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Hobby Electronics

April '79
40p

The Telephone System
An exchange of ideas

Capacitors
The inside story

Electronics In Warfare
The battle for supremacy

Transistor Tester Project
Sorting the good from the bad

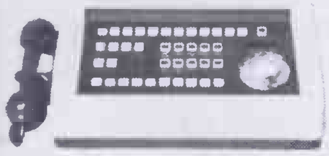
555 Circuits
This IC timer explored

Catalogue Survey
Buying by mail

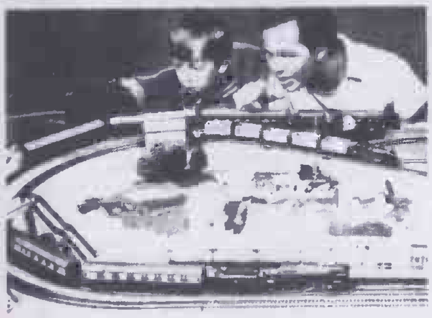
Hobby Electronics

Vol. 1. No. 6

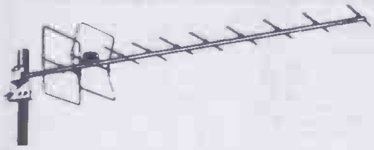
April 1979



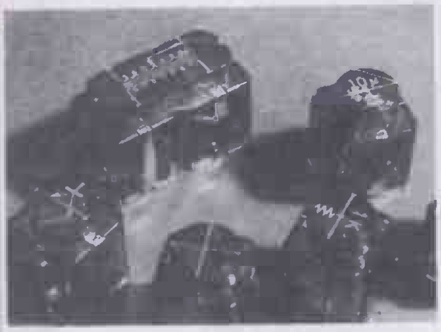
An exchange of ideas



Get on the right track



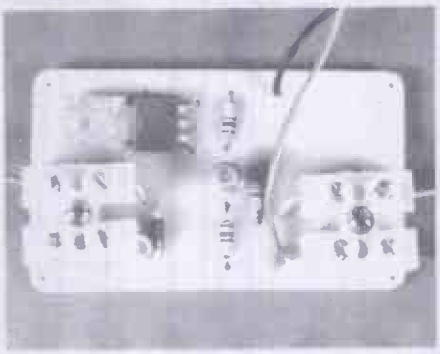
How they work



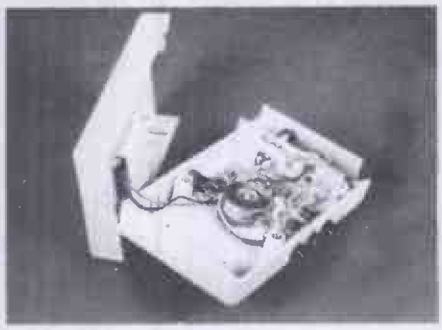
Denshi modular plug-in construction kit

The inside story

The electron goes to war



We're not around the bend, just flushed with success



An invaluable piece of test equipment

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(A DIVISION OF GOTHIC ELECTRONIC COMPONENTS LTD)
PO Box 290
8 Hampton Street
Birmingham B19 3JR

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MAIL ORDER ONLY

ALL PRICES IN PENCE EACH UNLESS OTHERWISE STATED

CAPACITORS

Electrolytic Axial Leads — Order Code
10% to +50% Tol — Cap 015 + μF + V d.c.

μF \ V d.c.	16	25	40	63
1.0				8
1.5				8
2.2				8
3.3				8
4.7				8
6.8			8	9
10		7		9
15	7		8	10
22		7		12
33	7		8	
47		7	10	12
68	8			
100		8	12	
150	8	9		29
220	12		24	34
330			28	37
470		21	30	44
680	19	28	36	50
1000	23	28	55	
1500	32	36		
2200	39			

Electrolytic Can Type — Order Code
High Ripple, IEC Grade 1, Low E.S.R. — Cap HR + μF + Volts
Supplied complete with Vertical Fixing Clip

Capacitance	Voltage	Ripple 1A @ 85°C	1.4A @ 50°C	Price
2200 μF	16V	1A	1.4A	166
4700 μF	16V	2.6A	3.6A	184
10000 μF	16V	5.8A	8.1A	222
22000 μF	16V	9.8A	13.7A	346
2200 μF	25V	1.3A	1.8A	175
4700 μF	25V	4.6A	6.4A	201
10000 μF	25V	8.0A	11.2A	264
22000 μF	25V	12.8A	17.9A	438
1000 μF	40V	0.9A	1.2A	168
2200 μF	40V	2.4A	3.3A	188
4700 μF	40V	5.6A	7.8A	231
10000 μF	40V	9.2A	12.8A	367
1000 μF	70V	1.8A	2.5A	190
2200 μF	70V	4.0A	5.6A	235
4700 μF	70V	7.5A	10.5A	376
1000 μF	100V	4.0A	5.6A	222
2200 μF	100V	7.8A	10.9A	346

Miniature Low Value — Order Code
Polystyrene, Axial, ·1% Tol., ≥ 63V D.C. Wkg — Cap 424
Ceramic Plate, Radial, Low K, 1.8pF–8.2pF · .25pF Tol, 10-330pF · 2% Tol, 100V D.C. Wkg — Cap 632
Ceramic Plate, Radial, Med K, ·10% Tol, 100V D.C. Wkg — Cap 630
Ceramic Plate, Radial, High K, −20% to +80% Tol, 63V D.C. Wkg — Cap 629
+ Value

pF	424	632	630	629
1				
1.2				
1.5				
1.8		5		
2.2		5		
2.7		5		
3.3		5		
3.9		5		
4.7		5		
5.6		5		
6.8		5		
8.2		5		
10		5		
12		5		
15		5		
18		5		
22		5		
27		5		
33		5		
39		5		
47		5		
56		6		
68		6		
82		6		

pF	424	632	630	629
100	16	6		
120	16	8		
150	16	8		
180	16	6		
220	16	6		
270	18	8		
330	18	8		
390	18		5	
470	18		5	
560	16		5	
680	16		5	
820	16		5	
1000	16		5	5
1200	16		5	
1500	18		6	
1800	18		6	
2200	18		6	6
2700	18		6	
3300	18		6	
3900	18		6	
4700	23		7	6
5600	23			
6800	23			
8200	23			

nF	424	632	630	629
10	25			6
12	26			
15	26			
18	27			
22	28			8
27	38			
33	41			
39	43			

Electrolytic Radial Leads — Order Code
−10% to +50% Tol. — Cap 034 + μF + Volts

μF \ V d.c.	6.3	10	16	25	35	40	50	63
.47								6
.68								6
1.0								6
1.5								6
2.2								6
3.3								6
4.7						6		7
6.8				6			7	8
10			6			7		8
15			6	7			8	10
22		6	7			8	10	
33			7	8		10		
47		7	8		10			
68			8	10				
100		8	10					
150		10						
220	10							

Tantalum Bead — Order Code
·20% Tol. — Cap PR + μF + Volts

μF \ V d.c.	3.15	6.3	10	16	25	35
0.1						9
0.15						9
0.22						9
0.33						9
0.47						9
0.68						9
1						9
1.5						10
2.2				9		11
3.3				9	11	14
4.7				10	14	15
6.8		9		11	15	16
10		10	11	14	16	20
15		11	14	15	20	
22	11	14		16		
33		15	16	20		
47		16	20			
68	16	20				
100	20					

Trimmers

250V D.C. Wkg. Film Dielectric, Miniature

Range	Price	Order Code
1.4 – 4.1pF	19	Cap 808 A
2 – 8pF	19	Cap 808 B
2 – 20pF	21	Cap 808 C
5.5 – 59.5pF	29	Cap 808 D

500V D.C. Wkg. C004 EA Tubular Type

Range	Price	Order Code
.8 – 3.8pF	46	Cap 802 3
.8 – 6.8pF	48	Cap 802 6
1 – 13pF	61	Cap 802 12
1.7 – 19.7	62	Cap 802 18

Polyester Radial Leads — Order Code
Dipped Type, ·20% Tol, ·· 250V D.C. Wkg. C280/352 Style — Cap 352
Moulded Type, ·10% Tol, ≥100V D.C. Wkg. 10.2mm Pitch Centres — Cap 360
Moulded Type, ·10% Tol, ≥100V D.C. Wkg. 7.6mm Pitch Centres — Cap PHE280
+ Value

μF	352	360	PHE280
.001		5	6
.0015		5	6
.0022	5	6	7
.0033	5	6	7
.0047	5	6	7
.0068	5	6	7
.01	5	6	7
.015	5	7	8
.022	5	7	8
.033	5	7	8
.047	5	7	8
.068	6	8	9
.1	6	8	9
.15	7	9	
.22	8	10	
.33	10		
.47	12		
.68	15		
1.0	19		
1.5	27		
2.2	32		

CASES

Small Desk Console — Boss Industrial Mouldings
Slope Front Console, Recessed Top
ABS Base, C/W Brass Bushes, In Orange
1mm Aluminium Top Panel Finished Grey

		Order Code
W161, D96, H39 (57)	186	Case BIM1005 OR
W215, D130, H47 (73)	268	Case BIM1006 OR

Plastic Boxes — Boss Industrial Mouldings
Moulded Box and Close Fitting Flanged Lid
ABS Box, C W Brass Bushes, and Lid In Orange

		Order Code
L112 W62 D31	87	Case BIM2003 OR
L150 W80 D50	115	Case BIM2005 OR
L190 W110 D60	195	Case BIM2006 OR

Instrument Case — Boss Industrial Mouldings
Covers Manufactured from 14SWG Aluminium
Chassis Manufactured from 18SWG Mild Steel
Covers Finished Orange
Chassis Finished Matt Black

		Order Code
W250 D167.5 H 68.5 (Chassis 153mm Deep)	1480	Case BIM3000 OR

Plastic Boxes with Metal Lids — Boss Industrial Mouldings
Recessed Top Box
ABS Base, C/W Brass Bushes, In Orange
1mm Aluminium Top Panel Finished Grey

		Order Code
L85 W56 D29	97	Case BIM4003 OR
L111 W71 D42	130	Case BIM4004 OR
L181 W96 D53	182	Case BIM4005 OR

Diecast Boxes — Boss Industrial Mouldings
Diecast Box and Flanged Lid
Aluminium Box and Lid in Natural Finish

		Order Code
L113 W63 D31	104	Case BIM5003 NA
L152 W82 D50	181	Case BIM5005 NA
L192 W113 D61	280	Case BIM5006 NA

VERO ELECTRONICS PRODUCTS

2.5" x 5" .1" pitch Veroboard	59	VERO 21069J
3.75" x 5" .1" pitch Veroboard	66	VERO 21072D
2.5" x 1" .1" pitch Veroboard (5)	70/Pack	VERO 21076C
3.75" x 5" .1" pitch Plain Board	56	VERO 21078E
5.82" x 2.9" .1" pitch V-Q DIP Board	111	VERO 21084E
Spot Face Cutter	89	VERO 21013A
Pin Insertion Tool for .040 type pin	122	VERO 21015F
DS Pins .040 (100)	38/Pack	VERO 21087G
SS Pins .040 (100)	38/Pack	VERO 21017B
6mm Board Standoff (100)	181/Pack	VERO 21321K
15mm Board Standoff (100)	215/Pack	VERO 21322G
19mm Board Standoff (100)	226/Pack	VERO 21323D
Verowire Kit (1-pen, 2-wire, 25-comb)	375/Kit	VERO 21341D
Verowire Combs (100)	407/Pack	VERO 21339F
Verowire Wire (4)	228/Pack	VERO 21340G
Flip Top Box, Small, Black	192	VERO 21317D
Flip Top Box, Large, Black	250	VERO 21319J

Small Desk Consoles — Boss Industrial Mouldings
Slope Front Console, Recessed Top
ABS Base, C/W Brass Bushes, In Orange
1mm Aluminium Top Panel Finished Grey
Ventilation Slots In Base

		Order Code
W105 D143 H32 (56)	206	Case BIM6005 OR
W170 D143 H32 (56)	271	Case BIM6006 OR
W170 D214 H32 (82)	375	Case BIM6007 OR

All Metal Desk Consoles — Boss Industrial Mouldings
Slope Front Console, Recessed Top
Two Piece All Aluminium Construction
Ventilation Slots In Rear and Base
Choice of 15° or 30° Sloping Front
Off White Top Panel, Blue Base

		Order Code
W102 D140 H28 (51) 15° slope	1018	Case BIM7151A
W165 D211 H33 (76) 15° slope	1350	Case BIM7154A
W254 D287 H33 (76) 15° slope	1572	Case BIM7156A
W356 D287 H33 (76) 15° slope	1823	Case BIM7158A
W102 D140 H28 (76) 30° slope	1018	Case BIM7301A
W165 D183 H28 (102) 30° slope	1202	Case BIM7303A
W254 D259 H28 (102) 30° slope	1572	Case BIM7306A
W356 D259 H28 (102) 30° slope	1823	Case BIM7308A

Eurocard Size Desk Console — Boss Industrial Mouldings
Slope Front Console
ABS Case, C/W Brass Bushes, In Orange
1mm Aluminium Top Panel, Finished Grey

		Order Code
W169 D127 H45 (70)	375	Case BIM8006 OR

HARDWARE

D.I.L. Sockets

		Order Code
8 Pin Low Profile Socket Tin	11	DIL SKT 8
14 Pin Low Profile Socket Tin	13	DIL SKT 14
16 Pin Low Profile Socket Tin	14	DIL SKT 16
24 Pin Low Profile Socket Gold	66	DIL SKT 24
28 Pin Low Profile Socket Gold	78	DIL SKT 28
40 Pin Low Profile Socket Gold	127	DIL SKT 40

Heatsinks

Individual Type for 1 x T05 50°C/W	10	Sink 5F
Individual Type for 1 x T066 10.5°C/W	26	Sink TV2
Individual Type for 1 x T03 7.2 C/W	24	Sink TV3
Individual Type for 1 x T0126 17°C/W	23	Sink TV4
Individual Type for 1 x T0220 17 C/W	23	Sink TV5

P.C.B. Components

Dalo Pen, Blue Ink, Slow Drying	92	Pen 33PC

Fuseholders
Suit 20mm x 5mm fuses.

P.C.B. Mounting, Open Type	8	Fuse/H20B
Chassis Mounting, Open Type	17	Fuse/H20C
Panel Mounting, Screwdriver Slot	77	Fuse/H20PT
Panel Mounting, Finger Release	56	Fuse/H20P

Fuses
20mm x 5mm Glass

Quick Blow, Range 100mA–5A	8	Fuse 20
Slow Blow, Range 250mA–5A	22	A/S Fuse 20

+ Rating

Lampholders, Panel Mounting
Similar In Style to Fuse/H 20P
Low Voltage Type Suits LES and M/F Bulbs.

Low Voltage, Red, Amber or Green	75	Lamp LV
Internal Neon 200/240V Red or Amber	95	Lamp N

+ Colour

Bulbs, Low Voltage, L.E.S.

6V, 0.36W; 6.5V, 1W; 14V, 0.75W.	22	Bulb LES

+ Voltage

RESISTORS

Carbon Film, Fixed

				Order Code
0.25W, E24 Values 1R0-10M, 5% Tol.	1.5 ea.	90p/100 (Mult 10/Value)	£7.90/1000 (Mult 100/Value)	Res RD¼
0.5W, E12 Values 1R0-4M7, 10% Tol.	2 ea.	1.25p/100 (Mult 10/Value)	£10.10/1000 (Mult 100/Value)	Res RD½

+ Value

Metal Film, Fixed

0.5W, E24 Values, 5R1-1M, 2% Tol.	6 ea.	3.80/100 (Mult 10/Value)	£32.40/1000 (Mult 100/Value)	Res MR30
2.5W, E12 Values 10R-27K, 5% Tol.	13 ea.	7.90/100 (Mult 10/Value)		Res PR52

+ Value

Metal Glaze, Fixed

0.5W, E24 Values, 1M-33M, 5% Tol.	10 ea.	5.40/100 (Mult 10/Value)	Res VR37

+ Value

Skeleton Presets, Miniature — Order Code

0.1W, E3 Values, 100R-1M, Lin. Vertical Mounting	7	Min Preset V
0.1W, E3 Values, 100R-1M, Lin. Horizontal Mounting	7	Min Preset H

+ Value

Skeleton Presets, Standard

0.3W, E3 Values, 100R-4M7, Lin. Vertical Mounting	10	Std Preset V
0.3W, E3 Values, 100R-4M7, Lin. Horizontal Mounting	10	Std Preset H

+ Value

Potentiometer, Rotary

0.5W, E3 Values, 1K-2M2 Lin.	34	Pot Lin
0.25W, E3 Values, 4K7-2M2 Log	34	Pot Log

+ Value

DIGITAL INTEGRATED CIRCUITS

4000 Buffered C MOS – High Speed
5 15V 'B' Series, Up to 20MHz

HEF4000	14	HEF4046	100	HEF4514	250
HEF4001	14	HEF4047	87	HEF4515	299
HEF4002	14	HEF4049	28	HEF4516	90
HEF4006	95	HEF4050	28	HEF4517	382
HEF4007	14	HEF4051	69	HEF4518	69
HEF4008	80	HEF4052	72	HEF4519	55
HEF4011	14	HEF4053	72	HEF4520	65
HEF4012	14	HEF4066	37	HEF4521	188
HEF4013	32	HEF4067	380	HEF4528	99
HEF4014	84	HEF4068	14	HEF4532	120
HEF4015	60	HEF4069	14	HEF4534	510
HEF4016	35	HEF4070	14	HEF4539	110
HEF4017	55	HEF4071	14	HEF4543	155
HEF4018	65	HEF4072	16	HEF4555	78
HEF4019	46	HEF4073	16	HEF4556	78
HEF4020	88	HEF4075	16	HEF4557	386
HEF4021	85	HEF4076	85	HEF4585	97
HEF4022	82	HEF4077	14	HEF4724	171
HEF4023	14	HEF4078	16	HEF40097	90
HEF4024	45	HEF4081	16	HEF40098	73
HEF4025	14	HEF4082	16	HEF40106	62
HEF4027	32	HEF4085	64	HEF40160	119
HEF4028	52	HEF4086	64	HEF40161	119
HEF4029	60	HEF4093	50	HEF40162	119
HEF4030	46	HEF4094	175	HEF40163	119
HEF4031	200	HEF4104	166	HEF40174	119
HEF4035	110	HEF4502	91	HEF40175	119
HEF4040	68	HEF4505	571	HEF40192	140
HEF4041	75	HEF4508	51	HEF40193	140
HEF4042	54	HEF4510	70	HEF40194	119
HEF4043	79	HEF4511	110	HEF40195	117
HEF4044	84	HEF4512	98		

7400 T.T.L.

N7400N	9	N7444N	83	N74122N	39	N74192N	60
N7401N	11	N7445N	65	N74123N	37	N74194N	80
N7402N	11	N7446AN	62	N74125N	32	N74195N	79
N7403N	11	N7447AN	51	N74126N	32	N74198N	120
N7404N	12	N7448AN	44	N74128N	74	N74199N	139
N7405N	12	N7450N	13	N74132N	46	N74221N	160
N7406N	25	N7451N	13	N74145N	60	N74279N	116
N7407N	27	N7453N	15	N74147N	125	N74298N	200
N7408N	13	N7454N	13	N74148N	83	N74365N	150
N7409N	13	N7460N	13	N74150N	65	N74366N	150
N7410N	11	N7470N	26	N74151N	46	N74367N	120
N7411N	18	N7472N	22	N74153N	55	N74368N	150
N7412N	17	N7473N	23	N74154N	96		
N7413N	23	N7474N	23	N74155N	53		
N7414N	46	N7475N	28	N74156N	48		
N7416N	22	N7476N	26	N74157N	49		
N7417N	23	N7480N	43	N74158N	54		
N7420N	11	N7483N	63	N74160N	74		
N7421N	26	N7485N	65	N74161N	74		
N7425N	27	N7486N	23	N74162N	74		
N7426N	22	N7490N	30	N74163N	74		
N7427N	22	N7491AN	60	N74164N	65		
N7428N	30	N7492N	33	N74165N	65		
N7430N	11	N7493N	31	N74166N	93		
N7432N	21	N7494N	74	N74170N	134		
N7433N	30	N7495AN	48	N74173N	111		
N7437N	21	N7496N	46	N74174N	63		
N7438N	21	N74100N	88	N74175N	62		
N7439N	60	N74107N	25	N74180N	80		
N7440N	12	N74109N	42	N74181N	165		
N7442N	40	N74116N	148	N74182N	69		
N7443N	79	N74121N	23	N74192N	65		

74LS

N74LS00N	15	N74LS28N	32	N74LS138N	85	N74LS253N	105
N74LS01N	16	N74LS30N	16	N74LS139N	85	N74LS257N	104
N74LS02N	16	N74LS32N	24	N74LS153N	76	N74LS258N	107
N74LS03N	16	N74LS33N	32	N74LS154N	122	N74LS260N	26
N74LS04N	16	N74LS37N	24	N74LS155N	80	N74LS261N	300
N74LS05N	23	N74LS38N	24	N74LS156N	80	N74LS266N	40
N74LS08N	16	N74LS40N	22	N74LS157N	54	N74LS273N	130
N74LS09N	22	N74LS42N	53	N74LS158N	60	N74LS283N	116
N74LS10N	16	N74LS51N	22	N74LS160N	120	N74LS290N	90
N74LS11N	22	N74LS54N	16	N74LS161N	78	N74LS293N	100
N74LS12N	23	N74LS55N	22	N74LS162N	130	N74LS298N	100
N74LS13N	38	N74LS73N	29	N74LS163N	78	N74LS324N	170
N74LS14N	74	N74LS75N	40	N74LS164N	90	N74LS365N	105
N74LS15N	24	N74LS76N	33	N74LS170N	200	N74LS366N	105
N74LS20N	16	N74LS78N	33	N74LS173N	100	N74LS367N	105
N74LS21N	22	N74LS83AN	97	N74LS174N	100	N74LS368N	105
N74LS22N	24	N74LS85N	70	N74LS175N	100	N74LS373N	150
		N74LS86N	33	N74LS181N	320	N74LS374N	150
		N74LS90N	45	N74LS190N	91	N74LS375N	100
		N74LS92N	70	N74LS191N	95	N74LS378N	160
		N74LS93N	45	N74LS192N	128	N74LS386N	35
		N74LS95BN	65	N74LS193N	130	N74LS390N	170
		N74LS96N	116	N74LS194N	150	N74LS393N	170
		N74LS107N	38	N74LS195AN	120	N74LS395N	180
		N74LS109N	38	N74LS196N	80	N74LS490N	130
		N74LS112N	40	N74LS197N	110	N74LS670N	170
		N74LS113N	38	N74LS240N	160		
		N74LS114N	38	N74LS241N	160		
		N74LS125N	40	N74LS242N	160		
		N74LS126N	40	N74LS243N	160		
		N74LS132N	60	N74LS244N	160		
		N74LS136N	37	N74LS251N	90		

LINEAR INTEGRATED CIRCUITS

CA3011	92	NE592K	162
CA3018	75	RC4136	130
CA3020	191	TBA120S	79
CA3028A	86	TCA580	346
CA3046	76	TCA730	450
CA3048	245	TCA740	450
CA3080E	70	TDA1008	326
CA3089E	253	TDA1022	648
CA3130E	90	TDA1028	338
CA3140E	38	TDA1029	338
CA3189E	266	TDA1034B	217
LM301AN	30	TDA2581	266
LM308N	95	TDA2640	292
LM318N	200	TL081CP	75
LM319N	216	TL084CN	140
LM324N	70	UA709CT	46
LM339N	71	UA709CN	40
LM381N	110	UA710CN	41
LM381AN	180	UA711CN	65
LM382	120	UA741CT	42
		UA741CN	18
		UA747CN	50
		UA748CN	35
MC1458N	35		
MC1496N	97	**Voltage Regulators**	
NE531	119	LM309DA (K)	108
NE536T	216	UA723CN	38
NE540	225	UA7805CU	65
NE555N	25	UA7812CU	65
NE556N	60	UA7815CU	65
NE560N	351	UA7905CU	86
NE561N	427	UA7912CU	86
NE562N	461	UA7915CU	86
NE565N	120	UA78L05CS	32
NE566N	155	UA78L06CS	32
NE567N	170	UA78L12CS	32
NE570N	405	UA78L15CS	32
NE571N	459		

OPTO ELECTRONICS

			Order Code
Light Emitting Diodes, Individual			
.125" (3mm)	Red	14	CQY54
	Green	17	CQY95
	Yellow	19	CQY97
Panel Mounting Clip to suit.		3	LED3 Clip
.2" (5mm)	Red	15	CQY24A
	Green	17	CQY94
	Yellow	19	CQY96
Panel Mounting Clip to suit.		5	LED5 Clip
Light Emitting Diodes – 7 Segment Display			
.3" (7.6mm)	C. Anode R.H. Decimal Pt. Red	160	XAN3061
	C. Anode R.H. Decimal Pt. Green	199	XAN3051
	C. Cathode R.H. Decimal Pt. Red, Low current drain	160	XAN3074
.6" (15.2mm)	C. Anode L.H. Decimal Pt. Red	230	XAN6620
	C. Anode L.H. Decimal Pt. Green	230	XAN6520
	C. Cathode L.H. Decimal Pt. Red	230	XAN6640
Photoresistors			
ORP12		90	ORP12
ORP61		90	ORP61
Phototransistors			
OCP71		180	OCP71
BPX25		175	BPX25
BPX29		175	BPX29
Photocoupler			
FCD820		150	FCD820

SWITCHES

Miniature Toggle – Honeywell

				Order Code
SPDT		2A/250V A.C., 5A/28V D.C.	58	SW 8A1011
SPDT	C/Off		67	SW 8A1021
SPDT	Double Bias To Centre		75	SW 8A1041
SPDT	Single Bias To Centre		75	SW 8A1051
SPDT	Bias		70	SW 8A1061
DPDT			86	SW 8A2011
DPDT	C/Off		92	SW 8A2021
DPDT	Double Bias To Centre		102	SW 8A2041
DPDT	Single Bias To Centre		102	SW 8A2051
DPDT	Bias		96	SW 8A2061

Miniature Push – C & K

SP	Push To Make, Momentary	0.5A/250V A.C., 1A/28V D.C.	54	SW 8531
SP	Push To Break, Momentary		54	SW 8533

Slide – Switchcraft

DPDT	Standard Actuator	36	SW 46206
DPDT	Slot Actuator, Voltage Change, Marked 110/240	43	SW 46206F

SEMICONDUCTORS

Diodes

IN827	193	IN4006	7	BB110G	61	OA202	9
IN914	4	IN4007	8	BY127	15		
IN916	5	IN4148	3	BY206	34		
IN4001	4	IN5402	15	BYX10	19	**Microwave**	
IN4002	4	IN5404	16	OA47	10		
IN4003	6	BAX13	5	OA90	7	BAW95D	1091
IN4004	6	BAY38	27	OA91	7	CL8960	2592
IN4005	7	BB106(4)	122	OA200	9	CXY11C	1280

Zener Diodes

400mW C4V7-C33		1.3W C7V5-C75	
BZY88/BZX79 + Voltage	8	BZX61 + Voltage	16

Transistors

2N929	37	2N4427	206	BC478	24	BSX88	18
2N1893	30	2N4856	158	BC547	12	MJE340	48
2N2218A	28	2N4858	134	BC548	10	MPF102	32
2N2222	21	2N4860	122	BC548B	15	OC28	107
2N2369	19	2N5294	43	BC549	12	OC35	95
2N2369A	20	2N5416	108	BC549B	20	OC45	82
2N2646	42	2N5457	35	BC557	14	OCP71	180
2N2894	49	2N5458	30	BC558	14	TIP29A	41
2N2895	28	2N5459	32	BC559	17	TIP29C	53
2N2904	24	2N6258	432	BCY34	97	TIP30A	44
2N2904A	24	40673	80	BCY70	14	TIP30C	57
2N2905	22	AC188	22	BCY71	14	TIP31A	43
2N2905A	24	AD161	38	BCY72	15	TIP31C	58
2N2906	19	AD162	38	BD131	35	TIP32A	49
2N2907	22	BC107	10	BD132	35	TIP32C	63
2N2907A	25	BC107B	14	BD135	38	TIP41A	59
2N2918	330	BC108	10	BD136	37	TIP41C	69
2N2926G	11	BC108B	14	BD137	38	TIP42A	59
2N3053	17	BC108C	16	BD138	39	TIP42C	69
2N3054	50	BC109	10	BD139	35	TIP2955	68
		BC109B	17	BD140	35	TIP3055	54
2N3055	50	BC109C	18	BF115	28	TIS43	32
2N3055		BC147	7	BF180	37	ZTX109C	14
Full ISB Test	86	BC148	9	BF181	37		
2N3340	30	BC149	8	BF257	35		
2N3442	141	BC157	10	BF258	32		
2N3702	8	BC158	9	BF259	36		
2N3703	11	BC159	11	BFR90	303		
2N3704	8	BC177	15	BFS21	428		
2N3705	9	BC178	15	BFX13	23		
2N3706	9	BC179	18	BFX84	26		
2N3707	9	BC182	10	BFX85	26		
2N3708	9	BC182L	11	BFX86	30		
2N3709	11	BC183	10	BFX87	22		
2N3773	270	BC183L	11	BFX88	26		
2N3819	20	BC184	10	BFY50	15		
2N3820	39	BC184L	11	BFY51	15		
2N3866	97	BC212	10	BFY52	18		
2N3903	20	BC212L	11	BFY90	97		
2N3904	8	BC213	10	BLX65	238		
2N3905	12	BC213L	11	BLY35	1889		
2N3906	12	BC214	10	BLY93A	2706		
2N3962	95	BC214L	11	BPX25	175		
2N4347	227	BC327	17	BPX29	175		
2N4401	20	BC328	15	BRY39	45		
2N4403	20	BC337	16	BSW69	33		
2N4416	86	BC338	14	BSX20	19		

SEMICONDUCTORS

Rectifier Bridges		Order Code
1A 400V S.I.L.	93	BY179
1.4A 60V S.I.L.	84	BY164
1.5A 100V D.I.L.	33	VM18
1.5A 400V D.I.L.	35	VM48
1.5A 100V	45	W01
1.5A 400V	52	W04
2A 100V	89	VS148
2A 400V	109	VS448
6A 100V	143	VH148
6A 400V	183	VH448
10A 100V	172	VJ148
10A 400V	201	VJ448
15A 100V	215	VL148
15A 400V	226	VL448
30A 100V	242	VK148
30A 400V	260	VK448
S.C.R.'s		
4A 400V	54	C106D
12A 400V	108	TIC126D
Triacs		
10A 500V	124	BT138-500
15A 500V	177	BT139-500
23A 500V	492	BTW41-500

MAINS TRANSFORMERS

Order Code

Secondaries may be connected in series or parallel to give wide voltage range
Primaries 0-220, 240V

6VA – Clamp Type Construction
Approx. 18% Regulation. F.C. 54, H36, W35

0-4.5V, 0-4.5V Secondaries	220	Trans 6VA	45
0-5V, 0-6V			60
0-12V, 0-12V			120
0-15V, 0-15V			150
0-20V, 0-20V			200

20VA – Clamp Type Construction
Approx. 16% Regulation F.C. 70, H48, W46

0-4.5V, 0-4.5V Secondaries	335	Trans 20VA	45
0-6V, 0-6V			60
0-12V, 0-12V			120
0-15V, 0-15V			150
0-17.5V, 0-17.5V			175
0-20V, 0-20V			200

55VA – Clamp Type Construction
Approx. 10% Regulation F.C. 92, H64, W57

0-6V, 0-6V Secondaries	540	Trans 55VA	60
0-12V, 0-12V			120
0-15V, 0-15V			150
0-20V, 0-20V			200
0-30V, 0-30V			300

100VA – Frame Type Construction
Approx. 6% Regulation H87, W74, D64

0-25V, 0-25V Secondaries	825	Trans 100VA	250
0-40V, 0-40V			400

COMMUNICATIONS INTEGRATED CIRCUITS – PLESSEY

SL360C	242	SL641C	384								
SL362C	302	SL650C	865								
SL610	230	SL651C	786								
SL611C	230	SL652C	329								
SL612C	230	SL680C	230								
SL613C	394	SL701C	220								
SL620C	347										
SL621C	347	SL1610C	166	SL1623C	251	SL1680C	170	SP8629	446	SP8690	907
SL622C	854	SL1611C	166	SL1625C	225	SL6600C	890	SP8630B	1361	SP8760B	680
SL623C	629	SL1612C	166	SL1626C	251	SL6640C	401	SP8655B	1058	SP8790B	454
SL624C	321	SL1613C	193	SL1630C	166	SL6650C	378	SP8657B	1058	SP8794B	454
SL630C	218	SL1620C	225	SL1640C	193			SP8659B	907		
SL640C	384	SL1621C	225	SL1641C	193			SP8660B	907		

Monitor

MADAME ZELDA BEWARE

This has go to be the most 'spirited' use for an MPU yet. The Zodiac Astrology Computer is the latest in a line of MPU-based games. The device will generate a detailed horoscope chart, just by entering the subjects date and time of birth. On pressing the appropriate buttons it will present you with a planetary chart and even suggest do/don't actions for any day, past-present or future. A third advice mode will indicate whether a particular course of action is advisable or not. Presumably it will also predict if you'll have the £26 needed to buy the device when it goes on sale in June.

WATCH OUT

Three new LCD watches from Unik just announced. They all sport the now mandatory six digits (how did we ever live with only four), Unik have the usual alarm/chrono/solar permutations in the range. One interesting feature however is the inclusion of an easily accessible battery hatch, no more expensive trips to the jeweller. Prices from £20 to £30, available now.

TRANSISTOR TESTER

This handy little box will test transistors and diodes in circuit. Up to now in-circuit testers have always given ambigious results, mainly due to low value resistors in the circuit. Ampmace claim to have overcome these drawbacks by injecting the junction under test with a comparatively large controlled current. Another innovation is the use of an audio indicator rather than the more usual moving-coil meter. A steady tone indicates the junction under test is OK, a warble or silence means short circuit and open circuit respectively. Ampmace can be found at: Unit 96, Somers Road, Rugby, Warwicks.

ALPHANUMERIC DISPLAY

The type of display that can show digits as well as letters seem to have been largely ignored by the amateur electronics market up to now. Perhaps with the introduction of a new stand-alone module from Hewlett Packard this will change. The price at the moment is still a little prohibitive to the amateur but as we all know these have a habit of falling dramatically as production and sales increase. Hewlett Packard claim the device needs the minimum of interfacing to make it operational, further details can be obtained from HP at King Street Lane, Wokingham, Berks.

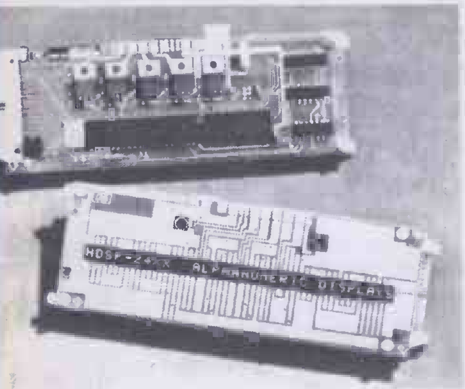
ULTRASONIC CLEANER

We thought this was someone's Action Man in a fridge, but it turned out to be a full-sized man in a Ultrasonic cleaning tank. He's holding a smaller version of the cleaner in his hands, what you would use the big one for, heaven knows, but the small one finds plenty of uses cleaning jewellery and other delicate articles. Both of the cleaners are manufactured by Kerry Ultrasonics Ltd and can be found in Hitchin Herts.

SPEAKEASY

Thought we'd heard the last of chess-playing MPUs for a while, but this was not to be. News has just arrived of the latest generation of Chess Challenger, called the 'Voice Chess Challenger', you've guessed it, it talks. We just hope it tells potential purchasers it's price, around £250. As the importers point out, it would be a good idea for the blind. Apparently the program used is the strongest so far, and works at nearly twice the speed of it's nearest rival. It should be on sale over here in July but if you can't wait Spectrum Games should be able to give you some information, find them at 113-115 Gloucester Road, London, SW7 4TE.

News from the Electronics World



DAEDALUS BLUEPRINTS

Following the Daedalus feature in January HE the British Interplanetary Society have been flooded with requests for more information on the project. The BIS have now made available the three most detailed blueprints about the project. Price for all three is £2.00, from the Executive Secretary, British Interplanetary Society, 12 Bessborough Gardens, London, SW1V 2JJ. (After 1st May address will be 27/29 South Lambeth Road, London, SW8 1SZ.)

BOOK REVIEW

It's very difficult these days to recommend a book on electronics to the newcomer but such a book recently came into our offices. Called 'Digital Integrated Circuits and Computers' by Barry Woolard it deals specifically with digital electronics. Books of this type, in the past, were usually either too specific or covered the subject too broadly. This book takes the novice right from the most basic principles, to Boolean Algebra, right up to concepts of programming computers. It even taught us here at HE a thing or two. The book costs £3.25 and is published by McGraw-Hill, number 07082337.

WRAP UP WELL

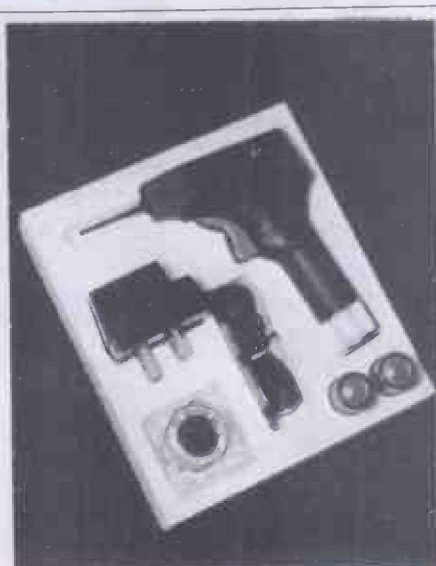
Thought to be the only purpose-designed wire wrapping tool for the hobby market, the OK wire wrapping gun comes with an impressive range of features. The gun is battery-powered (rechargeable) and based on the design of the company's industrial version of the tool. It comes complete with a charger and a handy dispenser containing 15 metres of .25 mm wrapping wire. It looks a little pricey at £46 but anyone who has tried wire-wrapping by hand will vouch for it's value. Contact OK Machine Tool Ltd, 48a The Avenue, Southampton, for more details.

RADIO PAGERS

No the picture does not show Batmans utility belt, its a handy sized radio pager made by Motorola now being used by the Post Office for their paging network. The box will emit a loud beep if someone is trying to get in contact with you, all you have to do is pick up a phone, dial a pre-arranged number and have your message relayed to you.

PAGERS TWO

Multitone, the people who first developed the radio-pager back in the fifties recently announced the aquisition of a contract worth £600 000 to supply the Russians with a paging system for the 1980 Olympic games in Moscow. The contract calls for two main installations the first, in Moscow itself has a capacity for 3000 separate channels. The other site in Tallinn will have only 200 users, (this area will be used for most of the water-sport activities). Both systems will feature a novel addition to the conventional audible bleep, in the shape of a seven segment display. A number (or series of numbers) flashed on the display will indicate which pre-arranged response has to be taken in the event of a call. The receiver also has a memory so any call, if ignored can be recalled at a more convenient time.

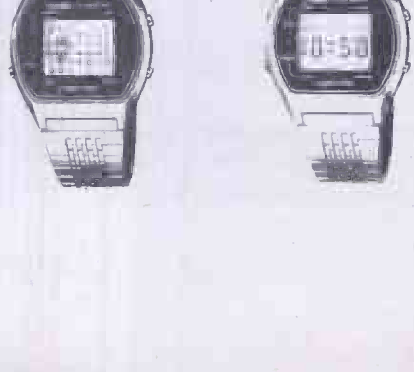


CASIO CORNER

During an average month we get to see a fair number of new calculators, this month is no exception. One company in particular, Casio, seem to bring out something like one new calculator a month. This time they have excelled themselves with three new releases. The first is a fairly conventional alarm/clock/calculator, with a usefully-angled display. Called the CQ81, it will sell at around the £20 mark. The other two are both scientific, FX2500 and FX3100 respectively. Both have the usual bewildering array of buttons and functions, the FX3100 even does something called 'rectangular polar co-ordinate conversion permutations: 'Sounds quite painful. Find out for yourself for around £25 (FX25100) and £30 (FX3100).

CALENDAR WATCH

Latest watch offering from Casio features a full monthly calendar on the LCD display. The watch has all the normal functions you would expect, (Casio claim superior accuracy on the watch side, around 10 seconds a month.) Price for knowing the date is around £85 (or less). Called the 47CS23B, it should be in the shops now.



Telephones

In Britain, we all take telephones for granted, but nevertheless many aspects of our society would be rendered helpless without this form of communication. Angus Robertson examines how our telephone system has developed, and what the Post Office has up its sleeve for the future.

THE TELEPHONE SYSTEM that we know today had its origins in 1753 when a letter was written to the *Scotch Times* describing an electric telegraph based on static electricity and was slowly developed until a 13 mile telegraph line was installed by Charles Wheatstone between Paddington and West Drayton in 1838, followed in 1850 by the first undersea cable between England and France and the first successful transatlantic cable in 1866. But passing telegrams was only the beginning, and in 1876 a Scotsman working in America, Alexander Graham Bell filed his first patent for the telephone (some three hours before Elisha Gray applied for a similar patent).

In 1878, Bell demonstrated his telephone to Queen Victoria on the Isle of Wight with calls to Southampton and London and the Bell Telephone Company (founded the year before in America) had some 778 customers. The first exchange opened in 1878 in New Haven, Connecticut, followed the year after by the first manual exchange in London.

The automatic exchange

Manual telephone exchanges have many disadvantages, particularly where a 24 hour telephone service is to be provided to a small community since the exchanges are not of sufficient size to justify full time operators who not only tended to provide unreliable service, especially during the night, and were open to corruption.

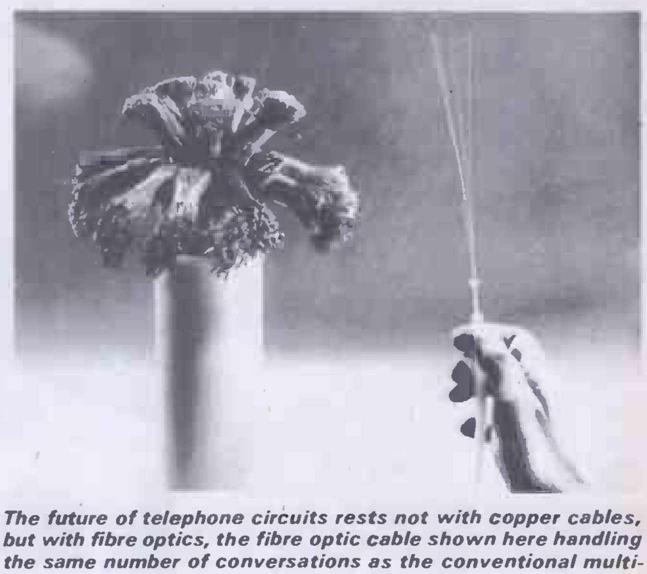
This latter aspect (and the increasingly poor service being provided by over-worked operators) caused a Kansas City undertaker by the name of Almon B Strowger to investigate automatic switching to prevent the wife of a rival undertaker who worked as an operator in the manual exchange from illegally transferring calls destined for Strowger to her husband. Although Strowger developed the automatic step-by-step switching system that still bears his name today, his system was further developed by other companies and the first automatic telephone exchange was introduced in Milwaukee in 1896. Similar exchanges were installed all over the world during the following 80 years with the first British automatic exchange in Epsom in 1912.

Although a continuous programme of development through the twenties and thirties enabled the Strowger system to dominate the automatic switching market, so much so that even in 1976, the British Post Office (the General Post Office (GPO) ceased to exist in 1969) was still installing new Strowger exchanges in the main cities, and even today existing Strowger exchanges are still being extended. But the step-by-step operating principle of Strowger exchanges requires a vast number of mechanical moving parts which are expensive to manufacture and require regular routine maintenance. There are also a substantial number of relays only required for initially setting up the call, and which lay idle during the conversation.

The crossbar system

The Crossbar switching system was developed by the Ericsson company in Sweden and rather than providing step-by-step switching, is effectively a matrix of contacts controlled by vertical and horizontal bars, and unlike a Strowger selector, can carry several conversations simultaneously. Reliability is rather better than Strowger and crossbar switches are controlled from common groups of relays which are only engaged during the actual *setting up* of the call — thus termed common control. This has another advantage since in America the relay common control units are replaced by a computer which enables many new customer and exchange facilities to be offered such as computerised billing. Crossbar was developed during the twenties and thirties and gained total acceptance in the United States and many other countries, but unfortunately in Britain after the Second World War there was an enormous demand for new and replacement telephone equipment. The PO British manufacturers had little experience with crossbar manufacture, and being unwilling to import the technology, nor delay until development was complete, Strowger switching systems were again manufactured in large quantities, most of which are still in use today.

The late fifties and sixties saw the development of



The future of telephone circuits rests not with copper cables, but with fibre optics, the fibre optic cable shown here handling the same number of conversations as the conventional multi-core cable.

In the United States, CB radio and telephones technology combine to offer fully portable telephones without any wires, but with full outgoing dialling and incoming ringing.

semi-electronic exchanges which operated using the same common control ideas as crossbar, but instead used highly reliable sealed reed relays as the switching element with totally electronic control. The British Post Office hoped to 'skip' large crossbar exchanges and move directly to the even more reliable electronic exchanges, but unfortunately the first such exchange installed in Highgate Wood in 1962 was rather ahead of its time and failed to carry its full traffic load; this set-back forced the Post Office to reconsider its earlier decision and install crossbar exchanges, which began making an appearance in the early seventies. By 1976, there were 5,206 Strowger local exchanges compared to only 359 crossbar, while 669 small *TXE2* semi-electronic exchanges had been installed in rural areas. But the *TXE2* semi-electronic exchange which is designed for up to 2000 lines, is of little use in cities where 10 000 line exchange units are typically used. The larger *TXE4* has taken many years in development and the first field trial being in 1969 at Tudor in North London, but the first opened only in late 1977. These *TXE4* exchanges are the first in Britain to offer stored programme control which potentially offers a variety of new facilities to subscribers. It is perhaps interesting to note that the standard *TXE4* uses discrete transistor bistable based logic circuits and threaded wire memories, in other words technology 10 years old, so STC has developed the updated *TXE4A* which now uses TTL and MOS shift register technology to provide a considerable cost saving over the *TXE4* exchanges only just being installed by the PO.

The American Way

Meanwhile in the States, the *No 1 ESS* (electronic switching system) introduced in the late sixties, uses similar switching technology to the British *TXE4* with sealed reed relays, but rather than using dedicated electronics, the *No 1 ESS* uses full computer control and can handle from 10 000 to 70 000 lines, while a smaller version, the *No 2 ESS* operates with between 1000 and 10 000 lines. As with all most common control United States exchanges, touch tone push button dialing is available together with a variety of other services such as call waiting, providing a bleep (indication that somebody is calling) and enabling the first call to be held while answering the second ($3.66/month), call forwarding providing automatic transfer ($2.25/month), three way calling allowing three people to converse simultaneously ($3.35/month) and speed calling providing exchange storage of either eight or 30 different numbers ($2.25/month for eight, $3.96/month for 30 members). All these various functions can be easily accomplished by the computer controlling the exchange which is also able to provide bills detailing the actual called number and length of each long distance call. While it might be suggested that the United States is currently perhaps 15 years ahead of Britain in exchange technology and range of services available, in 1976 less than 25% of Bell System subscribers in the United States had international dialing available, while some 80% of British subscribers now have the facility to dial direct to about 360 million telephones in 76 countries, and new countries are being added each month. Indeed, the British Post Office is currently investing about £120 million in a new international telephone switching centre in Mondial House, London — this compares with £2m to £10m for an average telephone exchange.

Some telephones in the United States not only allow calls be made, but also include clocks and calculators.

Digital dialling

But all the previous exchanges will be obsolete by the turn of the century, to be replaced by totally electronic exchanges based on digital solid state switching — since a name has not yet been established for the British entry in this field, the name *System X* has been temporarily attached. Although the British Post Office intends to install the first *System X* exchanges in 1981 at Woodbridge in Suffolk (930 lines) and a junction tandem exchange (inter exchange circuits) at Baynards House in the City of London. System X has no mechanical parts and is basically a specialised computer, and as such requires a fraction of the space of Strowger and *TXE4* — and for each person required to build a *System X* exchange, 10 people are required to build *TXE4*, and

25 for Strowger, and this has of course caused certain alarm among the trade unions.

System X

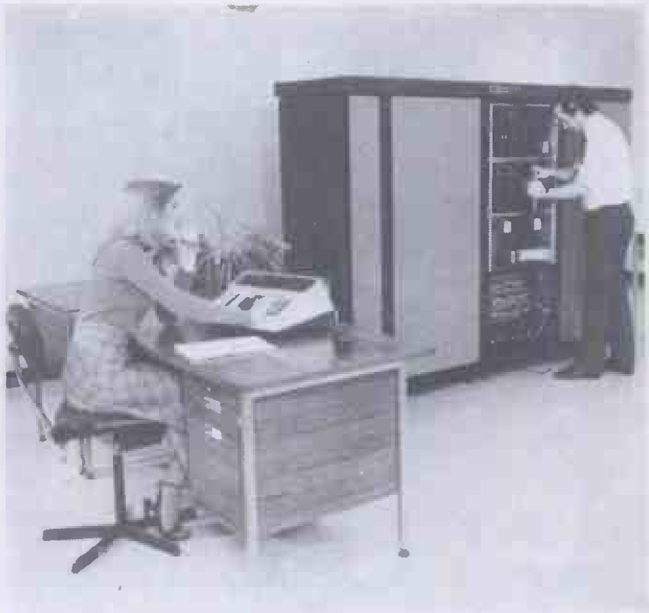
System X development has been based on the hardware subsystems such as switching, message transmission, signalling, and processing, while software subsystems include call processing and accounting, maintenance and control, and operating systems. Although many of the software features have been in use in American computer controlled crossbar exchanges for many years, the switching is solid state and based on purely digital means. Basically, the analogue voltages from the telephone instrument pass to an analogue to digital converter (ADC) and then into the digital random access memory (RAM) into which the digital signals are continually passed, one bit from each of the thousands of conversations to be switched being stored, and then read out in a different time slot (time division multiplex). This system is not unlike a large relay matrix, except that RAM is considerably more economical than mechanical contacts, that is once the signals are in the digital domain.

Pulse Code Modulation (PCM)

Although there is no digital switching yet in the British telephone network, there are a substantial number of digital (PCM) circuits between exchanges — PCM allows 30 digital circuits to be provided along two ordinary copper wire cable pairs (one go, and one return), thus enabling 15 times more circuits to be provided between exchanges without laying extra cables under the roads. When *System X* is introduced, the intermediate A-to-D, and D-to-A stages can be bypassed providing considerable simplification in exchange equipment. This can be taken a stage further by eliminating many of the cables between exchange and telephone instruments.

In urban areas the local cable distribution system is layed under pavements with houses being connected by buried cables to manholes where the main cable is joined. These local cables are fed back to green street cabinets where interconnections may be made, before being fed into large multicore cables back to the local exchange. When digital technology is introduced, it will be possible to introduce switching into these cabinets, controlled by the exchange computers, with resultant decrease in cabling costs. *System X* digital exchanges enable switching to be performed virtually instantaneously, provided suitable signalling is used.

A typical Strowger exchange using contacts which rotate past banks of contacts.

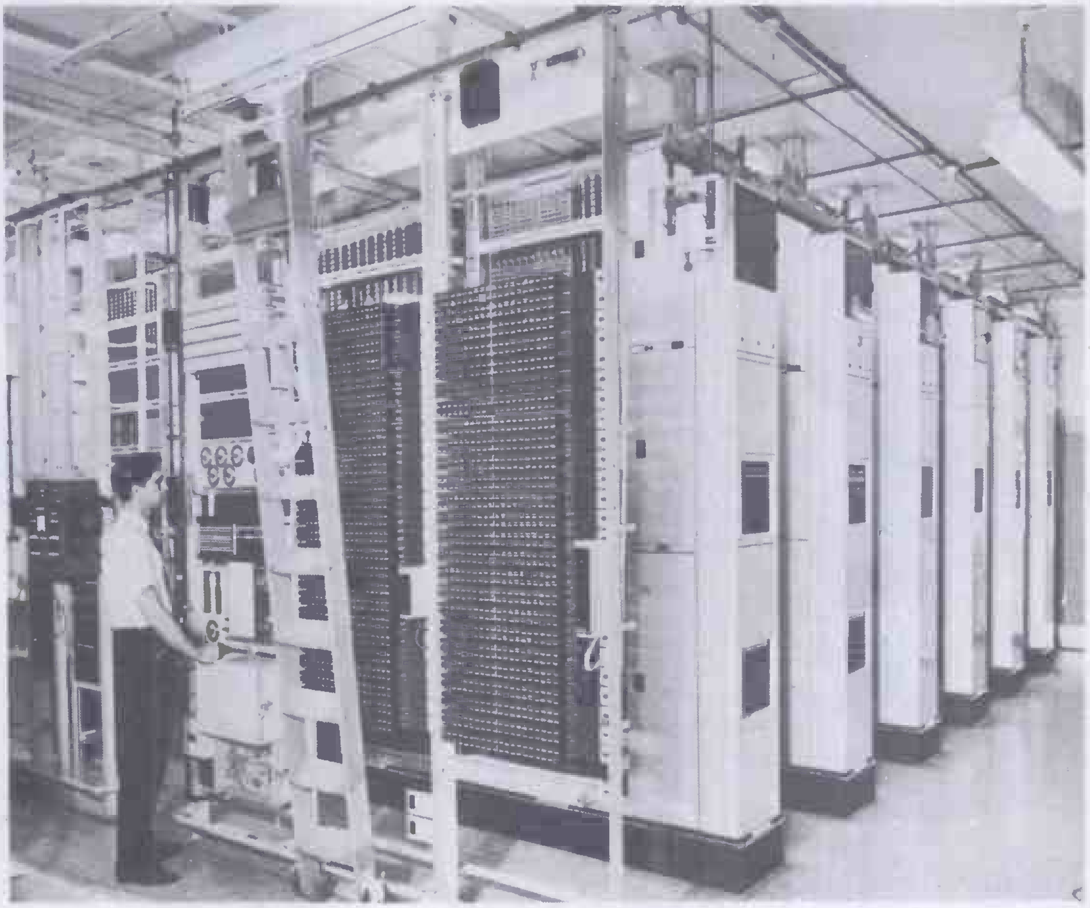


Plessey PDX 800 line electronic digital exchange (PABX) — an electromechanical equivalent would have totally filled the room.

Dialling delays

The British telephone system is currently based on impulse signalling as provided by rotary telephone dials. This operates at a maximum speed of 10 impulses per second, so STD numbers can take up to 15 seconds to actually dial. The Strowger exchanges again only operate on a step-by-step principle, and so take several seconds after dialling is finished to complete the call to the dialled exchange.

Although crossbar exchanges can provide virtually instantaneous switching thus enabling calls to be connected very rapidly, this only occurs in practice when all the exchanges in the network operate at similar speed, and currently the vast majority of the British network is old-fashioned Strowger. In America, the network is based on crossbar, and so call set-up time was primarily restricted by the time required to dial the number. With this in mind, the American Bell System introduced its *Touch-Tone* push button telephone using multi-frequency (MF) dialling. This is based on two different audio tones being transmitted together upon depression of each push button, there being seven tones in all, which are detected in the exchange and converted into a form suitable for the exchange switching. For instance, crossbar exchanges operate using a common register which accepts and stores the dialled number, and when



Modern crossbar exchange with subscribers meters in foreground — the actual crossbar switch can be seen at the top of the rack comprising horizontal and vertical rows of contacts which, when activated by electromagnets, join rows together.

sufficient digits are received, a path is selected through the exchange in one step.

Within the exchange, the registers communicate with each other by sending digits along six wires in parallel. So although all crossbar exchanges will convert dialled pulses into these six parallel signals, they can rather more rapidly convert MF pulses, and this is how the American Bell System managed to provide almost instantaneous connections using *Touch-Tone* phones.

In Britain, the 'keyphones' presently being installed merely store key depressions, and then dial out pulses at identical speed to a dial telephone. So although they provide quicker and more accurate keying, the call takes just as long to connect. The electronics required to store these digits obviously requires power, and this is normally provided by a battery charged from the phone line; in later direct line powered models a capacitor provides power during the dialling pulses which short circuit the telephone wires, obviously preventing power driving the electronics. Since MF telephones send tones down the wires, they do not short the wires which are thus able to provide continuous power for the tone generator — incidently, this also means less interference for telephone users because the 50 V spikes created by dialling impulses are eliminated.

As mentioned earlier, the *TXE4* semi-electronic and *System X* digital exchanges provide the capability of offering further facilities such as automatic alarm calls, automatic call transfer to another number, three party connection (conference), abbreviated dialling and call waiting when notification of a second incoming call is made during an existing conversation. These facilities will be introduced experimentally on certain *TXE4* exchanges during 1979, but many such facilities require extra keys for commands, other than the usual 1 to 0 digits, and on MF keypads, these are provided as * and # keys, and as such will be necessary for many new telephone features to be provided. *System X* exchanges will use MF telephones, and so the PO was put in a situation where it could continue installing old-fashioned impulsing keyphones as at present (which are somewhat unreliable and cost about £50 each, five times that of a standard dial phone), and all of which will be rendered obsolete when *TXE4* and *System X* exchanges are opened, or start installing multifrequency keyphones, and this is the decision now taken.

British touch phone

To enable MF keyphones to be installed on present Strowger exchanges, electronic converters will be installed on the first selectors of principal exchanges to convert MF tones into pulses for the electromechanical mechanisms. With crossbar exchanges it is even easier since all registers are common already. The PO hope to have the principal exchanges operating with MF keyphones during the early eighties, although it will be several years later that the advantages are felt as more electronic exchanges are introduced.

Meanwhile, one particularly interesting new telephone being introduced is the *X-Press Callmaker*. This looks like a normal keyphone, but has a few extra buttons and switches which enable 10 entire directory numbers to be stored for recall by pressing just two buttons, and the callmaker also stores the last number entered into the keyphone, so if the called number is engaged, or if the infuriating woman says "all lines are engaged, please try later", as is so common just as you complete dialling 14 digits for America, then it only requires a quick press on one button for the entire number to be redialled automatically. Rental is anticipated at £7 per quarter. Another interesting item is the ultra lightweight telephone headset (called *Starset* by Pye TMC). Although telephone headsets bring visions of speaking horns as used on current PO headsets, almost every other country in the world now has available ultra lightweight headsets which comprise a hearing aid type receiver mounted behind the ear, with a miniature transparent tube poking toward the mouth. The weight is so little, that the biggest problem is walking off with it still plugged in, which can be very painful on the ear — but one learns fast. Although headsets are currently predominantly for operators and telephones sales people, this headset can be used by executives who prefer two hands free during phone conversations, and find loudspeaking telephones impractical due to background noise. Estimated rental is £6 per quarter.

The business world

Despite the Post Office promotion of business telephones, the business equipment presently available leaves much to be desired. The PO has a monopoly on private branch telephone exchanges with less than 100 extensions, but the automatic exchanges (PABXs) offered today (that is if you can actually get one) are Strowger based and have been virtually unchanged for almost 30 years. They require a separate room for the equipment, with bulky lead acid batteries to drive the selectors. Although more modern large PABXs are available from private suppliers, these may only be used where more than 100 extensions are required. Again, the present *Keymaster* intercom systems are expensive to install with only two exchange lines maximum. America has used the Key System since 1938, offering hold and five lines — and this is seen in most American offices, but we have nothing comparable except very expensive 10 line key and lamp units and manual exchanges which require a full time operator.

But during the seventies, this PO attitude has been changing, and several new business systems are in the pipeline. One of these is the new Small Business System developed by Pye TMC, and this uses special keyphone telephone instruments with 16 extra keys which can be used to access exchange lines, or other extensions. SBS will take up to 10 exchange lines, and 30 extensions, all connected using only 4 wires, unlike Key systems which use dozens of expensive wires. Many facilities are included such as call transfer, number stores and conference calls. For larger businesses, the *CDSS1 Call Connect System* is designed to replace all Strowger PABXs, offering up to 120 extensions with a maximum of 40 exchange lines and private circuits. Switching is totally digital using the same time division multiplex

Pye TMC X-Press Callmaker keyphone (£7 a quarter from PO) which stores 10 numbers and allows the last entered to be redialed by pressing a button.

technique as *System X,* and offering dial pulse or MF telephones, with many business facilities such as transfer, conference calls, call diversion, call back etc. The *CDSS1* comprises only a single filing cabinet sized rack designed to be located in the corner of the office taking 4 sq ft, rather than the 70 odd sq ft required for a present Strowger exchange room. Installation will also be very much quicker and cheaper — *CDSS1* can also potentially communicate digitally with *System X* exchanges, with perhaps three cable pairs replacing the 30 or 40 required when analogue telephone circuits are used, as at present.

Computer chat

One particular advantage offered by *System X* and such digital exchanges is that the computer processors at each exchange are able to communicate with each other passing such information as the originating number to the final exchange. This information is required, for instance, for call transfer where a new route from the originating exchange might have to be set up for the transfered call and it enables operators to receive visual indication of calling numbers. It should also deter obscene phone calls since tracing calls no longer involves time consuming tracing of selector contacts and wiring schedules showing which contacts are connected back to which previous selector, but merely a request into a computer terminal with an immediate answer. This does have serious implications regarding privacy of phone calls, particularly when the 'authorities' become interested in your callers, and this should be prevented before it becomes possible. It is significant that in the United States, telephone line 'tapping' is never permitted *inside* exchanges but only on external cables, while in Britain telephone exchange staff reportedly actively assist such tapping. It has even been rumoured that certain telephone exchanges in Ulster are almost totally under the control of computers wired to banks of tape recorders for phone tapping purposes.

Nevertheless, the introduction of digital telephone exchanges will enable many beneficial new services to be introduced, provide much faster call set-up times and most importantly, clear, clean, interference free digital lines where one can actually hear the calling party. **HE**

electronics today international

What to look for in the May issue: On sale April 6th

SAW POINT

Its goodbye to the faithful IF strip as we know it. SAW will soon be found in TV receivers, replacing the usual array of coils and capacitors. You can expect to see and hear a lot more about them in the future, be one jump ahead and read the exposé in next month's ETI. P.S. SAW-=Surface Acoustic Wave!

HEADPHONE AMPLIFIER

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DOUBLE DICE

OK, so you've seen them before. Ours have a novel method of display decoding, switchable odds to allow adaptation for wargaming, etc. Single board construction makes life easier and overall we think its a nice one!

See what you think next month.

How It Works — AM/FM

The second in our occasional series by Gordon King. This time he turns his attention to radio, and goes in and out of the ins and outs in great, easily explained, detail. Masses of circuits to illustrate the points, and a must for anyone remotely interested in the field.

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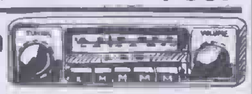

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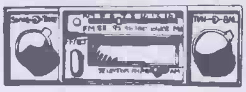

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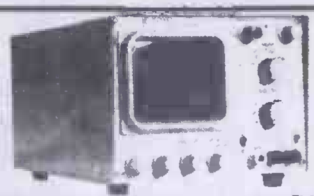

SPECIFICATIONS

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VERTICAL AXIS (Y) Deflection Sensitivity — 100m V division Bandwidth (between 3 dB points) — DC — 5MHz Input Attenuator — (calibrated) — 9 step 0 1 0 2 0 5 1 2 5 10 20 50 div Input Impedance — 1 Meg 40 pf in shunt Input Voltage — Max — 600V P P

HORIZONTAL AXIS(X) Deflection Sensitivity — 0-400mV division Bandwidth (between 3 dB points — 1Hz-350KHz Gain Control — Continuous when time bases in EXT position Input Impedance — 1 Meg Input Voltage — Max — 600V P P

TIME BASE Sweep Range (calibrated) — 100msec div to 1μ sec div in 5 steps FINE Control — Variable between steps — includes time-base calibration position Blanking — Internal — on all ranges

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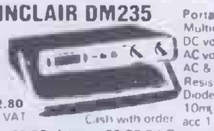

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Model Train Controller

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THE HE TRHO CONTROLLER enables the speed of a 12V model train to be varied smoothly from zero to maximum, with excellent power control under all conditions. The control over the near-zero to medium-speed range is particularly impressive, and it permits highly realistic shunting, etc. The speed control output can provide maximum mean currents up to above 1.5A, which is enough to power two trains simultaneously. The output is fully protected against short circuits. If a short occurs across the tracks the output power immediately shuts off, and is restored automatically when the short is removed.

The controller is provided with two fully protected outputs in addition to the speed control described. One of these is a fixed 12V DC output, which can be used to power the electronics section of one or two additional speed controllers if required. The third output is a fixed 15V AC, which can be used to power circuit accessories such as electric point motors, etc, and can deliver up to almost three amps. The controller has a total output power rating of 50VA.

Our prototype train controller built in a Verobox. It cannot be seen from this photograph but holes should be drilled into the case to provide adequate ventilation otherwise the heat buildup can cause the safety cut-out thermistor to trip.

ON THE RIGHT TRACK

The controller can be built as a completely self-contained unit, with one controlled and two auxiliary outputs, or if preferred only the electronic control section need be built and can be used as an add-on unit that is powered from the 15V AC output of an existing power controller such as the Hornby 900.

As a point of general interest it should be noted that the electrical measurement conventions used in the model railway world are not always the same as those used in the electronics world. What Hornby call 15 volts AC, for example, is really 17 volts AC, and what they call 12 volts DC is really 15 volts DC. In our description of the HE controller above, we have used model railway conventions when describing available output voltages.

CONSTRUCTION

The controller can either be built up as a completely self-contained unit, as shown in the main circuit diagram, or can be built as an add-on unit that is powered from the 15 volt AC output of an existing controller such as the Hornby 900. In the latter case the unit should be built exactly as shown in the main circuit diagram, except for the omission of transformer T1, thermal trip TH1, and mains switch SW3: the 15 volt AC input to the add-on unit should be connected to its 15V AC output terminals.

Note that no attempt should be made to power the add-on unit from the 12V DC output of an existing controller by also omitting bridge rectifier BR1 and connecting the 12 volt supply to the 12V output terminals of the add-on unit, since it is imperative for correct operation of the unit that only a clean full-wave rectified signal, with no standing DC components, should appear on its 12V DC terminals. Also note that, for the same reason, large capacitive loads must not be connected across the 12V DC terminals of either version of the speed controller circuit.

Whichever version of the unit is to be built, start by wiring up the components on the PCB, as shown in the overlay. Take particular note of the connections to unijunction transistor Q1 and silicon controlled rectifier SCR1. A pair of terminal pins should be fitted in the holes provided in the board at this stage, so that capacitor Cx can be fitted, if necessary, at a later stage.

When the board is complete, wire it and all remaining components into a suitable case. If you are building the self-contained version of the unit, see the notes under Buylines. Note that thermal trip TH1 is connected in series with the primary of transformer T1, and should have its leads protected by sleeving. Take care to ground all metalwork, particularly the front panel.

LOAD SHUNTING?

Lamp LP1 acts as a permanent load across the output of the unit, and helps improve its regulation. It can either be freely mounted within the case of the unit, as in our prototype, or mounted on the front panel, where it will give a visual indication of the power output level of the unit.

When construction is complete, connect the controlled output of the unit to a railway layout, place an engine on the track, and check that the unit functions correctly. Switch SW2 controls the direction of the locomotive, and RV1 with ganged switch SW1 controls the speed. Speed should be maximum when RV1 is rotated fully clockwise, and zero when RV1 is turned fully anti-clockwise. The speed should be a very slow crawl when RV1 is rotated anti-clockwise against the pressure of its

How it Works

THE THERMAL TRIP.

THE MAINS INPUT to the unit is fed to step-down transformer T1 via ON/OFF switch SW3 and the component marked as TH1. TH1 is a special 'thermal trip' thermistor, which has a unique set of characteristics which are used to protect the transformer and bridge rectifier BR1 in the event of a short circuit or overload being placed across either of their outputs. TH1 is designed to trip when the power loading of T1 rises to about 50 VA.

Under normal circumstances, when an overload is not placed across the transformer secondary, TH1 has a resistance of only about 30 ohms, and causes negligible power loss in the circuit. As the 50 VA overload condition is approached, the TH1 resistance rises to about 50 ohms, and its temperature rises to about 105°C, but it still causes only a negligible power loss in the circuit.

Beyond this point, any further increase into the 50 VA overload region causes the resistance and temperature of TH1 to increase rapidly, until almost the entire supply voltage is dropped across it and the current through the transformer primary is reduced to negligible levels: the resistance of TH1 in fact increases from about 50 ohms to 100k when its temperature rises from 100°C to 150°C. TH1 thus gives complete protection to T1 and BR1 against overloads or even short-circuits across their outputs. Once the overload is removed, the temperature of TH1 falls back below 105°C and it effectively resets itself.

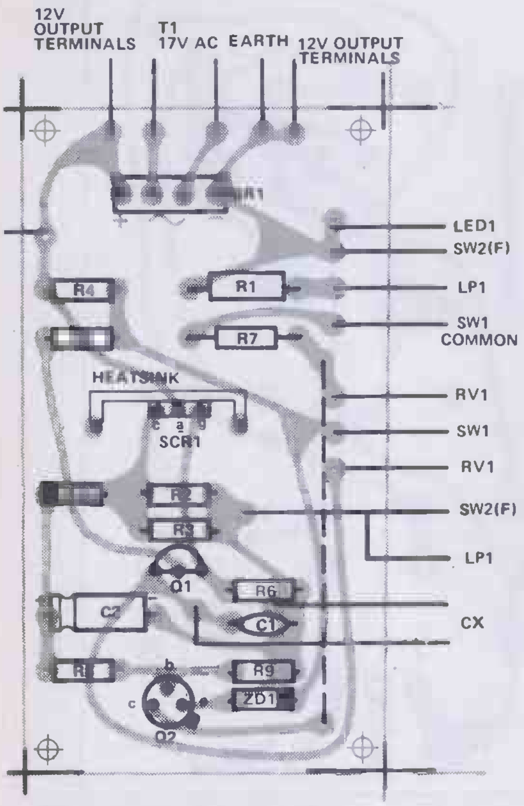
THE SPEED CONTROL CIRCUITRY

The 17 volts AC output of the transformer is full-wave rectified by bridge rectifier BR1 and is fed to fixed-load LP1-R1 and to the external railway tracks via direction-control switch SW2 and via the electronic speed control circuitry, which acts essentially as a fast power switch that is connected in series with the BR1 output leads, and which can go through a complete OFF-ON-OFF switching sequence in a single half-cycle of the BR1 ouput voltage: when the electronic 'switch' is closed throughout full half cycles, full power is fed to the external track: when the 'switch' is closed for only half of each half-cycle, half power is fed to the track, and when the 'switch' is open throughout all half-cycles, zero power is fed to the track.

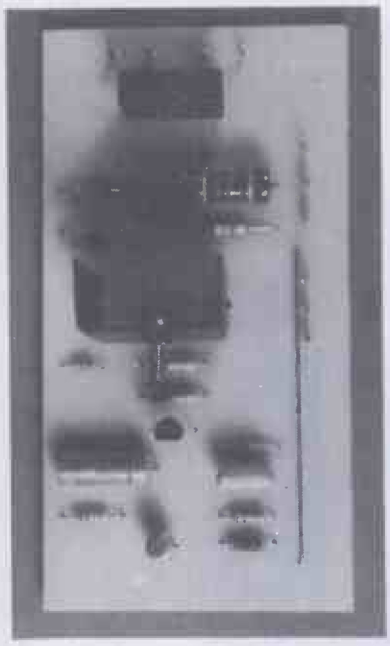
Silicon controlled rectifier SCR1 is the main element of the electronic switch described above, and is triggered in each half-cycle by a variable-delay generator designed around unijunction transistor Q1. The action of SCR1 is such that it is normally off, but turns on and self-latches for the remaining duration of a half-cycle when its gate is triggered by Q1: SCR1 turns off automatically at the end of each half-cycle as its anode current falls towards zero. The SCR1 triggering delay can be varied from near-zero (full power output) to almost the full duration of a half-cycle (minimal power output) in each half-cycle via RV1 and C1, and RV1 thus serves as the speed-control pot: the delay can be made total (zero power output) by opening ganged switch SW1.

Monitor resistors R2 and R3 are wired in parallel and connected in series with the cathode of SCR1, and thus have a voltage developed across them that is proportional to the output current to the track. This voltage is fed to the base of Q2 via D1-C2-R8 and R9, which together form an overload detecting network. Q2 disables the Q1 unijunction delay generator when it is activated, and thus removes the power drive from the track. The action of the network is such that the output is disabled immediately if the peak output current rises above roughly 2.4 A (about 1.5 A mean): this overload is temporarily 'remembered' by C2, and is rechecked automatically once or twice a second (by occasionally firing SCR1 for part of a half cycle) until the overload is removed, at which point Q2 turns off and enables Q1 to operate in its Normal manner.

Zener diode ZD1 limits the peak voltage across Q1 to a safe value of 10 volts. LED 1 (a light emitting diode) is connected across the output of bridge rectifier BR1 via R10, and is mounted on the front panel of the controller to indicate the ON state of the unit.



The component overlay. Note that R10 and the LED are in series behind the front panel.



The PCB before wiring into the case. The bridge rectifier is on the right, the 1W resistor near it with the SCR bolted to its heatsink near the middle.

Parts List

RESISTORS

R1	47R 1W 10%
R2, 3	1R0 ¼W 5%
R4	470R ¼W 5%
R5, R6	100R ¼W 5%
R7	4k7 ¼W 5%
R8	22k ¼W 5%
R9	100k ¼W 5%
R10	820R ¼W 5%

CAPACITORS

C1	47n Polyester, Mylar etc
C2	10u 25V electrolytic
Cx	See text

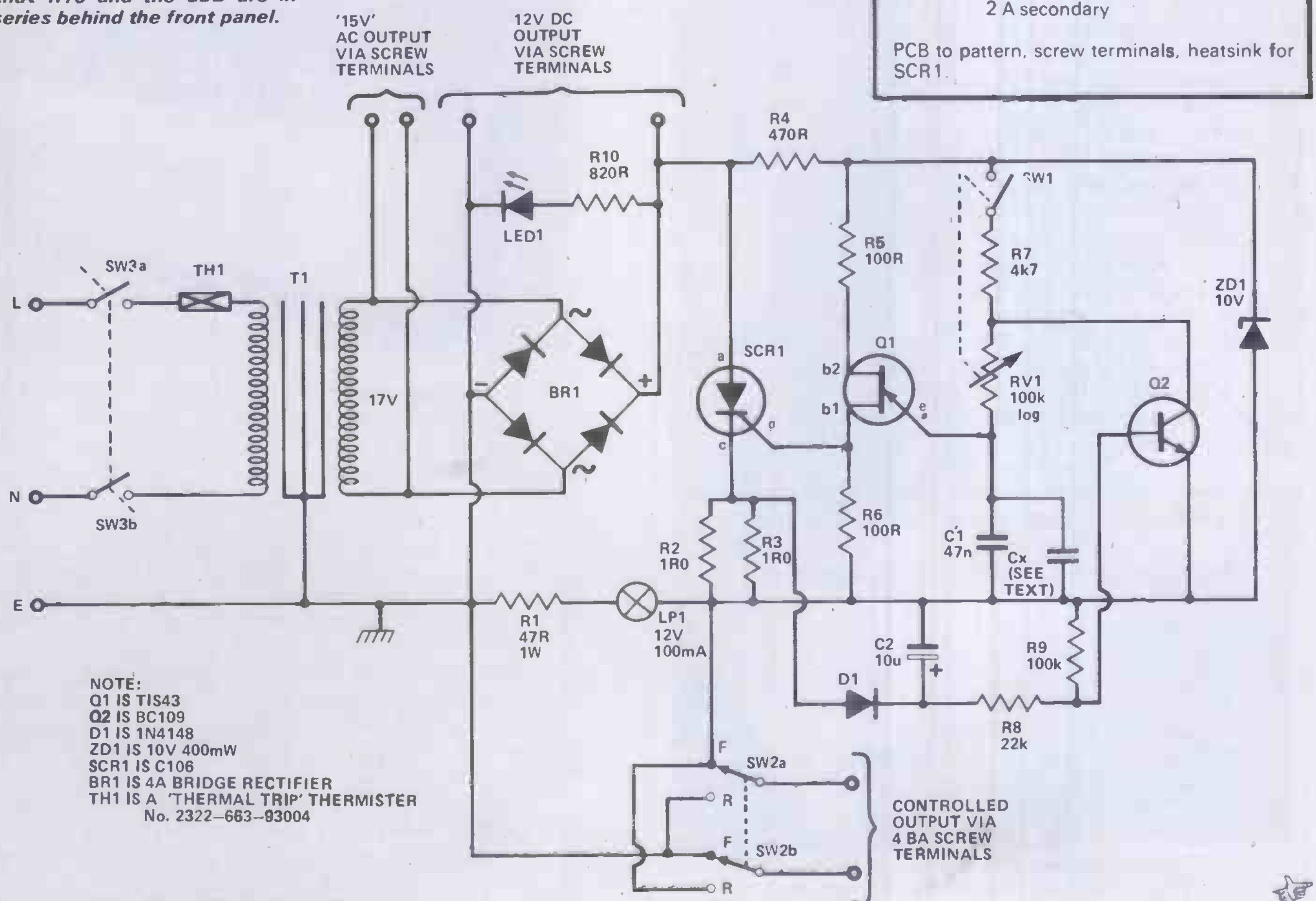
SEMICONDUCTORS

Q1	TIS43
Q2	BC109
SCR1	C106
D1	1N4148
BR1	50 V, 4 A Bridge Rectifier
ZD1	10 V 400mW zener diode
LED1	TIL 220

MISCELLANEOUS

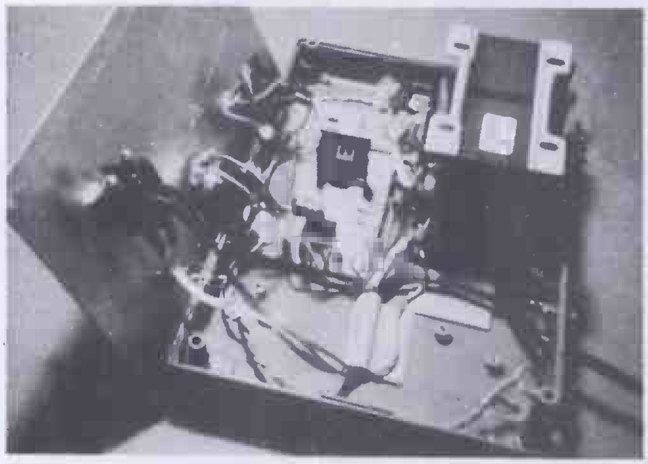
RV1	100k log rotary pot with switch (SW1)
SW2, 3	DPDT (Double pole, double throw) toggle switch
TH1	Mullard 'Thermal Trip' Thermistor Type 2322-633-93004 (see Buy Lines)
LP1	Bulb, 12 V 100 mA
T1	Transformer, 250 V primary, 17 V 2 A secondary

PCB to pattern, screw terminals, heatsink for SCR1.

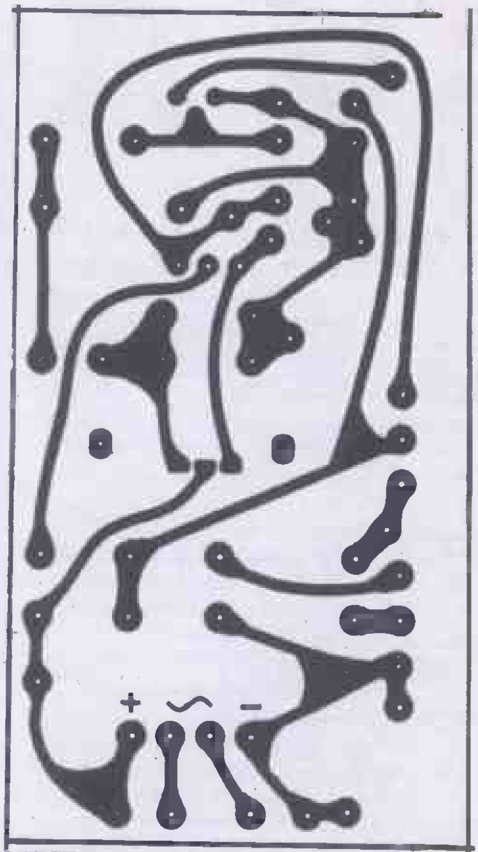


The circuit of the Model Train Controller.

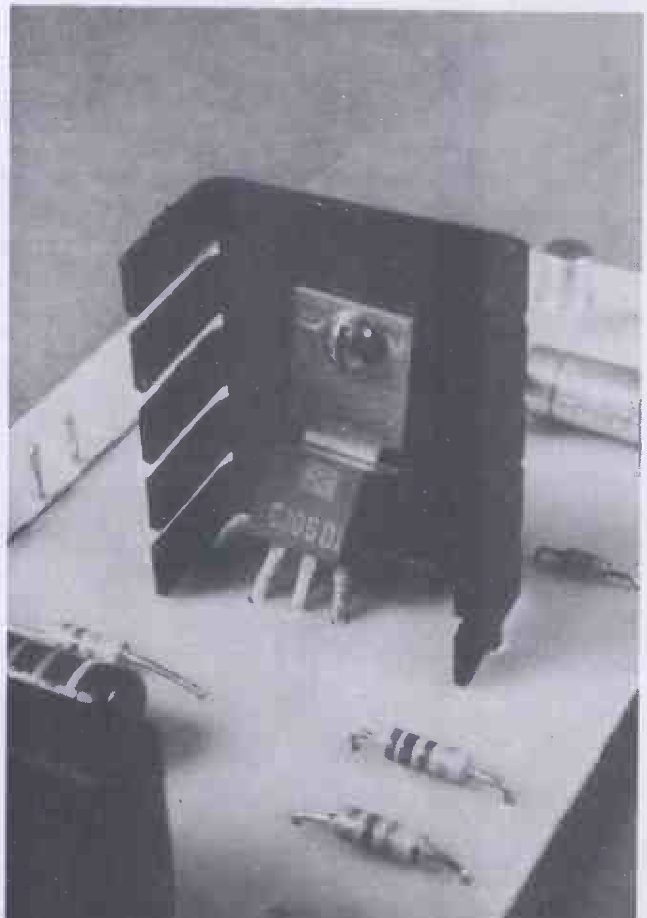
ganged switch: the speed of this crawl can be reduced by connecting capacitor Cx in place on the PCB. The value of Cx (if it is required) should be established by trial and error, starting at 10n and going up in small step and should be made no larger than is absolutely necessary. **HE**



Inside view of the complete unit. Design by Ray Marston, unit built by Steve Ramsahadeo both of the HE Project Team.



The PCB pattern of the model train controller shown full size.



Close-up of the SCR bolted to the heatsink which itself has lugs going through the PCB.

All components except TH1 and T1 are readily available. TH1 is a thermal trip thermistor, and is available from sTevenson Electronic Components (see advertising pages) for 65p plus 30p minimum carriage charge.

Transformer T1 should ideally be a 17V type with a 50 VA (3 A) or greater rating. On our prototype we used a type ET 1015 transformer, which has two sets of 17V, 2 A windings, and wired the windings in parallel to give a total current rating of 4 A. If you do the same, make sure that the windings are correctly phased by first connecting one set of ends together and then checking with a voltmeter that negligible AC voltage appears between the two free ends; if all is well, complete the connections.

The ET 1015 transformer is manufactured by Essex Transformers Ltd. We obtained ours from Maplin Electronic Supplies under order number WB22Y (Tr 34V HP), price £5.62.

TV Aerials

You've all seen them, but do you know how they work? It's not so easy as it first seems. Find out now and never be lost for words at parties.

WHEN AN ELECTRIC CONDUCTOR is placed in a radio frequency field an emf (electromotive force) is induced into it in rather the same way as an emf is induced into the secondary winding of a transformer when the primary winding is connected to a source of alternating current (AC). My previous article dealing with TV signals has already explained how such signals are generated and propagated in space. This article gives a basic impression of how TV aerials work and what factors influence their choice for particular locations.

Since we live in a world which is permeated with electromagnetic radio signals from multiple transmitting stations it follows that in virtually any conductor will be induced emfs corresponding to these signal fields. You can easily prove this merely by connecting pretty well any electric conductor to the aerial terminal of a sensitive radio receiver and tuning in. Depending on frequency, signals from the world over will be received. I recall a long time ago using the springs of my bed to run my crystal set and later my short-wave set; but because the latter consumed external energy I was obliged by violent parental reaction to resort to the former after falling asleep with the headphones on. Not because of the high cost of electricity — I think we were still on gas! — but because during my slumbers I became restless (probably thinking about the reception of New York on a one-valver) and pulled the set complete with lead-acid accumulator on to the new carpet with dire results.

A crystal set is a good illustration of the realness of electromagnetic wave energy. The required signal is merely tuned by a coil and capacitor; then rectified by a diode, and the resulting audio modulation fed direct to sensitive headphones. In other words, the headphones are worked directly by the energy of the signal.

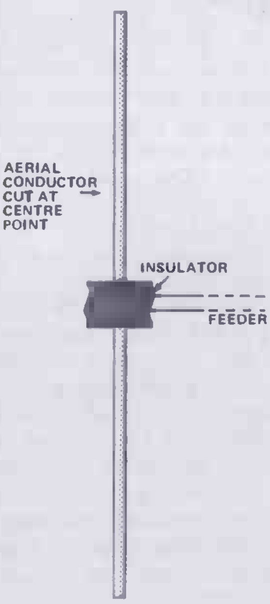


Fig. 1. Basic centre-fed half-wave dipole.

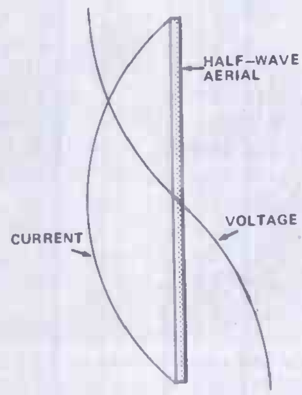


Fig. 2. Voltage and current distribution of a tuned half-wave dipole.

WIRE-LESS

In the days of the crystal set it was found that the longer the aerial attached to it the louder the sound from the headphones. This was because the closer the length of the aerial came to the signal half-wavelength, the greater the signal pick up. In those days we were working on relatively long wavelengths. Such as aerial was called a long-wire aerial, but to be a half-wavelength on 200 kHz long-wave it would need to be 750 m long. Hence the full extraction of signal energy was never achieved, though it got better as the aerial was made longer. Also, of course, the amount of signal induced into an aerial depends on the strength of the signal field.

The earlier article showed that the strength diminishes as the inverse square of the distance from the transmitting aerial. The signal field is measured by a special meter calibrated in terms of microvolts per meter (μV/m) in conjunction with an aerial of specific parameters which is supported at a certain height above Earth. For TV and FM radio the transmitting authorities issue signal strength contour maps where the contours are either in μV/m or in dB with respect to 1 μV/m. Thus a field of 60 dB is a thousand times above 1μV/m, or 1 mV/m. Such maps are useful for a rough guide of field strength; but topography can affect the local field strengths of the VHF and UHF bands in particular.

TUNED IN

Unlike a long-wire aerial, a TV aerial is specifically tuned to the band of frequencies over which it is to operate. The conductor length is cut so that it corresponds to the mean frequency of the channel or channels of the stations it is to receive. The simplest TV aerial, therefore, is merely a metal rod whose length corresponds to the half-wavelength of the signal frequency. The emf induced into the aerial by the signal, though, has to be conveyed with the least loss to the receiver, and a common way of achieving this is to cut the rod at its centre point, support the two halves by an insulator so that their ends are close together but not touching, and then to connect the signal feeding cable (called a feeder or downlead) across these two ends. The idea is shown in Fig. 1.

Now, when a half-wave aerial is responding to a signal of corresponding wavelength, the signal current through it rises to a maximum at the centre and falls to a minimum at each end, while the signal voltage across it rises to a maximum at each end and falls to a minimum at the centre, as shown in Fig. 2. Exactly the same current/voltage distribution obtained when the rod is cut at the centre provided the aerial remains tuned to the signal. Because at the centre point the voltage is at a minimum and the current at a maximum, it follows that this is the point of least impedance (a low impedance, of course, gives rise to a high current and a low voltage). In free-space, the impedance at the centre point is, in fact, close to 75 ohms.

The signal is then fed from the aerial to the receiver through a cable whose characteristic impedance is close to 75 ohms. When this is done and when the receiver end of the cable is also terminated to 75 ohms, which is provided by the aerial input circuit of the TV receiver, the signal from the aerial is conveyed to the receiver with the minimum loss, which corresponds to the intrinsic attenuation of the cable.

THE DIPOLE

When the rod is severed at its centre point as shown in Fig. 1, the aerial is commonly referred to as a centre-fed dipole (dipole, because it effectively posseses two poles). It is also possible to obtain signal from one of the two high impedance ends by a special coupling transformer often composed of coaxial cable, which reduces the end impedance to match that of the feeder. Such an aerial is called an end-fed dipole. Because the aerial is cut to correspond to half the wavelength of the signal the term half-wave dipole is in common use.

An aerial will still gather optimum signal when it is greater than half the wavelength of the signal provided its length corresponds to integral multiples of half the wavelength of the signal. For example, it could be full-wave, one-and-half-wave, etc.

It was shown in the previous article that the signal wavelength is equal to the radio wave (light) velocity (close to 300 m per μs) divided by the frequency of the signal in Hz when the velocity is in m/s. The frequency of UHF Channel 52 vision signal is 719.25 MHz, which puts the full wavelength at 0.417 m and the half wavelength at 0.208 m. A half-wave dipole would not be cut exactly to that length, however, because of a function known as the velocity factor of the aerial, which is determined by the length/diameter ratio of the rod, which also governs the bandwidth of the aerial. The aerial causes the signal velocity to decrease slightly from the true free-space value, which means that the physical half wavelength of the aerial itself is always slightly greater than the signal half wavelength — about 10% greater on average, depending on the nature and bandwidth of the aerial. To resonate exactly at Channel 52 vision frequency, therefore, the aerial length would be close to 0.229 m.

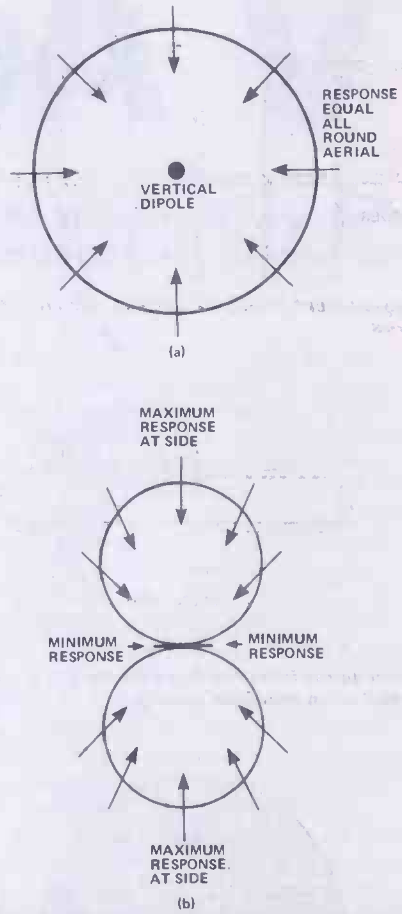


Fig. 3. A single dipole mounted vertically has the omni-directional polar response around it (a) and the figure-of-eight response when mounted horizontally (b).

BANDWIDTH

The precise length of a TV aerial is not really that critical because other factors come into play, including the bandwidth (which, as just noted, depends on the conductor length/diameter ratio) and the inclusion of other elements, such as a reflector and directors. Indeed, it is important for a TV aerial to have a respectable bandwidth in order to work properly from the three stations of a group (e.g., BBC-1 and 2 and ITV). UHF TV aerials are, in fact, designed for specific channel groups, which are Group A (red code) for Channels 21-34, Group B (yellow code) for Channels 39-53, and Group C/D (green code) for Channels 48-68.

From what we have seen so far it will be appreciated that apart from tuning the signal correctly, an aerial of improper length will also fail to match the feeder connected to it, so that additional losses will result.

The half-wave dipole forms the foundation of all TV aerials, though they differ in detail. As stated in the previous article the aerial needs to be disposed to correspond to the plane of polarization of the signal. Most UHF signals are horizontally polarized requiring the elements to be placed horizontally in space. Many of the VHF signals are vertically polarized. The elements of these aerials are longer than those of their UHF counterparts because of the lower frequency and hence

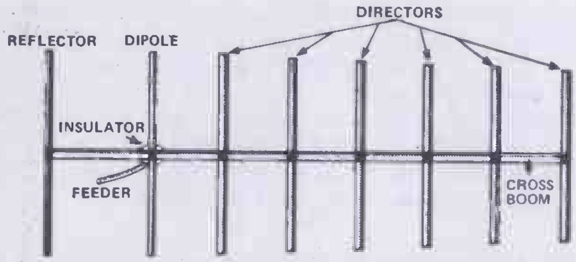


Fig. 4. Multi-element (Yagi) TV aerial, showing dipole, reflector and directors.

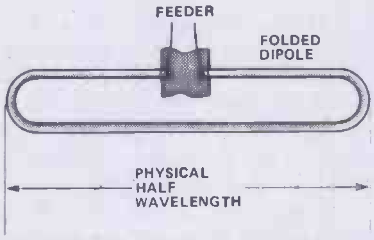


Fig. 5. When a dipole is folded like this the centre impedance is four times that of an unfolded dipole.

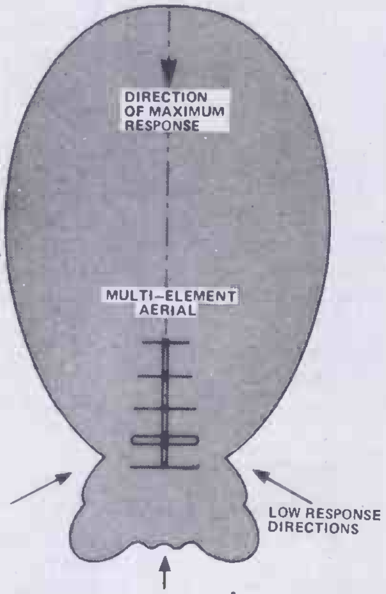


Fig. 6. Impression of the polar diagram of a multi-element Yagi array.

longer wavelength, and they are generally seen to be vertically disposed.

The vast majority of UK TV receivers are designed for 75-ohm coaxial cable aerial connection. Coaxial cable is an unbalanced cable made up of an outer flexible conductive screen and an inner conductor centred by an insulating dielectric. The characteristic impedance of the cable arises from the inductance of the conductors and the capacitance between them. The conductors also, of course, have pure DC resistance. When such a cable (feeder) is terminated correctly at both ends the signal lost is essentially a function of the DC resistance; but if the terminations are incoorect standing waves can be set up on the cable and severely reduce the signal coupled to the receiver. The attenuation of feeder increases with increase in frequency, so a cable of given unit-length attenuation at VHF will have significantly more attenuation at UHF — more at the higher UHF channel numbers than at the lower ones. For the least loss of signal at UHF, therefore, only good quality low-loss cable should be employed; this also applies to the VHF channels in fringe, difficult or weak signal areas when it is necessary to use a high-gain aerial in particular.

BALANCING ACT

Since coaxial cable is unbalanced and the centre point of a dipole balanced, the design of the aerial sometimes tends to apply a correction at the feeder terminating point so that the coaxial feeder appears as a balanced coupling to the dipole; but direct coupling from the centre point of the dipole to coaxial feeder does not detract too much from the overall performance, and many aerials are of this basic design.

When a half-wave dipole is vertically disposed it responds to signals equally (provided it is in clear space and not affected by the feeder, which is one reason why a balanced coupling is sometimes used) arriving from all directions horizontally, and is said to have an omni-directional polar diagram, as shown at (a) in Fig 3. When the aerial is horizontally disposed then signals arriving horizontally are picked up broadside on (either side) and the response to signals arriving along the axis is very small. Such an aerial is said to have a figure-of-eight polar diagram, as shown at (b) in Fig 3.

It is possible to increase the response of signal capture capability of an aerial for signals arriving from a given direction by making the aerial directional. The aerial then favours signals arriving from that direction, while attenuating or discriminating against signals arriving from the other directions. Directionality is attained by the addition of so-called parasitic elements placed behind (reflector) or in front (director) the main dipole, as shown in Fig 4. The optical analogue of a reflector is the reflector placed behind the bulb of a car headlamp, and of a director the lens placed in front of the bulb of a torch, for example. Both beam the light forward. With a directional aerial, therefore, it is possible to turn it so that the "beam" lies in the direction of the wanted signal. Some long-distance (DX) enthusiasts use remotely-controlled rotators for turning their aerials.

Directionally is very useful. For example, if an unwanted signal arriving from a different direction from the wanted signal is causing interference, then a directional aerial can be orientated to provide the maximum discrimination against the unwanted signal. Such directionality is essential in hilly and heavily built-up areas where "ghosting" (see the previous article) is troublesome owing to signal reflections. Moreover, because the response of a directional aerial is concentrated over a smaller angle than that of an omni-directional aerial, the effective pick up efficiency of the former when "on-beam" is considerably greater than that of the latter.

THE GAIN GAME

One way of expressing aerial gain resulting from directionality is to refer an ordinary single-element half-wave dipole to unity (0 dB) gain and the directional aerial to the gain in advance of unity. A 2:1 gain increase corresponds to 6 dB; a 4:1 increase to 12 dB, etc. Multi-element aerials have on-beam gains of 12 dB or more, depending on the number of parasitic elements used and the design of the aerial (eg, spacing between the elements, bandwidth, etc).

The reflector is slightly longer than the dipole and the directors slightly shorter. There is usually a single reflector (or reflector system) though there may be a number of directors, depending on the gain and directionality parameters of the design. The length of each director diminishes slightly with increasing number from the dipole. When parasitic elements are added the centre-point-impedance of the dipole falls, which makes it necessary for a matching arrangement to be employed to couple the 75-ohm coaxial feeder.

A very successful method of maintaining the correct impedance matching is to fold the dipole, as shown in Fig. 5. The length from the top of the bottom folds is still the physical half wavelength, but the fold causes the signal current to be shared equally by the two parallel conductors (joined at the top and bottom), which causes the impedance at the centre of the folded part to increase by a factor of four. This is just about right, for when parasitic elements (reflector and directors) are added the impedance drops by about the same factor, so the folding restores the fed impedance to 75 ohms again!

The polar diagram of a multi-element aerial is governed by the number of parasitic elements used in the design, the different lengths (nominally the reflector is about 10% longer than the dipole, the first reflector about 10% shorter and subsequent directors reducing at the rate of about 5% with increasing number, though in some designs the directors are all the same length), and make-up of the dipole and the spacings between the different elements. There are no hard and fast rules for the required results (gain, bandwidth, polar diagram, etc.) can be achieved in a number of ways. This is why one can observe aerials of different configurations in a given channel group reception area.

BANDWIDTH AND GAIN

An impression of the directionality of a multi-element aerial is given in Fig. 6. There is no doubt here that the maximum pick up occurs along the main beam, with minimal response points at the rear and sides. The designer needs to compromise to obtain all the requirements. Gain, for example, will suffer if the design is for a wide bandwidth, while the nature of the polar diagram and the number of subsidiary lobes at the rear and sides can be affected by the spacing of the reflector from the dipole and the distance between the reflectors, which can also affect the gain and bandwidth. One requirement is to ensure that the fed impedance of the aerial remains sensibly constant over the frequency range of interest, and the parameters just mentioned can also affect this.

Beyond a certain number of elements, the addition of more elements brings into play the law of diminishing returns, so to obtain further useful improvement it is usual to stack either broadside or one above the other two arrays and to connect them both to the common downlead ensuring correct phasing and matching. The spacing between them may also be critical. Sometimes two *pairs* are stacked in a box-of-four configuration. Each time there is a doubling up the gain rises by 3 dB. The directional characteristics can also be improved by this method, and by careful design and critical spacing of the arrays it is possible to place a null in the polar diagram at the angle round the aerial system corresponding to the direction of an unwanted interfering signal.

THE YAGI ARRAY

Multi-element aerials are described as Yagi arrays, after the name of the Japanese engineer who evolved the principle. The parasitic elements are not coupled to the feeder (it is only the dipole which is fed), but these elements nevertheless respond to the signal and reflect additional signal back to the dipole, thereby reinforcing its own pick up. For this to happen correctly the element spacing is critical, as already mentioned.

There is a kind of Yagi array on which all the elements are fed. This is called a log periodic aerial. Each element, therefore, can be regarded as a fed dipole, the length and spacing of which follow a law of geometric progression. All the dipoles are connected together in alternating polarity and the result is a 'tapering resonance'. For example, if a dipole at the middle of the array corresponds to the wavelength of a given signal, then those behind act as reflectors and those in front as directors. The technique provides wide bandwidth, constant terminating impedance and a stable polar diagram over the entire required frequency range. The gain of such an array, though, is below that of a proper Yagi.

The diagram in Fig. 7 shows how the directionality of a multi-element array can be exploited for minimising the pick up of a reflected signal. Here the direct signal is being picked up on the main beam while the reflected signal is arriving at an angle where the response of the aerial is small. In some bad cases of ghosting it is best to orientate the aerial for maximum *discrimination* against the reflected signal (or signals) rather than for maximum response of the direct signal.

In summary, then, for difficult reception areas a

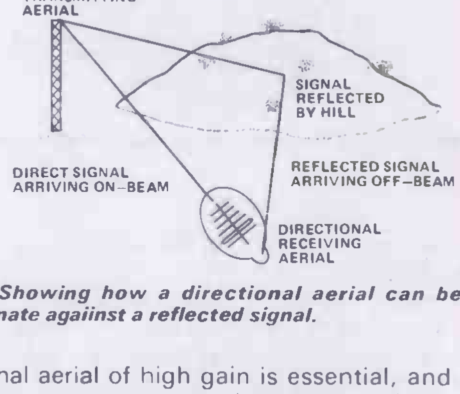


Fig. 7. Showing how a directional aerial can be used to discriminate agaiinst a reflected signal.

directional aerial of high gain is essential, and directionality assumes even greater importance where reflected signals can cause ghosting on the picture, even though the direct signal may be relatively strong. To relieve traffic interference on a main road site the aerial should be orientated as far as possible so that the back of the aerial faces into the road. At sites distance from a transmitter a high-gain aerial is required to 'capture' as much of the signal as possible to prevent the noise produced by the first stages of the receiver from showing as 'grain' on the background of the picture. At such a location it is also very important to couple the aerial to the receiver through high-grade coaxial cable. Low-grade cable can attentuate the signal at the top end of Band V by as much as 6 dB (if not more), which means that a 500 μV aerial signal would be reduced to 250 μV at the receiver!

In fringe areas aerial height is also very important (see the previous article) for the signal field in free-space conditions increases proportionally with height. For those with a mathematical turn of mind the signal field can be expressed as

$$E = 2.28\sqrt{P}(ht\ hr/\lambda d^2)$$

where E is the signal field in mV/m, P the effective radiated power of the transmitter, ht and hr the respective heights of the transmitting and receiving aerials, λ the wavelength of the signal in metres and d the distance from the transmitter in metres. This shows that by doubling the aerial height the signal field is also doubled, but by doubling the transmitter power the field is increased by only 1.414 times, or 3 dB.

CLOSE TO HOME

At sites faily close to a powerful station a less complex aerial would generally be suitable; but, again, this is not subjected to a general rule because much depends on topography. There are rare locations where a set-top aerial may provide good reception; but even fairly close to a transmitter a loft aerial is to be preferred, especially on the UHF channels since the signal reaching the aerial can be greatly affected by people moving about in the house.

In an area of very weak signal field, provided the signal is not being blocked by hills or buildings, a low noise set-aside or mast-head preamplifier can be useful; but this should only be considered after all steps have been taken to improve the aerial system proper, including the use of low-loss feeder.

As a final thought, a very large percentage of poor TV reception complaints investigated by the Post Office are caused by inadequate aerial systems. **HE**

Kit Review

Electroni-Kit Construction Kit

Don't be deceived by the simplicity of the kit under review this month. It could be a valuable teaching aid, or introduction to electronics.

KIT REVIEW THIS MONTH is somewhat unusual. We've taken a look at a rather novel piece of electronic equipment, called the ELECTRONIKIT-EX SYSTEM. The 60 experiments (the system can be expanded up to 150) contained in the box range from the most basic electrical principles involving nothing more than a light bulb, to a one transistor frequency doubler.

A CASE IN POINT

The case itself deserves a mention. Made from a tough ABS plastic it has a carrying handle built-in, making the entire unit portable, quite a useful feature this for some of the more ambitious projects.

All the circuit components are neatly housed in small transparent boxes, and connections between the various modules are made by thin spring-metal strips down the side of the boxes. On the top of each box the relevant circuit symbol is stamped.

The unit under review was pleasantly free from intermittancy, although we suspect that with vigorous use and the passage of time the connections may become a little less sound.

Built into the case is an IC amplifier module which drives a loudspeaker in the more advanced projects, so there's no mucking about with soldering irons and screwdrivers.

MANUAL OPERATION

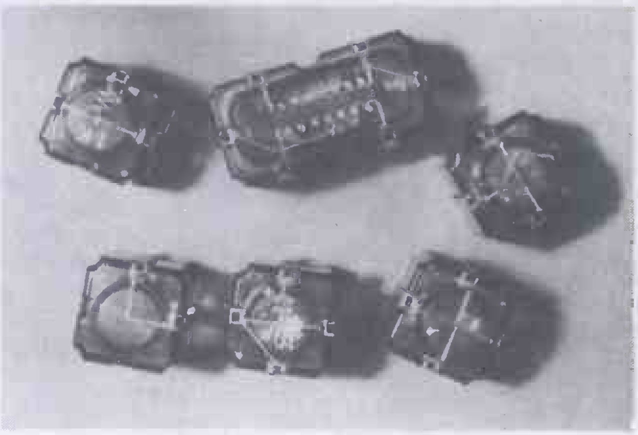
The manual, which is an integral part of the whole system leaves a lot to be desired.

The circuit titles may have made sense in Japanese but the British reader may not find them sufficiently descriptive. ''Fixed Bias 1-Transistor +IC amplifier (resistive load)'' is actually a microphone amp driving a speaker. This point is amusing rather than inaccurate.

Each circuit is accompanied by a complete ''plug-in-drawing'' — very clear and easy to duplicate. The theoretical circuit is also shown.

We had quite a lot of amusement at the expense of the accompanying text: ''Let's make an experiment with an oscillatory circuit by using an antenna coil.'' Also it does virtually nothing to explain what you've done or how the circuit works. If you want to build the circuit 9/10 — if you want to understand it 2/10.

The Electronikit as it comes in it's box, the only extras needed are the batteries.



Top view of the circuit blocks, the symbol of the component is stamped on top of each module.

The distributors are very aware of the shortcomings of the manual and have told us that a new version is being prepared. The example supplied with the kit leads us to believe that Japanese technical translators ply their trade with nothing more than an English dictionary and a bent pin.

LIE DETECTOR

It's interesting to note that the sixty projects described in the manual require the services of only one transistor (apart from what might be lurking in the amplifier module). Such is Japanese ingenuity. Our favourite project was the 'lie detector', relying upon skin resistance to vary the frequency of a slow running oscillator, some rather interesting results were obtained from one nameless female member of the HE staff.

One or two small niggles: we found it fairly difficult to relate the circuit built on the peg-board to the rather unconventionally-drawn diagrams in the manual, perhaps this will be remedied with the new manual.

TUT TUT TUT

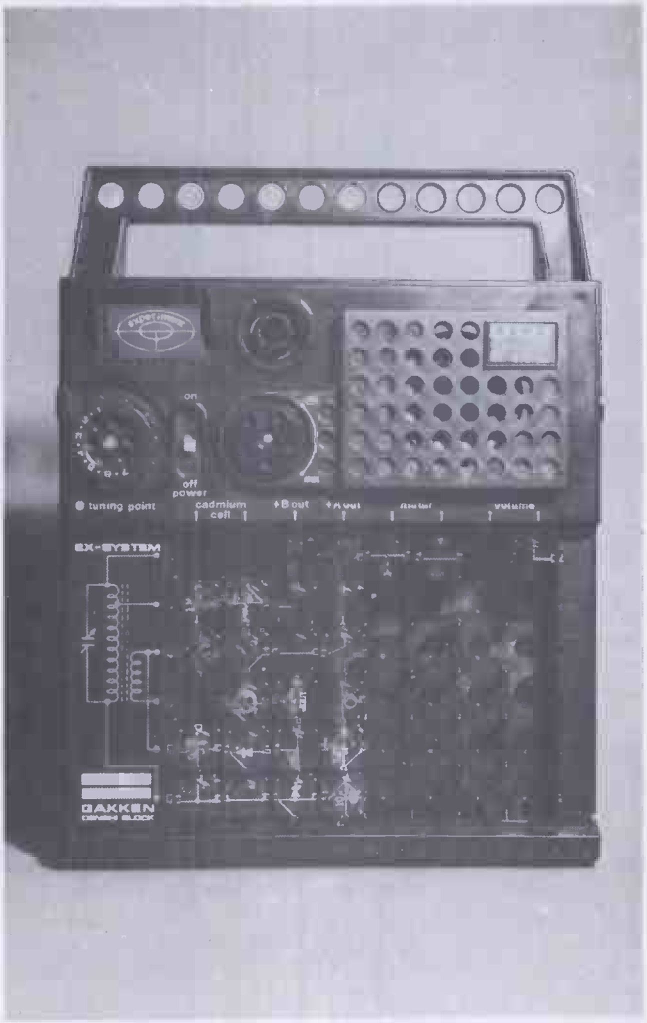
Reading through the selection of circuits that can be built with the kit we came across at least two that would infringe the Post Office-Wireless Telegraphy Act — naughty naughty.

With the manual comes a rather out-dated book on electronics which provides a little background theory but tends to dwell rather too much on valves, but is interesting nonetheless.

BACK TO THE ELECTRONICS

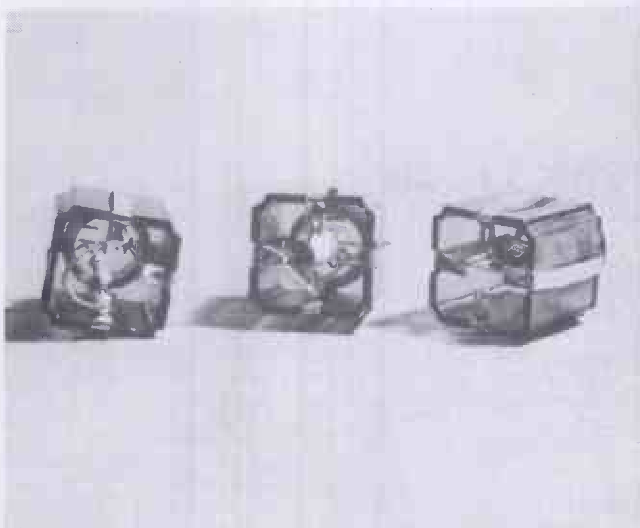
Building a particular project is rather like doing a jigsaw. All the circuit modules are arranged on a type of peg-board, according to the diagrams in the manual (we were pleasantly surprised to find that all the experiments worked first time).

Batteries, aerial coils, tuning capacitor and the amplifier module are all contained within the casing, so virtually all the connections are made by the metal strips on the circuit modules or on the side of the project case.



A complete circuit built with the Electronikit, it's somewhat difficult to relate the circuit built to the diagram in the manual.

Halvor takes a lie detector test, will we be getting a wage rise? Not this year judging by the smile on his face.



Inside view of the circuit modules, the strips on the side of the boxes make the connections in the circuits.

Also the signal tracer and signal injector circuits both fail to carry any warnings about poking about in the backs of potentially lethal mains-drive equipment — please note, honourable Japanese manual writer.

The instruction manual lets down an otherwise excellent kit, however there is an improved version on the way, according to the suppliers.

TEACHING AID OR TOY?

We ran into some problems in our attempts to categorize this device. Was it a toy or a teaching aid? It's really both, depending upon the extent of your interest in electronics. It makes an ideal gift for any youngster wishing to learn about electronics, similarly we adults (supposedly) at HE had a great deal of fun playing with it.

It's value as a teaching aid is somewhat suspect, but this again could be easily remedied by the re-writing of the manual, so bearing that in mind it would be ideal for anyone of any age to learn some basic electronic principles.

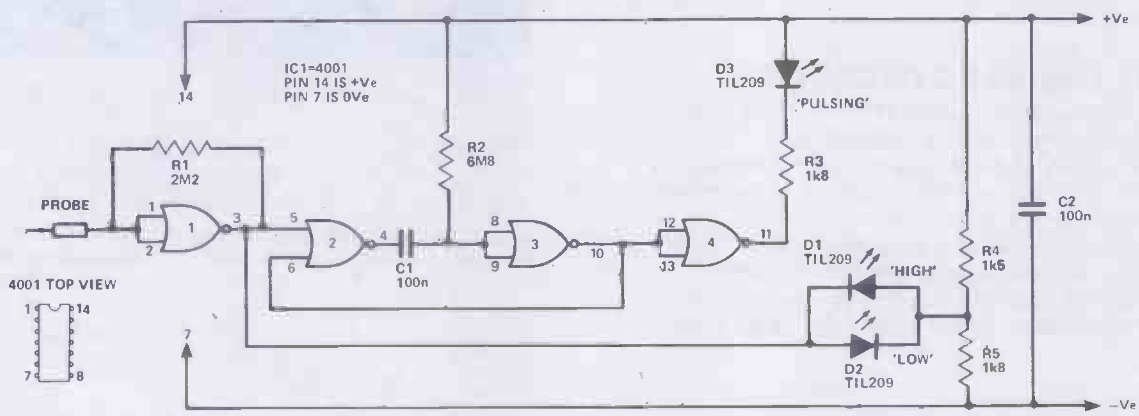
At around £24 it may seem slightly expensive, but where else can you buy around half a dozen radios, an electronic bird, or a water-quality indicator for that kind of money?

Looking through the manual we discovered that it lists all of the other projects right up to number 150, and this happens to be something called a Sphygmometer, we don't know what it is either so as soon as the editorial budget allows we'll get the expansion kit and find out!

In summary, good fun, great value but let down by the manual.

HE

Short Circuit



CMOS LOGIC PROBE

A logic probe is a device which is used when testing digital circuits, and it shows the logic state at the selected test point. In common with most designs this one can indicate four input states, as follows:

1. Input high (logic 1).
2. Input low (logic 0).
3. Input pulsing.
4. Input floating.

The circuit uses the four 2 input NOR gates contained within the 4001 CMOS device, and is primarily intended for testing CMOS circuits. The probe derives its power from the supply of the circuit being tested. The first gate has its inputs tied together so that it operates as an inverter, and it is biased by R1 so that roughly half the supply potential appears at its output. A similar voltage appears at the junction of R4 and R4, and so no significant voltage will be developed across D1 and D2 which are connected between this junction and gate 1 output. Thus under quiescent conditions, or if the probe is connected to a floating test point, neither D1 or D2 will light up. If the input is taken to a high logic point, gate 1 output will go low and switched on D1, giving a "high" indication. If the output is taken to a low test point, gate 1 output will go high and D2 will be switched on to indicate the "low" input state.

A pulsed input will contain both logic states, causing both D1 and D2 to switch on alternately. However, if the mark space ratio of the input signal is very high this may result in one indicator lighting up very brightly while the other does not visibly glow at all. In order to give a more reliable indication of a pulsed input gates 2 to 4 are connected as buffered output monostable multivibrator. The purpose of this circuit is to produce an output pulse of predetermined length (about half a second in this case) whenever it receives a positive going input pulse. The length of the input pulse has no significant effect on the output pulse. D3 is connected at the output of the monostable, and is switched on for about half a second whenever the monostable is triggered, regardless of how brief the triggering input pulse happens to be. Therefore a pulsing input will be clearly indicated by D3 switching on.

The various outputs will be:
Floating input—all L.E.D.s off.
Logic 0 input—D2 switched on (D3 will briefly flash on).
Logic 1 input—D1 switched on.
Pulsing input—D3 switched on, or pulsing in the case of a low frequency input signal (one or both of the other indicators will switch on, showing if one input state predominates).

Reader's Letters

Please send submissions for the letters page to: Hobby Electronics, 25-27 Oxford Street, London W1. Mark the envelope "Letters Page." Letters which are too long for publication will be suitably edited.

Dear Sir

As a reader of your parent journal ETI since issue number one, I would like to congratulate you on an excellent magazine.

I would like to comment on a point in the 'Letters Page' in the March issue. Whilst I fully support the use of SI units and prefixes, could you not help standardization further by adopting circuit symbols and conventions of BS 3939? All technical colleges are required to teach the preferred symbols by the City and Guilds, and many manufacturers are producing circuit diagrams for their equipment to this standard.

P. D. Simmons,
Newhaven.

Using standard symbols is a problem. We're in favour of standardization but the things we are doing already, such as 4k7 instead of 4.7k and 2n instead of 2000pF are confusing many readers. We are taking the gentle approach and are moving over slowly.

Dear Sir

re PROPOGATE in this you
have really come a cropper
I would suggest in your next issue
You should spell it PROPA

J. H. R. Gardner (Headmaster)
East Yorkshire.

Please sir don't give us the cane
'promise we won't do it again
the error shows up to our cost
that HEs only dictionary's been lost.

Dear Sir

I only discovered your magazine in January and I was extremely impressed. For me it fills a cavernous gap in the market. I have a fair but patchy knowledge of principles on which things work but little access to the practicalities of project building. The magazine takes you gently by the hand and leads you through the jargon. But it is also good on other levels, particularly the more theoretical series by Ian Sinclair.

I once worked on a magazine for junior doctors, converting the opaque utterances of great specialists into something that was straightforward, quick and dare I say even fun to read, so I know good stuff. Keep it up.

Martin Rush,
Northern Ireland.

Thank you for all of your comments, it's only from letters like these (both praising and criticising) that we know how we're doing. Elsewhere in this issue there is a questionnaire, from past surveys in ETI we have learned a lot and have been able to make several changes. So keep the letters coming and fill in the questionnaire and hopefully we'll have an even better HE.

Dear Sir

Regarding the item headed 'Luxembourg Effect', HE March 79, page 70. The effect described is *not* the Luxembourg Effect but is multi-path fading.

P. J. Wilson,
Surrey.

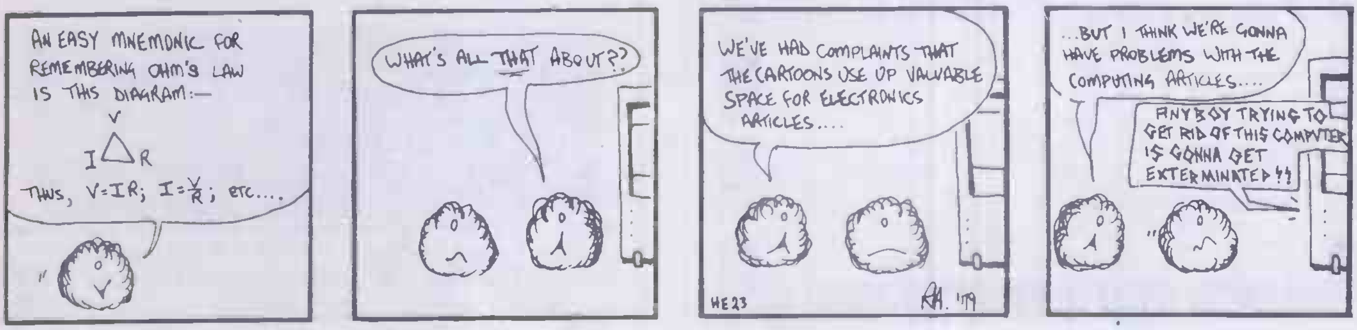
Dear Sir

The effect you describe in your article 'Interfering Waves', is not the Luxembourg Effect but fading — the type often called selective fading, because the carrier is liable to fade at a different time from the sidebands, which causes severe distortion — and was known long before Radio Luxembourg was built.

E. F. Good
(address supplied)

Sorry!

Mr Good is correct; the Luxembourg Effect is a term which should be reserved for the intermodulation effect in the Ionosphere (he's been reading Wireless World!); though to my generation of amateurs, the phrase was always used for severe fading.—K. T. Wilson.



Capacitors

Are you in a dilemma over dielectrics? or just confused by capacitors? then read on. Richard Maybury takes a look at the often ignored subject of the dielectric material in fixed capacitors.

FIRSTLY WE SHOULD EXPLAIN that this article is not intended to be an in-depth study of the workings of the capacitor, that has been done so many times before, usually punctuated by complicated formulae. This article is designed to give an insight into the construction of capacitors, with particular reference to their dielectric material (more of which later).

From our point of view (the capacitor users) the ideal capacitor will be physically small with as great a range of capacitance as possible. Any leakage (current paths across the plates) should be minimal. This capacitor should ideally be stable with regard to both capacitance and leakage, under as many adverse conditions as possible. It should be able to operate with a large variation of applied AC and DC potentials, current and frequency, enjoy a long and healthy life and cost next to nothing.

Faced with all these constraints the poor old capacitor manufacturer may well be seen burying his head in his hands in despair, but compromise to the rescue, the ideal capacitor does not exist as such — but you can bet your boots there's one available for the application you have in mind.

Let's take a look at the (almost limitless) choice on the amateur market, and to what use they can be best put.

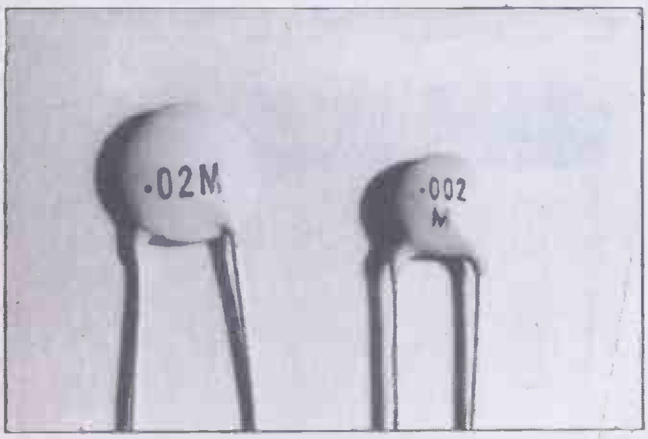
The first capacitors were possibly just two plates of metal placed close to each other, the insulating material being air. (On a historical note if you've read Erich Von Dannikens *"Chariots of the Gods"* you may be convinced otherwise. Apparently in the old testament there are instructions for building an Ark (a kind of altar) you were required to construct a wooden box, lined on the inside and outside with gold leaf, anyone touching this sacred shrine would be struck down by lightning; we'll leave you to draw you own conclusions about the suitability of wood as a dielectric!).

Air spacing is the oldest and simplest type of capacitor, it can still of course be found today, namely the variable capacitors. We won't dwell too long on this just long enough in fact to point out that the measurement of dielectric quality uses air as the standard, air has a dielectric value of 1 (a polystyrene capacitor has a dielectric value of 2.5 at 50 Hz, so you can see that apart from its use as the standard it's not too clever as a dielectric material).

Far and away the most common type of capacitor in use today is the Ceramic capacitor

THE CERAMIC CAPACITOR

The ceramic capacitor is available in several physical shapes, and two distinct grades: *low Permittivity* (low-K) and *high Permittivity* (high-K). Both types are physically small (small compared to other types of capacitor), both are relatively fragile physically but there the similarity ends.



A couple of miniature ceramic capacitors the value is stamped on the side, often a major source of confusion.

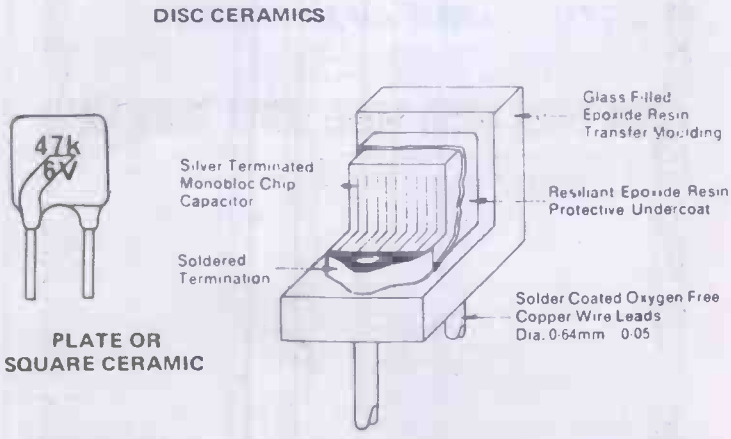
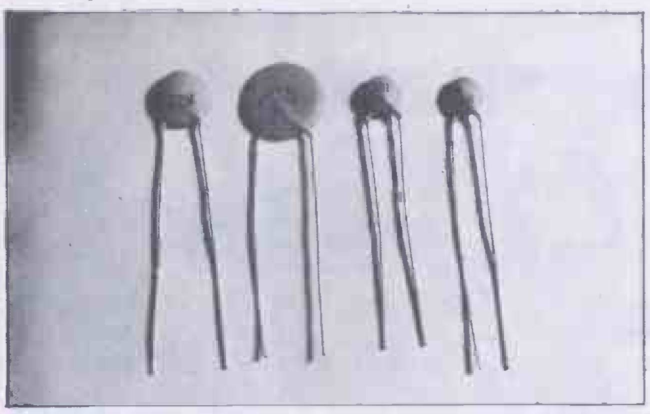


Fig. 1. Cut-away diagram showing construction of Ceramic Capacitors.

High-K ceramics suffer large non-linear changes of value with temperature and strength of applied AC/DC fields (the capacitance will decrease as the voltage rises) the value will also change with frequency (up to 20% in the 1 kHz-10 MHz range).

As High-K types are none too stable they find applications only in non-critical positions ie. DC blocking, by-passing and de-coupling but these account for a very high proportion of all uses.



Four 'low k' ceramic capacitors.

LOW-K CERAMICS

These are the opposite of High-K types in many respects, low-loss, good temperature stability and wide frequency and voltage ranges. In some cases they are deliberately manufactured to be temperature conscious for thermal compensation in temperature sensitive equipment.

Ceramic capacitors are made in a variety of styles (see Fig 1), their shape often affects the frequency range, e.g. tubular ceramic operate up to about 50 MHz, disc or plate to 100 MHz, feed through to 500 MHz, and button ceramic to 1000 MHz.

Because of the simplicity of their construction the capacitance range of ceramics is usually towards the low end (one or two picofaradw (pF) upwards). The construction is often nothing more than a round disc of ceramic material, the two faces coated with a metallic film to which the connecting wires are attached. The capacitance will depend upon the thickness of the disc and cross-sectional area of the metal coating. The resulting device is then dipped into a variety of coating materials to offer a degree of protection.

PLASTIC FILM CAPACITORS

There are three main types of plastic-film capacitors: Polystyrene, Polyester and Polycarbonate.

Polystyrene is probably the most common at the moment.

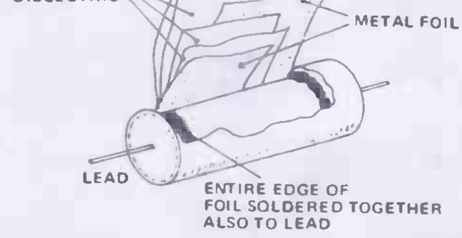
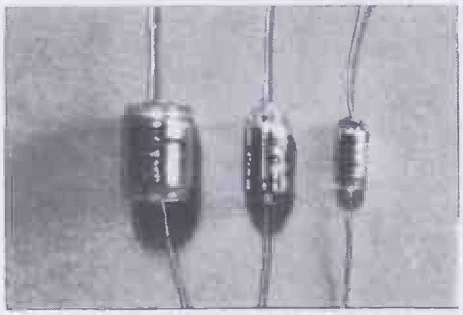


Fig. 2. Method of forming Polystyrene capacitors, note that entire edge of rolled foil is connected to the lead-outs.

POLYSTRENE

This type of plastic-film capacitor is constructed using interleaved sheets of polystrene film and metal (usually aluminium) foil, the beginning of the roll is staggered to enable the leads to be attached (see Fig. 2). In certain applications, instead of a separate foil layer a thin coating of metal is deposited onto the plastic film directly (this technique applies equally to polyester and polycarbonate types). The resulting sandwich of plastic and metal foil is rolled tightly into a tubular shape (this tube may then be flattened to suit a rectangular encapsulation which gives greater edge-on component packing density).



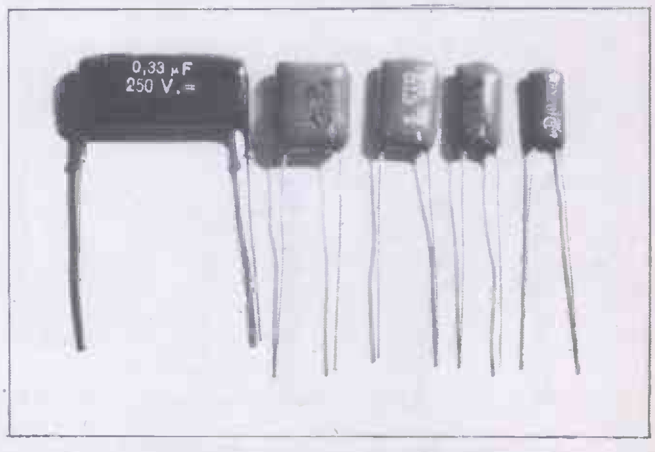
Polystyrene capacitors, easily destroyed by excess heat.

Electrically the polystyrene capacitor has average-to-good characteristics, the voltage range can extend to 650 V, they find many applications in tuned circuits, coupling frequencies of up to 100 MHz. The higher values (10nF and above) can be used for by-pass etc.

The polystyrene capacitor does have one or two drawbacks; it's extremely sensitive to heat, not in the sense of capacitance changes but physically, they melt very easily! They are also sensitive to attack from a wide variety of solvents and greases, so a great deal of care should be taken with polystyrene capacitors, firstly when soldering and secondly in their application to ensure they do not come in contact with harmful chemicals.

POLYESTER AND POLYCARBONATE

Polyester capacitors can be examined along with Mylar, Melinex and polypropelene materials, they all have basically the same dielectric properties, they all,



Resin dipped polyester capacitors.

however have superior electrical characteristics to polystyrene, particularly in the case of Polycarbonate capacitors. All of the plastic-film capacitors (apart from polystyrene) have excellent resistance to attack from corrosive or solvent chemicals.

Polycarbonate in particular seems to have become a definite favourite among digital equipment manufacturers, possibly due to their very high tolerance rating. They are usually a lot smaller physically, for a given voltage rating, than other plastic-film capacitors.

One last property of plastic-film capacitors is the ability of some types to 'self-repair'; these are metallized-film capacitor. In the event of an arc jumping through the dielectric film (it will never be completely impervious) the area around the arc will vapourise thus clearing the fault, and reducing the possibility of another arc. This does not happen on any other type of capacitor, a dead short will usually result after such an arc.

MICA AND PAPER

Both these types of capacitor were once popular but now have largely disappeared from the amateur electronics scene; they do however have specialised properties that ensures their continued manufacture.

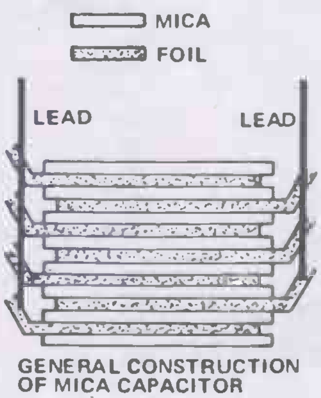


Fig. 3. Construction of Mica capacitors, the entire assembly is then dipped into a bath of fluid coating to ensure a hermetic seal, and prevent ingress of harmful chemicals.

MICA

Mica is a natural mineral which can be cut into very thin slices; a variety of methods are used in their manufacture (Fig. 3). Moulded Mica types are made from layers of Mica, interleaved with metal film, the range of capacitance of this type is about 10pF-100nF.

Silver Mica capacitors are noted for their very high stability and are often used in oscillators and filters. They are usually quoted as 5% tolerance or better and have a value range of 5-3300pF.

Metal-clad Mica types are used in high power RF circuits.

Button Mica capacitors exhibit low inductance and are mostly constructed in stand-off or feedthrough style, the main applications being in UHF circuits. Finally there are Dipped Mica types; these are dipped in a resin coating at below atmospheric pressure, and used where reliability is the prime concern; values range from 10pF to 100nF.

PAPER

Paper capacitors are rarely seen these days except where high voltage AC and DC currents are to be found; in these situations paper is just about the best dielectric.

The method of construction is similar to the plastic-film type of capacitor, but instead of plastic the dielectric consists of a layer of impregnated paper, the substance used for the impregnation can be one of several natural oils, waxes or synthetic resins.

As in the plastic-film types, the construction can be by one of two methods: metal foil or metallized film. Unlike other types zinc is often used instead of aluminium. The use of zinc usually results in a device considerably smaller than an aluminium type. The voltage range of paper capacitors is considerably larger than that of most other types, often extending up to 4 kV.

Encapsulation of paper types usually consists of a thin coating of synthetic resin or metal cannister.

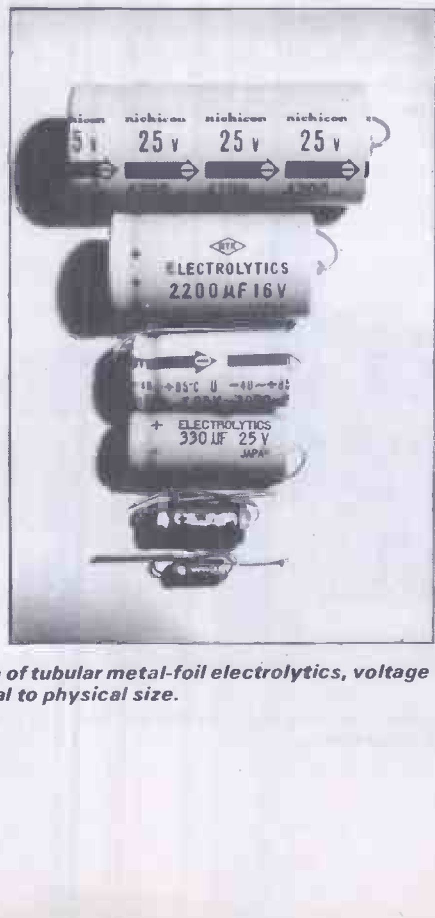
ELECTROLYTIC CAPACITORS

The difficulty of producing large value capacitors is highlighted by the electrolytic, it is at best a compromise, for example the tolerance is often quoted as −20+100% or −50+100%!

Electrolytics fall into three distinct groups, the conventional type, most often encased in a metal cannister, the non-polarised electrolytic, usually a little larger than a capacitor of the same value, and finally the Tantalum, a fairly recent newcomer to the capacitor field.

(At this point it must be said that there are several other types of capacitor we have not dealt with. It is very unlikely that they will be encountered by the average amateur, however it might be an idea to take a look at them in a future article.)

Getting back to the electrolytic capacitor, we'll deal with the most common type first, the metal foil type.



A selection of tubular metal-foil electrolytics, voltage is usually proportional to physical size.

METAL FOIL ELECTROLYTICS

Electrolytic capacitors consist basically of two aluminium foils interleaved with an absorbant paper, and wound tightly into a cylinder. Contacts are provided by tabs of aluminium attached to the foils. The winding is impregnated with an electrolyte and housed in a suitable container, usually an aluminium can, which is hermetically sealed (see Fig. 4).

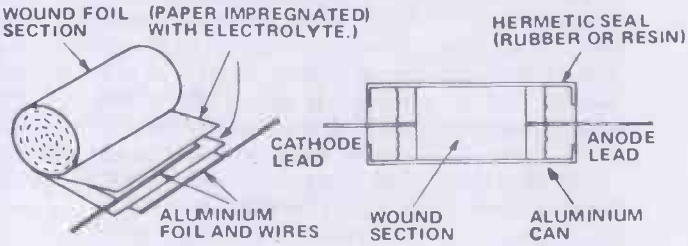


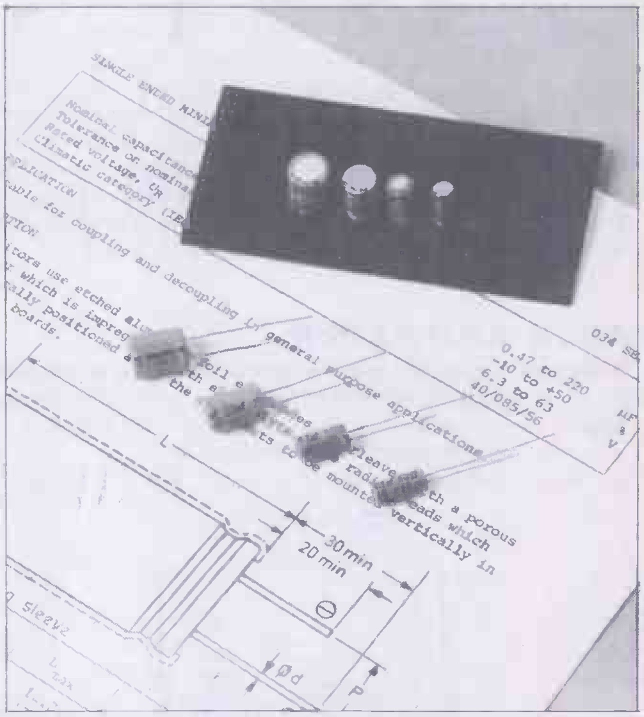
Fig. 4. Electrolytic capacitors, use a similar method of construction to Polystyrene capacitors, note that the start if the roll is staggered to enable the lead-outs to be attached.

A dielectric layer is 'formed' electrolytically on the surface of one aluminium foil which acts as the positive plate or anode, of the capacitor. The electrolyte serves as the second plate of the capacitor and also to repair any flaws in the oxide film when the electrolyte is polarised. The second foil, usually called the cathode, provides contact with the electrolyte. Since this film will have a thin oxide layer, due to natural oxidation, it will also possess very high capacitance. The thinness of the oxide film, and their high breakdown potential, is responsible for the very high capacitance per unit volume and high working voltages of electrolytic capacitors.

Similar to the plain foil type of electrolytic is the Etched foil electrolytic, the aluminium foil on the anode and cathode are chemically etched to increase the surface area and hence the capacity, this results in a physically smaller device but has the disadvantage of not being able to withstand high AC currents, compared with plain foil types.

Some 'power' electrolytics in the background, tags are usually used instead of leads.

The capacitance value and leakage both increase with temperature on foil electrolytics, leakage also increases with applied DC voltage, this increase becomes more rapid at voltages above its rated working voltage. This can lead to excessive heat dissipation, and ultimately to its destruction. Most electrolytics are designed to withstand short surges of up to 20% over the rated working voltage.



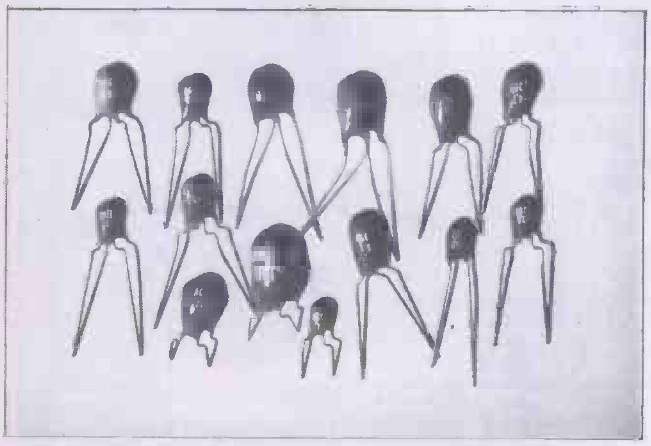
Some new miniature PCB-mounting electrolytics, for greater component density.

NON-POLARISED ELECTROLYTICS

These capacitors are constructed using several foils in one winding and connected back-to-back. They are usually larger than polarised capacitors of equivalent value since double the foil area is normally required, the

Just some of the multitude of capacitors currently available to the amateur.

leakage current will often increase as a result. These capacitors are most often used in speaker crossover networks or speaker coupling circuits. Values are obtainable from 1u to 100u.



Miniature tantalum capacitors, small size, large capacity, but usually low working voltage.

TANTALUM CAPACITORS

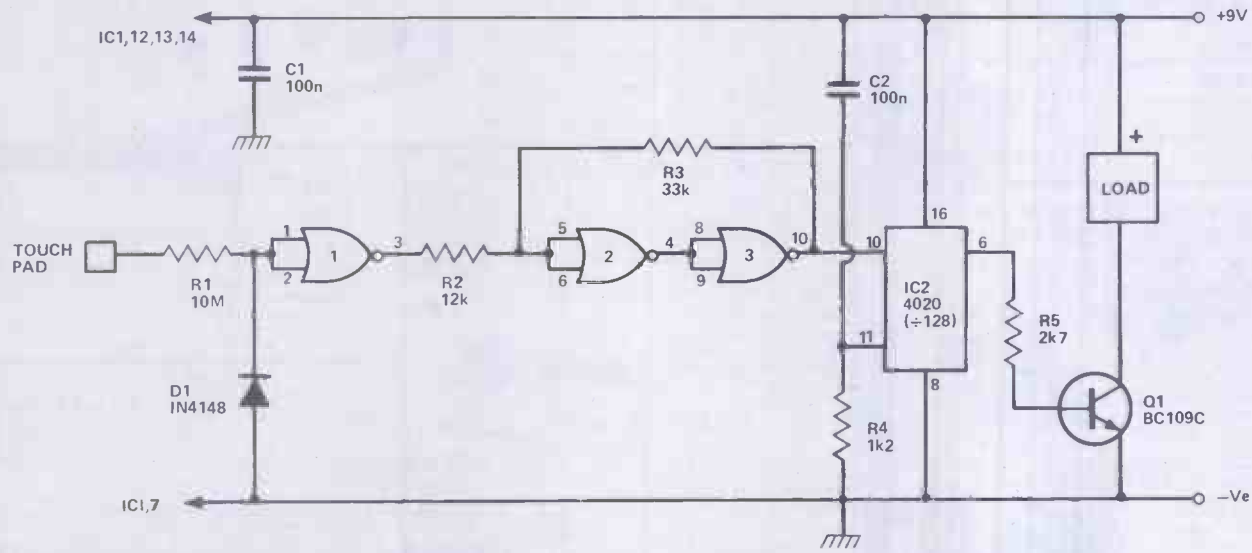
Tantalum oxide is used as the dielectric. This has a much greater permittivity than aluminium oxide resulting in high value capacitance in a relatively small space, they will normally be polarised.

There are three different types of Tantalum capacitor. These are the tantalum foil, similar in construction to ordinary electrolytics. Solid tantalum, this uses manganese dioxide (a semiconductor) as the electrolyte, and a tantalum anode. These are often coated in epoxy resin or a polyester sleeve with epoxy seals. The third type is the wet sintered tantalum, this type is rarely seen other than in specialised applications and can be manufactured to a very high tolerance.

Tantalum capacitors have a much lower voltage rating than electrolytic capacitors, typically 3-100 V for the solid type, up to 125 V for the wet sintered type and up to 450 V for foil tantalums. Tolerance is typically −20% to +50%. Their small size makes them ideal for transistorised applications.

HE

Short Circuit



TOUCH SWITCH

This touch switch is designed to provide on/off switching for 9 volt battery operated equipment having a current consumption of up to 100 mA. It has a single touch contact which is briefly touched in order to change from on to off or vice versa. The circuit is operated by stray pick-up of mains hum which is coupled to the input of gate 1 (which like the other three gates employed in the unit is connected to act as an inverter) via R1 when the input contact is touched. As IC1 is a CMOS device it has a very high input impedance, and the input signal will be capable of switching gate 1 input from one logic state to the other. The input impedance of the circuit is so high that the reverse resistance of D1 is used to tie the input to earth under quiescent conditions, so as to prevent spurious operation. R1 acts as a low pass filter in conjunction with the input capacitance of the circuit, and this attenuates high frequency noise which may be present on the 50 Hz mains signal.

The output from gate 1 still contains significant noise products, and also has a rise time which is inadequate to drive the final stage of the circuit. This is overcome by using the trigger circuit based on gates 2 and 3. R3 tends to hold gate 2 input in the same state as gate 3 output, resisting any change in logic state caused by gate 1 output due to the coupling through R2. This resistance to change is termed 'hysteresis'. R2 has a lower value than R3, and so gate 1 can operate the trigger circuit if its output signal is of adequate amplitude. The main 50 Hz signal will be strong enough, but the noise spikes will not, and are thus eliminated from the output of the trigger. Once the output of the trigger starts to change state, the coupling through R3 provides a triggering action which ensures a rapid change.

IC2 is a 14 stage binary (divide by 2) counter, and Q1 is driven from the output of the seventh stage via current limit resistor R5. C2 and R4 provide a positive reset pulse to the counter at switch on so that the outputs are low, and Q1 is switched off. The controlled equipment forms the load for Q1, and obviously receives no significant power. If the touch contact is operated, a 50 Hz signal is fed to IC2 and the 7th stage output changes state every 64 pulses. As this output goes high and low the load is switched on and off. In practice the contact is touched just until the unit switches to the desired state (which one tends to do automatically).

The unit consumes only about 1 uA. in the "off" mode and approximately 3 mA in the "on" state.

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Viscount IV unit in teak simulate cabinet. Silver finish rotary controls and pushbuttons with matching fascia, red mains indicator and stereo jack socket. Functions switch for mic magnetic and crystal pickups, tape tuner and auxiliary. Rear panel features two mains outlets DIN speaker and input sockets plus fuse 20x20 watts RMS 40x40 watts peak. For use with 8 to 15 ohm speakers.

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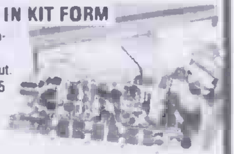
30x30 WATT AMPLIFIER IN KIT FORM



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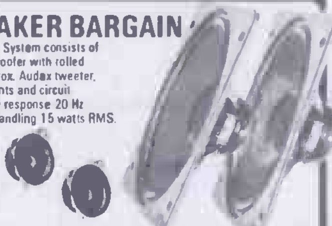

Stereo pair 350 kit. System consists of 13" x 8" approx. woofer with rolled surround; 2½" approx. Audax tweeter, crossover components and circuit diagram. Frequency response 20 Hz to 20 KHz. Power handling 15 watts RMS. 20 watts max. 8 ohm impedance.

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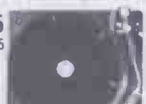
BSR P200



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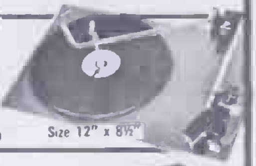

Record changer with cueing device fitted with stereo ceramic cartridge ready to fit into your own plinth.

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AM/FM DIGITAL CLOCK RADIO Accurate 4 Digit Electronic Clock with ½" LED display Buzzer and snooze timer	£11.95
125 Watt Power Amp Module	£13.95
Mains power supply for above unit.	£3.50
MULLARD Built power supply	£1.50
DECCA 20w Stereo speaker kit comprising 2 8" approx bass units + 2 3½" approx tweeter inc crossovers	£20.00
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PORTABLE RADIO/CASSETTE RECORDER. AM/FM with clock. LW, MW, SW, VHF mains/battery operation	£41.95

VIDEOMASTER COLOUR SHOT TV GAME

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£29.95
P&P £2.50

Size approx. 13⅜" x 5¼" x 6¾"
50 watts rms. 100 watts peak output. Big features include two disc inputs, both for ceramic cartridges, tape input and microphone input. Level mixing controls fitted with integral push-pull switches. Independent bass and treble controls and master volume.
SPECIAL OFFER. The above 50 watt amp plus 4 Goodmans Type 8P. 8" speakers. Package price £45.00 + £4.00 P&P.

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Size approx. 14" x 4" x 10¼".
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Output 100 watts RMS 200 watts peak.

70 watt 140 watt peak p&p £4.00 **£57**
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HElp us to help You

HOBBY ELECTRONICS has been going for about five months now, so we feel it's about time to ask you, the readers, what you think of it so far. We realise this sort of thing is a bit of a chore so we're prepared to bribe you. The first 50 replies out of the HE hat will receive a brand new HE tee-shirt. As an added incentive the questionnaire form has our address printed on the back, so all you have to do is fold it up, stamp it and pop it in the nearest post box.

1. Please tick your interest in each of these features

	Readership			Rating (if read)		
	Read Fully	Scanned Over	Not Read	Good	Average	Poor
Monitor						
Short Circuits						
Into Electronics						
Kit Review						
Train Controller						
Cistern Alarm						
Transistor Tester						
Electronics in Warfare						
Capacitors						
Catalogue Survey						
Phone System						
Next Instalment						
TV Aerials						
Good Evans						

2a. Please underline any feature you found particularly interesting
b. Circle any feature you found poor or uninteresting
c. Mark an asterisk (*) next to the single best feature

3. PROJECTS

Tick any of the following projects that you may have built

Stereo Amp
Waa-Waa Pedal
Bedside Radio
Digital Dice
Photon Phone
Metronome
Audio Mixer
Graphic Equ.
Touch Switch
Tone Control
Vari Wiper
Flash Trigger
S/W Radio
Sine/Square Gen
Car Alarm
Scratch Filter
Light Chaser
Photo Timer
Casanova's Cndle

(a) Underline any that you found particularly interesting.
(b) Put an asterisk (*) next to any project that gave you trouble in either building or getting to work properly.
(c) Put a K next to any project that was built from a kit.
(d) Put a M next to any project that was built using mail-order components.

4. AREAS OF INTEREST
Tick any of the following fields that you find interesting
Simple Projects
Complex Projects
Home Computing
Video
Hi-Fi
SW Listening
Amateur Radio
Electronic Applications

5. How were you introduced to HE? (Delete as appropriate)
Impulse buy/Friends copy/Newspaper ad./Commercial radio/ETI.

6. How many other people read your copy? ....

7. The competition

	READ				OPINION			RATING
	Regularly	Often	Never	Used to Read	Good	OK	Poor	
ETI								
Everyday Electronics								
Practical Electronics								
Practical Wireless								
Wireless World								
Elektor								
Radio Constructor								
Television								

On an arbitary 1-20 scale with HE rating 10, please rate your opinion of our competitors.

Please mark an asterisk (*) next to any magazines you subscribe to.

8. Are you employed in the electronics industry? YES/NO

9. Are you still studying? YES/NO

10. Highest academic achievement ....

11. Age ....

12. Sex .... Male/Female

Space for witty comments ....

13. Annual income (nearest £500) ....
(Don't answer the above question if you find the question offensive.)

14. GENERAL COMMENTS

a) What do you consider to be HE's best points
b) What do you consider to be HE's weakest points
c) What do you consider could be improved or omitted altogether, or would like to see included in HE in the future

Please use space on reverse side

First
Fold

← Second Fold

Stamp
please

Hobby Electronics
25-27 Oxford Street,
London WIR 1RF

Name: ....

Address: ....

....

....

← Third Fold and Tuck In

Space for Question 14.

(a)

(b)

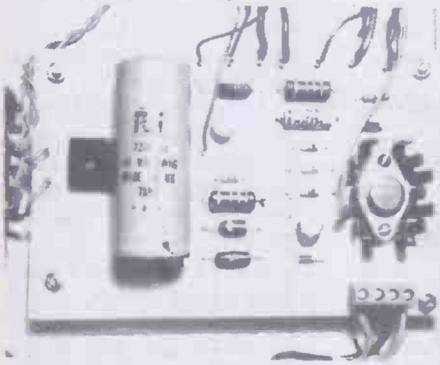
(c)

First
Fold

Hobby Electronics

Next Month

Power Supply Project



An essential piece of test gear. Our project will give 0-30 V (infinitely variable) at 1 amp and is short circuit protected to prevent nasty things happening when you do something silly — this will also protect your components to some extent.

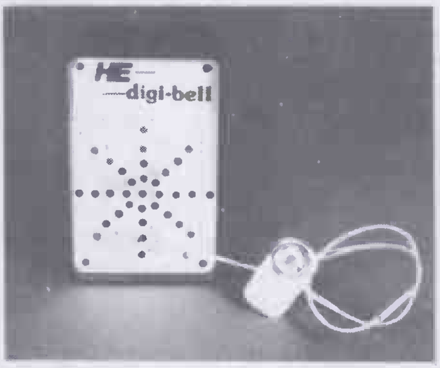
Multimeters

Ray Marston introduced test gear in the March issue, next month he takes a look at multimeters, describes what is important in the spec, how they work and looks at the circuit of a current design.

Binary Numbers

We've been so indoctrinated with decimal counting that most of us think it's natural law to use 10 as our number base. Computers are much easier to design if they use numbers to the base 2. Confusing? You won't after it's made clear in next month's issue.

Electronic Doorbell



Not only is the sound generated electronically, we've done away with the bell-push and replaced this with a touch switch.

Electronic Music

With modern circuitry it is possible to produce practically any sound in the audio spectrum and musicians have been fast to take advantage of this. From the electronic organ things moved rapidly to the synthesiser but there's a whole lot more to the field. Next month Tim Orr, a professional designer of synthesisers, describes some of the techniques and discusses what's available.

White Noise Effects Unit

Sorry we couldn't find room for this one in this issue but all is OK for next month. The circuit generates its own "ssh" and then tailors this to simulate a variety of sounds.

Personal communications

The messenger with the cleft stick, the post, the telegram, the phone: communications have become more and more personal — and faster. There are already a variety of systems for communicating with people wherever they are. Angus Robertson looks at the field of personal communication next month.

Parking Meter Timer

For less than the cost of a single fine, you can build our pocket timer that'll remind you that the 'penalty' flag is about to pop on your parking meter.

The May issue will be on sale on April 13th

The items mentioned here are those planned but circumstances may affect the actual contents.

Electronics in Warfare

Ron Harris reveals his war-like nature and looks at how our old friend the electron is being sent to war.

ELECTRONIC WARFARE—

A selective est

LIKE IT OR NOT the largest single growth area for electronics is warfare. If and when there is another serious conflagration, the side that emerges victorious will be the one best able to wage electronic warfare (EW).

Research into better methods of confounding and confusing the opposition's intelligence and communication continues apace. Jamming is perhaps the best known. Basically this consists of broadcasting loads of rubbish, and anything else you can think of, all over the wavelength the baddies are trying to talk to each other on.

However just about every aspect of warfare is being 'updated' these days by the insidious electron. Developments happen fast in this field, and some of them are very very interesting indeed.

Herein we present a selective digest of some of the more interesting electronic aspects of military affairs which have happened in the past year or so.

Of course the **really** interesting stuff is well and truly classified, but it is interesting to contemplate the level of technology inherent in these publicised items, and speculate just how much **further** on must be the forefront of which we'll hear nothing until it too is outdated enough to publish . . .

LIGHT WEIGHT RADIO?

About to be issued to U.S. forces is a 'backpack' radio which has a range of 300 miles, weighs only 14 lbs and operates from rechargeable cells with a time of 16 hours between charges.

Naturally it can operate over a temperature range from below zero to beyond 100° F.

JAMMING THE TIDES!

Still the best way to detect a submarine charging around beneath the sea is to lower a detector of some sort beneath the surface and listen for the noise it makes — sonar.

However with the increasing noise generated by tankers and freights as their size and numbers increase, and the decreasing amount of din generated by modern subs, it's getting more difficult to be sure that what you're listening to is in fact an enemy sub about to blast you out of the water.

To make things more uncomfortable yet, the Russians are rumoured to be developing an acoustic 'jammer' to really confuse things.

These devices would work by generating greatly exaggerated ship type noises in an area where their forces are operating to shield them, or indeed in an area where they aren't — just to be confusing!

Indentification systems employ sophisticated processing circuits now, to sort out the sound of Reds from the sound of cod. It is possible though that a jammer could totally confuse even the best of these.

HMS Resolution, one of Britain's Polaris missile submarines. Since these vessels are the hardest of all war machines to guard a country against, this is where most ECM effort is being directed. Modern sonar can identify a submarine 'class' by the distinctive sound pattern it generates and there are some computerised air-borne search radars with sufficient resolution to do the same job by the radar 'profile of the periscope . . . .'

WHO'D BE A PILOT!

Due to ever increasing quality of ECM (electronic counter measures) and missile tactics, it is now estimated that in the event of another war in Europe, half the aircraft committed to combat would be lost within the first seven days.

Half the planes attacking ground targets will be on the ground themselves inside nine days.

ISRAELI TV SHOW

A new air-to-surface (ASM) missile is being deployed by the Israelis. It is called the LUZ-1 and uses TV guidance systems. Once the target has been lined up on the screen, the pilot can "fire-and-forget" the missile which will keep its own mind on the job.

WHOSE SIDE THEY ON?

Soviet electronic technology cannot compete qualitively with the West, due to lack of commercial competition and a too long held regard for valves, but their surface-to-air (SAM) missiles use the best ICs available — made by Texas Instruments.

So many are produced that apparently the Pact has no trouble laying hands on huge quantities.

HUNT THE RADAR

A detector that can be used to monitor anti-personnel, anti-aircraft, fire-control and mortar locating radar transmissions has been developed in America.

This can be carried by one man (it weighs 8lb)

The MRCA (Multi-Role Combat Aircraft) Tornado, wings swept back and fully armed. In it's interceptor role the aircraft carries extensive ECM equipment to give it a 'stand off and deliver' ability when engaging enemy aircraft.

In the combat support role the Tornado is a superb ground attack and one of it's first priorities in the event of hostilities would be to strike at enemy radar and intelligence gathering establishments, leaving the F14's and F16's to win control of the air.

An RAF HARRIER operating from Gutersloh in West Germany. These VTOL (Vertical Take-Off and Landing) fighters can operate from any clearing large enough for them to sit in, and by virtue of their excellent low flying abilities form a powerful (dispersed) strike capability.

SOUND THINKING

In World War II most infantry casualties were caused by artillery fire. Modern fire is greatly increased in 'killing power' and accuracy, although methods of spotting where the fire is coming from have changed little. The best methods involve watching the shells in flight using radar and computer tracing them back to source.

A new machine called TACFIRE is a computer system coming into use with NATO. It is a method of collating all the data from spotting equipment, accurately placing the firing guns and issuing orders for returning the fire. Such diverse factors as wear and tear on the guns, weather influence, quality of shot and intelligence reports can all be automatically accounted for so that the return fire can be very accurate indeed.

Each battery commander will have a display unit which is linked to a central TACFIRE unit. The overall commander uses a central terminal to monitor and co-ordinate fire from each battery.

There will be observers placed in the front lines to provide updated information to TACFIRE, using digital encoding techniques. The infantry forces using artillery as support can also get continually updated intelligence on such factors as ammunition remaining to the artillery, positioning of enemy guns etc.

PROGRAMME TROUBLE

A recent NATO exercise that attempted to measure how effective ECM would be against attacking Warsaw Pact forces ran into trouble — it severely interfered with West German TV sets, and massive protests were lodged with the authorities. As a result a future exercise will have to give at least a week's notice before trying it again.

I hope the Pact give that much notice before the tanks roll over the border and if they attack during Crossroads we've had it!

AEROSOL ANTI-LASERS

Lasers are being used increasingly to keep attacking planes and missiles on target. A simple and cheap anti-laser scheme is being developed — an aerosol can triggered off by a photo-electric sensor.

Once a beam of light is detected, the can is fired off releasing a spray of boron mixed with potassium chlorate and titanium dioxide. This is a very efficient light scatterer and effectively renders the laser useless.

FRIEND OR FOE— WHO KNOWS?

Japanese technicians claim to have broken the Soviet Air Force IFF (Identification Friend or Foe) code after dismantling a piece of equipment from that Mig-25 which landed in Japan some time ago.

This code enables the pilot's radar to distinguish his own side's aircraft from the rest and hence refrain from lobbing missiles at them.

While the code has obviously been changed since then (!) this still gives a big hint as to how the other side use this radar — and how to jam it.

HERCULES ATTACKS

One of the world's largest aircraft the American Hercules transports have been modified to attack ground targets!

Thanks to the huge space available within these craft they can be packed with jamming and ECM equipment — and two 'Vulcan' cannon firing up to 6000 rounds a minute, a 40mm gun and a 105mm gun — which is about the size carried by the largest tanks of the day.

All this massive fire-power is mounted down the port side of the place, so that the pilot simply 'points' his wing at the target to be pretty sure of giving it a beating.

Very sophisticated low light TV and infra-red sensors are fitted so are several radar systems. This means that the planes can be used at night when their extreme vulnerability to anything larger than an armed budgie is not such a handicap.

SOVIET ELECTRONIC WARFARE IN JAM

US and USSR doctrines on the use of electronic warfare (EW) differ greatly. For instance in the invasion of Czechoslavakia in 1968, the USSR fooled NATO into thinking normal manoeuvres were occuring until they actually crossed the border into the country.

Each Soviet Front (Army) has a signal interception (EW) regiment attached to it for "enhancing surprise and impact". No equivalent US or NATO formation exists.

During the 1973 Arab-Israeli dust up, the Egyptians employed Soviet doctrine, and caused havoc to Israeli communications from October 6th-8th. Once the Israeli gained the initiative though, all jamming abruptly ceased.

BETTER THAN WE THOUGHT

Soviet warships are using the new SS10/SSN14 dual-role missile in ever increasing numbers.

The SSN14 is a winged rocket powered torpedo for use against ships and submarines. Its range is 30 miles and is fired in the direction of radar or sonar contacts.

The torpedo separates from its carrier at a distance predicted by the ship's computers, and homes into the target itself.

One nagging question raised by this weapon is the range of the sonar used to determine the SSN14s targets. Previously Soviet sonar was thought to be inferior to NATO systems. Now however . . .

F15 and F16 vs MIG 29

Russia is testing its new MIG29 fighter for use in the early 1980s. NATO sources are concerned that this machine could challenge the F15 and F16 American fighters which up to now enjoy unrivalled supremacy in the air. These craft get their edge from manoeuvrability — and a fantastic degree of ECM, meaning *their* missiles are liable to hit home, but they are damn difficult to hit themselves!

FROM MILAN TO MOSCOW

Interesting to note the similarity between Russia's new anti-tank guided missile (ATM) and NATO's best, the Milan.

Like the Milan it is wire guided and can be fired from a vehicle or by a man on the ground. Like the Milan the range is about 2 km with a speed of 150-200 metres per second.

Like the Milan it can go through some 600mm of armour at the end of its flight. Given the quantity and quality of security leaks from West Germany — and the Russians' willingness to copy a good thing, could be the new missile is not *identical* to the Milan, could it.

THE US NAVY DEFEATS ITSELF.

During recent fleet manouvres the US Navy gave its Electronic Warfare Group free reign to attempt to disrupt a fleet action by purely electronic methods.

The result was a complete disintegration of communications and command, with ships attacking their own forces and leaving alone *enemy* ships thinking them decoys thanks to fake transmissions and signals. EW 1, US Navy 0.

The experience is said to have "severely shaken top brass".

RAPIER Ground-to-Air missile tracker system in operation.

TSC 500 portable satellite communications terminal,

SEASPRAY radar scanner mounted on the nose of a Westland Lynx helicopter.

Navigation console on a RAF NIMROD submarine hunter-killer aircraft.

The ZB 298 mobile radar for short-range ground surveillance, it can also be used for artillery or mortar fire ranging or aiming.

Ferranti PADS (Position and Azimuth Determining System). A digital inertial navigation system for accurate artillery survey purposes.

A COAT WHICH TURNS

Soviet subs are coated with a rubber-like substance to lessen sound reflections used by sonar to detect them.

However the shape of subs is somewhat complex, and making the stuff 'stick' is very difficult.

After prolonged spells at sea areas of the coat come loose and produce a 'flapping' noise which is MORE audible to sonar, and easily recognised.

IT'S IN THE BOOK

The latest US Army Field Manual states that "electronic warfare training is the most vital a unit can receive".

However one specialist claims that present jamming gear works "once in six times" and is poorly understood. As an example witness what happened when *one* jammer was aimed at two battalions during exercises last year.

Command control — (officers keeping track of their men) was completely eradicated. The companies affected were "destroyed", the HQ wiped out and a hole in the defences created. All this from just *one* little unit.

With the Soviet potential for EW currently 20 times NATOs, although not as technically impressive, it could be that battlefield communications will be well nigh impossible . . .

BIG EARS

Almost all aircraft detection devices are radar based. They emit a beam which bounces off the airplane and is detected upon return.

In modern battles though this method can amount to suicide. The beam can be (and is) detected, with the consequence that it is accompanied on its return journey by a few tons of high explosive.

NATO is well advanced with work on a passive aircraft detection system which simply listens for the noises made by the craft, and electronically sorts the signals to match up with stored 'signatures' of known airplane types.

A system of this kind would only be really useful if its range equalled that of existing radar systems.

NEUTRON BOMB

Consider this:
Warsaw Pact forces have been attacking through the Fulda Gap for five days. French divisions are racing across Germany to shore up the ever weakening lines of decimated American and British defenders. Most of the NATO armour has been crushed by continual waves of Russian T-62 and T-72 tanks wearing the new (British developed) Chobham armour.

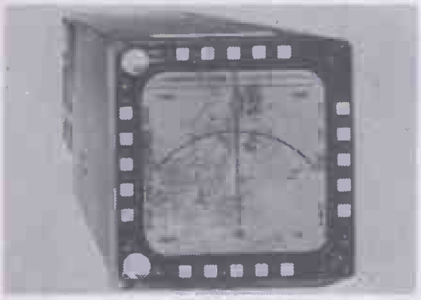
ORLANDO laser-guided projectile being fired from an M109 self-propelled artillery vehicle.

Stocks of anti-tank missiles are low, and Russian electronic warfare is proving more effective than was thought possible. Both front line divisions have only one third their forces intact to repel any new offensive . . .

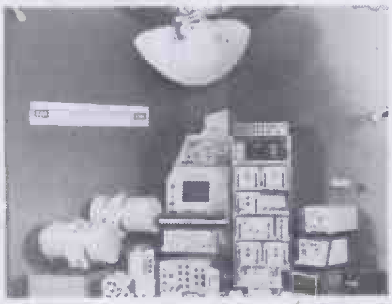
At 0600 division HQ receives authorisation to deploy tactical nuclear weapons "in limited sense to achieve deflection of new offensive action".

At 0700 a huge artillery barrage blankets the NATO lines, right between the British and American armour positions. As it lifts finally, a solid line of T-72 tanks at least 200 strong emerges from the woods and smoke just 2000 metres ahead of the line. Behind come wave after wave of mechanised infantry rolling forward armed with anti-tank and anti-personnel missiles. It looks like its all over.

NATO aircraft are nowhere to be seen. The line begins to break, then orders come down to hold-'tacnuke strike' Decontaminants are readied.



***COMED** cockpit display, a combined moving-map and electronic data display module.*



***SEARCHWATER**, one of the most advanced airborne radar systems for submarine location.*

***RAPIER** Ground-to-air missile system with practice missiles at the ready.*

The Chieftains pull back from the fringes of the packed enemy tanks.

Divisional Artillery trains its 8in howitzers to target, Lance missiles are armed . . . and fired . . .

Bright flashes appear 80 metres above the ranks of T72 forces. Huge holes are blown in the formations . . . but not enough. NATO troops are disappointed sorely, and the enemy keeps coming.

Suddenly tanks begin slewing around crazily, smashing into each other, the front tank scatters and the APCs roll to a stop. Crews are running about, falling . . . the advance is halted. Orders go out and the counter attack begins.

The first use of the neutron bomb in World War Three is over.

CYMBALINE anti-mortar radar. By hitting the projectile with a radar beam at two points on it's flightpath the unit is able to 'project back' the firing position. This enables the operator to 'call down' fire upon the enemy's head with great accuracy. CYMBALINE is light enough to be removed from it's trolley and comfortably carried by four men.

EFFECTS AND TRUTHS

The neutron bomb is no science fiction dream (or nightmare) anymore. The W70-3 warhead is being developed for use with the Lance missile which produces "an enhanced radiation effect maximising target destruction and minimising damage to surrounding area and friendly populace". Much play was made in the press of this weapon, and the possible effects on cities of such a device.

In fact the main use would be against massed enemy armour. Enemy tanks within 200 metres are destroyed. Beyond that blast effects are sharply reduced, but lethal radiation effects extend about 1km. Within 900 metres of the explosion centre enemy troops are destroyed immediately, and at 1100 metres they would be stunned for about 45 mins, and probably die within a week. Between 10000 and 16000 metres effects will be minimal at first, but enemy troops caught here have only 2 weeks to live.

Friendly forces can enter the blast area after ½ hour has passed with no ill effects.

Protection from neutron bombs is hard to come by. About five inches of armour plate will stop the radiation, but absorbing the neutrons causes the plate to emit lethal radiation itself! Tank crews are therefore no better off . . .

Some material does shield, thick concrete is better than armour, but you need about 10in to be effective. Damp earth is even better and 15in of this will effectively protect a person from the effects. Prepared positions will thus prove effective, although neutron weapons are not liable to be employed in this manner.

As the weapon is, in reality, an artillery shell for the 8in guns already in active deployment it could be made available and used very rapidly in a tactical situation such as that described above.

Undoubtedly the supreme tactical weapon — but would it lend to escalation? **HE**

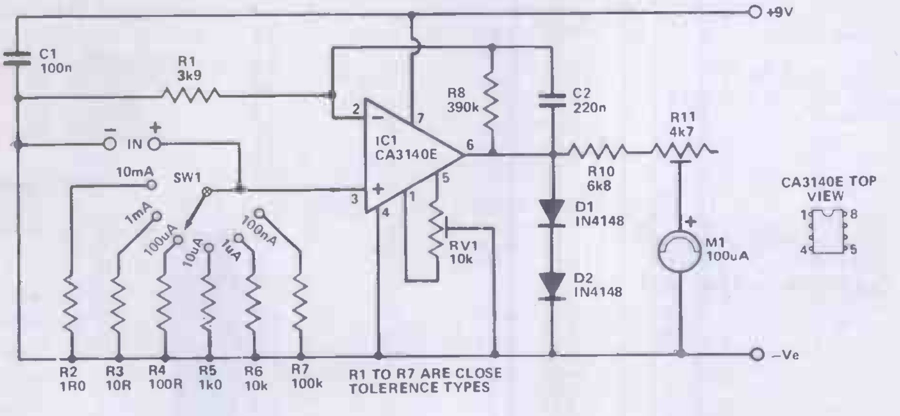
A follow-up article on Electronic Warfare will appear in our sister magazine ETI in the May issue.

Many thanks to the Ministry of Defence, Ferranti Ltd and EMI for the photographs.

Short Circuit

NANOAMP METER

It is not possible to accurately measure currents of a few microamps or less using an ordinary panel meter or multimeter. In order to make such measurements it is necessary to use an active circuit such as the one shown here. It can be built as a self-contained unit or used as part of an instrument requiring a highly sensitive current meter. The sensitivity is from 100nA to 10mA. FSD in six ranges; the higher ranges being included to permit calibration, and because many multimeters have very few low current ranges.



M1 is connected in a 1 V FSD voltmeter circuit which also uses R10 and R11. The latter is adjusted to give the unit the correct sensitivity. IC1 is an Op Amp connected in the non-inverting mode and having a DC voltage gain of about 100 times (set by feedback network R8-R1). C2 reduces the AC gain to only about unity so as to improve stability and imunity to stray pick-up. The non-inverting input of IC1 is biased to the 0 V rail by whichever of the range resistors (R2-R7) is selected by SW1. In theory this gives zero output voltage and no meter deflection, but in practice it is necessary to compensate for small offset voltages using offset null control, RV1.

If an input current is connected to the unit, a voltage will be developed across the selected range resistor, this voltage being amplified to produce a positive meter deflection. With R2 switched into circuit, 10mA is needed to give full scale deflection of M1, since 10mA will cause 10mV to be developed across R2 (E = 1 x r, = 0.01 A x 1 ohm, = 0.01 V or 10 mV), and this will be amplified one hundfed fold by IC1 to give one volt at the output. On successive ranges the range resistor is raised by a factor of ten, reducing by a factor of ten the current required at the input to develop 10 mV and give full scale deflection of M1.

This arrangement relies on the amplifier having a very high input impedance so that it does not drop a significant amount of input current, and this is achieved by using a FET input op amp having a typical input resistance of 1.5 million meg ohms. D1 and D2 prevent the output voltage of IC1 from exceeding more than about 1.3 volts, and they thus protect M1 against overloads.

When adjusting RV1 start with its slider at the pin 5 end of the track (there should be a strong deflection of M1), and then back it off just far enough to zero the meter, and no further.

New Books from the HE Book Service

28 Tested Transistor Project £1.15
Richard Torrens. The projects can be split down into simple building blocks which can be recombined for ideas of your own.

Electronic Projects for Beginners £1.55
F. G. Rayer. Divided into 'No Soldering Projects,' Radio and Audio Frequency, Power Supplies and Miscellaneous.

Solid State Short Wave Receivers for Beginners £1.15
R. A. Penfold. Several modern circuits which give a high level of performance even though only a few inexpensive components are used.

Linear IC Equivalents and Pin Connections . . . £2.95
Adrian Michaels. Gives most essential data for popular devices.

Popular Electronic Projects £1.65
R. A. Penfold. A collection of the most popular types of circuits and projects using modern, inexpensive and freely available components.

Projects in Opto Electronics £1.45
R. A. Penfold. Covers projects using LED's, Infra-red transmitters and detectors, modulated light transmission and also photographic projects.

52 Projects using IC 741 . . . . £1.15
Rudi and Uwe Redmet. Translated from an enormously successful German book with copious notes, data and circuitry.

50 FET (Field Effect Transistor) Project £1.45
F. G. Rayer. Contains something of interest for every class of enthusiast. Short Wave Listener, Radio Amateur, Experimenter or audio devotee.

How to Build Advanced Short Wave Receivers £1.40
R. A. Penfold. Full constructional details are given for a number of receivers plus circuits for add-ons such as Q-Multiplier, S-meter etc.

Digital IC Equivalents and Pin Connections . . . £2.70
Adrian Michaels. Covers most popular types and gives details of packaging, families, functions, country of origin and manufacturer.

How to Build your own Metal and Treasure Locators £1.20
F. G. Rayer. Gives complete circuit and practical details for a number of simple metal locators using the BFO principle.

Essential Theory for the Electronics Hobbyist £1.45
G. T. Rubaroe gives the hobbyist a background knowledge tailored to meet his specific needs.

Beginners Guide to Building Electronic Projects . £1.45
R. A. Penfold. Covers component identification, tools, soldering, constructional methods and examples of simple projects are given.

50 Projects using IC CA3130 . . . . £1.15
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Cistern Alarm

There is nothing worse than waking up in the morning to find that your cistern has overflowed. Most of us have been in that unfortunate position at one time or another. This simple circuit will give an audible warning and hopefully prevent an expensive disaster.

A CISTERN ALARM is probably the most unglamorous name imaginable for a project but it's the sort of device you bitterly regret not having built when you're ankle deep in water. The circuit is very straightforward in operation, relying on the inherent resistance of tap water to allow a current to pass between two strategically placed sensors.

The unit can be fitted in a variety of ways By using a stiff pair of wires for the probes it could be hung over the edge of the cistern or if a more permanent installation is required a probe could be glued or screwed to the cistern body. The height (see Fig 1) of the probe tips, relative to the water will vary according to the particular cistern used but as a general rule the tips of the sensor should be level with the overflow pipe.

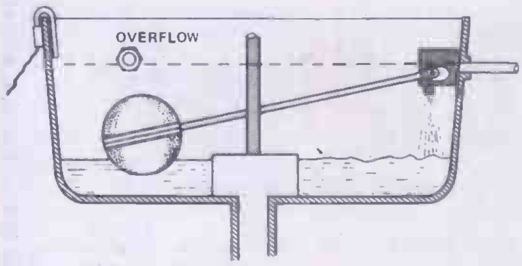


Fig. 1. How to mount the sensor probes in a typical cistern.

FLUSHED WITH SUCCESS

Two suggestions for sensor probes (see Fig 2) are shown. Of course it very much depends on the individual installation on how you approach the problem but one of the types shown should cover most applications. The first is simply two lengths of stiff (non-corrosive) wire bent into a hook and hung over the rim of the cistern casing. The second consists of two plated dome-head screws fitted into a block of Perspex, the sensor can then

The Cistern Alarm connected to the bell and battery.

be glued (particularly on the older metal type of cistern) or screwed to the casing.

No matter what type of sensor you decide upon, a great deal of care must be taken to ensure that the leads to the alarm are well protected against splashes, particularly where the wires join the sensor probes.

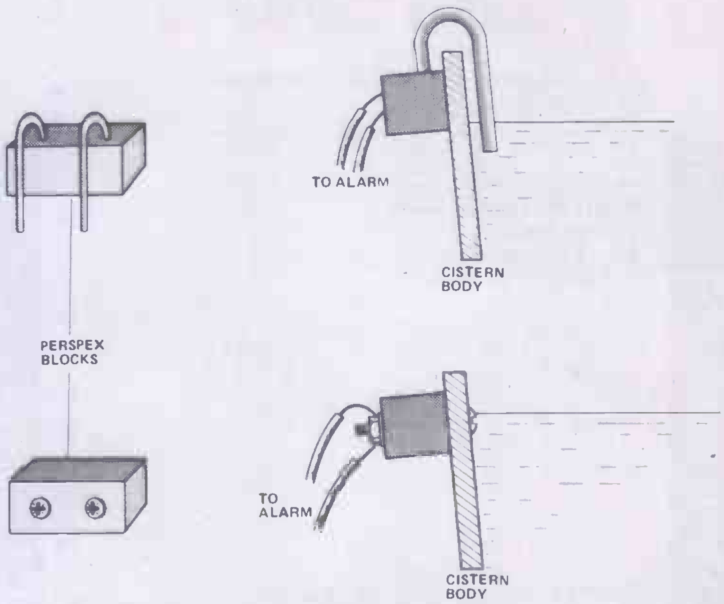
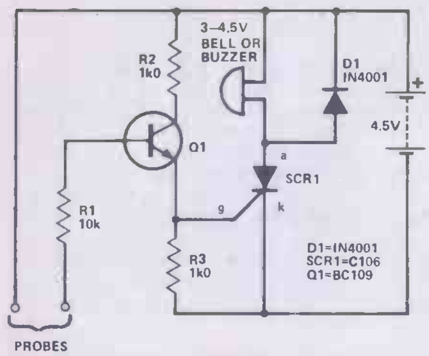
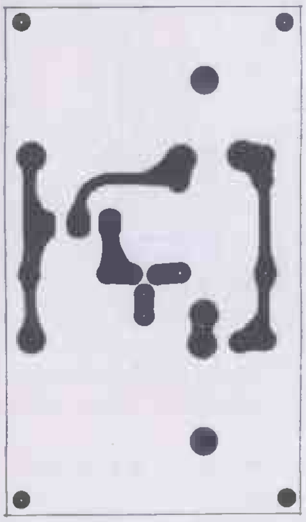


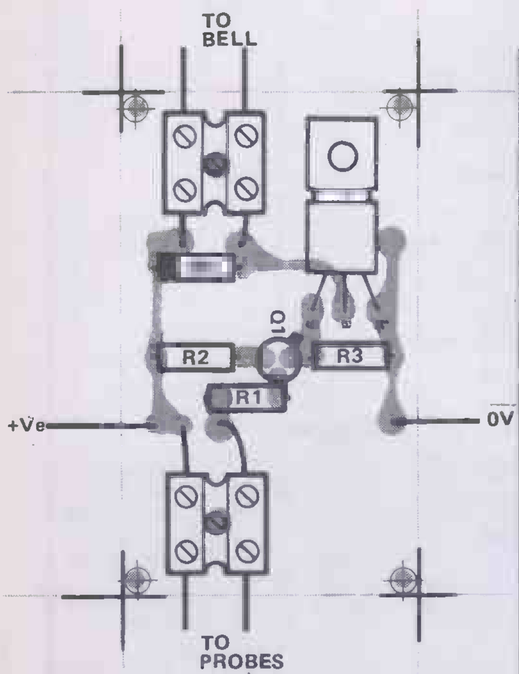
Fig. 2. Two suggestions for construction of sensor probes, the lower one is best suited to the older metal cisterns



Circuit diagram for the Cistern Alarm.



PCB foil pattern for the HE Cistern Alarm.



PCB overlay for the Cistern Alarm, ensure the thyristor is mounted the right way round, terminal blocks were used on the prototype to retain the leads to the bell and sensor probe.

How it Works

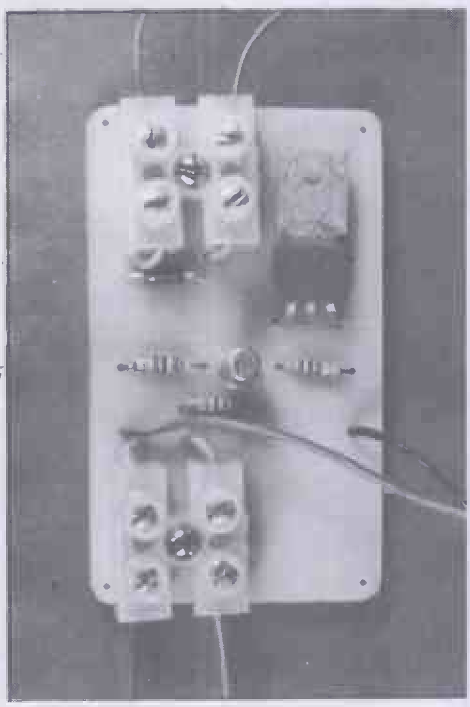
The two sensor probes are connected between the + ve line and the base of Q1 (via R1 current limiter). If a sufficiently small resistance (ie water 20-50 k) is connected between the probes Q1 will conduct. The emitter of Q1 will rise towards the supply rail potential, as the emitter is connected to the Gate of SCR 1 it will cause the Thyristor to 'fire' and become an effective short circuit. At this point the bell will begin to sound. Normally under DC conditions a thyristor will 'latch', this means that even if the gate voltage is removed the thyristor will continue to conduct, until the supply is removed. However, because an electric bell (or buzzer) has an interrupter contact fitted to the striker arm the DC supply to the bell is constantly being switched on and off, preventing the thyristor from latching.

The diode D1 is connected across the bell to prevent any 'back EMF' from destroying the semi-conductors (it can rise to several hundred volts!)

ROUND THE BEND

Sorry about the side headings but we can't resist the occasional pun. All the electronics are mounted on a single PCB, the bell used in the prototype was a small self-contained type obtainable from most hardware or chain stores. The use of a bell might appear quite surprising to some but this was quite deliberate. Apart from the fact that an electro-mechanical bell takes a lot of beating when it comes to volume, the action of the bell involves a constant interruption to the supply current, an important property when using a Thyristor (see How It Works).

As the alarm is to be left on for most of the time it was decided to omit an on-off switch, the standby current will be in order of 2-5 uA so if a sufficiently large battery is used (Eveready 126) the alarm should remain active for many months (even years).



Top view of the alarm, note the orientation of the thyristor.

Parts List

RESISTORS. (all ¼w 5%)

R1	10k
R2	1kO
R3	1kO

SEMICONDUCTORS

Q1	BC109
SCR1	C106D
D1	1U400I

MISCELLANEOUS

PCB — As Pattern
Bell — See footnote

Battery — Eveready 126 (4.5V)

There should be no problems with any of the components, the bell should operate at 4.5 volts, it is obtainable from most large hardware or chain-stores.

Approximate cost — £3.00.

Short Circuits

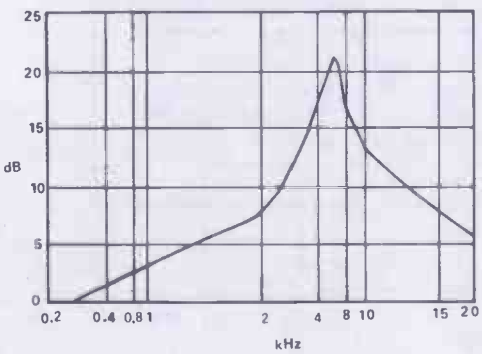
TREBLE BOOSTER

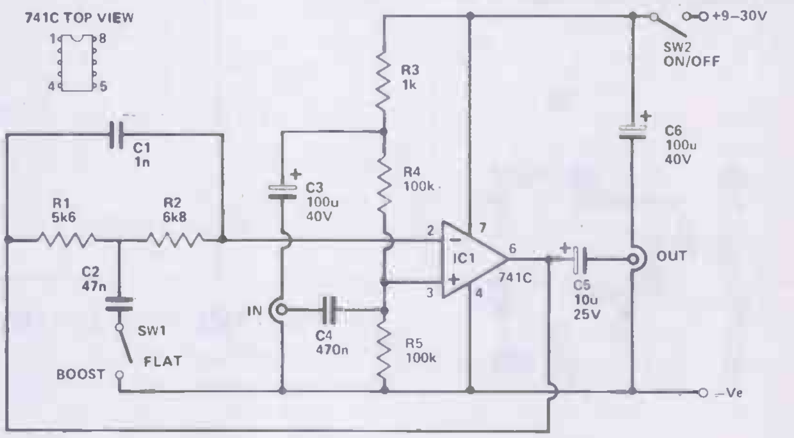
A treble booster circuit can be used with an electric guitar (and also electronic instruments) to boost the higher order harmonics and give a more "brilliant' sound. A circuit of this type gives a fairly flat response at bass and most middle audio frequencies, with the upper-middle and lower treble frequencies being given a substantial amount of boost. It is normal to give only a modest amount of emphasis to the upper-treble in order to give good stability and a low noise level, and this also prevents the output from sounding too harsh. The frequency response of this treble booster is shown in the accompanying graph.

The circuit is basically just an op. amp. (IC1) used in the non-inverting amplifier mode. The non-inverting input is biased by R4 and R5 via a decoupling network which is comprised of R3 and C3. C4 and C5 give DC blocking at the input and output respectively. With SW1 open there is virtually 100% negative feedback through R1, R2 and C1, giving the circuit unit gain and a flat response. Closing SW1 brings C2 into circuit, and this decouples some of the feedback through R1 and R2 at frequencies of more than a few hundred Hz, giving the required rising response. Feedback through C1 at high treble frequencies causes the response to fall away above about 5.5kHz, and prevents the very high frequency harmonics from being excessively emphasised.

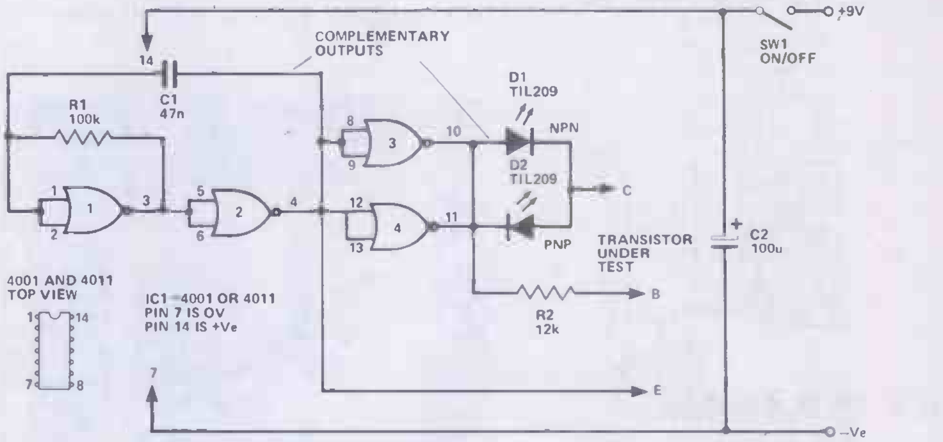
As the unit has unity gain at frequencies where boost is not applied it can simply be connected between the instrument and the amplifier.

THE FREQUENCY RESPONSE OF THE TREBLE BOOSTER





QUICK TRANSISTOR CHECKER



This very simple and inexpensive circuit is not designed to measure any transistor performance figures, but is intended for quick testing to show whether or not the test device is functional. The basic method of testing a transistor is to first connect a supply to its emitter and collector terminals and check that no significant current flows. If the base terminal is then given a small forward bias, this will be amplified in the form of a large collector-emitter current.

This circuit is based on a CMOS quad 2 input NAND or NOR gate IC. Either type is suitable as each gate has its two inputs connected together so that it acts as an inverter. The first two inverters are used in conjunction with R1 and C1 as a conventional CMOS oscillator operating at a frequency of a few hundred Hz. The other two inverters are connected in parallel, and fed from the output of the oscillator so that they provide a complementary output. In other words, one output will be positive and the other will be negative except during the brief periods when the outputs change state.

The collector and emitter of the transistor are fed from the outputs via D1 and D2, and the base is fed from one output via R2. If we assume that an NPN device is being tested, when gate 2 output is positive and the other output is negative, the transistor will not be forward biased by R2 (it will be reverse biased in fact) and it should pass no significant collector current. If it is a short circuit device and does pass such a current, this will pass through D2 which will light up and indicate the fault. When the outputs are in the opposite states, the transistor will be forward biased by R2 and should conduct heavily, causing D1 to pass a current and light up. Failure of D1 to come on indicates an open circuit or very low gain device. PNP devices operate with the opposite polarity, and so when testing one of these it is D2 that should switch on, and D1 which should remain off.

Summary

One LED on = functional device, type (ie PNP/NPN) as indicated.
Both LEDs on = short circuited device.
No LEDs on = open circuit or very low gain device.
Diode or rectifier testing (anode to collector, cathode to emitter).
D1 on = functional device.
D2 on = connected with wrong polarity.
Both LEDs on = short circuited device.
No LEDs on = open circuit device.

Next Installment

Multivibrators again, but these two are somewhat different as you will see

EVER FOLLOWED A SERIAL? Not, we must add, one of these telly-epics that goes on for fifty thousand instalments, all looking pretty much alike. No, our serial is the serial multivibrator (MV), a circuit which isn't as well known as it deserves to be.

Everybody knows the classic MV circuit, with its cross-coupled transistors. Cross-coupled means that each collector is connected to the base of the other transistor, and this shows up as a cross-over of connection on the circuit diagram (Fig. 1). In a conventional MV of this type (which we could call a parallel MV), one transistor is fully conducting (bottomed) and the other cut-off; the action of the circuit ensures that this state changes over at regular intervals.

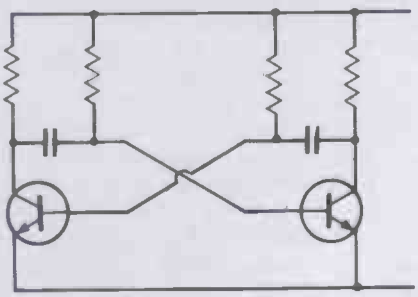
A serial MV is quite a different beast. The cross-coupling still exists, but the transistors are connected so that they are in series (hence the name) and the same current flows through both of them In addition, both transistors must be bottomed or cut-off together.

Serial MV's make use of the principle called complementary symmetry. Boiled down a bit, that means that you use both types of transistors, PNP and NPN. The difference between the two is the voltages that are needed. A PNP transistor conducts when its base is negative to its emitter and its collector also negative. An NPN transistor conducts when its base is positive to its emitter and its collector is positive. The difference is indicated on the symbols by the direction of the arrow head of the emitter — it's towards the base of the PNP and away from the base of the NPN. There's no indication on the actual transistor iteslf, apart from the type number.

POLARITY CHECK

If you buy transistors like the 2N2219 (NPN) and 2N290S (PNP), then the cases are identical, and only

Fig. 1. Old faithful, the classic cross-coupled MV circuit.



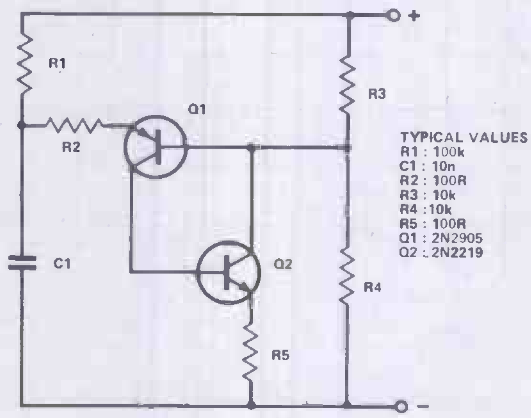


Fig. 2. One type of serial MV, with typical values.

the type numbers can act as a check. If your transistor came un-numbered, mark them before you forget because it isn't easy to tell them apart without testing — and that takes time.

One very useful serial MV circuit is shown in Fig. 2. It uses a pair of transistors, one NPN, the other PNP connected as shown with the collector of each one connected directly to the base of the other. This is the cross-connection which is needed for any MV circuit, what makes it slightly unusual is that both of these couplings are direct — no capacitors are used. The timing is done by one capacitor only, C1 which is connected between the emitter of the PNP transistor and ground. Lets see what happens in the course of a cycle of the action.

When the circuit is switched on at first, the voltage at the base of Q1 (which is connected to the collector of Q2) comes up right away. With the component values shown in Fig. 2, this voltage will be 6 V because the resistors R3 and R4 have equal values. The emitter voltage of Q1 doesn't rise right away, though. C1 is connected between the emitter of Q1 and the ground line, and no capacitor will allow the voltage across its plates to change instantly.

DISCHARGE TIME

When a capacitor charges or discharges through a resistor R, the time it needs to reach half of the supply voltage is about 0.7 C x R. This amount of time will be in units of milliseconds if C is in units of μF and R in units of kilohms. For example, if C1 = 0.05μF and R = 100k, then CR = 105 x 100 which is 5 milliseconds, so that the time needed to charge to half of the supply voltage is 0.7 x 5 ms = 3.5 milliseconds.

During the time that C1 takes to charge, no current, apart from an unmeasurably small amount of leakage, will flow through the transistors, because both Q1 and Q2 are biased off. This state of affairs will continue until the voltage at the emitter of Q1 reaches about 0.5 V above the voltage of the base of Q1.

Because Q1 is a PNP type, it will start to conduct when its emitter voltage is about 0.5 V more positive than its base voltage. This will happen at about the time of 0.7 CR we have calculated, so that current will start to flow through Q1. The first effect of this current is to provide base current for Q2, which is an NPN transistor. With just a trace of current into the base of Q2, this transistor will conduct, and the current flowing between the collector and the emitter of Q2 will cause the collector voltage to drop because of the voltage drop across R4 caused by the extra current. The base of Q1 is connected to the collector of Q2 however, so that when the voltage of the collector of Q2 drops, Q1 is switched fully on, passing as much current as is needed to keep its emitter voltage about 0.5 V above its base voltage. The full current passed through Q1, flows as base current into Q2 saturating this transistor, so that its collector voltage can drop very low, to only 0.2 V higher than its base voltage. There is now a low-resistance conducting path from the emitter of Q1 to the emitter of Q2, and C1 therefore discharges through the transistors and through R5. This discharge causes the voltage at the emitter of Q1 to drop suddenly, and the voltage at the emitter of Q2 to rise suddenly, for as long as it takes to discharge the capacitor.

Once the capacitor has discharged, however, the current which was keeping Q2 switched on dries up because R1 cannot supply so much current. A tiny rise of voltage at the base of Q1, caused by the current at the base of Q2 being reduced is enough to start the circuit switching back to its original state. When the rise of voltage at the base of Q1 cuts off Q1; Q2 is also cut off, allowing the voltage at the base of Q1 (which is also the voltage at the collector of Q1) to rise suddenly to the value set by R3 and R4. Now we're back where we started — with C1 discharged, the base of Q1 at half of the supply voltage, and the capacitor charging again through R1. R2 limits the emitter current of Q1, preventing damage to Q1.

SAWTOOTH

The serial MV gives quite different waveforms (Fig. 3) at different parts of the circuit. Across the capacitor C1, the waveform is approximately a sawtooth as the capacitor charges slowly and discharges rapidly. The waveform across R5 is a short positive-going pulse when the capacitor discharges. At the collector of Q2, the waveform is a negative-going pulse.

Like most MV circuits, this serial MV is tolerant of changes of components, but there are limits. In particular, R5 must have a low value, a maximum of 100 R is suggested. The reason is that with a higher value, the current through R5 can cause the emitter voltage of Q2

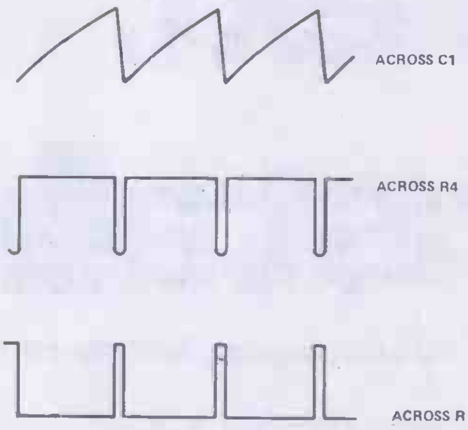


Fig. 3. Serial MV waveforms.

to rise high enough for the circuit to 'stick', with R1 providing enough current through Q1 and so into the base of Q2 to keep both transistors switched on. Sticking can similarly be caused if the value of R1 is too low. A minimum value of 47 k is often suggested for this resistor. Most circuits use R3 = R4, but this is not necessary as long as the voltage at the base of Q1 is not biased too much or too low — in this case with a 12 V supply not above 9 V nor below 3 V. When R3 is not equal to R4, the charging time of the capacitor will not be the 0.7 CR which we assumed.

Another type of serial MV is shown in Fig. 4 using this time a capacitor connected to the base of an NPN transistor. The second transistor in the circuit is, once again, a PNP type, and the action of the circuit can best be imagined by starting just when the supply voltage is switched on.

OPERATION

At switch-on, the voltages across R1, R3, R4 can rise rapidly so that the base of Q2 is biased positively to just under 6 V. With no voltage at the emitter of Q2, this is a reverse bias, since Q2 is a PNP type. The base voltage of Q1 is zero at the instant of switch-on because C1 has not charged. As a result, Q1 is also cut off. The collector voltage of Q1 is high, almost at supply voltage, because only the charging current of C1 and the steady current of R3, R4 flows through the load resistor R1.

Once again, C1 charges until the base voltage of Q1, rises to a level at which Q1 can conduct. This voltage will be about 1 V higher than the voltage of the base of Q2 because there are two base-emitter junctions in the path from the base of Q1 to the base of Q2. Whenever a trace of current starts to flow into the base of Q1, however, a much greater current will pass between the collector and the emitter of Q1, switching on Q2 so that both transistors conduct.

With both transistors conducting, there are some sudden voltage changes. The collector voltage of Q1, drops to about the same voltage as the emitter of Q2, because with Q1 conducting heavily, there is only about 0.2 V difference between emitter and collector voltages. C1 will discharge through the base of Q1, to about the same voltage. Because of the current through R1 however, the voltage at the collector of Q1 will drop,

Next Installment

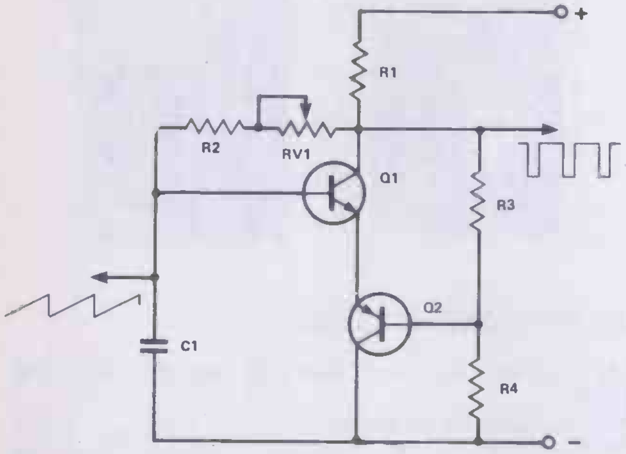


Fig. 4. Another type of serial MV.

causing the base voltage of Q2 to drop so that a low voltage is reached all round.

Once again, though, a drop in the current caused when the capacitor has completed its discharging action can cause the action to reverse. As the current drops, the voltage at the collector of Q1 starts to rise, bringing the voltage at the base of Q2 up as well.

This will cause both transistors to cut-off, because C1 cannot charge quickly enough to let the base voltage of Q1 rise in this time. With both transistors cut-off, the collector voltage of Q1 is restored to its starting value of just below supply voltage, and the whole cycle starts again.

In this circuit, a sawtooth waveform is again available across C1, and a short negative pulse can be obtained at the collector of Q1, at the same time as the capacitor discharges. R2 should have a value of not less than 47k, to avoid sticking.

Those types of serial MV's are circuits which give sawtooth and narrow pulse waveforms. The normal parallel MV circuit can give a sawtooth waveform at each base but a short pulse is usually obtained by using a MV astable to trigger a monostable. The use of a serial astable can therefore be a valuable saving in components and circuitry if short pulses at a variable repetition rate are needed.

No more instalments — our serial's ended!

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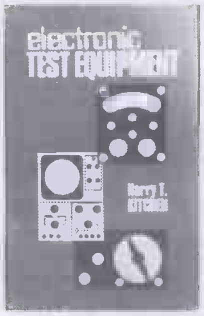

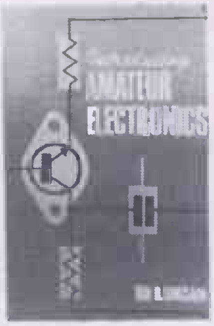

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Into Electronics

by Ian Sinclair Part 6

This month we look at Logic Circuits and their uses — from Automatic Control Systems to Digital Watches.

LAST MONTH'S LOOK at the wave-generating effects of positive feedback left out one device, mainly because it doesn't generate any wave by itself. It's the bistable; and it's distinguished from all the others in its family (astables and monostables) by having no capacitors and no time constants. It doesn't sing, it doesn't dance on one leg, what does it do?

Take a look at the bistable circuit in Fig. 6.1. The circuit looks just like an astable multivibrator, except that there are no coupling capacitors, just the resistors R2 and R3. Suppose that Q1 is conducting, so that its collector voltage is bottomed. That means there is no current flowing through R2 into the base of Q2, which is cut off. With Q2 off, current flows from the supply through R4 and R3 to keep Q1 conducting. It'll stay that way as long as the circuit is switched on, or until it's switched over. How do we switch it over? Easy, just earth input A momentarily. That cuts off Q1, switches on Q2, and the positive feedback makes sure that the changeover will be really fast. Now Q2 is on, and Q1 is off, and it will stay that way until switched off or until input B is earthed.

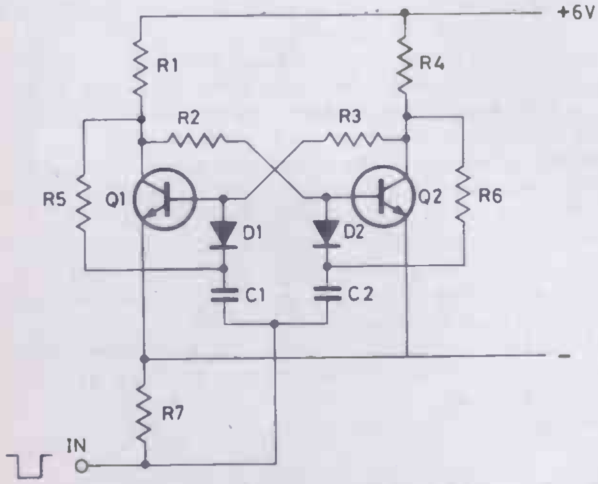


Fig. 6.2 Bistable counter with steering diodes. Use values R1 - R4 as in 6.1, but with R5, R6=100 k, C1, C2=0.01μF, R7= 10 k, D1, D2, silicon diode such as1N4148. Supply 6 - 9V battery.

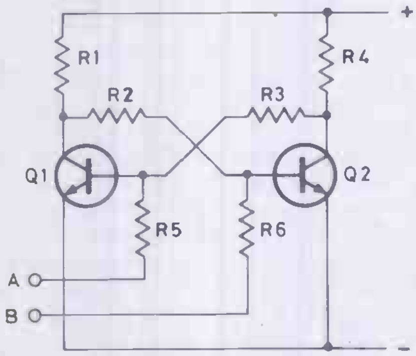


Fig 6.1 Bistable multivibrator. To try it out, use values: R1, R4 = 4k7, R2, R3 = 47k, R5, R6 = 47k. Q1, Q2 can be any NPN general-purpose transistors such as 2N1711, 2N2209, BFY50. Supply, 6-9 V battery.

STEERING BISTABLES

Very interesting, but is it useful? Well, we can certainly make some use of the circuit as it stands — it's useful for making square waves out of sinewaves, for example, but the addition of what is called a 'steering system' makes this into one of the most-used types of circuit in modern electronics. Fig. 6.2 shows the simple bistable with the addition of steering diodes which make it into a scale-of-two or flip-flop. We've added three resistors, two capacitors, and two diodes to the basic circuit; fasten your seatbelts so that we can run through what happens.

Suppose that Q1 is conducting, with its collector voltage bottomed, and Q2 is off, so that its collector voltage is high. The base voltage of Q1 must be at about 0.6 V, and its collector voltage at about 0.2 V; these are the normal voltages for a bottomed silicon transistor. These voltages are also the bias voltages for the diode D1, so that D1 has about 0.6 V on its anode and 0.2 V on its cathode — almost, but not quite, conducting. How about D2? It's connected to Q2, whose base is cut off, at about 0.2 V (because it's connected to the collector of Q1) and with its collector at a voltage very close to the supply voltage, perhaps 5 V. D2 must, therefore, be reverse biased, then, with 0.2 V on its anode and about 5 V on its cathode.

That sets the scene, then, with D1 almost conducting and D2 thoroughly reverse biased. Now imagine what happens when a negative trigger pulse arrives at the input. The trigger pulse is a brief change of voltage, negative because the voltage drops suddenly from zero to a negative value and then returns to zero. The duration of this pulse can be short, a micro-second or so, but the effect on the circuit is not brief. If we make the size (amplitude) of the negative pulse somewhere between 1 V and 6 V, assuming a 6 V supply, then the pulse can pass current through only one of the diodes, D1, because only D1 is biased so that it can conduct on a pulse of that size. Current flowing through D1, caused by the negative pulse, will cut off Q1 and switch on Q2, so leaving the circuit with the conditions reversed. Q2 is now conducting and Q1 is now off.

FLIPPING BIAS

Of course, the bias on the diodes has also flipped over. D1 is now reverse biased, and D2 is almost conducting. On the next trigger pulse, then, Q2 will cut off and Q1 will switch on again. Two negative pulses at the input have put the conditions back where they were at the beginning. If we take the output of this bistable circuit as being the voltage at the collector of Q2, then this voltage has gone from high to low to high again for an input of two pulses. This output is itself a single negative pulse, so that the circuit has produced one negative pulse at the output from two negative pulses at the input.

Since the output of this circuit is a negative pulse, we can use it as a trigger pulse for another identical circuit. The same sort of action is going to take place in this second bistable circuit, so that two complete pulses from the first bistable will produce one complete pulse from the output of the second bistable. Of course, we need four trigger pulses into the input of the first bistable to give us two pulses from its output; the complete circuit therefore needs four trigger pulses in for one complete pulse out. Now take a deep breath and think of what will happen if we have three of these bistable circuits connected in a chain (Fig. 6.3.) How many trigger pulses into the first bistable will give one pulse at the output of the third bistable? Yes, eight is the answer, and so it goes on. If we have N bistables connected in a chain like this, we need 2^N pulses in to give one pulse out.

ORGANIC BISTABLES

This type of bistable circuit acts as a counter, then, counting not in the scale of ten but in the scale of two, and it's the basis for all the remarkable circuits that make calculators and computers possible. More about that later in Part 8. Before we leave the bistable counter, though, remember that it can have several uses that are not concerned with computing or calculating. The division-by-two is itself a very useful feature for several applications. Just to take one example, dividing the frequencyof a note of sound by two means obtaining a sound which is exactly one octave lower. This makes a bistable an essential part of the circuits of electronic organs and synthesisers, because if we use a set of oscillators to generate a scale of notes of very high sound frequencies, dividers, which are just bistables, can be used to produce all the lower frequencies. That way we have 12 oscillators (because there are 12 notes in an octave) to keep in tune, and the other notes must be of the correct pitch, a lot easier than using a separate oscillator for each note.

Fig 6.3 A chain of bistable counters, with the Q2 collector of bistable 1 connected to the input of bistable 2 and the Q2 collector of bistable 2 connected to the input of bistable 3.

This frequency division is also used for timekeeping. Electronic watches use crystal oscillators (remember?) to ensure a very stable frequency. These oscillators work at anything from about 38 kHz upwards, so that to operate a display that flips numbers every second, a large number of bistable stages will be needed. It simply wouldn't be possible if we had to build each bistable from separate transistors, but integrated circuits (ICs) make it possible to build the complete oscillator and divider circuit in one set of operations and on one tiny chip of silicon.

TWO'S COMPANY

All of this counting in twos affects the design of all the circuits that we use along with bistables. When we count in the scale of two, there are only two digits, 0 and 1. These are particularly easy to represent electrically, because we can so easily arrange that the voltage of the collector of a transistor is either high, with the transistor completely off, or low, with the transistor bottomed. Practically every system uses what's called positive logic, with high collector voltage representing the digit 1 and low meaning 0. The terms, 'logic 1 and logic 0' therefore mean collector voltage high and collector voltage low respectively.

CERTAIN FLIPPERS MAKE THINGS EASY

Now this sort of counting system has lots of advantages, and one of them is that it's pretty certain. If we use circuits like bistables, the outputs are either on or off, they never hang around at any voltage between these two states, so that there's no doubt about which digit is represented by the voltage at any collector. We can forget about linear amplification and bias, and simply design circuits with lots of positive feedback to make sure that they flip over fast and completely. Problems like noise and interference shouldn't cause so much trouble when all of the transistors are either cut-off or bottomed. One slight snag is that 2 is rather a small number to use as a counting base, so that lots of bistable circuits are needed to handle even moderately large numbers; once again the use of ICs helps us out. A more serious problem is that we need at some stage to enter numbers into, and read numbers out of, a set of counting bistables, so that conversion to and from decimal numbers is needed. Once again, the use of ICs has simplified things, so that we can make these encoder and decoder circuits on single silicon chips.

ARE YOU GATING ENOUGH?

All the circuits that we call digital circuits make use of bistable counters but some other types of circuits are needed as well. Counting, for example, has to be

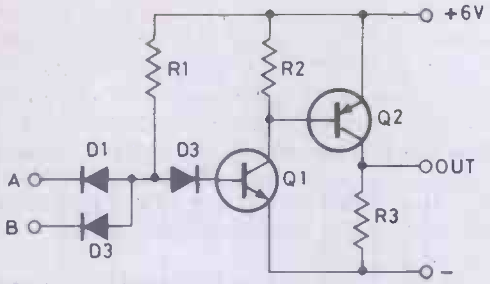


Fig 6.4 A gate circuit using diodes and transistors.

stopped and started, and the type of circuits we use for stopping and starting counters are next on our list. They're called gates. Digital gates are like any other sort of gates, to let anything through you have to open them.

Take a look at the circuit in Fig. 66.4. This is intended as a digital circuit, so that the inputs will either be zero volts (connected to earth) or supply voltage, and we expect the output to be one of these two voltage levels as well. Suppose both of the inputs, A and B are earthed, low, logic zero. Current will then flow through R1 and through D1 and D2 to earth, and the voltage across D1 or D2 will be around 0.55 V, the usual voltage across a conducting diode. That sort of voltage isn't enough to start current flowing through both D3 and the base-emitter junction of Q1, so that Q1 is off and its collector voltage is high. A high collector voltage means that there's only a small voltage between the base and the emitter of Q2, which is a PNP type. A PNP transistor needs to have its base voltage lower than is emitter voltage to turn it on, so Q2 is off. With Q2 off, the output voltage is LOW, logic 0.

Now if we take one of the inputs, A or B, and connect it to the +6 V supply, then it makes no difference to the circuit action, because all we've done is to reverse-bias one of the diodes, D1 or D2. Current will still flow through R1 and through the other diode, so that the voltage will stay low and Q1 stays off. If, however, we connect both inputs, A and B, to +6 V, then both of the diodes, D1 and D2, are reverse biased, and current now flows through D3 and into the base of Q1, turning on Q1. Some of the collector current of Q1 will flow through the base-emitter junction of Q2 (PNP, remember) so that this transistor is turned fully on. The output now is high, at logic 1.

This sort of gate has been described in detail because if you can understand the working of one sort of gate, you will soon find it easy to understand other types. It's called an AND gate. The name? Well, to make the output high, logic 1, we need to have input A *and* input B high, also at logic 1.

THE TRUTH, THE WHOLE TRUTH

Circuits like this are never built nowadays, because all of the gate circuits we need are obtainable as ICs. The circuits that *are* used inside the ICs are very complex; very often we don't know what the circuit is, so that we need some method of remembering what each gate does. One such easy way is the use of a truth table. A truth table shows what the output of a gate will be for each possible combination of inputs. Now for the AND gate we've just looked at, the output is 1 only when both inputs are 1, so that the truth table is as shown in Fig. 6.5. A shorthand way of writing the action is 1 . 1 = 1, where the dot means AND, and the equals means 'gives'. The use of these 'equations' forms a branch of mathematics called **Boolean Algebra.**

A	B	OUT
0	0	0
0	1	0
1	0	0
1	1	1

Fig 6.5 The truth table for the circuit of Fig. 6.4.

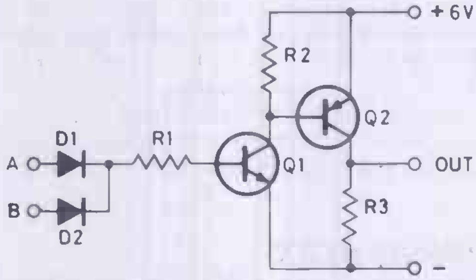
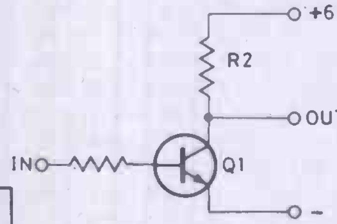


Fig. 6.6 A simpler gate circuit with a different truth table.

A	B	OUT
0	0	0
1	0	1
0	1	1
1	1	1

Fig. 6.7 The truth table for the circuit of Fig. 6.6.



IN	OUT
0	1
1	0

Fig. 6.8 A simpler inverter (NOT-gate) and its truth table.

How about some other gates? Fig. 6.6 shows another variation of the previous circuit, using fewer diodes this time. Once again there are two inputs, A and B. With both input voltages low, at logic 0, Q1 is unbiased and so Q2 is also unbiased, with no current flowing. The output voltage is low, logic 0. If we now connect A to +6 V, then current flows through D1 and R1 into the base of Q1. D2 is reverse-biased so that it plays no part in the action. With Q1 switched on, Q2 is also on, and the output voltage is high, logic 1. The same result is obtained if input B is high and input A low, except that diode D2 now conducts and D1 is reverse-biased. In fact, the output is at logic 1 when A or B is high (or both), and the circuit is an OR gate. The truth table for this gate is shown in Fig. 6.7.

Classed among the gates is the simple inverter circuit, sometimes called the NOT gate (Fig. 6.8), which is just an unbiased amplifier. When the input voltage is high, the output voltage is low, and vice versa. The truth table isn't too difficult!

a.

A	B	OUT
0	0	1
1	0	1
0	1	1
1	1	0

b.

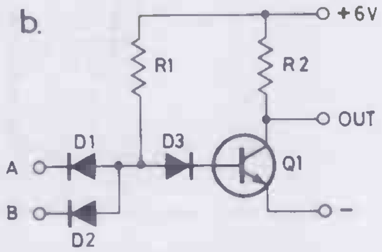


Fig. 6.9 The NAND gate. (a) Truth table, (b) a circuit using diodes and a transistor.

A	B	OUT
0	0	1
1	0	0
0	1	0
1	1	0

Fig. 6.10 The truth table for the NOR gate.

Fig. 6.11 Gate symbols — three-input gates are shown.

... NOR ANY DROP TO DRINK

Two other common types of gates are just combinations of AND, OR and NOT gates, but are often easier to make. The NAND gate has the truth table shown in Fig. 6.9a. The output is high unless both inputs are 1, when the output becomes 0. The circuit of Fig. 6.9b is one form of a NAND gate, and you can see that it's just the circuit of Fig. 6.6 without the PNP stage. The name of the gate comes from NOT AND, because its truth table is that of an AND gate followed by a NOT. Inevitably, there's a NOR gate, which is the NOT-OR. Its output goes to zero one input or the other goes high, and the truth table is shown in Fig. 6.10.

To save having to draw circuits of the gates themselves, we use symbols. These aren't universally standardised, but practically everyone working in electronics uses the (American) symbols which are shown in Fig. 6.11. For teaching electronics, the British Standard symbols are dutifully noted, then forgotten.

GROUPIE GATING

Gates are designed to give a signal out for a definite combination of signals in. Railway signalling, for example, has for years depended on mechanical gating systems, so that signals cannot be set to accept a train until the points have been correctly set. Electronic gates are smaller and faster to operate, so that we can make gating actions which are much more complicated, all from the set of gates we know, the AND, OR, NAND, NOR and NOT.

Just for starters, look at the set of gates in Fig. 6.12. This shows four inputs, all to NAND gates, with the outputs of the NAND gates feeding into a NOR gate. What is the truth table for this lot? A drop of Boolean Algebra can solve this fairly quickly, but it's the hard slog for us. Four inputs means sixteen possible combinations (2^4) of inputs, all different, so we start by writing them all down. It's easier if we're fairly methodical about it, so we write columns for the numbers in order, and in the column write the binary numbers in sequence up to 1111. A quick count should now show that we have 16 lines of figures, and provided that we have kept to the binary sequence, we should then have every possible combination of ones and zeros. Now draw two more columns for the outputs of the NAND gates, and label them (X and Y) and one final column for the output Q of the NOR gate. The table is now ready to complete, the worst part is over.

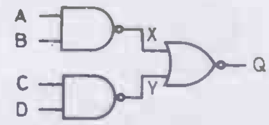


Fig. 6.12 A gate circuit made from standard components.

A	B	C	D	X	Y	Q
0	0	0	0	1	1	0
0	0	0	1	1	1	0
0	0	1	0	1	1	0
0	0	1	1	1	0	0
0	1	0	0	1	1	0
0	1	0	1	1	1	0
0	1	1	0	1	1	0
0	1	1	1	1	0	0
1	0	0	0	1	1	0
1	0	0	1	1	1	0
1	0	1	0	1	1	0
1	0	1	1	1	0	0
1	1	0	0	0	1	0
1	1	0	1	0	1	0
1	1	1	0	0	1	0
1	1	1	1	0	0	1

Fig. 6.13 Finding the truth table from the gate circuit.

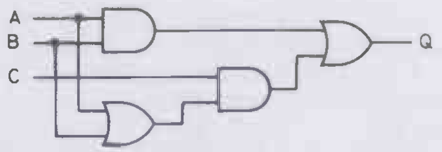
Starting with the NAND gate whose output is X, ignore inputs C and D and concentrate on inputs A and B. X will be at zero only when A = 1 *and* B = 1. For all other inputs, X = 1, so that we can complete the X column fairly quickly. Now ignore A and B and fill in the columns for C and D, with their output, Y. Once again, because the gate is a NAND type, Y is zero only when C and D are both 1; all other values of Y are 1, and can be marked in.

Now for the last column. The action of the NOR gate is that the output is low if either input is high, and will be 1 only when both inputs are low. There's only one line in which X=Y=0, and that's the last line. For this logic circuit, then Q = 1 for A = B = C = D = 1, so that the circuit is a 4-input AND gate. Simple, really!

The point of all this is that with the basic gates we can make a circuit with any sort of truth table we want, so that the output will be 1 for whatever set of inputs we like to specify.

DE-LUXE, PIPING HOT LOGIC

Suppose, for example, we have a central heating system that is controlled by logic gates. The system has a boiler



A	B	C	Q
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

Fig. 6.14 A 2-out-of-3 gate truth table, and one suitable circuit.

which can be switched on by a relay which clicks over when the gate that operates it goes to logic 1. The hot water from the boiler will heat the radiators in the house only when it is pumped through the pipes, and the pump is switched by another relay similarly arranged so that it can be operated by the output of a logic gate. How about inputs? Well, we could imagine that this is a de-luxe system and that we have detectors for outside air temperature, inside air temperature in all rooms, water temperature, and also, of course, a time switch. What sort of system could we design?

To start with, the time switch could operate a bistable that switched AND gates. That way we could have the heating pump operated by one set of gates during the day and another set during the night — a bit of an improvement on the usual single thermostat. Then we could make good use of the temperature detectors in the rooms — we could, for example arrange the gating so that we had a 1 output if two out of three selected rooms were at a lower temperature than the set amount. The truth table for such a 2 out of 3 arrangement is shown in Fig. 6.14. The gate arrangement shown alongside should produce this truth table — check it out for yourself.

Of course we could arrange that the rooms we chose for the night temperature measurements were not the same rooms as we used for the daytime measurement, and we would also want to ensure that the water was not pumped around when the air temperature inside was high enough. Another thermostat senses the temperature of the water in the hot-water cylinder, and the boiler fires if the pump is working OR if the cylinder temperature is low. Complicated? Not really, and to do the same actions by any other methods would be a nightmare — which is why so many houses waste heat needlessly.

PRACTICE MAKES PERFECT

Logic circuits can be built with separate transistors (these are called discrete circuits) but it's much simpler to make use of the ready-made ICs which are cheap and easily obtainable. The best types for experimental work are the ones referred to as TTL (Transistor-Transistor Logic). A typical circuit for a TTL gate (it's a 2-input NAND gate) is shown in Fig. 6.15. The gate consists of four transistors, a diode, and four resistors, and four

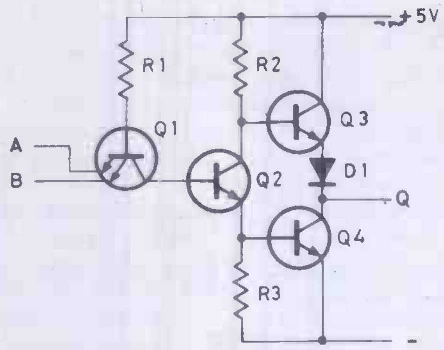


Fig. 6.15 A TTL NAND-gate circuit.

gates like this can be packed onto one tiny silicon chip with plenty of room left. The IC coded SN7400N contains just this package of four NAND gates.

The action is something like this. The transistor Q1 at the input is made with two separate emitters, taken to different connections, A and B. We can make more emitters, so a seven-input is obtainable. The base of Q1 is connected to the supply voltage through R_1, so that if either emitter of Q1 is earthed, the transistor can conduct between collector and emitter. The collector, though, is connected directly to the base of Q2, so that when A or B is earthed and Q1 conducts, this has the effect of connecting the base of Q2 to earth, switching Q2 off. O.K. so far? If A or B is low, Q2 is off; if both A and B are high, Q2 is switched on.

When Q2 is off, its collector voltage is high, so that Q3 is switched on. The emitter voltage of Q2 is low, so that Q4 is off. The output is high, connected to +5 V through Q3. When Q2 is on, its collector voltage is low and its emitter voltage is high, so that Q3 is off and Q4 is on. Perhaps you'd like to make up a truth table for each part of the circuit just to convince yourself.

Now this type of circuit may look rather odd compared to most of the transitor circuits you've built or seen, but there are good reasons. One is that these circuits are easy to make in IC form, another is that they switch over very quickly — on an average it takes one of these gates only 13 ns to switch over — that's just the time it takes a beam of light to travel the length of a fairly large room. It's these types of fast-switching circuits that are used in most computers at the moment, although pocket calculators and micro-computers use a different (MOS) type of circuit which is not so fast-switching.

THE RIOT ACT

The way these circuits are designed, though, means that we have to use them correctly, so here are the rules.

Rule 1. The supply voltage has to be 5 V. You can get away with 4.5 V, but you can't get away with 6 V. The supply should preferably be a stabilised 5 V mains supply. Reason? The inputs are always to the emitters of transistors with the bases connected to supply voltage. If you use a 6 V supply, far too much base current will pass when an emitter is earthed. Remember that the base current is limited only by R1 in Fig. 6.15.

Rule 2. Inputs of gates have to be supplied either from the outputs of other gates or from some switching arrangement that will connect them either to earth through a large value resistor (anything over 1k), then it behaves just as if it had been left unconnected or connected to + 5 V. The reason is that the input circuit is like that of an emitter follower output, and the emitter tries to follow the base. Inputs from switches, relay contacts, or transistor collectors are useable.

Rule 3. The output of a gate will switch anything from 5 to 10 inputs of other gates. This is called the fan-out of the gate, so that the gate with a fan-out of 10 will drive ten more gate inputs. If you want to use the output of a gate, so that a gate to drive a relay, a power transistor should be used so that the power treansistor operates the relay, and the gate operates the transistor. The reason this time is that the tiny transistors inside the IC cannot be expected to handle a large amount of power.

BEGINNERS JOIN HERE

How do you start on practical logic circuit construction? Well, there's a very easy method that won't take up much more room in this Part — follow the series that appeared in ETI! The name of the series was *Digital Electronics by Experiment,* and it started in October 1977. Good soldering.

The TTL circuits which are so useful for learning about digital logic are not ideal for all applications. For one thing, they need a well-stabilised 5 V supply, and 5 V is an awkward figure for the experimenter who has to rely on batteries. Another snag is that TTL circuits take quite a lot of current. The eight TTL ICs that are used in the board for the series, Digital Electronics by Experiment, take a total current of around 0.5 A when they are all working, and that's an amount of current that a dry battery will not happily supply, so that a mains power pack is needed. The big plus factor for the TTL circuits from our point of view is that they are easy to handle, readily available, and not easily damaged.

LOGICAL FET-TISH

There's another family of logic ICs, though, called variously CMOS, Cos-Mos, MaCMoS, and so on. Unlike TTL circuits which use ordinary (bipolar) transistors in integrated form, CMOS ICs use MOSFETS (Metal-Oxide-Silicon FETs) in integrated form. These FET circuits can be used to make up the usual range of gates and bistables that we expect to use, and in addition a few circuits (such as transmission gates) that are not possible with TTL circuits.

What makes these CMOS circuits attractive, though, is that they can be operated on voltages ranging from about 4 V up to 12 V, so that the popular 9 V battery (PP3) can be used as a power supply for most CMOS circuits. In addition, the use of FETs means that the input resistances are very high, and CMOS circuits can be operated with very low currents. A CMOS output can drive a large number of inputs, because practically no current is needed. This also is a bonus point for battery operation, because it means that CMOS circuits take very little battery current and batteries have a long life unless the circuit includes components (like LED displays) which have a greater appetite for current. Incidentally, the name CMOS comes from Complementary MOS, because the FETs that are used are of two types, P-channel and N-channel, corresponding to PNP and NPN bipolar transistors respectively.

With so much going for them, why don't we use CMOS for all our digital work? Well, we do use them a lot, and you'll see them used in H.E. projects, they're also used in all pocket calculators and in digital watches, but they are not the ideal type of ICs for learning about digital circuits. The reason is the very high input resistance. As we mentioned earlier, any electronic component which has a high input resistance is easily damaged by the electrostatic voltages which exist on your hands, on insulating materials, and on any isolated prices of metal — any metal that is not connected to earth by a resistance of less than a few megohms. The result is that if we pick up a CMOS IC and touch the pins — it's dead. Not the best introduction to digital logic circuits, is it?

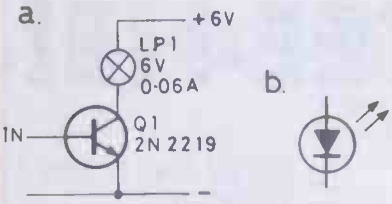
We get around the problem in two ways. One is that the circuits have built-in diodes which help to short-circuit excessive voltages. The other is the fact that damage can occur only when one lead is at a very different voltage from another. Now when the IC is connected into its circuit, all of the pins will be connected through resistors either to earth or to supply voltage, and the voltage between two pins can't be more than the battery voltage, which is safe enough. Our main problem, then, is just to get the darn thing into circuit in one piece. CMOS ICs come packed with their pins embedded in plastic foam. It's not any old foam, but a conducting material that makes sure that all the pins are shorted together, keeping them all at the same voltage. Keep the ICs in this and they're safe, come sparks or lightning.

DO NOT TOUCH!

Now for the awkward bit — how do we put them into the circuit. Well, we build all the rest of the circuit first, checking to make sure that each pin of the IC will be connected to a part of the circuit which has components connected, or is earthed. The CMOS IC goes in last, and there two ways of dealing with this. One way is to solder IC holders into the circuit instead of soldering in the ICs directly. We then hold the ICs by the ends of the case, fingers away from the pins, whip off the plastic foam, and plug in the ICs, making sure that we've got them the right way round. Unless we are particularly unlucky we should be able to do this without touching any of the pins. The other method is direct soldering. The negative line on the board is connected to earth through a flexible wire fitted with croc. clips. The ICs are fitted, one at a time into their places, and the pins are soldered in one at a time using an earthed soldering iron. The earth pin of the IC is soldered in first, then the + supply pin, then all the others. This is no more trouble once you have had a bit of experience, but the less experienced constructor is advised to use holders at first — apart from anything else, it's a darn sight easier to remove ICs.

GLOW-WORM'S BENEFIT

One little item we haven't touched on yet, how do we know when a gate or bistable output is high? Voltmeters being the price they are, we need some sort of display. For transistor circuits, as good a method as any is a 6 V 60 mA cycle dynamo rear light bulb. If we use 6 V supplies fpr our transistor circuits, then a 6 V bulb in series with a transistor collector, will indicate when the collector voltage is low (bulb on), Fig. 6. 16a. The trouble with this is that 60 mA is rather a lot of current to have to pass just tp indicate whether a transistor is on or off, and it's certainly too much to load onto our TTL ICs.



$I_{f\,max}$	$I_{f\,typ}$	$V_{f\,typ}$	$V_{r\,max}$
50mA	12mA	2·1 V	3 V

Fig. 6.16 Displaying a binary digit. (a) transistor-and-lamp, (b) LED symbol, (c) LED typical characteristics. This LED has a forward voltage drop of 2.1 V at 12 mA. Note the low peak reverse voltage of only 3 V. LEDs must always be protected from reverse voltage.

For most display purposes, then, we make use of LEDs. The name is short for Light-Emitting Diode, and that's just what they are diodes that emit light when current passes through them. These aren't silicon or germanium diodes, but they are P-N junctions made using compound materials such as Gallium Arsenide or Indium Phosphide. It just happens that crystals of these materials are transparent, so that any light generated happens to be visible to the eye.

UNTIL DEATH US DO PART

How does the junction come to be giving out light? It's caused by an effect called recombination, when an electron and a hole find each other and live happily ever after. In normal diodes or transistors we try to avoid recombination like the plague, because it removes electrons and holes from circulation. When recombination takes place, energy is released, the same amount of energy as was needed to separate the electron from the hole in the first place. As it happens, the amount of energy that is released is just the right amount to create a light ray; the colour of the light depends on the amount of energy.

LEDs behave otherwise like any other semiconductor diodes, but they need a higher voltage between anode and cathode to conduct, about 2 V for some types. The symbol is shown in Fig. 6.16b along with typical data.

The LED principle is also used in making seven-segment displays (Fig. 6.17) which, as the name suggests, have seven bar-shaped strips of LED. These can be used to display all the numbers 0 to 9, and also a few letters, and are used to show the outputs of bistable counters. Wait, though, bistables count in scale of two,

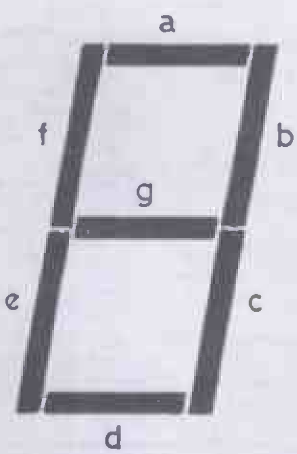
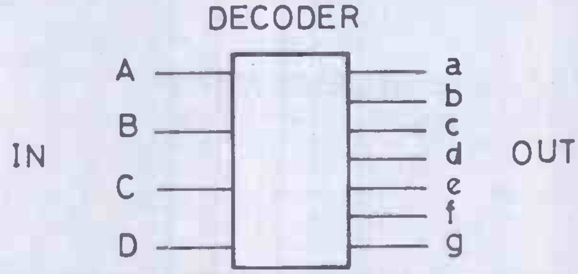


Fig. 6.17 The seven-segment display.

and these displays are decimal — something wrong here? There would be, but as it happens there's an IC which acts as a binary to seven-segment converter — put in a binary number and out come the voltages which light up the correct strips of the display to show the decimal number. The truth table, shown in Fig. 6.18, looks a bit fearsome, but it's all done with the usual set of NAND, NOR and NOT gates.

Right now, another type of display is becoming available, though still a bit pricey. This is the LCD display. LCD means Liquid Crystal Display, and the liquid crystals are curious substances (related to amino-



A	B	C	D	a	b	c	d	e	f	g
0	0	0	0	1	1	1	1	1	1	0
0	0	0	1	0	1	1	0	0	0	0
0	0	1	0	1	1	0	1	1	0	1
0	0	1	1	1	1	1	1	0	0	1
0	1	0	0	0	1	1	0	0	1	1
0	1	0	1	1	0	1	1	0	1	1
0	1	1	0	0	0	1	1	1	1	1
0	1	1	1	1	1	1	0	0	0	0
1	0	0	0	1	1	1	1	1	1	1
1	0	0	1	1	1	1	1	0	1	1

Fig. 6.18 Binary-to-seven segment decoder truth table. The number 1 under a segment letter (a to g) indicates that segment is lit. Note that a four-input binary number can have values up to 15 (1111) but only a count of 9 is diplayed by this decoder. Hexadecimal decoders display letters to indicate the numbers 10, 11, 12, 13, 14 and 15.

acids, if chemistry grabs you) which can be turned from opaque to transparent by applying a small electric field. These displays can be made into the seven-segment pattern, and have the great advantage that they need very little current. Unfortunately, they need a high-frequency AC supply, and the life is limited because the liquid crystal material is broken down by sunlight. Watch displays have a ultra-violet filter to extend the life of the liquid crystals, but two to five years is reckoned a good life time. **HE**

Next month we stop looking at components and circuits for a bit, and start looking at how we make use of them all. Systems is the name of the game, and next month's systems are domestic ones — radio, recording and TV.

A breadboard as big as your ideas.

EXPERIMENTOR 325 £2.54
The ideal Breadboard for 1 chip circuits. Accepts 8, 14, 16 and up to 22 pin IC's. Has 130 contact points including two 10-point bus-bars.

EXPERIMENTOR 600 £7.88
The Breadboard for quick construction of Microprocessors and other circuits. EXP 600 has 550 contacts including two 40-point bus-bars with 0.6" centres.

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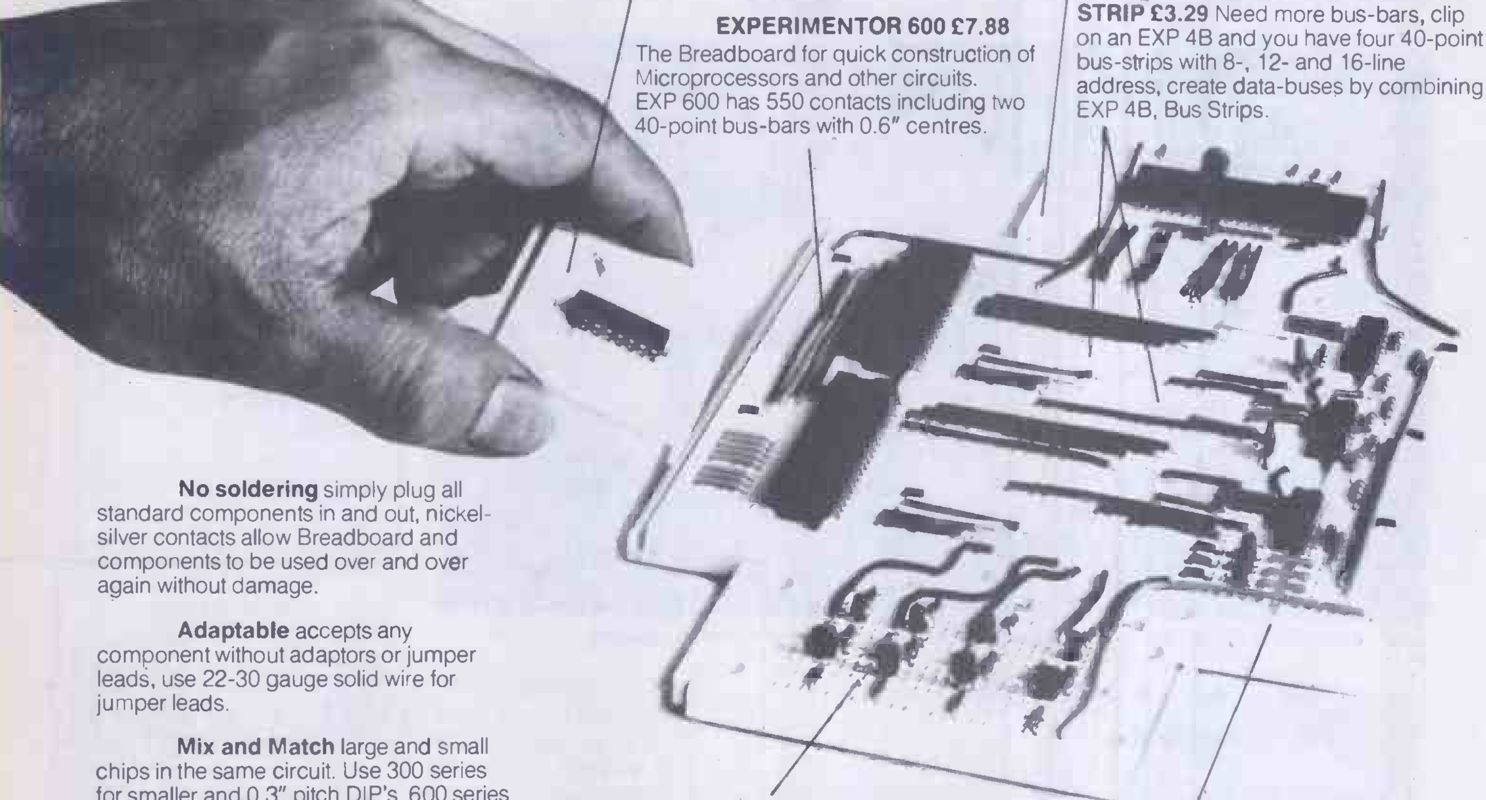
Perfect for checking out Microprocessors. EXP 650 has 270 contacts including two 20-point bus-bars with 0.6" centres.

EXPERIMENTOR QUAD BUS STRIP £3.29 Need more bus-bars, clip on an EXP 4B and you have four 40-point bus-strips with 8-, 12- and 16-line address, create data-buses by combining EXP 4B, Bus Strips.



No soldering simply plug all standard components in and out, nickel-silver contacts allow Breadboard and components to be used over and over again without damage.

Adaptable accepts any component without adaptors or jumper leads, use 22-30 gauge solid wire for jumper leads.

Mix and Match large and small chips in the same circuit. Use 300 series for smaller and 0.3" pitch DIP's. 600 series for Microprocessors with 0.6" centre channel for full fan-out with larger chips.

Smallest to Biggest, remember CSC's Breadboards "snap-lock" together so you can start with a small idea and expand your ideas to as Big a Breadboarding area as you like.

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EXP 350, specifically designed for the hobbyist working with up to 3 x 14 DIP IC's. With 270 contact points including two 20-point bus-bars the EXP 350 accepts any size DIP with 0.3" spacing.

Marked Contact Points transfer component by component from letter/number position on Breadboard to finished P.C. Board or Wiring Table.

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The hobbyists ideal Breadboard, accepts 6 x 14 DIP or 5 x 16 DIP, has 550 contact points including two 40-point bus-bars, accepts any size DIP with 0.3" spacing.

Tailor-Made Breadboards e.g. a project requires up to 5 x 14 DIP chips and needs up to six bus-bars. Which to buy? Easy from the table below select an EXP 300 plus an EXP 4B, total cost £10.58.

Pick any project that you want to build, or any part of a project that you want to test or modify.
Count up the number of IC's you need for the project.
Then simply look up in the box opposite the Breadboard you require.
If you need more than two bus-bars simply add the correct number of Quad-Bus Strips. GET STARTED NOW FOR AS LITTLE AS £2.54.

MODEL NO.	NUMBER OF CONTACT HOLES	IC CAPACITY (14-pin DIP's)	UNIT PRICE (includes Post & VAT)
EXP 300	550	6	£7.29
EXP 600	550	use with 0.6" PITCH DIP's	£7.88
EXP 350	270	3	£4.21
EXP 650	270	use with 0.6" PITCH DIP's	£4.70
EXP 325	130	1	£2.54
EXP 4B	FOUR 40-point Bus-Bars	—	£2.30

How to order. Telephone 0799 21682 and give your Access, American Express or Barclaycard number, and your order will be in the post that night. Or send your order, enclosing cheque, postal order, or stating credit card number and expiry date. For full catalogue showing all CSC products for the engineer and hobbyist send large S.A.E.

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BI-PAK	C
CATRONICS	C/L
CHROMASONICS	C
ELECTROVALUE	C
GREENBANK	L
GREENWELD	C
HEATHKIT	C
MAPLIN	C
MARSHALLS	C
RCS	L
SINTEL	C
STEVENSON	C
TARGET	C
WATFORD	C

Just a small selection of the many catalogues available to the electronic hobbyist.

Two of the more ambitious catalogues, both have an impressive range of goods for sale.

UNLESS YOU HAPPEN TO LIVE somewhere near the southern end of the Edgware Road in London it's a fair bet you've bought components by mail-order at one time or another.

Luckily for us in this country we are well served by mail-order companies, and a healthy competition exists between them. It's quite possible to save several pounds even on a small project, just by shopping around between the companies.

The adverts we see in the magazines (we hope you only read HE), cannot hope to show even a fraction of the goods they stock, so the only recourse is to get hold of some of the catalogues that most mail-order companies produce. The quality of these works vary from a couple of duplicated sheets (the more elaborate ones are stapled together), to what can only be described as books — often in full colour, several hundred pages long.

SURVEY

Some time ago we asked several mail-order companies to send us an example of their current catalogue and got a fairly mixed response; some declined to send us one altogether! Others said they would send us one, but they mysteriously never arrived. From the ones that arrived we obtained some very interesting results, as you will see later.

In order to be as objective as possible we put the results in table-form. We'll briefly outline all the criteria used in assessing the catalogues.

No. of pages	Cost of catalogue	VAT inc. price	Post and packing	Guarantee exchange	Additional data	Transistor pin-outs	IC pin-outs	Notes	COMMENTS
36	30p	√	Free over £2	√	×	×	×		Fair prices, good selection.
67	45p	×	25p	√	√	×	Some	1	Specifically for the radio amateur.
31	Free (sae)	×	Variable	√	×	×	×		Mainly audio equipment and accessories.
22	Free (sae)	×	Free	√	×	×	×		Mostly tools and hardware.
128		×			√	√	√		
60	40p	√	30p min	√	√	√	√		Another one for the radio amateur.
24	40p	√	25p	√	Some	Some	Some	2	Good selection, fair prices.
120	Free (sae)	×	25p	√	√	√	√		Slightly expensive, but very comprehensive.
—									Computer specialist.
62	30p	√	20p min	√	Some	Some	×		Good selection, prices competitive.
40	Free (sae)	√	—	—	—	—	—		Kits only — superb selection.
280	75p	√	Free	√	√	√	√		About the best there is.
47	40p	√	40p	√	√	√	√		Massive selection, reasonable prices.
16	Free (sae)	√	Variable	√	×	×	×		
23	Free (sae)	×	35p min	√	×	×	Some		IC and MPU specialist.
45	Free (sae)	√	30p	√	√	√	√		Surperb selection — very cheap.
48	15p	√	50p min	√	√	√	√		Fairly run-of-the-mill.
92	50p+25p pp	×	30p min	√	√	√	Some		Excellent catalogue, a little expensive at 50p.

TABLE 1 — Breakdown of what the catalogues have to offer

Notes. 1: Ambit Part 2 available soon. 2: 45 pence voucher with catalogue.

FORMAT

The format of a catalogue often reflects its price, obviously a couple of duplicated sheets costs a lot less to produce than a magazine style catalogue.

NUMBER OF PAGES

Again directly proportional to cost, in most cases the more pages there are the greater the range of components on sale. Also worth looking for are illustrations, a good clear picture is better than a whole page of meaningless waffle.

COST OF CATALOGUE

The price of a catalogue can range from literally the cost of an SAE to 75p. It's surprising, though, what you can get for nothing. In fact, one of the best ones we came across was free!

VAT

Nasty one this, it can make an otherwise very good catalogue into a nightmare, just try adding the cost of two rates of VAT to a component list of around twenty items. If possible stick to the catalogues that include VAT in the price.

POST AND PACKING

Again a great deal of variation, some are free, others are free on orders over a certain amount, some even quote a P+P charge on each item. Beware using too many companies for one project as it's easy to forget how much the P+P is adding up to!

GUARANTEE/EXCHANGE

No problem here, all the catalogues we read operated an adequate exchange service. Since the introduction of mail-order protection schemes, that most reputable magazines operate, the chances of losing your money are small; remember though it only applies if the goods were ordered from an ad. in the magazine, not from a catalogue.

ADDITIONAL DATA

It's very important in our view that anyone who sell components (especially the more unusual or complicated devices) should provide some pin-out diagrams at least, transistors and ICs in particular. Some of the more elaborate efforts have become invaluable sources of reference to us at HE.

COSTA PLENTY

The final part of the survey was intended to give a rough idea of how pricey each company is. This proved to be more difficult than we anticipated.

TABLE 2. Comparison of prices for two recent projects from HE.

Supplier	Project 1	Project 2	Comments
Ace	254	316	All the prices are in pence and include VAT and the cost of post and packing
Chromasonic	268	240	
Electrovoice	327	352	
Greenweld	244	269	
Maplin	243	277	
Marshalls	338	367	
Stevenson	212	203	
Target	322	323	
Watford	240	299	

NOTE. Project 1 — Rumble scratch filter excludes case, knobs, PCB, etc.
Project 2 — Push-button dice excludes case, PCB, etc.

Maplin and Ambit, Maplin will supply almost anything, Ambit are very much geared towards the radio enthusiast.

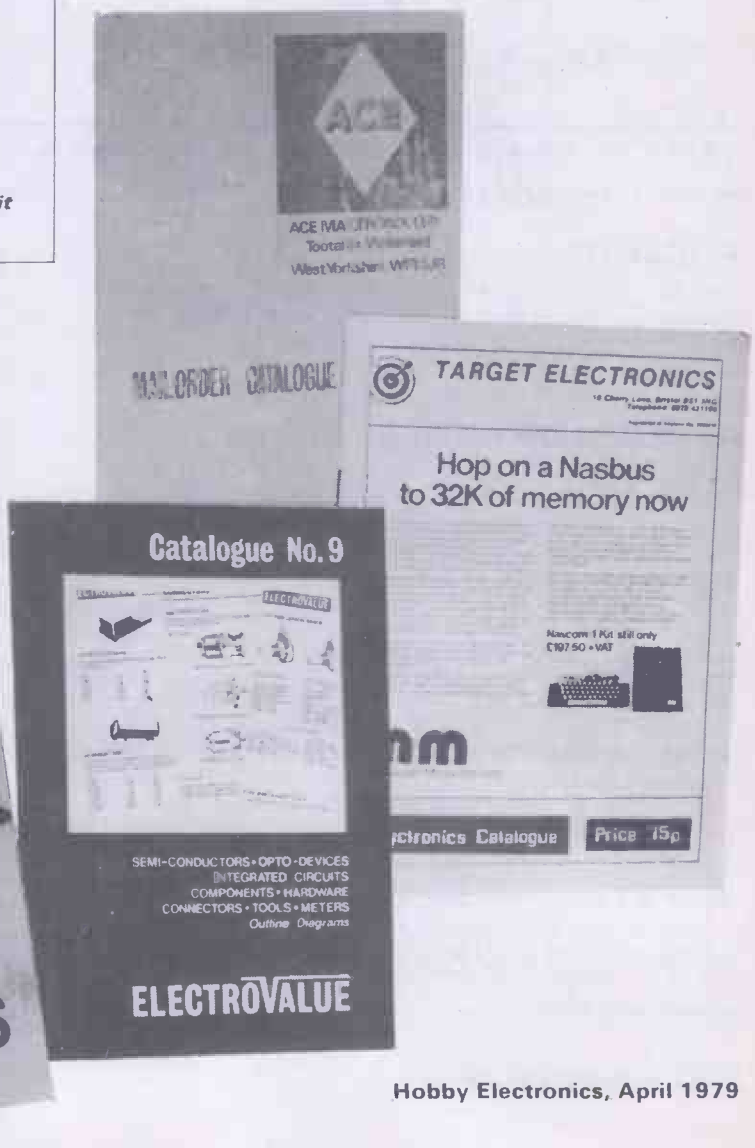
The method we finally settled on was to cost two projects from recent issues of HE. In all fairness we must point out that the figures obtained may not be strictly accurate, some companies did not stock all the parts. (In these cases we added to the list the cost of the component from the cheapest supplier.) VAT figures were rounded down to the nearest penny. The figures we obtained, however, are we believe within a few pence of the correct price. The final results are thus representative of the companies' overall price structure.

SUMMARY

The results are pretty clear. A few companies stand out head and shoulders above all the others; this is not however a reflection of their services, that is for you to tell us about. We could hardly order anything under our own name for fear of preferential treatment. So if you've had any interesting experiences with the mail-order services please write in and tell us and maybe we can do a follow up on the ones we missed.

Although some catalogues are clearly better than others, all are worthwhile having; we didn't think one of them was overpriced or not worth having.

Cast your eyes over our tables and see how the mail-order companies compare. There are some very surprising results. **HE**



Hobbyprints

An easy, patented method of making PCBs for HE projects.

For some time it has been possible to buy acid resist rub-down pads and track — in fact we use them in the HE workshops and they work very well. HOBBYPRINTS take this idea a stage further — the complete PCB pattern is already on the sheet and can be rubbed down in seconds — and the patterns are nice and crisp, made from the original artwork, used for the prototype.

If you have the facilities for ultraviolet exposure, HOBBYPRINTS make excellent masters — being solid black on a translucent film. With this method you can use the HOBBYPRINTS time and time again!

HOBBYPRINTS are produced exclusively for HE, and the whole system is protected by patents 1445171 and 1445172. Each month we will be bringing out a new HOBBYPRINT, containing the patterns for each issue's projects.

We're sorry for the delays in sending off the Hobbyprints, we'll be sending them out as soon as possible.

HOBBYPRINT A (November HE)
5 Watt stereo amplifer, Waa-Waa pedal, Bedside radio.

HOBBYPRINT B (December HE)
Digital dice, Photon (2 copies), Metronome, Audio mixer.

HOBBYPRINTS C (January HE)
Graphic Equiliser, Touch switch, Vari-Wiper, Flash Trigger.

HOBBYPRINT D (February HE)
Short Wave Radio, Sine/Square generator, Scratch/Rumble filter, Car Alarm.

HOBBYPRINT E (March HE)
Light Chaser, Photo Timer, Casanova's Candle, (2 copies), Tone Control (2 copies).

HOBBYPRINT F (April HE)
Train controller, Cistern Alarm, Transistor Tester

How to use HOBBYPRINTS.

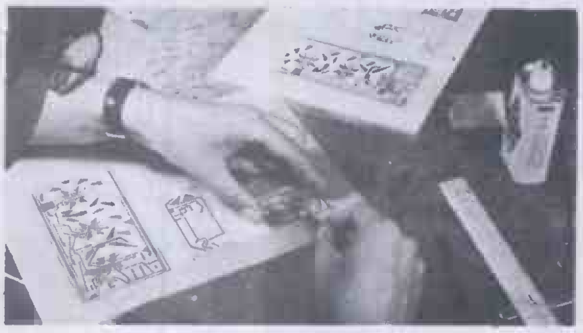
1. Clean the PCB as you would for any work giving it a rub down with fine sandpaper (we even supply this in the kit). A quick wipe over with lighter fuel will help to remove any grease marks.

2. Lay down the HOBBYPRINT and rub over with a soft pencil until the pattern is transferred to the board. Peel off the backing sheet carefully making sure that the resist has transferred. If you've been a bit careless there's even a 'repair kit' on the sheet to correct any breaks!

3. Cut the board to size and put it in the Ferric Chloride.

4. When etching is completed, wash the board and use the sandpaper or a scouring powder to remove the resist. The resist pattern is pretty hardy but is easily removed at the final stage.

5. All you've got to do now is drill the board. Time? Only about ten minutes from beginning to end plus etching time (15 minutes usually with a good acid).



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Transistor Gain Tester

The HE Transistor Tester is somewhat unusual in that it does not use a moving-coil meter but an LED to give a visual indication of the transistors gain.

A TRANSISTOR TESTER is probably one of the most useful pieces of test equipment (apart from a multimeter) that the aspiring electronics enthusiast could hope to own. Most commercial testers check a variety of parameters. However, if a tester could just measure the vital gain factor as well as giving a go-nogo indication this should prove to be quite adequate for most purposes.

The HE tester does just that, one unusual feature is the use of an LED (Light-emitting Diode) to indicate the transistors condition, rather than the usual moving-coil meter.

Our prototype transistor tester built by John Fitzgerald, a new addition to the HE Project Team. Two transistor sockets are fitted near the control (which has not been calibrated here) while sockets are fitted on the side of the case to take flying leads which can be fitted with croc clips.

TRANSISTOR GAIN MEASUREMENT

In the common-emitter configuration the current gain Ic/IB is known variously as Beta or h_{FE} and many vary considerably according to the particular value of collector current, collector-emitter voltage and temperature at which one decides to make the measurement. Thus for repeatability these current and voltage values at least should be known to be constant and this is achieved in this unit.

CONSTRUCTION

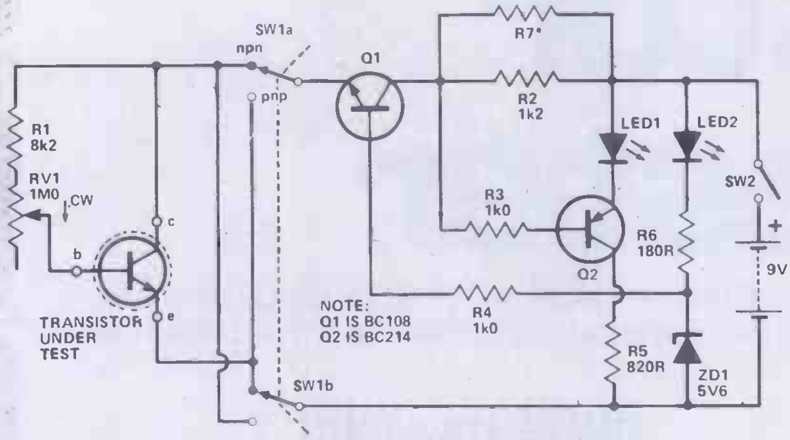
A PCB layout for the majority of components is given; due to the rather uncertain volt-drop across the particular LEDs used the current-sampling resistor R2 is made larger than needed and shunted during calibration by R7. If no calibrating milliammeter is available, fit R2 = 1 kilohm and omit R7, R3 and R4 limit currents to safe values regardless of possible short-circuits during transistor testing; R1 limits base current to the TUT to a maximum of 0.5 mA even when RV1 is at zero resistance. SW1 sets the transistor under test (TUT) collector to positive if NPN and to negative if a PNP type; SW2 is a push-to-test spring return type.

In the prototype the TUT may be connected with test clips on flying leads or plugged in to a transistor holder.

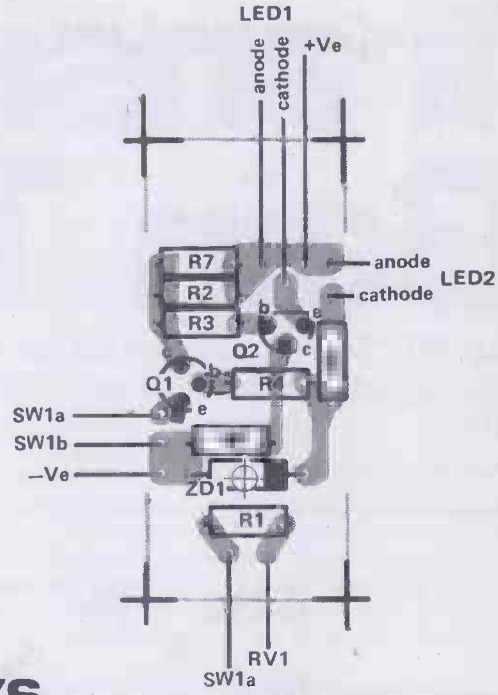
GAIN $h_{FE} = I_C/I_B$	$I_C = 2.5$mA I_B (μA)	R_B 1.84 × h_{FE}(kΩ)
5	500	9.2
10	250	18.4
15	166	27.5
20	125	37
30	83	55
40	62	73
50	50	92
75	33	140
100	25	184
150	17	275
200	2	370
300	8	550
400	6	730
500	5	920

FIG 3

Relating h_{FE} and required value of R_B assuming 5 V supply in Fig. 2.



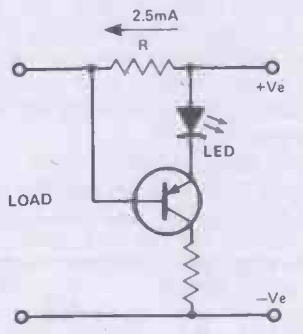
The circuit of the Transistor Gain Tester.



The component overlay on the PCB with the wiring connections.

How it Works

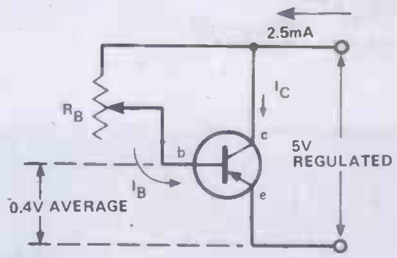
A meter movement is both fragile and expensive (and surprisingly bulky, too) so an LED is used to indicate that the current through a resistor is of a known value, 2.5 mA being chosen as reasonable for many common transistor's collector current. Assuming that the potential difference (PD) across the LED in Fig. 1. is 2 V and across the base-emitter junction is



OV6, when the voltage across R reaches 2V6 the transistor amplifies the small base current that flows and passes a considerably larger current through the LED. The maximum current that the transistor and LED can pass is then limited by another resistor in the collector circuit.

The battery voltage is monitored by a second LED, a series 5V6 zener diode ensuring that when the battery voltage drops below about 7V5 the LED extinguishes. The zener diode provides a useful reference voltage to feed the base of a series NPN regulator transistor that will supply the transistor under test (TUT) with a fairly stable voltage of (5V6 - 0V6), i.e. 5V.

Base current to the (TUT) in Fig. 2, is taken very simply via a variable resistor fed from the stable collector voltage and thus calibration accuracy is maintained over the range of battery voltage 7V5 to 9 V.



Calibration is derived from the I_C I_B relationship and Ohms Law as follows: the base-emitter volt-drop of a silicon transistor is typically OV6 while for a germanium transistor it is typically 0V2. Hence if the voltage at the 'top' of R_B is assumed to be 5V and the voltage at the 'bottom' as taken as an average value 0V4 (half-way between silicon and germanium values) then the current delivered by R_B to a transistor base obeys Ohms Law and is given by $I_B = 4V6/R_B$. Now since $h_{FE} = I_C/I_B$, a rearrangement of these formulae results in

$$h_{FE} = \frac{I_C \times R_B}{4V6} = \frac{2.5mA \times R_B}{4V6}$$ or it may be given as $$R_B = \frac{4V6 \times h_{FE}}{2.5\ mA} = 1.84 \times h_{FE}\ \text{kilohms}$$

A table of results, Fig. 3 is given relating h_{FE}, R_B and I_B for the particular voltages and currents used in this unit but the explanation given will allow other voltages for battery or zener diode to be used and a different collector current to be chosen if desired, the reader inserting these values in the formula and then reaching for his faithful calculator!

It should be noted that no correction has been made for the inclusion of the base current needed for transistors of gains less than twenty or so, the 2.5 mA 'collector' current indicated in these instances being the addition of $(I_B + I_C)$. At gains greater than twenty the small lack of accuracy is masked by other tolerances.

Transistor Gain Tester

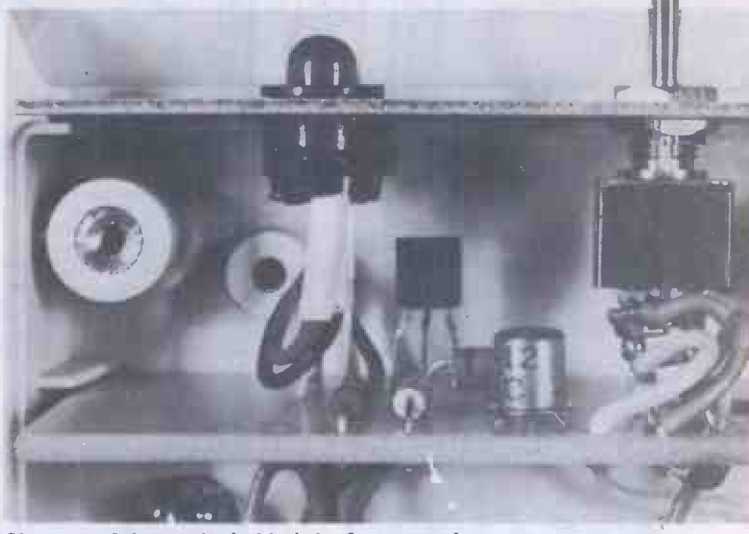
Parts List

RESISTORS. (All ¼ W 5%)
R1, 8k2
R2, 1k2
R3, 4, 1k0
R5, 820R
R6, 180R
R6, 180R
R7 See text.

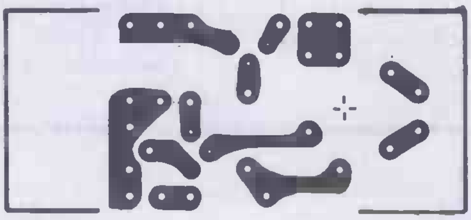
SEMICONDUCTORS
Q1, BC108
Q2, BC214L
ZDI, 5V6 400 mW Zener diode
LED 1, 2. TIL 209

MISCELLANEOUS
SW1 a/b DPDT switch (slide, or toggle)
SW2 SPST push to make
PCB to pattern
Transistor socket — see text.
Case to suit
PP3 battery and connector.

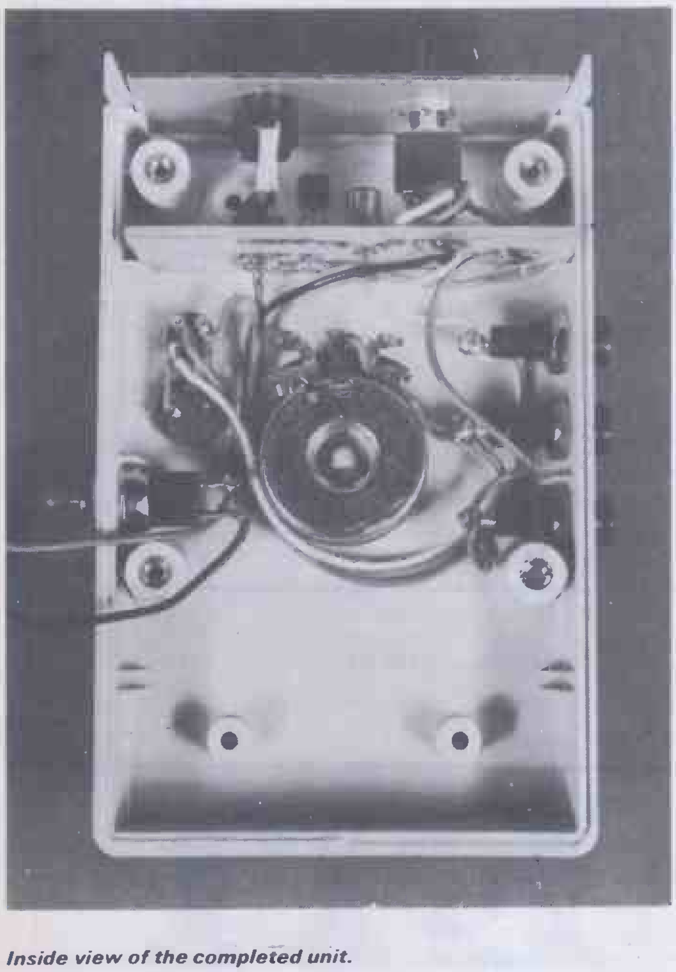
Approximate cost £3-£4



Close-up of the works behind the front panel.



The PCB pattern shown full size.



Inside view of the completed unit.

For neatness and versatility the e-b-c connections are made to a 3-pin DIN socket and two plugs used, one with flying leads and the other with a TO18 socket fixed in place with epoxy adhesive. There is of course no reason why you should not fit sockets and/or leads direct to the test unit.

CALIBRATION

When assembled, connect a variable resistor of around 2k in series with a milliammeter across the collector-emitter connections of the TUT. Close SW2 — the 'battery check' LED will light — and adjust the variable resistor until the milliameter indicates 2.5 mA (or as you may choose otherwise). Now with a known 2.5 mA current flowing in the 'collector' circuit, offer different values of resistance across R2 (around 4k7 probably) until LED1 is well lit, the same brilliance as LED2 and yet such that a drop from 2.5 mA to, say 2.2 mA results in LED1 being extinguished. Having selected your value for R7 solder it in place on the circuit board and LED1 is now calibrated to light at 2.5 mA.

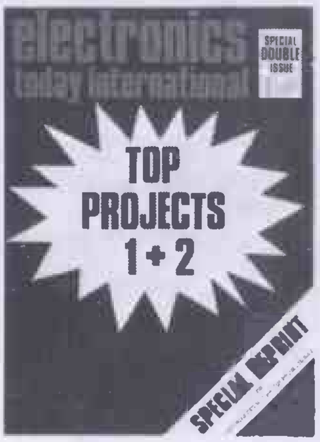
With SW2 closed, measure the collector-emitter voltage of the TUT. There *should* be some 5 V present but it is wise to actually measure and use the indicated voltage to aid your dial calibration if a particular zener diode of differing characteristics to that in the prototype is used.

Dial calibration is done last, quite simply, with an ohmmeter connected across the collector and base leads of the TUT, a transistor *not* in a circuit as well of course, and SW2 being open. Mark a card with h_{FE} values at appropriate points as RV1 pointer is adjusted in conjunction with Fig. 3, later trimming the card to shape, glueing down and then varnishing it beneath the pointer knob. In the prototype a dial was attached to a small knob and this dial calibrated and varnished.

In use, a transistor is connected to the flying leads or socket, PNP or NPN selected, SW2 pressed and RV1 adjusted until LED1 changes from 'off' to 'on', when the gain is indicated by the dial or scale. Simple, fast and short circuit proof!

It is worth remembering that the bigger germanium transistors have appreciable leakage as a matter of course and this leakage is frequently larger than 2.5 mA, the leaky transistor thus appearing to be short-circuit. As a general rule, if a silicon transistor leaks it is fit for the dustbin only; an ohmmeter is still a very useful first test of a transistor's polarity and leakage. **HE**

SPECIALS



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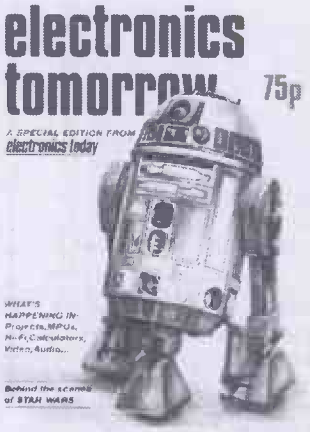

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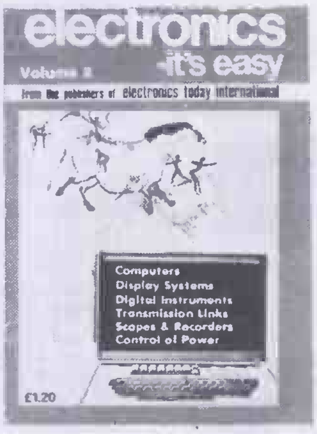

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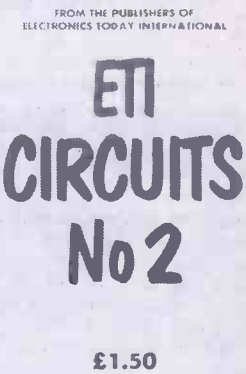

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I DON'T KNOW about you, but I like playing games. It's a sad fact though that most of my friends enjoy pub encounters of the alcoholic kind far more than the cut and thrust of a game of monopoly. To find a single person for a game of Mastermind is quite a struggle let alone the three necessary for a game of bridge. Once again it is electronics in the form of the MPU that has come to my rescue.

You've probably heard of MPUs, a lot of hysterical things have been said about them, to some writers in the popular press they seem to be a form of Anti-Christ. In fact the MPU is just the central part of a computer encapsulated in a single multi-legged IC. They are also very cheap.

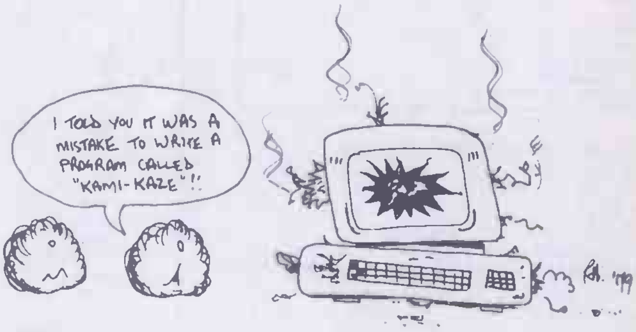
It's not taken game manufacturers very long to realise that these cheap devices which, with a bit of skilful programming, can be endowed with something resembling intelligence, there could be a boon to the games market. A rash of MPU based games was brought onto the market for Christmas and the signs are that at the end of this year the *only* game to buy will be an electronic one.

My favourite game at the moment has to be the Invicta Mastermind machine. This game makes you think, that is, you try to guess the hidden code in the least number of tries rather than the undignified exercise of solving the code in the least amount of time. The arcade type "reaction" games — road race et al — are all well and good, but the novelty soon wares off and then they are only used as a weapon to bore unwelcome callers.

NOT SO SIMPLE SIMON

The latest game in the States, and hence the next craze we are likely to see is a game called Simon. I've had many attempts at putting down on paper what this game does, but on reading them back they all seem confusing. If you don't like being confused, skip the next paragraph.

Simon presents the player with four coloured buttons, the object of the game being to press these in a sequence given by the machine. At first you have to press only one button, most people get this far. The machine soon expects you to remember a whole string of buttons which must be pushed in the correct order to continue and when, or if, you manage this it will tell you which colour button to add to the end of this ever lengthening chain. Quite a memory test and I'm told great fun. Confused, you won't be after the next issue of Hobby Electronics.



HISTORY TODAY

I keep on reading, in Hobby Electronics and other such high quality publications, that the world of electronics is a fast changing, exciting new field. So it is. It's also true that the world of education is anything but dynamic and fast moving — no disrespect to any teachers that have read this far. When these two worlds come into contact a certain amount of problems arise.

When I was at school, and that's only seven years ago, the only contact I had with electronics was a brief encounter with the operation of the valve during a Physics lesson. Hardly preparing me for the big world outside, unless of course I decided on a career in the repair of vintage radios.

Today there are signs that the situation is improving but a friend of mine at college seems to have spent most of his time building a single transistor radio, a worthwhile task, but again not much use in the modern world. Many of his friends learn more about electronics from magazines like HE than they do in the class room. I realise that not every member of a class will be interested in electronics, but for those who are why not make the course up to date, in doing so you will make it more interesting and much more valuable to all concerned.

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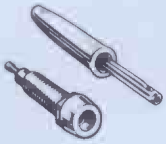

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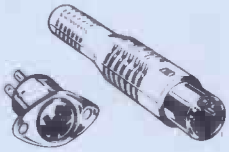

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1N4001	4p	1N5401	13p
1N4002	4p	1N5402	15p
1N4004	5p	1N5404	16p
1N4006	6p	1N5406	18p

BZY88 series 2V7 to 33V 8p each.

LINEAR

A SELECTION ONLY! DETAILS IN CATALOGUE.

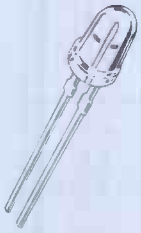
709	25p	LM324	50p	NE556	60p
741	22p	LM339	50p	NE565	120p
747	50p	LM380	75p	NE567	170p
748	30p	LM382	120p	SN76003	200p
CA3046	55p	LM1830	150p	SN76013	140p
CA3080	70p	LM3900	50p	SN76023	140p
CA3130	90p	LM3909	60p	SN76033	200p
OA3140	70p	MC1496	60p	TBA800	70p
LM301AN	28p	MC1458	35p	TDA1022	650p
LM318N	125p	NE555	25p	ZN414	75p

OPTO

LEDs	0.125in.	0.2in.	
Red	TIL209	TIL220	9p
Green	TIL211	TIL221	13p
Yellow	TIL213	TIL223	13p
Clips	3p	3p	

DISPLAYS

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



RESISTORS

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

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

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

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CAPACITORS

HERE ARE JUST A FEW OF THE CAPACITORS STOCKED

TANTALUM BEAD	each
0.1, 0.15, 0.22, 0.33, 0.47, 0.68,1 & 2.2uF @ 35V	9p
4.7, 6.8, 10uF @ 25V	13p
22 @ 16V, 47 @ 6V, 100 @ 3V	16p

MYLAR FILM	
0.001, 0.01, 0.022, 0.033, 0.047	3p
0.068, 0.1	4p

RADIAL LEAD ELECTROLYTIC

63V	0.47	1.0	2.2	4.7	10	5p
			22	33	47	7p
	100					13p
			220			20p
25V	10	22	33	47		5p
	100					8p
		220				10p
				470		15p
	1000					23p
10V		220				5p
				470		9p
	1000					13p
		2200				23p

74LS

		LS95	65p
		LS123	56p
		LS125	40p
		LS126	40p
LS00	16p	LS132	60p
LS01	16p	LS136	36p
LS02	16p	LS138	54p
LS03	16p	LS139	50p
LS04	16p	LS151	50p
LS08	16p	LS153	50p
LS10	16p	LS155	80p
LS13	30p	LS156	80p
LS14	70p	LS157	45p
LS20	16p	LS164	90p
LS30	16p	LS174	60p
LS32	24p	LS175	60p
LS37	26p	LS190	80p
LS40	22p	LS192	70p
LS42	53p	LS193	70p
LS47	70p	LS196	80p
LS48	48p	LS251	60p
LS54	16p	LS257	55p
LS73	29p	LS258	55p
LS74	29p	LS266	40p
LS75	44p	LS283	60p
LS76	35p	LS290	55p
LS78	35p	LS365	45p
LS83	60p	LS366	45p
LS85	70p	LS367	45p
LS86	33p	LS368	45p
LS90	45p	LS386	35p
LS93	45p	LS670	180p

TTL

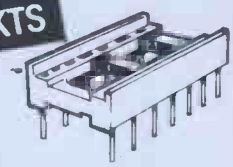
		7493	34p
		7494	52p
		7495	52p
		7496	50p
7400	12p	74121	25p
7401	12p	74122	33p
7402	12p	74123	40p
7404	12p	74125	35p
7408	14p	74126	35p
7410	12p	74132	50p
7413	25p	74141	56p
7414	48p	74148	90p
7420	12p	74150	70p
7427	24p	74151	50p
7430	12p	74156	52p
7442	43p	74157	52p
7447	55p	74164	70p
7448	58p	74165	70p
7454	14p	74170	125p
7473	25p	74174	68p
7474	25p	74177	58p
7475	32p	74190	72p
7476	28p	74191	72p
7485	70p	74192	64p
7489	145p	74193	64p
7490	32p	74196	55p
7492	35p	74197	55p

CMOS

FULL DETAILS IN CATALOGUE

		4029	60p
		4040	68p
4001	15p	4042	54p
4002	15p	4046	100p
4007	15p	4049	28p
4011	15p	4050	28p
4013	35p	4066	40p
4015	60p	4068	20p
4016	35p	4069	16p
4017	55p	4071	16p
4018	65p	4075	16p
4023	15p	4093	48p
4024	45p	4510	70p
4026	95p	4511	70p
4027	35p	4518	70p
4028	52p	4520	65p

SKTS



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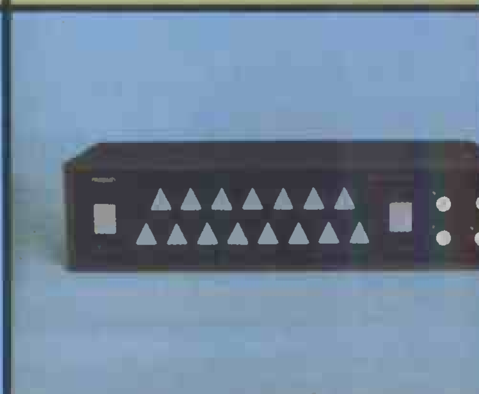

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