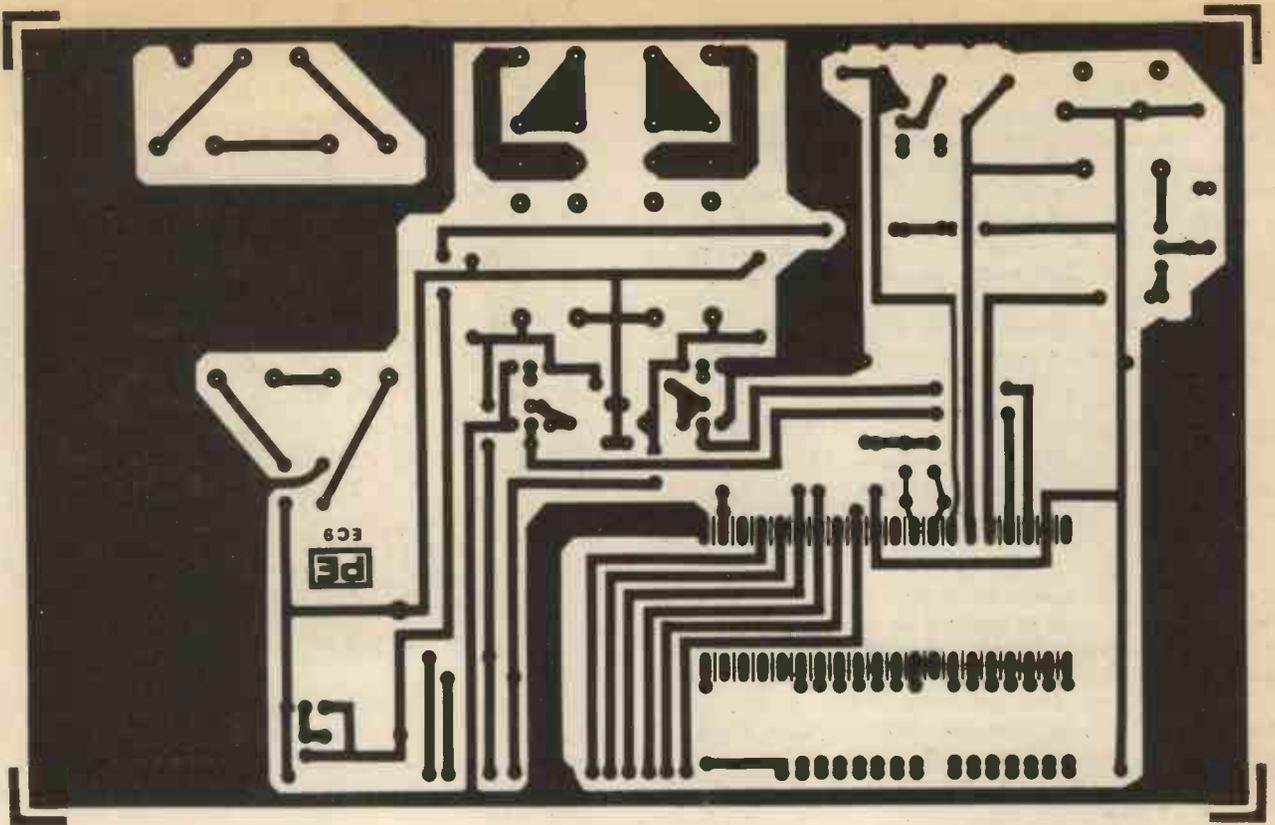
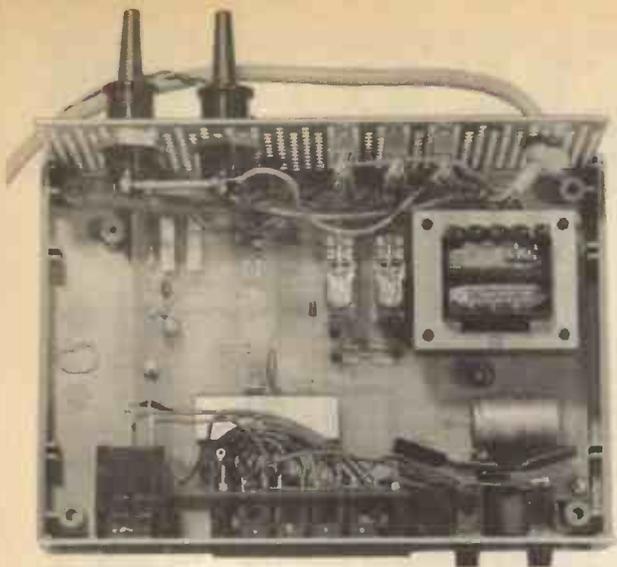


Fig. 2. Relay drive circuit and p.s.u.



Figs. 3 and 4. P.c.b. and component layout



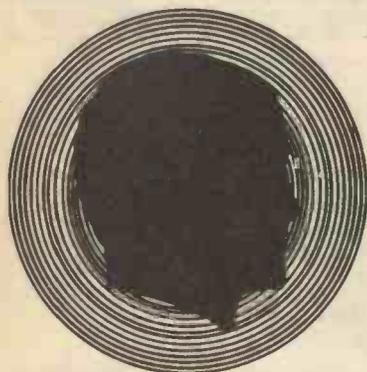
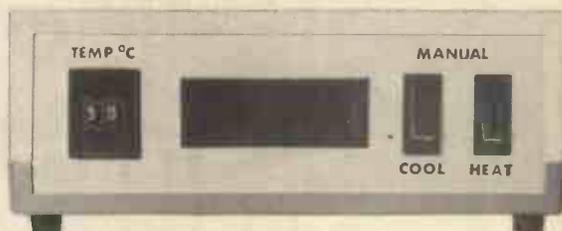
Finally the diodes D9-D12 which form the sensor should have their leads cut short and be soldered together then insulated so that there is no danger of a short circuit by encapsulating in epoxy for example. The sensor diodes should then be connected to the controller via a length of wire, sufficient to place them far enough away from the

controller so as not to be affected by the heat coming from it. Don't forget to check the diodes polarity before connecting up. The circuit should now be ready for bolting into the box and fixing on the lid.

MODIFICATIONS AND ADJUSTMENTS

Hysteresis can be set to 2°C or 4°C by connecting diode D21 either between pins 2 and 6 or between pins 2 and 7 on IC1.

Before applying power to the circuit set VR1 and VR2 to mid positions, and do not short out VR2 when calibrating. To calibrate put the sensor in melting ice. After about 30 seconds adjust VR1 until the display reads zero. Now put the sensor in boiling water—when the display reading has settled adjust VR2 until the display reads 99 then zero—this represents 100°C, the “one” display being on the unused pins 36-38 of IC1. The calibration procedure should be repeated.



INGENUITY UNLIMITED

BATTERY MONITOR

MOST published designs for battery condition indicators light an l.e.d. when the battery nears exhaustion. However, a light may easily be overlooked if continuous and a significant improvement may be made by running the l.e.d. from an oscillator at 1 or 2Hz.

This circuit accomplishes this by employing an inexpensive dual op-amp as both a comparator and an oscillator. Half

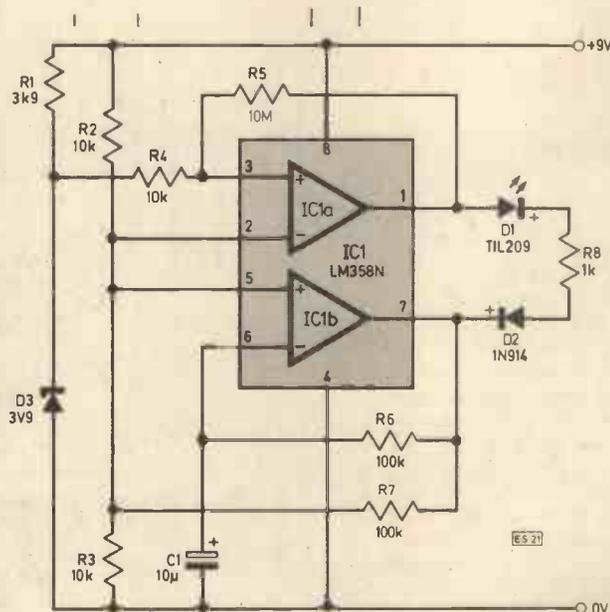
of the supply voltage is derived from R2 and R3, and this is compared with a Zener reference; so when the battery voltage lowers, the output of IC1a becomes positive. R4 and R5 apply hysteresis.

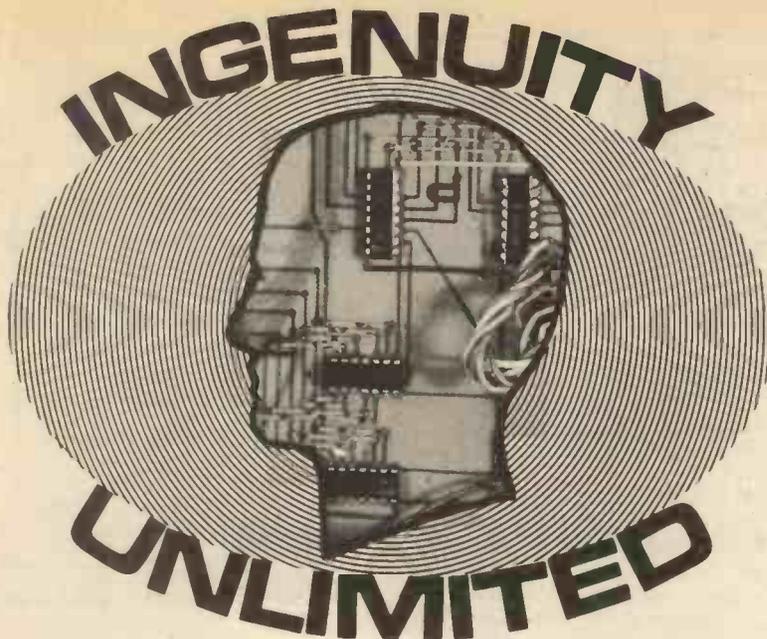
IC1b forms an oscillator with a frequency of 1Hz. With the output of IC1a high, D1 flashes with a peak current of about 5mA. When IC1a output is low, the l.e.d. cannot light. D1 protects the l.e.d.

from reverse voltage breakdown in this condition.

Because of the low current consumption of IC1, only 2mA are drawn from the battery. With a 9V battery, the values are as shown, but for a larger battery voltage, D3 and R8 should be increased in proportion. Maximum supply voltage is 32V.

D. P. Akerman,
Coventry.





A selection of readers' original circuit ideas. It should be emphasised that these designs have not been proven by us. They will at any rate stimulate further thought.

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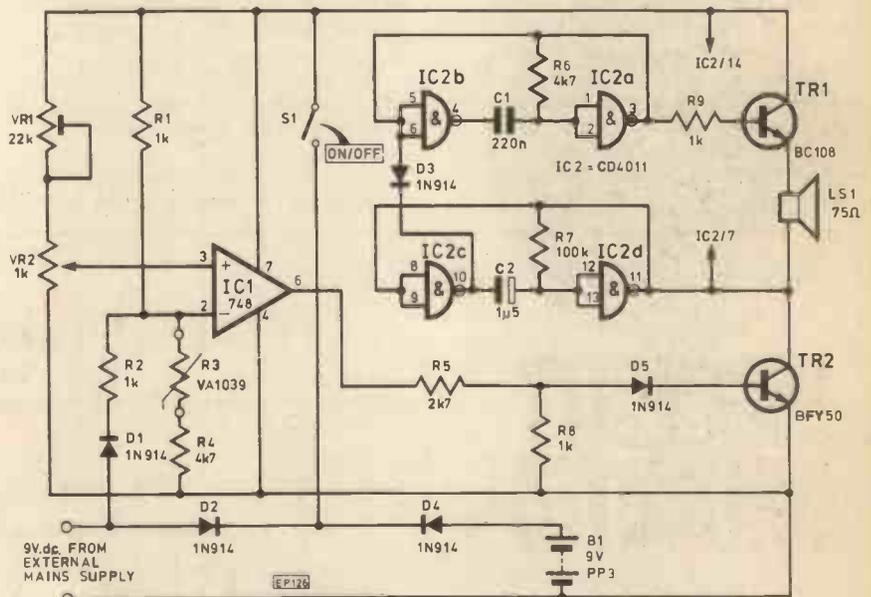
Each idea submitted must be accompanied by a declaration to the effect that it is the original work of the undersigned, and that it has not been accepted for publication elsewhere.

FREEZER TEMPERATURE ALARM

THIS circuit was designed to give an audible alarm if, for any reason, the cabinet temperature of a deep freeze should rise above -10°C , thus giving time to take action to save the contents of the deep freeze from defrosting. Due to the high cost and low reliability of batteries, a mains powered unit was required. In order to eliminate the possibility of a power cut going unnoticed and ruining the contents of the freezer, the circuit was arranged such that loss of mains power would also trigger the alarm, the power being obtained from a standby battery.

The heart of the unit is the 748 op amp which acts as a comparator of a set voltage obtained from VR1 and VR2 against a voltage dependent on the resistance of R3. As the temperature rises the resistance of the thermistor falls and the voltage at the inverting input falls thus turning on TR2 and the alarm formed around IC2.

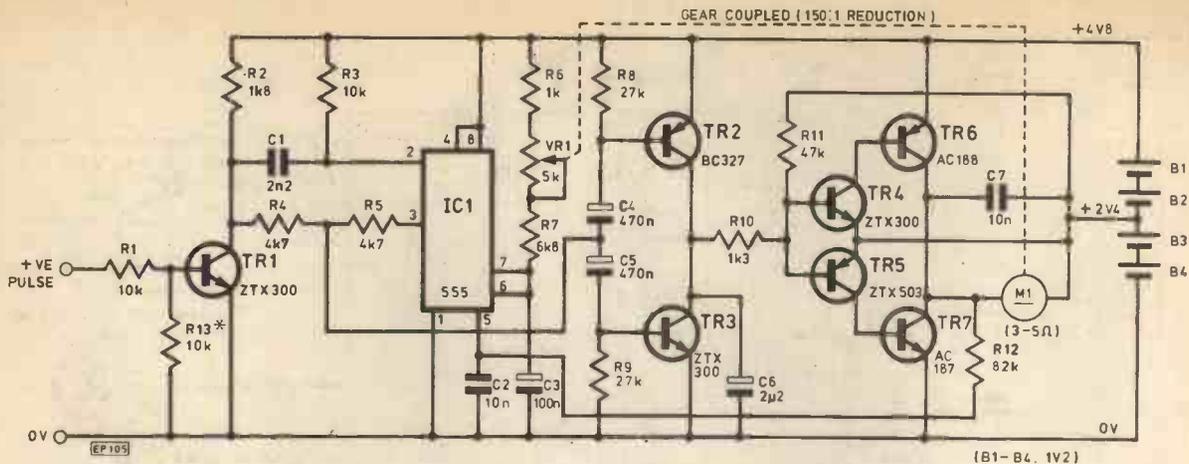
IC2a, IC2b, C1 and R6 form a high frequency oscillator. IC2c, IC2d, C2 and R7 form a low frequency oscillator. The two oscillators are linked by the diode, D3. The tone obtained from the speaker is thus a modulated high frequency tone or bleep, this sound being very noticeable with a very modest current consumption.



While mains power is available, the battery is isolated by the reverse biased D4, and no power is drawn from it. The two $1\text{k}\Omega$ resistors, R1 and R2, are effectively connected in parallel thus giving a total resistance of 500Ω to the inverting input from the +ve supply. When mains power is lost diode D4 will be forward biased and the battery will power the circuit. However, D1 will be reverse biased and so R2 will be out of circuit, and the effective resistance to the inverting input will rise to $1\text{k}\Omega$. Thus the voltage at this input will fall and the alarm will sound.

The only adjustment necessary is to calibrate VR1 and VR2 so that the alarm is just triggered at -10°C . A freezing mixture of ice and salt may be used for this. The state of the internal battery may be periodically tested by depriving the unit of mains power and listening for the alarm. The normal defrosting of the freezer is adequate for the testing of the rest of the circuit.

A. M. Smithers,
Tangmere,
Sussex.



DIGITAL SERVO AMPLIFIER

THIS servo amplifier was developed for one reason—minimum component count. This has been achieved by the use of a 555 timer used as a one shot or monostable. This has the advantage of saving transistors and diodes for the normal monostable arrangement. Also, although many op-amps can perform this function the 555 has the advantage of being able to work down to $-4V$, and has the ability to have its pulse-widths modified by applying a control voltage to pin 5. Fortunately, the normal position for deriving this voltage is of the correct sense ($-ve$ feedback). The selection of R12 to $82k\Omega$ depends on control pulse neutral;

servo mechanics and the degree of under/over shoot which is acceptable for a loss in amplifier gain and hence speed of the servo and its torque. R6, VR1 and R7 and C3 control the pulse width range of the monostable. R6 should be fixed, but if the feedback potentiometer value is not $5k\Omega$ then R7 and C3 can be adjusted to give the desired centre (mechanical) and range of monostable widths.

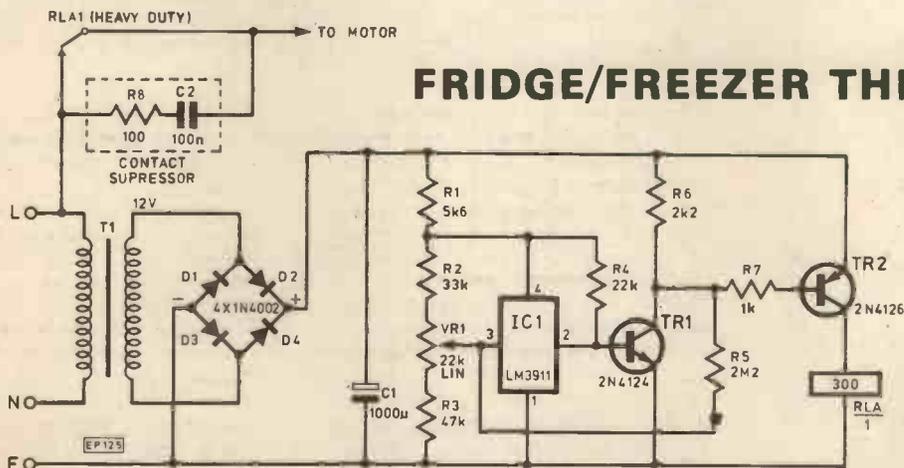
The values of VR1, R7 and C3 have been adjusted here for 1.5ms neutral and a range of 1ms (i.e. 1 ms minimum and 2ms maximum).

The value of R7 and C3 are interlinked and some trial and error is needed to ob-

tain the correct centre (mechanical) and pulse width range (servo travel). No problems with the ultra stable pulse widths produced by the NE555 have been encountered and hence servo drift, when clocked by a battery driven encoder (subject to pulse width changes with battery voltage falling). For $-ve$ pulse systems remove TR1 and associated R1, R2 and R13 and apply $-ve$ pulses to C1+R4 junction.

If room is available fit R13 ($10k\Omega$) in. $+ve$ going systems.

G. Pike,
Co. Antrim,
N. Ireland



FRIDGE/FREEZER THERMOSTAT

THE circuit is built around the LM3911 temperature control i.c. and is designed as a cheap electronic replacement for the mechanical thermostats fitted to fridges and freezers.

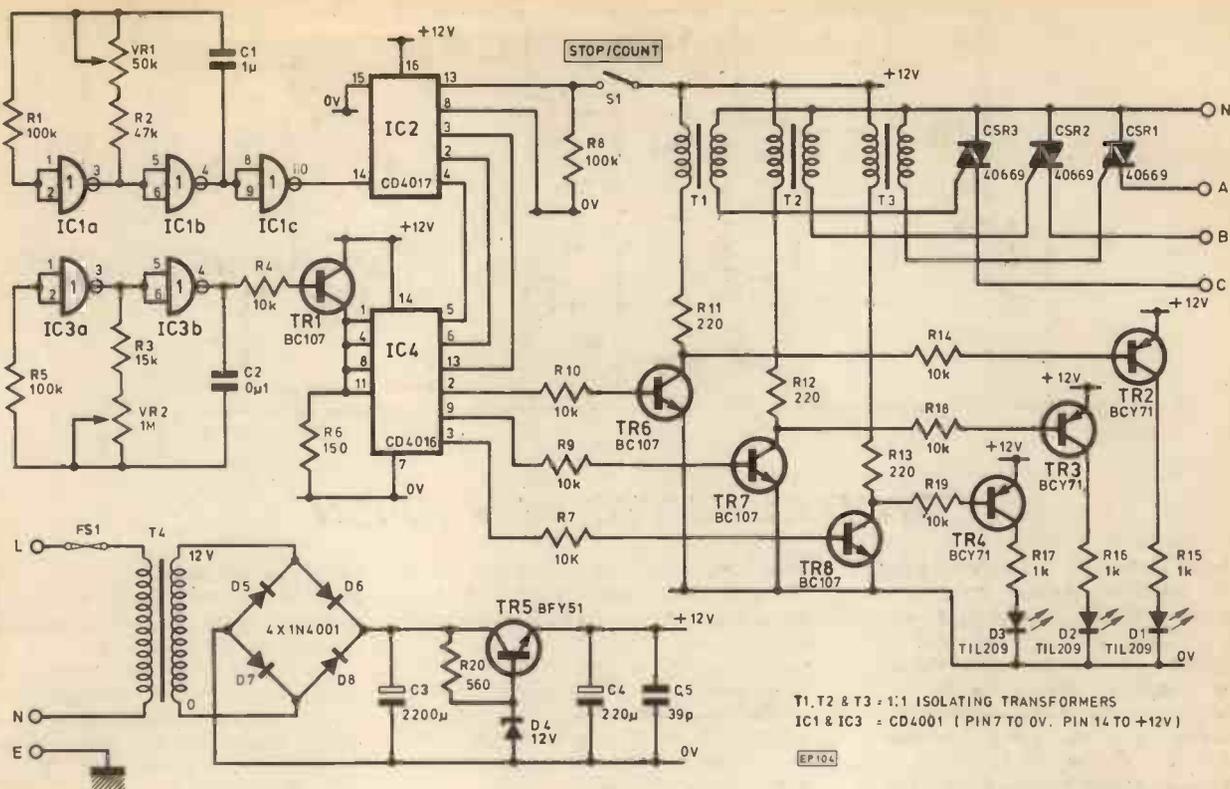
Resistor R1 provides a positive voltage to the i.c. internal stabiliser, pin 4. R2, VR1 and R3 provide a present reference voltage to the i.c., pin 3. The output, pin 2, is taken to TR1 base and controls the relay via TR2.

The i.c. is mounted on a piece of Veroboard in a suitable probe box in the freezer. As the probe temperature rises above the level set by VR1, the i.c. output drops below 0.7 volt. Transistor TR1 switches off and switches TR2 off. The relay releases and the break contacts close, starting the freezer motor. When the temperature has dropped sufficiently the i.c. output volts rise above 0.7 volt and the relay operates, stopping the motor.

Resistor R5 provides positive feedback to ensure a rapid switching of the relay and to provide a temperature difference between switch on and switch off.

The motor is controlled via the relay break contact so that in the event of a circuit failure, the relay will release and the motor will run continuously.

B. C. James,
Wilford,
Nottingham.



SEQUENTIAL LIGHT CHASER

THE design requirement for this light chaser was to have three channels but be capable of accepting up to ten. The circuit shown satisfies these conditions.

IC1 can be either a CD4001 or a CD4011 as can IC2 as the gates in these are used with their inputs joined. IC1a and IC1b form a slow running oscillator which can be varied by use of VR1. This potentiometer controls the speed at which the outputs switch. IC1c shapes the pulses from the oscillator before they are fed into a decade counter (CD4017). The outputs from the CD4017 are low until pulsed at which point the appropriate output goes high.

In the circuit only the outputs '0', '1' and '2' are shown, with output '3' being used to trigger the counter reset. A switch is included so that the count may be frozen at a desired point e.g. to check bulbs. For use with more outputs the reset would be connected to the 'Carry Out' pin, which

pulses only after each tenth input pulse.

IC3a and IC3b form a second oscillator running considerably faster than the first. This is buffered by a single BC107 transistor stage to provide enough current if more output stages are required. The output from the buffer is taken to the inputs of bilateral switches contained in the CD4016. The trigger voltage for these switches is provided by the outputs of the CD4017 which allows bursts of high frequency from IC1 oscillator to be passed to the triac firing circuits. VR2 in the second oscillator allows an interesting strobing effect to be produced in the output lamps.

The high frequency bursts are amplified by BC107 transistors which have 1:1 ratio insulation transformers in series with resistors in their collector lines. The transformers used had a breakdown voltage of 1.5kV and can be obtained cheaply, although they can be made by winding two layers of 26s.w.g. enamelled

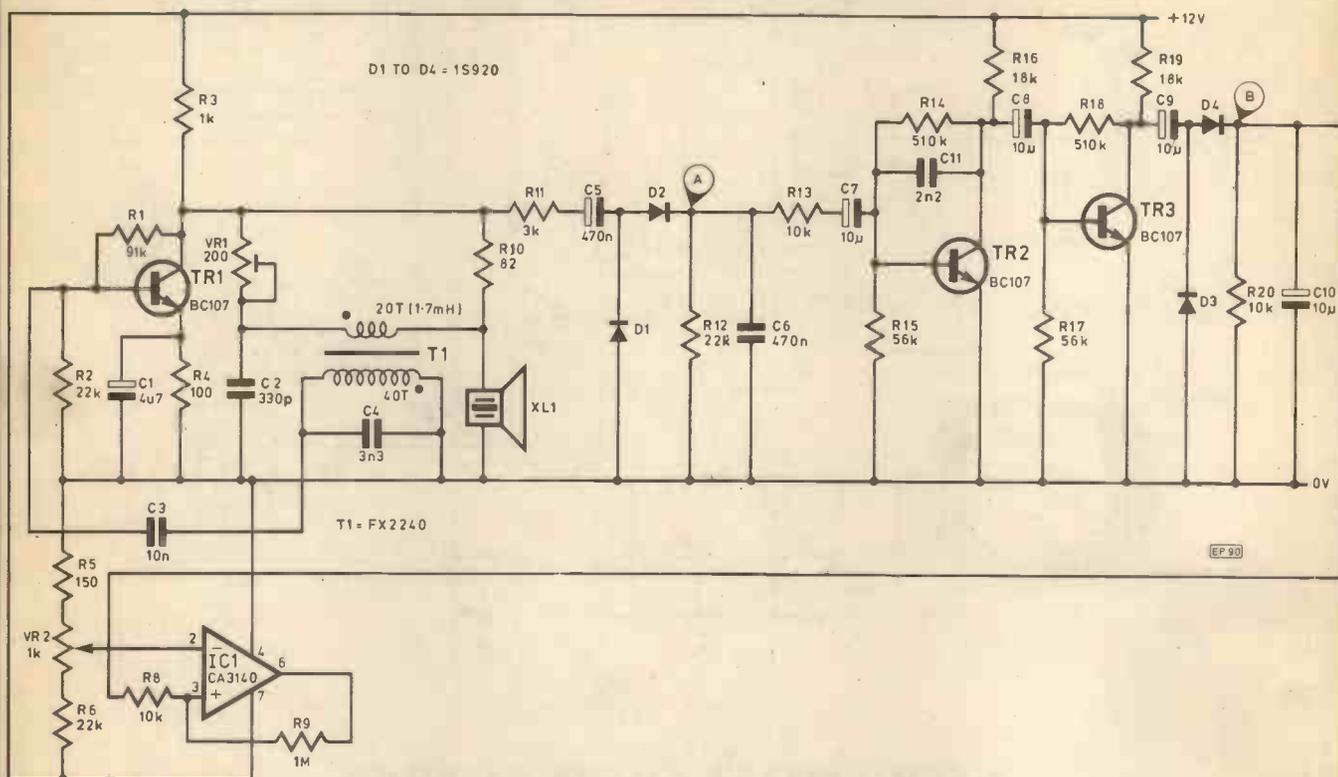
copper wire on a one inch piece of ferrite rod with a layer of p.v.c. tape between each winding. Each winding to have 30 turns.

One side of the secondary is connected to neutral and the other to the gate of the output triacs. The triacs specified handle at least 5A, but others may be chosen to suit individual applications.

A set of mimic lights are included, but these could be omitted to reduce cost. A simple regulated p.s.u. is shown which supplies 12V. It should be noted that the control side of the unit is *not* connected to the mains. This makes it very much easier to work on the electronics whilst switched on. The outputs of the triacs (A, B, C) go to the load which in turn is connected to mains live. The inputs of all unused gates must be connected to 0V or +12V.

N. R. Negus,
Upton-on-Severn,
Worcs.

MOTION DETECTOR



THIS circuit was designed as a motion detector, but it can be used as a level, proximity, air and gas flow switch; and in some cases as a gas leakage detector. Heart of the circuit is a 40kHz ultrasonic transducer.

One of the standard ways of detecting motion is by taking doppler shift measurements, but then one needs to use two transducers, one as a transmitter and the other as a receiver. But the circuit overcomes this disadvantage and is fairly simple to construct.

The transducer is used in series resonance as part of the oscillator, so that it determines the frequency of oscillation.

It is used in a bridge circuit. Here the voltage ratio between R10, and the impedance of the transducer at series resonance, determines the feedback voltage for oscillation. In this case, the frequency is about 40kHz.

This feedback ratio will vary depending on amplitude and phase of the transmitted signal reflected back to transducer, thereby modulating the amplitude of the oscillator. The output from the oscillator is rectified by diodes D1 and D2, to give a low frequency signal. Amplitude of this signal will depend on the distance between transducer and reflector.

If a reflector is placed quite close to the transducer, so that the reflected signal is large and 180° out of phase. The feedback voltage will decrease to a value below that required to keep the circuit oscillating. This characteristic of the circuit makes it possible for it to be used as a level switch by sampling the output at D1 and D2.

The low frequency a.c. signal at D1 and D2 is further amplified by transistors TR2 and TR3.

The output from transistor TR3 is rectified and filtered to give a d.c. voltage.

A CA3140 operational amplifier is used as a comparator, with a small amount of hysteresis, and an adjustable reference, so that one can adjust the sensitivity at a given distance from the transducer. It was possible to detect a person crossing at a distance of 3 metres from the transducer using the prototype.

All one needs to align it is a high impedance d.c. voltmeter. The voltage at point A is adjusted to one volt by potentiometer VR1. Have somebody move at the maximum distance you are interested in, and adjust the comparator reference VR2 accordingly.

If one is interested in using it as a burglar alarm, one can feed from point B to an R-S flip flop.

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Trondheim,
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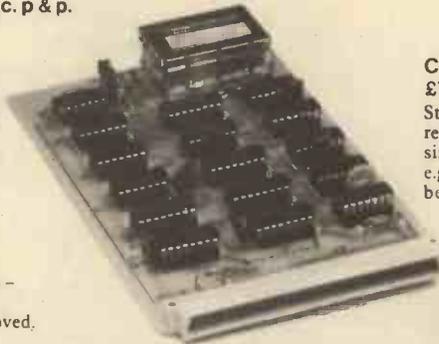
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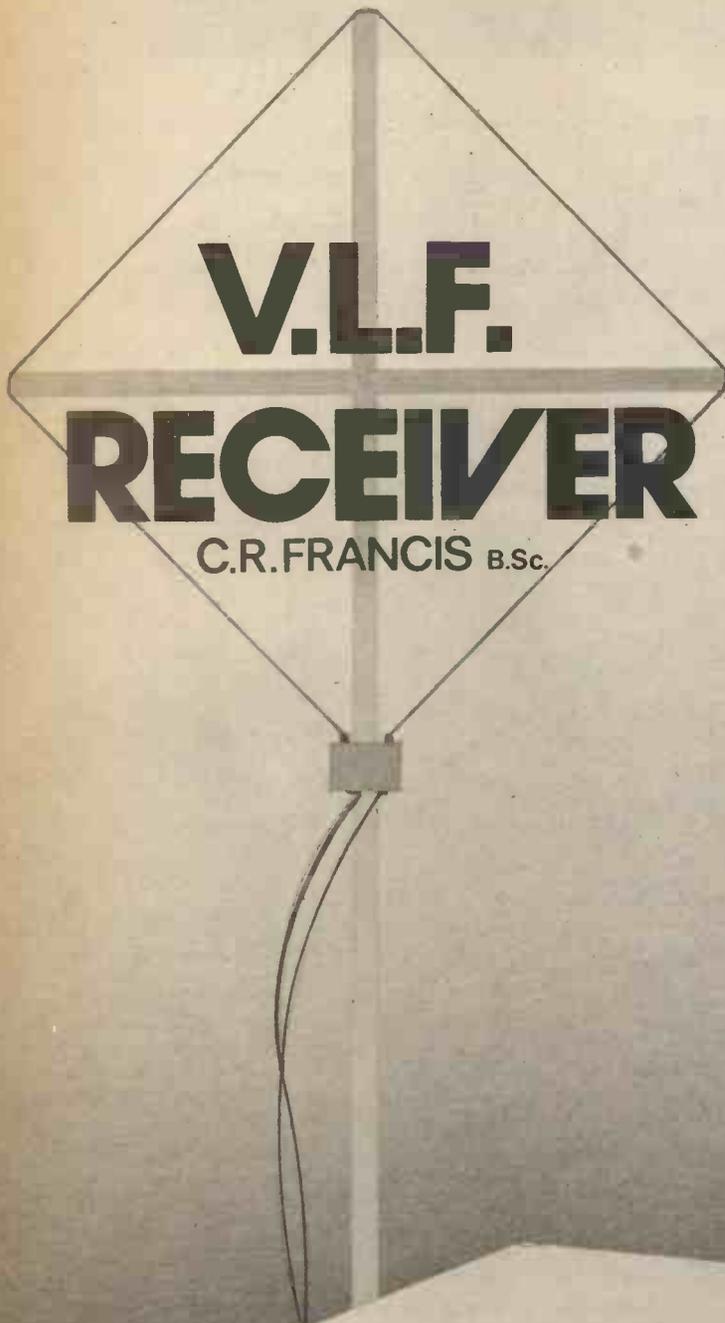
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THE ELF and VLF (extremely low and very low frequency) bands of the radio spectrum, which lie in the frequency range 300Hz to 30kHz, contain a number of interesting signals which are both man-made and naturally occurring. These were described in some detail in the September issue of PE, and are summarised in Fig. 1.

A portable receiving system which will enable these signals to be picked up will be described here. In designing such a system, careful attention has to be paid to interference problems. The signals of interest are on the whole rather weak, while the field strength due to mains electricity in a typical house is, by contrast, at a fairly high level. In the UK moreover, there is a very powerful VLF transmitter at Rugby, called GBR, which transmits at 16kHz and whose signal saturates the entire country. This signal is modulated by frequency shift keying, and non-linearities in the receiver may cause demodulation of this, producing interference. Signals from broadcast transmitters may also cause interference in the same way.

In this receiver these problems have largely been alleviated, but one or two sources of interference still remain, and they put constraints on the operating conditions. The first of these is interference from TV sets; this may be partially overcome by careful orientation of the aerial, but the best solution is to wait until transmissions have ceased in the evening. Many natural signals may only be received at night anyway, since they must penetrate the ionosphere. Another source is motor vehicles, and again this problem will often disappear after midnight. Next, proximity to broadcast transmitters gives rise to very high field strengths, so that the attenuation at RF built into the receiver may be insufficient. This also applies to the signal from Rugby and in some cases RF interference may prove to be a serious obstacle, though usually the problem will again disappear when the transmissions cease in the evening. Finally, nearby electricity substations will generate continuous interference. The only solution here is to take the receiver elsewhere.

THE RECEIVING SYSTEM

A block diagram of the receiving system is shown in Fig. 2. The aerial is a multi-turn loop, screened at RF. At VLF such an aerial appears as an inductance to the receiver, and we may therefore use a transformer to match the impedance of this to the high value presented by the front-end of the receiver. This has a further advantage in that the voltage of the signal is increased.



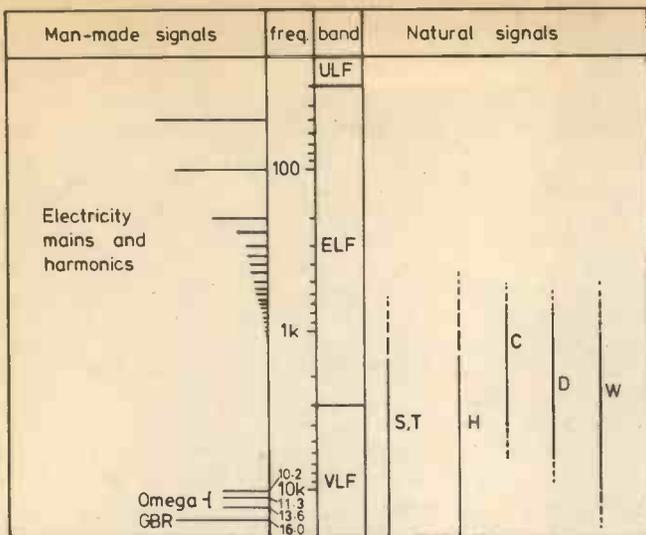


Fig. 1. Approximate frequency ranges of ELF/VLF signals. S: Sferics; T: Tweeks; H: Hiss; C: Chorus; D: Discrete emissions; W: Whistlers

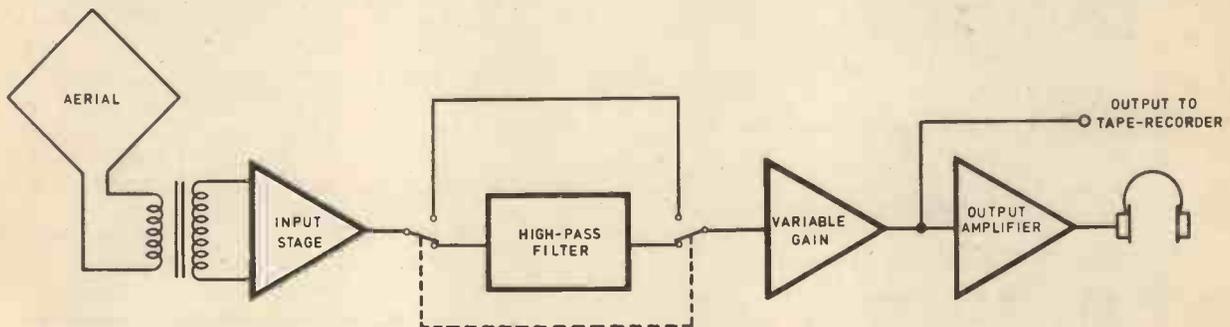


Fig. 2. Block diagram of the receiving system

The gain of the front-end is not defined by the use of negative feedback, and so will depend on the individual transistors used. It is, however, of the order of 40dB. The frequency response of this stage has been limited to 10kHz, to reduce the effect of the GBR signal. This filtering must be carried out as early as possible to minimise the chance of demodulating the GBR signal.

The signal then passes via a buffer stage to a passive high-pass filter, to remove the effect of mains and other low-frequency interference. This filter (and its buffer) may be switched out of the circuit, since the receiver may be used in remote areas where there is little interference. The next stage is a variable gain amplifier; the gain may be varied from 0dB to 60dB. The signal level is now high enough to drive a tape-recorder or other external equipment, and an internal output stage is also provided. This is completely separate; it is on a separate board and has its own power-supply to try to minimise the effects of unintentional positive feedback. There is, after all, a large amount of gain in the receiver. The output stage may be switched off if necessary, and it may of course be omitted entirely.

INPUT STAGE

The circuit diagram of the input stage is shown in Fig. 3. The input transformer, T1, has a turns-ratio of 100, and C1 is included to shunt RF signals. Part of the load for TR1, R3, is bootstrapped by C4, while C2 shunts this at frequencies above 10kHz.

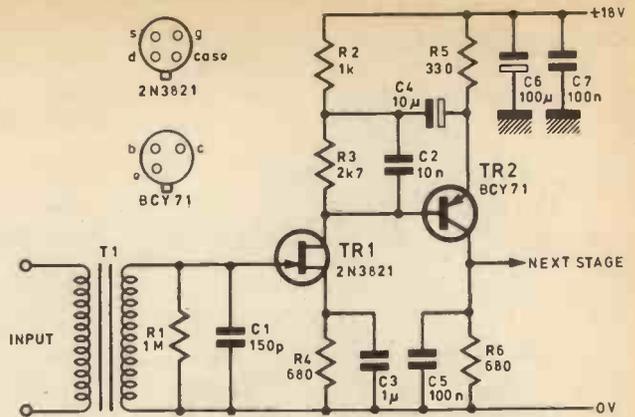


Fig. 3. Circuit diagram of the input stage

The input FET, TR1, gives the input stage a reasonably good noise performance since it is a fairly low noise device and provides useful gain. High gain in the input stage is essential in a low-noise receiver, so that the noise of following stages is negligible. Feedback is not used to limit the gain of this stage, so that the maximum gain is available.

PASSIVE FILTER

Fig. 4 shows the passive high-pass filter and its input buffer. This stage can be bypassed by the switch S1. The filter, comprising C9, C10, C11, L1 and L2 is a five element Tchebycheff high-pass, designed to have 0.28dB ripple in the passband. The cut-off frequency is about 1500Hz and the roll-off about 40dB per octave. For ideal operation the source and load impedance of this filter should be 220 ohms. IC1 is acting as a voltage follower, and has a very low output impedance; R7 therefore sets the source impedance. The load impedance is set by the parallel combination of R8 with the impedance between C11 and the virtual

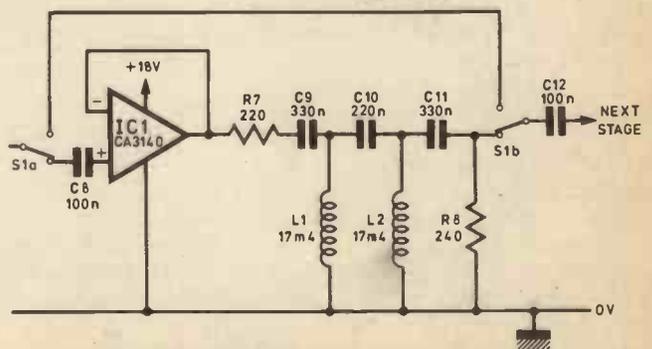


Fig. 4. Circuit diagram of the passive filter stage

earth at the inverting input of IC2. For a characteristic impedance of exactly 220 ohms, the values of the capacitive and inductive elements should be $C9$ and $C11 = 323\text{nF}$, $L1$ and $L2 = 17.4\text{mH}$ and $C10 = 206\text{nF}$. However the error introduced by using the preferred values for capacitance is acceptable.

OUTPUT STAGES

The next stage is shown in Fig. 5; it is a stage with variable gain. Negative feedback is varied by VR1, from 0dB to 60dB and since the bandwidth here is 10kHz, a 741 has adequate performance. The tape output is taken from this stage, via C13.

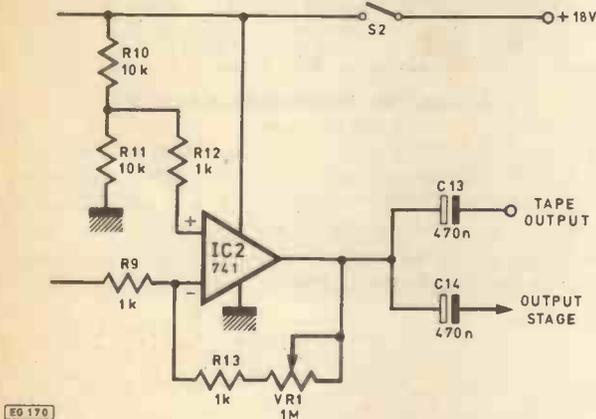


Fig. 5. Circuit diagram of the output stage

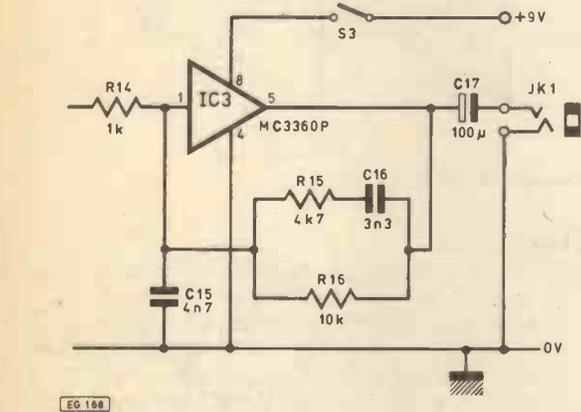


Fig. 6. Circuit diagram of the amplifier stage

The internal output amplifier is shown in Fig. 6. This is based on the Motorola MC3360P $\frac{1}{4}$ watt audio amplifier i.c. The power to this stage comes from a separate 9V battery and may be switched off independently from the receiver, by S3. The ground line of this stage is of course a common ground with the other circuitry.

THE AERIAL

A multi-turn loop aerial is used, made from a length of 15-core screened cable. A 5m length of this is adequate, though of course a longer piece or a larger number of cores will make a more sensitive aerial. It is unwise, however, to make an aerial of vastly different dimensions from those suggested without giving thought to matching the input transformer primary winding, and to possible resonances due to the combination of the loop inductance with its stray capacitance. Fig. 7 shows the main constructional features; the cores are connected by means of a piece of tagboard,

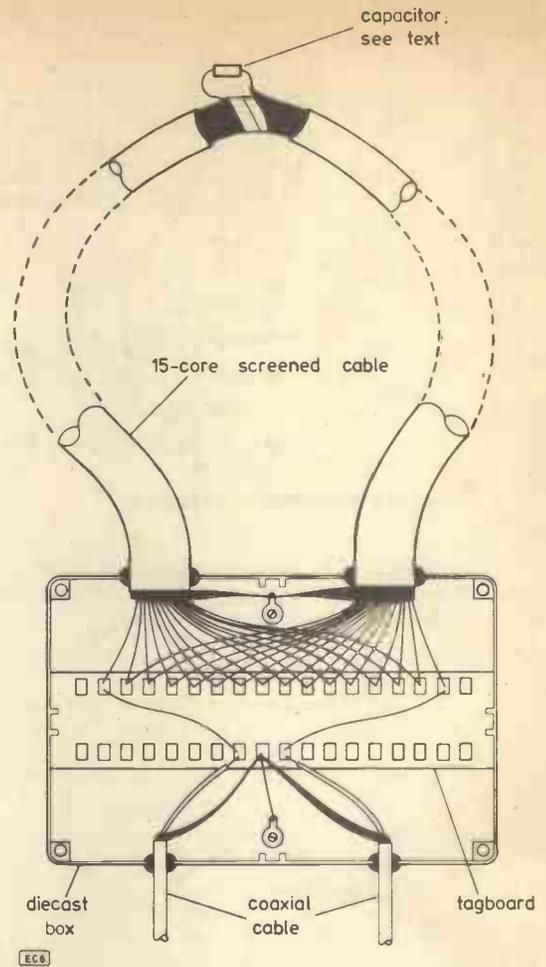


Fig. 7. Construction of the multi-turn aerial

within a metal box. Take care to produce one continuous wire with 15 turns, rather than, say, 15 separate single turns. This may be achieved by selecting a colour, say black, and soldering this to the first tag. Then solder the other end of the black to the brown at the next tag, the other brown end to the red, etc. The screen, and the screen of the output cables should be connected to the box.

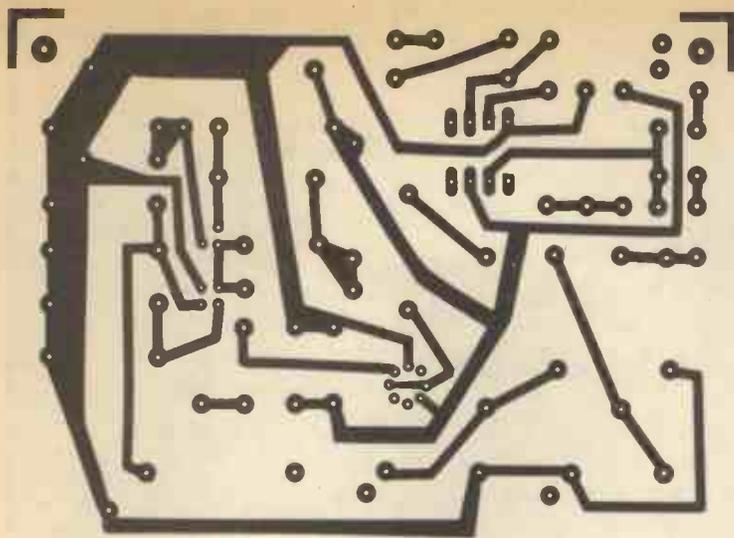
In theory the screen should be cut at some point and linked by a capacitor, as indicated in Fig. 7, so that the screen is complete at RF, but broken at VLF. While trying to reduce RF interference, however, the author has found that the gap may in fact be absent. Individual experiment may be needed here, and it is suggested that the aerial be first constructed with the screen intact.

Co-axial cable should be used for the output leads, and any good quality co-ax connectors may be used (BNC types were used in the prototype), since the low impedance of the aerial at VLF will not match any particular type of cable or connector.

The aerial should be fitted onto a frame consisting of two, five to six foot lengths of wood fitted together to form a cross. The diecast case can be fitted to the base of the frame and the aerial loop spread out around the frame to form a diamond shape.

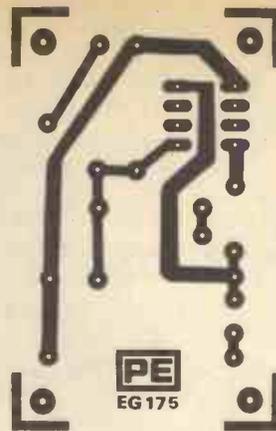
CONSTRUCTION

The receiver circuitry is carried by two printed circuit boards; the main receiver is shown in Figs. 8 and 9, while Figs. 10 and 11 show the output stage. Three coil assemblies are required, T1, L1 and L2. Pads have been provided on



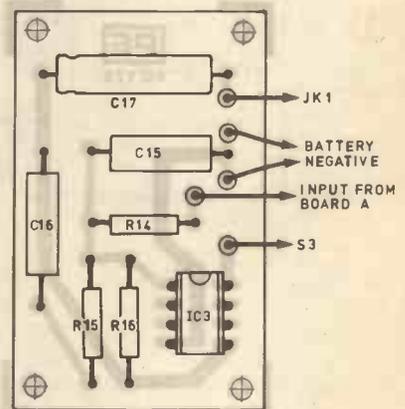
PE
EG174

Fig. 8. P.c.b. design for the receiver circuit



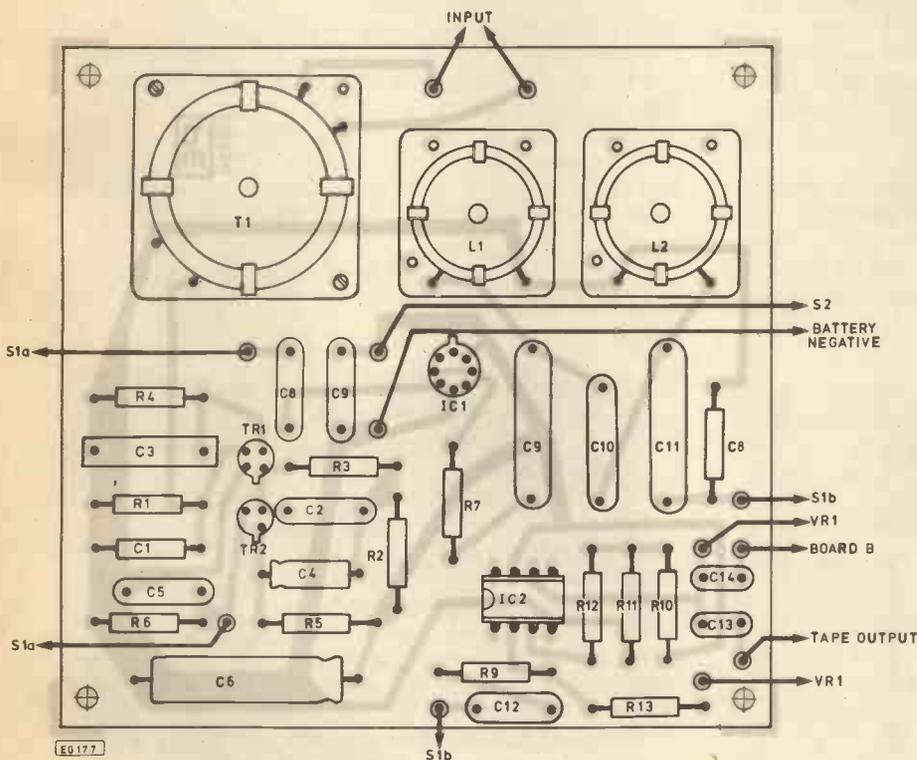
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Fig. 10. P.c.b. design for the amplifier circuit



EG176

Fig. 11. Component layout for the amplifier circuit

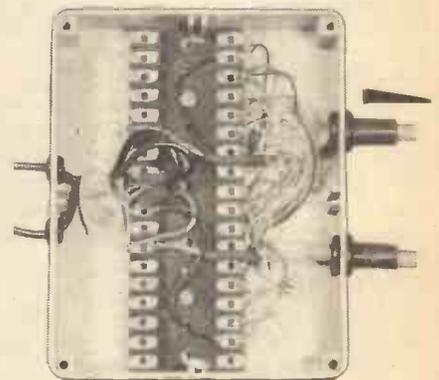


EG177

Fig. 9. Component layout for the receiver circuit

the receiver to suit the Mullard p.c.b. mountings for these cores; in the prototype receiver, however, steel cans (also manufactured by Mullard) were used, and the assemblies bolted to the case. Details of both of these alternatives are shown in the layout diagram, Fig. 12. Note that the use of a metal case is strongly advised; a diecast box was used for the prototype.

The input transformer core is the FX2240, a 25mm core.



Internal view of the aerial case

The primary, 5 turns of 34 s.w.g. enamelled copper wire, is wound on the bobbin first. The secondary windings, 500 turns of 35 s.w.g. are then wound on top of the primary. Although this is well below the manufacturers' quoted minimum number of turns to fill the bobbin, care should be taken in winding to keep the turns tight, otherwise there may not be room.

Inductors L1 and L2 are identical. They consist of 230

COMPONENTS . . .

Resistors

R1*	1M
R2*, R9, R12, R13, R14	1k (5 off)
R3*	2k7
R4*, R6*	680 (2 off)
R5*	330
R7	220
R8	240
R10, R11, R16	10k (3 off)
R15	4k7

* These resistors should preferably be metal film or thick film.

Capacitors

C1	150p
C2	10n
C3	1 μ
C4	10 μ elect
C5, C7, C8, C12	100n (4 off)
C6, C17	100 μ elect (2 off)
C9, C11	330n (2 off)
C10	220n
C13, C14	470n tant (2 off)
C15	4n7
C16	3n3

Semiconductors

TR1	2N3821
TR2	BCY71
IC1	CA3140T
IC2	741
IC3	MC3360P

Inductors

L1, L2	17.4mH (see text)
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Miscellaneous

- VR1, 1M log.
- T1, transformer (see text)
- S1, double pole changeover switch
- S2, S3, s.p.s.t. switch (2 off)
- JK1, $\frac{1}{4}$ in. jack socket (see text)
- Output socket to tape recorder
- Battery clips for PP7 battery
- Battery clips for PP3 battery (2 off)
- Tagboard
- 2 diecast boxes
- 5m 15-core screened cable
- 4m co-axial cable
- Co-ax plugs and sockets (2 off of each)
- Grommets

turns of 36 s.w.g. enamelled copper wire in an LA1226 18 mm pot core. Again, be sure to keep the turns tight.

The use of metal film resistors for the input stage (R1 to R6) is recommended, since these have better noise characteristics than other types. This is particularly important for the input resistor, R1. All the components in fact should be of high quality, in the interests of low noise.

If stereo headphones are to be used with the receiver, then a stereo headphone jack socket may be used. It should be made of plastic so that all the contacts are isolated from the case and wired up as shown in Fig. 6. This will put the two drive elements in series, since the output stage should not drive a load of less than 15 ohms.

TESTING AND USE

There is no setting up to be done. As an initial test, plug in a pair of headphones, and connect a short length of cable between the input sockets (or short out the primary winding of the transformer internally) and switch on. Noise from the input stage should be clearly audible. Without the short across the transformer oscillation may occur, but it is

unnecessary to try it! If oscillation occurs with the transformer shorted out, then positive feedback is to blame. Try reducing the gain control, switching off the internal amplifier and monitoring through an external amplifier, changing the layout or searching for an electrical fault.

If all is well, try the aerial. The best orientation for this is in the vertical plane; a light framework which will enable it to rotate about a vertical axis is advised, as this will enable interference sources to be nulled out. Plug the two coax cables from the aerial into the input sockets, switch the filter out of the circuit, set the gain to the lowest setting, and again switch on. It is more than likely, unless the hour

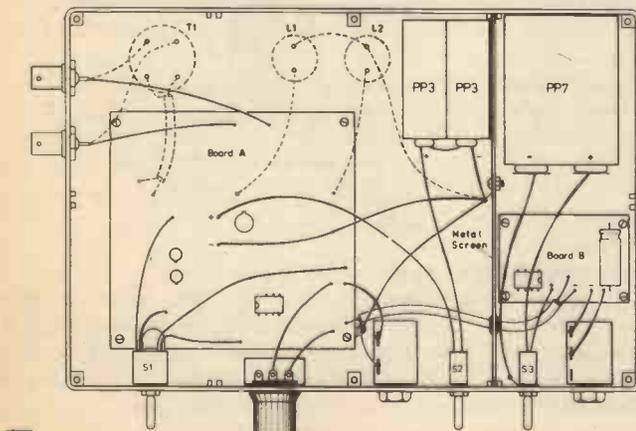
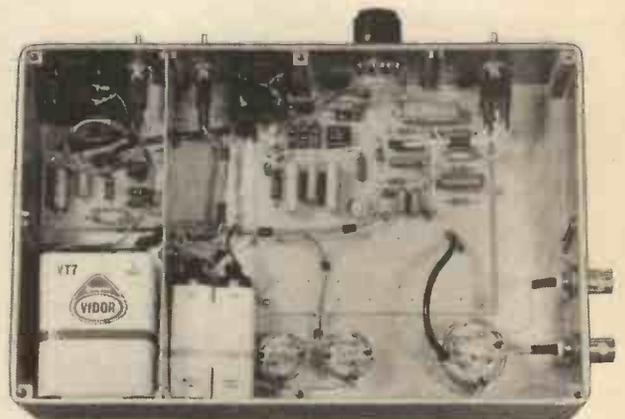


Fig. 12. Assembly of the receiver



is late, that all that will be heard is a loud hum from mains or TV pickup. Check that the filter reduces this. You would be well advised now to wait until fairly late in the evening, or of course to drive out to a remote site in the countryside.

In the meantime, the frequency response of the input stage of the receiver and the passive filter are shown in Fig. 13. Notice that the response is peaked near 1kHz, falling off by about 10dB at 10kHz. The relevance of this will become clear when the receiver is finally switched on once

the interference has reached acceptable levels, for one of the most distinctive signals which may be heard are the Omega transmissions near 10kHz. These are a series of tones, of length one second each, which repeat at 10 second intervals.

The aerial should be rotated so that the best interference compromise is reached. This operation can be quite tricky, since it will rapidly become apparent that the receiving system is quite capable of picking up signals radiated from the drive coils in the headphones, giving rise to unpleasant howls of positive feedback. Perhaps the best idea is to push the aerial around with a long stick! It is, incidentally, possible to pick up signals radiated from loudspeaker coils at some distance, even though their design should minimise such radiation. Furthermore, the receiver is microphonic; slight taps on the case will be readily audible, since they cause the transformer to vibrate.

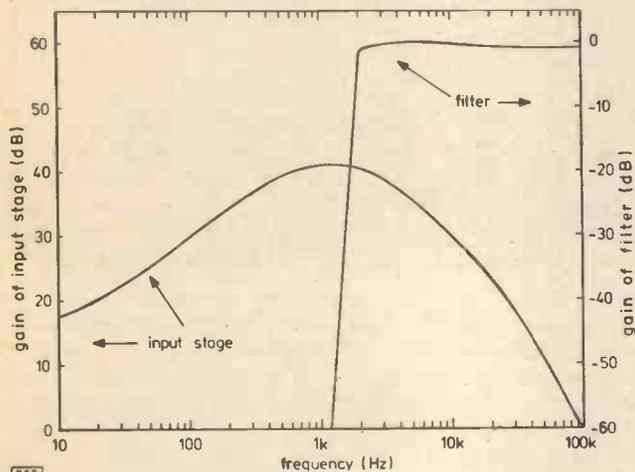
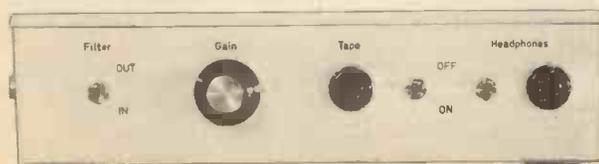


Fig. 13. Frequency response of the input stage and the passive high-pass filter

The signals which may be received have been described before, but a few words on their rate of occurrence in the UK would be in order. Sferics will almost always be heard, since lightning discharges from such an enormous area are being detected; and the virtually continuous nature of the crackling gives a vivid impression of the size of this area. They are, however, more frequent in the summer, and at this time will often limit the lowest intensity of whistler which may be detected.

Tweaks may be expected once or twice a minute, when there are many sferics, though this figure is variable and they are often not present at all.

Whistler rates depend on a number of factors. The geomagnetic latitude of the UK is favourable for whistler occurrence, but there are temporal factors. Whistlers tend to occur in groups lasting $\frac{1}{2}$ hour to about $2\frac{1}{2}$ hours; they tend to occur between the hours of midnight and dawn, and they are more common in winter than summer. The blanketing effect of sferics partially accounts for this seasonal effect, though seasonal variations in thunderstorm occur-



Front panel annotation

rence are also important. An average rate in the UK, over a year, is about one or two whistlers per minute.

Chorus, hiss and discrete emissions are rather more rare, since they tend to be higher latitude phenomena. They can be received in our latitudes, however, and they contribute much to the interest of listening to the strange sounds of natural VLF signals.

SIGNAL LEVELS

The signal strengths of whistlers vary greatly, and extend down to the background noise level. This is determined, in the absence of man-made interference, and at our latitudes, by sferics. In the winter the steady background of distant sferics has a field strength of about $20\mu\text{V/m}$, while in the summer numerous sferics from relatively nearby thunderstorms raise this to 200 to $700\mu\text{V/m}$. The upper limit of whistler signal strengths is a few mV/m .

The voltages these signals produce in the prototype aerial are approximately:

winter background noise:	$0.01\mu\text{V}$
summer background noise:	up to $0.5\mu\text{V}$
whistlers:	anything up to about $2\mu\text{V}$

TABLE 1

Now the random motions of the electrons in conductors give rise to noise, called Johnson noise, or thermal noise. The Johnson noise generated in the aerial is, for our 10kHz bandwidth, about $0.06\mu\text{V}$. Clearly, therefore, this defines the lowest signal we may detect (given a perfect receiver), and is higher than the background noise in the winter. Increasing the size of the aerial and/or reducing its d.c. resistance would improve this performance limitation, but the prototype aerial was considered to be a satisfactory compromise.

The input transformer, with its turns ratio of 100 brings these signals up to the following levels at the input to the receiver:

winter background:	$1\mu\text{V}$
summer background:	up to $50\mu\text{V}$
whistlers:	up to 0.2mV
Johnson noise in aerial:	$6\mu\text{V}$

TABLE 2

The noise generated in the receiver is equivalent to an input noise voltage of about $3\mu\text{V}$; this is not the best that can be achieved, but it ensures that the sensitivity of the receiving system is defined solely by the sensitivity of the aerial.

Incidentally, if you are wondering about the Johnson noise generated in R1; the noise generated by an open circuit 1M resistor is about $12\mu\text{V}$ under our conditions. However, R1 is effectively in parallel with the d.c. resistance of the secondary winding of T1, and the Johnson noise of this combination is negligible.

FURTHER READING

The definitive book on natural VLF signals is *Whistlers and Related Ionospheric Phenomena*, by R. A. Helliwell, published by Stanford University Press in 1965. Though this book has some fairly technical sections, it contains a fascinating atlas of natural VLF signals. Since it is the standard work in the field, most libraries should be able to obtain it. ★



MORE ABOUT JUPITER

The exploration of space is proceeding at such a pace that it seems to produce almost daily updating of information. The data on Jupiter is in such quantity that it is rather like zooming in on the planet with the result that detail is ever increasing. Pioneer 10 and Pioneer 11 added a new vista to the horizon and changed some of the old ideas yet also confirming that at least the thinking was in the right direction. Now Voyager 1 and Voyager 2 have added their astounding contribution. At the passage of the Pioneer 10 and 11 spacecraft much was learned about the magnetic field and other parameters. Voyager 1 and Voyager 2 have already transformed ideas of the atmosphere of the planet. For example Voyager 1 resolved the question of the coloured bands and the various changing spots particularly the Great Red Spot. Voyager 1 showed that the bands were caused by the effect of the high axial rotation speed of the planet. The action appears to be, that as the tops of clouds appear above the bulk of the atmosphere, they are immediately elongated along the main atmospheric surface. The reason, so simple that it should have been recognised before, for rapid rotation of the planet on its axis offered a clue. This rotation period is a few minutes less than 10 hours. The diameter of Jupiter is 142,700km at the equator (88,700m) this gives a figure of some 27,000 m.p.h. for the peripheral boundary of the atmosphere and the emerging clouds.

It is easy to accept that the spots are the constantly changing energy dissipation of the variable density clouds. During the period of four months that elapsed between the flypast of Voyager 1 and that of Voyager 2 considerable permanent changes appeared in the appearance of the area around the Red Spot (incidentally the so called Red Spot is a pale pink) also some of the first conclusions were the subject of some re-thinking. In the past, before the probes, there were a number of theories about the Red Spot.

One in particular was that of the 'Taylor' column. It was suggested that the Red Spot was the top of a supporting column of gas formed by dynamic wave conditions within the atmosphere of the planet. The first pass by Voyager 1 disposed of this and of all the previous thoughts because it appeared that in fact the Red Spot was an enormous cyclone type of activity some 21km in length east to west. This area between the pass of Voyager 1 and Voyager 2 four months later showed many changes including a reversal of movement of the peripheral activities. In the light of some of these findings there is a leaning again toward the idea of a more extensive connection with the lower atmosphere of the planet. The 'Taylor' column becomes again a possible. From the many thousands of drawings made by amateurs, particularly those of Jupiter Section of the British Astronomical Association, for the last 80 years or more, some useful correlation could be obtained. The requirement is for noticeable changes of the features over periods which could be correlated with photographs and their extensive detail.

While the drawings will give general shapes and outlines, those shapes will be easily interpreted in terms of the photographs. Cyclic changes whether from the immediate area of the planet or whether from solar effects would be visible. Observationally in spite of difficulties an enormous amount of data is available and even if the drawings are but 50 per cent accurate there is much to be gained. Indeed it could well be that this is a time when the efforts of amateurs throughout the world could be enlisted. There is no reason why sets of coded photographs should not be available for this purpose. Reference to the book *The Planet Jupiter* by Bertram M. Peak published in 1958, an outstanding classic in the literature by a former Director of the Jupiter Section of the BAA who personally observed directly over a period of 25 years, is very rewarding.

INTERESTING IO

The complication of the innermost satellites are of great interest especially Io. When the decametre radiations were first noted by Burke and Franklyn in America during 1955 a new wave of interest in the world of radio astronomy arose. Though only a small number of people took part in these activities (the writer included) the first ideas were that these radiations came from certain spots of the surface of the planet. A period of rotation was assigned which was slightly different from the axial rotation. Three areas were designated as being the origin. Beyond recognising these radiations no conclusions were really possible. As a participant in a National Aeronautics Space Agency contract the writer did not subscribe to the view that the radiations came from the planet but postulated a mechanism involving some sort of link with an ionised condition. This subsequently proved to be the case. It was put forward by Bigg an Australian meteorologist in 1964 that Io was responsible for a mechanism. This proved to be partly true as was found during a study in 1965 and 1966. In the meantime a link by current sheet or ionised bridge was put forward (by several of us) in relation to Io as an explanation. Pioneer 10 and 11 gave rather negative results

in this respect. However it has been now established by the Voyager missions that there is a torus of ionised material out at the orbit of Io. One other possibility is that Amalthea has some effect and more so now that it is known to be an elongated body whose axial rotation if any has not been established. It could be a possible trigger for the aurorae that has been observed.

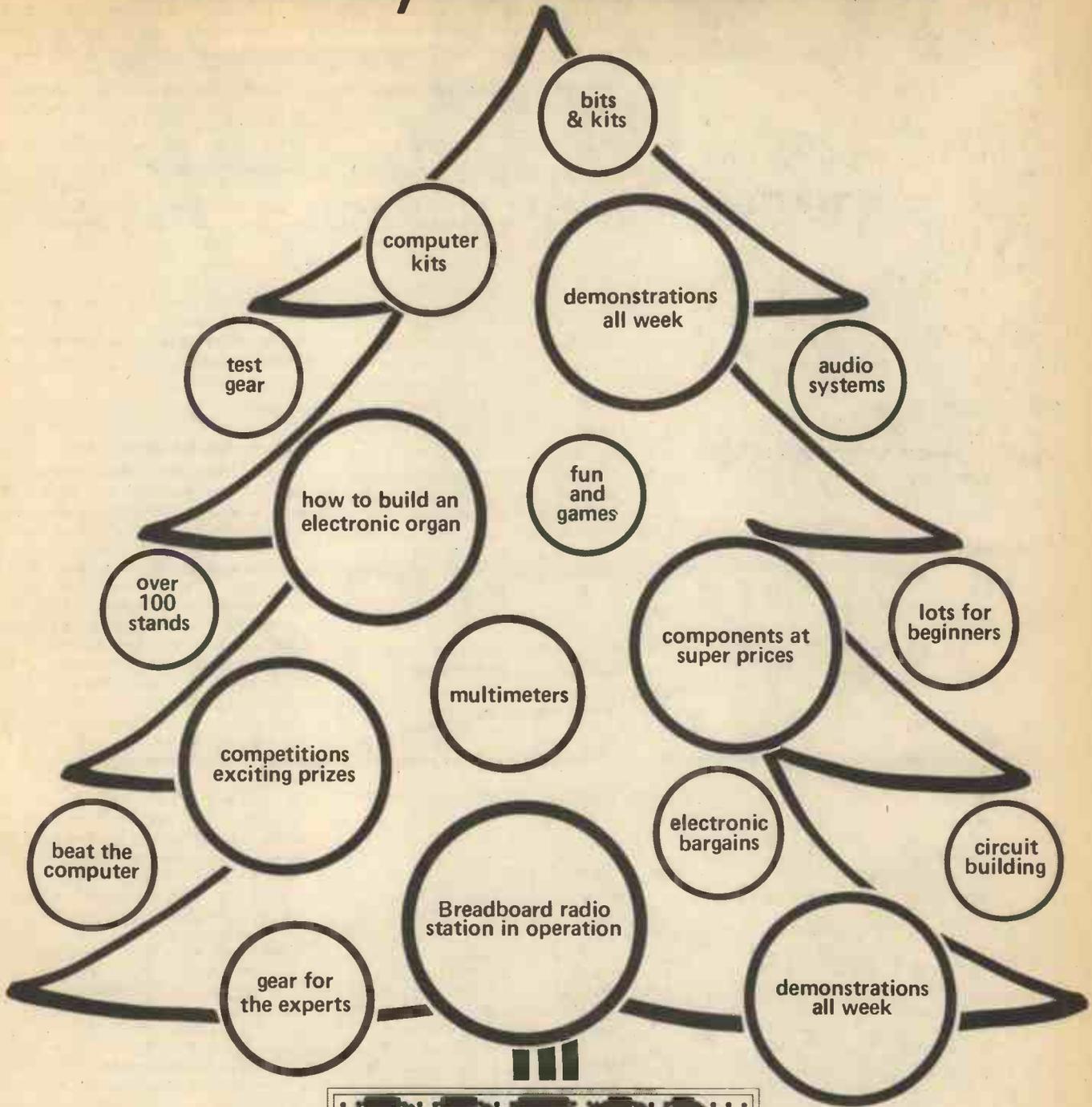
The finding of a ring of small particles is of special interest. Like that of Uranus the ring is much more tenuous and does not extend as far out as those of Saturn. Its appearance to probes is not perhaps surprising because Jupiter is itself so bright that the possibility of actually seeing it from Earth is very remote even if an eclipsing disk was used in the telescope. The particles are so small that they may well be primordial dust or this is another activity of Jupiter in cleaning up the debris of the solar system.

GALILEAN SATELLITES

The satellites, that is the Galilean satellites, seem to have a special individuality. Io is volcanic and in continuous activity and is unique in the solar system. Many years were spent in the observation of Io by optical astronomers from Earth based instruments but no clue about any activity was ever seen. Not until the probes came did knowledge of the satellites become possible. It is being suggested that the volcanic activity is perhaps less than a million years old. The reason for this being the case is not clear. A suggestion that the pull of the planet Jupiter as opposed to the two Galilean satellites Europa and Ganymede may account for the heating of Io. However it is not 'hot' in the sense of that of the Earth's interior. The 'hot spot' on Io is a mere 20 degrees compared with the -140 degrees of its surface. There are therefore no signs of molten material around its craters. Europa was a puzzle until the probes went by. It was found that Europa is also unique for it is 'bald'. It is probably composed mainly of ice, very thick, perhaps as much as 100km. Voyager 1 has shown that the surface is probably slushy ice so the surface changes are obliterated from the viewpoint of the probe. Ganymede the third of the Galilean satellites is different again from the others. It appears to be mostly water. It has a low density. There are abrupt divisions between the types of surface. Some areas are very dark and heavily cratered while others appear to be lighter and perhaps made up of ice in ridges. The state of the cratering suggests that this satellite is about the age of the Earth. Finally the fourth of the Galilean group and the outermost is Callisto.

This body is the most cratered body so far observed in the Solar System. The surface is so cratered that it will take 20 years to count them up. It would seem that this moon also is made up largely of water and belongs to the early period of 4000 million years. The observations of Jupiter have gone on for some 11 months and the amount of data to be analysed is formidable and while the probes go on their way to Saturn the first real work on the Jupiter results will begin. The exciting beginning can only result in the re-shaping of many current ideas.

The hobby electronics show



**BREAD
BOARD**

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1979

Royal Horticultural Halls
Elverton Street
Westminster SW1

6 CHANNEL MIXER

S.R.W. Grainger & C.R. Harding Part 2

In this final part board construction together with interwiring and final setting up will be detailed.

CONSTRUCTION

For the prototype printed circuit boards were used on the input channel amplifiers, this method was adopted because of the need to reproduce six identical circuits. However there is no reason why Veroboard (or similar) could not be used for construction providing dimensions are similar.

This involves the use of a two pole change-over interlocking push button switch system, however this can be replaced by a rotary selector switch as shown in Fig. 1.

All wiring in the mixer should be kept as neat as possible and all low level signal connections should be made with screened cable with the screen connected at one end only (this applies to the wiring of the 1kHz oscillator also). Connections to the bass and treble controls can be made with ordinary unscreened wire, providing the leads are kept

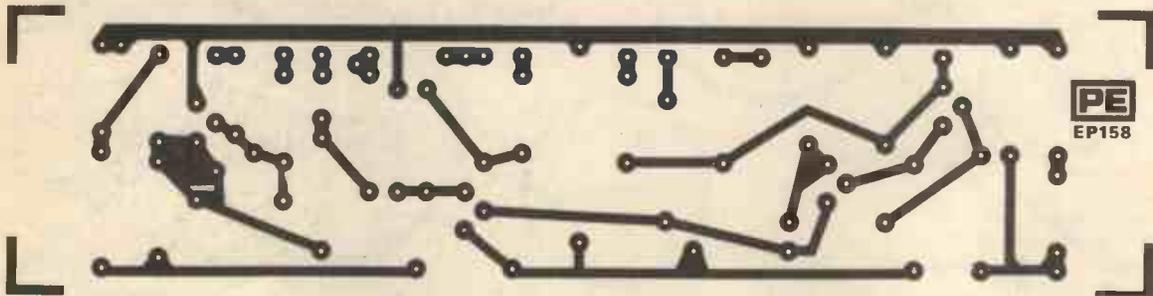


Fig. 10. Input channel amplifiers—six are required

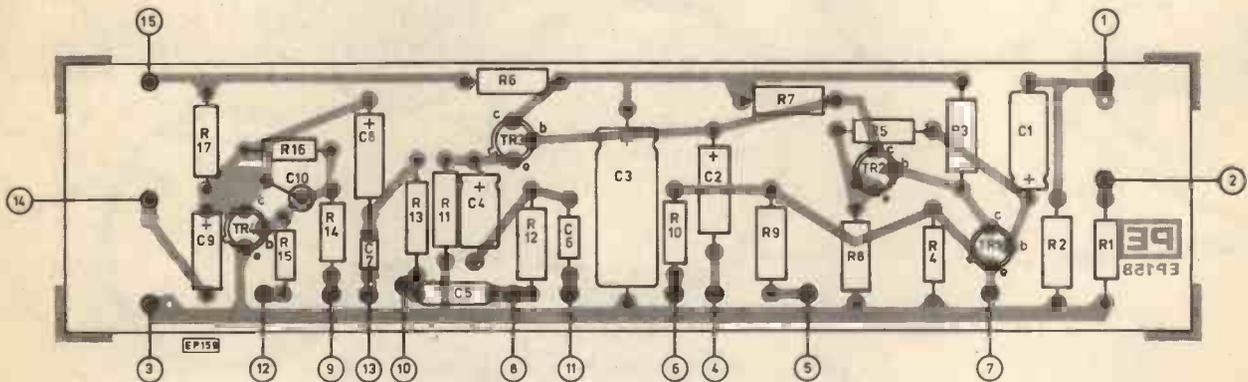


Fig. 11. Component layout for input amplifiers

The p.c.b. and component layout for the input channels is shown actual size in Fig. 10 and Fig. 11.

All the other circuits were constructed on Veroboard of 0.1in. matrix. The headphone amplifiers, output amplifiers, overload indicator, VU meter drive amplifiers and echo send amplifier and test oscillator were all built on one piece of Veroboard. The layout and track cutting diagram for this is given in Fig. 12. The power supply is built on a separate Veroboard as shown in Fig. 13.

The connections for the p.c.b. controls and gain switches on the input channels are shown in Fig. 16. The switching arrangement for pfl function switches is shown in Fig. 15.

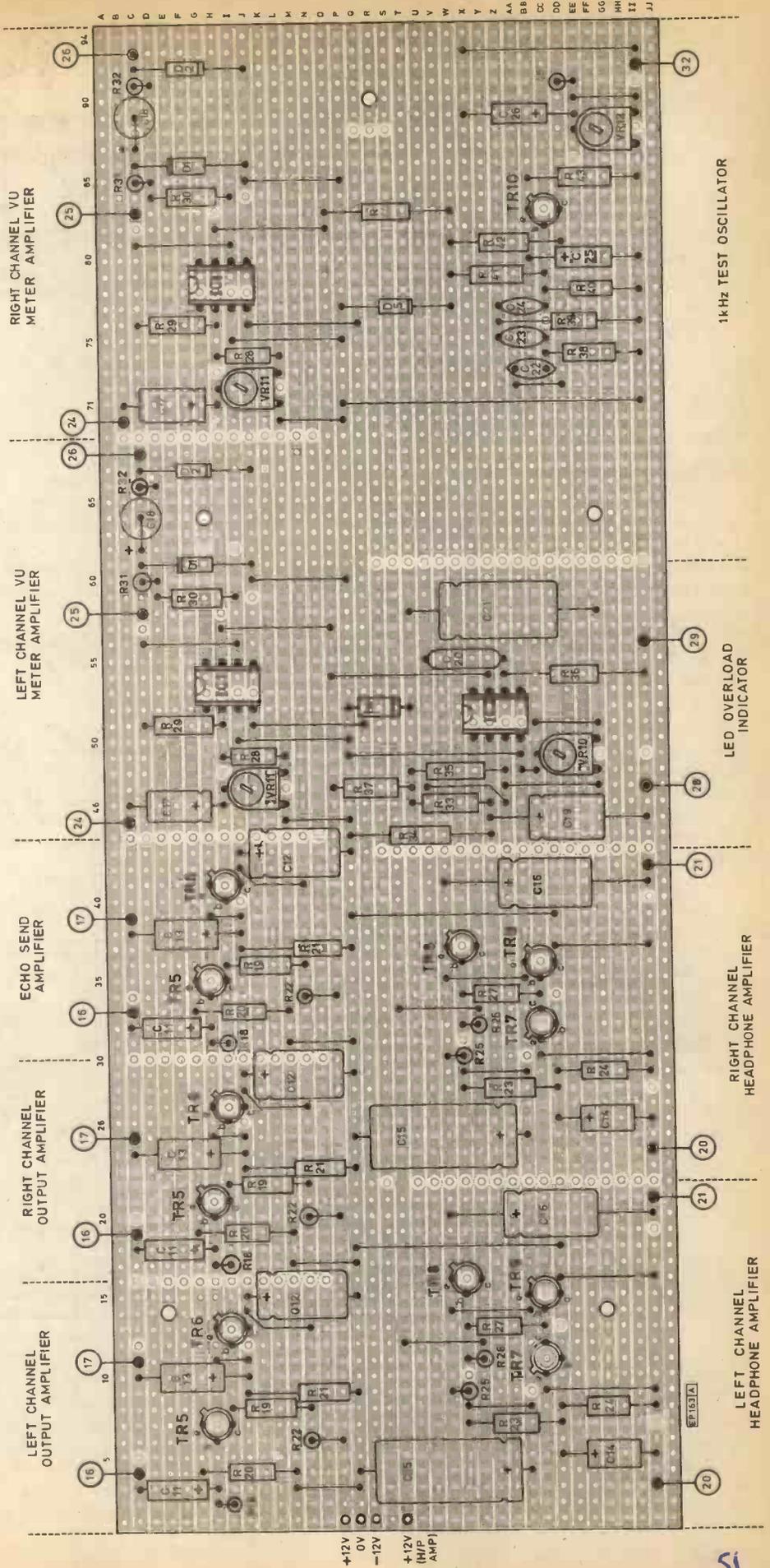
short. The transformer and power supply should be mounted as far away from the input channel boards as possible.

The input channel boards are mounted on their long edge, which leaves the connection pins accessible. They are held in position by use of a piece of slotted plastic which is sprung, the springs being attached to two pots by solder tags (or brackets).

The output boards can be mounted on the base panel of the mixer and wires run from the miniature looms bound with "Spirowrap" or similar.

A control panel cut-out guide is shown in Fig. 14. The control panel was made from 14 s.w.g aluminium which

Fig. 12. Main board that includes headphone amplifiers, output amplifiers, overload indicator, VU meter amplifier and test oscillator. This should be attached to the bottom panel as shown in the prototype layout in Part 1



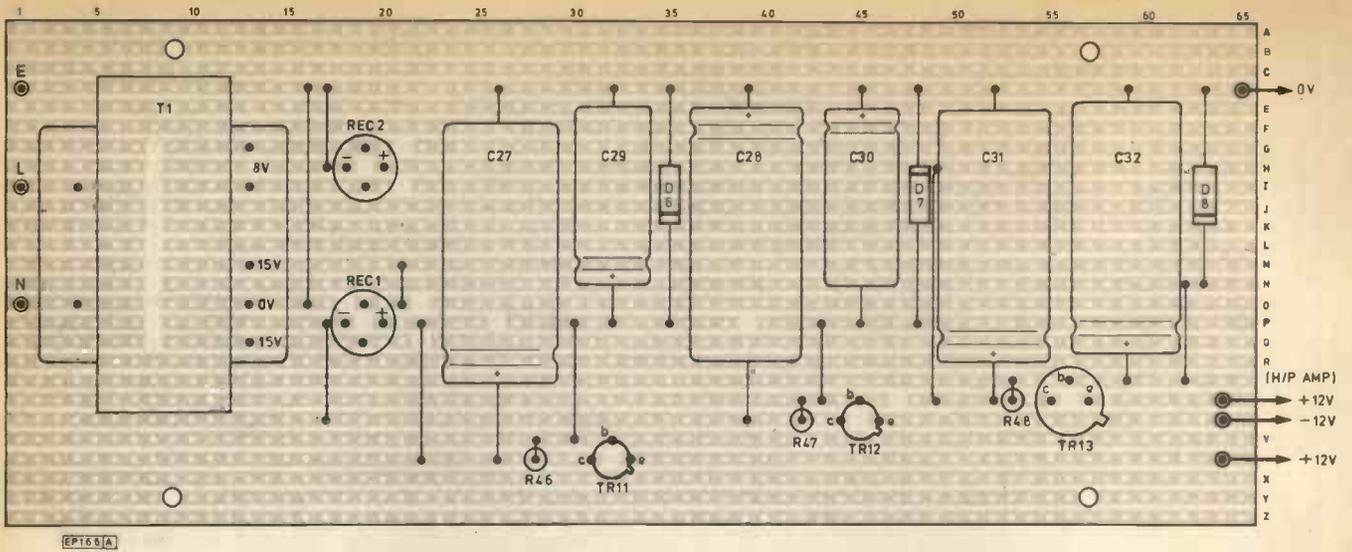


Fig. 13. P.s.u. board

provides adequate support and is easy to drill and file. Some hole sizes are omitted as these are to suit parts which are available to the constructor. These panel cut dimensions will need to be larger if slider pots are used on the input channel faders. The front was sprayed black (matt) and lettered with Letraset or similar and then given several coats of protective lacquer.

No details are given of the front and back panel drilling details, as these are to suit the input and output sockets used by the constructor. The front and back panels were made from 12 s.w.g. aluminium and attached to the side panels ($\frac{1}{2}$ in. solid teak) by $\frac{1}{2}$ in. angled aluminium.

A colour coding was adopted for the control knobs as follows:

- | | |
|---------------------------------|----------|
| Impedance and gain selector | — white |
| Pan control | — yellow |
| Bass control | — blue |
| Treble control | — red |
| Input channel echo send control | — green |
| Echo send master control | — black |
| Echo return master control | — black |
| Headphone volume control | — black |

These knobs were black with coloured inserts and for a contrast the channel faders used a different style of knobs, and the slider pots used the most readily available knobs.

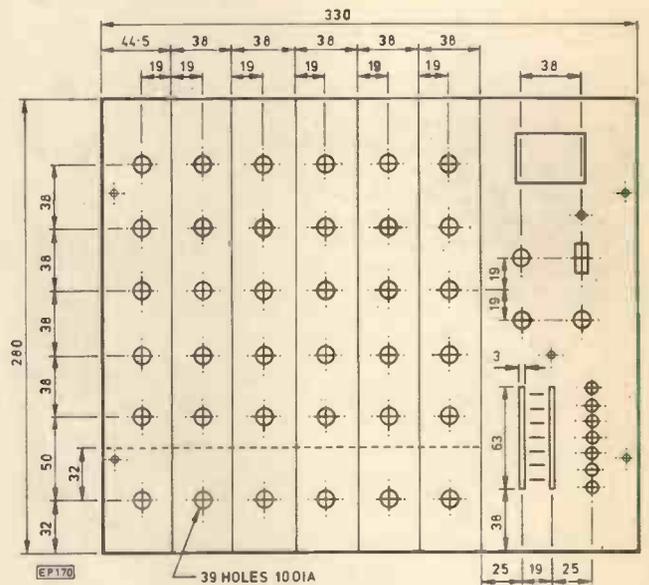


Fig. 14. Panel cut-out guide

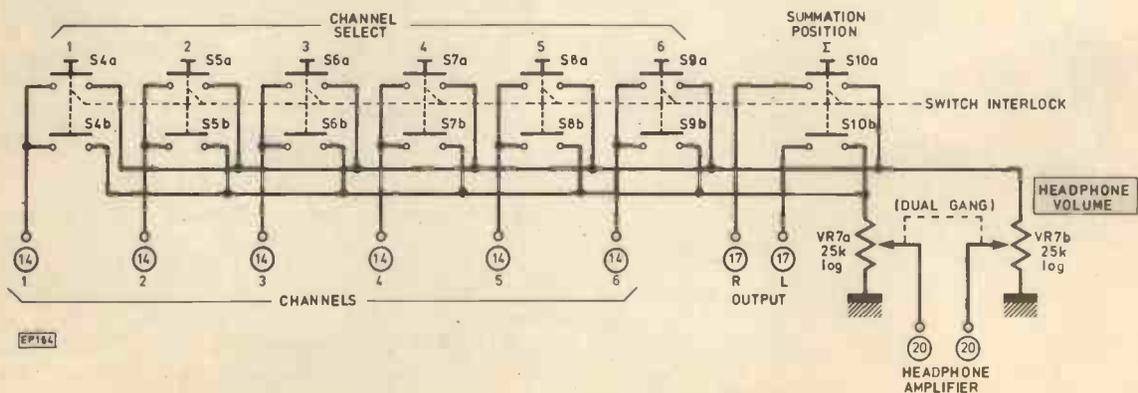


Fig. 15. Circuit for p.f.i. interlocking push switches

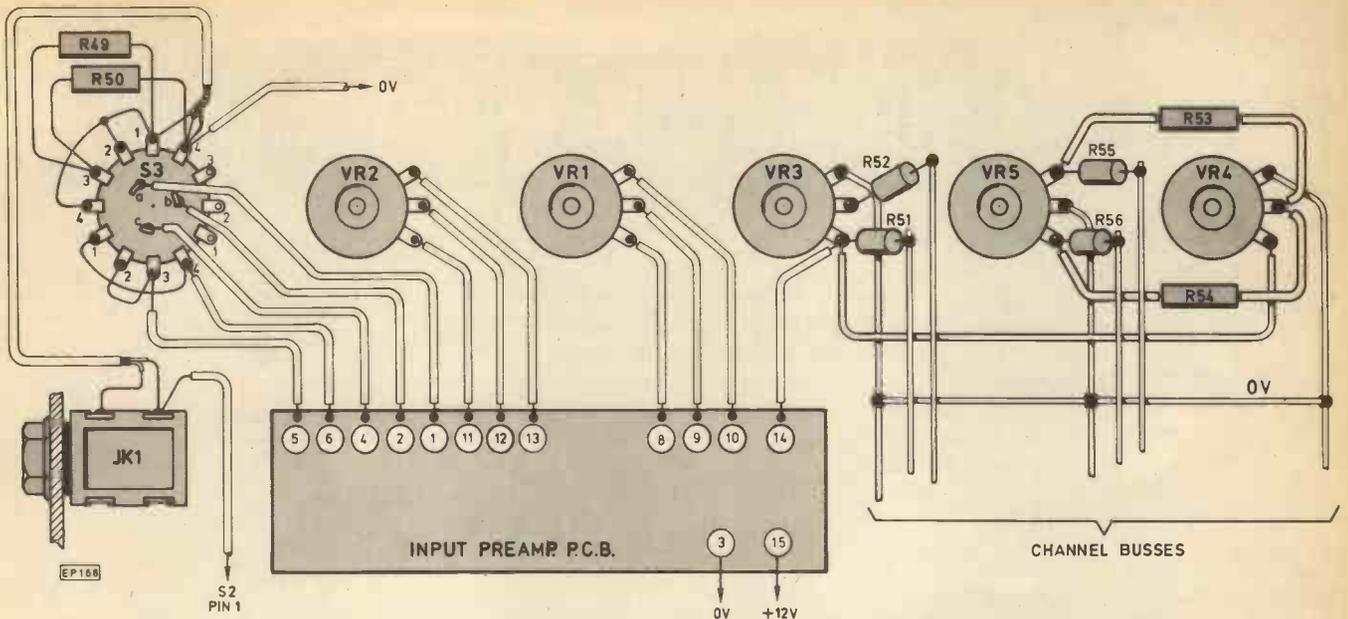
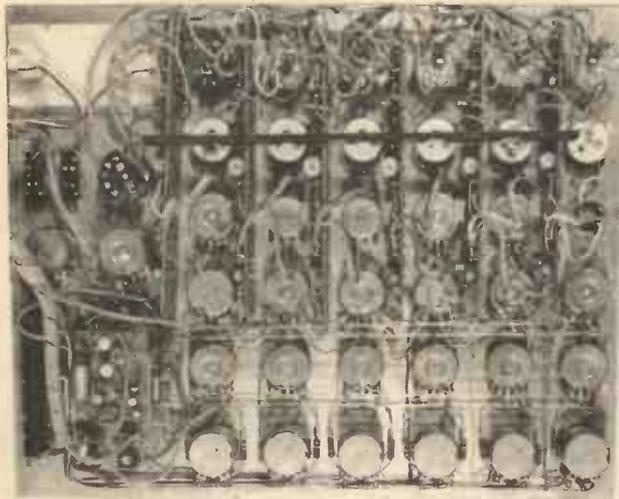


Fig. 16. Single channel control wiring to input amplifier



(Above) Prototype control panel layout. In the modified design the limiter switch is excluded. (Below) Headphone outlet is on the front panel with inputs to the rear

SETTING UP

1 KHz oscillator

The only adjustment required on this is that the output level on pin 32 should be set to 10mV. This should be done using an a.c. millivoltmeter or an oscilloscope, by adjustment of VR12. If an oscilloscope is available the shape of the sine wave can be seen, and should be observed to be fairly pure (distortion less than 10 per cent).

L.e.d. overload indicator

To set this circuit up an a.c. signal of 12mV peak-to-peak should be applied to one of the input amplifiers. The gain of this amplifier should then be set to 100 (using S3) and the output should measure 1.2V peak-to-peak, if this is not the case adjust the input signal level until it does. The preset pot on the overload indicator (VR10) should then be adjusted so that the l.e.d. just lights. This calibration will then suffice for all input channels.

VU meters

To calibrate these a signal from the 1kHz oscillator should be applied to one of the input channels via test selector switch and the gain adjusted to 100 and impedance 50 kilohms. The pan control on that channel should then be moved fully over to the left and the left master fader should be adjusted until the left output reads 1V r.m.s. on an a.c. millivoltmeter or oscilloscope. The calibration pot (VR11) on the VU meter amp should then be adjusted so that the meter reads 0dB. The procedure is then carried out for the right hand channel but with the pan pot fully over to the right.

All circuits should function first time in the mixer, with wide component tolerances, unless there has been a component failure or a mistake in the wiring. Care should be taken to select the correct input impedance and sensitivity (600 ohm input impedance is useful when using long microphone cables) but any overload of signal should be indicated by the overload indicator. The headphone monitoring facility provides useful quiet listening but can be routed to an external amplifier and speakers via an attenuator.





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ERROR CODES

IF DURING the execution of a program, the computer encounters a word it does not understand, or is asked to perform an impossible calculation, it *may* detect an error of a recognisable type and so inform the user. Some errors are undetectable and simply produce wrong answers or bizarre behaviour. If it does recognise a *standard* error, it will print up one of the standard error codes listed in the table.

This *self-checking* activity makes computer programs easier to debug, but there are pitfalls, because sometimes, though an error of a particular type has been flagged, it may be the consequence of a more subtle error elsewhere in the program. Experience is the only answer!

Table 3.1. ERROR CODES

Code	Definition
O /	Double dimension: variable dimensioned twice. Remember subscripted variables default to Dim. 10.
F /	Function call error: parameter passed to function out of range.
I /	Illegal direct: INPUT cannot be used in immediate mode.
N \	NEXT without FOR.
O /	Out of data: more READs than DATA.
O 7	Out of memory: program too big or too many nested GOSUBs, FOR NEXT loops or variables.
O ⚡	Overflow: result of calculation too large for BASIC.
S J	Syntax error: typing mistakes etc.
R \	RETURN without GOSUB.
U ✓	Undefined statement: attempt to jump to non-existent line-number.
/ Δ	Division by zero.
C J	CONTINUE errors: inappropriate attempt to CONT after BREAK or STOP.
L ✓	LONG string: string longer than 255 characters.
O ✓	Out of string space: same as O7.
S S	String temporaries: string expression too complex.
T 7	Type mismatch: string variable mismatched to numeric variable.
U \	Undefined function.

EDITING

The program may be edited by writing further lines or rewriting existing ones.

Try typing the following (to be added to last program):

15 PRINT "BYE"

Typing LIST will insert this new statement between lines 10 and 20. Similarly, typing:

10 PRINT "THIS"

will *overwrite* line 10. Typing 10 followed only by RETURN will simply wipe out line 10 altogether. If a mistake is made in typing a character, it may be deleted by pressing the RUB OUT key, which if pressed several times will delete that number of previous characters. Try the following correction:

PRINT "HELLL (press RUB OUT) O"

The third L will be deleted and the VDU will show:

HELLO

The entire current line being typed may be deleted *before* RETURN is pressed, by pressing (SHIFT) P, which displays an @ sign and places the cursor on the next line to await further instructions.

USE OF CASSETTE

Check that pin 10 of J2 is connected to the earphone output, and pin 9 (or 7) to the auxiliary or microphone input, and pin 8 and/or 11 to the Earth of the cassette machine. Any ordinary cassette recorder should be suitable, but the very cheapest cassette *tapes* are prone to giving continual errors. The best volume setting is found by trial and error for playback. Recording may be on automatic level or manual. A machine having a tape counter is preferable.

PLAYING BACK A PROGRAM

(a) Rewind tape to "leader" or blank area before program starts.

(b) Place computer in command mode and type NEW (and RETURN).

(c) Type LOAD but *do not* press RETURN, to avoid spurious "noise" being interpreted as data and loaded to the computer.

(d) Switch recorder to PLAY.

(e) Wait for a second or two—or for the "leader" to pass through, then press RETURN.

Some random noise characters may still be printed on the screen, and if one of these is a number, it could be interpreted as a program line. However, without this unlikely event the program is printed on the screen line by line. When playback is complete, pressing SPACE and then RETURN returns the machine to BASIC and the new program is resident for listing or running.

RECORDING A PROGRAM

This assumes a BASIC program is stored in the Computer ready for saving on cassette.

- (a) Rewind tape to blank noise-free portion of tape.
- (b) Type SAVE (RETURN).
- (c) Type LIST but do not RETURN.
- (d) Switch cassette to RECORD and allow "leader" to pass, plus a further 5 seconds to allow settling to constant speed, then press RETURN. The program will list on the screen as it is being recorded.
- (e) When recording is complete, wait a few seconds, turn off tape recorder and type LOAD (press RETURN), then press SPACE and RETURN.

USING THE MACHINE IN BASIC

After
OK

appears, the machine is said to be in the Command Mode. At this point, two types of data may be entered, *always terminated by pressing RETURN*.

- (i) COMMANDS
- (ii) BASIC Statements

These are described below:

N.B.

Spaces are always ignored in Commands and BASIC Statements (except in *literals* and *string* arguments).

If you make a typing error, press RUB OUT.

(1) COMMANDS

CLEAR This causes all variables (numeric or string) to be set to zero (or null)

LIST This can be used in several forms as detailed below:

LIST Causes the whole stored BASIC program to be listed line by line until either the listing is complete or CONTROL C is pressed.

LIST n Will list that line only

LIST n- Will list all lines from n to the end of the program

LIST -n Will list all lines up to n

LIST n-m Will list from line n to line m. This allows any part of a program to be viewed at will

NULL n Inserts n null before sending data to serial I/O devices

RUN Starts program execution from the first line with all variables cleared

RUN n As above but starts program at line n

NEW Wipes out current program

CONT Continues execution of program after Control C, or after a STOP statement encountered within the program

LOAD
SAVE } Cassette commands dealt with elsewhere

CONTROL C

This is effected by pressing the "CTRL" key, and (with CTRL pressed) typing a "C". It suspends Computer activity and prints a message to give the line number at which the break occurred. The Computer then returns to COMMAND MODE. Many BASIC Statements may also be used as commands if unaccompanied by a line number—for instance:

GOTO n

would cause the Computer to begin executing from line number n without clearing all the variables. Similarly, many of the above may be used in programs—thereby causing a program to command the machine.

(ii) BASIC Statements

There are two modes of use of the BASIC language when using an *interpreter* such as this. These will be called:

- (a) Immediate Mode
- (b) File Mode.

IMMEDIATE MODE

If a BASIC statement is typed while in the Command mode, it is executed immediately a RETURN is encountered, and lost after execution. In this mode the Compukit, with its fast powerful floating-point calculation ability is able to act as a super calculator. For instance, answers to such calculations as:

$$X = \frac{15.7 \times 13^{\sin(0.781)}}{87 \times 10^4}$$

are found immediately. In this case, the user would type:

PRINT 15.7 * 13 ↑ SIN (0.781)/87E4

to get the answer:

1.09796E-04

The immediate-mode use of the machine allows instant indication of remaining program space, by typing:

PRINT FRE (N)

The answer (after RESET) on an 8K machine should be 7420.

An important use of this mode is for program debugging. The last values of the variables are retained when a program stops. Type:

PRINT A, B, C, etc.

where A, B, C are the variables whose values are required. Quite complex immediate-mode programming may be written by employing colons to separate the various statements. In order to write and *retain* a program, the File Mode must be employed.

FILE MODE

To retain a program line for *later* execution, a line number must precede the instructions.

This numbered program line must not be confused with a display line. The computer accepts a maximum of 71 characters on a program line, and depending upon the Terminal Width set up after a system reset, the program line may occupy up to around four and a half lines of VDU display (if terminal width is 16).

Table 3.2. COMPUKIT MEMORY MAP

0000—00FF	Page Zero
0100—01FF	Stack
0130	NMI Vector
01C0	IRQ Vector
0200—0221	BASIC Flags & Vectors
0203	LOAD Flag
0205	SAVE Flag
0218	Input Vector
021A	Output Vector
021C	Control C Check Vector
021E	Load Vector
0220	Save Vector
0222—02FA	Unused
0300 end of RAM	BASIC Workspace
A000—BFFF	BASIC-in-ROM
D000—D3FF	Video RAM
DF00	Polled Keyboard
F000—F001	ACIA Serial Cassette Port
F800—FBFF	ROM
FC00—FCFF	ROM—Floppy Bootstrap
FD00—FDFF	ROM—Polled Keyboard Input Routine
FE00—FEFF	ROM—65V Monitor
FF00—FFFF	ROM—BASIC Support
FFFA	NMI Vector
FFFC	Reset Vector
FFFE	IRQ Vector

MACHINE CODE MONITOR

The machine code monitor program provides a simple but adequate method of loading and running machine code routines, including loading from cassette. To prevent these routines being overwritten by BASIC, MEMORY SIZE? (After RESET) must be answered with a number restricting the BASIC's use of RAM. The number n, thus typed, restricts BASIC according to the following map.

Address in Decimal	Use
0	Page Zero
255	
256	Scratch-pad RAM used by BASIC and system monitor
768	
769	BASIC workspace
n-1	
n	protected against use by BASIC
End of RAM	

It is clear from the above that n must be at least greater than 769. In a 4K machine, the end of RAM occurs at memory location 4095, and 8K finishes at 8191.

After RESET, the machine code monitor is entered by pressing M. The display:

0000 4C

then appears.

The first four characters form the address field, and the second two represent data (all in *hexadecimal* notation). Typing any hex characters at this point will load the address field; the data field is kept constantly updated as the address changes. Mistakes may be corrected by typing further characters, as these will continue to be loaded into the right hand position and then rotated left as further entries are made.

The following commands are available:

- / Changes to data mode to allow data to be loaded. RETURN then opens the next location.
- . Changes back to address mode.
- G (Used after setting up an address with .). This jumps to the address showing on the screen and begins execution.
- L Transfers control to cassette—loading 00FB with 00 transfers control back to the keyboard.

After L, the monitor is in data mode and simply accepts all its commands from cassette instead of the keyboard. Thus the cassette tape must have a series of commands, stored as ASCII codes from BASIC, to control the Monitor. To load a program from cassette, it must be stored byte by byte, separated by RETURNS and ending with:

.00FB/00

This loads 00FB with 00 which is the flag to switch the monitor back to accepting commands from the keyboard. The program can be run from cassette, if desired, by ending with G after setting up the start of the routine in the address field.

The following gives a list of important address locations in the machine code monitor.

Starting address	Effect of jumping to address shown
FE00	Restart location. Ending machine-code programs with a jump to this location has the same effect as pressing M after D/C/W/M?
FE0C	Bypasses UART and Stack Pointer initialisation as well as clearing decimal mode, but still clears screen.
FE43	Enters directly into address mode. Bypasses initialisation and screen clearing.
FE77	As last, but for data mode.

The following are *subroutines* which may be of use in user programs.

Starting address	Effect of jumping to subroutine
FE80	Inputs an ASCII character from the cassette UART.
FE93	Returns stripped ASCII number if 0-9 or A-F otherwise returns FF.
FEED	Inputs an ASCII character from the keyboard.

To test the machine-code monitor, the message program used to illustrate USR (last month) may be adapted as follows.

Place the monitor in address mode either by pressing RESET followed by M, or by pressing *full stop* if already in the monitor. Enter the characters 0500 followed by / to access data. Type in the following pairs of digits—each pair separated by pressing RETURN.

```
A2 00 BD 00 06 C9 5F F0
07 9D E5 D1 E8 18 90 F2
4C 43 FE
```

This ends with a jump to location FE43 which places the monitor in address mode after the message has been displayed, thus preventing the clear screen routine in the monitor from erasing the message immediately after its appearance.

The following pairs of hex digits are ASCII codes for the characters of the message. The list may be of any length but must start at 0600 and end with the pair 5F.

Press *full stop* and the n type 0600 followed by / and the following pairs separated by RETURNS:

```
43 4F 4D 50 55 4B 49 54 5F
```

To run the program, type

.0500G

This will display the message for which the ASCII codes are given above, and leave the machine code monitor in address mode for further use. Memory size need not be specified unless BASIC is to be entered and the above protected against being overwritten.

GRAPHICS

Character resolution graphics are used by the CompuKit whereby 255 different graphic characters are available to fill any given character slot. To view the available characters, the BASIC function CHR\$ may be used by typing, for example:

PRINT CHR\$(24)

followed by pressing RETURN. This causes a £ sign to be

printed. Each number between 1 and 255 inclusive, corresponds to a character, as 24 does to £. (0 corresponds to a null character).

Two of these numbers correspond to *non-printing* commands for the print head (whose position is continuously shown by the cursor).

PRINT CHR\$(10)

causes a line-feed, i.e. the cursor jumps to the next line and the screen scrolls upwards.

PRINT CHR\$(13)

causes a carriage return.

The rest of the numbers correspond to ASCII characters, special characters and graphic characters.

The ASCII characters start at 32 (SPACE) and finish at 127. These are all accessible from the keyboard. The uppercase is set with SHIFT-LOCK down, and lower case with SHIFT-LOCK up.

The other characters are inaccessible from the keyboard directly, and they must be printed using CHR\$(I). These general graphic characters are best seen by writing a program to print them on the screen. This will be given later.

The following is a list of special (as distinct from *graphic*) characters, with their corresponding numbers:

number	character	number	character
0	null	244	δ
10	line-feed	245	ψ
13	carriage-return	246	Ω
24	£	247	μ
32	Space	248	π
179	⇒	249	ε
180	⇐	250	λ
211	✓	251	φ
212	∫	252	β
241	α	253	ε
242	β	254	γ
243	ω	255	χ

In order to select a particular graphic character, a list of those available may be displayed on the screen with corresponding number next to each one. The following program achieves this by allowing the user to specify which block of characters are to be displayed; there are too many to appear at once! The instructions for the program are as follows.

The program is loaded and run. The words:

WHICH BLOCK?

appear. Answer with a number between 1 and 4 inclusive followed by a RETURN. The numbers 1 and 2 display the graphic characters available, 3 shows the special characters already shown, and 4 displays the ASCII set.

To exit the program, just press RETURN instead of a number.

The line numbers chosen for the program put it well above any other program you may be working on. If the program under development ends with an END, then the following program will never be entered by the command RUN, and so RUN 10000 will be necessary. This allows the graphic program to remain in memory as a reference for use as necessary. It will be lost if NEW is typed or if RESET is pressed followed by C.

The Program Listing

(Spaces may be omitted, and PRINT may be typed as ?)

```

10000 INPUT "WHICH BLOCK"; B : B = FL = 0
10010 IF B = 1 THEN S = 1 : F = 31 : GOTO 10060
10020 IF B = 2 THEN S = 128 : F = 219 : GOTO 10070
10030 IF B = 3 THEN S = 220 : F = 255 : GOTO 10060
10040 IF B = 4 THEN S = 32 : F = 127 : GOTO 10070
10050 GOTO 10000
10060 FL = -1
10070 FOR I = S TO F
10080 IF I = 10 OR I = 13 THEN GOTO 10110
10090 PRINT I; CHR$(I); : H = I + 3
10100 IF INT(H/7) = H/7 THEN PRINT : IF FL THEN PRINT
10110 NEXT
10120 PRINT
10130 GOTO 10000
  
```

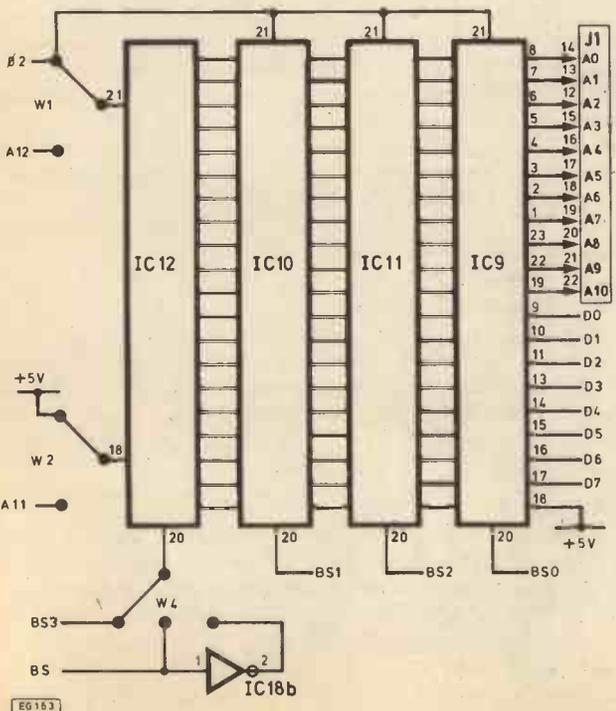
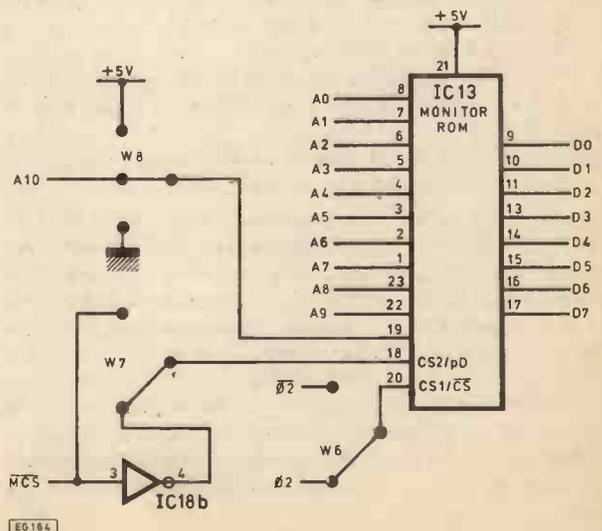


Fig. 3.1 (left). BASIC ROMs

Fig. 3.2 (below). Monitor ROM



When Block 2 is requested, some of the vertically adjacent symbols run into each other. Use CHR\$ in the immediate mode to inspect individual characters, e.g. :

PRINT CHR\$(161)

reveals that this character fills the entire character slot.

The fact that characters run into each other in this manner allows the user to build up quite complex graphic patterns as well as graphs and bar-charts, etc. The user may find it useful to store the above program on cassette tape for future reference.

HARDWARE—BINARY COUNTING CHAINS

The clocking requirements for the system are supplied by the crystal oscillator and binary counting chains (see Fig. 2.5). Two gates of IC58, plus X1, form an 8MHz oscillator buffered by a further gate in IC58, and divided by 8 (IC29, which has a spare $\div 2$). Before IC29's $\div 8$ function, the CLK line feeds the Dot clock of the VDU with 8MHz. This governs the length of time available for displaying one of the dots of a character on the TV screen. Given the speed with which the electron beam strobos across the screen and the Dot time, the width of a dot may be calculated. A frequency of 8MHz gives a dot size sufficiently small to fit about 48 characters across the screen (each 8 dots wide), while of low enough frequency to pass easily through the UHF modulator and IF stages of a TV set.

The D output of IC29 (at 1MHz) then feeds the ϕ in line of the MPU, the C0 line of the VDU, and the counting chain of 74163's (or 74161's) IC59-61 and IC30. The constraints on the counting chain are that it must produce ripple-count outputs for C1-C6 in between line-sync pulses separated by 64 μ s. Note: $2^6 =$ maximum of 64 characters per line. There must be three outputs (C8-C10) for the row inputs to the character generator, and a further four outputs (C11-C14) for the 16 horizontal lines of characters. The entire picture must then be repeated at 50 times a second with a suitable frame-sync pulse. The final count output from the bottom of the chain is then inverted, and fed to load the chain elements.

Capacitor C3 is used to set the BAUD rate for the Cassette and serial interface via a further counter, IC57, and some decoding logic IC63 and IC58.

THE VDU

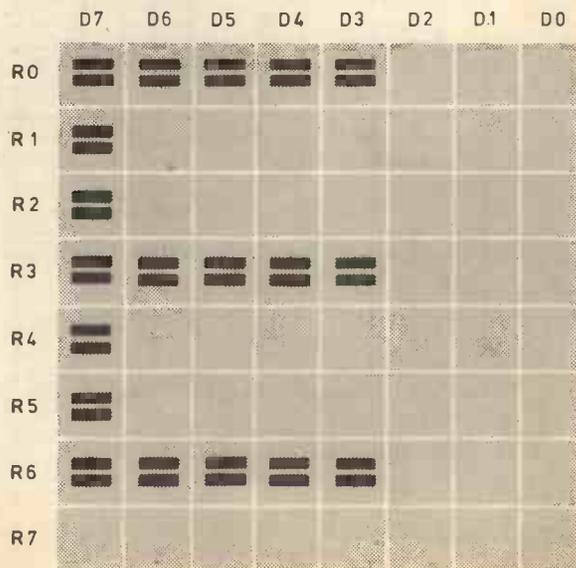
The block diagram of Fig. 1.2 shows the basic parts of the VDU and the circuit diagram (Fig. 2.2) gives the details referred to below.

The VDU RAM holds a screen full of characters (1024 in all). Through IC53-IC55 the RAM address lines (VA0-VA9) are either fed from the counter chain, or the MPU Address Bus, depending upon the state of \overline{VA} (VDU Access). When \overline{VA} is at "1", C1-C6 and C11-C14 are connected through to VA0-VA9, and when \overline{VA} is at "0", the MPU busses have direct Read/Write access to the VDU RAM. Reading or writing of data is controlled by the bi-directional buffers IC24 and IC25, which also disconnect the VDU RAM from the MPU Data Bus when the counter chain is supplying addresses to VA0-VA9. Thus when \overline{VA} is in the zero state, the VDU RAM acts just like any other block of Read/Write memory, here based at location address D000 hex. This allows the screen to be read or written to during a program. With \overline{VA} at "1", the ten VDU RAM addresses are derived from the counters sequentially. The RAM is in the READ condition when not selected by the MPU, and the contents of the RAM locations are sent to the character generator for interpretation into bit patterns forming characters on the screen

Each character in the Character Generator (IC41) is stored as an 8 x 8 matrix of white and black dots. White is stored as a "1". The characters appear on the outputs of IC41 (D0-D7) one row at a time, see Fig. 3.3. Here an "E" is being displayed on one of the 16 lines of text on the TV screen. C8, C9 and C10 from the counter chain determine which row (R0-R7) is being output at any time. The sequence of events is as follows: C1-C6, C11-C14 contain an address of a location in VDU RAM and hence of a character on the screen. The contents of this location (8 bits in parallel) are fed to IC41 which then parallel outputs the 1's and 0's (white and black dots) of one row of the character along D7-D0. Here, five 1's and three 0's are output to form the top row of the "E". IC42 serialises this parallel information at 8MHz, and sends it out in a stream to IC70 to be mixed with TV sync. information, etc. displayed along a TV line as the electron beam strobos across the screen. This takes 1 μ s, and each successive 1 μ s sees IC42 loaded with another character-row for the same treatment. Note: LD is fed from C0 to 1MHz via a monostable (half of IC71) to give a short negative going pulse, and CLK is at 8MHz. This is the Dot clock, so named because each cycle displays one of the 8 dots of a character on the screen. After the top row of the "E" has been displayed, the top row of the next character on that line must be fetched. Again, C8, C9, C10 will not change, but C1-C6 will, hence selecting the next VDU RAM location, and so on until C1-C6 have displayed one row of 64 characters. Some of these are lost at the end of the line, as the Dot clock is only at 8MHz. When C1-C6 have finished rippling through, C7 changes and the whole is repeated. C6 synchronises the TV line (at 64 μ s intervals) and thus starts a new line via IC65 on its downward edge. C7 is not used in the process and thus C1-C6 must count through twice before C8, 9, 10 increment to a new row of the character; this causes each row of dots to occupy two TV lines as shown in Fig. 3.3.

As C8, 9, 10 increment, the complete set of 16 TV lines builds up a row of text. The next step is to increment C11-C14 to address the next row of characters stored in the VDU RAM. The complete frame of 256 TV lines is built up as C1-C14 count through. Normally, in TV transmissions, another frame slightly different from this, is interlaced in the

Fig. 3.3 Dot structure of an ASCII Character on the VDU screen



spaces between the lines of the first frame. Also, each half frame is composed of more lines. Here, C15, via IC71, provides a frame-sync. pulse to the TV, and the above process repeats exactly—each line occupying its previous position. The resolution thus obtained is not as high as a normal TV picture, but is more than adequate for 16 lines of VDU information.

The frame-sync. is delayed by half of IC65 to allow the TV picture to be moved up the screen, and hence prevent the bottom left character from being lost. This is the most important character slot on the screen and must be displayed clearly. The value of R33 and C8 may be adjusted to ensure its readability on any TV.

About 48 characters are able to be displayed on a normal TV, and hence about 16 characters are lost from the edges of the screen. At least 5 are missing from the start of the line and the rest from the end. The software of the COMPUKIT thus uses just those slots from the 6th to the 54th to prevent loss of information. The others are available to the user, however, and may be forced into display by adjusting a TV or monitor to "underscan". The RAM locations are still perfectly valid and may be used as normal.

A note about graphics should be made at this point. Since an 8 x 8 matrix of dots is used for characters in general and only a 7 x 5 matrix is used for the ASCII characters, spaces of varying sizes are left between text characters, both horizontally and vertically. However, the COMPUKIT's character generator is very rich in blocks, lines and special patterns which use the full 8 x 8 array of dots. By this means, adjacent graphic characters may be chosen to run into each other, and graphs, large patterns, block diagrams, etc. may all be constructed from basic components. Also, some extra characters are included such as £, π, ♦ etc. for a very full variety of uses.

ADDRESS DECODING AND MEMORY

Address decoding is performed via 74138's and 74139's with some extra gating. The address map defines the operation of this block and it is described here in full electrical detail. A TTL data book will provide all the information necessary to understand how this block works. RS0–RS7 are *selects* for the RAM (8 blocks of 1K, each

comprising two 2114's). BSO–BS3 select the BASIC ROMs, and MCS selects the monitor ROM. ACS selects the ACIA for the cassette. RKB and WKB are Read and Write selects for the keyboard and WVE and RVE for the VDU.

The RAMs are addressed so that IC31 and IC45 are at the lowest addresses and hence form the first 1K block of RAM (based at 0000). Addresses increase from right to left in pairs (the 2114 being arranged as 1K by four bits), IC32 and IC42 are next and so on. The ROMs are arranged to allow other options. When the 64K bit ROM is available, the four BASIC ROMs may occupy one package. A11 and

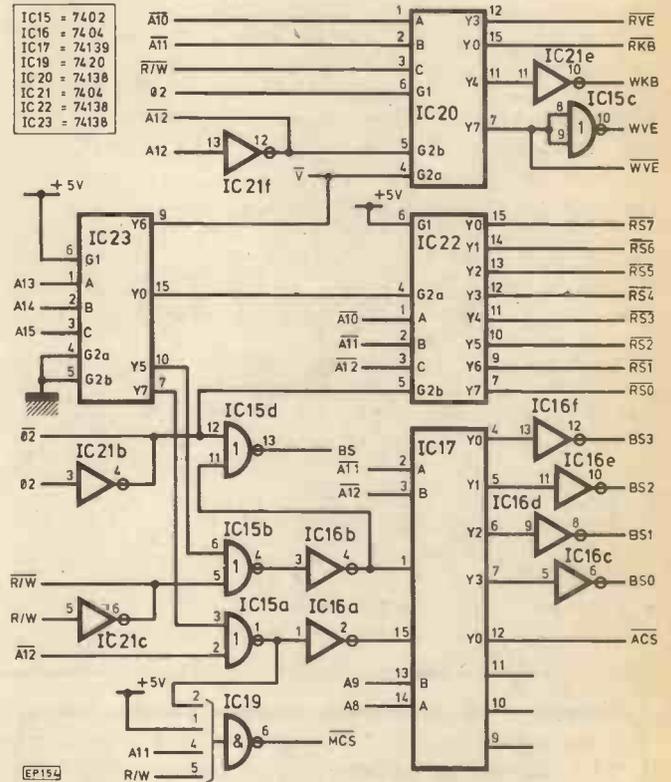


Fig. 3.5 (above). Address decoding

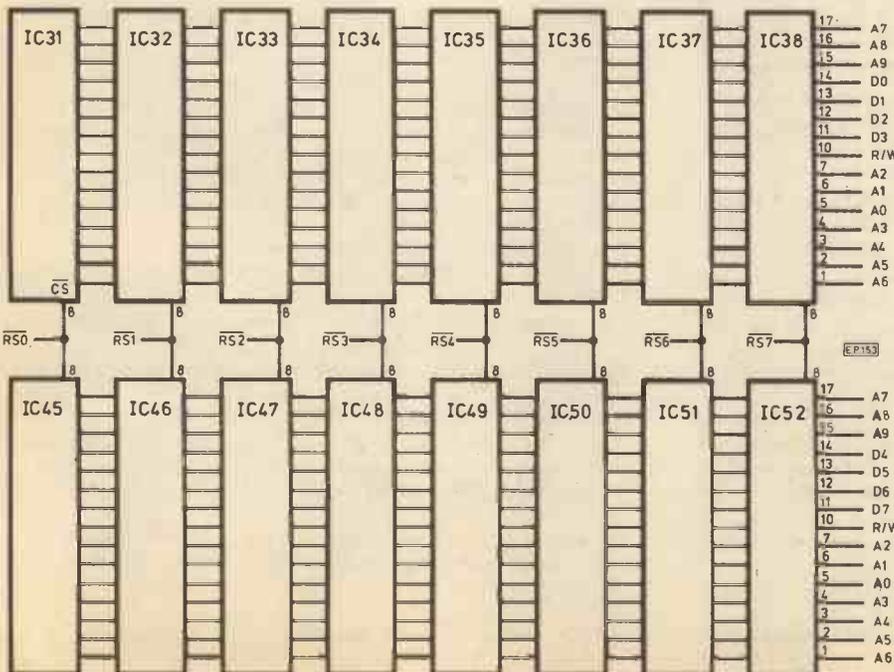


Fig. 3.4 (left). RAM configuration for 8K bytes

A12 will be needed and an address decoded line to select it. This already exists on the COMPUKIT; BS supplying the necessary address decoding. W1, W2 and W4 are pads next to the ROMs bringing these lines in. When this option is available, there will be three spaces free for ROMs or EPROMs of the user's choice. The COMPUKIT even allows for an active high or low BS line via IC18.

The Monitor ROM also has some flexibility in packaging and this is catered for, as shown.

PROCESSOR AND EXPANSION SOCKET J1

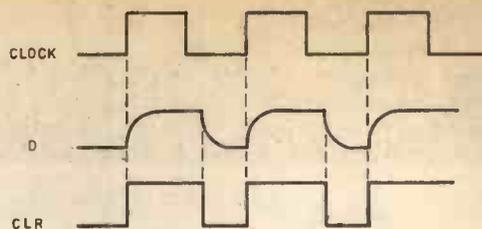
The processor is shown (Fig. 2.4) feeding all the Busses and control lines internally as well as externally, via J1, whose data lines are fully buffered by IC6 and IC7. External devices decide the direction of data flow through these buffers by DD. This socket allows any external logic to overtake the MPU system via interrupts and can easily be extended to control anything. External memory may be added via the socket; disc storage, S100 Bus expansions, etc. may all be plugged in directly.

SERIAL AND CASSETTE INTERFACE

The serial interface is controlled by IC14 (ACIA). This is primarily to drive a cassette interface. However, sockets and pads are provided for extra components to allow the ACIA to drive an RS232 interface if required. This will not be described here but is shown in the diagram.

The ACIA receives its clock from C3 of the counting chain via IC57, IC63 and IC58. Options exist, as shown, to separate the Tx and Rx clocks. In addition, driving the clock from C2, C1 or C0 will increase and BAUD rate from 300 by a factor of 2, 4 or 8 respectively.

The ACIA's Tx and Rx data lines are fed to the cassette interface as shown. The transmitter uses a 7476 (IC64) to present a high or low tone to the recorder as a "1" or "0" to be recorded. This follows the usual Kansas City recording format.



EO 178

Fig. 3.6 Timing diagram

Receiving depends upon the time-constant of a monostable. IC66 and IC62 are used to convert the sine-wave input, from cassette, to a square-wave suitable for the monostable IC69, and the clock input of a D-type flip-flop (IC63). While the tone is high, the 74123's time-constant is set such that the Q-output has no time to reset to zero before the next positive edge at B forces it high again. D and CLR of IC63 thus remain high, as Q does, and Rx DATA presents a constant "1". When a low tone arrives, the cycles arriving at B are long enough to allow Q to reset, after its positive-going timing pulse, before B encounters a further positive-going edge forcing Q high again. This gives the timing diagram shown in Fig. 3.6 for IC63.

The leading edge of D is slowed by R62 and C55. The zero on CLR now sets Q to zero and, because D's rising edge is slowed down, IC63 sees a zero on D when the clock goes high, thus preserving the zero on Q, and hence the circuit decodes a constant zero for as long as the low tone continues.

This sort of circuit is quite reliable at 300 BAUD and any instability will be due either to a large variation in tape speed, or to the value of R53 and C11 having been incorrectly chosen, thus allowing the negative-going edge on D to arrive too soon.

NEXT MONTH: Conclusion of series

Countdown

Organisers: Please send details of exhibitions and other events to Mike Abbott at least six weeks in advance. Inclusion will be subject to space etc.

Racalex '79—October 2-4. Royal Lancaster Hotel, London. Details: Racial Electronics Ltd., Western Road, Bracknell, Berks. RG12 1RG.

Eltro Hobby '79—October 3-7, Killesberg Exhibition Grounds, Stuttgart. Details: 01-236 0911.

Internecon UK '79—October 16-18. Metropole, Brighton.

Retailing in the 80's—Automation for Profit—October 23, 24, 1979. International Press Centre, London. Conference taking a broad view of the relationship between the retail manager and computer. Details: Online Conferences Ltd. Tel: Uxbridge (0895) 39262.

Satellite Communications (conference)—October 30, 31. London Press Centre. Will "tele-conferencing" replace business travel? Who will finance this expanding technology, and how should outer space be shared between the nations? Details: Online Conferences Ltd. Tel: Uxbridge (0895) 39262.

Personal Computer World Show—November 1-3. West Centre Hotel, London.

Compec—November 6-8, 1979. Grand Hall, Olympia, London. Details: Iliffe Promotions Ltd. Tel: 01-261 8437/8.

Professional Viewdata Exhibition '79—November 7 & 8. West Centre Hotel, London.

Technical Innovation In The Service Of The Elderly and Disabled—Markets And Needs (symposium)—November 19-21. Berlin. Details: H. S. Wolff, Clinical Research Centre, Watford Road, Harrow, Middlesex.

Electronics '79—November 20-23. Olympia, London. Details: 021-705 6707.

Breadboard '79—December 4-8. Royal Horticultural Halls, Westminster. Details: Trident International Exhibitions. Tel: 0822 4671.

IEA/Electrex—February 25-29, 1980. National Exhibition Centre, Birmingham. Details: Industrial and Trade Fairs Ltd. Tel: 021-705 6707.

Viewdata '80—March 26-28. Wembley Conference Centre, London. Conference and exhibition. Details: Online Conferences Ltd. Tel: Uxbridge (0895) 39262.

Computer-Aided Design (conference and exhibition)—March 31-April 2, 1980. Metropole, Brighton. Details: Organisers, CAD 80. Tel: 0483-31261.

Communications '80—April 14-18. National Exhibition Centre, Birmingham. Details: ITF Exhibitions. Tel: 021-705 6707.

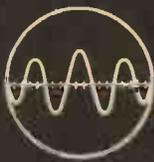
Electronic Test and Measuring Instrumentation—April 22-24, 1980. Wythenshaw Forum, Manchester. Details: Trident.

International Conference On The Electronic Office—April 22-25, 1980. London Penta Hotel. Organised principally by the Institute of Electronic and Radio Engineers, 99 Gower St., London WC1E 6AZ.

All-Electronics Show (1980)—April 29-May 1, Grosvenor House, London. Details: 0799-22612.

The Mersey Micro Show—April 30, May 1, 2, 1980. Adelphi Hotel, Liverpool. Exhibition and seminars, with the cooperation of Liverpool University. Details: Online Conferences Ltd. Tel: Uxbridge (0895) 39262.

IBC 80—September 20-24. Metropole Centre, Brighton, UK. Details: Secretariat, IEE, Savoy Place, London WC2R 0BL.



TUAC

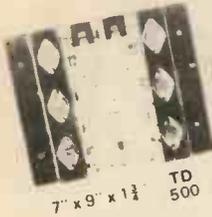
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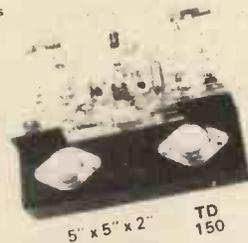
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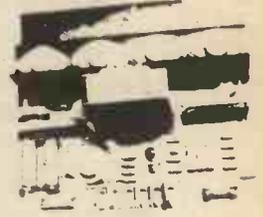
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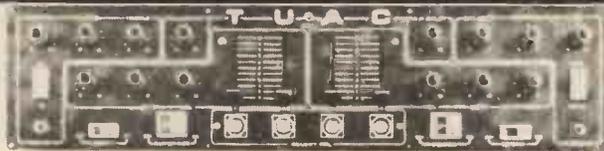
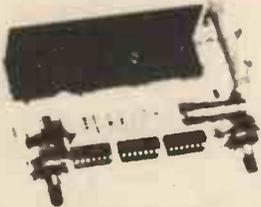
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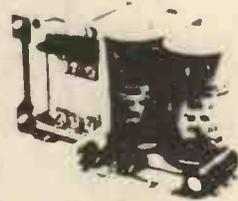
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ONE MAN'S VIEWS ON THE PRESENT SITUATION

IN Holland, despite strong local opposition to Citizens Band Radio, the Dutch Government recently succumbed to public pressure and announced new legislation for the legal introduction of CEPT—22 channel standard in the 27MHz band. The new legislation was announced on January 22 by the media. In the eyes of the users this is a victory of the individual, in the form of public pressure, over the system.

As one can see, this type of problem often arises in the early underground stages of mass illegal use of CB, and has forced governments (Australia and Holland) to accept the fact that the thousands of users just cannot be ignored. The barometer swings from simple observation and monitoring of CB through enforced restriction on use, to eventual capitulation that it is just not feasible to track down or squash all opposition and CB users. So common sense prevailed in Holland, with the introduction of a 27MHz legal band, allowing thousands of users to crawl out of their burrows into the open air and talk, talk, talk.

Until January, the Dutch government had imposed heavy legislation against CB'ers—to the extent that it was possible to be prosecuted for possession. Naturally legalisation has brought out into the open all those underground users, and does pose a dilemma of whether they should be prosecuted for possession (if proved) before the Act was introduced.

The Dutch analogy is very similar to the CB situation in the UK, and I doubt whether anyone is so naive as to think otherwise. One only has to note the numerous reports that appear from the "authorities", quite apart from the many articles that have been appearing in a variety of magazines, and even the public debates over the radio.

ILLEGAL USERS

To ignore the existence of the ever increasing number of illegal CB users in the UK would be plain stupidity—it is a fact of life and as such should be recognised. The public, the press and others are becoming bolder—witness the articles that are appearing on subjects of pirate radio stations and CB rigs.

On a general basis, CB users in the UK could be divided into two groups; either professional, and these are mainly lorry drivers, or non professional—the CB hobbyists. The first group—the drivers—can use CB completely legally when travelling in many parts of Europe (on the 27MHz band) and not only does it alleviate the boredom of a long haul, it can in many instances be beneficial to road users.

CB is not a new thing, it has been particularly well tried and tested in the USA, and is an extremely important factor in improving communications from base or mobile stations in large towns, in the countryside or indeed, anywhere. The arguments for the other side, i.e. those opposed to the idea of legalisation look weak in the light of the fact that 19 countries have already welcomed CB users into their fold.

Sooner or later CB should become legal here, if the percentage of users keeps growing at the present rate, no government will be in a position to track them down or even control the 27MHz band. So basically all the rhetoric and academic discussion will serve no purpose except to delay the inevitable introduction of legislation and prolong interference caused by poor equipment being used illegally.

Once again it seems that the UK will be the last one to have her foot in the door. In the meantime, people will get caught for illegal use and suffer the consequences.

The CB Association's President, Mr. James Bryant sent an open letter to the then Prime Minister—Mr. Callaghan (January 12th) pointing out the rapid growth in the illegal use of CB radio in this country and urged him to legalize CB radio in Britain. Perhaps the most significant point made in this letter was the estimation by The Citizen Band Association that there were then about 15,000 illegal users in the country and that their number is increasing by roughly 2,000 per month. One does not need to be a mathematician to work out, that if this premise is true, then by the end of the summer holiday period there will be around 30,000 CB'ers in Britain, and that is no small number!

RADIO CONTROL

What about the actual legislation—it is worth considering one point—that recently the Society of Model Aeronautical Engineers have made a request to the Home Office for the use of a Radio Control band at 35MHz.

When one considers that 21 years have passed since CB was introduced by the US government—in 1958—to fill a need for a low-cost communication system available to everyone and requiring no technical skill, the attitude of the UK government seems old fashioned and wary. CB radio in the States was operated on 23 channels initially but in 1977 positive practice culminated in the addition of new channels making up a total number of 40, used by private citizens for personal or business communication on frequencies between 26.965MHz to 27.28MHz with the 27.065MHz channel used solely for emergency communications involving road safety, personal safety and property safety, and communications necessary to render assistance to motorists.

Lack of any legislation in the UK means that the type and quality of equipment will vary enormously—power output and number of channels etc.—and as such may interfere with legal emergency services, which obviously is to be avoided. An associated problem for CB'ers is that underground conditions force camouflage on mobile units, so one will find people driving around with completely unsuitable types of aerials, often generating signal harmonics and thus theoretically interfering with legal radio equipment users.

Radiomodellers on the other hand also face problems with the possibility of interference whilst working on 27.12MHz band. A conversation with an experienced radiomodeller who "flies" every Sunday in the Richmond area, shows that many modellers are not opposed to CB, however, there have been recent cases where expensive models crashed or were sent out of control. Naturally it is not possible to prove that these accidents were a result of CB rigs working in the area. The fact is that illegally operated CB rigs could theoretically affect radio-controlled equipment such as flying models. The consequences of this fact are serious, bearing in mind possible speeds of 120 miles per hour and model weight of up to a few kilos, especially when many radio modellers operate in public parks at weekends.

EQUIPMENT

There is a variety of different equipment in the potential reach of people determined enough to operate illegally on the 27MHz band. It seems to be exceptionally easy to buy CB equipment and associated CB accessories in London, both as second hand gear or brand new. Price ranges vary from about £40/£50 for a portable unit up to £260 for a high quality (69 channel s.b.) unit.

In 1976, the FCC estimated in excess of 10 million CB users in the USA and naturally American made equipment dominates both the legal and illegal CB market in Europe. There are also many European manufacturers on the scene from Switzerland, Belgium, Denmark, West Germany, Italy and Spain. Both European and American equipment is designed to operate on 27MHz, with variations in the number of channels, power output etc. As a result it is easy to see that the number of designs on the world market is large and many companies are rushing into CB production.

As no licence is required in the States to listen to the 27MHz band, a whole range of

CB convertors has been recently introduced as they have proved extremely useful for listening to CB traffic reports, weather and road conditions. In some cities Channel 9 (emergency) and Channel 14 (communication) are monitored by volunteer CB patrols who provide concerned citizens with a communication line to local police for reporting suspicious or criminal activity. Indeed the idea is widely accepted all around the world and called "React International"—emergency monitoring services (Channel 9—27.165MHz). "React" teams are active on a 24 hour basis in over 12 countries and their work has already saved the lives of victims of traffic accidents and freak weather conditions such as snow storms or typhoons.

CODE

Citizens band Radio operators have largely adopted the APCO 10 Code—developed originally by the police for their standard questions and answers, the code is easy to learn and useful in bad radio conditions. The CB subculture in the USA has taken things further, producing a bulk of speciality CB magazines and technical CB services. They have even developed a CB slang—which seems to be "double-dutch" to any outsiders.

Whatever ones feelings are about CB any technical or social discussion will produce good and bad aspects of the phenomena but my personal feelings are that the positive points outweigh the negative ones.

APCO 10 CODE

10- 1 Signal weak	10-18 Urgent
10- 2 Signal good	10-19 (In) Contact
10- 3 Stop transmitting	10-20 Location
10- 4 Affirmative (OK)	10-21 Call . . . by phone
10- 5 Relay (to) . . .	10-22 Disregard
10- 6 Busy	10-23 Arrived at scene
10- 7 Out of service	10-24 Assignment completed
10- 8 In service	10-25 Report to (meet) . . .
10- 9 Say again	10-26 Estimated time of arrival
10-10 Negative	10-27 License/Permit information
10-11 On duty	10-28 Ownership information
10-12 Stand by (stop)	10-29 Records check
10-13 Existing conditions	10-30 Danger/Caution
10-14 Message/Information	10-31 Pick Up . . .
10-15 Message delivered	10-32 Units needed: Specify
10-16 Reply to message	10-33 Help me quick
10-17 Enroute	10-34 Time

EDITORIAL NOTE

We believe the Home Office is revising its attitude on CB and understand that at a recent meeting between a Minister of state at the Home Office and an all party delegation of M.P.s, agreement was reached on the availability of frequency space and that the introduction of CB would not require new legislation.

Apparently the M.P.s expect the Home Office to come up with a programme for the introduction of CB for discussion at their next meeting in November. The all party group is advocating a service basically similar to the proposals of the Citizens Band Association—a VHF FM system with built in station identification.

Unfortunately, it is apparent that the Home Office still does not recognise the urgency of the situation if the illegal use is to be kept down, we believe this to now be crucial. Might we suggest that those who are in favour of CB in the UK, and particularly anyone who may suffer from the illegal use of 27MHz, write to the Home Secretary Mr. William Whitelaw M.P., House of Commons, London SW1 0AA, in support of the adoption of a VHF service as a matter of urgency. This we believe is now the only way to protect the 27MHz band from illegal use, and probably a way of achieving the best possible CB system for the UK.

It is known that the Prime Minister is in favour of CB and it would now seem to be a few belligerent civil servants in the Home Office that have to be overcome.

MICRO-BUS

Compiled by DJD.

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

THIS month's Micro-Bus compares the speed of four micros on a simple programming task: the conversion of a number from binary to decimal. The techniques involved in optimising the execution time of a machine code program are illustrated for the four micros, and the differences between them are discussed for the benefit of readers unfamiliar with their instruction sets. One of the micros is the new 6809, and another reason for performing this comparison is to see if the 6809 lives up to Motorola's claim that it is the "fastest 8-bit microprocessor".

Obviously one benchmark cannot give a representative idea of the performance of a

micro. The binary-to-decimal routine was chosen for the comparison because, while being interesting due to the need for indexed addressing in two different areas of memory, it does not favour the quirks of any particular instruction set.

BINARY TO DECIMAL

The binary-to-decimal routine converts a 16-bit unsigned binary number into its decimal equivalent. The routine is supplied with the number to be converted in a suitable register (or registers), and with the address of where the result should be stored. The result can be anywhere in memory, and occupies five suc-

cessive locations, one decimal digit per location. The routine, as given in many programming handbooks, is represented by the flowchart in Fig. 1. The variable N is the original binary number, and the five digits of the result are DIGIT(4) to DIGIT(0); D is a temporary counter for the digits.

The program works as follows: the first digit, DIGIT(4), is the number of tens of thousands, and so is obtained by counting how many 10,000s can be subtracted from N before it goes negative. Then the number of thousands is found by repeatedly subtracting 1,000, and so on, finally subtracting 1 to find the units.

SPEED OPTIMISATION

It is said that in most programs 90 per cent of the time is spent executing 10 per cent of the instructions, and the first step in optimising the speed of a program is to identify the time-consuming 10 per cent, which is normally the innermost loop of the program. The next step is to make this section of the program execute as fast as possible. The innermost loop in the flowchart of Fig. 1 begins at LOOP 2, and consists of a double-byte subtraction, a test, and an increment. This loop is executed once for each power of ten subtracted; in other words, the number of iterations is the sum of the decimal digits of the number being converted. The slowest number will be 59.999, needing 5+9+9+9+9 or 41 iterations.

An immediate improvement can be made by realising that the last digit is just the remainder after calculating the first four digits, so there is no need to repeatedly subtract 1 from it. This futile calculation can be removed from the program, reducing the number of iterations to 32. A second, less obvious, saving is gained by noticing that to implement the inner loop of Fig. 1, two branch (or jump)

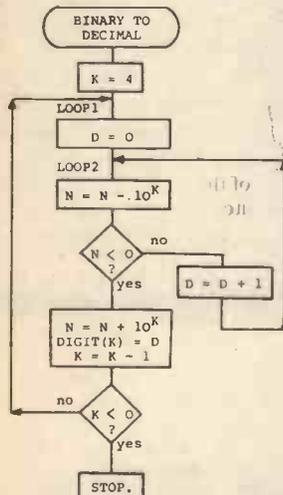


Fig. 1. Flowchart for a routine to convert a binary number N into decimal.

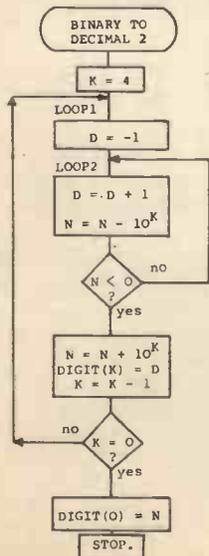


Fig. 2. Flowchart for an improved version of the binary-to-decimal routine.

instructions will be needed: one to test if N is negative, and one to jump back to the start of the loop after incrementing D. The second of these can be dispensed with by incrementing D at the start of the loop, and then either jumping over the increment instruction the first time round the loop, or counting from -1.

All the programs presented here incorporate these two improvements, and the optimised flowchart is shown in Fig. 2. Other methods used for trimming off cycles from the four programs depend on the idiosyncracies of each micro's instruction set, and are described for the four conversion routines.

6800

The binary-to-decimal conversion routine for the 6800 is shown in Fig. 3. In the 6800, direct (zero-page) addressing is the fastest mode, so rather than using indexed addressing each time round the inner loop, the power of

```

* BINARY TO DECIMAL FOR 6800
* NUMBER IN A, B
* RESULT STORED AT X
0000 0005 RESULT RMB 5
0005 0002 DIGITS RMB 2
0007 0002 XTENS RMB 2
0009 0002 POWER RMB 2
000B 2710 KIOTAB FDB 10000
000D 03E8 FDB 1000
000F 0064 FDB 100
0011 000A FDB 10

0013 86 EA BINDEC LDA A, ESEA A, B=59999
0015 C6 5F LDA B, E5FF FOR TEST
0017 CE 0000 LDX E, RESULT
001A DF 05 STX DIGITS SAVE X
001C CE 000B LDX KIOTAB
001F DF 07 LOOP1 STX XTENS
0021 EE 00 LDX O, X
0023 DF 09 STX POWER
0025 DE 05 LDX DIGITS
0027 6F 00 CLR O, X
0029 20 02 BRA NOINC
002B 6C 00 LOOP2 INC O, X
002D 0A 0A NOINC SUB B, POWER+1
002F 92 09 SBC A, POWER
0031 24 F8 BCC LOOP2
0033 DB 0A ADD B, POWER+1
0035 99 09 ADC A, POWER
0037 08 INX X
0038 DF 05 STX DIGITS
003A DE 07 LDX XTENS
003C 08 INX X
003D 08 INX X
003E 8C 0013 CPX KIOTAB+8
0041 26 DC LOOP LDX LOOP
0043 DE 05 LDX DIGITS
0045 E7 00 STA B, O, X
0047 39 RTS
    
```

Fig. 3. Binary-to-decimal routine for the Motorola 6800.

```

* BINARY TO DECIMAL FOR 6502
* NUMBER SUPPLIED IN A, X
* RESULT STORED AT (PNO)
0000 LO =, #020 FOR ACORN
0020 HI =, #+1 NUMBER BEING CONVERTED
0021 HI =, #+1 DITTO
0022 PNO =, #+2 ADDRESS OF RESULT
0028 27 PLOTAB .BYTE $27, $03, $00, $00
0028 10 .BYTE $10, $E8, $64, $0A

002C A9 EA BINDEC LDA ESEA A, X=59999
002E A2 5F LDX E5FF
0030 85 21 STA HI
0032 86 20 STX LO
0034 D8 CLD
0035 A0 00 LDX #0 FOR BINARY
0037 A2 FF LOOP1 LDX E5FF
0039 38 SEC COUNTER
003A E8 20 LOOP2 INX LO
003B A5 20 LDA LO
003D F9 28 00 SBC PLOTAB+4, Y
0040 85 20 STA LO
0042 A5 21 LDA HI
0044 F9 24 00 SBC PLOTAB, Y
0047 85 21 STA HI
0049 80 EF BCS LOOP2
004B A5 20 LDA LO
004D 78 28 00 ADC PLOTAB+4, Y
0050 85 20 STA LO
0052 A5 21 LDA HI
0054 79 24 00 ADC PLOTAB, Y
0057 85 21 STA HI
0059 8A TXA
005A 91 22 STA (PNO), Y
005C C8 BNE INY
005D C0 04 CPV E4
005F D0 D6 BNE LOOP1
0061 A5 20 LDA LO
0063 91 22 STA (PNO), Y
0065 60 RTS
    
```

Fig. 4. Binary-to-decimal routine for the MOS Technology 6502.

ten is first stored at POWER so that direct addressing can be used for the subtract operations with a saving of 4 cycles.

The 6800 routine differs from the flowchart of Fig. 2 in that the digit locations are incremented directly, eliminating the need for a temporary counter; although the indexed increment instruction costs an extra cycle in the inner loop, there turns out to be a net

saving. This is not a very flattering program for the 6800 as it very clearly shows up the disadvantages of having only one index register.

6502

In the 6502 all arithmetic operations use the accumulator, so for double-byte arithmetic the accumulator must be repeatedly loaded from memory and stored to memory, making the program of Fig. 4 relatively long. Since the 6502 does not have any 16-bit registers, the address of the result must be held in memory, and the digits are stored using post-indexed indirect addressing. An extra saving is gained by splitting the table of powers of ten into two halves so that the Y index register can be used for indexing both the powers of ten and the digits of the result; the X register is then free for use as the digit counter.

```

; BINARY TO DECIMAL FOR 6502
; NUMBER IN HL - RESULT AT IX
; FOR RESULT
0000 0005 DEC: DEFS 5
0005 10 27 KIOTAB: DEFV 10000
0007 EB 03 DEFV 1000
0009 64 00 DEFV 100
000B 0A 00 DEFV 10

000D 21 5F EA BINDEC: LD HL, 59999 ; TO TEST IT
0010 DD 21 00 00 LD IX, DEC
0013 FD 21 05 00 LD IX, KIOTAB
0018 3E FF LOOP1: LD A, OFFH ; GET POWER
001A FD 5E 00 LD E, (IX) ; OF TEN
001D FD 56 01 LD D, (IX+1) ; CLEAR CARRY
0020 87 OR A
0021 ED 52 LOOP2: SBC HL, DE
0023 3C INC A
0024 D2 21 00 JP NC, LOOP2
0027 19 ADD HL, DE ; STORE DIGIT
0028 DD 77 00 JUMP: LD (IX), A ; NEXT DIGIT
002B DD 23 INC IX ; NEXT POWER
002D FD 23 INC IX ; OF TEN
002F FD 23 INC IX
0031 7B LD A, E
0032 FE 0A CP 10
0034 C2 18 00 JP NZ, LOOP1
0037 DD 75 00 LD (IX), L ; REMAINDER
003A C5 RET ; FINISHED
    
```

Fig. 5. Binary-to-decimal routine for the Zilog Z80.

Z80

The program for the Z80, Fig. 5, closely follows the flowchart of Fig. 2. The OR A instruction, which at first sight achieves nothing, is used to clear the carry bit. Because it is rather awkward to test the value of the index register to determine when four digits have been completed, as in the other routines, this program checks to see if the lower byte of the power of ten, E, is equal to 10. It is a pity that the Z80's indexed addressing instructions need an extra byte prefix, because this reduces the speed advantage of using them.

6809

The Motorola 6809 is the newest of the four processors discussed here, and the chips are only just becoming available. It is an upgraded version of the 6800, and is compatible with the 6800 at the level of source code, which means that the routine for the 6800 in Fig. 3 could be re-assembled straight into 6809 instructions. However, the 6809 contains so many new addressing modes, registers, and additions to the 6800 instruction set that it is worth writing the routine from scratch.

The "ADDD .X+" instruction illustrates the power of the instruction set: this instruction performs a double-byte addition of the bytes pointed to by X into the 16-bit D register, and then increments X twice. It therefore replaces four of the instructions in the 6800 version. The provision of a Y index register in the 6809 makes it possible to eliminate from the 6800 version a further seven instructions that were needed to load and store the X register between uses.

* BINARY TO DECIMAL FOR 6809 *
* NUMBER IN D - RESULT AT Y *

```

0000 0005 RESULT RMB 5
0005 2710 K1OTAB FDB 10000
0007 03E8 FDB 1000
0009 0064 FDB 100
000B 000A FDB 10

000D CC EASP 3 BINDEC LDD $59999 FOR TEST
0010 BE 0005 3 LDX K1OTAB
0013 10BE 0000 4 LDR ERESULT
0017 6F A1 6 LOOP1 CLR O,Y
0019 20 02 3 BRA NOINC
001B 6C A4 6 LOOP2 INC O,Y
001D A3 84 6 NOINC SUBD O,X
001F 24 FA 3 BCC LOOP2
0021 31 21 5 PRN5 LEAY 1,Y T.E. INY
0023 E3 81 9 ADDD ,X++
0025 BC 000D 4 CMF K1OTAB+8
0028 26 ED 3 BNE LOOP1
002A E7 A4 4 STB O,Y REMAINDER
002C 39 5 RTS RETURN

```

Fig. 6. Binary-to decimal routine for the Motorola 6809.

The resulting program for the 6809, Fig. 6, is half the length of the 6800 version, and is the neatest of the programs presented here. It is a direct translation of the flowchart of Fig. 2 into instructions, without the need for any tricks, temporary locations, or extra operations.

PROGRAM EXECUTION TIMES

Each program can be divided into three parts. First there is the inner loop beginning at the label LOOP 2 which, as explained above, is executed 32 times for a worst-case number of 59,999. Then there is the outer loop beginning at LOOP 1 which is executed once for each digit, or a total of four times. Finally there are the remaining instructions, at the start and end of the programs, which are executed only once. The number of cycles for each of these sections of each program is shown in Table 1, together with the total number of cycles for the whole routine.

	6800	6502	Z80	6809
INNER LOOP (x 32)	17	25	29	15
OUTER LOOP (x 4)	75	62	159	39
REST (x 1)	30	28	67	19
TOTAL CYCLES	874	1076	1631	655
TOTAL TIME (secs)	57	71	53	43

TABLE 1

The bottom row of Table 1 gives the time, in seconds, for each routine to convert the number 59,999 a total of 65,536 times (a convenient loop count). These times are for a Z80 running with a 2MHz clock, and for the other three processors running at 1MHz, to allow for the different way the Z80 handles instruction timing. This seems fairer than comparing the processors running with the same clock rate, because the clock rate used by a system will normally be determined by the speed at which the memory will run, this tending to be a more expensive part of the system than the processor itself.

The 6800, 6502 and 6809 all access memory for one machine cycle, whereas in the Z80 the shortest memory access, the op-code fetch, lasts for two machine cycles: the Z80 can therefore run with twice the clock rate on the same memory as the other micros.

The result of the comparison is that the 6809 wins the race, followed by the Z80 and 6800, and the 6502 follows closely behind. Anyone writing a faster version of any of these routines should set up a loop to execute the routine 65,536 times, and check that the time taken agrees with the prediction from counting the number of cycles. If any substantially better routines are received, they will be presented in a future Micro-Bus.

EIGHT EIGHTS SOLUTION

August's Micro-Bus gave a program for the Mk14 microprocessor kit and posed the following problem: with the program running on an Mk14, what is the shortest sequence of key-presses that will cause eight eights to light up on the displays? Despite the apparent simplicity of the program, shown in Fig. 7, the problem is extremely tantalising and can only be solved by the following sequence of 45 keys:

```

0 2 3 2 4 2 3 2 5
2 3 2 4 2 3 2 6 2
3 2 4 2 3 2 5 2 3
2 4 2 3 2 7 2 3 2
4 2 3 2 5 2 3 1 0

```

This solution is unique, except that the order of the 0 and 1 at the end can be reversed, and other keys can be exchanged for the 1 key.

Although this solution looks complicated, there is an underlying pattern that yields to a little scientific investigation. Some experimentation with the program soon reveals the following rules about its behaviour:

- (1) Only the keys 0 to 7 need be considered. (All the other number keys just do the same as key 1.)
- (2) Every time a key is pressed one display is alternately illuminated with an "8", and blanked.
- (3) Numbering the displays 0 to 7 from right to left, keys 0, 1, and 2 always operate the corresponding display.
- (4) Keys 3 to 7 only operate the corresponding display if the display immediately to the right is on and all the other displays to the right are off; otherwise they operate display 1.

With these rules established it is then fairly simple to produce the desired result. First observe that since 0, 1 and 2 can be switched on at any time (rule 3) they are better left off for the moment, so press 0 as a first move to get all the displays blank. Now, to get 3 on we must first get 2 on by itself (rule 4) by pressing 2. Having operated 3 there are two options: operate 3 again, getting back to the previous state, or operate 2, getting to a new state. We choose the latter and continue in this way, always pressing the key that gets to a new state of the displays. The results of the first few steps are shown:

```

Key: Display: 7 6 5 4 3 2
Start      0 0 0 0 0 0
2          0 0 0 0 0 1
3          0 0 0 0 1 1
2          0 0 0 0 1 0
4          0 0 0 1 1 0
2          0 0 0 1 1 1
3          0 0 0 1 0 1
2          0 0 0 1 0 0
5          0 0 1 1 0 0

```

The state "111111" (displays 2 to 7 on) is reached after 42 key-presses. In addition there is the key-press at the start to get 0 off, and two at the end to get 0 and 1 on, making the 45-key sequence given above.

GRAY CODE

The sequence of states of the displays 2 to 7 may be familiar as a binary Gray code for the numbers 0 to 41. The Gray code was invented in the 1940's by Frank Gray, a

research physicist at the Bell Telephone Labs, to prevent errors in pulse-code modulated signals. In binary Gray codes each number differs from its neighbours by the alteration of only one bit, and they are now widely used in encoding applications where a normal binary code might give a false reading when changing between two adjacent states.

PROGRAM OPERATION

A fully commented version of the Eight Eights program is given in Fig. 7. The program

```

; EIGHT EIGHTS PROBLEM
0185 KYBD = X'0185 ;IN MONITOR
0080 = X'02 ;EXTENSION AS OFFSET
007F EIGHT = X'7F ;SEGMENT CODE FOR '8'
0000 OF18 = -OF18

OF18 C484 ; BEGIN: LDI L(KYBD)-1
OF1A 33 ; XPAL 3
OF1B C40F ; LDI H(DISBUF)
OF1D 36 ; XPAL 2
OF1E C401 ; BACK: LDI H(KYBD)
OF20 37 ; XPAL 3
OF21 01 ; XAE
OF22 C440 ; RIGHT: LDI L(DISBUF) ;E = P3H
OF24 32 ; XPAL 2 ;POINT P2 TO
OF25 C47F ; LDI EIGHT ; DISPLAY BUFFER
OF27 E280 ; XOR E(2) ;CHANGE STATE OF
OF29 C480 ; ST E ; DISPLAY E
OF2B SHOW: LDI E ;DISPLAY ROUTINE
OF2C 90FD ; JMP SHOW ;COMMAND KEY RETURN
OF2E 03 ; SCL ;NUMBER KEY RETURN
OF2F C402 ; LDI 2
OF31 7E ; CAL
OF32 94EE ; JP ;RIGHT
OF34 C601 ; LOOP: LD R1(2) ;IF SO-CHANGE DISPLAY
OF36 98FC ; JZ LOOP ; FIND FIRST NON-BLANK
OF38 32 ; XPAL 2 ; DISPLAY
OF39 60 ; XRE ;GET DISPLAY NUMBER
OF3A D40F ; ANI X'0F ;15 NUMBER = KEY 7
OF3C 98E4 ; JZ RIGHT ;IF SO-CHANGE DISPLAY
OF3E 90DE ; JMP BACK ;ELSE-CHANGE NUMBER 1
OF40 0000 ; ; DISPLAY BUFFER - STARTS ALL BLANK
DISBUF: BYTE 0,0,0,0,0,0,0,0

0000 ; .END

```

Fig. 7. SC/MP program for the Eight Eights problem posed in the last Micro-Bus.

makes use of the display routine KYBD in the Mk14 monitor: this routine displays the segment codes stored in the eight bytes pointed to by P2, and returns after a key-press with the value of the number key in the E register. In the Eight Eights program the eight bytes OF40 to OF48 are displayed, since P2 is set up to contain OF40. The segment codes X'00 and X'7F are stored in those locations to display either a blank or an "8" respectively.

A jump to the label RIGHT changes the state of display number E, where E represents the contents of the extension register. Alternatively, a jump to BACK sets E to the top byte of P3. Initially this will be zero, so when the program is first run display 0 is illuminated; on subsequent times round the loop the top byte of P3 will contain X'01 and so a jump to BACK will change display 1. Each time a key is pressed the program decides whether to jump to RIGHT and change the display corresponding to the key number, or to jump to BACK and change display 1. A jump to RIGHT is only allowed if the key number, E, is less than 2, or if display E is on and all those to the right of E are off (i.e. zero).

From this information, and the program listing, it should be clear how the program works. The names of the winners of the three VDU kits will be announced in the next Micro-Bus.

SELF-REPLICATION AGAIN

In the June 1979 Micro-Bus a nine-statement BASIC program was presented that would list a copy of itself at the terminal. Mr. Langdon Proctor, of Denmark, has pointed out that any BASIC program can be made self-replicating by including a LIST command as of the statements. The program '10 LIST' is thus a one-line solution to the original problem!

readout

... from our postbag

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

Faster than light?

Sir—In your May issue of "Practical Electronics" referring to *Industry Notebook* there was mention of the Tektronix 7104 oscilloscope. The trace writing speed is described as "... an almost incredible 20cm/ns." This is a remarkably apt description since the speed of light, 300×10^6 metres/s., is 30cm/ns. by my maths. The combination of forward speed and deflection must put the beam velocity after deflection very close to the velocity of light indeed.

Assuming the stated bandwidth of 1GHz is the 6dB point, the deflection amplifiers should still have some response at 2GHz, requiring a writing velocity above the speed of light. I had always believed that it was, theoretically, impossible to exceed the speed of light but I am now beginning to wonder.

B. Page,
Southend-on-Sea,
Essex.

The extraordinary 7104 is in fact capable of spot velocities exceeding the speed of light even though at this setting the bandwidth specification would have to be exceeded by 500MHz at 3dB.

But Einstein can rest easy as his law has not been violated since the cathode is a continuous source of electrons reaching the swept spot at different points in time, not one electron moving across the scope screen at 30cm/ns.—Ed.

CB suggestions

Sir—I refer to your Editorial in the August issue on the subject of CB radio.

While I believe that those people wishing to use CB are as entitled to a part of the spectrum as anyone else, including the commercial interests, I doubt very much whether any allocation of frequencies, or licence conditions will be found to apply to those so lacking in social conscience as to put at hazard many thousands of pounds' worth of radio-controlled models, and cause interference to other users of the spectrum who have as much right as they to its use.

Having said that, I believe that there are two model control bands, one of which is at UHF, around the 450MHz area. While it will not be compatible with other CB equipment on 27MHz, it will satisfy the object of CB, which I understood in the USA to be "short range person to person communication". I have not seen any equipment for the higher band commercially available, so I could be wrong about this allocation.

The other possibility is to set a final date

for the phasing out of TV transmissions in the 41MHz band (405 line system), and put in a CB allocation, effective on the final date. Secondly, in view of the interference possibility, it could be made a condition of the licence that successful completion of the licence regulations and transmitter interference section of the Radio Amateur's Exam (suitably modified on licence regulations) be proved. Further, that the name and address of purchasers of CB equipment be noted by the seller, as is the case with much Amateur equipment. Of course, the people who are lacking in the consideration for other users mentioned above, will then set up a protest about too many regulations, but having listened to CB USA style, it would surely be preferable to the usual idiocy and sometimes obscenities one hears.

Finally, I would suggest that the address of the Post Office interference investigation department be made widely available, and that a requirement of the complaint be a tape recording of the interference; which should ensure that the offender is known about and found.

Peter J. Brent,
Fareham,
Hampshire.

Sir—In my opinion the reason that CB has not been legalised here is because of the mess left by previous administrations ignoring the CB issue from its inception.

What can Mr Whitelaw do? Conform with the rest of the world and legalise CB on 27MHz, to the wrath of aero modellers who have a great deal of capital tied up in 27MHz equipment. This frequency also has DX problems. Or he could decide to put CB on 230–232MHz, an unused band which would give an excellent service but would create anomalies between the UK and the rest of the world, plus inherent customs difficulties. Which ever way he turns, this is his dilemma; not CB, but where CB.

A few ignorant cranks are still opposed to CB, the sacred cow brigade, who want to hear only their own voices.

I do not believe that a man like Mr Whitelaw feels that the UK citizen is less fit than an Italian, German, Frenchman or Dutchman, to name a few, to operate profitably a CB network in terms of lives saved, property protected and fuel saved.

One thing is certain, CB will flourish within the law or outside it. With proper control CB can start to serve the community like nothing since sliced bread.

Nigel Longbotham,
Cramlington,
Northumberland.

Logical software

Sir—In the August issue of PE a letter—Logical software—by Mr H. S. Lynes expressed the views of many of my friends and myself. This being the use of software to 'replace' lots of hard wired logic for projects like Intelligent House Alarm, Heating Controller, etc.

Microprocessors together with plug-in PROMs (with necessary programs) could "look after" various systems, via interfaces. Appropriate PROMs could be selectable by switches on a PROM card connected to say UK101 via an expansion socket. A cheap PROM programmer could also be interfaced. Using PROMs obviates the need to load programs from cassettes.

I think logical software for UK101 plus hardware would generate interest among your readers who could contribute as well.

That would be making a practical use of a microprocessor rather than using it as an expensive toy for "Star Wars" and "Noughts and Crosses" (after all UK101 costs £219+VAT).

B. Jani,
Tufnell Park,
London.

We hope to be able to publish a good PROM programmer soon after the CompuKIT UK101 series. This will be useful with almost any computer and will plug into COMPUKIT.—Ed.

Newbear 77-68

Sir—I was pleased to see P. Birnie's excellent review of the 77-68 system.

In his review he is critical of the fact that Newbear do not provide BUG 2 in ROM. In fact Newbear provide an alternative monitor board MON 2 which was not mentioned. This board supports MIKBUG or similar monitors in ROM or EPROM.

An alternative to MIKBUG has been developed by Terry Cassell called T-BUG. This monitor, while maintaining MIKBUG compatibility, contains code to drive the VDU board as a scrolling display as well as various useful additions to the MIKBUG range of commands.

The advantage of MON 2 with T-BUG, or even MIKBUG, is that a vast amount of readily available M6800 software may be run, in most cases, unaltered.

My post bag often contains comments from users concerning the difficulty of getting available code to run under a MON 1 board as it has a completely different memory map to MIKBUG.

In my opinion the principal advantage of 77-68 over products such as NASCOM, TRITON and COMPUKIT is that it is very extendable having a backplane/board construction with the bus being well buffered. It turns out to be an eminently modifiable system and most systems are tailored by the constructor in one way or another.

Dr. P. Bryant,
Hon. Editor 77-68 Newsletter,
The Bumbles,
Well Meadow,
Shaw, Newbury.

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SCHMITT TRIGGER CIRCUITS

D. F. BOWERS B.Sc.

It is often required, especially in the field of digital control, that a circuit should provide information as to whether an analogue signal is above or below a certain threshold. Where the threshold is fixed, the circuit used is known as a comparator and where the threshold alters in opposition to the circuit output, the circuit is said to have hysteresis. Because such circuits normally switch rapidly (in comparison to the rate of change of input voltage) they have also been classed under the general heading of trigger circuits.

HYSTERESIS

Hysteresis is often required in trigger circuits for one of two main reasons:

- (i) Because available comparator circuits have finite gain, inputs close to the threshold voltage can produce indeterminate outputs or even oscillation. Hysteresis ensures that as signals begin to cross the threshold, the latter itself moves to make the output more decisive.
- (ii) If a relatively slowly changing input is noisy or has ripple superimposed upon it, multiple triggering at the threshold may occur. Adding hysteresis can remove this.

The amount of hysteresis required is dependent on the comparator gain in case (i) and on the ripple magnitude in case (ii).

IDEAL TRIGGER

The ideal trigger can be visualised as a 'black box' as shown in Fig. 1, together with its transfer characteristics.

The output has two distinct states, controlled by the voltage on input. When the input voltage rises above a certain threshold value (V_{ON}) the output assumes the 'on' state and when the input falls below a certain value (V_{OFF}) the output assumes the 'off' state. The value $V_{ON} - V_{OFF}$ is called the hysteresis of the trigger. The input characteristic can thus be specified either by quoting V_{ON} and V_{OFF} or by quoting the mean of these values together with the hysteresis value.

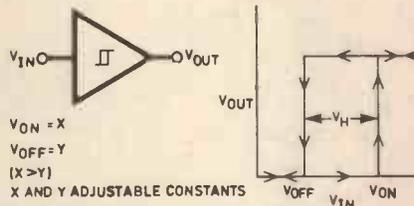


Fig. 1. Ideal trigger with associated transfer characteristic

The latter is sometimes specified as a percentage of the mean threshold.

The output states should correspond to levels compatible with following circuitry, and the input should draw as little current as possible. The threshold values should be both predictable and easily adjustable, and also exhibit high stability. The trigger should switch in as short a time as practicable.

PRACTICAL TRIGGERS

One of the first papers on this subject was presented by Otto H. Schmitt. His trigger circuit had a fixed lower threshold and an adjustable upper threshold, and was basically a long-tailed triode pair with positive feedback. The circuit switched comparatively slowly by present day standards ($\approx 10\mu s$) but was of course much faster than electromagnetic relays which were commonly used instead. Replacing Schmitt's triodes with bipolar switching transistors can speed up the operation ($< 200ns$) and a typical circuit is shown in Fig. 2.

TRANSISTORISED TRIGGER

Assuming TR1 is turned off (V_{IN} low), the base of TR2 is biased at approximately +6.8 volts by the voltage divider R1, R3 and R4. The emitters of both transistors are then at 6.2 volts due to the V_{bc} of TR2. If V_{IN} approaches 6.8 volts, a critical voltage is reached where TR1 begins to conduct and regeneratively turns off TR2. If the input voltage is now lowered below another critical value ($< 5.2V$) TR2 will again switch on.

The present tendency is to refer to all trigger circuits with this type of characteristic as Schmitt Triggers, even if different principles of operation are

employed. Other configurations have f.e.t.s instead of bipolar transistors, or sometimes use complementary devices. Often, a speed up capacitor is included across R3.

DISADVANTAGES

The circuit described has the advantage that the hysteresis level is substantially independent of temperature, but unfortunately is dependent on V_{CC} . The actual thresholds also include a V_{bc} term which is dependent on temperature, and another problem is that the output low voltage is always greater than VR_5 .

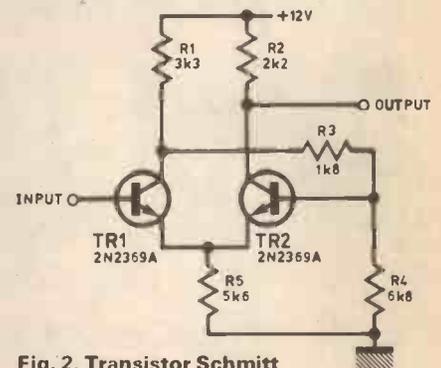


Fig. 2. Transistor Schmitt

The input characteristics are also far from ideal, since the input transistor draws considerably more base current when turned on than when turned off. A resistor is sometimes included in series with V_{IN} to limit this current if V_{IN} rises much above the 'on' threshold.

Added to the fact that the precise thresholds are quite difficult to ascertain, these disadvantages make this configuration somewhat awkward to implement, except in non-critical applications.

All these problems, except perhaps the hysteresis dependence on V_{CC} , can be

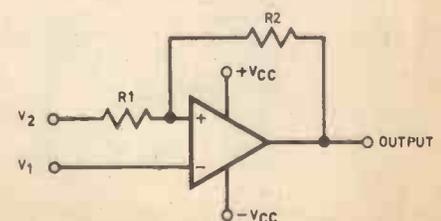


Fig. 3. Op amp Schmitt

alleviated by using operational amplifiers as the active switching element, but switching will generally be slower, since many operational amplifiers can only slew at around $70V/\mu s$, even if uncompensated, and have relatively long propagation delays.

OP AMP TRIGGERS

The use of operational amplifiers greatly simplifies trigger design, especially if the maximum output voltages can be accurately determined. Uncompensated operational amplifiers can generally be used directly and switch much faster than compensated types.

The basic configuration is shown in Fig. 3, and can be used to provide triggers of the inverting, non-inverting or differential type. The voltage at the non-inverting input will be:

$$\frac{R_1}{R_1 + R_2} V_{OUT} + V_2$$

and since the feedback is positive, the output will switch high if:

$$V_2 > V_1 - \frac{R_1}{R_1 + R_2} V_{OUT}(\text{low})$$

and will switch low if:

$$V_2 < V_1 - \frac{R_1}{R_1 + R_2} V_{OUT}(\text{high})$$

So clearly the hysteresis level is given by:

$$V_H = \frac{R_1}{R_1 + R_2} [V_{OUT}(\text{high}) - V_{OUT}(\text{low})]$$

and is symmetric of about the threshold if $V_{OUT}(\text{high}) = -V_{OUT}(\text{low})$ and one of V_1, V_2 is zero. Since most operational amplifiers run off symmetrical supply rails, and can swing very close to them, the formula for a ground referenced trigger becomes:

$$V_{\text{threshold}} = 0V, V_H = \frac{2R_1}{R_1 + R_2} V_{CC}$$

where $V_{CC} = \pm$ supply voltage.

In the inverting mode, V_2 will be grounded and in the non-inverting mode V_1 will be grounded, but note that in the latter case the drive impedance of V_2 should be low compared to $(R_1 + R_2)$ to prevent loading by the output. A Zener clamped output may be used where V_H must be accurately defined (see Fig. 4) and the Zener voltage

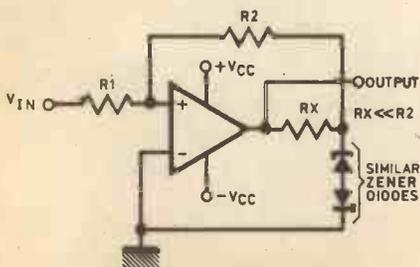


Fig. 4. Trigger with clamped output

plus the Zener forward voltage drop ($\approx 0.7V$) should replace V_{CC} in the hysteresis calculation. In the case of asymmetric output voltages, graphical techniques can greatly ease calculations.

COMPARATORS AS TRIGGERS

It is often desirable to use voltage comparators as triggers, since generally they switch faster than operational amplifiers. Indeed, with some comparators a small amount of hysteresis (1-5mV) is advised because of the finite gain problem mentioned previously.

The same treatment can broadly be given to comparators as for operational amplifiers bearing in mind that many have asymmetric (logic compatible) outputs and occasionally open collector (or emitter) outputs, where the pull-up (or down) resistor comes into the R_2 term in the threshold calculation, in the high (or low) state respectively. Problems also sometimes arise with the propagation delay, which effectively disconnects the positive feedback for the delay period, giving rise to possible instability.

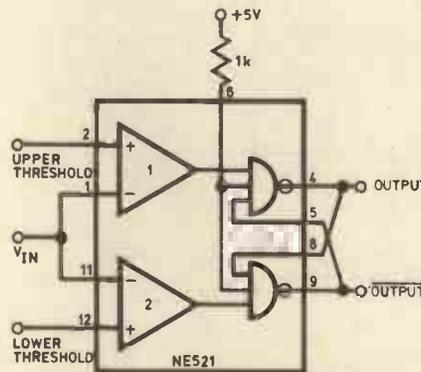


Fig. 5. I.c. programmable trigger

A neat trigger design using a dual comparator is shown in Fig. 5. This circuit enables the upper and lower thresholds to be accurately fixed by external reference voltages, making the trigger very versatile. The two gated outputs of the NE521 are arranged to form an R-S latch, set by comparator 1 and reset by comparator 2. The resulting output thus goes high when the input rises above the upper threshold, and goes low when the input falls below the lower threshold. (This configuration actually forms part of the internal circuitry for the popular 555 timer i.c. which can be used without modification to provide a Schmitt trigger with upper and lower thresholds of $\frac{2}{3} V_{CC}$ and $\frac{1}{3} V_{CC}$ respectively.) Replacing the R-S latch by an external J-K flip-flop ensures that the output only changes in synchronism with a clock pulse, which is often a useful feature. With an external flip-flop, naturally other comparators can be used instead of the 521.

TRIGGERS WITHIN LOGIC DESIGNS

An important application of trigger circuits is in logic interfacing where the signals presented to the logic must conform to specifications regarding level and risetime. Analogue signals from photocells, thermistors, etc., are clearly unusable directly, for both reasons. Quite often any trigger used will be required to operate from the logic supply voltage and preferably use as few discrete components as possible, especially where many triggers are used for mundane applications (such as R-C switch debouncing). The two most common logic systems (CMOS and TTL) will be considered here.



Fig. 6. Trigger formed from CMOS inverters

CMOS LOGIC TRIGGERS

Since CMOS gates have a very high input impedance and reasonable gain, it is possible to use them as switching elements in Schmitt triggers, in much the same manner as operational amplifiers are used. A common (non-inverting) configuration is shown in Fig. 6, using two CMOS inverters. Positive feedback is applied via R_1 , and the typical hysteresis obtained is tabulated in Fig. 7. The actual threshold is dependent on the switching point of the first inverter ($\frac{V_{DD}}{2} \pm 40\%$)

and is thus somewhat indeterminate, although reasonably stable with changes in temperature. The hysteresis tends to act symmetrically about the threshold provided this is fairly close to V_{DD} . The threshold can be shifted by means of a resistor connected between the input to the first inverter and V_{DD} or ground.

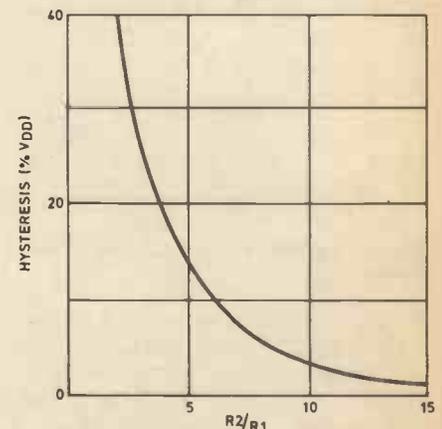


Fig. 7. Graph of hysteresis

Another method of using gates as triggers (Fig. 8) utilises the interdependence of switching characteristics between inputs of a multiple input gate. Varying

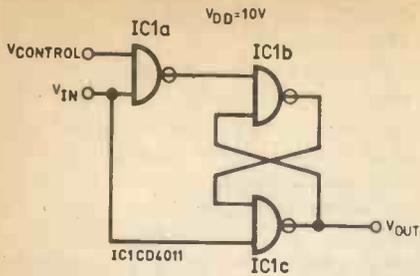


Fig. 8. Trigger utilising interdependence of CMOS gate inputs

$V_{Control}$ alters the input characteristics of gate I, which determines the upper switching point is determined by the input characteristics of IC1c, and is independent of $V_{Control}$. Thus varying $V_{Control}$ alters the hysteresis, typical values being shown in Fig. 9. Similar remarks about the threshold apply as for the previous example, but in this case the hysteresis acts asymmetrically, tending to raise the threshold. Replacing the NAND gates with NOR gates causes the hysteresis to lower the threshold. Note the similarity of this configuration to the circuit of Fig. 5.

INTEGRATED CMOS TRIGGERS

The CMOS logic families include several Schmitt triggers all intended for interface of noisy or slowly changing input signals. In general, these triggers feature very high noise immunity, unconditional input stability, and very high input impedance. On the black side, all have relatively long propagation delays (up to 600ns for the CD4093B) and poor threshold stability with respect to supply voltage.

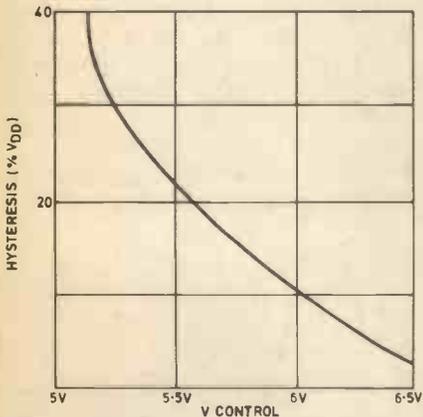
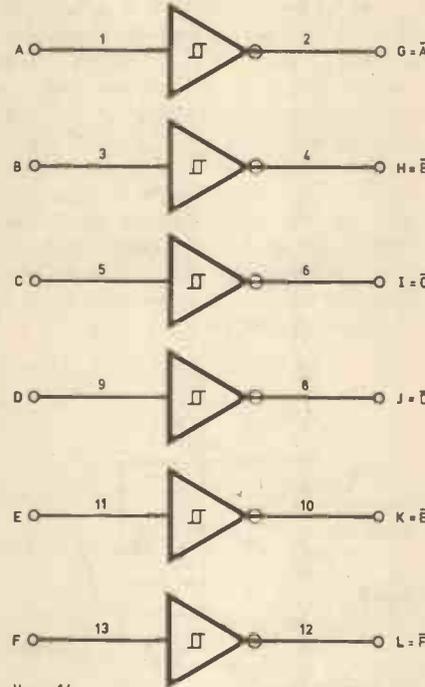


Fig. 9. Varying hysteresis with control voltage

Typical fixed-threshold triggers are the CD40106 and CD4093B. The CD40106 is a hex-inverting trigger (Fig. 10) featuring good threshold and hysteresis stability with changes in temperature. Fig. 11 shows typical threshold values for three different supply voltages for each individual trigger. The CD4093 is a quad trigger each of which has two inputs, functionally equivalent to a NAND gate. The threshold

levels are the same as for the CD40106 provided one input is tied to V_{DD} , but are raised slightly if both inputs are used. Typical hysteresis remains unchanged.

Another interesting trigger is the MC14583, which obtains its trigger effect using three resistors to control the transfer characteristics of an inverter. By varying these three resistors the threshold can be externally controlled. The 14583 comes in a dual package and also features non-inverting, inverting tri-state and EXCLUSIVE OR-ed outputs, making it especially useful as a transmission line receiver.



$V_{DD} = 14$
 $V_{SS} = 7$

Fig. 10. CD40106 hex inverting Schmitt trigger

V_{DD} (V)	5	10	15
V_{ONMAX}	3.6	7.1	10.8
V_{ONMIN}	2.2	4.6	6.8
V_{OFFMAX}	2.8	5.2	7.4
V_{OFFMIN}	0.9	2.5	4.0
V_{HMAX}	1.6	3.4	5.0
V_{HMIN}	0.3	1.2	1.8

Fig. 11. Switching characteristics for the CD40106

TTL SCHMITT TRIGGERS

The TTL 7400 series features three Schmitt triggers, all three available in standard and low power Schottky versions, and one (74S132) available in standard Schottky. Additionally, several other TTL i.c.s feature Schmitt characteristic inputs for reasons mentioned below. All these triggers feature temperature compensated hysteresis (typically less than 2% variation over the military temperature range). Propagation delay is around 15ns for the standard and low-power Schottky versions, and around 8ns for

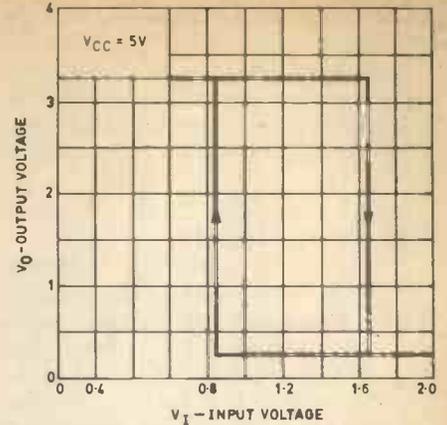


Fig. 12. Switching characteristics for the 7400 Schmitt trigger family

the Schottky versions, making them fairly fast devices. The 7414 (74LS14) is a hex inverting trigger, the 7413 (74LS13) is a dual 4-input NAND trigger and the 74132 (74LS132), is a quadruple 2-input NAND trigger.

All have the typical switching characteristic shown in Fig. 12, and have the usual TTL input current source characteristics, making them low input impedance circuits.

OTHER TTL DEVICES

A fairly common use of Schmitt triggers is as digital line receivers, where line capacitance and interference produces poor signal edges and noisy information. As a result, many line receivers have intrinsic hysteresis to sharpen up signal edges and to eliminate spurious noise signals. Some examples are the 74LS242 transceiver from the 7400 series, 75152 dual receiver (with adjustable hysteresis) from the 7500 series, and also the AMD 1489 (quad) and N8T37 (hex) line receivers.

Other functions occasionally incorporate Schmitt triggers, an example being the 74221 dual monostable multivibrator which will thus trigger reliably from inputs with transition rates as slow as 1 volt/second.

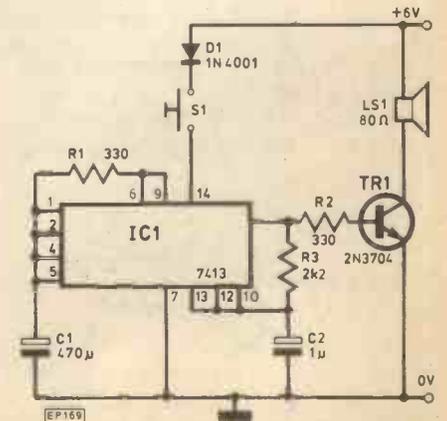
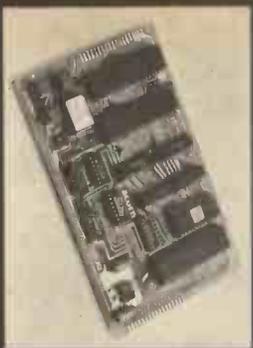


Fig. 13. Doorbell circuit employing dual Schmitt triggers

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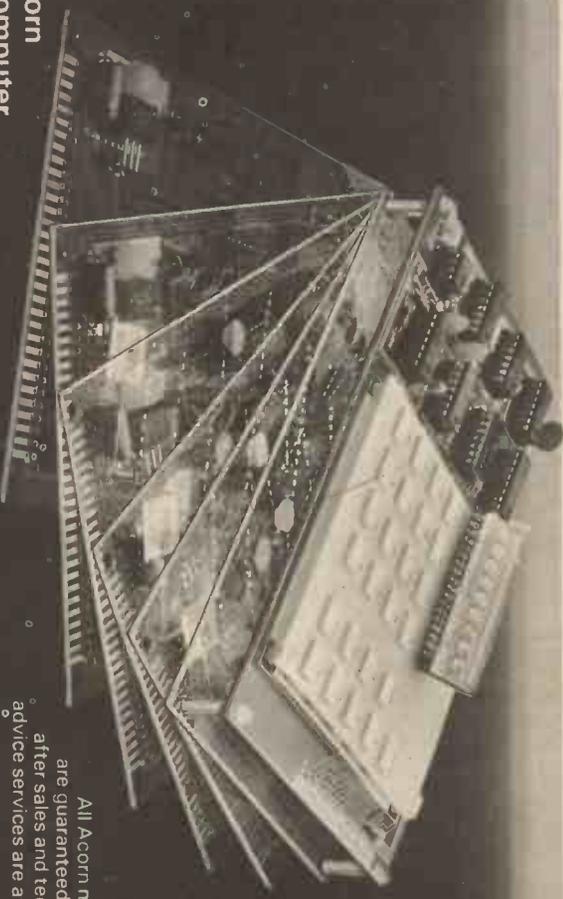


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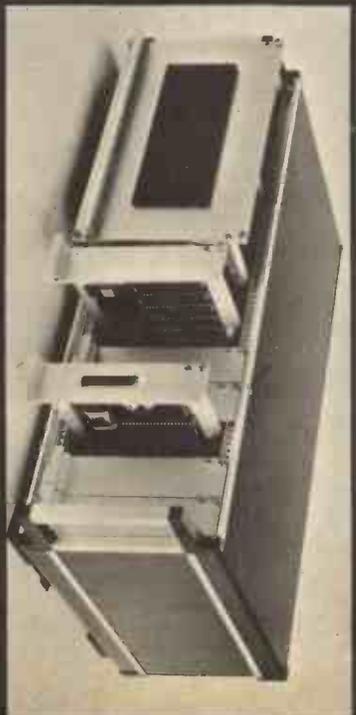
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- | | |
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| B—set breakpoint | O—Output to P.I.O. |
| C—Copy | Q—Query input port |
| E—Execute | R—Read tape |
| G—Generate | S—Single step |
| H—Operate as half duplex, terminal. | T—Tebulate memory |
| I—Intelligent copy | U—activate user I/O drivers |
| J—Execute at FFA | V—Verify tape |
| K—set keyboard options | W—Write tape |
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BM 4	7.2	11.6	13.9	20.4
BM 5	6.9	12.6	15.0	21.7
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BM 7	28.2	27.6	31.8	50.9
BM 8		5.2	6.2	12.3



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7402	0.11	7486	0.22	74172	6.30	4031	0.50	4163	1.05	LM309-14	0.85	22 pin	0.22
7403	0.11	7489	0.42	74173	1.15	4025	0.15	4164	1.05	LM381N-14	1.40	24 pin	0.24
7404	0.11	7489	1.65	74174	0.85	4026	1.16	4174	1.05	LM710-14	0.30	28 pin	0.26
74M04	0.23	7490	0.32	74175	0.60	4027	0.42	4175	0.98	LM711N-14	0.30	40 pin	0.37
7405	0.12	7491	0.64	745175	1.00	4028	0.65	4194	1.05	MC130P-14	0.88	81LS89	1.25
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7407	0.22	7494	0.72	74178	1.80	4031	1.85	4428	0.38	LM339-14	0.80	81LS97	1.25
7408	0.13	7495	0.50	74179	1.50	4032	0.60	4445	0.90	SN75110N	0.40	MICROPROCESSOR	
7409	0.13	7496	0.48	74180	0.85	4033	1.25	4449	0.19	SN76003N	1.60	CRYSTALS	
7410	0.11	7497	1.90	74181	0.58	4034	1.15	4501	0.18	SN76013N	1.25	FREQUENCY	
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7413	0.24	74107	0.26	74184	1.30	4038	0.95	4507	0.50	TA5550B	0.32	0.300	3.50
7413	0.24	74109	0.32	74185A	1.30	4039	2.75	4508	2.50	TA6618	0.88	1.000	3.25
7414	0.50	74110	0.36	74186	5.00	4040	0.58	4510	0.82	TBA120S	0.66	1.008	3.25
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7418	0.23	74113	0.30	74190	0.58	4042	0.67	4512	0.82	TBA800	0.78	2.000	3.25
7417	0.23	74116	1.50	74191	0.88	4043	0.80	4513	1.85	TBA810S	0.75	2.097	3.25
7420	0.11	74118	0.80	74192	0.82	4044	0.80	4514	2.30	TBA820S	0.88	2.457	3.25
7421	0.20	74119	0.50	74193	0.82	4045	1.25	4515	2.60	TC27050	1.60	3.278	2.60
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7428	0.23	74123	0.38	74197	0.58	4049	0.33	4519	0.90	REGULATORS	4.433	2.60	
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AS330	0.23	74130	0.50	74273	2.05	4053	0.72	4526	1.25	7805-T0220	0.70	5.185	2.60
7432	0.22	74132	0.55	74278	1.65	4054	1.00	4527	1.40	7812-T0220	0.70	5.875	2.60
7433	0.30	74134	0.38	74279	1.10	4055	1.05	4528	0.82	7815-T0220	0.70	6.000	2.60
7437	0.21	74135	0.70	74283	1.65	4060	1.00	4529	1.30	7824-T0220	0.70	6.144	2.60
7438	0.21	74136	0.52	74284	3.40	4061	0.48	4530	0.78	7905-T0220	0.78	6.553	2.60
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7452	0.23	74154	0.82	4009	0.40	4079	0.17	4555	0.75	GREEN	0.25	0.35	
7453	0.11	74155	0.50	4010	0.40	4082	0.18	4556	0.75	LED clip			
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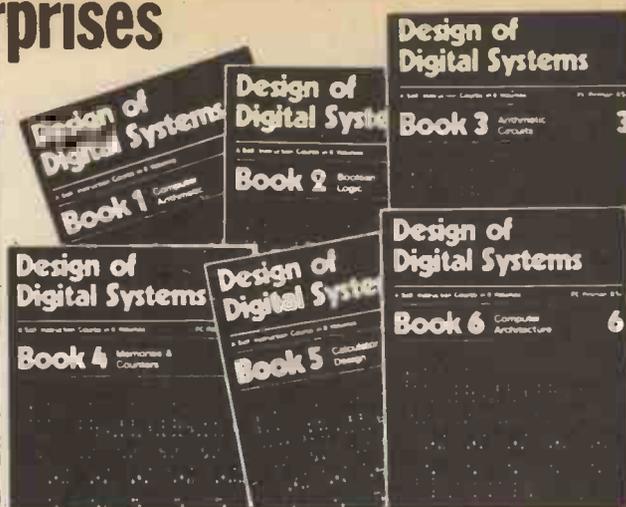
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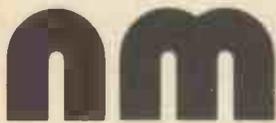
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Hours, mins, secs., month, date, day. 6 digits, 3 flags plus continuous display of day and date or seconds. Back-light. Only 9mm thick.

£12.65

Guaranteed same day despatch.



M4

MULTI ALARM 6 Digits 10 Functions

- Hours, mins., secs.
- Months, date, day.
- Basic alarm.
- Memory date alarm.
- Timer alarm with dual.
- Time and 10 country zone.
- Back-light.
- 8mm thick.

£18.65



M5

FRONT-BUTTON Alarm Chrono Dual Time

6 digits, 5 flags, 22 functions. Constant display of hours and mins., plus optional seconds or date display. AM/PM indication, month, date. Continuous display of day. Stop-watch to 12 hours 59.9 secs., in 1/10 second steps. Split and lap timing modes. Dual time zones. Only 8mm thick. Back-light. Fully adjustable open bracelet. Guaranteed same day despatch



£22.65

M6

SOLAR QUARTZ LCD Chronograph with Alarm

Dual Time Zone Facility
6 digits, 5 flags, 22 functions. Solar panel with battery back-up. 6 basic functions. Stop-watch to 12 hours 59.9 secs., in 1/10 sec., steps. Split and lap timing modes. Dual time zones. Alarm. 9mm thick. Back-light. Fully adjustable bracelet.



£27.95

M7

ALARM CHRONO with 9 world time zones

- 6 digits, 5 flags.
- 6 basic functions.
- 8 further time zones.
- Count-down alarm.
- Stop-watch to 12 hours 59.9 secs. in 1/10 sec. steps.
- Split and timing modes.
- Alarm.
- 9 mm thick.
- Back-light.
- Fully adjustable bracelet.

£29.65



M8

SOLAR QUARTZ LCD Chronograph

Powered from solar panel with battery back-up. 6 digit, 11 functions. Hours, mins, secs., day, date, day of week. 1/100th, 1/10th, secs., 10X secs., mins. Split and lap modes. Back-light, auto calendar. Only 8mm thick. Stainless steel bracelet and back. Adjustable bracelet. Metac Price

£12.65

Guaranteed same day despatch.



M9

SEIKO Alarm Chrono

LCD, hours, mins., secs., day of week, month, day and date, 24 hour Alarm, 12 hour chronograph, 1/10th secs., and lap time. Back light, stainless steel, HARDEX glass. List Price £130.00

METAC PRICE

£105.00



M10

SEIKO MEMORY BANK

Calendar watch M354
Hours, mins., secs. Month, day, date in 12 or 24 hour format all indicated continuously. Monthly calendar display month, year and all dates for any selected month over 80 year period. Memory bank function. Any desired dates up to 11 can be stored in advanced. 2 year battery life. Water resistant. List Price £130

Metac Price **£79.50** M11



M11

SEIKO-STYLE Dual time-alarm Chronograph

Mineral glass face. Battery hatch for DIY battery replacement. Top quality finish with fully adjustable bracelet.

£35.00



M12

HANIMEX Electronic LED Alarm Clock



Features and Specification:
Hour/minute display. Large LED display with p.m. and alarm on indicator. 24 Hours alarm with on/off control. Display flashing for power loss indication. Repeatable 9-minute snooze. Display bright/dim modes control. Size: 5.15" x 3.93" x 2.36" (131mm x 11mm x 60mm). Weight: 1.43 lbs (0.65 kg). AC power 220V.

£9.65 Thousands sold!

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M13

HANIMEX portable LCD clock radio



- Time set & alarm controls.
- Snooze & sleep controls.
- Wake to music or alarm.
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- Battery operated. No plug required.
- Receives all standard AM radio broadcasts.
- Drawstring carrying case included.
- Back-light.
- Batteries supplied free. **£17.95**
- Quartz crystal controlled. M14

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M15

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OUTSTANDING FEATURES

- DUAL TIME. Local time always visible and you can set and recall any other time zone (such as GMT). Also has a light for night viewing.
 - CALENDAR FUNCTIONS include the date and day in each time zone.
 - CHRONOGRAPH/STOPWATCH displays up to 12 hours, 59 minutes, and 59.9 seconds.
 - On command, stopwatch display freezes to show intermediate (split/lap) time while stopwatch continues to run. Can also switch to and from timekeeping and stopwatch modes without affecting either's operation.
 - ALARM can be set to anytime within a 24 hour period. At the designated time, a pleasant, but effective buzzer sounds to remind or awaken you!
- Guaranteed same day despatch. M16

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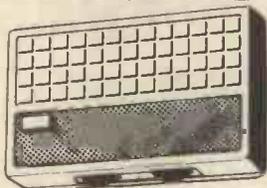
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Per stereo pair
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Belt drive chassis turntable unit semi-automatic, cueing device.

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BSR Manual single play record deck with auto return and cueing lever, lined with stereo ceramic cartridge 2 speeds with 45 r.p.m. spindle adaptor ideally suited for home or disco use.

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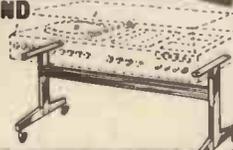
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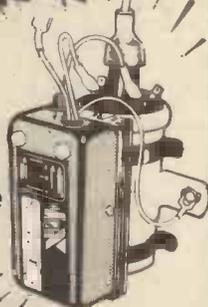
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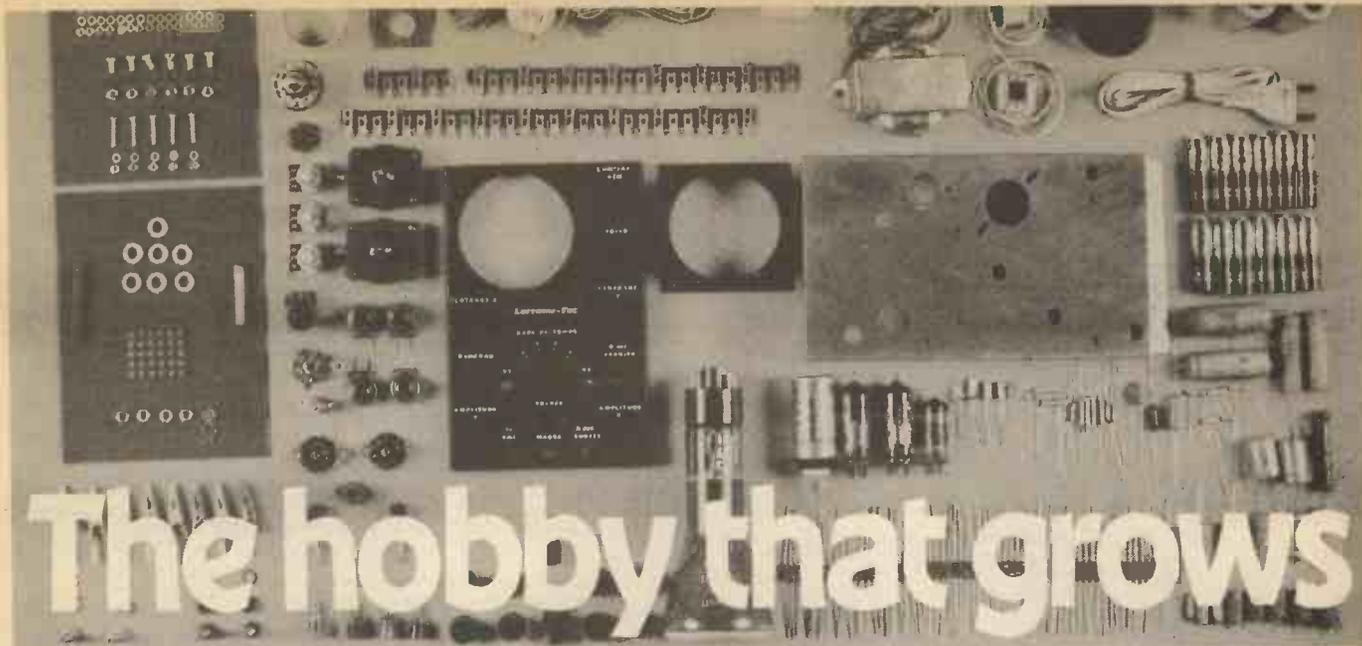
IF YOUR REQUIREMENT IS NOT FEATURED BELOW
SEND FOR OUR TRANSFORMER CATALOGUE PRICE 40p

Type	Voltage	Current	£	p/p	Type	Voltage	Current	£	p/p
06FE06	6+6	0.5A EACH	1.82	60p	60FE24	24+24	1.2A EACH	4.58	102p
08FE06	6+6	0.6A EACH	2.19	80p	80FE24	24+24	1.5A EACH	5.66	120p
12FE06	6+6	1A EACH	2.43	72p	50FE28	28+28	0.75A EACH	3.74	84p
20FE06	6+6	1.6A EACH	3.06	84p	60FE28	28+28	1.1A EACH	4.58	102p
50FE06	6+6	3A EACH	3.74	84p	80FE28	28+28	1.4A EACH	5.66	120p
60FE06	6+6	4A EACH	4.58	102p	20FE30	30+30	0.35A EACH	3.06	84p
06FE09	9+9	0.3A EACH	1.82	60p	50FE30	30+30	0.75A EACH	3.74	84p
08FE09	9+9	0.5A EACH	2.19	80p	60FE30	30+30	1A EACH	4.58	102p
12FE09	9+9	0.75A EACH	2.43	72p	80FE30	30+30	1.2A EACH	5.66	120p
20FE09	9+9	1A EACH	3.06	84p	MULTITAP RANGE VOLTAGES AVAILABLE 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30				
50FE09	9+9	2.5A EACH	3.74	84p					
60FE09	9+9	3A EACH	4.58	102p	30FE30		1A	4.00	84p
06FE12	12+12	0.25A EACH	1.82	60p	60FE36		2A	4.80	102p
08FE12	12+12	0.3A EACH	2.19	60p	80FE36		3A	5.88	120p
12FE12	12+12	0.5A EACH	2.43	72p	CENTRE TAP SECONDARY				
20FE12	12+12	0.8A EACH	3.06	84p					
50FE12	12+12	1.8A EACH	3.74	84p	06FE30	6-0-6	1.80A	1.80	60p
60FE12	12+12	2.5A EACH	4.58	102p	08FE40	9-0-9	1A	2.18	60p
80FE12	12+12	3A EACH	5.66	120p	12FE50	12-0-12	1A	2.40	72p
06FE15	15+15	0.2A EACH	1.82	60p	20FE80	20-0-20	1A	3.00	84p
08FE15	15+15	0.25A EACH	2.19	80p	50FE80	20-0-20	2A	3.70	84p
12FE15	15+15	0.4A EACH	2.43	72p	60FE100	28-0-28	2.2A	4.50	102p
20FE15	15+15	0.6A EACH	3.06	84p	80FE70	24-0-24	3A	5.66	120p
50FE15	15+15	1.5A EACH	3.74	84p	90FE50	15-0-15	6A	8.80	120p
80FE15	15+15	2A EACH	4.58	102p	90FE80	30-0-30	3A	5.86	120p
80FE15	15+15	3A EACH	5.66	120p	100FE26	26-0-26	3.5A	6.05	138p
06FE20	20+20	0.15A EACH	1.82	60p	100FE28	28-0-28	3.5A	6.05	138p
12FE20	20+20	0.25A EACH	2.43	72p	100FE30	30-0-30	3A	6.05	138p
20FE20	20+20	0.5A EACH	3.06	84p	100FE36	36-0-36	3A	6.05	138p
50FE20	20+20	1.2A EACH	3.74	84p	150FE15	15-0-15	7A	7.47	150p
60FE20	20+20	1.5A EACH	4.58	102p	150FE26	26-0-26	5A	7.47	150p
80FE20	20+20	2A EACH	5.66	120p	150FE30	30-0-30	4A	7.47	150p
48FE12	0-6-12	4A	4.58	102p	150FE36	36-0-36	4A	7.47	150p
60FE12	0-6-12	5A	5.30	102p	150FE42	42-0-42	3A	7.47	150p
70FE12	0-6-12	8A	5.66	120p	250FE28	28-0-28	8A	8.60	175p
90FE12	0-6-12	8A	6.75	138p	250FE30	30-0-30	7A	8.60	175p
12FE24	24+24	0.2A EACH	2.43	72p	250FE42	42-0-42	5.5A	8.60	175p

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Pri 220/240 sec 0-12-15-20-24-30V
12, 15, 18, 20, 24, 30V or 12V-0-12V
and 15V-0-15V.

Ref	VA	Price	P & P
112	0.5	2.90	0.90
79	1.0	3.93	1.10
3	2.0	6.35	1.10
20	3.0	6.82	1.31
21	4.0	7.19	1.31
51	5.0	10.98	1.52
117	6.0	12.29	1.67
88	8.0	16.45	1.89
89	10.0	18.89	1.89
90	12.0	21.09	2.24
91	15.0	24.19	2.39
92	20.0	32.40	O.A.

CONTINUOUS RATINGS

EX-STOCK—

+ VAT 15%

**TRANSFORMERS
END OF LINE OFFERS**

Ref	VA	Price	P & P
30-Isolator 240V:240V	200VA	£4.54	£1.04
62-Isolator 240V:240V	250VA	£5.62	£1.04
63-Isolator 240V:240V	500VA	£11.50	£2.15
6-250-0-250 @ 100ma 1)	Sec 6-3V @ 3-5A 2)	Sec	£3.20 78p
0-5V, 6-3V @ 2/1 amp			
7-350-0-350V @ 100ma 1)	Sec 6-3V @ 3-5A 2)	Sec	£4.10 96p
0-5V, 6-3V @ 2/1 amp			
220-410-0-410V @ 180ma 1)	Sec 6-3V @ 4 amp CT 2)		
Sec 6-3V @ 2A 5V @ 2 amp			
M184 - To match EL84 15W		£1.62	32p
M616 - 0-240V: Screen 1)	13-0-13 1A, 2)	12V 150ma	£2.10 60p

M489 - 0-240V: 1400V @ 150ma, 6-3V @ 4A	£5.50	£1.04
M708 - 6K to 3KΩ matching transformer 5W	90p	40p
M679 - 120V x 2: 36V 1-6A	£3.00	78p
M865 - 100V Line to 4Ω 10 watts	£1.90	60p
M973 - 100V Line to 8Ω 40 watts	£2.90	60p
M1015 - Choke 8A @ 5mH 150A Surge	£1.50	45p
M1020 - 0-240V 12-0-12V @ 50ma	97p	41p
M1126 - 120/240V: 9-0-9V @ 1A	£2.40	71p
M1130 - 0-240 4500V @ 10ma	£4.86	£1.08
M1185 - 0-115-240V: 14V 50ma	75p	30p
M624 - 0-380V: 110V @ 13-6A	£10.70	£1.40

P.W. Purbeck oscilloscope transformer 250-0-250 6-3V: 12-9V £7.51 90p

Antex Soldering Irons 15W, 25W £4.58 Safety Stand £1.75 P & P 52p each

Solderless bread boarding U. Dec B for ICs etc. £6.99 P & P 40p VAT 15%

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

Ref	12V	24V	Price	P&P
111	0.5	0.25	2.42	0.82
213	1.0	0.5	2.90	0.90
71	2	2	4.46	1.10
18	4	2	4.46	1.10
85	5	2.5	6.16	1.10
70	6	3	6.99	1.10
108	8	4	8.16	1.31
72	10	5	8.93	1.31
116	12	6	9.89	1.52
17	16	8	11.79	1.52
115	20	10	15.38	2.39
187	30	15	19.72	2.39
226	60	30	40.41	O.A.

AUTO TRANSFORMERS

Ref	VA	(Watts)	£	P&P
113	15	0-115-210-240	2.73	0.81
64	75	0-115-210-240	4.41	1.10
4	150	0-115-200-220-240	5.70	1.10
67	500	0-115-200-220-240	12.09	1.91
84	1000	0-115-200-220-240	20.84	2.39
93	1500	0-115-200-220-240	25.61	O.A.
95	2000	0-115-200-220-240	38.31	O.A.
73	3000	0-115-200-220-240	65.13	O.A.
80S	4000	0-10-115-200-220-240	84.66	O.A.
57S	5000	0-10-115-200-220-240	98.46	O.A.

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125W (AL250)	£18.74

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*P & P 33p. VAT 15% *P & P 46p

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Pri 220/240V Sec 0-20-25-33-40-50V
Voltages available 5, 7, 8, 10, 13, 15, 17, 20, 33, 40 or 20V-0-20V and 25V-0-25V.

Ref	VA	Price	P & P
102	0.5	3.75	0.90
103	1.0	4.87	1.10
104	2.0	7.88	1.31
105	3.0	9.42	1.52
106	3.0	12.82	1.73
107	6.0	16.37	1.89
118	8.0	22.29	2.39
119	10.0	27.48	O.A.
109	12.0	31.79	O.A.

MAINS ISOLATORS (SCREENED)
PM 120/240 Sec 120/240V CT

Ref	VA	Price	P & P
*07	20	4.84	0.91
149	60	7.37	1.10
150	100	10.38	1.31
151	200	12.28	1.31
152	250	14.61	1.73
153	350	18.07	2.12
154	500	22.52	2.47
156	750	32.03	O.A.
155	1000	40.82	O.A.
157	1500	56.82	O.A.
158	2000	67.99	O.A.
159	3000	96.33	O.A.

*Pri 0-220-240V Sec 115 or 240V. State sec. volts required.

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

VA	Price	P & P	Ref
20	6.88	1.03	56W
75	8.80	1.31	64W
150	11.00	1.61	4W
200	12.08	1.67	65W
250	12.82	1.67	69W
500	20.13	1.89	67W
1000	30.87	2.65	84W
1500	28.82	O.A.	93W
2000	84.97	O.A.	95W

AVO TEST METERS
AVO 8 MK5 £88-10
AVO 71 £38-00
AVO 73 £48-70
AVO MM5 minor £32-95
Vee Megger £74-25
TT169 in circuit transistor tester £39-53
EM272 316 KΩ 1 volt £57-80
DA116 digital £108-30
BMT Megger £51-76
Clamp Meter to 300A £51-90
P & P £1-32 15% VAT

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500KΩ Res. In steel case £15-85 P & P £1-32
VAT 15%

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43mm x 43mm 82mm x 78mm
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0-30V 5-95 0-30V 6-70
VU Ind. Panel 48mm x 45mm 2-60
VU Ind. Edge 54 x 14mm 250µA F.S.D. 2-60
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Ref	£	P & P
3 amp	16.17	1.70
5 amp	20.65	2.47
5 amp	29.30	2.47

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171 500mA	2.30	0.52
172 1A	3.26	0.92
173 2A	3.98	0.90
174 3A	4.13	0.99
175 4A	6.30	1.10

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SCREENED MINIATURES

Ref	mA	Volts	£	P & P
238 200	3-0-3		2.83	0.63
212 1A, 1A	0-6-0-6		3.14	0.90
13 100	0-6-0-6		2.35	0.43
235 330, 330	0-9-0-9		2.19	0.43
207 500, 500	0-8-0-8-9		3.05	0.82
208 1A, 1A	0-8-0-8-9		3.88	0.90
236 200, 200	0-15-0-15		2.19	0.43
214 300, 300	0-20-0-20		3.08	0.43
221 700(DC)	20-12-0-12-20		3.75	0.43
206 1A, 1A	0-15-0-15-20		5.09	1.10
203 500, 500	0-15-27-0-15-27		4.39	1.10
204 1A, 1A	0-15-27-0-15-27		6.64	1.10
239 50	12-0-12		2.88	0.43

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COMPONENTS
1N4148 1-4p. 1N4002 3-1p. 741 8 dil 18p. 723 14 dil 31p. NE555 8 dil 25p. bc 182b, bc183b, bc184b, bc212b, bc213b, bc214a, bc47, bc548, bc549 5p. bp315, bp2bc 28p. 1p1c, dip4c 46p. bd131, bd136 33p. plastic electrolytic bc107 5p. fuses 20mm x 5mm cartridge -15, -25, -5, 1, 2, 3, 5 amp quickblow 1p. anti-surge 3-6p. resistors 5% 1/4W E12 10R to 10M 1p. 0-8p for 50+ of one value. polyester capacitors 250v -015, -068, -1m 15p. -01, -033, -33mf 2-8p. -022, -.047mf 3-3p. -.22, -.47mf 4-9p. polystyrene capacitors E12 63v 10 to 1000pf 3p, 1n2 to 10n 4p. ceramic capacitors 50V E6 22pf to 47n 2p. electrolytic capacitors 250v -5, -1, 2mf 5p, 25v 5, 10 5p, 16v 22, 33, 47, 88mf 5p, 100mf 6p, 220mf 7 5p, 330, 470mf 9p, 1000mf 9p. zeners 400mW E24 2v7 to 33v 7p, preset pots subminiature 0-1W horiz or vert 100 to 4M7 7-2p. potentiometers 1/4W 4K7 to 2M2 log or lin single 27p, dual 78p. LEDs 9-7p. IC Sockets 8 dil 8-6p, 14 dil 10-1p, 16 dil 12p.

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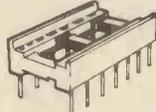
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7432	18p	74121	25p
7442	38p	74122	35p
7447	45p	74123	38p
7448	50p	74125	35p
7454	12p	74126	35p

CMOS			
4001	13p	4020	50p
4002	13p	4022	50p
4007	13p	4023	13p
4009	30p	4024	40p
4011	13p	4025	13p
4012	13p	4026	90p
4013	28p	4027	28p
4015	50p	4028	45p
4016	28p	4029	50p
4017	47p	4030	50p
4018	55p	4031	50p

FULL DETAILS IN CATALOGUE!

SKTS



Low profile by Texas

8pin	8p	18pin	14p	24pin	18p
14pin	10p	20pin	16p	28pin	22p
16pin	11p	22pin	17p	40pin	32p

Soldercon pins: 100:50p 1000:370p

PCBS

VEROBOARD

Size in.	0.1in.	0.15in.	Vero
25 x 1	14p	14p	Cutter 80p.
2.5 x 3.75	45p	45p	
2.5 x 5	54p	54p	Pin insertion tool 108p
3.75 x 5	64p	64p	
3.75 x 17	205p	185p	

Single sided pins per 100 40p 40p

Top quality fibre glass copper board. Single sided. Size 203 x 95mm. 60p each.

'Data' pens. 75p each.

Five mixed sheets of Alfac. 145p per pack.

OPTO

LED's	0.125in.	0.2in.	each	100+
Red	TIL209	TIL220	9p	7.5p
Green	TIL211	TIL221	13p	12p
Yellow	TIL213	TIL223	13p	12p

Clips 3p 3p

DISPLAYS

DL704	0.3 in CC	130p	120p
DL707	0.3 in CA	130p	120p
FND500	0.5 in CC	100p	80p

RESISTORS

Carbon film resistors. High stability, low noise 5%.

E12 series. 4.7 ohms to 10M. Any mix:

0.25W	each	100+	1000+
0.5W	1p	0.9p	0.8p
	1.5p	1.2p	1p

Special development packs consisting of 10 of each value from 4.7 ohms to 1 Meg-ohm (850 res) 0.5W £7.50. 0.25W £5.70.

METAL FILM RESISTORS

Very high stability, low noise rated at ¼W 1%. Available from 51ohms to 330k in E24 series. Any mix:

0.25W	each	100+	1000+
	4p	3.5p	3.2p

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TRANSISTORS

AC127	17p	BCY72	14p	ZTX500	16p
AC128	16p	BD131	35p	2N697	12p
AC176	18p	BD132	35p	2N3053	18p
AD161	38p	BD139	35p	2N3054	50p
AD162	38p	BD140	35p	2N3055	50p
BC107	8p	BFY50	15p	2N3442	135p
BC108	8p	BFY51	15p	2N3702	8p
BC108C	10p	BFY52	15p	2N3703	8p
BC109	8p	MJ2955	98p	2N3704	8p
BC109C	10p	MPSA06	20p	2N3705	9p
BC147	7p	MPSA56	20p	2N3706	9p
BC148	7p	TIP29C	60p	2N3707	9p
BC177	14p	TIP30C	70p	2N3708	8p
BC178	14p	TIP31C	65p	2N3819	15p
BC179	14p	TIP32C	80p	2N3820	44p
BC182	10p	TIP2955	65p	2N3904	8p
BC182L	10p	TIP3055	55p	2N3905	8p
BC184	10p	ZTX107	14p	2N3906	8p
BC184L	10p	ZTX108	14p	2N4058	12p
BC212	10p	ZTX300	16p	2N5457	32p
BC212L	10p			2N5459	32p
BC214	10p			2N5777	50p
BC214L	10p				

DIODES

1N914	3p	1N4006	6p
1N4001	4p	1N5401	13p
1N4002	4p	BZY88 ser.	8p
1N4004	4p		
4TT Full spec. product.			
1N4148	-£1.40/100. £11/1000		

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709	35p	LM350	80p	NE531	98p
741	16p	LM301AN	26p	NE555	23p
747	45p	LM308	60p	NE566	60p
748	30p	LM318N	75p	NE567	100p
7106	850p	LM324	45p	RC4136	100p
7107	900p	LM339	45p	SN76477	230p
CA3046	55p	LM378	230p	TBA800	70p
CA3080	70p	LM379S	410p	TBA810S	60p
CA3130	90p	LM380	75p	TDA1022	220p
		LM3900	50p	TL081	45p
		LM3909	65p	TL084	125p
		LM3911	100p	ZN414	80p
		MC1458	32p	ZN425E	390p
		MM57160	590p	ZN1034E	200p

CAPACITORS

TANTALUM BEAD

0.1, 0.15, 0.22, 0.33, 0.47, 0.68, 1 & 2.2uF @ 35V	8p
4.7, 6.8, 10uF @ 25V	13p
22 @ 16V, 47 @ 6V, 100 @ 3V	16p

MYLAR FILM

0.001, 0.01, 0.022, 0.032, 0.047, 0.068, 0.1	3p
	4p

POLYESTER

Mullard C280 series

0.01, 0.015, 0.022, 0.033, 0.047, 0.068, 0.1	5p
0.15, 0.22	7p
0.33, 0.47	10p
0.68	14p
1.0uF	17p

CERAMIC

Plate type 50V. Available in E12 series from 22pF to 1000pF and E6 series from 1500pF to 0.047uF

RADIAL LEAD ELECTROLYTIC

63V	0.47	1.0	2.2	4.7	10	5p
						7p
						13p
						20p
25V	10	22	33	47		5p
						8p
						10p
						15p
						23p

CONNECTORS

JACK PLUGS AND SOCKETS

	screened	unscreened	socket
2.5mm	9p	13p	7p
3.5mm	9p	14p	8p
Standard	18p	30p	15p
Stereo	23p	36p	18p

DIN PLUGS AND SOCKETS

	plug	chassis socket	line socket
2pin	7p	7p	7p
3pin	11p	9p	14p
5pin 180°	11p	10p	14p
5pin 240°	13p	10p	16p

1mm PLUGS AND SOCKETS

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4mm PLUGS AND SOCKETS

Available in blue, black, green, brown, red, white and yellow. Plugs: 11p each Sockets: 12p each

PHONO PLUGS AND SOCKETS

Insulated plug in red or black	9p
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Single socket	7p
Double socket	10p

LOUDSPEAKERS

56mm dia. 8ohms. 70p 64mm dia. 64ohms. 75p
64mm dia. 8ohms. 75p 70mm dia. 8ohms. 100p

Magnetic earpiece including 2.5 or 3.5mm plug. 15p each
Crystal earpiece including 3.5mm plug. 30p each

TRANSFORMERS

All 240V Primary.

0 - 6, 0 - 6 @ 0.5A or 0 - 9, 0 - 9 @ 0.4A.	175p
0 - 12, 0 - 12 @ 0.5A or 0 - 15, 0 - 15 @ 0.4A	235p
0 - 9, 0 - 9 @ 1.2A or 0 - 12, 0 - 12 @ 1A.	345p
0 - 12 - 15 - 20 - 24 - 30V @ 1.5A.	455p
0 - 20 - 25 - 33 - 40 - 50V @ 1A.	455p
0 - 20 - 25 - 33 - 40 - 50V @ 2A.	585p
0 - 20 - 25 - 33 - 40 - 50V @ 3A.	715p

Miniature type
6 - 0 - 6, 9 - 0 - 9, 12 - 0 - 12 @ 100mA. 95p

SOLDERING IRONS

ANTEX X25 (25W) or ANTEX CX (17W) 390p each
Reel of solder (39.6M) 240p each

POTENTIOMETERS

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Dual gang Log or Lin 5K - 2M2 80p each
Presets, sub min. type hor. or vert. 100Ω - 2M2 6p each

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SWITCHES

Subminiature toggle. SPDT 70p. DPDT 80p.
Standard toggle. SPST 34p. DPDT 48p.



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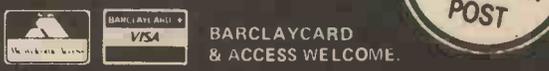
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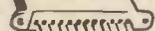
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SN74420N	0.55	74LS83AN	0.90	74LS197N	0.80	SN74S01N	0.77
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SN74555N	0.26	74LS189N	1.00	74LS393N	0.50	SN74S151N	0.76
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SN74574N	0.42	74LS192N	0.95	74LS398N	1.90	SN74S154N	1.20
SN74579N	0.42	74LS193N	0.95	74LS399N	1.65	SN74S155N	0.70

TRANSISTORS (see catalogue for full range)

2N235	0.30	2N708	0.30	2N1420	0.55	2N2219	0.38	40081	1.20	AC188	0.54	BC118	0.22	BCY33A	1.10	80140	0.43	BF157	0.48
2N388	0.80	2N718	0.30	2N1483	1.85	2N2219A	0.39	40232	0.60	AD188K	0.65	BC119	0.33	BCY34A	1.10	80142	0.70	BF159	0.37
2N389A	0.77	2N718A	0.50	2N1485	2.20	2N2220	0.39	40233	0.70	AD136	2.75	BC122	0.61	BCY38	2.20	80X14	1.32	BF160	0.40
2N398	0.80	2N720A	0.35	2N1501	0.35	2N2221	0.25	40234	0.65	AD142	1.45	BC123	0.65	BCY40	1.95	80X18	1.90	BF161	0.33
2N456	2.20	2N721	1.05	2N1524	0.60	2N2221A	0.25	40237	0.85	AD143	1.45	BC125	0.62	BCY42	0.85	80X32	2.67	BF168	0.44
2N489	4.90	2N722	0.45	2N1553	1.50	2N2222	0.25	40242	0.66	AD149	2.85	BC132	0.33	BCY43	0.76	80Y11	3.30	BF167	0.37
2N489A	5.40	2N727	0.50	2N1613	0.30	2N2222A	0.25	40251	1.15	AD150	3.10	BC134	0.22	BCY54	2.40	80Y17	3.30	BF170	0.76
2N489B	5.90	2N744	0.35	2N1637	0.72	2N2223	0.27	40254	0.96	AD161	1.00	BC135	0.22	BCY58	0.27	80Y18	3.30	BF173	0.35
2N490	4.99	2N753	0.35	2N1638	0.70	2N2223A	0.28	40264	0.95	AD162	1.00	BC138	0.21	BCY59	0.27	80Y20	1.10	TPF90	0.85
2N490B	6.50	2N760	0.35	2N1711	0.30	2N2224	0.48	40260	3.90	AF105	0.60	BC137	0.22	BCY68	2.20	80Y23	2.45	TP30A	0.54
2N490C	6.90	2N869	0.35	2N1889	0.30	2N2303	1.54	40309	0.60	AF108	0.82	BC138	0.44	BCY67	2.70	80Y24	2.85	TP30C	0.70
2N491A	5.75	2N914	0.38	2N1890	0.30	2N2368	0.27	40310	0.85	AF114	0.70	BC140	0.30	BCY70	2.01	80Y25	2.85	TP31A	0.54
2N491B	6.25	2N916	0.33	2N1893	0.30	2N2369	0.27	40311	0.55	AF115	0.70	BC141	0.32	BCY71	0.26	80Y38	1.10	TP31C	0.72
2N491	7.50	2N917	0.38	2N1907	0.55	2N2369A	0.27	40312	0.99	AF116	0.70	BC142	0.32	BCY72	0.18	80Y54	1.55	TP32A	0.59
2N492	6.25	2N918	0.45	2N1974	0.58	2N2405	0.66	40313	1.38	AF117	0.70	BC143	0.32	BCY77	0.70	80Y55	1.90	TP32C	0.59
2N492A	6.75	2N929	0.37	2N1990	0.45	3N81	3.50	40315	0.60	AF118	0.70	BC152	0.38	BCY78	0.43	80Y56	2.10	TP33A	0.86
2N492B	7.25	2N930	0.37	2N1991	0.45	3N82	3.25	40316	0.95	AF126	1.45	BC153	0.65	BCY79	0.41	80Y57	5.90	TP33C	1.18
2N492C	6.90	2N930A	0.37	2N20670	1.00	3N128	3.50	40317	0.60	AF125	0.70	BC154	0.30	BCY87	5.35	80Y58	5.50	TP34A	0.87
2N493A	7.99	2N930A	0.95	2N2102	0.50	3N139	1.60	40324	0.95	AF126	0.70	BC160	0.38	BCY88	3.99	80Y60	1.65	TP34C	1.13
2N493B	8.76	2N1131	0.32	2N2147	1.55	3N140	1.10	40325	1.35	AF139	0.75	BC161	0.38	BCY89	3.80	80Y61	2.75	TP35A	2.20
2N494	6.90	2N1132	0.35	2N2160	1.55	3N141	0.95	40326	0.48	AF172	0.70	BC175	0.43	80Y115	0.80	80Y62	2.75	TP36A	2.00
2N494A	7.65	2N1204	1.65	2N2192	0.58	3N142	0.70	40327	0										

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'Group 100'	'Group 35'	'Group 50/15'
12 inch 100 watt	12 inch 40 watt	15 inch 75 watt
£29	£15	£35
8 or 16 ohm	4 or 8 or 16 ohm	8 or 16 ohm

BAKER LOUDSPEAKER, 12 INCH, 60 WATT.
GROUP 50/12, 4 OR 8 OR 16 OHM HIGH POWER.
FULL RANGE PROFESSIONAL QUALITY.
RESPONSE 30-16,000 CPS
MASSIVE CERAMIC MAGNET
WITH ALUMINIUM PRESENCE CENTRE DOME. **£23**

4 CHANNEL TRANSISTOR MONOMIXER
Add musical highlights and sound effects to recordings. Will mix Microphone, records, tape and tuner with separate controls into single output. 9 volt battery operated. **£7.50**
Two channel stereo version - £9.

HEATING ELEMENTS WAFER THIN
Size 10 1/2 x 8 1/2 x 1/4 in. Operating voltage 200/250V a.c. 250W approx. Suitable for Heating Pads, Food Warmers, Convector Heaters, etc. Must be clamped between two sheets of metal or similar. ALL POST PAID - Discounts for quantity.
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MINI MODULE BAFFLE KIT Post 75p
EMI 15 x 8 1/2 in. 3-way Loudspeaker System 5in. Bass 5in. Middle 3in Tweeter with 3-way Crossover & Ready Cut Baffle. Full assembly instructions supplied. Response=60 to 20 000 C.P.S. 12 watt RMS. 8 ohms. £10.95 per kit. Two kits £20.
Suitable Bookshelf Cabinet £9.50 each.



SINGLE RECORD PLAYER
Fitted with auto stop, stereo cartridge. Baseplate. Size 11 x 8 1/2 in. Turntable Size 7in. diameter a.c. mains 240V 3 speeds plays all size records. **£7.95**
Two for £16. Post 75p.

NEW BSR SINGLE PLAYER £24.50
Model P182 3-speeds flared aluminium turntable. Post £1. "S" shaped arm, cueing device, stereo ceramic cartridge.
B.S.R. De-Luxe Autochanger with stereo cartridge, plays all size records. P. & P. £1. **£20.00**

BAKER 150 WATT ALL PURPOSE TRANSISTOR MIXER AMPLIFIER
Ideal for Groups, Disco, P.A. and Musical Instruments. 4 inputs speech and music 4 way mixing.
Output 4/8/16 ohm, a.c. Mains 240V.
Separate treble and bass controls.
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BAKER COMPACT 50 WATT AMPLIFIER
IDEAL FOR DISCOS, GROUPS, PUBLIC ADDRESS
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R.C.S. SOUND TO LIGHT DISPLAY MK II
Complete kit of parts with R.C.S. printed circuit. Three 1000W channels. Will operate from 200mV signal source. CABINET extra £4. **KIT = £18.00**

R.C.S. 10 WATT AMPLIFIER KIT
This kit is suitable for record players, tape play back, guitars electronic instruments or small PA systems. Two versions are available. The mono kit uses 13 semiconductors. The stereo kit uses 22 semiconductors. Both kits have printed front panel and volume bass and treble controls. Spec. 10W output into 8 ohms 7W into 16ohms. Response 20c to 20Kc. Input 100mV. high Imp. Size 9 1/2 x 3 x 2 1/2 in. A/C mains operated
Mono kit **£12.50** Stereo kit **£20** Post 45p
Easy to build. Full instructions supplied

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1, 2, 4, 5, 8, 16, 25, 30, 50, 100, 200mF 15V 10p. 500mF 12V 15p; 25V 20p; 50V 30p. 1000mF 12V 17p; 25V 35p; 50V 47p; 100V 70p. 2000mF 40V 60p; 25V 42p; 2500mF 50V 62p. 3000 mF 25V 47p; 50V 65p; 2700mF 76V £1. 4700mF 63V £1.20. 5000mF 6V 25p; 12V 42p; 25V 75p; 35V 85p. 5600mF 76V £1.76. 1200mF 76V 60p.

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8/350V 22p 8+8/450V 50p 50+50/300V 50p
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32/500V 75p 16+16/450V 50p 100+100/275V 65p
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Sizes: 14 1/2 x 12 1/2 x 4 1/2 in. £3. 16 x 14 x 3 1/2 in. £5. 15 1/2 x 13 1/2 x 4 in. £4. 17 1/2 x 9 1/2 x 3 1/2 in. £3. 14 1/2 x 14 1/2 x 2 1/2 in. Rosewood sides £4. 18 x 13 1/2 x 3 in. £6. 18 x 12 1/2 x 3 in. £6.
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1.5V d.c. operation over 300 hours continuous on SP2 battery fully adjustable swing and speed. Ideal displays teaching electro magnetism or for metronome. strobe. etc

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3A. 6. 8. 10. 12. 16. 18. 20. 24. 30. 36. 40. 48. 60	£12.50
5A. 6. 8. 10. 12. 16. 18. 20. 24. 30. 36. 40. 48. 60	£16.00
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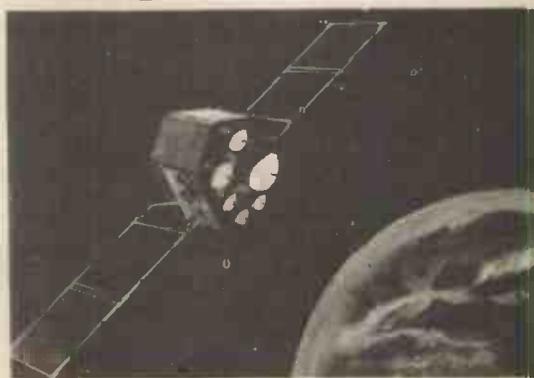
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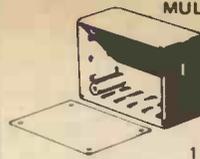
BIMENCLOSURES



ALL METAL BIMCASES
Red, Grey or Orange 14swg Aluminium removable top and bottom covers. 18 swg black mild steel chassis with fixing support brackets.
BIM 3000
(250x167.5x68.5mm) £15.52



MINI DESK BIMCONSOLES
Orange, Blue, Black or Grey ABS body incorporates 1.8mm pcb guides, stand-off bosses in base with 4 BIMFEET supplied. 1mm Grey Aluminium panel sits recessed with fixing screws into integral brass bushes.
BIM 1005 (161 x 96 x 58mm) £2.48
BIM 1006 (215 x 130 x 75mm) £3.48



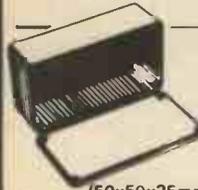
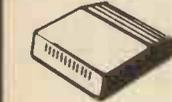
MULTI PURPOSE BIMBOXES
Orange, Blue, Black or Grey ABS with 1mm Grey Aluminium recessed front cover held by screws into integral brass bushes. 1.8mm pcb guides incorporated and 4 BIMFEET supplied.
BIM 4003 (85x56x28.5mm) £1.34
BIM 4004 (111x71x41.5mm) £1.84
BIM 4005 (161x96x52.5mm) £2.48

ALL METAL BIMCONSOLES



All aluminium, 2 piece desk consoles with either 15° or 30° sloping fronts, sit on 4 self-adhesive non-slip rubber feet. Ventilation slots in base and rear panel for excellent cooling. See latest catalogue for new styles and sizes

15° Sloping Panel		30° Sloping Panel		Colour Code	Top Panel	Base
BIM7151 (102x140x51[28] mm)	BIM7301 (102x140x76[28] mm)	£11.36	A	OffWhite	Blue	
BIM7152 (165x140x51[28] mm)	BIM7302 (165x140x76[28] mm)	£12.28	B	Sand	Green	
BIM7153 (165x216x51[28] mm)	BIM7303 (165x183x102[28] mm)	£13.43	C	Satin Black	Gold	
BIM7154 (165x211x76[33] mm)	BIM7304 (254x140x76[28] mm)	£14.83				
BIM7155 (254x211x76[33] mm)	BIM7305 (254x183x102[28] mm)	£16.36				
BIM7156 (254x287x76[33] mm)	BIM7306 (254x259x102[28] mm)	£17.71				
BIM7157 (356x211x76[33] mm)	BIM7307 (356x183x102[28] mm)	£18.83				
BIM7158 (356x287x76[33] mm)	BIM7308 (356x259x102[28] mm)	£19.92				



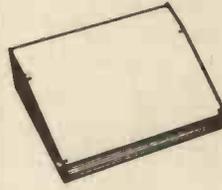
ABS & DIECAST BIMBOXES

6 sizes in ABS or Diecast Aluminium. ABS moulded in Orange, Blue, Black or Grey. Diecast Aluminium in Grey Hammertone or Natural. All boxes incorporate 1.8mm pcb guides, stand-off supports in base and have close fitting flanged lids held by screws into integral brass bushes (ABS) or tapped holes (Diecast).

	ABS		Diecast		Hammertone	Natural
(50x50x25mm)	N/A		BIM5001/11	£1.54	£1.23	
(100x50x25mm)	BIM2002/12	£1.09	BIM5002/12	£1.66	£1.32	
(112x62x31mm)	BIM2003/13	£1.27	BIM5003/13	£2.24	£1.70	
(120x65x40mm)	BIM2004/14	£1.51	BIM5004/14	£2.81	£2.11	
(150x80x50mm)	BIM2005/15	£1.72	BIM5005/15	£3.19	£2.72	
(190x110x60mm)	BIM2006/16	£2.69	BIM5006/16	£4.94	£3.96	

Also available in Grey Polystyrene with no slots and self-tapping screws
BIM 2007/17 (112x61x31mm) £1.06

LOW PROFILE BIMCONSOLES



Orange, Blue, Black or Grey ABS body has ventilation slots as well as 1.8mm pcb guides and stand-off bosses in base. Double angle recessed front panel with 4 fixing screws into integral brass bushes. 4 BIMFEET supplied.

BIM 6005 (143 x 105 x 55.5 [31.5] mm)	£2.76
BIM 6006 (143 x 170 x 55.5 [31.5] mm)	£3.58
BIM 6007 (214 x 170 x 82.0 [31.5] mm)	£4.83

EUROCARD BIMCONSOLES



Orange, Blue, Black or Grey ABS body accepts full or 1/2 size Eurocards, with bosses in the base for direct fixing. 1.8mm wide pcb guides incorporated and 4 BIMFEET supplied. 1mm Grey aluminium lid sits flush with body top and held by 4 screws into integral brass bushes.

BIM 8005 (169x127x70[45]mm)	£4.71
BIM 8007 (243x187x103[66]mm)	£6.70

BIMTOOLS + BIMACCESSORIES



MAINS BIMDRILLS

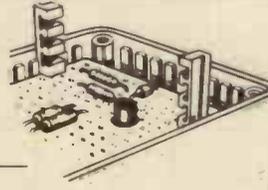
Small, powerful 240V hand drill complete with 2 metres of cable and 2 pin DIN plug. Accepts all tools with 1mm, 2mm or .125" dia. shanks. Drills brass, steel, aluminium and pcb's. Under 250g, off load speed 7500 rpm. Orange ABS, high impact, fully insulated body with integral on/off switch £11.21

Mains Accessory Kit 1 includes 1mm, 2mm, .125" twist drills, 5 burrs and 2.4mm collet £2.64

Mains Kit 2 includes Mains BIMDRILL as above, 20 assorted drills, mops, burrs, grinding wheels and mounted points, 1mm, 2mm, 2.4mm and .125" collets. Complete in transparent case measuring 230x130x58mm £23.57

BIMDAPTORS

Allows pcb's to be flat mounted sandwich fashion in BIMBOXES, BIMCONSOLES, and all other enclosures having 1.5mm wide vertical guide slots. One plastic BIMDAPTOR on each corner of pcb(s) enables assembly to be simply slid into place. 54mm long, 10 slots on 5mm spacing and can be simply snapped off to length. £1.15 per pack of 25.



BIMFEET

11mm dia. 3mm high, grey rubber self-adhesive enclosure feet. £0.81 per pack of 24.

12 VOLT BIMDRILLS

2 small, powerful drills easily hand held or used with lathe/stand adaptor. Integral on/off switch and 1 metre cable.

Mini BIMDRILL with 3 collets up to 2.4mm dia. £ 8.62
Major BIMDRILL with 4 collets up to 3mm dia. £14.49

Accessory Kits 1 have appropriate drills and collets as above plus 20 assorted tools. Mini Kit 1 - £16.10, Major Kit 1 - £20.70. Accessory Kits 2 have appropriate drills, collets plus 40 tools and mains-12V dc adaptor. Mini Kit 2 - £36.22, Major Kit 2 - £41.97. Accessory Kits 3 as appropriate Kits 2 plus stand/lathe unit. Mini Kit 3 - £48.30, Major Kit 3 - £54.05.

BIMPUMPS

2 all metal desoldering tools provide high suction power and have easily replaceable screw in Teflon tips. Primed and released by thumb operation with in-built safety guard and anti-recoil system.
BIMPUMP Major (180mm long) £8.51
BIMPUMP Minor (150mm long) £7.24



BIMIRONS

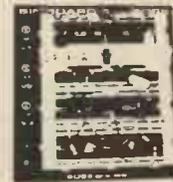
Type 30 General Purpose 27 watt iron with long life, rapid change element, screw on tip, stainless steel shaft and clip on hook. Styled handle with neon. £4.37
Type M3 Precision 17 watt iron, quick change tip, long life element, styled handle with clip on hook. £4.71



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DIL COMPATIBLE BIMBOARDS



Accept all sizes (4-50 pin) of DIL IC packages as well as resistors, diodes, capacitors and LEDs. Integral Bus Strips up each side for power lines and Component Support Bracket for holding lamps, switches and fuses etc. Available as single or multiple

units, the latter mounted on 1.5mm thick black aluminium back plate which stand on non slip rubber feet and have 4 screw terminals for incoming power.

BIMBOARD 1 has 550 sockets, multiple units utilising 2, 3 and 4 BIMBOARDS incorporate 1100, 1650 and 2200 sockets, all on 2.5mm (0.1") matrix.

BIMBOARD 1	£ 8.23
BIMBOARD 2	£19.99
BIMBOARD 3	£29.07
BIMBOARD 4	£38.14

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1, 2, or 3 BIMBOARDS mounted on BIM 6007 BIMCONSOLE with Integral Power Supply (±5 to ±15Vdc @ 100mA and fixed +5Vdc @ 1A) All O/P's fully isolated. Short circuit and fast fold back protection. Power rails brought out to cable clamps that accept stripped wire or 4mm plug.

DESIGNER 1	£58.65
DESIGNER 2	£64.97
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AA32	0-48	BCY72	0-15	MPSU66	0-56	1N4001	0-07	7407	0-46
AA33	0-21	BCZ11	1-72	NE555	0-52	1N4002	0-07	7408	0-23
AA35	0-39	BD115	0-52	NKT401	2-30	1N4003	0-08	7409	0-23
AA37	0-31	BD121	1-38	NKT403	1-99	1N4004	0-08	7410	0-18
AC107	0-69	BD123	1-38	NKT404	1-99	1N4005	0-09	7411	0-30
AC125	0-23	BD124	1-50	OA5	1-09	1N4006	0-09	7413	0-37
AC126	0-23	BD131	0-40	OA7	0-63	1N4007	0-10	7416	0-37
AC127	0-23	BD132	0-44	OA10	0-74	1N4009	0-17	7417	0-37
AC128	0-23	BD135	0-39	OA47	0-16	1N4148	0-07	7420	0-20
AC141	0-29	BD136	0-39	OA70	0-38	1N5400	0-15	7422	0-23
AC141K	0-40	BD137	0-40	OA79	0-35	1N5401	0-15	7423	0-37
AC142	0-23	BD138	0-46	OA81	0-36	1S44	0-05	7425	0-35
AC142K	0-38	BD139	0-49	OA85	0-35	1S920	0-08	7427	0-35
AC176	0-23	BD140	0-51	OA90	0-09	1S921	0-08	7428	0-49
AC187	0-23	BD144	2-30	OA91	0-09	2G301	1-15	7430	0-20
AC188	0-23	BD181	1-26	OA95	0-09	2G302	1-15	7432	0-35
ACY17	0-98	BD182	1-36	OA200	0-10	2G306	1-27	7433	0-37
ACY18	0-92	BD237	0-46	OA202	0-10	2N404	1-15	7437	0-37
ACY19	0-86	BD238	0-63	OA211	1-15	2N696	0-29	7438	0-37
ACY20	0-80	BDX10	1-05	OAZ200	1-15	2N697	0-29	7440	0-21
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ACY39	1-72	BDY20	1-44	OAZ206	1-15	2N705	1-38	7442	0-83
AD149	0-80	BDY60	1-72	OAZ207	1-15	2N706	0-17	7447A	1-04
AD181	0-40	BF115	0-40	OC16	2-30	2N708	0-23	7450	0-37
ASZ15	1-44	BF129	0-21	OC20	2-88	2N930	0-23	7451	0-21
AF106	0-52	BF153	0-23	OC22	2-88	2N1131	0-30	7453	0-21
AF114	0-86	BF154	0-20	OC23	3-16	2N1132	0-30	7454	0-21
AF115	0-86	BF159	0-26	OC24	3-45	2N1302	0-40	7460	0-21
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AF239	0-52	BF178	0-28	OC35	1-73	2N1307	0-58	7475	0-62
AFZ11	3-16	BF179	0-29	OC36	1-73	2N1308	0-63	7476	0-46
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AU113	1-96	BF197	0-14	OC75	0-74	2N2221	0-21	7494	0-92
AU110	1-96	BF200	0-31	OC76	0-63	2N2222	0-21	7495	0-83
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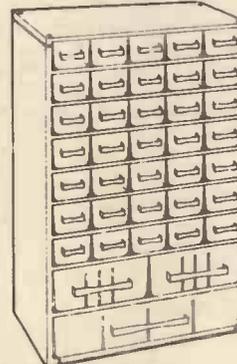
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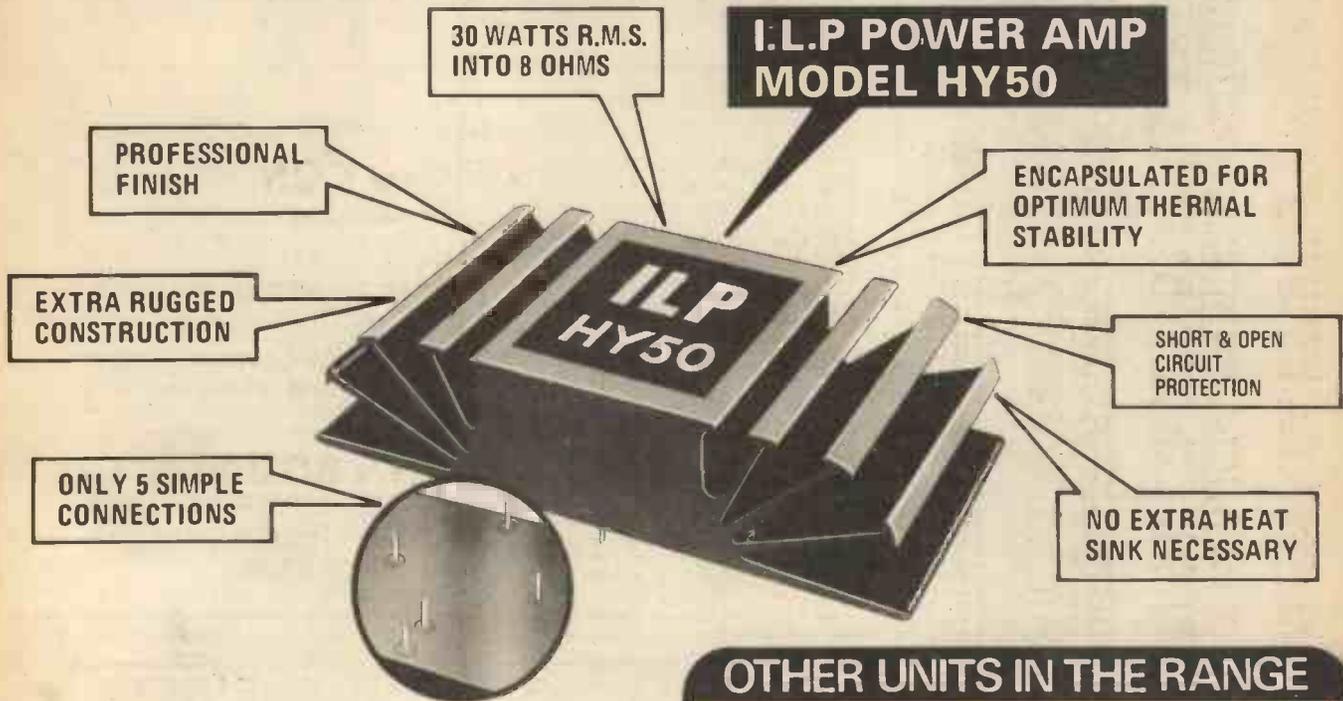
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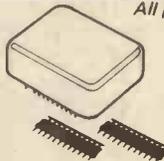
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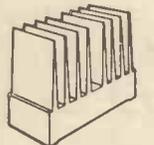
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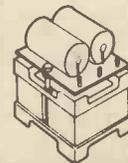
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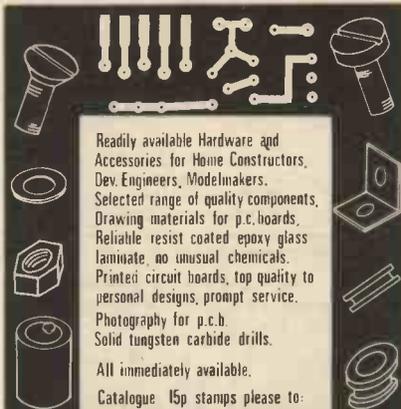
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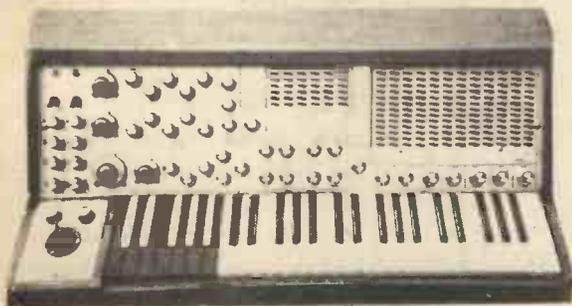
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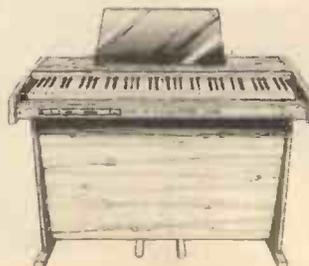
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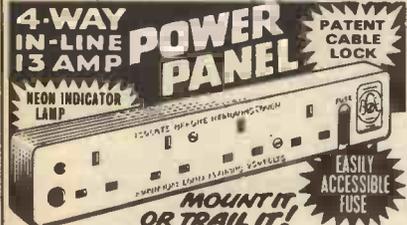
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INDEX TO ADVERTISERS

Acorn Computers	75	Kay & Co.	6
Adam Hall (P.E. Supplies)	93	L & B Electronics	11
Aitken Bros	78	Maclin-Zand	86
Astra Pak	76	Maplin Electronics	Cover IV
Aura Sounds	90	Marshall A. (London) Ltd.	87
A.U.S.	92	Metac	71, 79
Barrie Electronics	84	Mhel Electronics	94
Bi-Pak	4, 5	Microdigital	78
Bi-Pre-Pak	12	Mill Hill Supplies	90
Birkett J.	76	Modern Book Co.	95
Boffin Projects	93	Monolith	12
Boss Industrial	89	Newtronics	12
Breadboard	49	Noble Electronics	12
Brewster S.R.	3	P.H.W.K. & I. Yates	93
British National Radio & Electronics School	7, 83, 88	P.K.G. Electronics	94
Calscope	8	Pawbrooks	92
Cambridge Learning	77	Phonosonics	10, 11
Chromasonic	86	Progressive Radio	90
Chromatronics	80	Proto Design	94
Clef Products	94	Radio Component Specialists	88
Codespeed	86	Ramar Constructor Service	93
Commodore Business Machines	55	R.S.T. Valve Mail Order	90
Computer Components (Teleplay)	Cover II	Radio & T.V. Components	81
Continental Specialties Corporation U.K. Ltd	31	Romane Electronics	64
Crescent Radio	80	Sandwell Plant Ltd.	93
Crimson Elektrik	31	Saxon Entertainments	9
Crofton Electronics	8	Science of Cambridge	41
C.R. Supply Co.	92	Scientific Wire Co.	94
Delta Tech	80	Seahorse Electronics Ltd.	93
Digisound	6	Sentinel Supply	78
Dudley & Co. Ltd., John	94	Service Trading	Cover III
Ecoscope Instruments Ltd.	93	Sparks Developments	84
E.D.A.	82	Squires, Roger	3
Electronic Mail Order Ltd.	92	Stevens Electronic Components	85
Electrovalue	78	Sumico Ltd.	8
Fladar	82	Swanley Electronics	84
Flairline Supplies	95	Tandy	15
Fringewood Electronics	11	T.K. Electronics	14
Heathkit	64	Technomatic	96
Hiykon Ltd.	94	Tempus	95
Home Radio	14	Transam Components	13
H.S.B.C.	8	T.U.A.C.	63
I.C.S. Intertext	14, 92	Watford Electronics	2, 3, 16
I.L.P. Electronics	91	William Stuart Systems Ltd	94
Jayen Developments	6	Williamson Amplification	93
J.W.B. Radio	92	Wilmslow Audio	82

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325p Spool spool 100p Wire 80p Combes 7p each NE561B 425p NE565 130p NE566 130p NE567 175p NE567 175p NE571 425p RC4151 400p SAD1024A 1250p SFF9364 1150p SN76023N 175p SN76013N 175p SN76013ND 120p SN76023N 140p ICL7106 850p ICL8038 340p SN76477 250p SP8515 75p TAA121 275p TBA614B11 225p LM311 120p LM318 120p TBA800 90p LM319 200p LM324 75p LM339 75p LM347 95p TCA4500A 250p TD1A004A 300p TD1A008 320p TD1A010 225p TD1A022 60p TD1A024 120p TD1A034B 250p TD1A170 250p TD2A020V 325p TD2A020 320p TL071 60p TL072 60p TL074 150p TL082 90p TL084 130p TL170 50p UDN6118 320p UDN6184 320p ULN2003 100p KR2206 350p 5101 110p 6810 350p KR2216 675p KR2240 400p ZNA14 700p LM319 90p ZN424E 135p ZN425E 400p IN1034E 200p 95H90 800p	TRANSISTORS *BF881 25p *AC127/28 25p *AC176/28 25p *AC187/28 25p *AF16/7 30p *AD149 70p *AD161/2 45p *AU107 250p *BC107/8 11p *BC109 11p *BC117 12p *BC149 10p *BC157/8 10p *BC159 12p *BC166 12p *BC177/8 17p *BC179 17p *BC182/3 11p *BC184 11p *BC185 11p *BC192 12p *BC193 12p 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RELAYS SIEMENS, PLESSEY, etc.

RELAYS WIDE RANGE OF A.C. and D.C. RELAYS AVAILABLE from stock phone or write in your enquiries

FT3 NEON FLASH TUBE

High intensity multi turn high voltage, neon glow discharge flash tube. Design for ignition timing etc. £1.50, P. & P. 25p (£2.01 inc. VAT) 3 for £3, P. & P. 50p (£4.03 inc. VAT & P.).

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Magnetic Devices, 240V, A.C. Intermittent operation. Approx. 20 lb. pull at 1.25 in. Ex-equip. Tested. Price: £4.75 + 75p P. & P. (£6.33 inc. VAT & P.).

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P. & P. 35p (£3.85 inc. VAT & P.). N.M.S.

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D.P. C/O lever m/s switch mfg. by Cherry Co. USA. Precious metal low resistance contacts. 10 for £2.25 P. & P. 30p. Total inc. VAT £2.93 (min 10).

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Size 27mm x 5mm, 10 for £5.00 (inc. VAT £6.12) min quantity 10. 30p P. & P.

Heavy duty type, size 38 x 16 x 10mm, minimum quantity 10. £7.50 post paid (£8.63 inc. VAT & P.).

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Crouzet 1 rpm, 115V, A.C. Motor operating 2 Roller Micro switches (4 mm). Can be used on 240V, A.C. with either 0.25 mfd 250V, Condenser or 5-6K wirewound Resistor 7 watt. (not supplied). Price: £2.50 + 50p P. & P. (£3.45 inc. VAT & P.).

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Type L56/L11. Coil 240V 50 Hz. Contacts - 3 make: 600V; 20amp, 1 break: 600V; 20 amp. Price: £5.50 + 50p P. & P. (£6.90 inc. VAT & P.).

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16" 022 220 240V A.C. Aperture 10 x 4 1/2cm overall size 16 x 14cm. Price: £3.75 P. & P. 75p (inc. VAT £5.18).

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Precision 24 volt, D.C. 0-8 amp Blower that works well on 12V 0-4 amp D.C. Producing 30 cu.ft. min at normal air pressure. £4.50 P. & P. 75p (inc. VAT £6.04). N.M.S.

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Powerful continuously rated a.c. motor complete with 5 blade 6 1/2 in. or 4 blade 3 in. aluminium fan. Price £3.00, P. & P. 65p. (£4.20 inc. VAT & P.).

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INPUT 230/240V a.c. 50/60 OUTPUT

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3 KVA (15 amp MAX) £45.50
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10 KVA (50 amp MAX) £168.00
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25-0-25V at 2 1/2 amp £4.50 P. & P. 75p (£6.04 inc. VAT & P.)
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0.6V/12V at 20 amp £14.70 P. & P. £1.50 (£18.63 inc. VAT)
0-12V at 20 amp or 0-24V at 10 amp £12.00 P. & P. £1.50 (£15.53 inc. VAT & P.)
0-6V/12V at 10 amp £8.25 P. & P. £1.25 (£10.93 inc. VAT)
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Other types in stock, phone for enquiries or send see for leaflet.

HY-LIGHT STROBE KIT MK IV

Latest type Xenon white light flash tube. Solid state timing and triggering circuit: 230/240V a.c. operation. Designed for larger rooms, halls, etc. Speed adjustable 1-20 f.p.s. Light output greater than many Iso (called 4 Joule) strobes. Price £19.00. Post £1 (£23.00 inc. VAT & P.). Specially designed case and reflector for Hy-Light £8.80. Post £1 (£11.27 inc. VAT & P.).

XENON FLASHGUN TUBES

Range available from stock S A E for details



ULTRA VIOLET BLACK LIGHT

FLUORESCENT TUBES

4ft. 40 watt £10.00 (callers only) 2ft. 20 watt £8.20. Post 75p. (£7.99 inc. VAT + P.) (For use in stan bin-pin fittings) Mir 12 in. 8 watt £2.80. Post 35p. (£3.62 inc. VAT + P.). 9 in. 6 watt £2.25. Post 35p. (£2.99 inc. VAT + P.). 6 in. 4 watt £2.25. Post 35p. (£2.99 inc. VAT + P.).

Complete ballast unit, for either 6", 9" or 12" tube 230V AC op. £3.50. Post 45p. (£4.54 inc. VAT + P.). Also available for 12V DC op. £3.50. Post 45p. (£4.54 inc. VAT + P.).

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WIDE RANGE OF DISCO LIGHTING EQUIPMENT

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Superior Quality Precision Made NEW POWER RHEOSTATS

New ceramic construction, embedded winding heavy duty brush assembly, continuously rated.

25 WATT 10/25/50/100/250/500/1kΩ/1.5kΩ, £2.40. Post 20p (£2.99 inc. VAT & P.).

50 WATT 25/50/100/250/500/1kΩ/1.5kΩ, £3.62 inc. VAT & P.).

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Black, Silver, Skirted knob calibrated in Nos 1-9 1 1/2 in. dia. brass bush. Ideal for above Rheostats 24p each.



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