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OCTOBER 1979

50p

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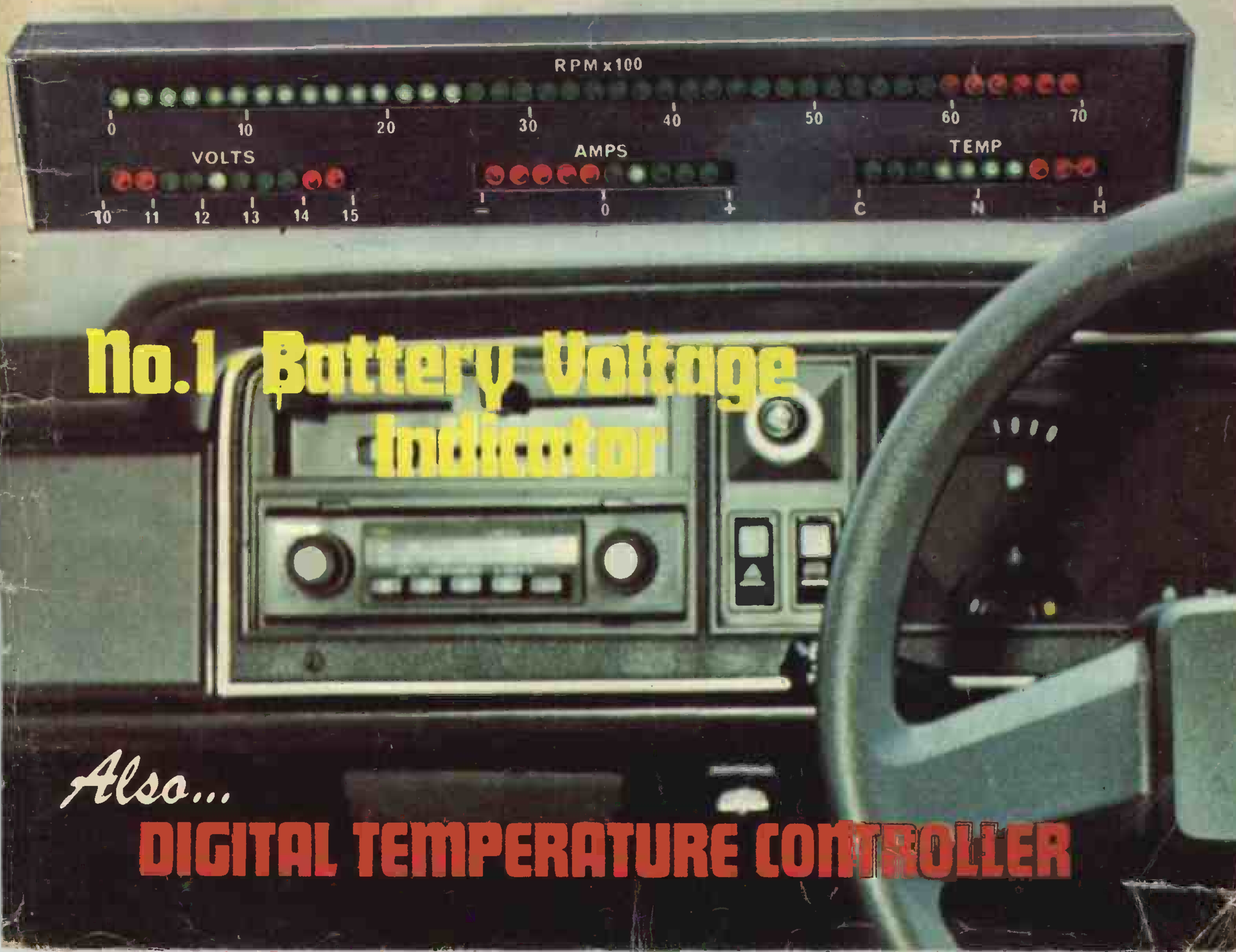
SOLID STATE INSTRUMENTS



No.1 Battery Voltage Indicator

Also...

DIGITAL TEMPERATURE CONTROLLER

PRACTICAL
ELECTRONICS

VOLUME 15 No. 10 OCTOBER 1979

CONSTRUCTIONAL PROJECTS

SOLID STATE INSTRUMENTS *by Michael Tooley B.A. and David Whitfield B.A., M.Sc.*
Battery Voltage Indicator—1. *First of a series* 24

DIGITAL TEMPERATURE CONTROLLER *by D. Coutts and P. McAllister* 32

V.L.F. RECEIVER *by C. R. Francis B.Sc.*
Listen to Sferics, Tweeks and Whistlers 42

6 CHANNEL MIXER—2 *by S. R. W. Grainger and C. R. Harding*
Wiring and final setting up 50

COMPUKIT UK101—Part 3 *by A. A. Berk B.Sc., Ph. D.*
Error codes, program recording and playback, running BASIC 56

GENERAL FEATURES

SEMICONDUCTOR UPDATE *by R. W. Coles*
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 *by D.J.D.*
A bi-monthly focus on micro's for the home constructor 67

SCHMITT TRIGGER CIRCUITS *by D. F. Bowers B.Sc.* 72

NEWS AND COMMENT

EDITORIAL 17

MARKET PLACE
New products 18
Chicago Consumer Electronics Show 20

INDUSTRY NOTEBOOK *by Nexus*
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 *by Frank W. Hyde*
More about Jupiter, Interesting Io, Galilean Satellites 48

PATENTS REVIEW
Class A Transistor Amplifier 54

COUNTDOWN 62

CB IN THE UK *by Dr. Mark Sawicki* 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)

WATFORD ELECTRONICS

(Continued from opposite side)

DIODES	
AA119	15
AA129	25
AAY30	25
AAZ15	15
BA100	10
BY100	24
BY126	12
BY127	12
CRO33	157
OA9	75
OA47	12
OA70	12
OA79	12
OA81	15
OA85	12
OA90	6
OA91	6
OA95	8
OA200	9
OA202	8
IN914	4
IN916	5
IN400/2	5
IN4003	6
IN4004/5	6
IN4006/7	7
IN4148	4
IS44	20
3A/100V	18
3A/400V	20
3A/600V	27
3A/1000V	30

SCR's Thyristors	
0·6A/200V	30
0·8A30V	28
0·8A100V	30
0·8A200V	35
1A600V	70
5A300V	35
5A600V	43
8A300V	48
8A600V	85
12A300V	59
12A500V	92
12A800V	150
15A700V	195
BT106	150
BT116	150
C106D	38
TIC44	22
TIC45	28
2N4444	140

BRIDGE RECTIFIERS (plastic case)	
1A/50V	20
1A/100V	22
1A/200V	25
1A/400V	29
1A/600V	34
2A/50V	35
2A/100V	44
2A/200V	46
2A/400V	53
2A/600V	65
4A/100V	72
4A/200V	75
4A/400V	79
4A/600V	105
4A/800V	120
6A/100V	73
6A/200V	78
6A/400V	85
BY164	56
VM18 DIL	40

ZENERS
Rng: 2V7-39V 400m W **9p**
Rng: 3V3-33V 1 3W **15p**

VARICAPS	
MVAM115	140
BA102	25
BB104	40
BB105B	40
BB106	40

Noise Diode	
Z5J	160

TRIACS	
3A/100V	48
3A/400V	50
8A/100V	54
8A/400V	64
8A/500V	85
8A/800V	108
12A/100V	60
12A/400V	70
12A/800V	130
16A/100V	95
16A/400V	105
25A/400V	160
25A/800V	295
40669	110

DIAC	
ST2	20

SPEAKERS	
8Ω 0·3W	
2"; 2½"	74
2·5; 3"	74
40Ω 2·5"	78
64 Ω 2·5"	74
8Ω 5W 7"x4"	250
8Ω 3W 6"x4"	160

ALUM.BOXES	
3x2x1"	54
2½x5x1½"	72
4x4x1½	72
4x2½x1½"	72
4x5¼x1½"	85
4x2½x2"	72
5x4x2"	98
6x4x2"	108
7x5x2½"	145
8x6x3"	185
10x7x3"	210
10x4½x3"	175
12x5x3"	215
12x8x3"	265

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2½x5"	56p	50p	—	31p
3¾x3¾"	55p	50p	—	—
3¾x5"	62p	67p	50p	43p
3¾x17"	218p	180p	141p	120
4¾x17"	280p	—	—	183p
Pkt of 36 pins				20p
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Pin insertion tool				120p

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SOLDERCON PINS
100 pins 50p: 500 pins 200p

OPTO ELECTRONICS LEDS Plus. Clip	
TIL209 Red 125"	13
TIL211 Grn 125"	18
TIL212 Yellow	22
TIL32 Infra Red	58
0·2" Red TIL220	15
0·2" Yellow, Grn, Amber	19
Square LEDS	48
OCP71	120
ORP12	63
2N5777	45

OPTO isolators	
IL74	48
TIL111/2	85
TIL117	110
7 Segment Displays	
LS400	265
TIL307	675
TIL312 & 313·3"	105
TIL321 ·5" C.An	115
TIL322 ·5" C.th	115
DL704 ·3" C.Cth	99
DL707 ·3" C.Anod	99
DL747 ·6" An	180
FND357	120
MAN3640	165
XAN351 ·3" Green	180

Liquid Crystal Display
3½ digit 875p; 4 digit 975p

VOLTAGE REGULATORS

1A	TO3	+ ve	—ve	
5V	7805	145p	7905	220p
12V	7812	145p	7912	220p
15V	7815	145p		—
18V	7818	145p		—
1A	TO220 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

SLIDE 250V	
1A DPDT	14
1A DPDT C/OFF	15
½A DPDT	13
4 pole 2-way	24
PUSH BUTTON Spring loaded Latching	
SPST on off	60
SPDT C/over	65
DPDT 6 Tag	85

TOGGLE 2A 250V	
SPST	28
DPST	34
DPDT	38
4 pole on off	54
SUB-MIN TOGGLE	
SP changeover	59
SPST on off	54
SPST biased	85
DPDT 6 tags	70
DPDT C/OFF	79
DPDT Biased	115
3 pole c/over	150

MINIATURE Non Locking
Push to make 215 Push Break 25

ROCKER: 5A, 250V, SPST 23

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

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1·80MHz	385p	10·7MHz	323p
1·832MHz	362p	12MHz	392p
1·6MHz	395p	14·318118M	300p
3·2768MHz	323p	18MHz	323p
4MHz	290p	18·432M	33p
4·032MHz	323p	20MHz	362p
4·433619M	135p	27·648MHz	350p
5 0MHz	355p	48MHz	323p
		100MHz	300p

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14 pin	12p
16 pin	13p
18 pin	16p
20 pin	22p
22 pin	25p
24 pin	36p
28 pin	39p
36 pin	—
40 pin	50p

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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)**
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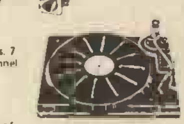

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AC179	£0.29
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AC180K	£0.32
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BC479	£0.23
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2N3616	£1.21
2N3646	£0.10
2N3702	£0.09
2N3703	£0.09
2N3704	£0.08
2N3705	£0.08
2N3706	£0.09
2N3707	£0.09
2N3708	£0.08
2N3709	£0.08
2N3710	£0.08
2N3711	£0.08
2N3819	£0.21
2N3820	£0.40

THYRISTORS

1 amp — TO 5 Case

Volts No:	Price
50 THY1A/500	£0.29
100 THY1A/100	£0.32
200 THY1A/200	£0.36
400 THY1A/400	£0.43
600 THY1A/600	£0.51
800 THY1A/800	£0.66

3 amp — TO 66 Case

Volts No:	Price
50 THY3A/50	£0.32
100 THY3A/100	£0.34
200 THY3A/200	£0.37
400 THY3A/400	£0.48
600 THY3A/600	£0.57
800 THY3A/800	£0.74

5 amp — TO 66 Case

Volts No:	Price
50 THY5A/50	£0.41
100 THY5A/100	£0.51
200 THY5A/200	£0.57
400 THY5A/400	£0.65
600 THY5A/600	£0.79
800 THY5A/800	£0.93

7 amp — TO 48 Case

Volts No:	Price
50 THY7A/50	£0.55
100 THY7A/100	£0.58
200 THY7A/200	£0.65
400 THY7A/400	£0.71
600 THY7A/600	£0.89
800 THY7A/800	£1.05

10 amp — TO 48 Case

Volts No:	Price
50 THY10A/50	£0.58
100 THY10A/100	£0.65
200 THY10A/200	£0.71
400 THY10A/400	£0.80
600 THY10A/600	£1.13
800 THY10A/800	£1.40

16 amp — TO 48 Case

Volts No:	Price
50 THY16A/50	£0.62
100 THY16A/100	£0.66
200 THY16A/200	£0.71
400 THY16A/400	£0.88
600 THY16A/600	£1.03
800 THY16A/800	£1.59

SILICON RECTIFIERS

200mA

IS920 50V	£0.07
IS921 100V	£0.08
IS922 150V	£0.09
IS923 200V	£0.10
IS924 300V	£0.11

1 Amp

IN4001 50V	£0.05
IN4002 100V	£0.05
IN4003 200V	£0.07
IN4004 400V	£0.08
IN4005 600V	£0.09
IN4006 800V	£0.10
IN4007 1000V	£0.11

1.5 Amp

IS015 50V	£0.10
IS020 100V	£0.11
IS021 200V	£0.12
IS023 400V	£0.14
IS025 600V	£0.16
IS027 800V	£0.18
IS029 1000V	£0.23
IS031 1200V	£0.28

3 Amp

IN5400 50V	£0.16
IN5401 100V	£0.17
IN5402 200V	£0.18
IN5404 400V	£0.19
IN5406 600V	£0.24
IN5407 800V	£0.28
IN5408 1000V	£0.34

10 Amp

IS10/50 50V	£0.21
IS10/100 100V	£0.24
IS10/200 200V	£0.26
IS10/400 400V	£0.40
IS10/600 600V	£0.48
IS10/800 800V	£0.58
IS10/1000 1000V	£0.69
IS10/1200 1200V	£0.79

30 Amp

IS30/50 50V	£0.64
IS30/100 100V	£0.79
IS30/200 200V	£1.06
IS30/400 400V	£1.43
IS30/600 600V	£2.02
IS30/800 800V	£2.23
IS30/1000 1000V	£2.65
IS30/1200 1200V	£3.31

60 Amp

IS70/50 50V	£0.86
IS70/100 100V	£0.96
IS70/200 200V	£1.38
IS70/400 400V	£2.01
IS70/600 600V	£2.58
IS70/800 800V	£2.87
IS70/1000 1000V	£3.45

OPTOELECTRONICS

LED'S (diffused)

O/no.	Type	Price
1501	Size ·125mm RED	£0.11
1502	Size ·125mm GREEN	£0.21
1503	Size ·125mm YELLOW	£0.21
1504	Size ·2mm RED	£0.11
1505	Size ·2mm GREEN	£0.21
1506	Size ·2mm YELLOW	£0.21
1509	Size ·2mm CLEAR	£0.12

SUPER 'Hi-Brite' Type

1521	Size ·3mm (·125) RED	£0.11
1522	Size ·5mm (·2) RED	£0.11
1514	ORP12 Light dependant resistor	£0.63
1520	OCP71 Photo transistor	£0.40

LED CLIPS

1508/·125 pack of 5 ·125 clips	£0.17
1508/·2 pack of 5 ·2 clips	£0.20

DISPLAYS

DL303 RED 7 segment D.P. left (·30" height) common anode single digit O/NO: 1523 £0.80

DL707 RED 7 segment D.P. left (0·3" height) common anode single digit O/NO: 1510 £0.92

DL527 RED 7 segment D.P. left (0·50" height) common anode Two-digit reflector O/NO: 1524 £1.95

DL727 RED 7 segment D.P. right (·510" height common anode Two-digit light pipe O/NO: 1521 £2.53

DL747 RED 7 segment D.P. left (·630" height) common anode Single-digit light pipe O/NO: 1511 £1.72

OPTO-ISOLATORS

Isolation Breakdown – Voltage 1500 – continuous fwd current 100mA.

CIL74 Single-channel 6 pin DIP standard type – optically coupled pair with infra-red LED emitter and NPN silicon photo transistor O/NO: 1497 £0.57

CILD74 Multi-channel 8 pin DIP two isolated channels O/NO: 1498 £1.15

CILQ74 Multi-channel 16 pin DIP four isolated channels O/NO: 1499 £2.53

2nd GRADE LED PAK
A pack of 10 standard sizes and colours which fail to perform to their very rigid specification, but which are ideal for amateurs who do not require the full spec. O/NO: 1507 £1.72

74 SERIES TTL ICs

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
7400	£0.10	7427	£0.27	7472	£0.23	74105	£0.43	74163	£0.71
7401	£0.12	7428	£0.29	7473	£0.28	74107	£0.27	74164	£0.78
7402	£0.12	7430	£0.12	7474	£0.28	74110	£0.41	74165	£0.78
7403	£0.12	7432	£0.25	7475	£0.33	74111	£0.66	74166	£0.89
7404	£0.12	7433	£0.34	7476	£0.28	74118	£0.92	74174	£0.74
7405	£0.12	7437	£0.25	7480	£0.50	74119	£1.35	74175	£0.71
7406	£0.25	7438	£0.24	7481	£0.97	74121	£0.27	74176	£0.66
7407	£0.25	7440	£0.13	7482	£0.78	74122	£0.44	74177	£0.66
7408	£0.14	7441	£0.57	7483	£0.66	74123	£0.46	74180	£1.72
7409	£0.14	7442	£0.46	7484	£1.01	74136	£0.59	74181	£0.66
7410	£0.12	7443	£0.80	7485	£0.78	74141	£0.63	74182	£0.80
7411	£0.19	7444	£0.80	7486	£0.25	74145	£0.63	74184	£0.80
7412	£0.17	7445	£0.74	7489	£1.95	74150	£0.78	74190	£0.78
7413	£0.27	7446	£0.69	7490	£0.36	74151	£0.55	74191	£0.71
7414	£0.57	7447	£0.55	7491	£0.73	74153	£0.55	74192	£0.69
7416	£0.26	7448	£0.64	7492	£0.40	74154	£0.94	74193	£0.66
7417	£0.26	7450	£0.12	7493	£0.34	74155	£0.57	74194	£0.71
7420	£0.12	7451	£0.12	7494	£0.86	74156	£0.57	74195	£0.69
7421	£0.23	7453	£0.12	7495	£0.57	74157	£0.57	74196	£1.20
7422	£0.18	7454	£0.12	7496	£0.57	74160	£0.66	74197	£1.20
7423	£0.24	7460	£0.12	74100	£0.97	74161	£0.71	74198	£2.12
7425	£0.21	7470	£0.28	74104	£0.44	74162	£0.71	74199	£2.12
7426	£0.26								

CMOS ICs

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
CD4000	£0.16	CD4015	£0.87	CD4026	£1.38	CD4043	£1.01	CD4070	£0.19
CD4001	£0.17	CD4016	£0.48	CD4027	£0.57	CD4044	£0.94	CD4071	£0.19
CD4002	£0.18	CD4017	£0.86	CD4028	£0.78	CD4045	£1.61	CD4072	£0.19
CD4006	£1.05	CD4018	£0.97	CD4029	£0.97	CD4046	£1.49	CD4081	£0.19
CD4007	£0.19	CD4019	£0.48	CD4030	£0.55	CD4047	£1.00	CD4082	£0.20
CD4008	£1,05	CD4020	£1.03	CD4031	£2.30	CD4049	£0.48	CD4510	£1.13
CD4009	£0.51	CD4021	£0.94	CD4035	£1.15	CD4050	£0.48	CD4511	£1.09
CD4010	£0.55	CD4022	£0.94	CD4037	£1.09	CD4054	£1.26	CD4516	£1.15
CD4011	£0.17	CD4023	£0.17	CD4040	£1.01	CD4055	£1.15	CD4518	£1.15
CD4012	£0.18	CD4024	£0.74	CD4041	£0.87	CD4056	£1.55	CD4520	£1.15
CD4013	£0.48	CD4025	£0.17	CD4042	£0.82	CD4069	£0.19	CD4014	£0.92

LINEAR ICs

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
CA3011	£0.92	CA3130	£1.06	MC1350	£1.38	UA710C	£0.46	SN76115	£2.18
CA3014	£1.55	CA3140	£0.80	MC1352	£1.61	72710	£0.34	SN76660	£0.86
CA3018	£0.74	LM301	£0.33	MC1469	£3,39	UA711C	£0.36	SL414A	£2.24
CA3020	£1.95	LM304	£1.84	MC1496	£1.03	72711	£0.36	TAA550B	£0.40
CA3028	£0.92	LM308	£1.15	NE536	£3.05	UA723C	£0.52	TAA621A	£2.30
CA3035	£1.61	LM309	£1.72	NE550	£1.09	72723	£0.52	TAA621B	£2.87
CA3036	£1.15	LM320-5V	£1.72	NE555	£0.27	UA741C	£0.27	TAA661	£1.72
CA3042	£1.72	LM320-12V	£1.72	NE556	£0.69	72741	£0.27	TAD100	£1.49
CA3043	£2.12	LM320-15V	£1.72	NE565	£1.38	741P	£0.23	TBA540	£2.41
CA3046	£0.80	LM320-24V	£1.72	NE566	£1.38	UA7447C	£0.69	TBA810S	£0.86
CA3052	£1.84	LM380	£0.97	NE567	£1.95	72747	£0.69	TBA810	£1.12
CA3054	£1.26	LM381	£1.66	UA702C	£0.52	UA748	£0.40	TBA820	£0.80
CA3075	£1.72	LM3900	£0.66	72702	£0.52	72748	£0.40	TBA9200	£2.87
CA3081	£1.72	MC1303L	£0.97	UA703	£0.28	748P	£0.40	TCA270S	£2.30
CA3089	£2.30	MC1304	£2.18	UA709	£0.28	SN76013N	£2.01	TBA800	£0.92
CA3090	£4.14	MC1310	£1.09	72709	£0.52	SN76023	£2.01		
CA3123	£2.18	MC1312	£2.18	709P	£0.28	SN76110	£1.72		

AUDIO MODULES

Amplifiers

AL20	5 watt amplifier module	£3.73
AL30A	7-10 watt amplifier module	£4.35
AL60	15-25 watt amplifier module	£5.39
AL80	35 watt amplifier module	£8.44
AL120	50 watt amplifier module	£13.74
AL250	125 watt amplifier module	£19.24

Pre-amplifiers

PA12	Stereo pre-amplifier module	£8.94
PA100	Stereo pre-amplifier module	£18.45
PA200	Stereo pre-amplifier module	£19.07

Power Supplies

PS12	Power supply (24 volts DC)	£1.72
SPM80	Stabilised power supply (33V)	£5.06
SPM120/45	Stabilised power supply (45V)	£6.67
SPM120/55	Stabilised power supply (55V)	£6.67
SPM120/65	Stabilised power supply (65V)	£6.67
SG30	Power supply for equaliser	£4.37

Miscellaneous

MPA30	Stereo magnetic cartridge pre-amp	£4.42
S.450	Stereo tuner	£26.72
Stereo 30	Complete 7 watt stereo amplifier board	£22.66
BP124	Siren alarm module 5 watts	£4.02
GE100MKII	10 channel mono graphic equaliser	£23.00

SOCKETS

1611	8 pin DIL	£0.09
1612	14 pin DIL	£0.11
1613	16 pin DIL	£0.12
1720	18 pin DIL	£0.18
1721	20 pin DIL	£0.20
1722	22 pin DIL	£0.22
1614	24 pin DIL	£0.24
1615	28 pin DIL	£0.26
1723	40 pin DIL	£0.34
1616	T018 transistor	£0.13
1617	T03 transistor	£0.37
16117	T05 transistor	£0.13
1724	14 pin DIL Wire wrap gold plated Cambion	£0.25

G.P. SWITCHING TRANSISTORS

T018 sim to 2N706/8 BSY27/28/95A ALL usable devices no open & shorts. ALSO available in PNP sim. to 2N290/BCY70.
20 for 57p – 50 for £1.15 – 100 for £2.07 – 500 for £9.20 – 1,000 for £16.10 – when ordering state NPN/PNP.

SILICON DIODES G.P.

300mW 40PIV (min) sub min FULLY TESTED ideal for Organ builders.
30 for 57p – 100 for £1.72 – 500 for £5.75 – 1,000 for £10.35.

METAL FOIL CAPACITOR PAK

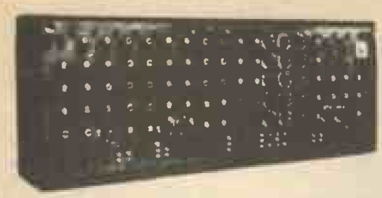
Containing 50 metal foil capacitor – like Mullard C280 series – mixed values ranging for ·01uf-2·2uf. Complete with identification sheet O/NO: 16204 £1.38.

JUMBO PAK SEMICONDUCTOR

16222 – Transistors Germ and Silicon Rectifiers-Diodes-Triacs-Thyristors-ICs and Zeners ALL NEW & CODED. Approx. 100 pieces offering the amateur a fantastic bargain PAK and an enormous saving £2.58.

ALL PRICES INCLUDE VAT. ADD 35p POST PER ORDER

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	£52.07
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 78B	£1.16
Text photocopy		

ELEKTOR ANALOGUE REVERB UNIT

Using i.c.s instead of spring-lines the main unit has a maxium 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

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 55-1	£2.25

TREMOLO UNIT

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

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

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

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

P.E. VOLTAGE CONTROLLED FILTER

Extracted from P.E. Minisonic project.

Set of basic components, PCB & chart	KIT 65-1	£7.88

P.E. RING MODULATOR

Extracted from P.E. Minisonic project.

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

ELEKTOR RING MODULATOR

Compatible with the Formant & most other synthesisers

Set of basic components	KIT 87-1	£4.86
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 costed, C.W.O., U.K. orders only. This voucher must accompany order. Valid until end of month on cover of P.E.

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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.
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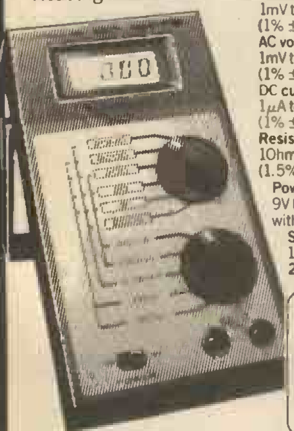
Top value test equipment from TANDY

LCD DIGITAL MULTIMETER.

Low-cost hand held digital multimeter with a full 3½ digit LCD display. 0.5% basic accuracy, auto polarity operation. 10 Mohm DC input impedance.
Reading to ± 1999.



Scales:
DC volts:
1mV to 1000V
(1% ± 1 digit accuracte).
AC volts:
1mV to 500V
(1% ± 2 digits accurate).
DC current:
1μA to 200mA
(1% ± 1 digit accurate).
Resistance:
1Ohm to 20 MOhms
(1.5% ± 1 digit accurate).
Power source:
9V battery or AC
with optional adaptor.
Size:
155 x 75 x 30 mm.
22–198

PRICE **53.19**

LOW–COST LCD MULTIMETER

A portable, compact sized multimeter with a full 3½ digit LCD display. Auto polarity operation, low battery indicator. 10 MOhm Input impedance.

Scales:
DC volts:
2–20–200–1000V.
AC volts:
200–500V.
DC current:
2–20–200MA.
Resistance:
2–20–200–
2000 KOHM.
Power source:
9V battery or AC adaptor.
Size:
37 x 85 x 130 mm.
22–197

PRICE **39.93**

COMPONENTS AND PARTS

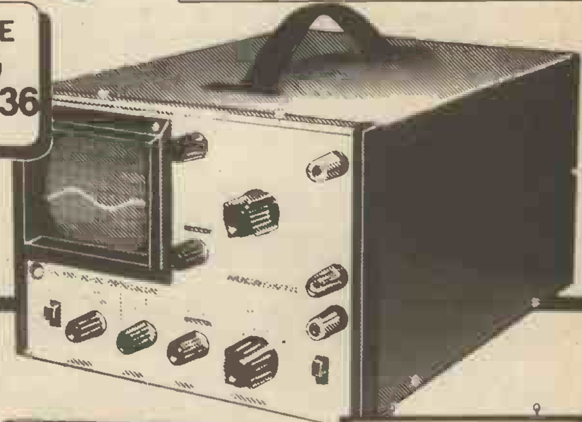
CAT. No.	DESCRIPTION	PRICE
276–032	LED	4 for 69p
276–033	LED	2 for 48p
276–034	LED	2 for 59p
276–142	Infra-Red Emitter Detector Pair	£1.37
277–1003	12V DC Automotive Digital Clock Module	£17.52
276–9110	6 pin edge connector for 277–1003	40p
276–1373	Power Transistor Mounting Hardware	50p
276–1363	TO–220 Heat Sink	60p
276–1364	TO–3 Heat Sink	81p

PRICE **137.36**

AC/DC 8 MHz OSCILLOSCOPE

A new approved 8MHz version of last years' winner! The advance design features of this oscilloscope make it an absolute essential for industrial uses on production lines, in laboratories and schools. Ideal for radio and TV servicing, audio testing, etc.

Specifications:
Horizontal axis: Deflection sensitivity better than 250mV/DIV. Vertical axis: Deflection sensitivity better than 10mV/DIV (1DIV–6mm). Bandwidth: 0.8MHz. Input impedance: 1MOhm parallel capacitance 35pF. Time base: Sweep range: 10Hz–100kHz (4 ranges). Synhronization: Internal (–) Size: 200 x 155 x 300 mm. Supply: 220/240 V/50Hz. 22–9501.



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PE VOLUME 15 No. 10 OCTOBER 1979

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

EDITOR
Mike Kenward
Gordon Godbold ASSISTANT EDITOR
Mike Abbott TECHNICAL EDITOR
Alan Turpin PRODUCTION EDITOR
David Shortland PROJECTS EDITOR
Jack Pountney ART EDITOR
Keith Woodruff ASSISTANT ART EDITOR
John Pickering SEN. TECH. ILLUSTRATOR
Isabelle Greenaway TECH. ILLUSTRATOR
Judith Kerley SECRETARY

Editorial Offices:
Westover House,
West Quay Road, Poole,
Dorset BH15 1JG
Phone: *Editorial* Poole 71191

We regret that lengthy technical enquiries cannot be answered over the telephone (see below).

ADVERTISEMENT MANAGER **D. W. B. Tilleard** } 01-261 6676
SECRETARY **Christine Pocknell** }
CLASSIFIED MANAGER **Colin Brown** 01-261 5762

Advertising Offices:
King's Reach Tower,
King's Reach, Stamford Street, SE1 9LS
Telex: 915748 MAGDIV-G

Make Up/Copy Dept.: 01-261 6601

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

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

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

Back Numbers
Copies of most of our recent issues are available from: Post Sales Department, IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 0PF, at 75p each including Inland/Overseas p&p.

Binders
Binders for PE are available from the same address as back numbers at £3·75 each to UK or overseas addresses, including postage and packing, and VAT where appropriate. Orders should state the year and volume required.

Subscriptions
Copies of PE are available by post, inland or overseas, for £10·60 per 12 issues, from: Practical Electronics, Subscription Department, Oakfield House, Perrymount Road, Haywards Heath, West Sussex RH16 3DH.

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

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 and David Shortland

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 Invertor, 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

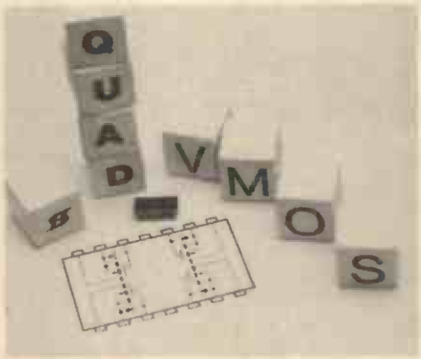
Most of their components are full specification devices but Codespeed also offer untested packs in varying degrees of guarantee of satisfaction. So if you are a bit of a gambler you could chance your shirt in the following way; "4/5 digit displays in manufacturer's support frames, header and tie bars 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 Seafield Road, Copnor, Portsmouth PO3 5BJ.

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, l.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 l.e.d. light source ensures long operating life and high immunity to ambient light. Transmitter and receiver are compact units measuring only 90·5 × 40 × 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 10μV. 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.

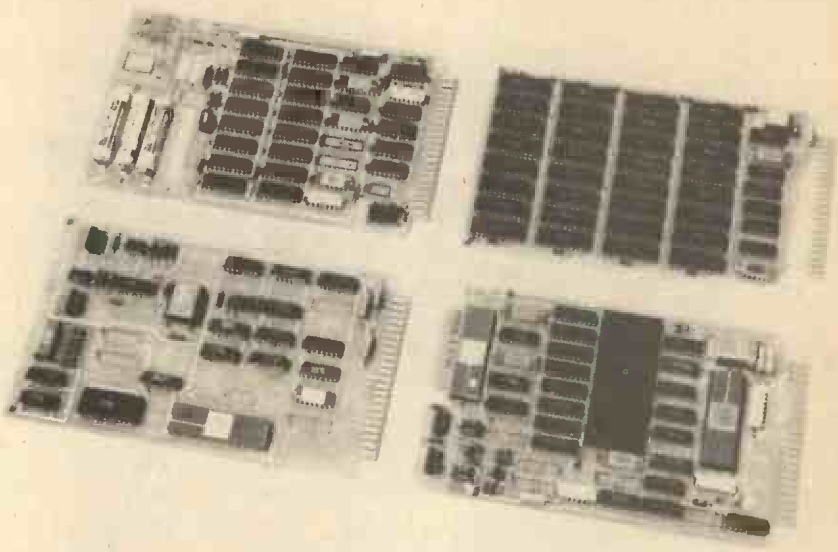
How many of these would you need to bolt on your bonnet to power all the car instruments in our new series?

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 × 7·5in. (114 × 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 tuning 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 600Ω 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 600Ω load.

The variable d.c. offset amplitude control, once set, holds the output signal to within ±0·5dB 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 ±10V.

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 3½ 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 0·1μA and resistance to 0·1Ω. 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).

Market Place

CHICAGO CONSUMER ELECTRONICS SHOW

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).

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 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.

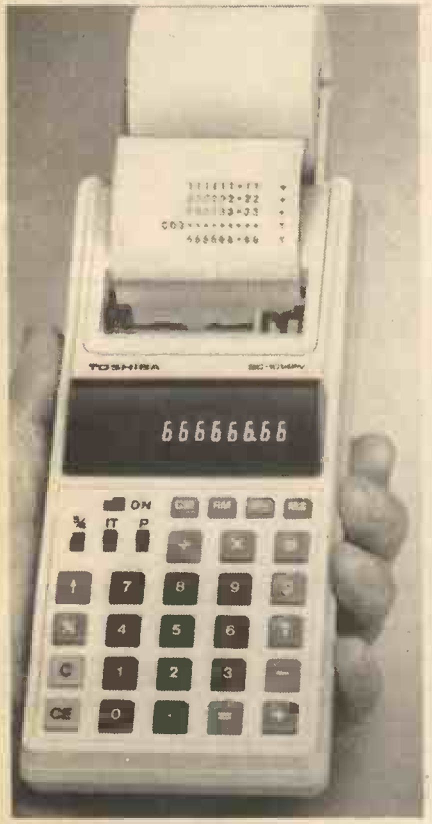
Apart from domestic TV recording Toshiba are expecting this system to be valuable where rapid random access to digital information is required (20ms to access track in use, 4·4s to range all tracks). Just the device to bolt on to a home computer. The simplified mechanism

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.

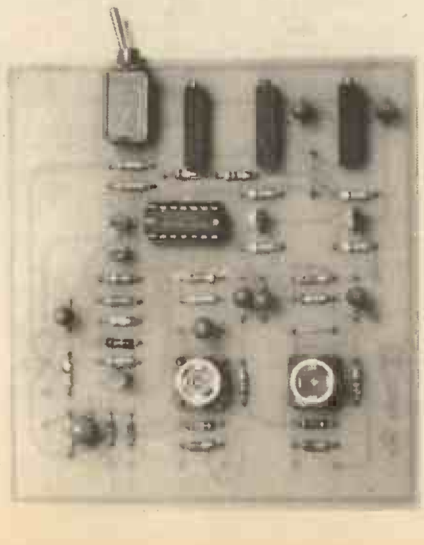
If you can't get in to Bloomingdale's or Macy's with your $25 there was a project in the June issue of PE which had a similar capability although not the same range.

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 performance 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 convertors 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 convertor 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 convertors 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

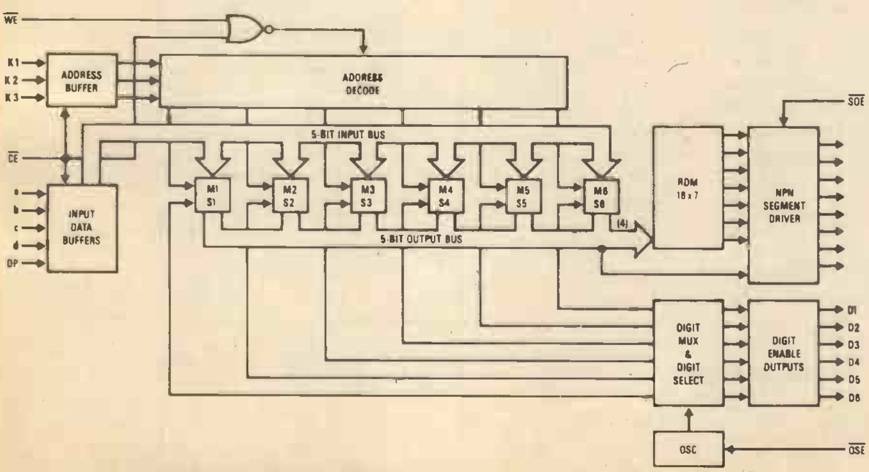
Hmmm! enough to make you think twice about the "economies" of multiplexing, isn't it? Well, not to worry, because National have spotted the problem and built up some very nifty multiplexed display subsystems and put the whole mess on to a single CMOS chip.

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!



Internal circuitry of National MM 74C917

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 baulked 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 $1\frac{1}{2}$ 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)

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.

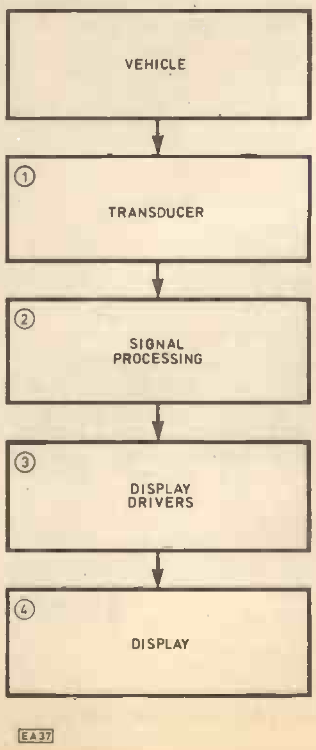
The design should give good rejection to supply fluctuations, which are of a considerable level in motor vehicles.

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

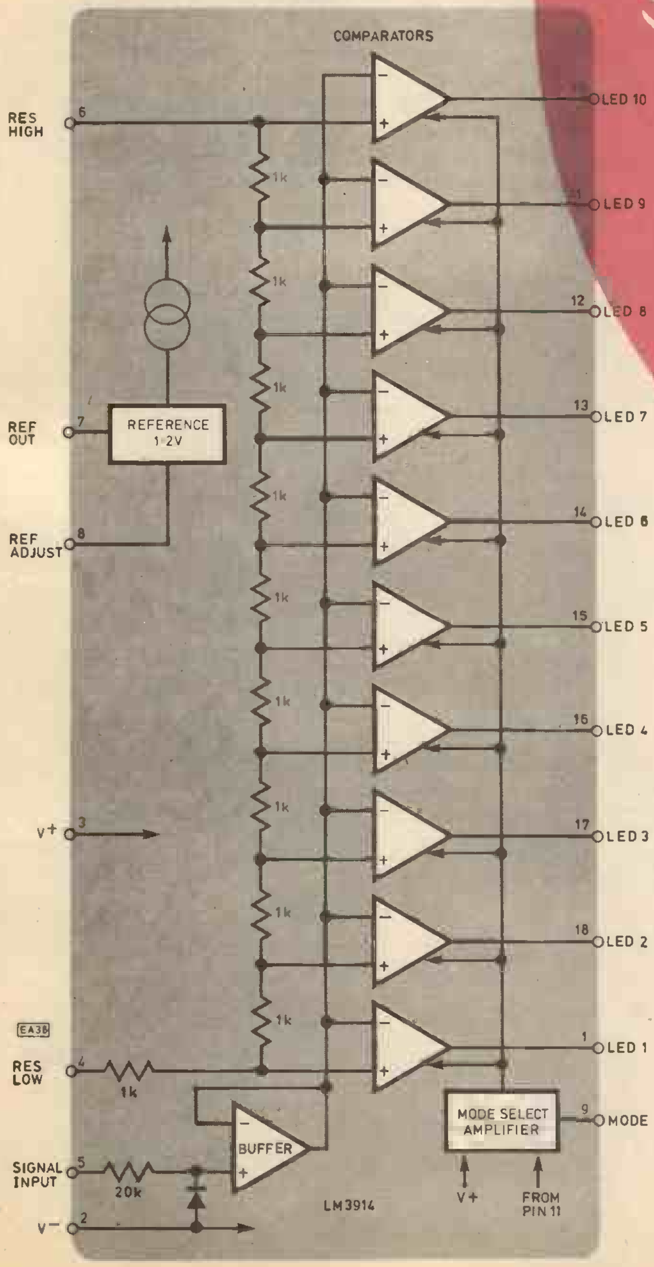


INSTRUMENTS

Michael Tooley B.A.   **David Whitfield** B.A. M.Sc.

A series of articles on vehicle projects using the LM3914

Fig. 2. LM3914 block diagram



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.

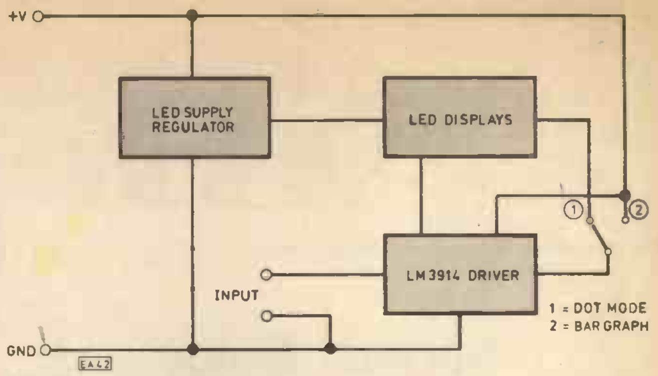
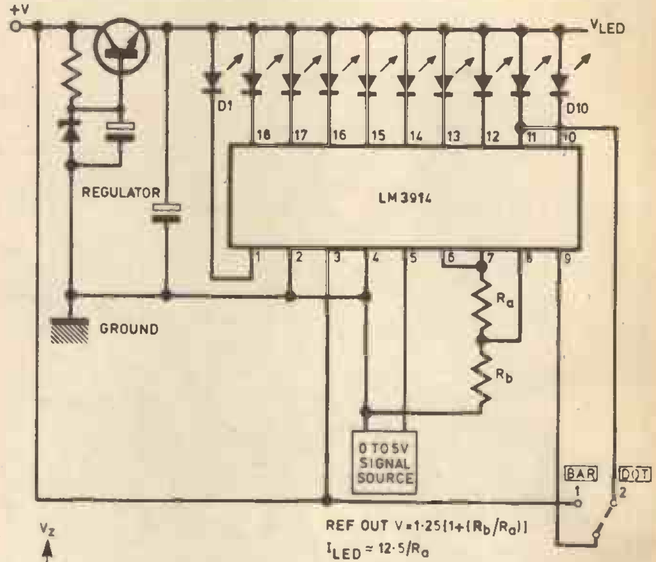


Fig. 3. Block diagram of basic 10-l.e.d. display

Fig. 4. Circuit of basic 0-5V display module

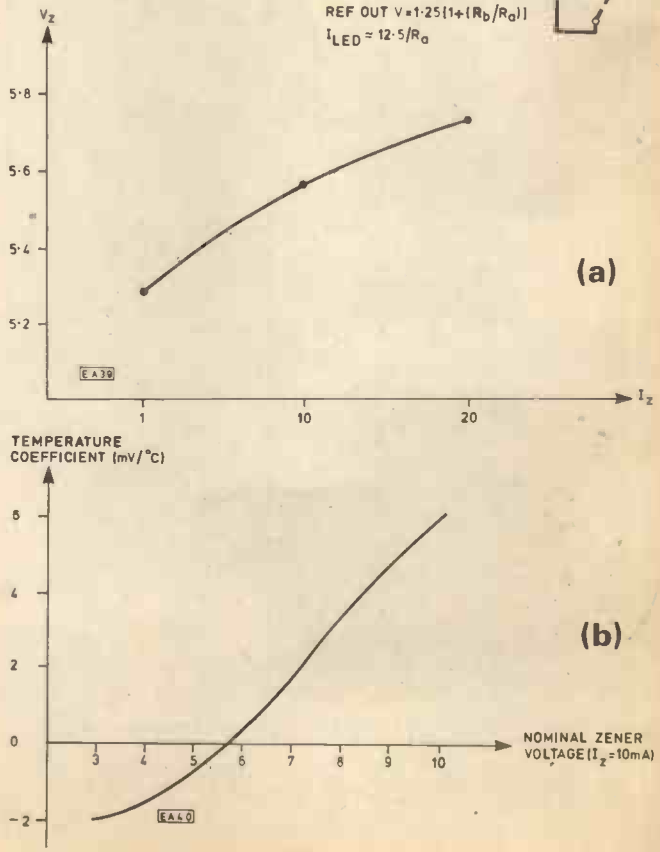


BATTERY CONDITION INDICATOR

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.

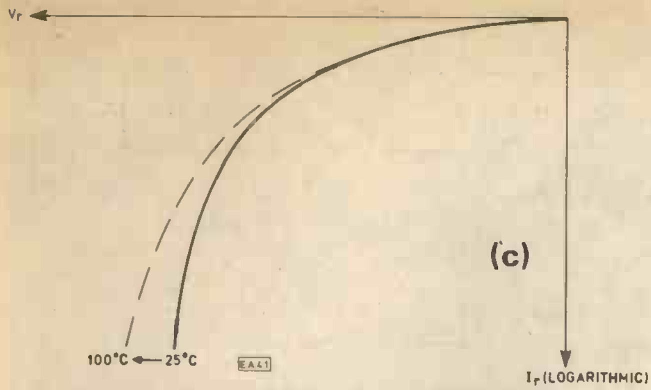


Fig. 5 (above and opposite). Graphs showing reverse characteristics of Zener diodes. (a) Voltage vs. bias current for BZY88 C5V6. (b) Temperature coefficient vs. voltage at I const. (c) Voltage vs. bias current and temp.

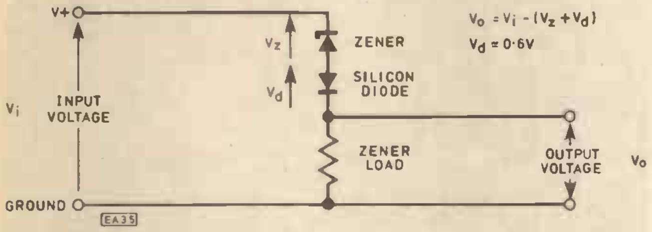


Fig. 6. Zero-referred signal circuit

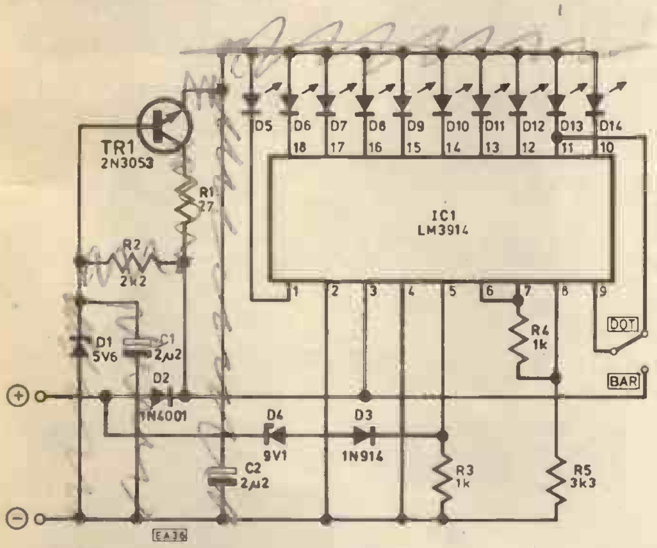
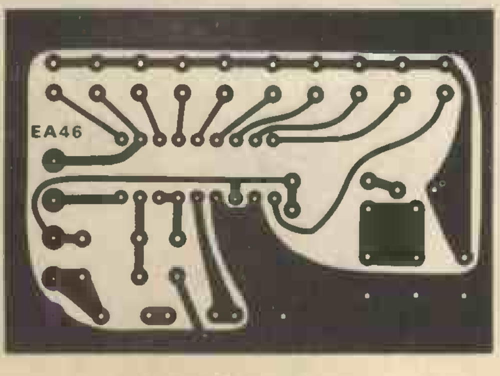


Fig. 7. Full circuit diagram of the Voltage Indicator



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 teminated 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.

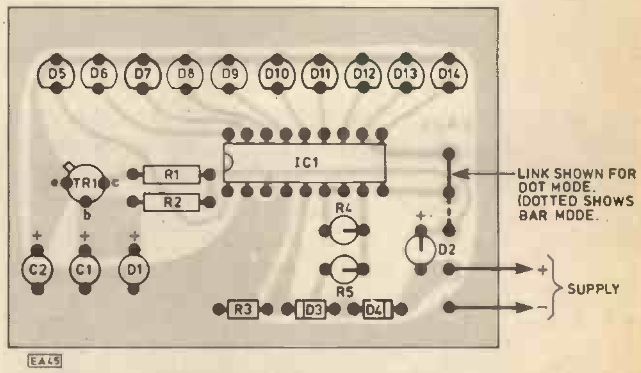


Fig. 9 (above). Component layout of p.c.b. version of Battery Voltage Indicator

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

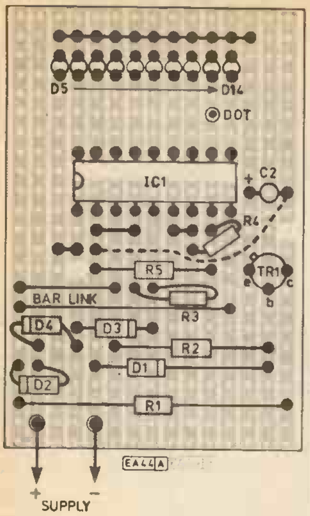
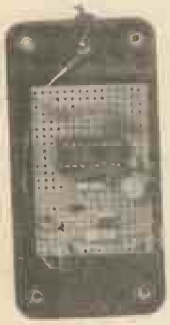


Fig. 10. Alternative Component layout using stripboard (21 track cuts)



COMPONENTS . . .

Resistors

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

All resistors ¼W 5% unless otherwise stated.

Capacitors

C1	2µ2	10V
C2	2µ2	25V

Semiconductors

D1	BZY88C5V6
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.

	Illumination Supply Voltage	
L.e.d. number	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:

$$I_{LED} = 12{\cdot}5/R4$$

The full-scale indication value is:

$$V_{FSI} = 1{\cdot}25\,(1 + R5/R4)$$

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 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. ★

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

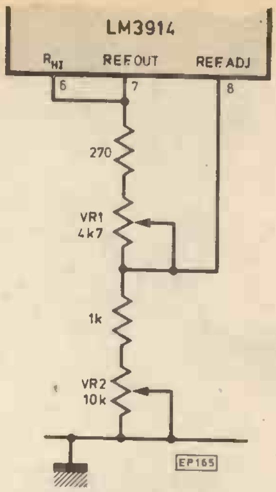


Fig. 11. Variation of l.e.d. brightness

NEXT MONTH: engine r.p.m. counter

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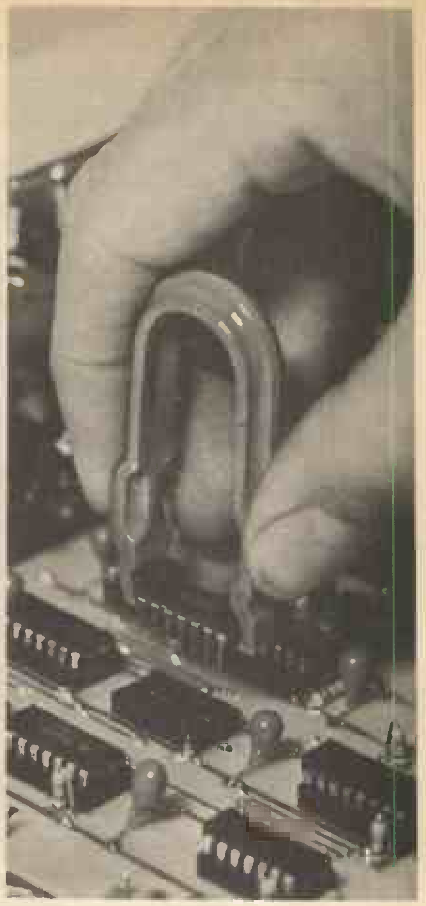

Now you can get them out! Back in May we gave you a free I.C. Insertion Tool—these are still available from the editorial office for £1 each inclusive—now you can have its companion the I.C. Removal Tool, perhaps even more useful, and again extras are available for 50p each inclusive.

Simply place the tool over the ends of 8, 14 or 16 pin d.i.l. i.c.s. and pull them out—it's that easy now!

News Briefs

ELECTRONICS CLUB AT MARGATE

A NEW electronics club has been started, called *Thanet Electronics Club*. Meetings are held every Thursday at the Quarter Deck, Margate, from 7,30 p.m. Other activities include camps, shows and visits. For youth (especially girls!!), it says in their literature. Further details: Ken Smith, The Electronics Laboratories, University of Kent, Canterbury CT2 7NT.

ON COURSE

SOUTH London College. A short course (ten lectures) will run on microprocessors, their hardware/software and applications, commencing October 2, 1979, and every following Tuesday at 6.30–8.30 p.m. A knowledge of digital principles is assumed. Course fee is £7.

Applications for *Microprocessors and their applications*, to Mr. A. A. Rowlands (course organiser), South London College, Knights Hill, London SE27 0TX.

AUTOMATIC FARE COLLECTION

WESTINGHOUSE are to design new ticket machines, gates and the communications network for the London Underground. Implementation is planned for the mid 1980's.

Fraud estimated at £8m a year should be virtually eliminated.

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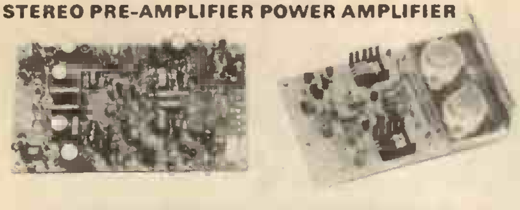

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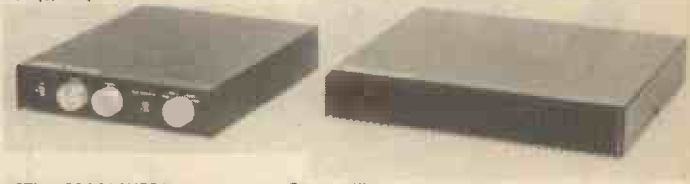

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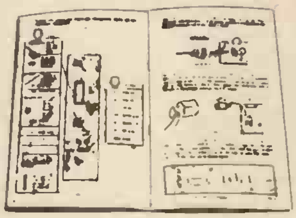

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DIGITAL TEMPERATURE CONTROLLER

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 bimetalic 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).

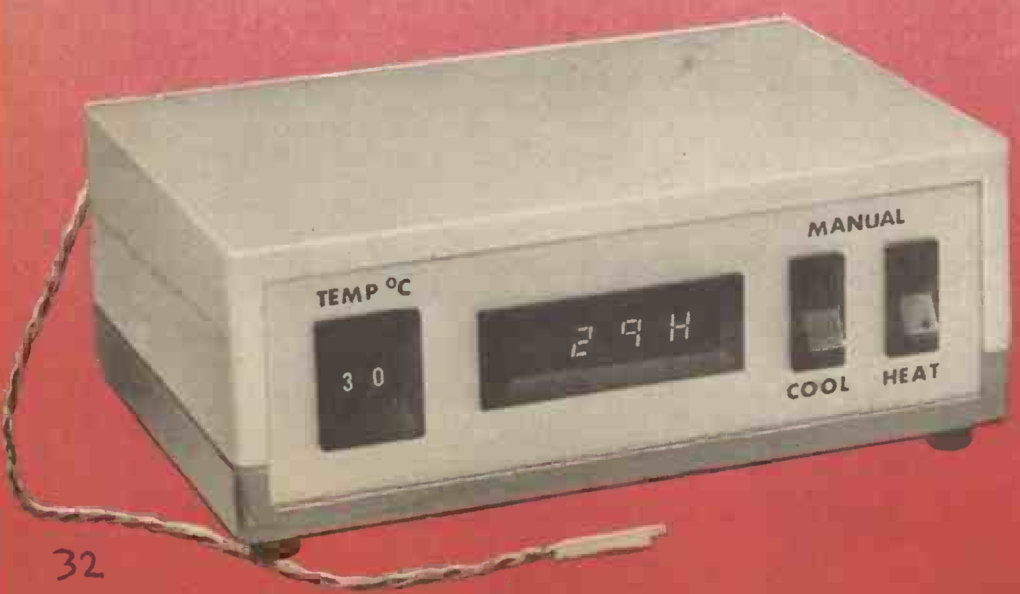
CONTROLLER CIRCUIT

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



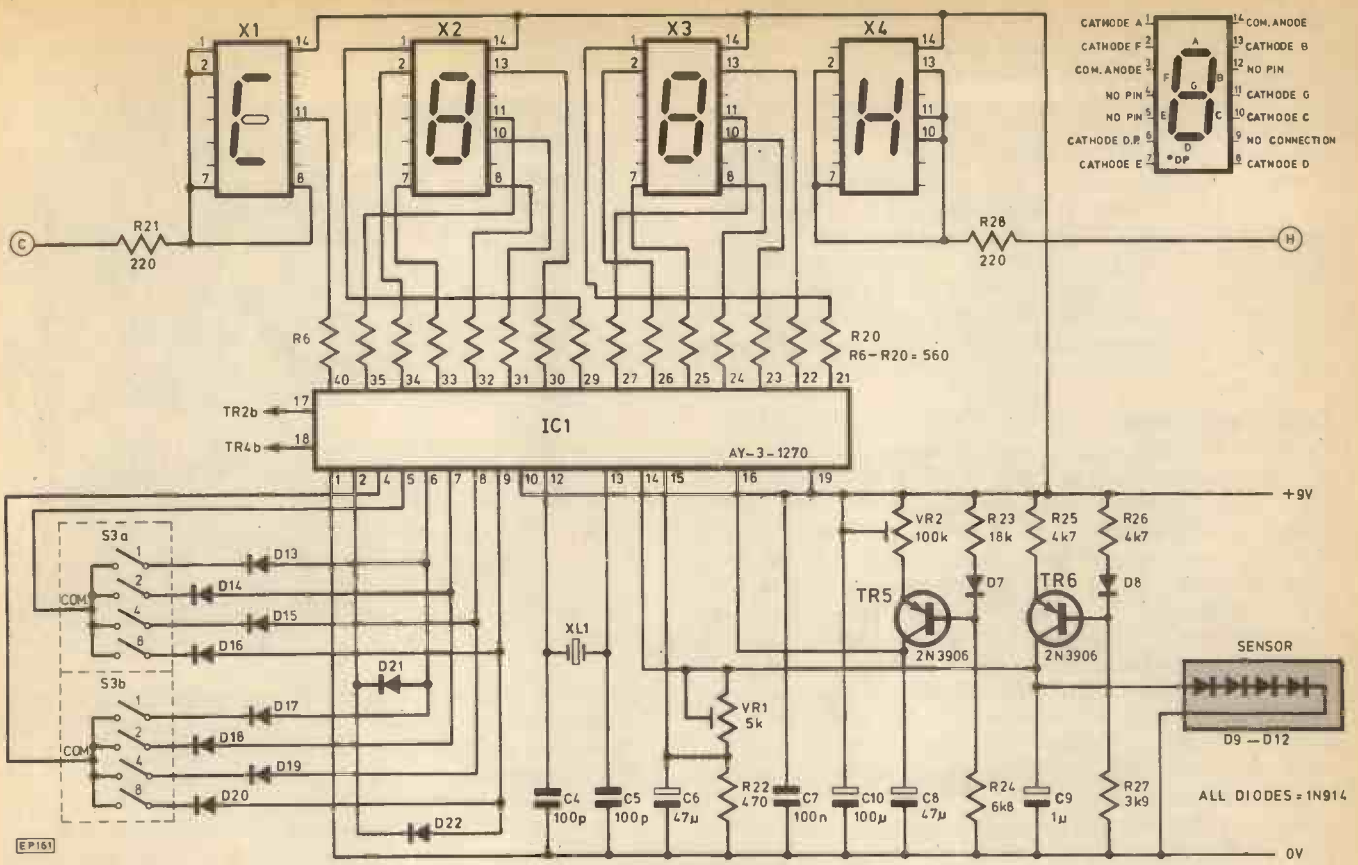


Fig. 1. Circuit of controller

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
	205 x 140 x 75mm case (Marshall's)
SK1, SK2	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

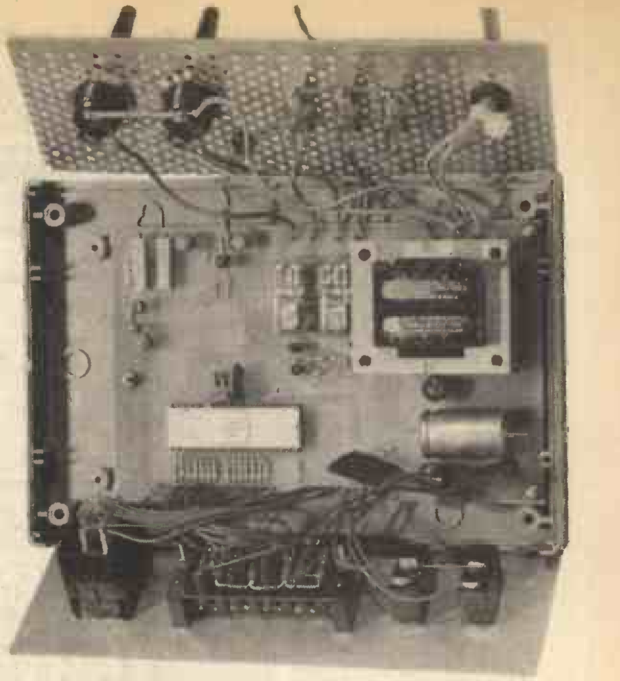
XL1, C4 and C5 form the oscillator circuit. (XL1 is a ceramic resonator). The diode matrix connected to pins 4-9 determine the actual temperature to which the temperature is controlled. Diode D22 selects l.e.d. drive mode (if this diode is left out, the chip produces a.c. output signals for driving l.c.d.s). 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.

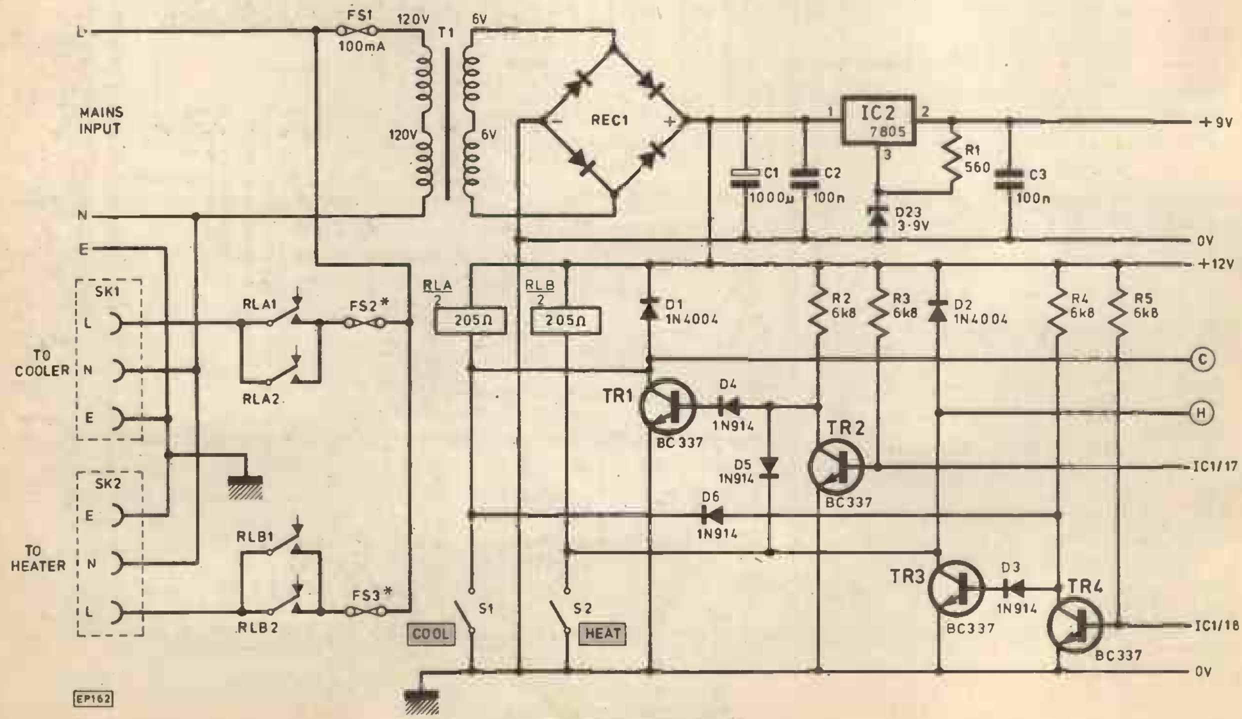
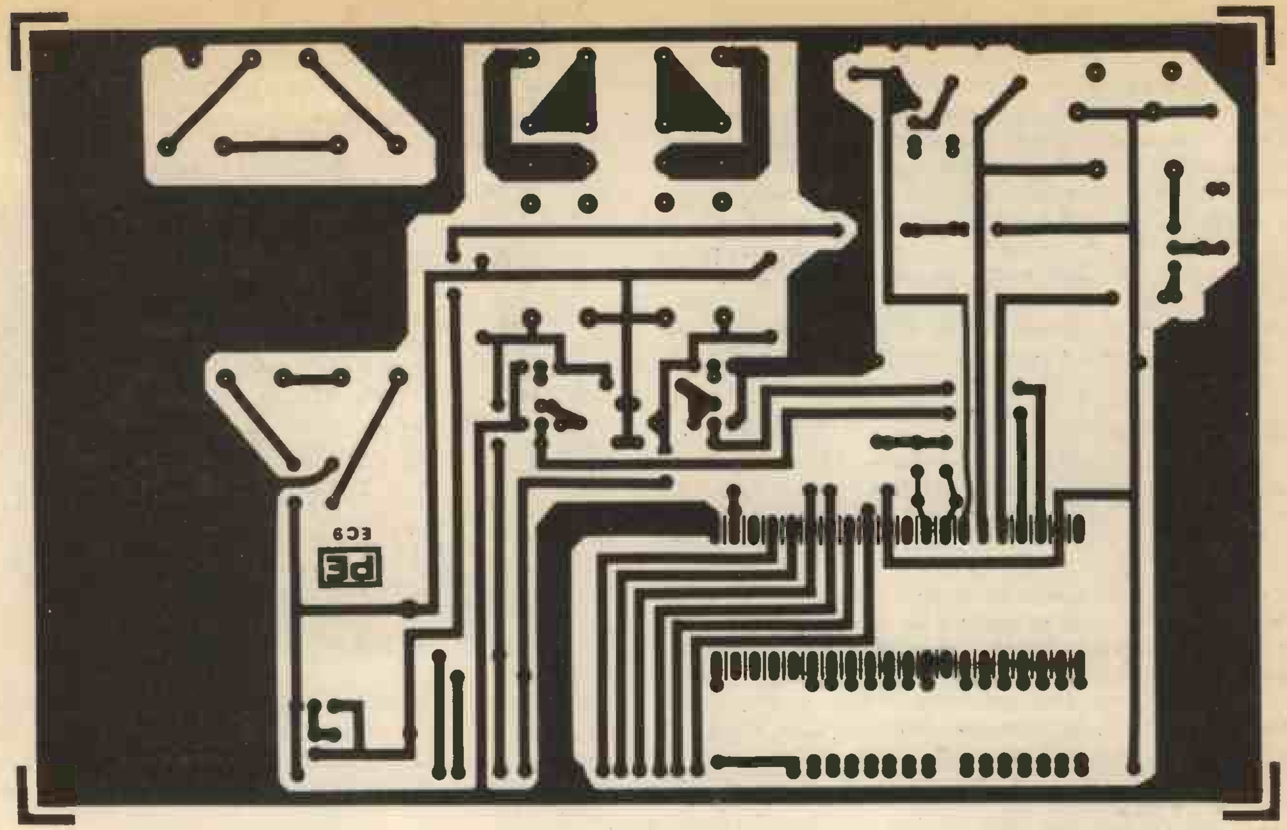
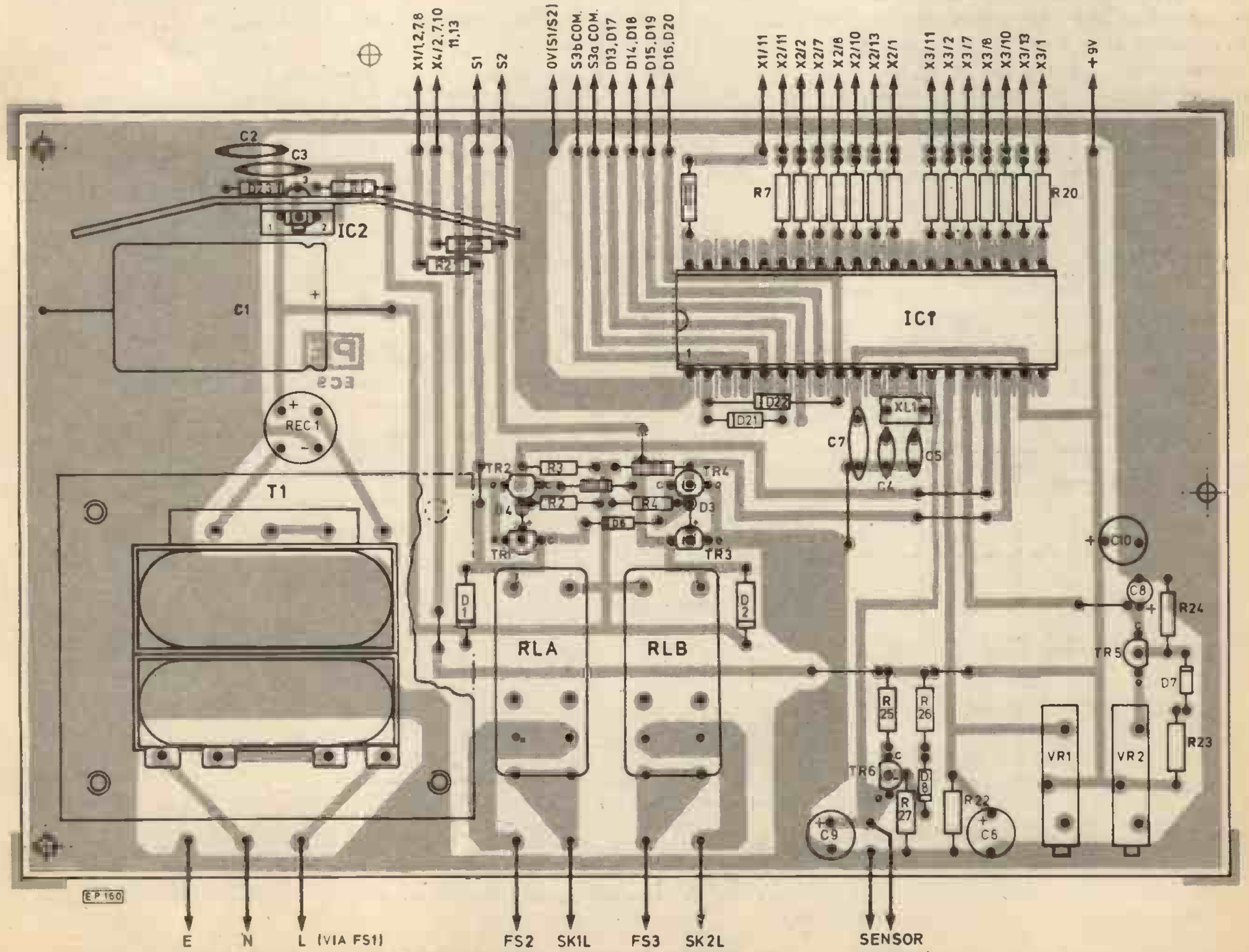
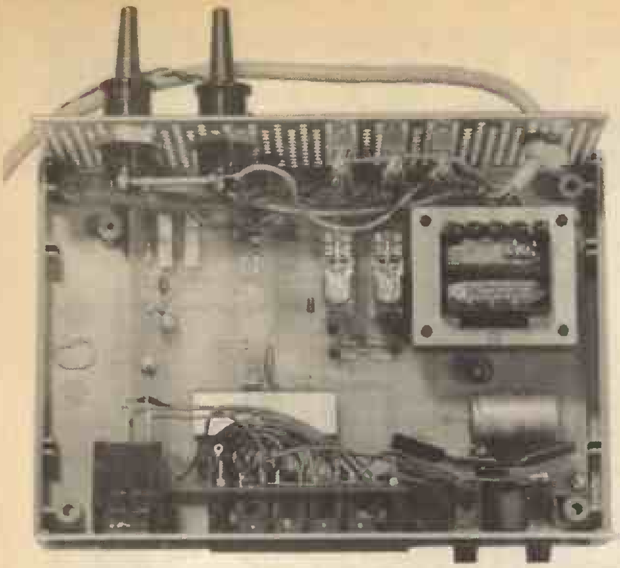


Fig. 2. Relay drive circuit and p.s.u.





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

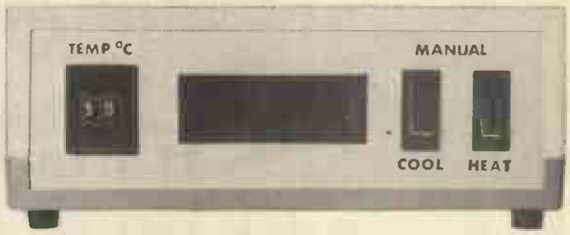


Finally the diodes D9-D12 which form the sensor should have their leads cut short and be soldered together then insulated so that there is no danger of a short circuit by encapsulating in epoxy for example. The sensor diodes should then be connected to the controller via a length of wire, sufficient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



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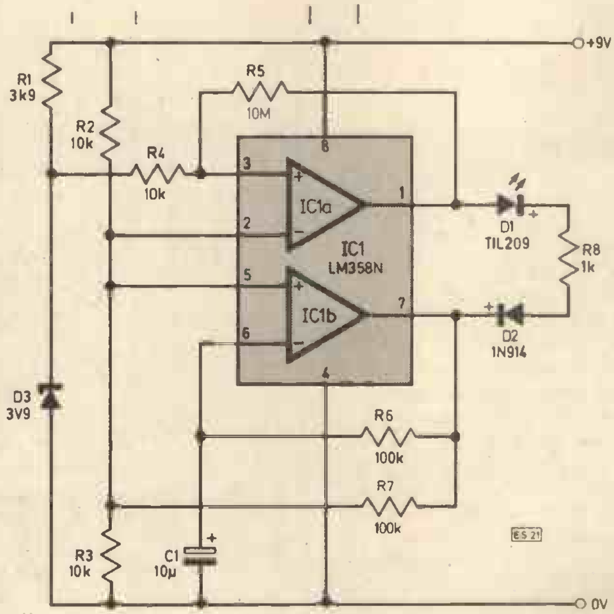

BATTERY MONITOR

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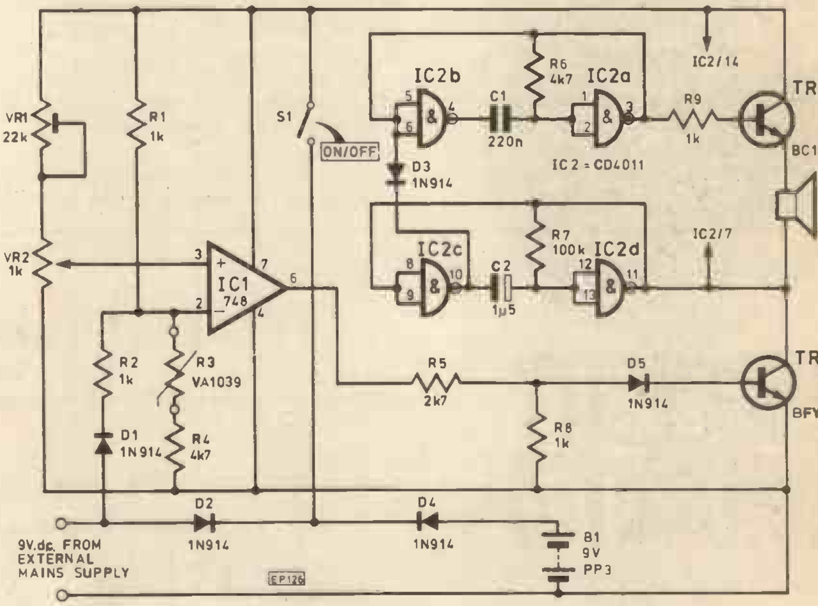
Each idea submitted must be accompanied by a declaration to the effect that it is the original work of the undersigned, and that it has not been accepted for publication elsewhere.

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.

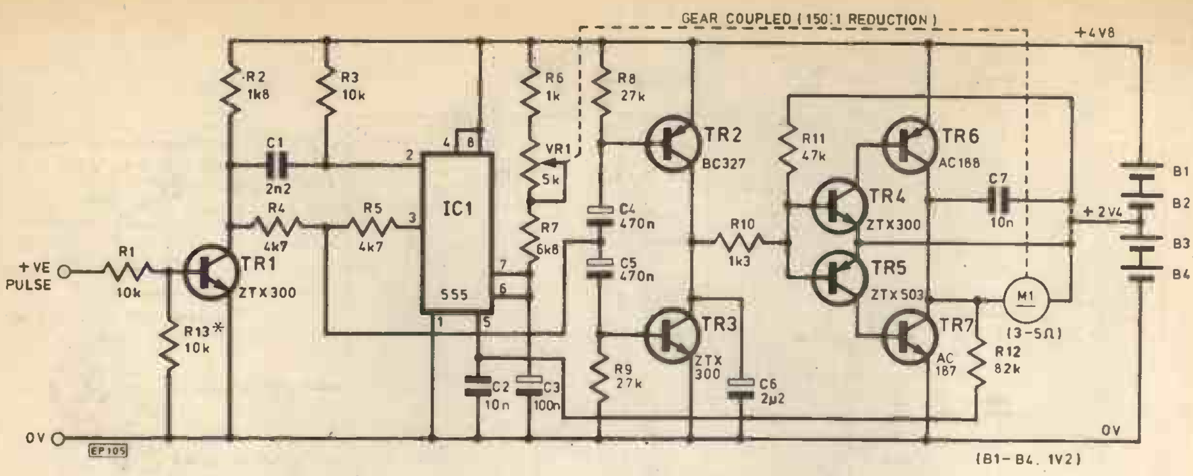
The heart of the unit is the 748 op amp which acts as a comparator of a set voltage obtained from VR1 and VR2 against a voltage dependent on the resistance of R3. As the temperature rises the resistance of the thermistor falls and the voltage at the inverting input falls thus turning on TR2 and the alarm 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 1kΩ 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 1k. 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

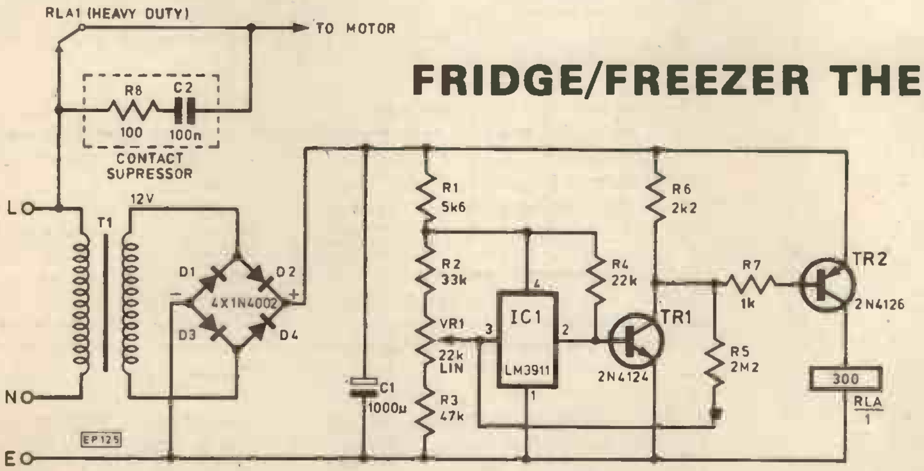
THIS servo amplifier was developed for one reason—minimum component count. This has been achieved by the use of a 555 timer used as a one shot or monostable. This has the advantage of saving transistors and diodes for the normal monostable arrangement. Also, although many op-amps can perform this function the 555 has the advantage of being able to work down to —4V, and has the ability to have it's 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 82kΩ 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 5kΩ 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 obtain 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 charges 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 (10kΩ) 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.

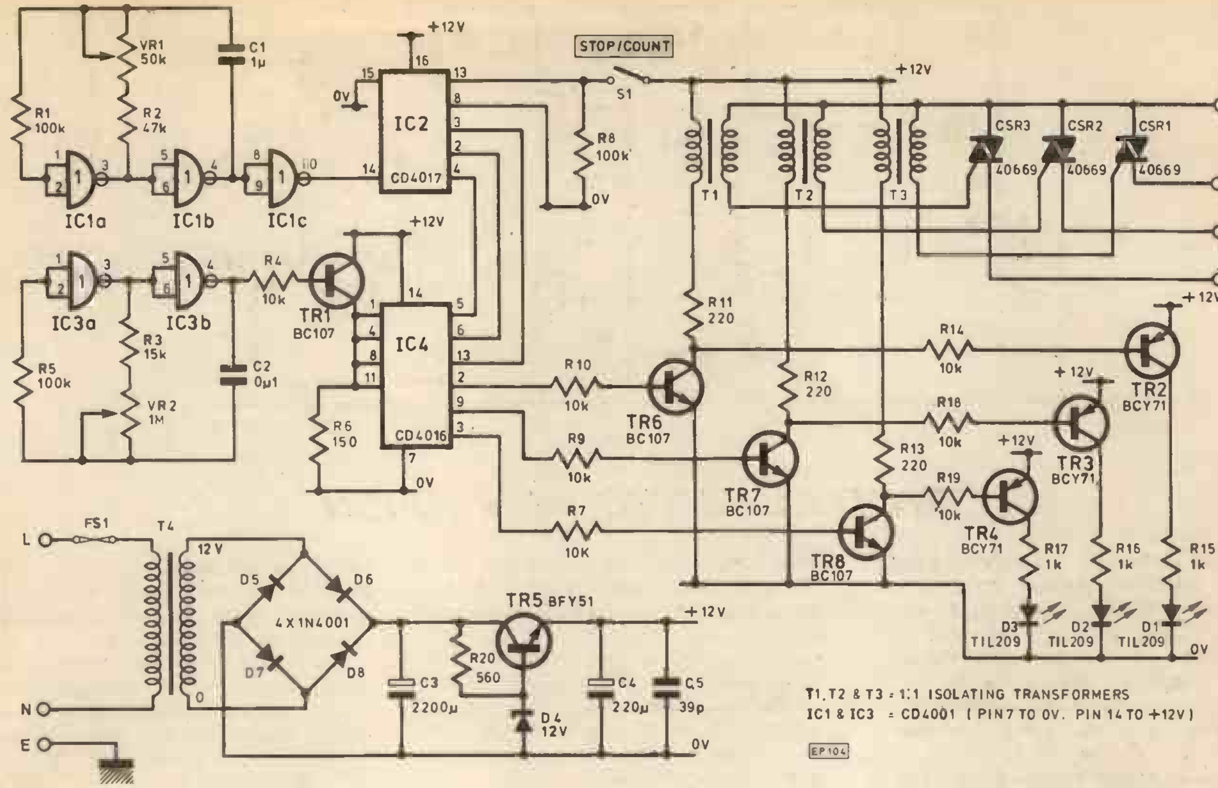
Resistor R1 provides a positive voltage to the i.c. internal stabiliser, pin 4. R2, VR1 and R3 provide a present reference voltage to the i.c., pin 3. The output, pin 2, is taken to TR1 base and controls the relay via TR2.

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 ICb 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 bilaterial 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.

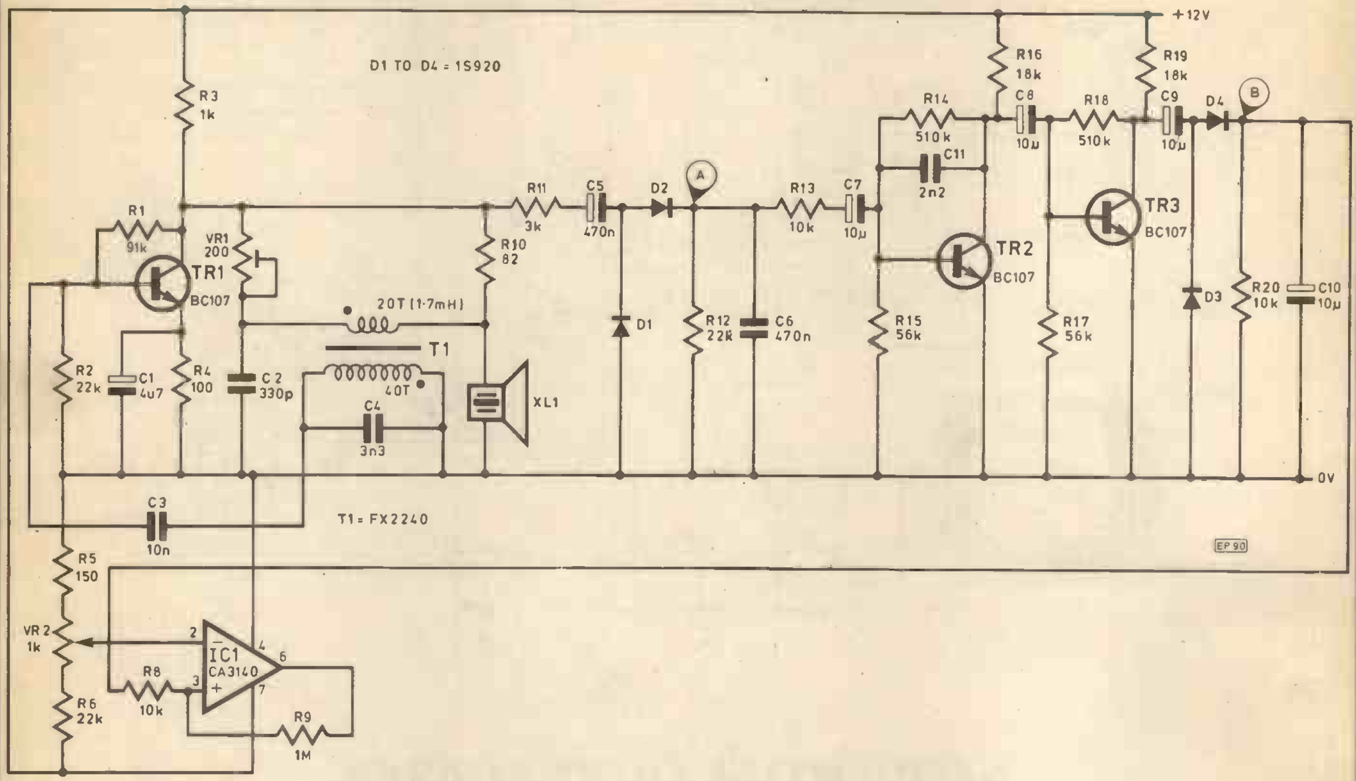
The high frequency bursts are amplified by BC107 transistors which have 1 : 1 ratio insulation transformers in series with resistors in their collector lines. The transformers used had a breakdown voltage of 1·5kV and can be obtained cheaply, although they can be made by winding two layers of 26s.w.g. 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 hystereses, 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.

S. Choudhari,
Trondheim,
Norway

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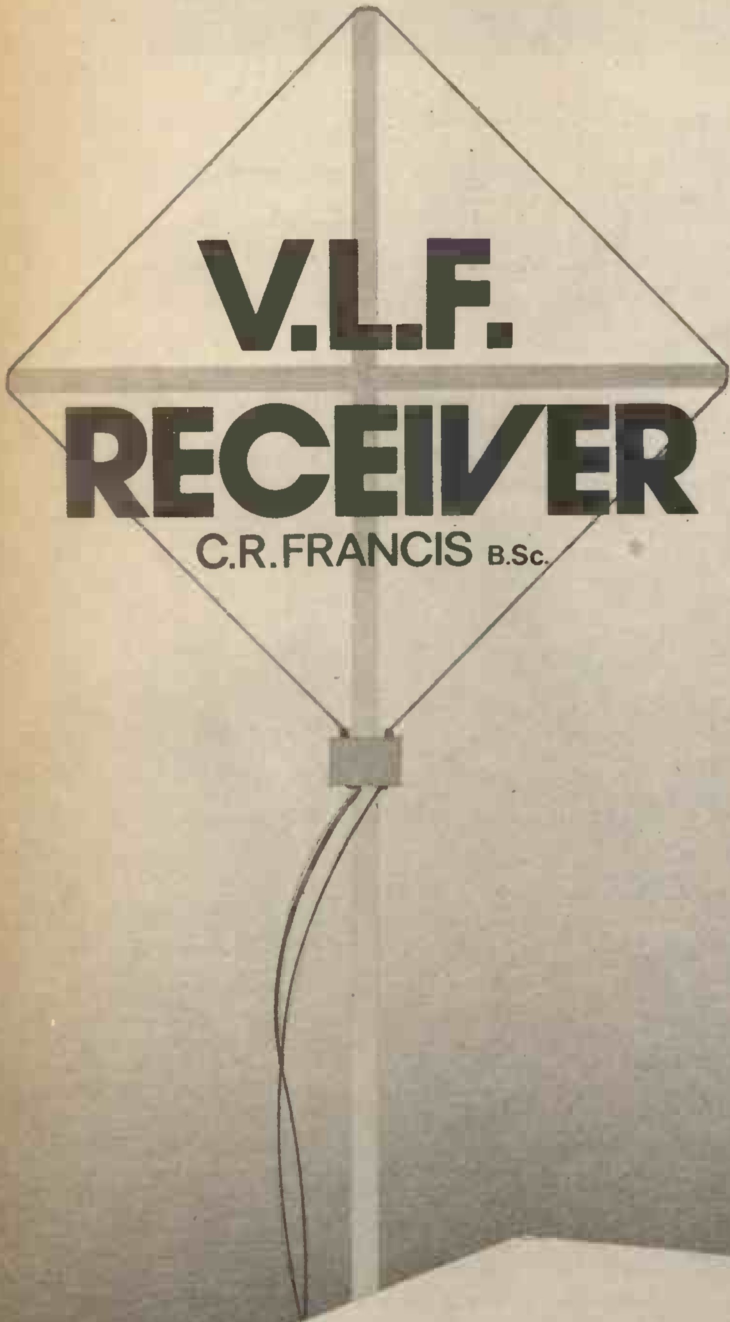
V.L.F. RECEIVER

C.R. FRANCIS B.Sc.



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.

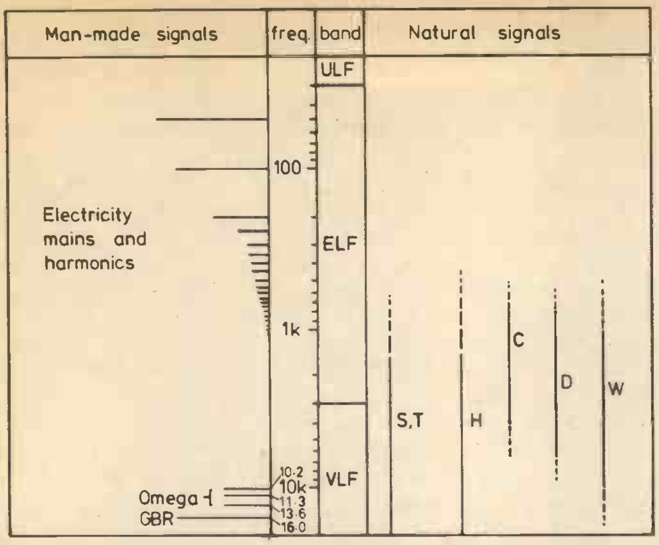


Fig. 1. Approximate frequency ranges of ELF/VLF signals. S: Sferics; T: Tweeks; H: Hiss; C: Chorus; D: Discrete emissions; W: Whistlers

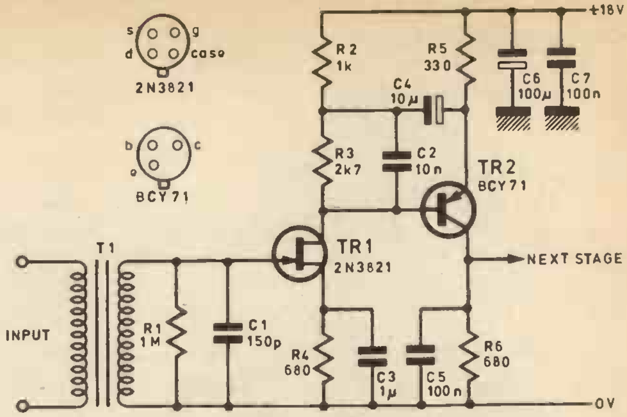


Fig. 3. Circuit diagram of the input stage

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.

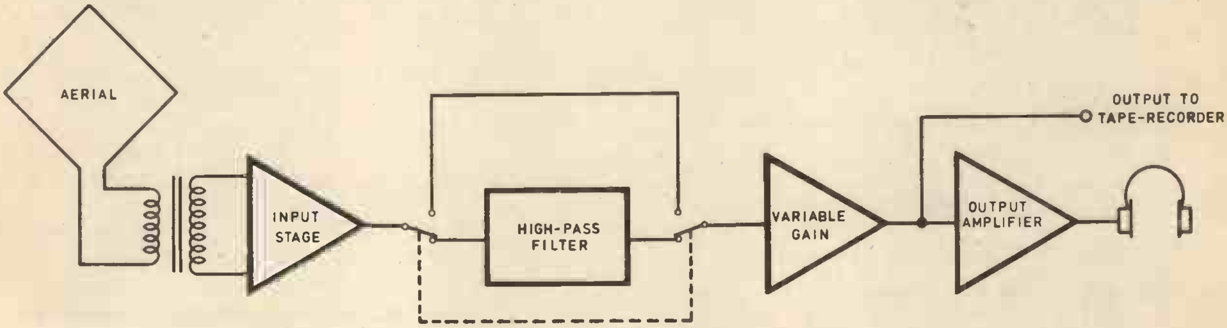


Fig. 2. Block diagram of the receiving system

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.

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

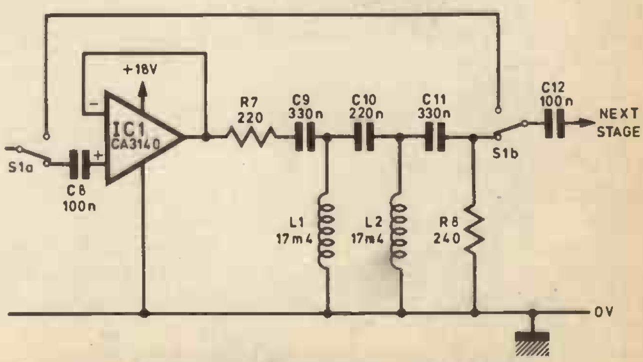


Fig. 4. Circuit diagram of the passive filter stage

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 = 323nF, L1 and L2 = 17·4mH and C10 = 206nF. 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.

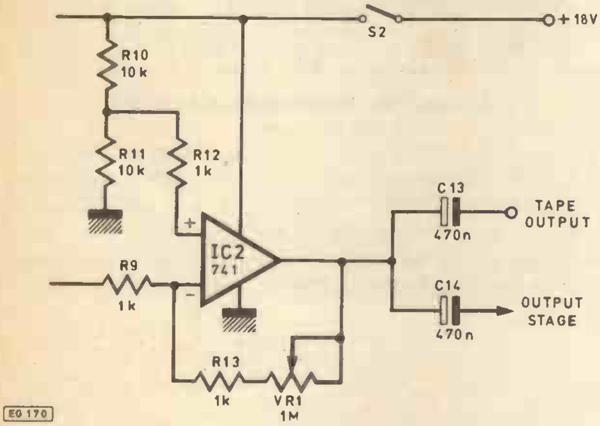


Fig. 5. Circuit diagram of the output stage

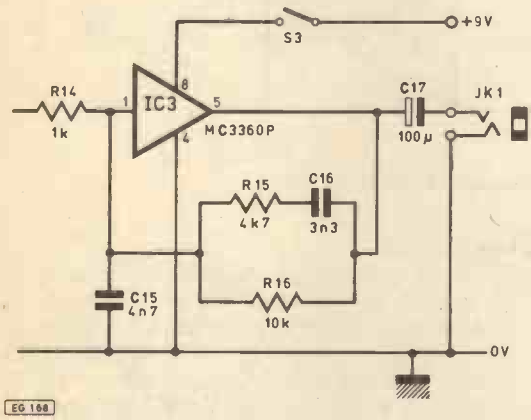


Fig. 6. Circuit diagram of the amplifier stage

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,

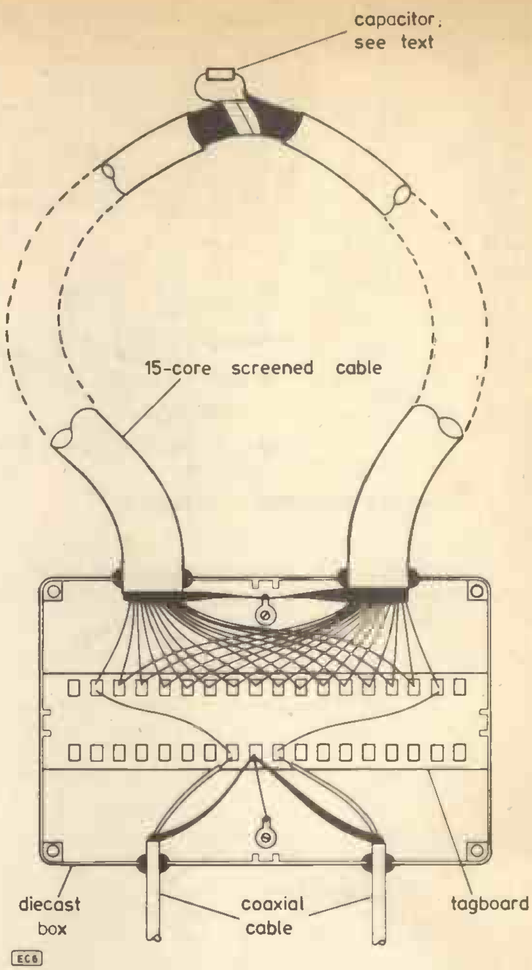


Fig. 7. Construction of the multi-turn aerial

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

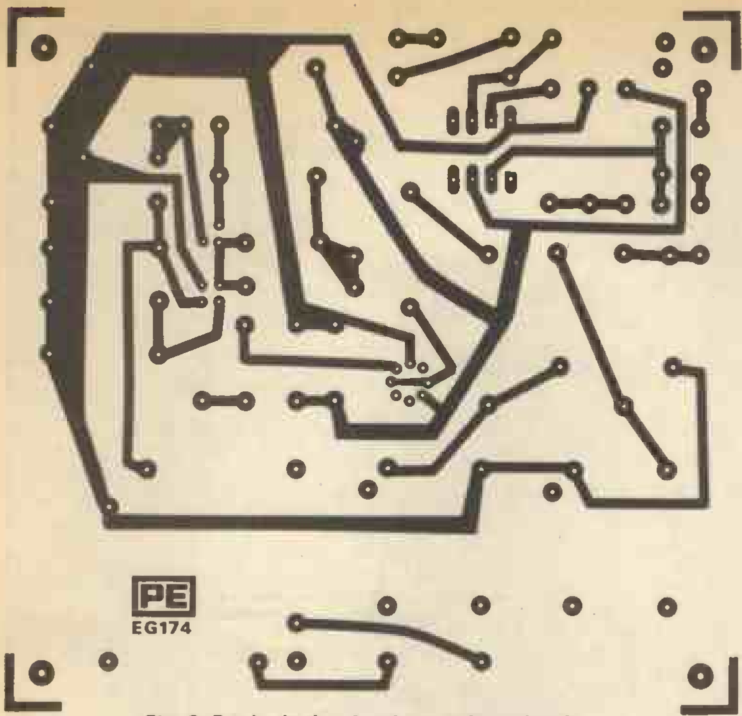


Fig. 8. P.c.b. design for the receiver circuit

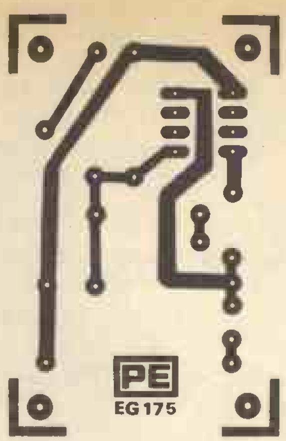


Fig. 10. P.c.b. design for the amplifier circuit

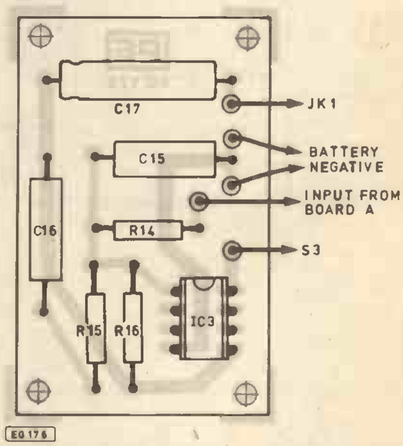
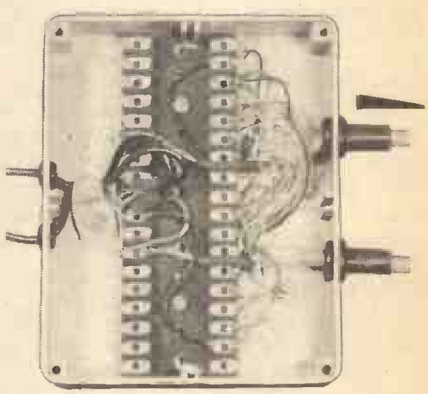


Fig. 11. Component layout for the amplifier circuit



Internal view of the aerial case

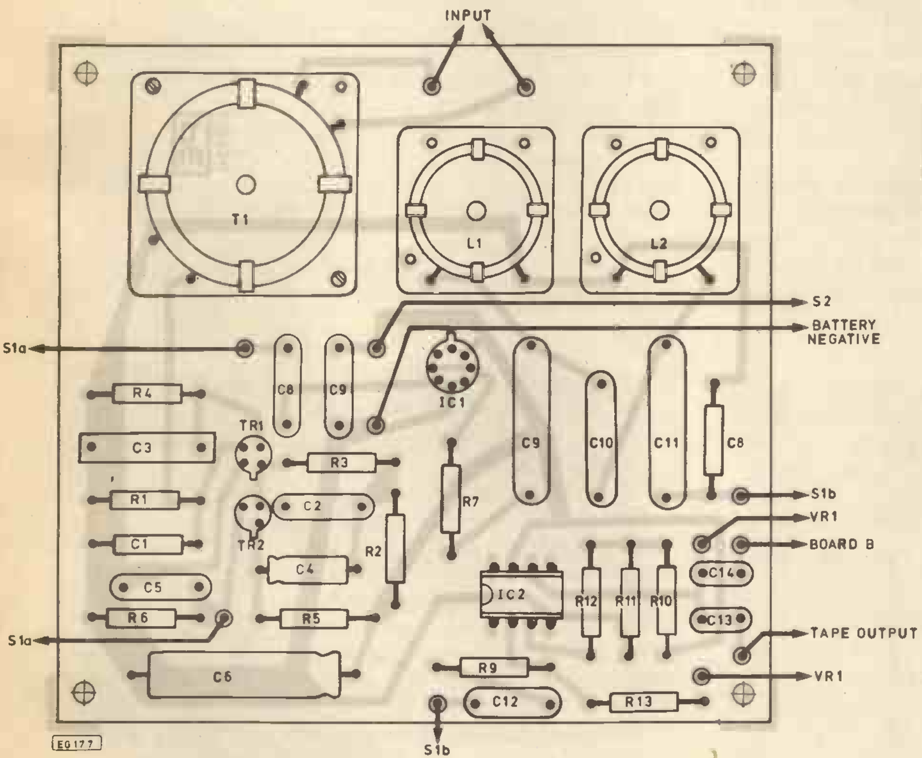


Fig. 9. Component layout for the receiver circuit

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. 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	1µ
C4	10µ elect
C5, C7, C8, C12	100n (4 off)
C6, C17	100µ 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)

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.

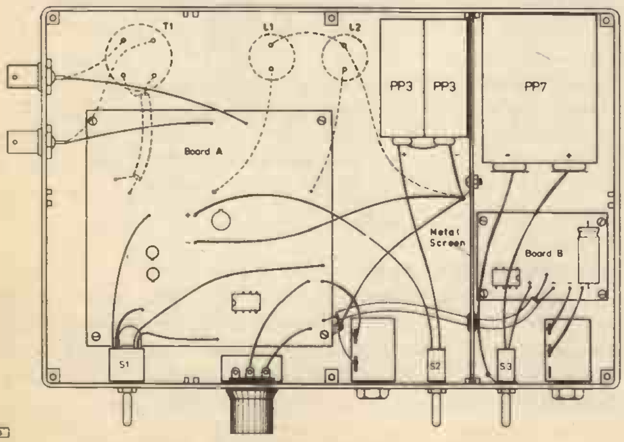
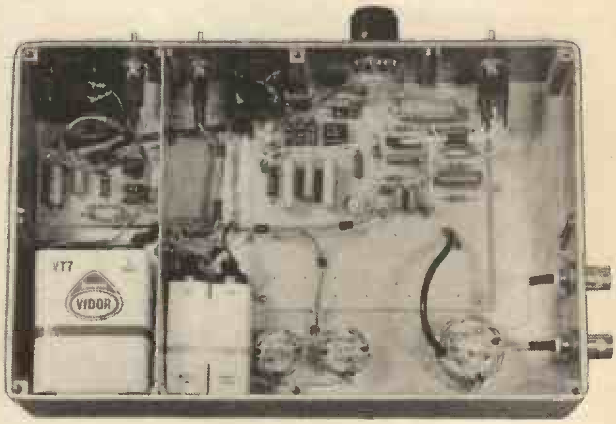


Fig. 12. Assembly of the receiver

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



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.

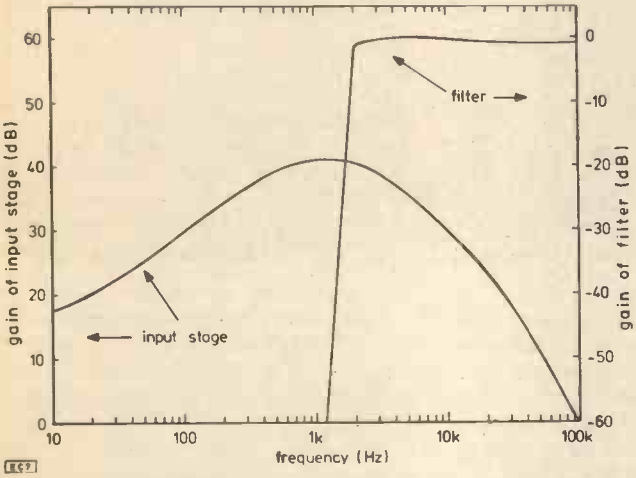


Fig. 13. Frequency response of the input stage and the passive high-pass filter

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.

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

Front panel annotation

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 20µV/m, while in the summer numerous sferics from relatively nearby thunderstorms raise this to 200 to 700µV/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:	0·01µV
summer background noise:	up to 0·5µV
whistlers:	anything up to about 2µV

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 0·06µV. 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:	1µV
summer background:	up to 50µV
whistlers:	up to 0·2mV
Johnson noise in aerial:	6µV

TABLE 2

The noise generated in the receiver is equivalent to an input noise voltage of about 3µV; 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 12µV 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. ★

FRANK W. HYDE

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.

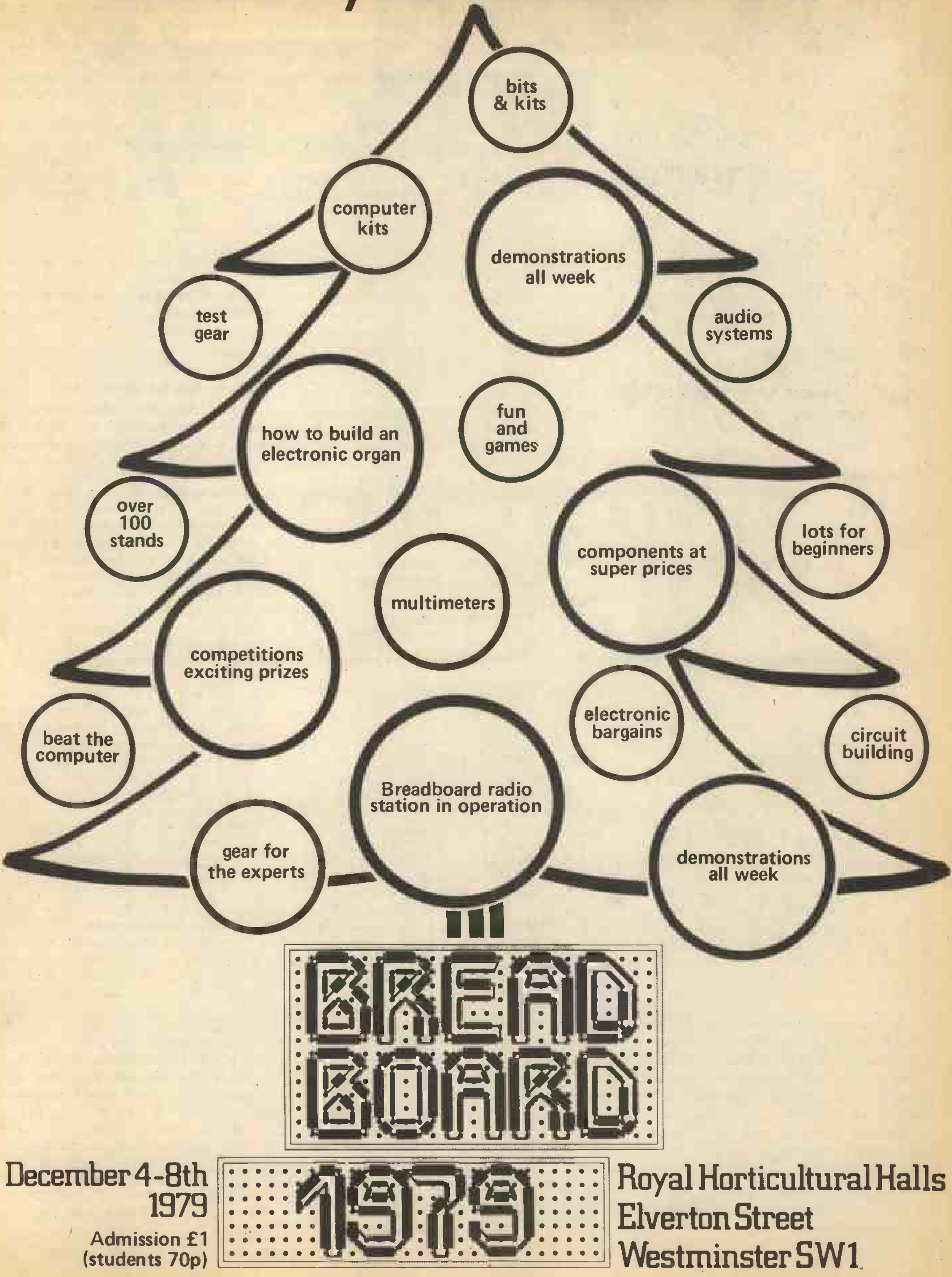
The finding of a ring of small particles is of special interest. Like that of Uranus the ring is much more tenuous and does not extend as far out as those of Saturn. Its appearance to probes is not perhaps surprising because Jupiter is itself so bright that the possibility of actually seeing it from 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



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

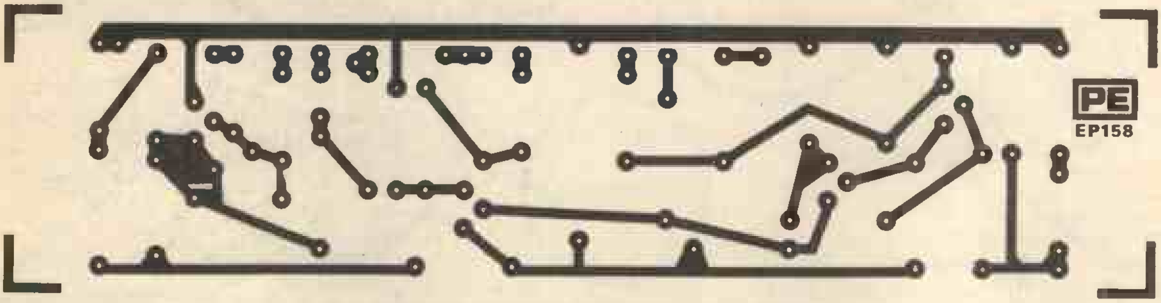


Fig. 10. Input channel amplifiers—six are required

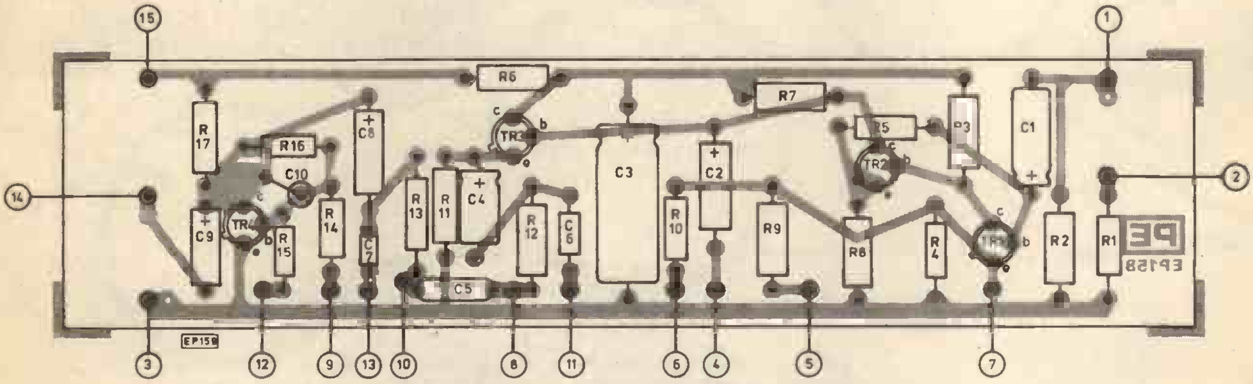


Fig. 11. Component layout for input amplifiers

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.

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

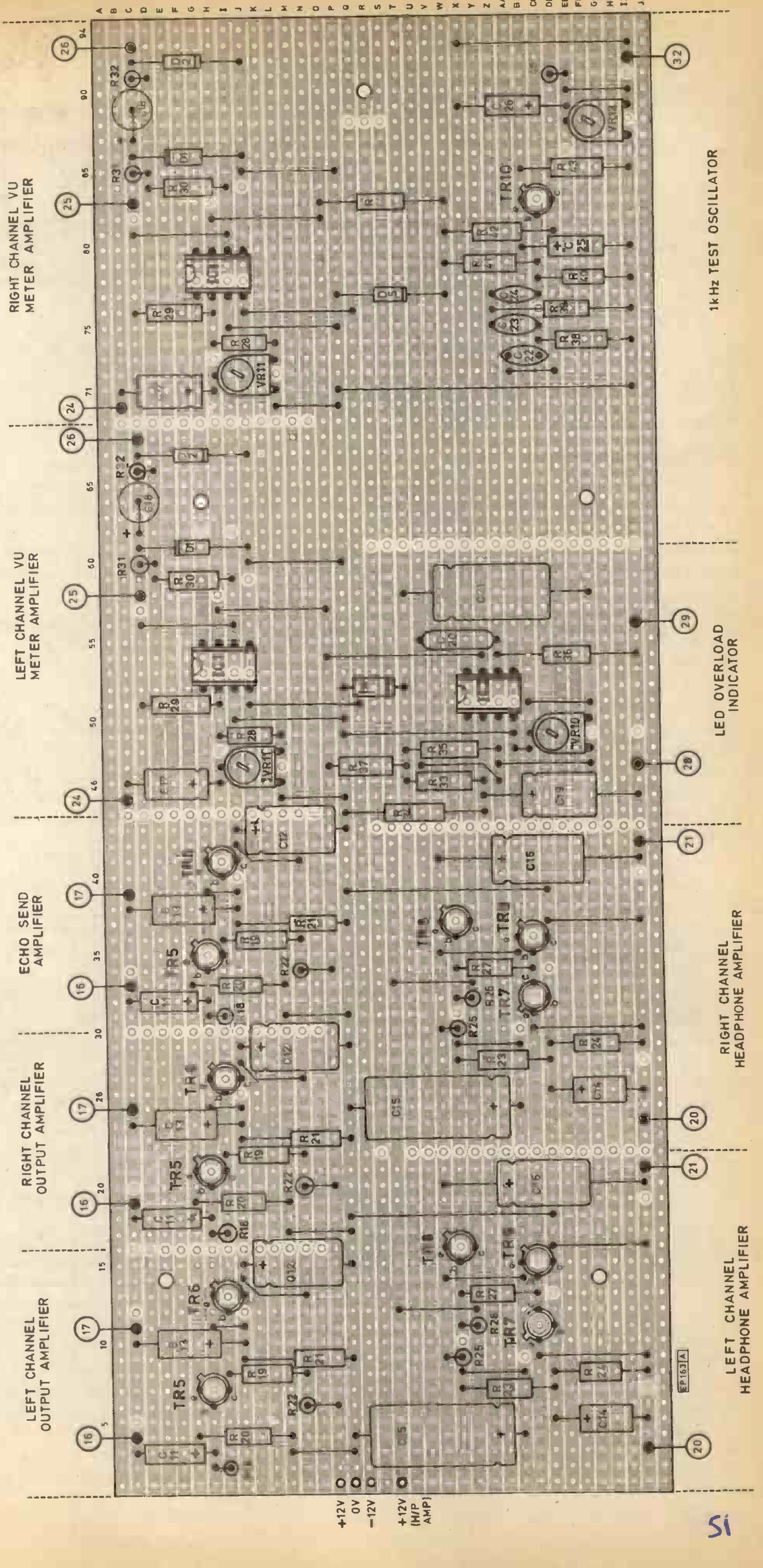


Fig. 12. Main board that includes headphone amplifiers, output amplifiers, overload indicator, VU meter amplifier and test oscillator. This should be attached to the bottom panel as shown in the prototype layout in Part 1

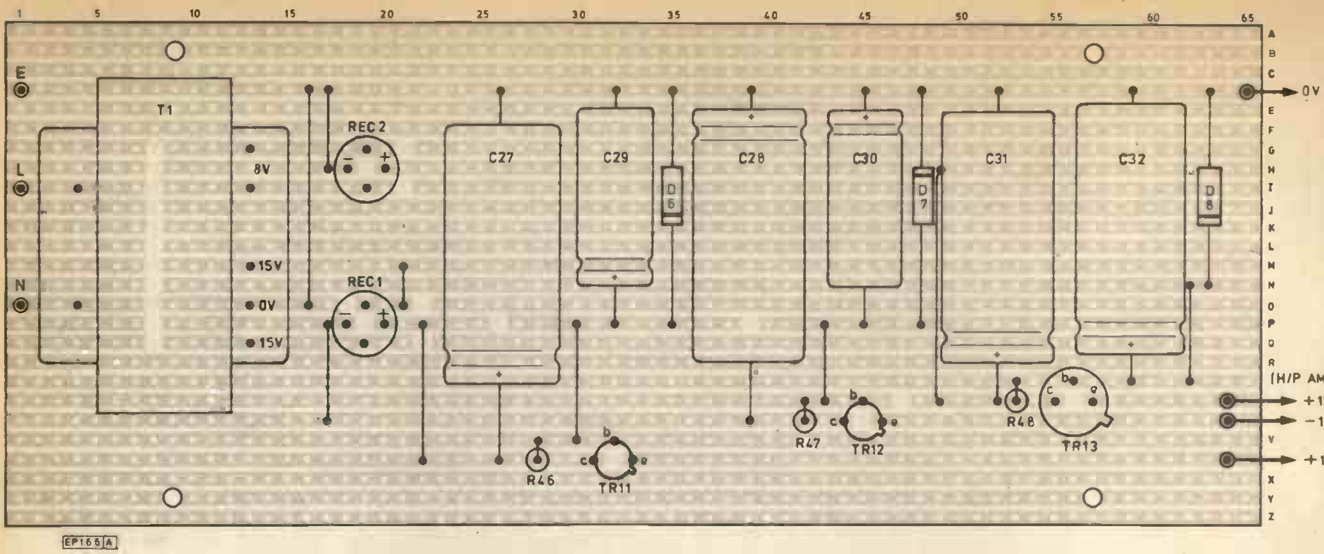


Fig. 13. P.s.u. board

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.

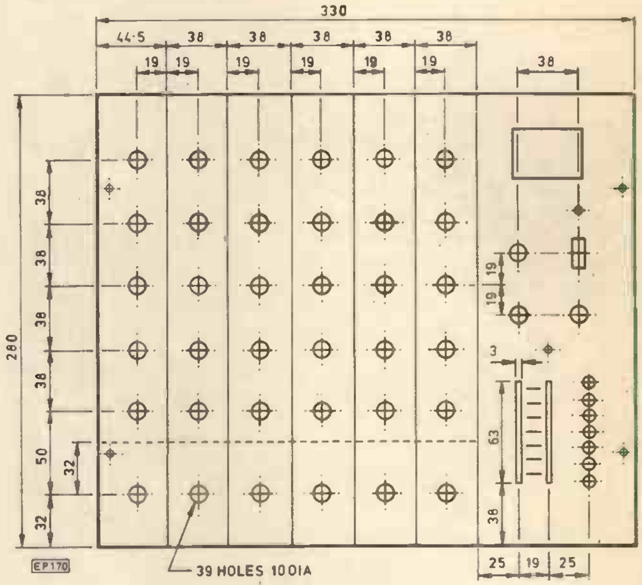


Fig. 14. Panel cut-out guide

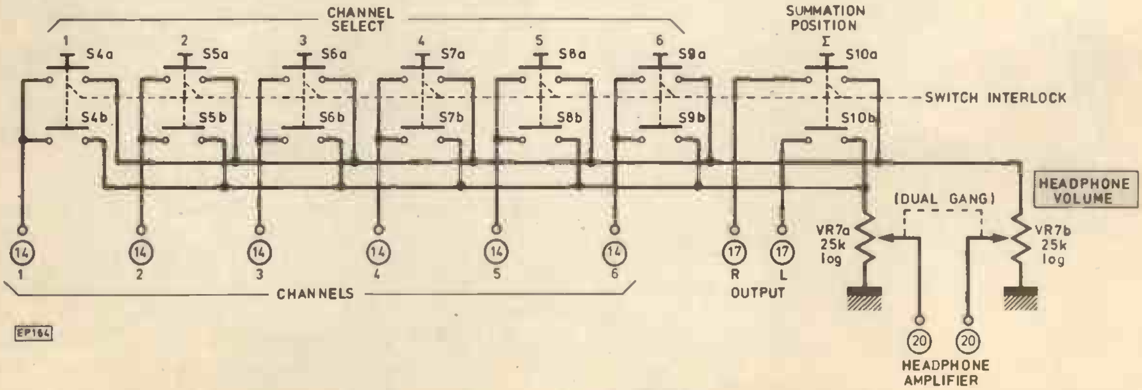


Fig. 15. Circuit for p.f.l. interlocking push switches

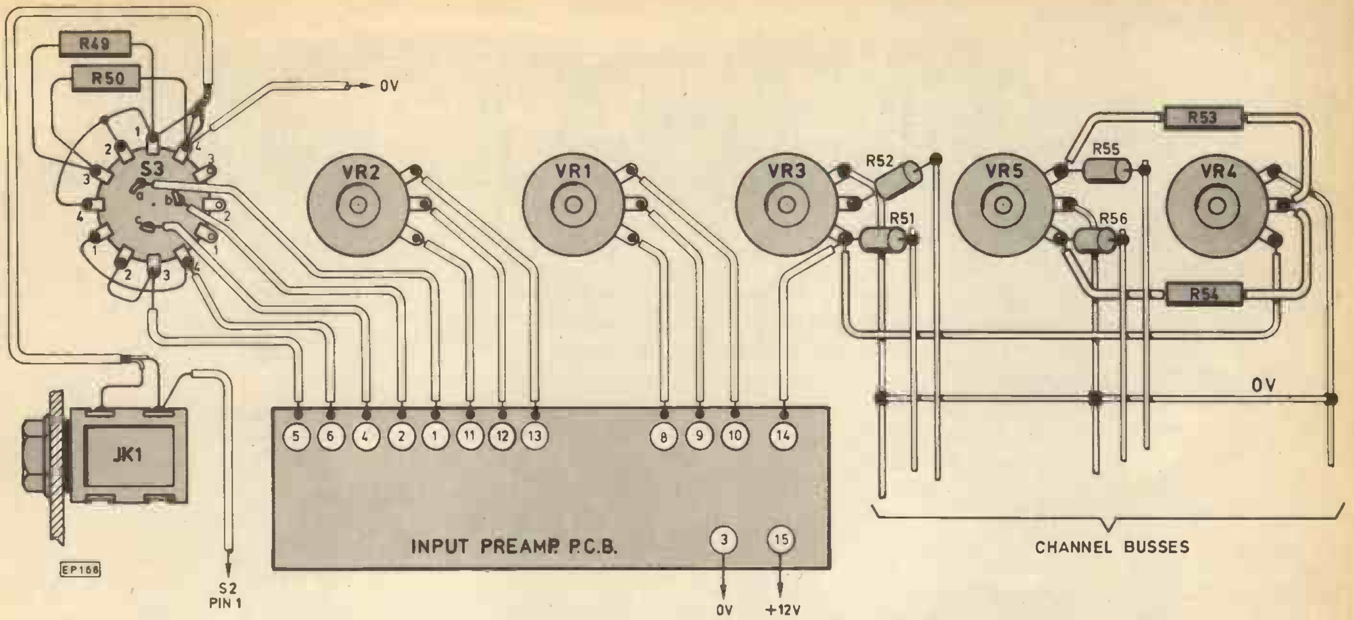
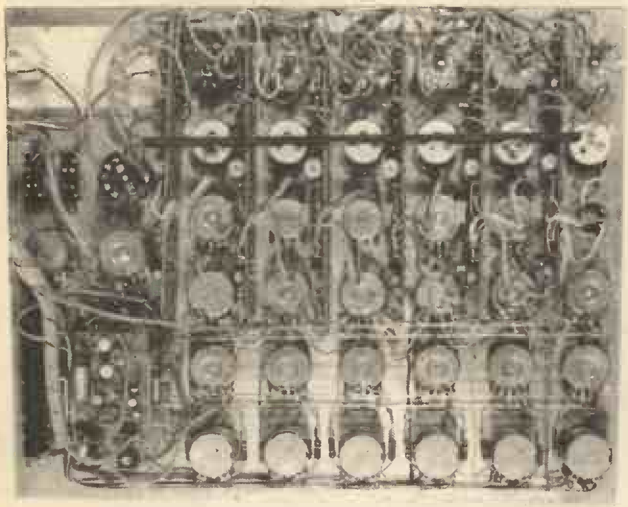


Fig. 16. Single channel control wiring to input amplifier



(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

1Khz 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 OdB. 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.

★

PATENTS REVIEW...

Copies of Patents can be obtained from : the Patent Office Sales, St. Mary Cray, Orpington, Kent Price 95p each

Fig. 1

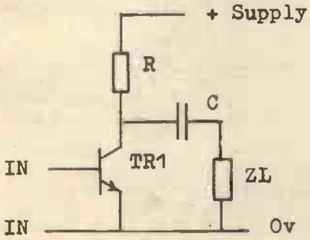


Fig. 2

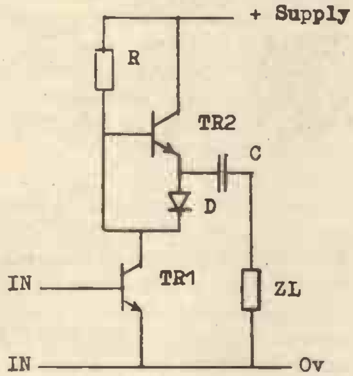
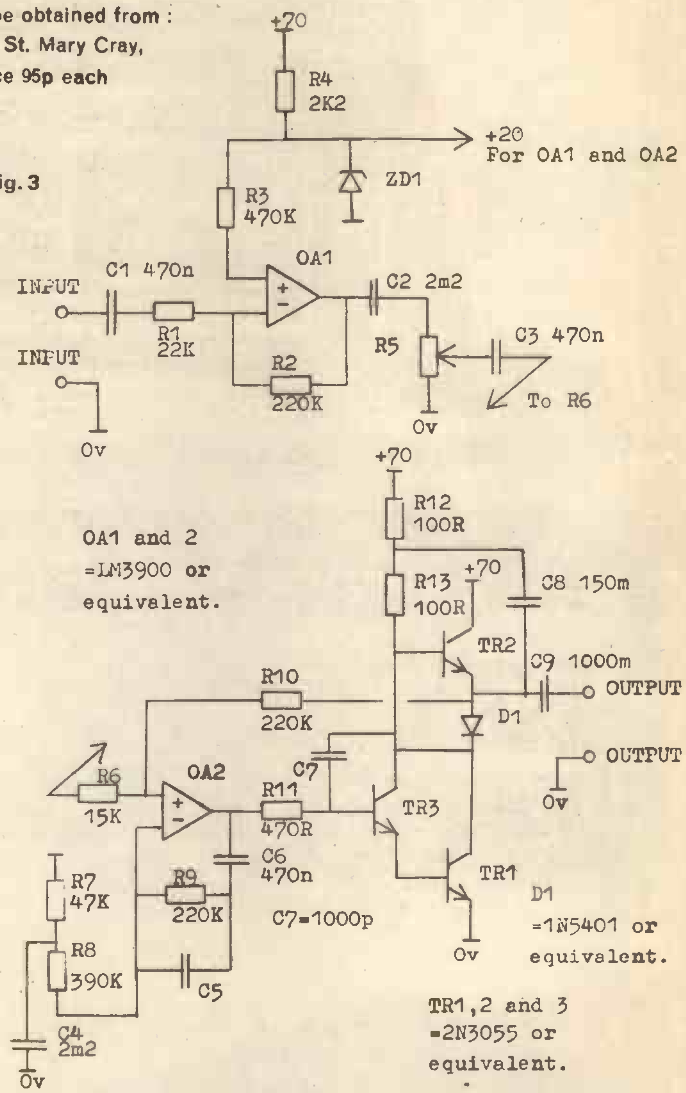


Fig. 3



CLASS A

Keith Garwell of Stoke-on-Trent was recently granted (under the old laws) British Patent 1 527 293. This covers a new type of Class A transistor amplifier. In a letter published in the hi-fi press Garwell claimed that the circuit has "most of the advantages of Class A without the attendant poor efficiency" and that although "the configuration is still being developed . . . present models are giving good results". Fig. 1 of Garwell's patent shows a simplified conventional Class A circuit. With no input signal applied, the collector voltage on TR1 is stable and there is no current in load ZL. This is the quiescent state. When an input causes the current in TR1 to decrease, the collector becomes more positive and current flows in the load via capacitor C. When the input causes the current in TR1 to increase, the collector becomes less positive, and current flows out of the load via capacitor C. During the positive-going state the current supply to the load is limited by the value of resistor R and the quiescent current in resistor R is of the same order of magnitude as the maximum load current required. But the quiescent current represents wasted power. A similar situation obtains for the negative-going state. The inventor aims to raise the conversion efficiency by replacing the passive load R with an active composite network. As shown in Fig. 2 transistor TR2 and diode D are added to resistor R. A positive-going collector potential on TR1 causes diode D to reverse bias so that it will not conduct. TR2 then turns on the supply of current to the load. During the negative-going state TR1 draws current from the load via diode D in its conducting state. The diode cathode is thus negative with respect to the anode and transistor TR2 turns off. Thus the only current handled by TR1 in addition to the load current is that flowing through resistor R, and this is reduced with respect to the conventional situation. A circuit is shown in Fig. 3 which is suitable for an audio amplifier which will deliver approximately 50 watts into an eight ohm load from a 250 millivolt input and a power supply of 70 volts d.c.

COMPUKIT UK 101

SINGLE BOARD COMPUTER

PART 3

A.A. BERK B.Sc. Ph.D.

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 ┐	Out of memory: program too big or too many nested GOSUBs, FOR NEXT loops or variables.
O ϟ	Overflow: result of calculation too large for BASIC.
S ┘	Syntax error: typing mistakes etc.
R \	RETURN without GOSUB.
U √	Undefined statement: attempt to jump to non-existant line-number.
/ ◢	Division by zero.
C ┘	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 O┐.
S ʃ	String temporaries: string expression too complex.
T ┐	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:

$$X = \frac{15{\cdot}7 \times 13^{\sin(0{\cdot}781)}}{87 \quad \times 10^4}$$

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

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 upper-case 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	ξ
180	⇐	250	λ
211	√	251	ϕ
212	ʃ	252	β
241	α	253	ε
242	β	254	γ
243	ω	255	ɣ

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 : 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 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
```

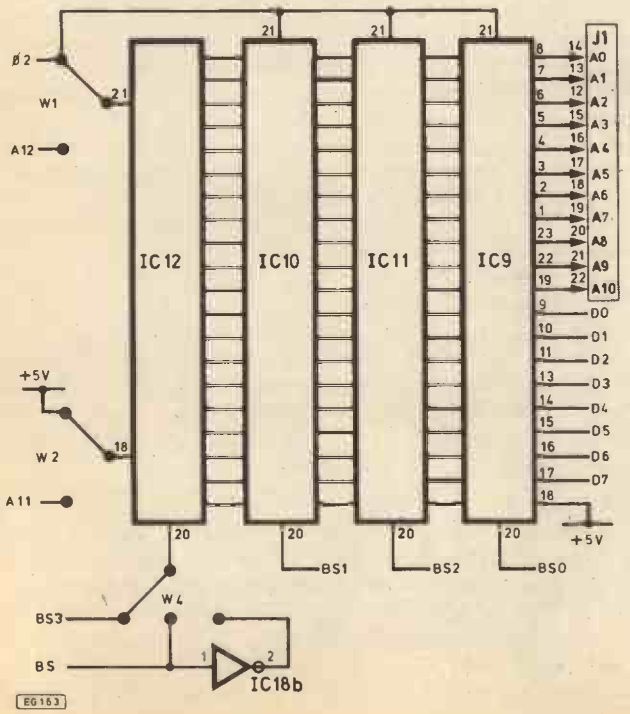
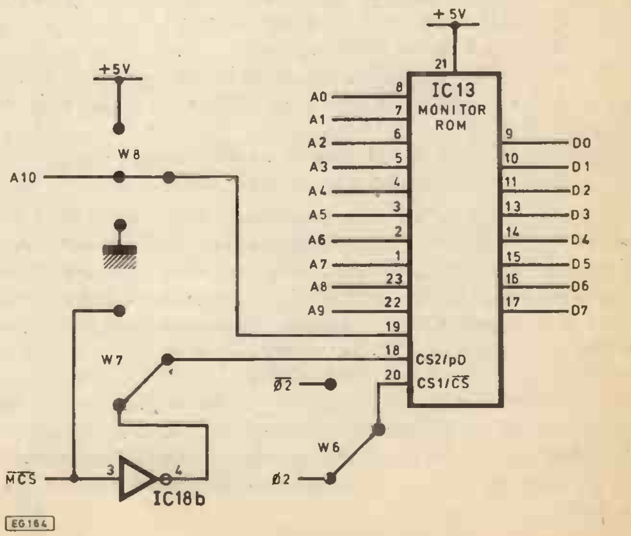


Fig. 3.1 (left). BASIC ROMs

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 ÷2). Before IC29's ÷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 strobes 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 ϕ0in 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 64µs. 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

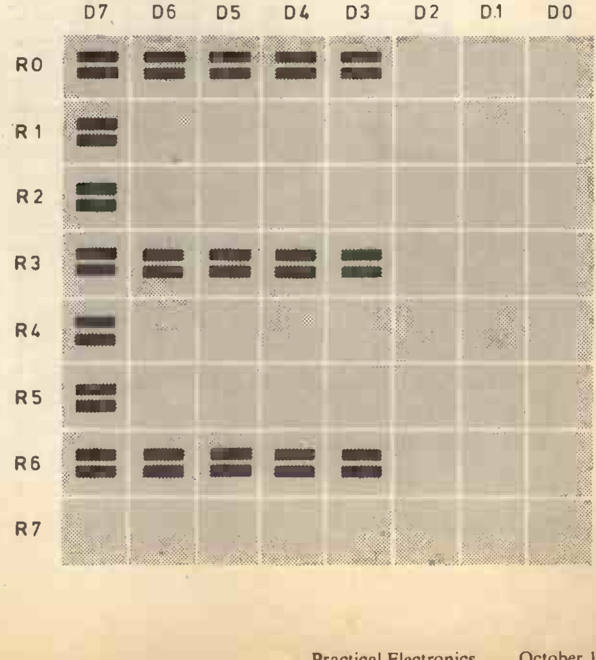
The block diagram of Fig. 1.2 shows the basic parts of the VDU and the circuit diagram (Fig. 2.2) gives the details referred to below.

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 × 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 strobes across the screen. This takes 1µs, and each successive 1µs 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 64µs 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. $\overline{\text{RS0}}$–$\overline{\text{RS7}}$ are *selects* for the RAM (8 blocks of 1K, each comprising two 2114's). BS0–BS3 select the BASIC ROMs, and $\overline{\text{MCS}}$ selects the monitor ROM. $\overline{\text{ACS}}$ 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

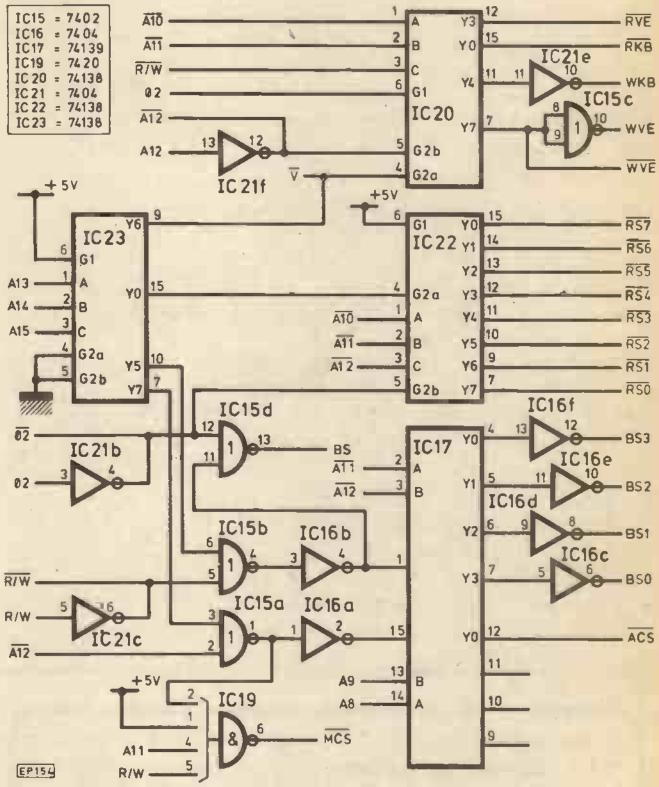


Fig. 3.5 (above). Address decoding

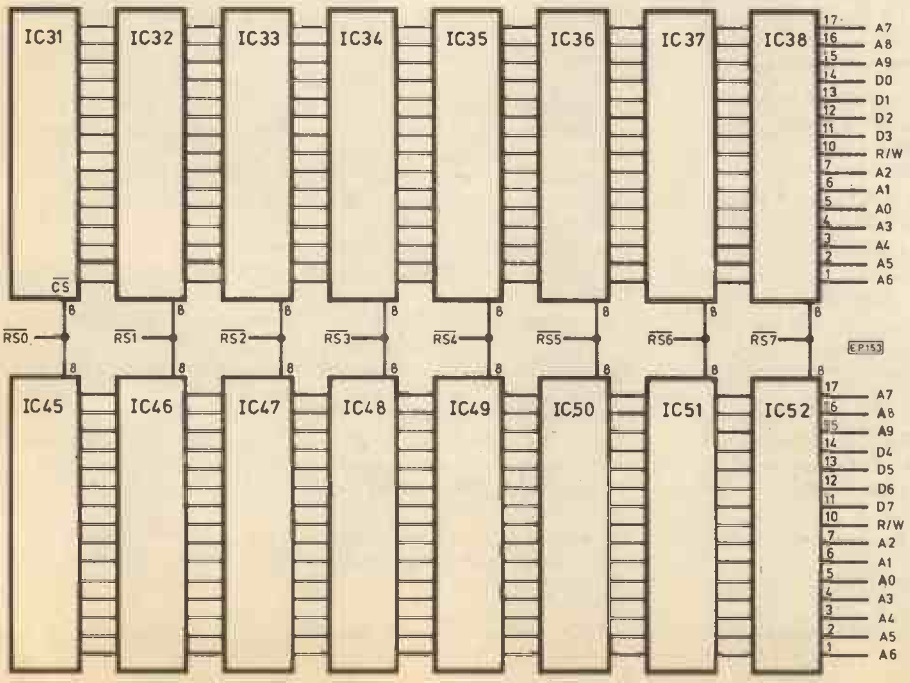


Fig. 3.4 (left). RAM configuration for 8K bytes

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.

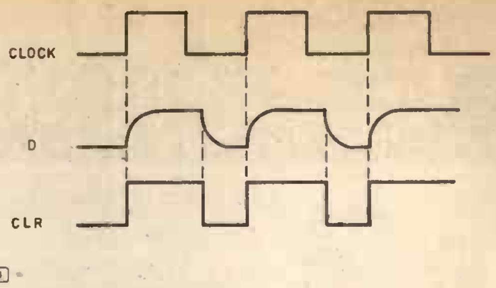


Fig. 3.6 Timing diagram

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

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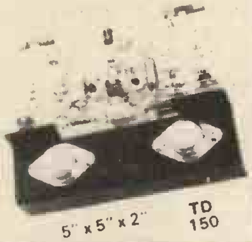

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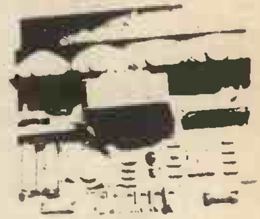

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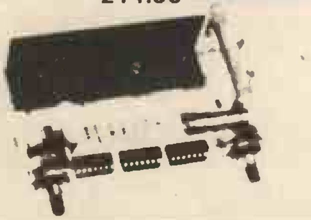

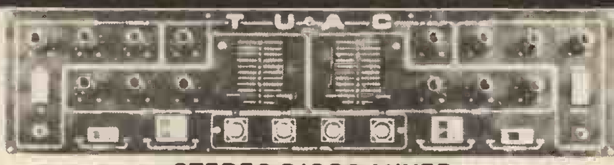

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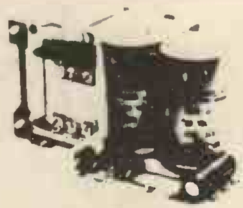

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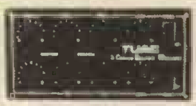

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74LS00	13p	74LS40	21p	74LS136	32p	74LS221	120p
74LS01	14p	74LS47	80p	74LS138	70p	74LS244	200p
74LS02	13p	74LS48	92p	74LS139	70p	74LS245	250p
74LS03	14p	74LS49	95p	74LS151	55p	74LS247	92p
74LS04	15p	74LS73	29p	74LS153	55p	74LS248	92p
74LS05	25p	74LS74	32p	74LS155	80p	74LS249	90p
74LS08	16p	74LS75	38p	74LS156	94p	74LS251	85p
74LS09	20p	74LS76	36p	74LS157	55p	74LS273	200p
74LS10	16p	74LS78	40p	74LS158	55p	74LS279	85p
74LS11	21p	74LS83	90p	74LS160	110p	74LS283	70p
74LS12	23p	74LS85	75p	74LS161	74p	74LS290	68p
74LS13	34p	74LS86	31p	74LS162	118p	74LS293	88p
74LS14	70p	74LS90	42p	74LS163	70p	74LS298	90p
74LS15	22p	74LS93	51p	74LS164	95p	74LS352	98p
74LS20	15p	74LS95	75p	74LS173	90p	74LS353	98p
74LS21	22p	74LS107	36p	74LS174	90p	74LS365	95p
74LS22	22p	74LS109	36p	74LS175	92p	74LS366	95p
74LS26	24p	74LS112	38p	74LS190	88p	74LS367	95p
74LS27	25p	74LS113	38p	74LS191	88p	74LS368	95p
74LS28	30p	74LS114	38p	74LS192	100p	74LS374	160p
74LS30	19p	74LS123	60p	74LS193	100p	74LS386	30p
74LS32	24p	74LS125	40p	74LS195	110p	74LS670	170p
74LS37	22p	74LS126	40p	74LS196	80p		
74LS38	25p	74LS132	70p	74LS197	100p		

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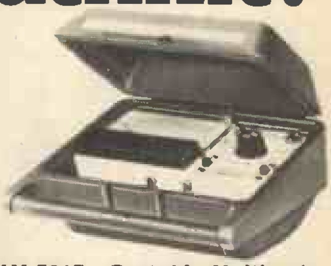

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ONE MAN'S VIEWS ON THE PRESENT SITUATION

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

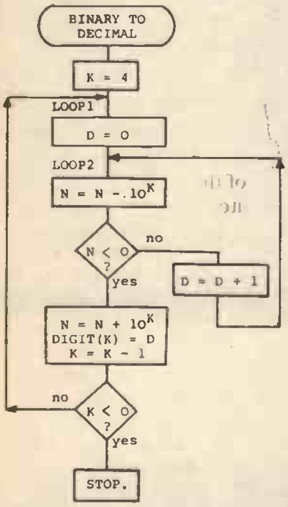


Fig. 1. Flowchart for a routine to convert a binary number N into decimal.

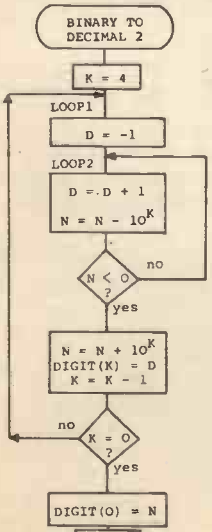


Fig. 2. Flowchart for an improved version of the binary-to-decimal routine.

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

```
                 * BINARY TO DECIMAL FOR 6800
                 * NUMBER IN A,B
                 * RESULT STORED AT X
0000 0005        RESULT RMB    5
0005 0002        DIGITS RMB    2          POINTS TO RESULT
0007 0002        XTENS  RMB    2          POINTS TO POWERS
0009 0002        POWER  RMB    2          HOLDS LATEST POWER
000B 2710        K1OTAB FDB    10000
000D 03E8               FDB    1000
000F 0064               FDB    100
0011 000A               FDB    10
                 *
0013 86 EA       BINDEC LDA A  £$EA       A,B=59999
0015 C6 5F              LDA B  £$5F         FOR TEST
0017 CE 0000            LDX    £RESULT
001A DF 05              STX    DIGITS     SAVE X
001C CE 000B            LDX    £K1OTAB
001F DF 07       LOOP1  STX    XTENS
0021 EE 00              LDX    0,X        GET POWER OF TEN
0023 DF 09              STX    POWER      FOR USE LATER
0025 DE 05              LDX    DIGITS
0027 6F 00              CLR    0,X        CLEAR DIGIT
0029 20 02              BRA    NOINC      AVOID INCREMENT
002B 6C 00       LOOP2  INC    0,X        INCREMENT DIGIT
002D D0 0A       NOINC  SUB B  POWER+1
002F 92 09              SBC A  POWER
0031 24 F8              BCC    LOOP2
0033 DB 0A              ADD B  POWER+1    RESTORE
0035 99 09              ADC A  POWER
0037 08                 INX               NEXT DIGIT
0038 DF 05              STX    DIGITS
003A DE 07              LDX    XTENS
003C 08                 INX               POINT TO NEXT
003D 08                 INX                 TABLE ENTRY
003E 8C 0013            CPX    £K1OTAB+8
0041 26 DC              BNE    LOOP1
0043 DE 05              LDX    DIGITS     LAST DIGIT
0045 E7 00              STA B  0,X        STORE REMAINDER
0047 39                 RTS               RETURN.
```

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                        .=$0020           FOR ACORN
0020                LO      .=.+1 NUMBER BEING CONVERTED
0021                HI      .=.+1 DITTO
0022                PNO     .=.+2 ADDRESS OF RESULT
0024   27           P1OTAB  .BYTE $27,$03,$00,$00
0028   10                   .BYTE $10,$E8,$64,$0A
                    ;
002C   A9 EA        BINDEC  LDA   £$EA            A,X=59999
002E   A2 5F                LDX   £$5F
0030   85 21                STA   HI
0032   86 20                STX   LO
0034   D8                   CLD                   FOR BINARY
0035   A0 00                LDY   £0
0037   A2 FF        LOOP1   LDX   £$FF            COUNTER
0039   38                   SEC
003A   E8           LOOP2   INX
003B   A5 20                LDA   LO
003D   F9 28 00             SBC   P1OTAB+4,Y
0040   85 20                STA   LO
0042   A5 21                LDA   HI
0044   F9 24 00             SBC   P1OTAB,Y
0047   85 21                STA   HI
0049   B0 EF                BCS   LOOP2
004B   A5 20        STORE   LDA   LO              RESTORE
004D   79 28 00             ADC   P1OTAB+4,Y
0050   85 20                STA   LO
0052   A5 21                LDA   HI
0054   79 24 00             ADC   P1OTAB,Y
0057   85 21                STA   HI
0059   8A                   TXA                   GET DIGIT
005A   91 22                STA   (PNO),Y         SAVE IT
005C   C8                   INY
005D   C0 04                CPY   £4              ALL DONE?
005F   D0 D6                BNE   LOOP1
0061   A5 20                LDA   LO              REMAINDER
0063   91 22                STA   (PNO),Y         SAVE IT
0065   60                   RTS                   RETURN.
```

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

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 Z80
                      ; NUMBER IN HL - RESULT AT IX
                      ;
0000  0005            DEC:     DEFS  5          ; FOR RESULT
0005  10 27           K1OTAB:  DEFW  10000
0007  E8 03                    DEFW  1000
0009  64 00                    DEFW  100
000B  0A 00                    DEFW  10
                      ;
000D  21 5F EA        BINDEC:  LD    HL,59999   ; TO TEST IT
0010  DD 21 00 00              LD    IX,DEC
0014  FD 21 05 00              LD    IY,K1OTAB
0018  3E FF           LOOP1:   LD    A,0FFH
001A  FD 5E 00                 LD    E,(IY)     ; GET POWER
001D  FD 56 01                 LD    D,(IY+1)   ;   OF TEN
0020  B7                       OR    A          ; CLEAR CARRY
0021  ED 52           LOOP2:   SBC   HL,DE
0023  3C                       INC   A
0024  D2 21 00                 JP    NC,LOOP2
0027  19              JUMP:    ADD   HL,DE      ; RESTORE
0028  DD 77 00                 LD    (IX),A     ; STORE DIGIT
002B  DD 23                    INC   IX         ; NEXT DIGIT
002D  FD 23                    INC   IY         ; NEXT POWER
002F  FD 23                    INC   IY         ;   OF TEN
0031  7B                       LD    A,E
0032  FE 0A                    CP    10         ; LAST ONE?
0034  C2 18 00                 JP    NZ,LOOP1
0037  DD 75 00                 LD    (IX),L     ; REMAINDER
003A  C9                       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         K10TAB FDB   10000
0007       03E8                FDB   1000
0009       0064                FDB   100
000B       000A                FDB   10
                        *
000D CC    EA5F       3 BINDEC LDD   £59999    FOR TEST
0010 8E    0005       3        LDX   £K10TAB
0013 108E  0000       4        LDY   £RESULT
0017 6F    A4         6 LOOP1  CLR   0,Y
0019 20    02         3        BRA   NOINC
001B 6C    A4         6 LOOP2  INC   0,Y
001D A3    84         6 NOINC  SUBD  0,X
001F 24    FA         3        BCC   LOOP2
0021 31    21         5 PRN5   LEAY  1,Y       I.E. INY
0023 E3    81         9        ADDD  ,X++
0025 8C    000D       4        CMPX  £K10TAB+8
0028 26    ED         3        BNE   LOOP1
002A E7    A4         4        STB   0,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 Fig. 3	6502 Fig. 4	Z80 Fig. 5	6809 Fig.6
INNER LOOP (× 32)	17	25	29	15
OUTER LOOP (× 4)	75	62	159	39
REST (× 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 numver 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      E       =      X'80        ;EXTENSION AS OFFSET
     007F      EIGHT   =      X'7F        ;SEGMENT CODE FOR '8'
0000 0F18              .=0F18
               ;
0F18 C484      BEGIN:  LDI    L(KYBD)-1
0F1A 33                XPAL   3
0F1B C40F              LDI    H(DISBUF)
0F1D 36                XPAH   2
0F1E C401      BACK:   LDI    H(KYBD)
0F20 37                XPAH   3
0F21 01                XAE                ;E = P3H
0F22 C440      RIGHT:  LDI    L(DISBUF)   ;POINT P2 TO
0F24 32                XPAL   2           ;  DISPLAY BUFFER
0F25 C47F              LDI    EIGHT
0F27 E280              XOR    E(2)        ;CHANGE STATE OF
0F29 CA80              ST     E(2)        ;  DISPLAY E
0F2B 3F        SHOW:   XPPC   3           ;DISPLAY ROUTINE
0F2C 90FD              JMP    SHOW        ;COMMAND KEY RETURN
0F2E 03                SCL                ;NUMBER KEY RETURN
0F2F C402              LDI    2
0F31 78                CAE                ;IS KEY LESS THAN 2?
0F32 94EC              JP     RIGHT       ;IF SO-CHANGE DISPLAY
0F34 C601      LOOP:   LD     @1(2)       ;FIND FIRST NON-BLANK
0F36 98FC              JZ     LOOP        ;  DISPLAY
0F38 32                XPAL   2           ;GET DISPLAY NUMBER
0F39 60                XRE                ;IS NUMBER = KEY ?
0F3A D40F              ANI    X'0F
0F3C 98E4              JZ     RIGHT       ;IF SO-CHANGE DISPLAY
0F3E 90DE              JMP    BACK        ;ELSE-CHANGE NUMBER 1
               ;  DISPLAY BUFFER - STARTS ALL BLANK
0F40 0000      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 0F40 to 0F48 are displayed. since P2 is set up to contain 0F40. 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 one 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 $\times 10^6$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 anomolies 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 compatability, 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.

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 hesteresis value.

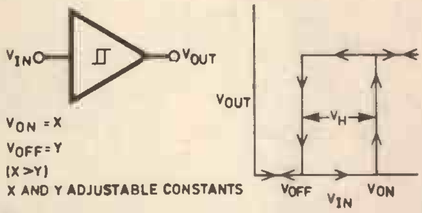


Fig. 1. Ideal trigger with associated transfer characteristic

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 ($\simeq$10µs) 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_{be} 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 tendancy 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_{be} term which is dependent on temperature, and another problem is that the output low voltage is always greater than VR5.

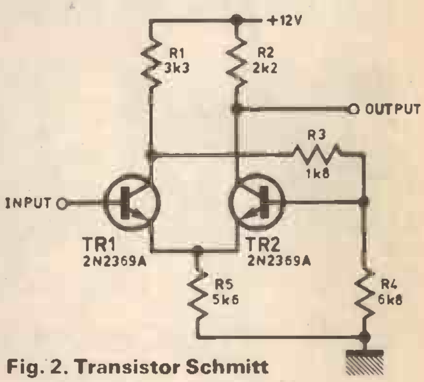


Fig. 2. Transistor Schmitt

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

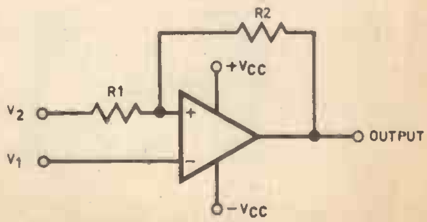


Fig. 3. Op amp Schmitt

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/μs, 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:

$$\frac{R1}{R1+R2}\, V_{OUT} + V_2$$

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

$$V_2 > V_1 - \frac{R1}{R1+R2}\, V_{OUT}(\text{low})$$

and will switch low if:

$$V_2 < V_1 - \frac{R1}{R1+R2}\, V_{OUT}(\text{high})$$

So clearly the hysteresis level is given by:

$$V_H = \frac{R1}{R1+R2}\,[V_{OUT}(\text{high}) - V_{OUT}(\text{low})]$$

and is symmetric of about the threshold if V_{OUT} (high) $= -V_{OUT}$ (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:

$$V_{\text{threshold}} = 0\text{V},\ V_H \triangleq \frac{2R1}{R1+R2}\, V_{CC}$$

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 (R1 + R2) 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

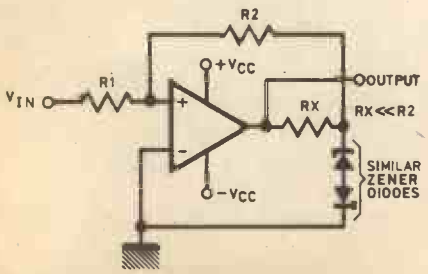


Fig. 4. Trigger with clamped output

plus the Zener forward voltage drop ($\triangleq$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 R2 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.

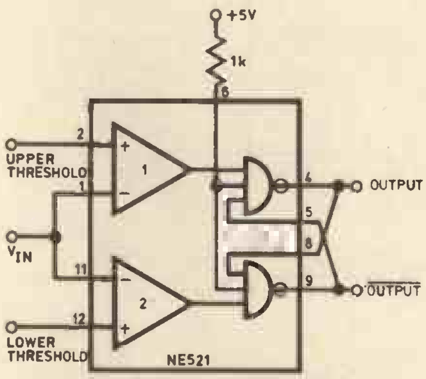


Fig. 5. I.c. programmable trigger

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 ouputs 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.

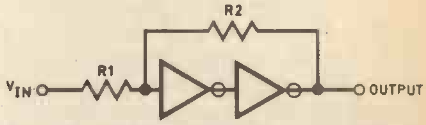


Fig. 6. Trigger formed from CMOS inverters

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 R1, and the typical hysteresis obtained is tabulated in Fig. 7. The actual threshold is dependent on the switching point of the first inverter $\left(\frac{V_{DD}}{2} \pm 40\%\right)$ 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.

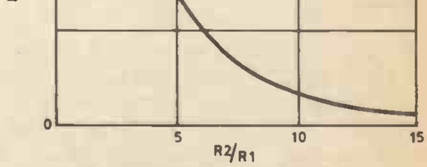


Fig. 7. Graph of hysteresis

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

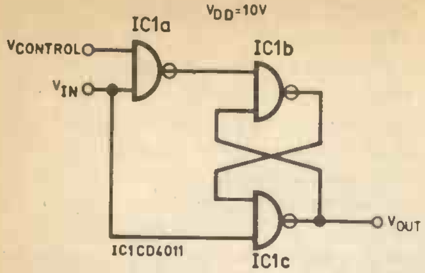


Fig. 8. Trigger utilising interdependence of CMOS gate inputs

$V_{Control}$ alters the input characteristics of gate 1, 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.

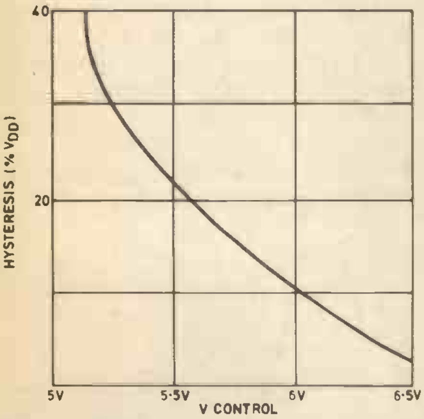


Fig. 9. Varying hysteresis with control voltage

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.

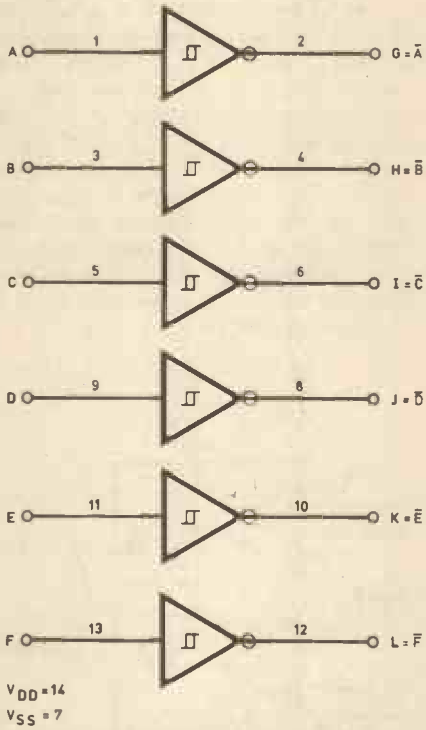


Fig. 10. CD40106 hex inverting Schmitt trigger

V_{DD} (V)	5	10	15
V_{ON} MAX.	3·6	7·1	10·8
V_{ON} MIN.	2·2	4·6	6·8
V_{OFF} MAX.	2·8	5·2	7·4
V_{OFF} MIN.	0·9	2·5	4·0
V_H MAX.	1·6	3·4	5·0
V_H MIN.	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

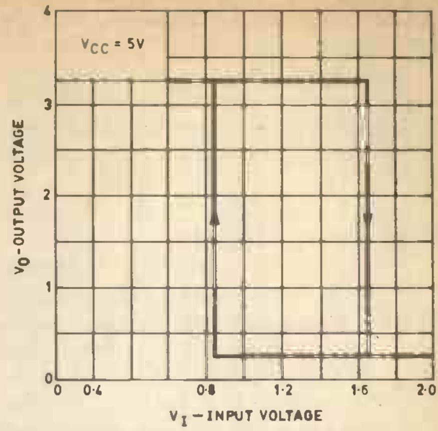


Fig. 12. Switching characteristics for the 7400 Schmitt trigger family

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 tranceiver 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.

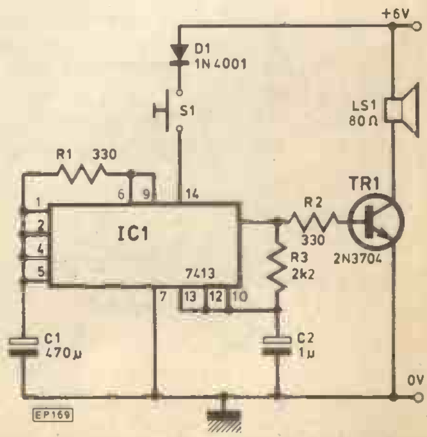
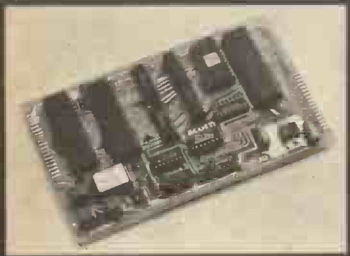
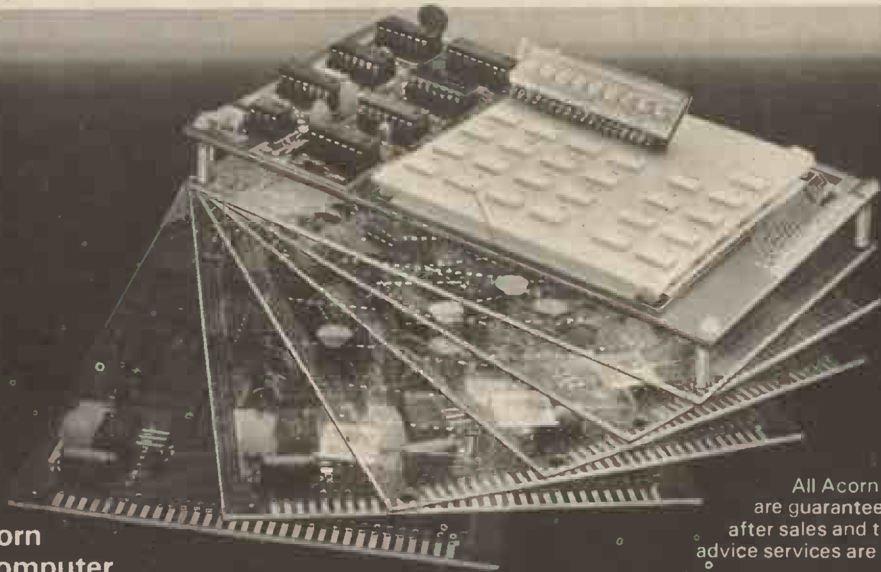
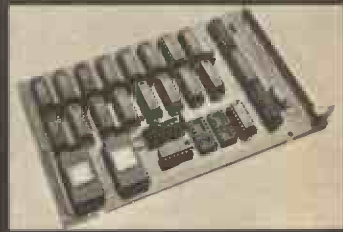


Fig. 13. Doorbell circuit employing dual Schmitt triggers

Three Trumps from Acorn







Acorn Controller

Designed as an industrial controller module, it is based on the 6502 CPU with 2K Eprom, 1.25K ram and 32 I/O lines. In eurocard format it is provided with an onboard monitor (2 × 74S571) giving comprehensive development and debugging facilities. Also available in minimum configuration for low cost OEM applications.

The Acorn Microcomputer

The Acorn controller module mounted beneath a matching eurocard with hex keyboard, 8 digit seven segment display and CUTS tape interface requires only a single unstabilised power supply to form the powerful Acorn microcomputer.

Although designed for expandability the Acorn Microcomputer is a complete development system for the Acorn controller and together with the Acorn Users Manual provides the perfect introduction to hex programming; the carefully optimised monitor has the following functions:

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Set of sub-routines for use in programming
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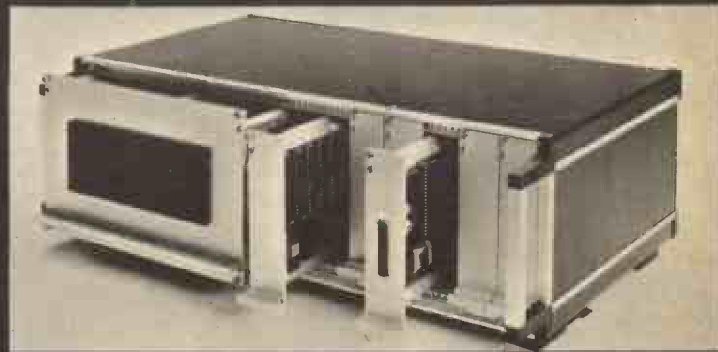
The first in our series of expansion cards is the Acorn 8K + 8K "state of the art" memory module. On a matching eurocard it provides 8K of ram (2114) and 8K of Eprom (2732) or 4K of Eprom (2716). It requires a single 5V rail, is designed for direct connection via a 32 way edge connector to the Acorn bus and is fully buffered for wiring into any system. Two onboard sockets provide independent positioning of Eprom and ram.



Software available soon includes 4K-Editor-Assembler-Disassembler, 4K Proprietary Fast Basic, Disc operating system with full file handling.
Although a standard strip of veroboard is all that is required for a full backplane, a racking system can be made available by Acorn Computers. The rack shown includes the VDU interface, two memory cards and dual floppy disc interface.

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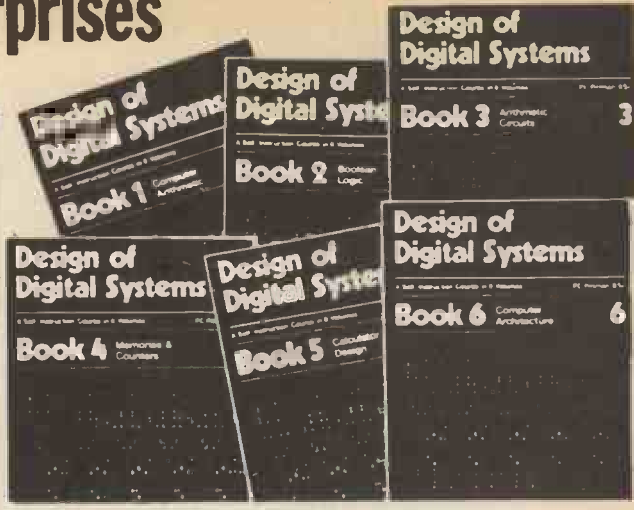

UNDERSTANDING DIGITAL ELECTRONICS

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These courses were written by experts in electronics and learning systems so that you could teach yourself the theory and application of digital logic. Learning by self-instruction has the advantages of being faster and more thorough than classroom learning. You work at your own pace and must respond by answering questions on each new piece of information before proceeding.

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Book 3 Half adders and full adders; subtractors; serial and parallel adders; processors and arithmetic logic units (ALUs); multiplication and division systems.

Book 4 Flip flops; shift registers; asynchronous and synchronous counters; ring, Johnson and exclusive-OR feedback counters: random access memories (RAMs) and read only memories (ROMs).

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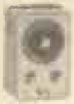

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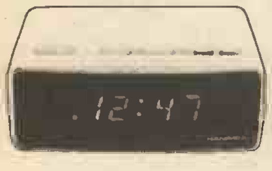

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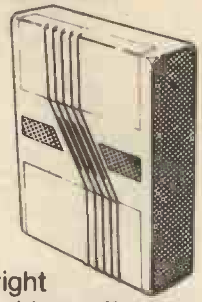

CHROMA-CHIME KIT

24 tune model!

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(Only present 24 tune repertoire currently available.)

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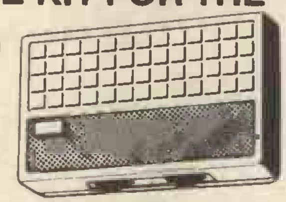

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LM348 90p
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7413 27p
7414 48p
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7417 25p
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7422 16p
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7428 26p
7432 20p
7433 30p
7437 19p
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7450 13p
7451 13p
7453 13p
7454 13p
7460 13p
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74100 80p
74105 43p
74107 20p
74109 27p
74110 42p
74121 26p
74122 36p
74123 42p
74125 37p
74126 37p
74132 48p
74141 50p
74142 192p
74145 55p
74151 48p
74153 48p
74154 65p
74155 48p
74156 40p
74157 40p
74160 59p
74161 50p
74163 50p
74164 64p
74165 55p
74166 80p
74173 86p
74174 64p
74175 55p
74177 53p
74180 50p
74181 130p
74182 50p
74190 75p
74191 75p
74192 50p
74193 64p
74196 53p
74197 50p
74199 107

CMOS
4000 14p
4001/2 14p
4006 78p
4007 15p
4008 66p
4009 32p
4010 43p
4011 14p
4012 14p
4013 32p
4014 85p
4015 54p
4016 32p
4017 53p
4018 59p
4019 43p
4020 53p
4021 64p
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4023 14p
4024 43p
4025 14p
4027 32p
4028 48p
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4030 32p
4035 107p
4041 78p
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4043 64p
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4050 27p
4086 38p
4069 13p
4070 14p
4071 14p
4072 14p
4073 17p
4081 14p
4082 14p
4086 65p
4510 69p
4511 75p
5416 69p
4518 69p
4520 69p
4528 85p

TRANSISTORS
AC126 20p
AC127 20p
AC128 20p
AC151 27p
AC153 32p
AC176 20p
AC187 21p
AC188 21p
AD149 60p
AD161 40p
AD162 40p
AF239 45p
BC107/9 10p
BC117 18p
BC142 27p
BC143 32p
BC147 8p
BC149 9p
BC157 10p
BC158 10p
BC159 10p
BC171 12p
BC172 12p
BC173 4p
BC182 10p
BC184 10p
BC186 21p
BC187 26p
BC207 13p
BC212 11p
BC213 11p
BC214 14p
BC237 11p
BC301 18p
BC303 18p
BC328 19p
BC338 19p
BC547 12p
BC548 12p
BC549 13p
BC557 13p
BCY59 26p
BCY70 16p
BCY71 18p
BD115 50p
BD121 90p
BD123 90p
BD124 100p
BD131 38p
BD132 38p
BD135 38p
BD136 38p
BD137 42p
BD138 41p
BD139 42p
BD140 42p
BF167 30p
BF173 22p
BF180 27p
BF181 8p
BF184 21p
BF185 25p
BF194 10p
BF196 10p
BF197 10p
BF200 32p
BF224 20p
BFR39 27p
BFR40 27p
BFR79 27p
BFR80 30p
BFX29 27p
BFX85 32p
BFX87 25p
BFY50 22p
BFY51 22p
BSX20 22p
BU205 140p
BU208 200p
OC25 70p
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TIP33C 80p
TIP34A 75p
TIP35C 200p
TIP36A 220p
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TIP3055 55p
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2N1306 40p
2N1308 53p
2N1711 23p
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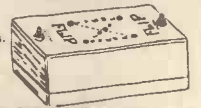

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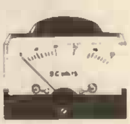
T26	0-10 M/A
T27	0-50 M/A
T28	0-100 M/A
T30	0-1 AMP
T31	0-2 AMP
T36	VU Meter
T43	0-30 V.DC
T35	"S" Meter



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SWR50

SWR/POWER METER £21 + £3.15 VAT Measures SWR and power.

SWR:-	1:3 1:1
Power:-	0 1KW ± 20%
Impedance:-	52 ohms
Frequency range:-	3.5 to 150 MHZ
Dims:-	145 x 75 x 57mm

SIRENS

S1 Siren. 125mm diameter gold coloured horn with fixing plate. Emits high-pitched wailing note of varying frequency – 16 cyc. per minute. 12 volts DC.

S2 As above but rapid noise frequency change – 160 cyc. per minute.

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SWR9

SWR and FS METER £12.50 + £1.87 VAT

For antenna adjustment. Has convenient relative field strength meter built-in.

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Accuracy:-	5%
Impedance:-	50 ohms
Frequency range:-	3 150 MHZ
Dims:-	120 x 50 x 55mm

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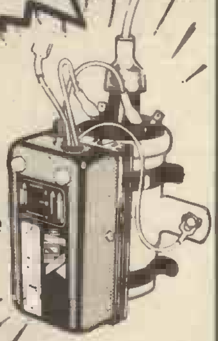
The latest kit innovation! from Sparkrite

Sparkrite- was featured by Shaw Taylor in 'DRIVE IN'



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- **Improved acceleration/top speeds**
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THE KIT COMPRISES EVERYTHING NEEDED

Die pressed epoxy coated case. Ready drilled, aluminium extruded base and heat sink, coil mounting clips, and accessories. Top quality 5 year guaranteed transformer and components, cables, connectors, P.C.B., nuts, bolts and silicon grease. Full instructions to assemble kit neg. or pos. earth and fully illustrated installation instructions.

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08FE06	6+6	0·6A EACH	2·19	60p
12FE06	6+6	1A EACH	2·43	72p
20FE06	6+6	1·6A EACH	3·06	84p
50FE06	6+6	3A EACH	3·74	84p
60FE06	6+6	4A EACH	4·58	102p
06FE09	9+9	0·3A EACH	1·82	60p
08FE09	9+9	0·5A EACH	2·19	60p
12FE09	9+9	0·75A EACH	2·43	72p
20FE09	9+9	1A EACH	3·06	84p
50FE09	9+9	2·5A EACH	3·74	84p
60FE09	9+9	3A EACH	4·58	102p
06FE12	12+12	0·25A EACH	1·82	60p
08FE12	12+12	0·3A EACH	2·19	60p
12FE12	12+12	0·5A EACH	2·43	72p
20FE12	12+12	0·8A EACH	3·06	84p
50FE12	12+12	1·8A EACH	3·74	84p
60FE12	12+12	2·5A EACH	4·58	102p
80FE12	12+12	3A EACH	5·66	120p
06FE15	15+15	0·2A EACH	1·82	60p
08FE15	15+15	0·25A EACH	2·19	60p
12FE15	15+15	0·4A EACH	2·43	72p
20FE15	15+15	0·6A EACH	3·06	84p
50FE15	15+15	1·5A EACH	3·74	84p
60FE15	15+15	2A EACH	4·58	102p
80FE15	15+15	3A EACH	5·66	120p
06FE20	20+20	0·15A EACH	1·82	60p
12FE20	20+20	0·25A EACH	2·43	72p
20FE20	20+20	0·5A EACH	3·06	84p
50FE20	20+20	1·2A EACH	3·74	84p
60FE20	20+20	1·5A EACH	4·58	102p
80FE20	20+20	2A EACH	5·66	120p

CHARGER TRANSFORMERS

Type	Voltage	Current	£	p/p
48FE12	0-6-12	4A	4·58	102p
66FE12	0-6-12	5A	5·30	102p
70FE12	0-6-12	6A	5·66	120p
90FE12	0-6-12	8A	6·75	138p
12FE24	24+24	0·2A EACH	2·43	72p

Type	Voltage	Current	£	p/p
60FE24	24+24	1·2A EACH	4·58	102p
80FE24	24+24	1·5A EACH	5·66	120p
50FE28	28+28	0·75A EACH	3·74	84p
60FE28	28+28	1·1A EACH	4·58	102p
80FE28	28+28	1·4A EACH	5·66	120p
20FE30	30+30	0·35A EACH	3·06	84p
50FE30	30+30	0·75A EACH	3·74	84p
60FE30	30+30	1A EACH	4·58	102p
80FE30	30+30	1·2A EACH	5·66	120p

MULTITAP RANGE

VOLTAGES AVAILABLE 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30

Type	Voltage	Current	£	p/p
30FE30		1A	4·00	84p
60FE36		2A	4·80	102p
80FE36		3A	5·88	120p

CENTRE TAP SECONDARY

Type	Voltage	Current	£	p/p
06FE30	6-0-6	1·80A	1·80	60p
08FE40	9-0-9	1A	2·16	60p
12FE50	12-0-12	1A	2·40	72p
20FE80	20-0-20	1A	3·00	84p
50FE80	20-0-20	2A	3·70	84p
60FE100	28-0-28	2·2A	4·50	102p
80FE70	24-0-24	3A	5·66	120p
90FE50	15-0-15	6A	5·80	120p
90FE80	30-0-30	3A	5·80	120p
100FE26	26-0-26	3·5A	6·05	138p
100FE28	28-0-28	3·5A	6·05	138p
100FE30	30-0-30	3A	6·05	138p
100FE36	36-0-36	3A	6·05	138p
150FE15	15-0-15	7A	7·47	150p
150FE26	26-0-26	5A	7·47	150p
150FE30	30-0-30	4A	7·47	150p
150FE36	36-0-36	4A	7·47	150p
150FE42	42-0-42	3A	7·47	150p
250FE28	28-0-28	8A	8·60	175p
250FE30	30-0-30	7A	8·60	175p
250FE42	42-0-42	5·5A	8·60	175p

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Ref	Amps	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	**8·79**	1·31
51	5·0	**10·86**	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	**24·18**	2·39
92	20·0	**32·40**	O.A.

50 VOLT RANGE

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	Amps	Price	P & P
102	0·5	**3·75**	0·90
103	1·0	**4·57**	1·10
104	2·0	**7·88**	1·31
105	3·0	**9·42**	1·52
106	4·0	**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.

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Ref	VA	Price	P & P
*07	20	**4·84**	0·91
149	60	**7·37**	1·10
150	100	**8·38**	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
155	750	**32·03**	O.A.
156	1000	**40·92**	O.A.
157	1500	**56·52**	D.A.
158	2000	**67·99**	O.A.
159	3000	**95·33**	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	**6·58**	1·03	56W
75	**8·50**	1·31	64W
150	**11·00**	1·31	4W
200	**12·02**	1·67	65W
250	**12·56**	1·67	69W
500	**20·13**	1·89	67W
1000	**30·67**	2·65	84W
1500	**28·62**	O.A.	93W
2000	**54·97**	O.A.	95W

12 OR 24V OR 12-0-12V

Pri 220-240 volts

Ref	12V (Amps)	24V (Amps)	Price	P&P
111	0·5	0·25	**2·42**	0·52
213	1·0	0·5	**2·90**	0·90
71	2	1	**3·86**	0·90
18	4	2	**4·48**	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	20·64	2·39
93	1500	0-115-200-220-240	25·61	0.A.
95	2000	0-115-200-220-240	38·31	0.A.
73	3000	0-115-200-220-240	65·13	0.A.
80S	4000	0-10-115-200-220-240	84·55	0.A.
57S	5000	0-10-115-200-220-240	98·45	0.A.

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

TRANSFORMERS END OF LINE OFFERS

Ref				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

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M973 – 100V Line to 8Ω 40 watts **£2·90** 60p

M1015 – Choke 8A · 5mH 150A Surge **£1·50** 45p

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M1126 – 120/240V: 9-0-9V · 1A **£2·40** 71p

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M1165 – 0-115-240V; 14V 50ma **75p** 30p

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13	100	9-0-9	**2·35**	0·43
235	330, 330	0-9, 0-9	**2·19**	0·43
207	500, 500	0-8-9, 0-8-9	**3·05**	0·82
208	1A, 1A	0-8-9, 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	0-15-20-0-15-20	**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
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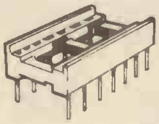

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AD162	38p	BFY50	15p	2N3703	8p
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BC109C	10p	MPSA56	20p	2N3708	8p
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BC177	14p	TIP31C	65p	2N3904	8p
BC178	14p	TIP32C	80p	2N3905	8p
BC179	14p	TIP2955	65p	2N3906	8p
BC182	10p	TIP3055	55p	2N4058	12p
BC182L	10p	ZTX107	14p	2N5457	32p
BC184	10p	ZTX108	14p	2N5459	32p
BC184L	10p	ZTX300	16p	2N5777	50p
BC212	10p				
BC212L	10p				
BC214	10p				
BC214L	10p				
BC477	19p				
BC478	19p				
BC548	10p				
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747	45p	LM379S	410p	TBA810S	100p
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	100					13p
			220			20p
25V	10	22	33	47		5p
	100					8p
		220				10p
				470		15p
	1000					23p

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JACK PLUGS AND SOCKETS

	screened	unscreened	socket
2.5mm	9p	13p	7p
3.5mm	9p	14p	8p
Standard	16p	30p	15p
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DIN PLUGS AND SOCKETS

	plug	chassis socket	line socket
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3pin	11p	9p	14p
5pin 180°	11p	10p	14p
5pin 240°	13p	10p	16p

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Single socket . 7p Double socket . 10p

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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

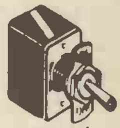
POTENTIOMETERS

Single gang Log or Lin 5K – 2M2 28p each
Dual gang Log or Lin 5K – 2M2 80p each
Presets, sub min. type hor. or vert. 100Ω – 2M2 6p each

CONTROL KNOBS

Ideal for use on mixers etc. Push on type with black base and marked position line. Cap available in red, blue, green, grey, yellow and black. 14p

SWITCHES



Subminiature toggle. SPDT 70p. DPDT 80p.
Standard toggle. SPST 34p. DPDT 48p.

Slide switches (DPDT) miniature or standard 15p.
Push to make switch. 15p. Push to break switch. 20p.
Wavechange switches: 1P12W, 2P6W, 3P4W, 4P3W. 43p

BOXES

Folded construction complete with screws.

3 x 2 x 1	52p	4 x 3 x 2	70p	6 x 4 x 3	95p
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BRIDGE RECTIFIERS

Type	Rating		Price	Type	Rating		Price	Type	Rating		Price
W005/								S005	2A	50V	0.39
T1005	1A	50V	0.28	PW01	6A	100V	0.95	S01	2A	100V	0.44
W01	1A	100V	0.30	PW02	6A	200V	0.97	S02	2A	200V	0.48
W02	1A	200V	0.32	PW04	6A	400V	1.08	S04	2A	400V	0.60
W04	1A	400V	0.40	PW06	6A	600V	1.18	S06	2A	600V	0.70
W06	1A	600V	0.50	PW08	6A	800V	1.28	S08	2A	800V	0.84
W08	1A	800V	0.60	PW10	6A	1000V	1.60	S10	2A	1000V	1.35
VM18	1A	100V	0.44	K005	25A	50V	2.20	B40C1500	1.5A	100V	0.53
VM28	1A	200V	0.48	K01	25A	100V	2.37	B40C3200	3.2A	100V	1.20
VM48	1A	400V	0.50	K02	25A	200V	2.75	B80C1500	1.5A	200V	0.82
BY164	1.4A	120V	0.75	K04	25A	400V	3.40	B80C3200	3.2A	200V	1.25
BY179	1A	800V	0.70	K06	25A	600V	3.99	PW005	6A	50V	0.90

CMOS *(see catalogue for full range)*

74C00N	0.24	74C76N	0.54	74C160N	1.11	74C221N	1.36	74C911N	7.70
74C02N	0.24	74C83N	1.30	74C161N	1.11	74C373N	1.87	74C112N	7.70
74C04N	0.24	74C85N	1.30	74C162N	1.11	74C374N	1.87	74C914N	1.41
74C08N	0.24	74C86N	0.64	74C163N	1.11	74C901N	0.54	74C915N	1.11
74C10N	0.24	74C89N	4.39	74C164N	1.04	74C902N	0.54	74C918N	1.15
74C14N	0.95	74C90N	0.85	74C165N	1.04	74C903N	0.54	74C922N	3.90
74C20N	0.24	74C93N	0.85	74C173N	0.90	74C904N	0.54	74C923N	3.74
74C30N	0.24	74C95N	1.04	74C174N	0.90	74C905N	7.28	74C925N	5.22
74C32N	0.24	74C107N	1.22	74C175N	0.90	74C906N	0.54	74C926N	5.22
74C42N	0.92	74C150N	4.14	74C192N	1.11	74C907N	0.54	74C927N	5.22
74C48N	1.38	74C151N	2.47	74C193N	1.11	74C908N	0.96	74C928N	5.22
74C73N	0.54	74C154N	3.68	74C195N	1.04	74C909N	1.63	74C932N	1.56
74C74N	0.56	74C157N	2.21	74C200N	6.70	74C910N	6.79		

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2.54mm (.1 inch) — Price
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32 Way Single £5.25

3.96mm
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10 Way Double £2.66
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Current rating ≤ 0.5 A≃
fixed contacts gold-plated. **£2.65**

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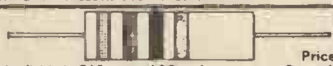

CARBON FIXED — Price
0.25 watt ±5% Tol. Available in E12 range 10Ω to 1 meg .... **2p each**
0.5 watt ±5% Tol. Available in E12 range 10Ω to 10 meg .... **3p each**
1.0 watt ±10% Tol. Available in E12 range 10Ω to 10 meg ...... **5p each**
2.0 watt ±10% Tol. Available in E12 range 10Ω to 10 meg ...... **9p each**

WIRE WOUND
2.5 watt +5% Tol. .22 to 330 ohms .... **10p each***
5 watt +5% Tol. .5 to 12K .... **12p each***
10 watt +5% Tol. 1 to 25K .... **14p each***

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0.5 watt ±2% Tol. E24 range 10Ω to 1 meg .... **4p each***
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TTL *(see catalogue for full range)*

SN74H05N	0.60	74LS75N	0.58	74LS194N	0.70	74LS490N	0.90
SN74H10N	0.55	74LS76N	0.42	74LS195N	0.70	74LS670N	1.90
SN74H11N	0.55	74LS78N	0.42	74LS196N	0.80	SN74S00N	0.77
SN74H20N	0.55	74LS83AN	0.90	74LS197N	0.80	SN74S03N	0.77
SN74H21N	0.55	74LS85N	0.95	74LS221N	0.80	SN74S04N	0.94
SN74H30N	0.55	74LS86N	0.44	74LS240N	1.50	SN74S10N	0.77
SN74H40N	0.55	74LS90N	0.64	74LS241N	1.50	SN74S20N	0.77
SN74H51N	0.55	74LS91N	1.20	74LS242N	1.25	SN74S40N	0.77
SN74H53N	0.55	74LS92N	0.70	74LS243N	1.25	SN74S64N	0.77
SN74H54N	0.55	74LS93N	0.64	74LS244N	1.50	SN74S65N	0.77
SN74H55N	0.55	74LS95AN	0.90	74LS245N	1.65	SN74S112N	1.70
SN74H60N	0.55	74LS96N	1.35	74LS247N	1.09	SN74S114N	1.70
SN74H62N	0.55	74LS107N	0.42	74LS248N	1.09	SN74S140N	0.77
SN74L00N	0.55	74LS109N	0.42	74LS249N	1.09	SN74S157N	2.95
SN74L02N	0.55	74LS112N	0.42	74LS251N	1.00	SN74S188N	2.70
SN74L04N	0.60	74LS113N	0.42	74LS253N	1.00	SN74S189N	1.81
SN74L47N	3.10	74LS114N	0.42	74LS257N	1.00	SN74S200N	3.50
SN74L74N	0.90	74LS122N	0.62	74LS258N	1.00	SN74S201N	3.71
SN74L85N	2.62	74LS123N	0.83	74LS259N	1.55	SN74S262N	12.50
SN74L93N	2.30	74LS124N	1.70	74LS261N	3.25	SN74S287N	2.95
74LS00N	0.26	74LS125N	0.50	74LS266N	0.44	SN74S288N	2.70
74LS01N	0.26	74LS126N	0.50	74LS273N	1.30	SN74S289N	1.81
74LS02N	0.26	74LS132N	0.85	74LS275N	3.20	SN74S300N	5.06
74LS03N	0.26	74LS136N	0.42	74LS279N	0.58	SN74S301N	3.71
74LS04N	0.29	74LS138N	0.65	74LS280N	1.65	SN74S387N	3.05
74LS05N	0.29	74LS139N	0.65	74LS283N	1.20	SN74S470N	5.06
74LS08N	0.26	74LS145N	1.30	74LS289N	3.74	SN74S471N	5.06
74LS09N	0.26	74LS147N	1.65	74LS290N	1.00	SN74S472N	13.48
74LS10N	0.26	74LS148N	1.35	74LS293N	1.00	SN74S473N	13.48
74LS11N	0.26	74LS151N	0.58	74LS295N	1.35	SN74S474N	13.48
74LS12N	0.26	74LS153N	0.58	74LS298N	1.35	SN74S475N	13.48
74LS13N	0.58	74LS154N	1.45	74LS299N	2.95	SN7490AN	0.36
74LS14N	0.75	74LS155N	0.80	74LS323N	3.50	SN7491AN	0.60
74LS15N	0.26	74LS156N	0.80	74LS324N	1.65	SN7492N	0.36
74LS20N	0.26	74LS157N	0.60	74LS325N	2.40	SN7493N	0.36
74LS21N	0.26	74LS158N	0.65	74LS326N	2.70	SN7494N	0.90
74LS22N	0.26	74LS160N	0.80	74LS327N	2.55	SN7495N	0.76
74LS26N	0.32	74LS161N	0.85	74LS348N	1.10	SN7496N	0.54
74LS27N	0.26	74LS162N	0.80	74LS352N	1.07	SN7497N	1.95
74LS28N	0.29	74LS163N	0.85	74LS353N	1.07	SN74100N	1.40
74LS30N	0.26	74LS164N	1.10	74LS365N	0.55	SN74107N	0.24
74LS32N	0.27	74LS165N	1.15	74LS366N	0.55	SN74118N	0.95
74LS33N	0.29	74LS166N	1.65	74LS367N	0.55	SN74119N	1.40
74LS37N	0.32	74LS168N	1.45	74LS368N	0.55	SN74121N	0.28
74LS38N	0.32	74LS169N	1.45	74LS373N	0.85	SN74122N	0.55
74LS40N	0.26	74LS170N	1.90	74LS374N	0.85	SN74123N	0.55
74LS42N	0.80	74LS173N	1.10	74LS375N	0.66	SN74124N	1.20
74LS47N	1.09	74LS174N	0.75	74LS377N	1.30	SN74125N	0.45
74LS48N	1.00	74LS175N	0.75	74LS378N	1.00	SN74141N	0.56
74LS49N	1.09	74LS181N	2.75	74LS379N	1.25	SN74145N	0.85
74LS51N	0.26	74LS183N	2.70	74LS386N	0.44	SN74148N	1.35
74LS54N	0.26	74LS189N	3.74	74LS390N	0.90	SN74150N	0.90
74LS55N	0.26	74LS190N	1.00	74LS393N	0.90	SN74151N	0.76
74LS63N	1.26	74LS191N	1.00	74LS395N	1.50	SN74153N	0.65
74LS73N	0.42	74LS192N	0.95	74LS398N	1.90	SN74154N	1.20
74LS74N	0.42	74LS193N	0.95	74LS399N	1.45	SN74155N	0.70

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LM340T-12	0.88	LM1307N	1.22	MC846P	0.70	CA3068	3.80
LM340T-15	0.88	LM1310N	2.10	MC848P	1.10	CA3070	1.90
LM340T-24	0.88	LM1351N	1.30	MC849P	0.70	CA3071	1.90
LM341P-5	0.56	LM1458N	0.45	MC857P	0.85	CA3072	1.90
LM341P-12	0.56	LM1496N	0.97	MC861P	0.85	CA3075	1.70
LM341P-15	0.56	LM1800N	1.94	MC1035P	1.90	CA3076	2.12
LM341P-24	0.56	LM1801N	2.25	CA3000	3.30	CA3080	0.85
LM345K	6.97	LM1808N	2.10	CA3001	4.25	CA3080A	2.10
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LM350K	6.50	LM1820N	1.16	CA3006	4.60	CA3088F	1.87
LM358N	0.60	LM1828N	1.90	CA3007	4.15	CA3089E	2.90
LM360N	3.00	LM1830N	1.90	CA3008	2.55	CA3090Q	4.40
LM370N	3.30	LM1845N	1.50	CA3012	1.65	CA3130	1.06
LM371H	2.35	LM1848N	1.98	CA3013	1.85	CA3140	1.04
LM373N	3.35	LM1850N	1.90	CA3014	2.20	L005T1	2.25
LM374N	3.35	LM1889N	2.50	CA3018	0.75	LF355N	0.80
LM377N	1.80	LM1890N	P.O.A.	CA3018A	1.10	LF356N	0.80
LM378N	2.40	LM2907N-8	1.80	CA3020	2.20	LF357N	0.80
LM379S	4.25	LM2917N-8	1.80	CA3020A	2.50	LF13201N	3.00
LM380N-8	0.96	LM3301N	0.60	CA3021	2.40	LF13331N	3.00
LM380N-14	1.08	LM3302N	0.55	CA3022	2.20	LF13741H	0.49
LM381AN	2.70	LM3401N	0.55	CA3023	2.20	LF13741N	0.38
LM381N	1.69	LM3900N	0.68	CA3026	0.70	LM114H	2.75
LM382N	1.32	LM3905N	1.15	CA3028A	0.90	LM301AH	0.40
LM384N	1.55	LM3909N	0.78	CA3028B	1.25	LM301-8	0.30
LM386N	0.88	LM3911N	1.10	CA3029	0.75	LM304H	1.50
LM387N	1.10	LM3913N	P.O.A.	CA3029A	0.90	LM307N	0.50
LM388N	1.00	LM3914N	2.79	CA3030	1.50	LM308H	0.95
LM389N	1.00	LM4250CN	1.30	CA3030A	2.20	LM308N	0.55
LM392N	0.87	LM78L05CH	0.85	CA3033	3.70	LM309KC	1.95
LM701B	2.99	LM78L12CH	0.85	CA3034	2.75	LM317K	3.35
LM701C	2.99	LM78L15CH	0.85	CA3035	1.95	LM317MP	1.35
LM702C	0.81	LM78L24CH	0.85	CA3036	1.21	LM317T	2.20
LM703LN	1.15	LM7805KC	1.56	CA3038	2.90	LM318N	2.45
LM709CH	0.70	LM7812KC	1.56	CA3038A	4.10	LM320T-5	1.86
LM709-8	0.50	LM7815KC	1.56	CA3039	0.77	LM320T-12	1.86
LM709-14	0.49	LM7824KC	1.56	CA3040	3.75	LM320T-15	1.86
LM710CH	0.67	LM78L05CZ	0.30	CA3041	1.65	LM320T-24	1.86
LM710-14	0.48	LM78L12CZ	0.30	CA3042	1.65	LM320MP-5	1.15
LM711CN	0.48	LM78L15CZ	0.30	CA3043	2.20	LM320MP-12	1.15
LM716	1.00	LM78L24CZ	0.30	CA3045	1.55	LM320MP-15	1.15
LM723CH	0.62	MC667P	2.75	CA3046	0.77	LM320MP-24	1.15
LM723C-14	0.45	MC671P	1.75	CA3047	2.20	LM323K	5.75
LM741CH	0.50	MC672P	1.75	CA3047A	3.70	LM324	0.76
LM741C-8	0.30	MC724P	2.10	CA3048	2.45	LM335	1.70
LM741C-14	0.50	MC789P	1.80	CA3049	1.98	LM337K	3.86
LM747CN	0.78	MC790P	3.10	CA3050	2.66	LM337MP	1.78
LM748-8	0.50	MC798P	2.20	CA3051	1.83	LM337T	2.98
LM748-14	0.50	MC799P	2.20	CA3052	1.78	LM338K	P.O.A.
LM900	0.50	MC832P	0.70	CA3053	0.77	*MC1327P	1.70
LM911	0.50	MC833P	0.70	CA3054	1.10	MC1330P	1.70
LM921	0.50	MC836P	0.82	CA3059	2.10	*MC1352P	1.20
LM923	0.50	MC837P	0.82	CA3060	2.50	*MC1433G	3.65
LM1303N	1.15	MC838P	2.35	CA3062	3.75	*MC1435G	2.20

TRANSISTORS *(see catalogue for full range)*

2N335	3.00	2N708	0.30	2N1420	0.55	2N2219	0.38	40081	1.20	AC188	0.54	BC118	0.22	BCY33A	1.10	BD140	0.43	BF157	0.48
2N388	0.80	2N718	0.30	2N1483	1.85	2N2219A	0.39	40232	0.60	AC188K	0.65	BC119	0.33	BCY34A	1.10	BD142	0.70	BF159	0.37
2N388A	0.77	2N718A	0.54	2N1485	2.20	2N2220	0.39	40233	0.70	AD136	2.75	BC122	0.61	BCY38	2.20	BDX14	1.32	BF160	0.33
2N398	0.80	2N720A	0.85	2N1507	0.35	2N2221	0.25	40235	0.65	AD142	1.45	BC123	0.65	BCY40	1.05	BDX18	1.90	BF161	0.65
2N456	2.20	2N721	1.05	2N1524	0.60	2N2221A	0.25	40237	0.45	AD143	1.45	BC125	0.22	BCY42	0.65	BDX32	2.67	BF166	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	BDY11	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	BDY17	3.30	BF170	0.76
2N489B	5.90	2N744	0.35	2N1637	0.72	2N2223	6.78	40254	0.66	AD161	1.00	BC135	0.22	BCY58	0.27	BDY18	3.80	BF173	0.37
2N490	4.99	2N753	0.35	2N1638	0.70	2N2223A	6.99	40264	0.95	AD162	1.00	BC136	0.21	BCY59	0.27	BDY20	1.10	TIP29C	0.65
2N490B	6.50	2N760	0.35	2N1711	0.30	2N2270	0.49	40280	3.70	AF106	0.60	BC137	0.22	BCY66	2.20	BDY23	2.45	TIP30A	0.54
2N490C	6.90	2N869	0.35	2N1889	0.30	2N2303	1.54	40309	0.60	AF109	0.82	BC138	0.44	BCY67	2.70	BDY24	2.65	TIP30C	0.70
2N491A	5.75	2N914	0.38	2N1890	0.30	2N2368	0.27	40310	0.85	AF114	0.70	BC140	0.30	BCY70	0.21	BDY25	2.85	TIP31A	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	BDY38	1.10	TIP31C	0.72
2N491	7.50	2N917	0.38	2N1907	5.95	2N2369A	0.27	40312	0.99	AF116	0.70	BC142	0.32	BCY72	0.18	BDY54	1.55	TIP32A	0.59
2N492	6.25	2N918	0.45	2N1974	0.98	2N2405	0.66	40313	1.38	AF117	0.70	BC143	0.32	BCY77	0.70	BDY55	1.90	TIP32C	0.82
2N492A	6.75	2N929	0.37	2N1990	0.45	3N81	3.50	40315	0.60	AF118	0.70	BC152	0.38	BCY78	0.43	BDY56	2.10	TIP33A	0.86
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2N493B	8.75	2N1131	0.32	2N2147	1.55	3N140	1.10	40325	1.35	AF139	0.75	BC161	0.38	BCY89	3.80	BDY61	2.75	TIP35A	2.20
2N494	6.90	2N1132	0.35	2N2160	1.55	3N141	0.95	AC126	0.48	AF172	0.70	BC175	0.43	BD115	0.88	BDY62	2.75	TIP36A	3.00
2N494A	7.65	2N1204	1.65	2N2192	0.58	3N142	0.70	AC127	0.48	AF178	1.30	BC204	0.12	BD116	1.35	BDY92	2.75	TIP41A	0.76
2N494B	8.40	2N1302	0.80	2N2193	0.50	3N143	0.88	AC128	0.48	AF186	0.55	BC205	0.17	BD121	2.20	BF115	0.39	TIP41C	0.97
2N494C	9.35	2N1303	0.80	2N2193A	0.52	3N152	1.10	AC151	0.43	AF200	1.30	BC206	0.17	BD124	2.20	BF119	1.10	TIP42A	0.86
2N549	3.25	2N1304	0.80	2N2194	0.42	3N153	1.89	AC152	0.54	AF201	1.30	BC207	0.17	BD131	0.55	BF121	0.60	TIP42C	1.08
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2N697	0.31	2N1306	1.00	2N2195	0.49	3N159	1.35	AC153K	0.59	BC114	0.22	BC209	0.17	BD135	0.40	BF134	0.60	TIP54	1.83
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2N699	0.58	2N1308	1.10	2N2217	0.55	3N200	2.85	AC176	0.54	BC116	0.21	BCY30A	1.10	BD137	0.41	BF152	0.27	TIP112	0.93
2N706	0.30	2N1309	1.10	2N2218	0.35	3N201	1.35	AC187	0.59	BC116A	0.22	BCY31A	1.10	BD138	0.41	BF153	0.27	TIP115	0.83
2N706A	0.30	2N1370	0.55	2N2218A	0.38	40050	1.70	AC187K	0.65	BC117	0.22	BCY32A	1.10	BD139	0.43	BF154	0.27	TIP117	0.99

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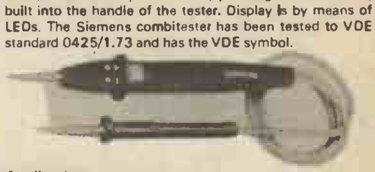

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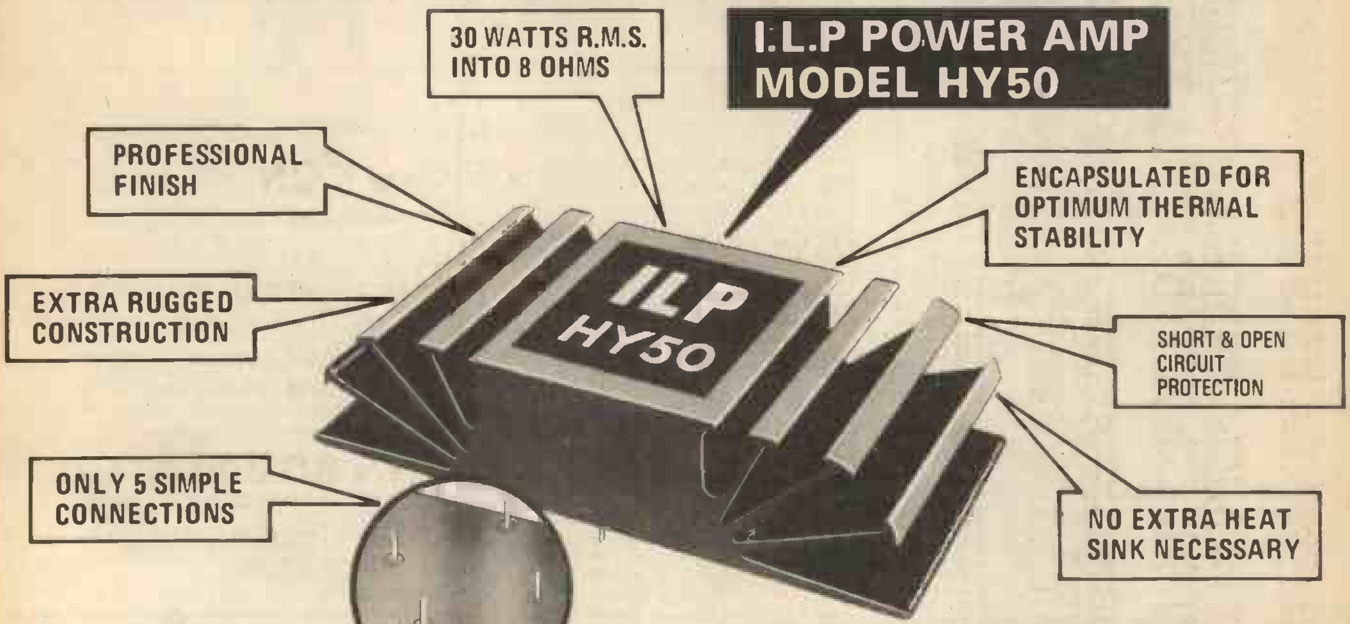

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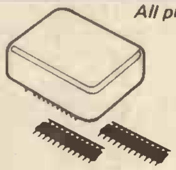

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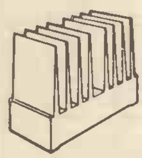

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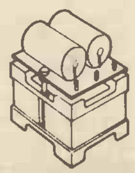

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INDEX TO ADVERTISERS

Acorn Computors ... 75
Adam Hall (P.E. Supplies) ... 93
Aitken Bros ... 78
Astra Pak ... 76
Aura Sounds ... 90
A.U.S. ... 92
Barrie Electronics ... 84
Bi-Pak ... 4, 5
Bi-Pre-Pak ... 12
Birkett J. ... 76
Boffin Projects ... 93
Boss Industrial ... 89
Breadboard ... 49
Brewster S.R. ... 3
British National Radio & Electronics School ... 7, 83, 88
Calscope ... 8
Cambridge Learning ... 77
Chromasonic ... 86
Chromatronics ... 80
Clef Products ... 94
Codespeed ... 86
Commodore Business Machines ... 55
Computor Components (Teleplay) ... Cover II
Continental Specialties Corporation U.K. Ltd ... 31
Crescent Radio ... 80
Crimson Elektrik ... 31
Crofton Electronics ... 8
C.R. Supply Co. ... 92
Delta Tech ... 80
Digisound ... 6
Dudley & Co. Ltd., John ... 94
Ecoscope Instruments Ltd. ... 93
E.D.A. ... 82
Electronic Mail Order Ltd. ... 92
Electrovalue ... 78
Fladar ... 82
Flairline Supplies ... 95
Fringewood Electronics ... 11
Heathkit ... 64
Hiykon Ltd. ... 94
Home Radio ... 14
H.S.B.C. ... 8
I.C.S. Intertext ... 14, 92
I.L.P. Electronics ... 91
Jayen Developments ... 6
J.W.B. Radio ... 92
Kay & Co. ... 6
L & B Electronics ... 11
Maclin-Zand ... 86
Maplin Electronics ... Cover IV
Marshall A. (London) Ltd. ... 87
Metac ... 71, 79
Mhel Electronics ... 94
Microdigital ... 76
Mill Hill Supplies ... 90
Modern Book Co. ... 95
Monolith ... 12
Newtronics ... 12
Noble Electronics ... 12
P.H.W.K. & I. Yates ... 93
P.K.G. Electronics ... 94
Pawbrooks ... 92
Phonosonics ... 10, 11
Progressive Radio ... 90
Proto Design ... 94
Radio Component Specialists ... 88
Ramar Constructor Service ... 93
R.S.T. Valve Mail Order ... 90
Radio & T.V. Components ... 81
Romane Electronics ... 64
Sandwell Plant Ltd. ... 93
Saxon Entertainments ... 9
Science of Cambridge ... 41
Scientific Wire Co. ... 94
Seahorse Electronics Ltd. ... 93
Sentinel Supply ... 78
Service Trading ... Cover III
Sparks Developments ... 84
Squires, Roger ... 3
Stevens Electronic Components ... 85
Sumico Ltd. ... 8
Swanley Electronics ... 84
Tandy ... 15
T.K. Electronics ... 14
Technomatic ... 96
Tempus ... 95
Transam Components ... 13
T.U.A.C. ... 63
Watford Electronics ... 2, 3, 16
William Stuart Systems Ltd ... 94
Williamson Amplification ... 93
Wilmslow Audio ... 82

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4043	90p
4044	90p
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3P/4W	45p
4P/3W	45p
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