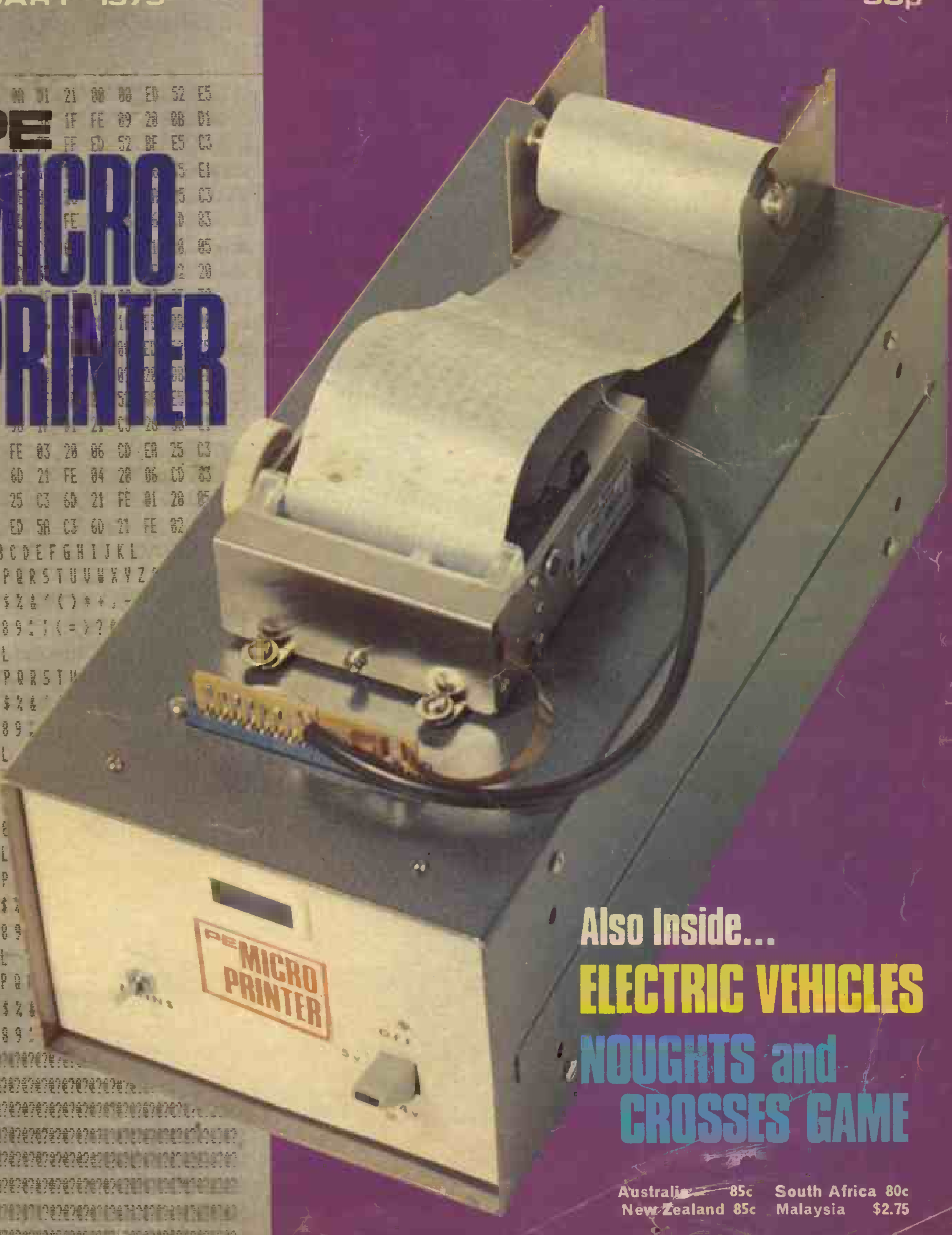
PRACTICAL

ELECTRONICS

JANUARY 1979

50p

PE MICRO PRINTER



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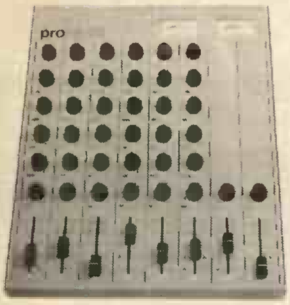

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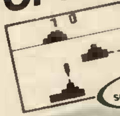

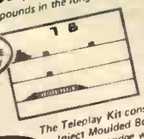
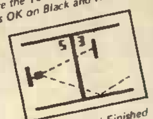


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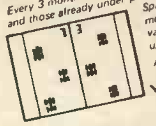

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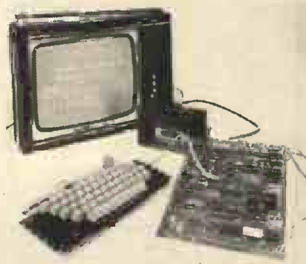

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PRACTICAL
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VOLUME 15 No. 1 JANUARY 1979

CONSTRUCTIONAL PROJECTS

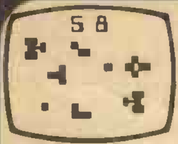
GENERAL FEATURES

NEWS AND COMMENT

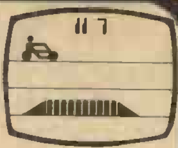
OUR FEBRUARY ISSUE WILL BE ON SALE FRIDAY, 12 JANUARY 1979
(for details of contents see page 51)

A MERRY CHRISTMAS AND A HAPPY 'VIDEO AND TIME' NEW YEAR

TUNE INTO BARGAIN TV GAMES AND COMPONENTS



tank battles



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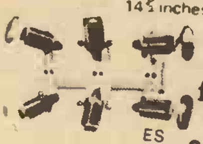

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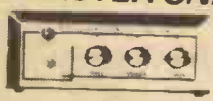

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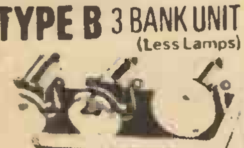

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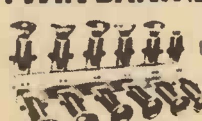
Length 31¾



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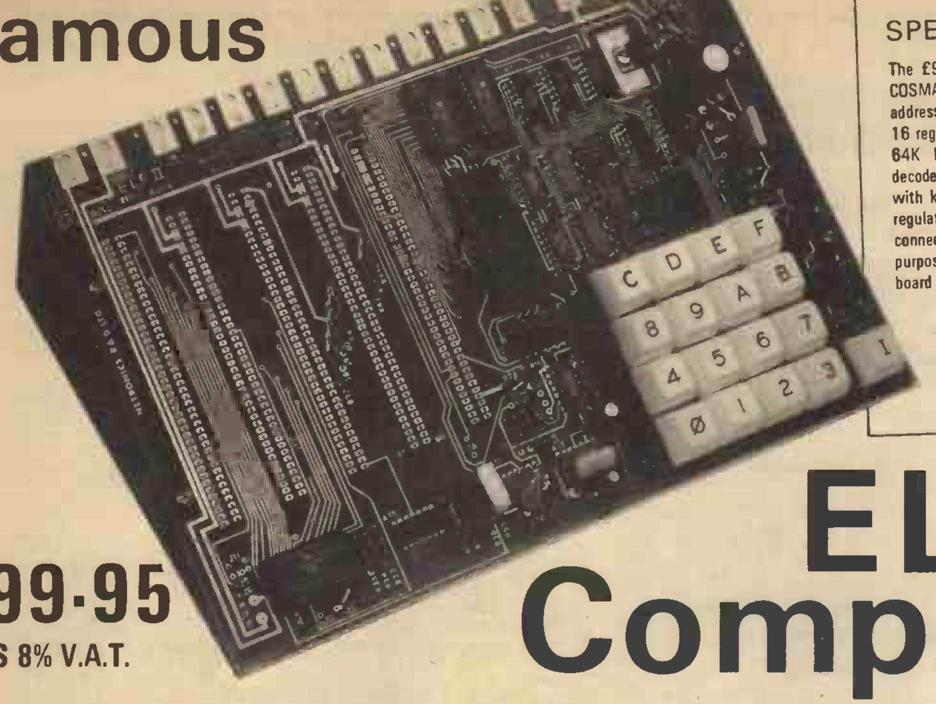

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☐ £109·56 including postage and V.A.T. for RCA COSMAC ELF II kit. ☐ £5·94 including postage and V.A.T. for power supply (required). ☐ £5·95 for RCA 1802 User's Manual. ☐ £5·95 including postage and V.A.T. for *Short Course on Microprocessor Computer Programming.*

☐ I want mine wired and tested with power supply, RCA 1802 User's Manual and *Short Course* included for just £164·10 including postage and V.A.T.

☐ I am also enclosing payment (including postage and V.A.T.) for the items checked at the left.

Total Enclosed £ ____________

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WATFORD ELECTRONICS

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ALL DEVICES BRAND NEW, FULL SPEC. AND FULLY GUARANTEED. ORDERS DESPATCHED BY RETURN OF POST. TERMS OF BUSINESS: CASH/CHEQUE/P.O.s OR BANKERS DRAFT WITH ORDER. GOVERNMENT AND EDUCATIONAL INSTITUTIONS' OFFICIAL ORDERS ACCEPTED. TRADE AND EXPORT INQUIRY WELCOME. P&P ADD 30p• TO ALL ORDERS UNDER £10.00. OVERSEAS ORDERS POSTAGE AT COST. AIR/SURFACE.

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POLYESTER CAPACITORS: Axial lead type. (Values are in µF)
400V: 0.001, 0.0015, 0.0022, 0.0033 7p; 0.0047, 0.0068, 0.01, 0.015, 0.018 9p; 0.022, 0.033, 10p; 0.047, 0.068 14p; 0.10 15p; 0.15, 0.22 22p; 0.33, 0.47 39p; 0.68 45p.
160V: 0.39, 0.15, 0.22 11p; 0.33, 0.47 19p; 0.68, 1.0 22p; 1.5 29p; 2.2 32p.
DUBILIER: 1000V: 0.01, 0.015 20p; 0.022 22p; 0.047 26p; 0.1 38p; 0.47 48p.

POLYESTER RADIAL LEAD (Values are in µF) **250V:** 0·01, 0·015, 0·022, 0·027 5p; 0·033, 0·047, 0·068, 0·1 7p; 0·15 11p; 0·22, 0·33 13p; 0·47 15p; 0·68 18p; 1·0 24p; 1·5 27p; 2·2 31p.

FEED THROUGH CAPACITORS 100µF 350V 8p

ELECTROLYTIC CAPACITORS: Axial lead type (Values are in µF) 500V: 10 40p; 47 68p; 250V: 100 65p; 63V: 0.47, 1.0, 1.5, 2.2, 2.5, 3.3, 4.7, 6.8, 8, 10, 15, 22 8p; 47, 32, 50 11p; 63, 100 27p; 50V: 1.0 7p; 50, 100, 220 25p; 470 50p; 1000 68p; 40V: 22, 33 7p; 100 12p; 2200, 3300 62p; 4700 64p; 35V: 10, 33 9p; 330, 470 32p; 1000 49p; 25V: 10, 22, 47 6p; 80, 100, 160 8p; 220, 250 13p; 470, 640 25p; 1000 27p; 1500 30p; 2200 41p; 3300 52p; 4700 54p; 16V: 10, 40, 47, 68 7p; 100, 125 8p; 330 14p; 470 16p; 1000, 1500 20p; 2200 34p; 10V: 4, 100 6p; 640 10p; 1000 14p.
70V: 2000 98p; 4700 121p; 50V: 10,000 255p; 40V: 2500 65p; 3300, 4700 70p; 15,000 450p; 25V: 4700 48p; 2200 37p; 325V: 200 + 100 + 50 + 100 190p.

TANTALUM BEAD CAPACITORS
35V: 0.1µF, 0.22, 0.33, 0.47, 0.68, 1.0, 2.2µF, 3.3, 4.7, 6.8; 25V: 1.5, 10; 20V: 1.5; 16V: 10µF 13p each, 47, 100 40p; 10V: 22µF, 33; 6V: 47, 68, 100; 3V: 68, 100µF 20p each.

POTENTIOMETERS (AB or EGEN)
Carbon Track, ¼W Log & ½W Linear values

500Ω, 1K & 2K (lin only), Single	27p
5KΩ-2MΩ single gang	27p
5KΩ-2MΩ single gang D/P switch	60p
5KΩ 2MΩ dual gang stereo	70p

OPTO ELECTRONICS★
LEDs plus clip

TIL209 Red	13
TIL211 Grn	18
TIL212 Yellow	22
·2" Red	15
·2" Yellow Green	19
Spare Clips	2
ORP12	63
2N5777	45
7 Seg Displays	
LS400	255
TIL307	675
TIL312 C An 3"	105
TIL313 C Cth 3"	105
TIL321 C An 5"	115
TIL322 C Cth 5"	115
DI704 C Cth ·3"	99
DL707 C.A. ·3"	99
FND357	120
MAN3640	175
LCD 3½ digit	915

MYLAR FILM CAPACITORS

100V: 0.001 0.002 0.005 0.01µF	6p
0.015 0.02 0.04 0.05 0.056µF	7p
0.1µF 0.2 9p 50V: 0.47µF	11p

SLIDER POTENTIOMETERS
0.25W log and linear values 60mm

5KΩ 500KΩ single gang	70p
10KΩ 500KΩ dual gang	80p
Self Stick Graduated Bezels	22p

CERAMIC CAPACITORS: 50V

0.5pF to 10nF	3p each
15nF 22nF 33nF 47nF	4p each
0.1µF	6p

PRESET POTENTIOMETERS
Vertical & Horizontal

0.1W 50Ω 5MΩ Miniature	8p
0.25W 100Ω 3.3MΩ Horiz	10p
0.25W 200Ω 4.7MΩ Vert	10p

POLYSTYRENE CAPACITORS
10pF to 1nF 8p; 1.5nF to 47nF 10p.

SILVER MICA (Values in pF) 3.3, 4.7, 6.8 10 12 18 22 33 47 50 68 75 82 85 100 120 150 220 9p each; 250 300 330 360 390 600 820 16p each; 1000 1800 2000 2200 20p each

RESISTORS — Erie make 5% Carbon Miniature High Stability Low noise

	RANGE	VAL	1-99	100+
¼W	2.2Ω-4.7M	E24	1.5p	1p
½W	2.2Ω-4.7M	E12	2p	1.5p
1W	2.2Ω 10M	E12	5p	4p
2% Metal Film	10Ω-1MΩ		6p	4p
1% Metal Film	51Ω-1M		10p	8p

100 price applies to Resistors of each type not mixed values

MINIATURE TYPE TRIMMERS

2.5 6pF 3 10pF 10 40pF	22p
5 25pF 5 45pF 60pF 88pF	30p

SWITCHES★

TOGGLE 2A 250V	
SPST	28p
DPDT	38p
4 pole on/off	54p
SUB-MIN TOGGLE	
SP changeover	59p
SPST on/off	54p
DPDT 6 tags	70p
DPDT Centre off	79p
DPDT Biased	115p
SLIDE 250V:	
1A DPDT	14p
1A DP c/over	15p
½A DPDT	13p
4 pole c/over	24p
PUSH BUTTON Spring loaded	
SPST on/off	60p
SPDT c/over	65p
DPDT 6 Tag	85p

COMPRESSION TRIMMERS

3-40pF, 10-80pF, 25-190pF	25p
100-500pF	45p

SPECIAL OFFER
IC741 (Texas) **17p•**
NE555 (Texas) **22p•**

SOLDERCON PINS•
100 pins 50p; 1000 pins 395p

	JACK PLUGS		SOCKETS		
	Screened chrome	Plastic body	open metal	moulded with break contacts	in line couplers
2·5mm	12p	8p	8p		11p
3·5mm	15p	10p	8p		12p
MONO	23p	15p	13p	20p	18p
STEREO	31p	18p	15p	24p	22p

	PLUGS	SOCKETS	In Line
DIN 2 PIN Loudspeaker	11p	7p	18p
3, 4, 5 Pin Audio	13p	8p	20p
CO-AXIAL (TV)	14p	14p	14p
PHONO assorted colours	9p	5p single / 8p double	15p / —
Metal Screened	12p	10p 3-way	20p
BANANA 4mm	11p	12p	—
2mm	10p	10p	—
1mm	7p	7p	—
WANDER 3mm	8p	8p	—

SWITCHES ★ Miniature Non-Locking
Push to Make 15p; Push to Break 25p
ROCKER (white) 10A 250V
SP changeover centre off 30p
ROCKER: (black) on/off 10A 250V 23p
ROCKER: Illuminated (white)
Lights when on: 3A 240V 52p
ROTARY: (ADJUSTABLE STOP) 1 pole/2-12 way 2p/2-6W 3p/2-4W 4p/2-3W 41p
ROTARY: Mains 250V AC. 4 Amp 45p

DIL SOCKETS ★ (Low Profile – Texas)
8 pin 10p; 14 pin 12p; 16 pin 13p; 18 pin 20p; 20 pin 27p; 24 pin 30p; 28 pin 42p; 40 pin 58p.

DIGITAL MULTIMETER

Announcing DM900 – The Digital Multimeter with a difference – It measures Capacitance too. *(as published in E.T.I. August 1978)*

Throw away your analogue meters, here's digital accuracy at only half the price of an equivalent commercial Multimeter.

The DM900 is a 3½ digit multimeter with an 0.5in L.C.D. display incorporating:

5 AC & DC Voltage ranges; 6 Resistance ranges.
5 AC & DC Current ranges; 4 Capacitance ranges.

The prototype accuracy is better than 1%.

This is a unique design using the latest MOS ICs and due to the minimal current drain, is powered by only one PP3 battery. There is also a battery check facility.

DM900 is an attractive hand-held lightweight device, built into a high impact case with carrying handle and has been ingeniously designed to simplify assembly.

Never before have all these features been offered to the electronics enthusiast in a single unit.

Price: **£54.50•** only (p&p insured add 80p)
Send SAE for leaflet.
Ready Built and tested units **£78.50•** including probes and carrying case (P&P insured 80p)
(Demonstration on at our shop)

PE VDU SYSTEMS

parts now available
(send SAE for list)

Convert your TV into a VDU by using the new Thomson-CSF, TV-CRT controller chip SF.F 96364. 16 lines by 64 characters, text refreshment, cursor management on TV screen, line erasing, line end erasing. Compatible with any computing system.

SFF 96364E	£11.75•
AY-5-1013UART	£4.50•
71301 ROM SFC	£8.20•
SFSB0102 RAM 1K	£2.05•
74LS163	£0.95•
MC1488	£0.85•
MC1489	£0.90•
SN75450	£1.20•
SN75451	£0.70•
SN75452	£0.70•
SN75454	£2.25•
2102 LF	£1.60•
2513	£5.95•
74LS132	£0.95•
81LS97	£1.09•
1 MHz crystal	£3.23•
14.31818 MHz	£2.70•
UHF Modulator	£2.50•

TTL 74★

7400	13
7401	13
7402	14
7403	14
7404	14
7405	16
7406	38
7407	38
740B	17
7409	17
7410	15
7411	20
7412	17
7413	30
7414	51
7416	30
7417	30
7420	16
7421	29
7422	24
7423	27
7425	27
7426	36
7427	27
7428	35
7430	17
7432	25
7433	40
7437	30
7438	33
7440	17
7441	74
7442	68
7443	115
7444	112
7445	94
7446	94
7447	82
7448	56
7450	17
7451	17
7453	17
7454	17
7460	17
7470	28
7472	25
7473	32
7474	27
7475	38
7476	36
7480	48
7481	86
7482	69
7483	72
7484	95
7485	106
7486	31
7489	210
7490	33
7491	75
7492	38
7493	32
7494	78
7495	65
7496	57
7497	189
74100	119
74105	62
74107	29
74109	54
74110	54
74111	68
74112	88
74116	198
74118	83
74119	119
74120	115
74121	25
74122	46
74123	48
74125	38
74126	57
74128	74
74132	73
74136	73
74141	56
74142	269
74143	314
74144	314
74145	65
74147	175
74148	109
74150	99
74151	64
74153	64
74154	96
74155	53
74156	80
74157	67
74159	210
74160	82
74161	92
74162	92
74163	92
74164	105
74165	105
74166	161
74167	198
74170	230
74172	625
74173	170
74174	87
74175	87
74176	75
74177	78
74178	102
74180	85
74181	165
74182	90
74184	135
74185	135
74188	275
74190	115
74191	105
74192	105
74193	105
74194	105
74195	95
74196	99
74197	85
74198	150
75150	110
75491	75
75492	80

CMOS★

4000	15
4001	17
4002	17
4006	105
4007	18
4008	87
4009	50
4010	50
4011	18
4012	18
4013	42
4014	86
4015	89
4016	45
4017	89
4018	89
4019	48
4020	99
4021	91
4022	88
4023	20
4024	66
4025	19
4026	180
4027	45
4028	81
4029	99
4030	50
4031	205
4032	100
4033	145
4034	196
4035	111
4036	325
4037	100
4038	108
4039	320
4040	105
4041	80
4042	75
4043	94
4044	88
4045	145
4046	128
4047	87
4048	58
4049	48
4050	48
4051	72
4052	72
4053	72
4054	110
4055	128
4056	134
4057	2570
4059	480
4060	115
4061	2380
4062	999
4063	110
4066	58
4067	380
4068	22
4069BE	20
4070	32
4071	21
4072	21
4073	21
4075	23
4076	85
4077	40
4078	21
4081	20
4082	21
4085	74
4086	73
40B9	150
4093	85
4094	190
4095	105
4096	105
4097	372
4098	110
4099	145
4160	109
4161	109
4162	109
4163	109
4174	110
4175	99
4194	108
4408	720
4409	720
4410	720
4411	995
4412F	1650
4412F	1380
4415F	795
4415V	795
4419	280
4422	545
4433	1180
4435	825
4440	1275
4450	295
4451	295
4490F	695
4490V	525
4501	17
4502	120
4503	69
4506	51
4507	55
4508	298
4510	99
4511	150
4512	98

LINEAR IC'S

702	75
709C 14 pin	35
710★	43
723★	45
733★	99
741C★ 8 pin	22
747C★	70
748C★	36
753	150
810	159
8038CC★	335
AY-1-0212	580
AY-1-1313	660
AY-1-1320	305
AY-1-5050	180
AY-1-5051	145
AY-1-6721/6	195
AY-3-8500★	385
AY-3-8710★	850
AY-5-1224A★	260
AY-5-1230★	450
AY-5-1315	560
AY-5-1317A	630
CA3011★	82
CA3020	170
CA3023	170
CA3028A★	80
CA3035	240
CA3043	190
CA3046	71
CA3048	200
CA3075	175
CA3080E★	70
CA3081	190
CA3089E	210
CA3090AQ	375
CA3123E	200
CA3130★	85
CA3140★	70
ICL7106E★	752
ICM7205★	1150
LD130★	452
LM301A	30
LM304	240
LM308	110
LM318	195
LM324★	79
LM339★	80
LM348★	95
LM379★	375
LM380	95
LM381	145
LM381AN	248
LM382	125
LM1458★	50
LM3900★	60
LM3909N★	70
LM3911★	125
M252AA★	750
M253AA★	795
MC724★	175
MC1303	88
MC1304P	260
MC1310	149
MC1312P	195
MC1488★	85
MC1489★	90
MC1495★	395
MC1496	92
MC1710★	79
MC3401	69
MC3340P★	150
MC3360P	120
MFC4000B	85
MFC6040★	97
MK50398★	635
MK50362★	650
MM2102-2★	170
MM2112★	105
MM2112-2★	295
MM57160★	620
NE518A★	210
NE555★	29
NE556D8★	60
NE560★	325
NE561★	395
NE562★	410
NE565A★	120
NE566★	160
NE567★	170
NE571★	420
RAM2102-2★	170
RC4136D★	120
ROM2513★	595
SG3402	295
SN76003N	175
SN76013N	140
SN76023N	140
SN76033N	175
SN76115N	215
SN76477★	225
SN76227	115
TAA621AX1	228
TAA960	300
TBA120S	70
TBA5400	215
TBA550Q	330
TBA641BX11	250
TBA651	180
TBA800	90
TBA810S	99
TBA820	70
TBA920Q	260
TDA1022★	575
TDA2020	320
TLO71CP★	60
TLO81CP★	52
TLO82CP★	96
TLO84CP★	130
UAA170	198
ZN414	90
ZN424	130
ZN425E★	410

TRANSISTORS

AC117★	35
AC125★	20
AC126★	20
AC127★	20
AC128★	20
AC141★	24
AC141K★	38
AC142★	24
AC142K★	38
AC176★	18
AC187★	20
AC188★	20
ACY17★	35
ACY18★	40
ACY19★	40
ACY20★	40
ACY21★	35
ACY22★	40
ACY28★	40
ACY39★	78
ACY40★	48
ACY44★	39
AD140★	69
AD149★	70
AD161★	42
AD162★	42
AF114★	25
AF115★	25
AF116★	25
AF117★	25
AF118★	55
AF121★	48
AF124★	55
AF125★	35
AF127★	35
AF139★	35
AF178★	70
AF180★	70
AF186★	50
AF239★	42
ASY26★	40
ASY27★	45
BC107★	9
BC1078★	10
BC108★	9
BC108B★	12
BC108C★	12
BC109★	9
BC109B★	12
BC109C★	12
BC113	17
BC114	19
BC115	19
BC116	19
BC117	15
BC118	19
BC119★	28
BC134	19
BC135	20
BC136	18
BC137	20
BC140★	28
BC142★	25
BC143★	25
BC147	7
BC148	7
BC149	8
BC153	14
BC154	14
BC157	10
BC158	11
BC159	11
BC160	27
BC167A	11
BC168C	12
BC169C	10
BC170	17
BC171	11
BC172	10
BC177★	17
BC178★	17
BC179★	17
BC182	9
BC182L	10
BC183	9
BC183L	10
BC184	9
BC184L	10
BC186	21
BC187★	28
BC212	9
BC212L	10
BC213	9
BC213L	11
BC214	9
BC214L	10
BC3078	14
BC308	13
BC328	13
BC338	12
BC441★	30
BC461★	30
BC477★	25
BC547	11
BC548	11
BC549C	13
BC557	13
BC558	12
BCY30★	57
BCY34★	75
BCY39★	80
BCY40★	78
BCY43	75
BCY58★	22
BCY59★	22
BCY70★	15
BCY71★	17
BCY72★	17
BCY78★	20
BD115★	62
BD121★	95
BD123★	98
BD124★	115
BD131★	38
BD132★	38
BD133★	43
BD135★	36
BD136★	37
BD137★	36
BD138★	36
BD139★	45
BD140★	50
BD142★	59
BD145★	198
BD222★	60
BD695A★	75
BD696A★	75
BDY17★	195
BDY60★	110
BDY61★	165
BF115★	22
BF154★	25
BF156★	29
BF167	25
BF173★	25
BF177★	24
BF178★	25
BF179★	30
BF180★	20
BF181★	30
BF182★	30
BF183★	30
BF184★	30
BF194	10
BF195	10
BF196	10
BF197	10
BF198	18
BF200★	28
BF224A	18
BF244	24
BF256★	50
BF257★	26
BF258★	30
BF259★	32
BF394	22
BF594	40
BF595	38
BFR39	25
BFR40	25
BFR79	28
BFR80	28
BFX29★	26
BFX81★	130
BFX84★	24
BFX85★	24
BFX86★	28
BFX87★	23
BFX88★	24
BFY18★	50
BFY50★	20
BFY51★	20
BFY52★	20
BFY71★	20
BSX20★	18
BSY65★	30
BSY95★	25
BSY95A★	25
BU105	140
BU205★	190
BU208★	228
E5567	65
MD8001★	158
ME4102	10
ME6002	14
MJ400★	90
MJ491★	190
MJ2955★	99
MJE340★	50
MJE370★	55
MJE371★	60
MJE520★	45
MJE521★	65
MJE2955★	99
MJE3055★	70
MPF102	30
MPF103	36
MPF104	36
MPF105	36
MPF106	50
MPF107	50
MPSA05★	24
MPSA06★	24
MPSA12	42
MPSA55	24
MPSA56	24
MPSA70	34
MPSU02★	58
MPSU05	48
MPSU06	54
MPSU52★	65
MPSU55★	53
MPSU56★	56
MPU131★	39
OC25★	120
OC26★	150
OC28★	99
OC29★	160
OC35★	80
OC36★	99
OC41★	48
OC42★	32
OC43★	55
OC44★	31
OC45★	20
OC46★	28
OC70★	19
OC71★	25
OC72★	30
OC76★	36
OC77★	76
OC79★	76
OC81★	28
OC82★	45
OC83★	48
OC84★	44
OC122★	48
OC123★	48
OC139★	85
OC140★	85
OC141★	85
OC170★	40
OC171★	40
OC201★	75
OC202★	85
OC203★	85
OC204★	85
TIP29	43
TIP29A	44
TIP29C	60
TIP30	47
TIP30A	47
TIP30B	64
TIP30C	65
TIP31★	40
TIP31A★	40
TIP31B★	40
TIP31C★	66
TIP32★	45
TIP32A★	49
TIP32B★	70
TIP32C★	70
TIP33★	80
TIP33A★	80
TIP33B★	100
TIP33C★	105
TIP34★	85
TIP34A★	85
TIP34B★	110
TIP34C★	110
TIP35★	219
TIP35A★	225
TIP35C★	270
TIP36A★	265
TIP36C★	325
TIP41A★	63
TIP41B★	73
TIP42A★	64
TIP42B★	82
TIP2955★	63
TIP3055★	60
TIS43	36
TIS44	45
TIS46	45
TIS50	47
TIS60	45
TIS62	45
TIS74	47
TIS90	18
TIS91	22
ZTX107	11
ZTX108	11
ZTX109	11
ZTX300	13
ZTX301	16
ZTX302	18
ZTX303	21
ZTX304	24
ZTX311	17
ZTX314	24
ZTX326	40
ZTX341	20
ZTX500	13
ZTX501	14
ZTX502	19
ZTX503	15
ZTX504	25
ZTX531	25
ZTX550	25
2N526★	58
2N696★	35
2N697★	21
2N698★	39
2N699★	39
2N706A★	19
2N707★	50
2N708★	19
2N914★	32
2N916★	27
2N918★	30
2N920★	51
2N930★	18
2N961★	61
2N1131★	22
2N1132★	22
2N1302★	35
2N1303★	50
2N1304★	50
2N1305★	28
2N1306★	35
2N1307★	50
2N1308★	46
2N1613★	23
2N1670★	150
2N1671B★	195
2N1893★	28
2N1986★	60
2N2160★	105
2N2217★	48
2N2218A★	31
2N2219A★	22
2N2220A★	20
2N2221★	23
2N2222★	20
2N2297	45
2N2303★	45
2N2368★	21
2N2369★	15
2N2476★	125
2N2483★	28
2N2484★	30
2N2646★	48
2N2784★	55
2N2846★	140
2N2894★	30
2N2904A★	22
2N2905A★	20
2N2906★	18
2N2907★	20
2N2907A★	22
2N2926G	10
2N29260	8
2N2926R	8
2N2926Y	8
2N3011★	24
2N3053★	20
2N3054★	49
2N3055★	55
2N3108	39
2N3121	40
2N3133	43
2N3135	33
2N3250	30
2N3252	36
2N3302	35
2N3442★	131
2N3563	20
2N3614★	169
2N3615★	135
2N3663	24
2N3702	10
2N3703	11
2N3704	10
2N3705	11
2N3706	10
2N3707	10
2N3708	10
2N3709	10
2N3710	16
2N3711	10
2N3715★	250
2N3772★	170
2N3773★	288
2N3819	22
2N3820	32
2N3823★	65
2N3824★	70
2N3866★	90
2N3903	16
2N3904	18
2N3905	18
2N3906	17
2N4037★	52
2N4058	17
2N4061	17
2N4064★	120
2N4236★	145
2N4289	20
2N4859	65
2N5135	42
2N5136	42
2N5138	20
2N5179★	60
2N5180★	80
2N5191★	65
2N5305★	24
2N5457	32
2N5458	32
2N5459	32
2N5485	32
2N5777★	45
2N6027	40
40311★	50
40313★	125
40316★	85
40317★	52
40324★	85
40326★	52
40327★	62
40347★	80
40348★	101
40360★	43
40361★	45
40362★	48
40407★	50
40411★	289
40412★	63
40467★	95
40576★	190
40594★	80
40595★	90
40603★	58
40636★	125
40673★	68

Diodes

IN4148	4
CRO33★	148
Zeners 400mw 2.7-33v	9

AND OTHER PROJECTS

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

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

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

KIMBER-ALLEN KEYBOARDS AND CONTACTS

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

3 Octave (37 notes)	£25·50
4 Octave (49 notes)	£32·25
5 Octave (61 notes)	£39·75

Contact Assemblies (gold-clad wire) for use with the above keyboards (1 required for each note):

Type GJ: Single-pole change-over	each 25½p
Type GB: 2 pairs of contacts, each pair normally open	each 28½p
Type GC: 3 pairs of contacts, each pair normally open	each 37½p
Type GE: 4 pairs of contacts, each pair normally open	each 46½p
Type GH: 5 pairs of contacts, each pair normally open	each 58½p
Type 4PS: 3 pairs of contacts plus single-pole changeover	each 57p

Printed Circuit Boards for use with GJ, GB and 4PS contacts (thus eliminating much interwiring) are available. Details in our lists.

RHYTHM GENERATOR

15-Rhythm Tempo, Timing and Logic control unit (excl. sw's but incl. PCB)	£9·75
10-Instrument Effects circuits	£14·23
PCB for Effects circuits	£4·25
Power Supply incl. PCB	£8·75

128-NOTE TUNE-PROGRAMMABLE SEQUENCER (P.E. Nov/Dec 77)

Enables a voltage controlled synthesiser to automatically play pre-programmed tunes of up to 32 pitches and 128 notes long. Programs are keyboard initiated and note length and rhythmic pattern are externally variable. (Please use order codes quoted in brackets.)

Main Circuit (Nov) excl. sw's (KIT 76-1)	£18·03
Power Supply (KIT 76-3)	£4·72
Trigger Inverter and Alt. Output (KIT 76-2)	£1·15
LED Counter (KIT 76-4)	£2·10
PCB (as published) for KITS 76-1 & 3 (PCB 76A)	£2·61
PCB for KITS 76-2 & 4 (PCB 76B)	£2·54

P.E. STRING ENSEMBLE (PE Mar-July 78)

The new keyboard string-instrument synthesiser.

Basic component sets:

Power Supply (KIT 77-1)	£8·77
Tone Generator (KIT 77-2)	£14·66
Diode Gates (KIT 77-3)	£18·81
Chorus Generator (KIT 77-4)	£19·08
Voicing System (KIT 77-5)	£7·38

Printed Circuit Boards:

Double-sided PCB for Power Supply, Tone Generator & Diode Gates with most of the Matrix wiring as printed tracking (PCB 77L/R)	£18.40
PCB for Chorus Generator (PCB 77C)	£2.65
PCB for Voicing System (PCB 77D)	£2.62

Fuller details of kits & PCBs are in our lists.

FORMANT SYNTHESISER (Elektor 1977/78)

Very sophisticated music synthesiser for the advanced constructor who puts performance before price. Details in our lists.

DISCOSTROBE (P.E. Nov. 76)

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

Basic component set	£18·19
Printed circuit board	£3·45

BIOLOGICAL AMPLIFIER (P.E. Jan./Feb. 73)

Multi-function circuits that, with the use of other external equipment, can serve as lie-detector, alphaphone, cardiophone etc.

Pre-Amp Module Components set (incl. PCB)	£3·95
Basic Output Circuits—combined component set with PCBs, for alphaphone, cardiophone, frequency meter and visual feed-back lampdriver circuits.	£6·59
Audio Amplifier Module Type PC7	£7·75

10% DISCOUNT VOUCHER (PE7/1)

TERMS: Correctly costed, C.W.O., U.K. orders over £50 goods value. Valid until end of month on cover of P.E. This voucher must accompany order.

TRANSISTORS

AC128	32p
AC176	28p
BC107	13p
BC108	13p
BC109	15p
BC109C	16p
BC177	18p
BC184	11p
BC187	18p
BC204	10p
BC209C	13p
BC213	11p
BC214	11p
BC262	18p
BC415	15p
BC478	15p
BD131	60p
BD132	44p
BF244A	32p
BF245A	38p
BSY95A	22p
MD8001	210p
OC71	20p
OC72	30p
RPY58A	62p
TIS43	50p
ZTX108	7½p
ZTX301	13p
ZTX384	12p
ZTX501	13p
2N2219	28p
2N2646	70p
2N2905	28p
2N2905A	29p
2N2906	22p
2N2907	24p
2N3054	68p
2N3055	76p
2N3702	12p
2N3704	12p
2N3819	24p
2N3820	61p
2N3823E	39p
2N5459	45p

INTEGRATED CIRCUITS

301	8-pin DIL	48p
318	8-pin DIL	220p
320-15	---	195p
324	14-pin DIL	87p
341-15	---	87p
709	8-pin DIL	48p
723	TO5	87p
723	14-pin DIL	51p
726	TO5	1005p
741	8-pin DIL	24p
748	8-pin DIL	57p
4007	14-pin DIL	17½p
4011	14-pin DIL	17½p
4024	14-pin DIL	46½p
4069	14-pin DIL	18p
4136	14-pin DIL	126p
AM2833	8-pin DIL	360p
AY10212	16-pin DIL	617p
AY16721/6		188p
CA3046	14-pin DIL	71p
CA3080	8-pin DIL	63p
CA3084	14-pin DIL	209p
FX209	16-pin DIL	729p
LM323	---	562p
M252	16-pin DIL	680p
MC3340	8-pin DIL	150p
MCM6810	24-pin DIL	670p
SG3402N	14-pin DIL	262p
STK025	---	595p
TDA1022	16-pin DIL	582p
XR2207	14-pin DIL	420p
ZN425E	16-pin DIL	375p

PRICES ARE CORRECT AT TIME OF PRESS.
E. & O. E. DELIVERY SUBJECT TO AVAILABILITY.

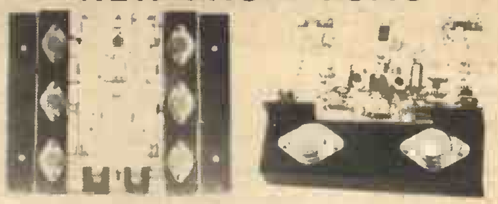
PHONOSONICS

TUAC

TRANSISTOR UNIVERSAL AMPLIFICATION CO. LTD.
PHONE 01-672 3137/672 9080
MANUFACTURERS OF QUALITY AMPLIFICATION AND LIGHTING CONTROL SYSTEMS

NEW FROM TUAC

TD500 TD150



7″ x 9″ x 1¾″ ULTRA QUALITY HIGH POWER 5″ x 5″ x 2″
New D.C. Coupled Design
AMPLIFIERS

Featuring—Electronic Short Open and Thermal Overload Protection.
Brief Spec.—Input Sensitivity 0·775 v. R.M.S. (O.D.B.) at 25K Ohms.
Frequency Response 20 Hz – 20 KHz. T.H.D. at full power 0·1%.
Hum and Noise—100 dB Relative full output.

T.D. 500 300W into 2 Ohms. 220W into 4 Ohms. 140W into 8 Ohms.	£45·00
Power supply P.S.300	£30·00
T.D.150 150W into 4 Ohms. 100W into 8 Ohms.	£26·25
Power supply P.S. 150	£18·50
T.D. 150 60 Version 60W into 8 Ohms. 40W into 15 Ohms.	£17·75
Power supply P.S.60	£15·50

Note—P.S. 300 will drive 2 T.D. 150 amplifiers
All output ratings are R.M.S. continuous sine wave output.

TO ORDER BY POST
Make cheques/P.O.s payable to TUAC LTD (PE 19) or quote Access/Barclay Card No. (We accept holders phone orders 01 672 9080.)
Post to:—
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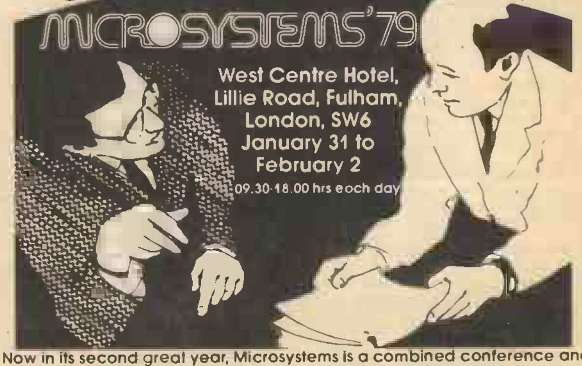
Send stamp for our free 28 page catalogue of LIGHTING & AMPLIFIER MODULES, etc

THE BRIDGE BETWEEN MANUFACTURERS & USERS OF MICROELECTRONICS



Now in its second great year, Microsystems is a combined conference and exhibition aimed at alerting industrialists and businessmen to the meaning of the microelectronic revolution.

The Exhibition is free. The Conference costs £55 + VAT for each of the first two, professional days (£95 + VAT for a two-day ticket), and £7 + VAT for the final, personal computing, day.

Microsystems is sponsored by 'Computer Weekly'.

'Microprocessors', 'Data Processing', 'Electronics Weekly', 'Systems International', 'Electron', 'Electrical Times', 'Electrical Review' and 'Wireless World' and is organised for them by Iliffe Promotions Ltd, Dorset House, Stamford Street, London, SE1 9LU.

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To: Microsystems, Room 821, Dorset House, Stamford Street, London, SE1 9LU.

Please send me: ☐ Conference details and registration forms
☐ A free exhibition ticket (Tick as required)

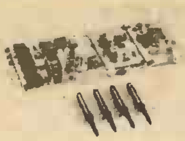
Name ....

Address ....

High quality audio modules for Stereo and mono

S450

STEREO FM TUNER Fitted with phase lock-loop



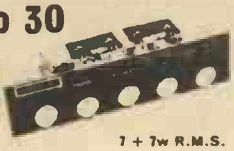
£23·24
+ 40p p&p
+ 12½% VAT

FREQUENCY RANGE	88–108 Mhz
SENSITIVITY	3·0 µV
BANDWIDTH	250 kHz
SPURIOUS REJECTION	50 dB
SELECTIVITY ± 400 kHz	55 dB
AUDIO OUTPUT (22·5 kHz deviation)	100 mV
STEREO SEPARATION	30 dB
SUPPLY REQUIREMENTS	20 to 30V (90mA max)
AERIAL IMPEDANCE	75 ohms
DIMENSIONS	240mm × 110mm × 32mm

The 450 Tuner provides instant programme selection at the touch of a button ensuring accurate tuning of 4 pre-selected stations, any of which may be altered as often as you choose, simply by changing the settings of the pre-set controls. Features include FET input stage. Vari-Cap diode tuning. Switched AFC LED Stereo Indicator.

Stereo 30

COMPLETE AUDIO CHASSIS



£19·18
+ 40 p&p
+ 12½% VAT

7 + 7w R.M.S.

OUTPUT POWER	7 Watts RMS
LOAD IMPEDANCE	8 ohms
TOTAL HARMONIC DISTORTION	Less than ·5% (Typically ·3%)
FREQUENCY RESPONSE	50 Hz to 20 kHz ± 3dBs
TONE CONTROL RANGE	± 12 dBs at 100Hz and 10kHz
SENSITIVITY	190 mV for full output
INPUT IMPEDANCE	1 M ohms
TRANSFORMER REQUIREMENTS	22 V.A.C. rated at 1A
DIMENSIONS (Less controls and panel)	200mm × 130mm × 33mm

The Stereo 30 comprises a complete stereo pre-amplifier, power amplifiers and power supply. This, with only the addition of a transformer or overwind will produce a high quality audio unit suitable for use with a wide range of inputs i.e. high quality ceramic pick-up, stereo tuner, stereo tape deck etc. Simple to install, capable of producing really first class results, this unit is supplied with full instructions, black front panel, knobs, main switch, fuse and fuse holder and universal mounting brackets.

AL60

25w R.M.S.

AUDIO AMPLIFIER MODULE 25 Watts RMS

£4·69 + 35p p&p
+ 12½% VAT

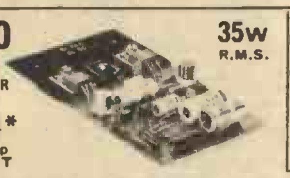
OUTPUT POWER	25 Watts RMS
SUPPLY	30–50 V
LOAD IMPEDANCE	8–16 ohms
TOTAL HARMONIC DISTORTION	Less than ·1% (Typically ·06%)
FREQUENCY RESPONSE	20 Hz to 30 kHz × 2 dBs
SENSITIVITY	280 mV for full output
MAX. HEAT SINK TEMPERATURE	90°C
DIMENSIONS	103mm × 64mm × 15mm

This high quality audio amplifier module is for use in audio equipment and stereo amplifiers and provides output powers up to 25 RMS with distortion levels below 0·1%.

AL80

35w R.M.S.

AUDIO AMPLIFIER MODULE



£7·34*
+ 35p p&p
+ 8% VAT

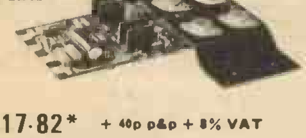
OUTPUT POWER	35 Watts RMS
SUPPLY	40–60 V
LOAD IMPEDANCE	8–16 ohms
TOTAL HARMONIC DISTORTION	Less than ·1% (Typically ·06%)
FREQUENCY RESPONSE	20 Hz to 30 kHz × 2 dBs
SENSITIVITY	280 mV for full output
MAX. HEAT SINK TEMPERATURE	90°C
DIMENSIONS	103mm × 64mm × 15mm

The AL80 is similar in design to the AL60 above and is of the same high quality but provides output powers up to 35W with distortion levels below 0·1%.

AL250

125w R.M.S.

POWER AMPLIFIER



£17·82* + 40p p&p + 8% VAT

OUTPUT POWER	125 Watts RMS continuous
OPERATING VOLTAGE	50–80 V
LOADS	4–16 ohms
FREQUENCY RESPONSE	25 Hz 20 kHz measured at 100 Watts
SENSITIVITY FOR 100 WATTS O/P AT 1 kHz	450 mV
INPUT IMPEDANCE	33 K ohms
TOTAL HARMONIC DISTORTION	
50 WATTS into 4 ohms	0·1%
50 WATTS into 8 ohms	0·06%

This unit, designated AL250, is a power amplifier providing an output of up to 125W RMS, into a 4 ohm load.

AL30A

10w R.M.S.

AUDIO AMPLIFIER MODULES

£3·79 + 35p p&p
+ 12½% VAT

MAXIMUM SUPPLY VOLTAGE	30 V
POWER OUTPUT for 2% THD	10 Watts RMS
TOTAL HARMONIC DISTORTION	Less than ·25%
LOAD IMPEDANCE	8–16 ohms
INPUT IMPEDANCE	100 K ohms
FREQUENCY RESPONSE	50 Hz–25 kHz ± 3 dBs
SENSITIVITY	75 mV for full output
DIMENSIONS	74mm × 63mm × 28mm

These low cost 5 and 10 watt modules offer the utmost in reliability and performance, whilst being compact in size.

SPM80

STABILISED POWER SUPPLY

£4·40 + 35p p&p
+ 12½% VAT

INPUT A.C. VOLTAGE	33–40V
OUTPUT D.C. VOLTAGE	33 V nominal
OUTPUT CURRENT	10 mA–1·5 amps
OVERLOAD CURRENT	1·7 amps approx.
DIMENSIONS	105mm × 63mm × 30mm

Designed to power two AL60s at 15 Watts per channel simultaneously. Circuit Techniques include full short circuit protection.

PA100

STEREO PRE-AMPLIFIER

£16·05
+ 40p p&p
+12½% VAT

FREQUENCY RESPONSE	20 Hz to 20 kHz × 1 dB
TOTAL HARMONIC DISTORTION	Less than ·1% (Typically ·07%)
SENSITIVITY INPUTS 1. TAPE	100 mV/100 K ohms } For an output 250 mV
2. RADIO TUNER	100 mV/100 K ohms
3. MAGNETIC P.U.	3·5 mV/50 K ohms
EQUALISATION	Within ± 1 dB from 20 Hz to 20 kHz
BASS CONTROL RANGE	± 15 dBs at 75 Hz
TREBLE CONTROL RANGE	+ 10–20 dBs at 15 kHz
SIGNAL/NOISE RATIO	Better than 65 dBs (All inputs)
INPUT OVERLOAD	Better than 26 dBs (All inputs)
SUPPLY	20 to 40 V
DIMENSIONS	300 × 90 × 33mm (less controls)

A top quality stereo pre-amplifier and tone control unit, the PA100 provides a comprehensive solution to the front end requirements of stereo amplifiers or audio units. The six push button selector switch gives a choice of inputs together with two filters for high and low frequencies.

MPA30

MAGNETIC CARTRIDGE PRE-AMPLIFIER

£2·98
+35p p&p
+ 12½% VAT

Enjoy the quality of a magnetic cartridge with your existing ceramic equipment using the MPA 30 which is a high quality pre-amplifier enabling magnetic cartridges to be used where facilities exist for the use of ceramic cartridges only.

SENSITIVITY	3·5 mV for 100 mV output
EQUALISATION	Within ± 1 dB from 20 Hz to 20 kHz
INPUT IMPEDANCE	50 K ohms
SUPPLY	18 to 30 V—re earth
DIMENSIONS	110 × 50 × 25mm (inc DIN socket)

PA12

STEREO PRE-AMPLIFIER

£7·78
+ 30p p&p
+ 12½% VAT

The PA12 Stereo Pre-Amplifier chassis is designed and recommended for use with the AL 20/30 Audio Amplifier Modules, the PS12 power supply and the T538 Transformer. Features include on/off volume, Balance, Bass and Treble controls. Complete with tape output.

FREQUENCY RESPONSE	20 Hz–20 kHz (—3dB)
BASS CONTROL	± 12 dB at 60 Hz
TREBLE CONTROL	± 14 dB at 10 kHz
INPUT IMPEDANCE	1 Meg. ohm
INPUT SENSITIVITY	300 mV
CROSSTALK	—60 dB
SIGNAL/NOISE RATIO	—65 dB
OVERLOAD FACTOR	± 20 dB
TAPE OUTPUT IMPEDANCE	25 K ohms
DIMENSIONS	152mm × 84mm × 25mm

PS12 POWER SUPPLY MODULE

Power supply for AL20A-30A, PA12, S450 etc.
Transformer T538.

Input A.C. Voltage 15–20V.
Output D.C. Voltage 22–30V approx. (Dependent upon input.)
Output Current 800mA maximum.
Dimensions 60 x 43 x 26mm.

£1·50
+ 12½% VAT + 35p p&p.

BP124 SIREN ALARM MODULE

American Police screamer powered from any 12 volt supply into 4 or 8 ohm speaker. Ideal for car burglar alarm, freezer break-down, and other security purposes.

ONLY £3·50
+ 8% VAT + 35p p&p.

MA60 HI-FI AMPLIFIER KIT

Build you own top quality amplifier, save yourself pounds. The MA60 kit comprises the following BI-kits modules, 2 × AL60 amps, 1 × PA100 pre-amp, 1 × SPM80 stab. power supply, 1 × BMT80 transf. giving 17 watts RMS per channel STEREO. All modules covered by the BI-PAK satisfaction or money back guarantee. Details of the above modules are in this ad.
Price £32·00 + 12½% VAT + 62p p&p.

TC60 KIT

A beautifully designed genuine TEAK WOOD veneered cabinet to put the professional touches to your home built amplifier. Full set of parts incl. Front & Back Panels, Knobs, Chassis, Fuses, Sockets, Noen, etc. Ideal for the MA60. Size: 425mm × 290mm × 95mm.
Price £19·95 + 12½% VAT + 86p p&p

TRANSFORMERS

T538 For use with S.450 AL30A MPA30
Order No. 2036 Price: £3·20 + 55p p&p + 12½% VAT
T2050 For use with Stereo 30
Order No. 2050 Price: £3·25 + 55p p&p + 12½% VAT
BMT80 For use with AL60 SPM80
Order No. 2034 Price: £5·40 + 86p p&p + 12½% VAT
BMT250 For use with AL250
Order No. 2035 Price: £6·35 + £1·10 p&p + 12½% VAT

BI-PAK

DEPT. PE1, P.O. Box 6, Ware, Herts.

LOOK !

Here's how you master electronics.

.... the practical way.

This new style course will enable anyone to have a real understanding by a modern, practical and visual method. No previous knowledge is required, no maths, and an absolute minimum of theory.

You learn the practical way in easy steps mastering all the essentials of your hobby or to further your career in electronics or as a self-employed electronics engineer.

All the training can be carried out in the comfort of your own home and at your own pace. A tutor is available to whom you can write, at any time, for advice or help during your work. A Certificate is given at the end of every course.

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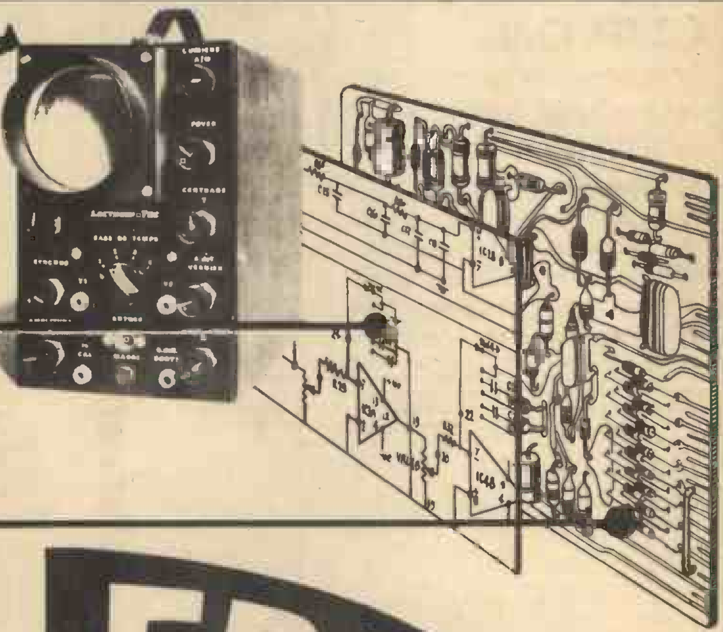
As the first stage of your training, you actually build your own Cathode ray oscilloscope! This is no toy, but a test instrument that you will need not only for the course's practical experiments, but also later if you decide to develop your knowledge and enter the profession. It remains your property and represents a very large saving over buying a similar piece of essential equipment.



2. Read, draw and understand circuit diagrams.

In a short time you will be able to read and draw circuit diagrams, understand the very fundamentals of television, radio, computers and countless other electronic devices and their servicing procedures.

3. Carry out over 40 experiments on basic circuits.

We show you how to conduct experiments on a wide variety of different circuits and turn the information gained into a working knowledge of testing, servicing and maintaining all types of electronic equipment, radio, t.v. etc.

4. Free Gift.

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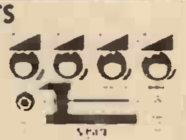

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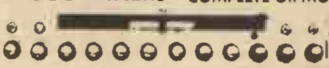

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PE/1/79

PE VOLUME 15 No.1 JANUARY 1979

A POINTLESS EXERCISE?

REGULAR readers and particularly constructors will no doubt be quick to notice a change in component designations this month. For some time we have been looking at the way we do things and considering possible improvements. This being the first issue of Volume 15 it seems like a good time to make the changes.

We have been looking at international standards, at what is common in industry, and our own style, and have decided to drop the decimal points from component values. On page 64 you will find an explanation and some examples of how the system works just in case you are not familiar with it.

One point we should make is that many companies appear to have gone half way with this system; we will use it for all component values and the Ω, F or H will be omitted in all cases. This change helps us as much as anyone; by using the new designations our production of drawings is quicker and "pointless" values are less prone to printing or drawing errors. The system is now widely accepted and many component suppliers recognise or use it and employ the differences brought about e.g. the use of nanofarad values for capacitors.

At this stage we are not planning any immediate further changes in style but your views on the use of boxes for resistors and capacitors would be appreciated for future consideration. For the present we will continue with our "BS alternative" symbols, at least they make it easier to read a circuit diagram.

IS ELECTRICITY THE ANSWER?

Once again our technical editor Mike Abbott has taken a look at developments allied to electronics and gives a glimpse into the future. A few months ago he was looking at energy from the oceans—now it's use of that power in electronic vehicles. The article brings out two important points:

1. There are probably many more modern electric vehicles in use than we realise.
2. The electric vehicle may not save us from pollution of the atmosphere as many have suggested.

The first of these points means that we are probably further along the development curve than the "man in the street" realises—this may be due to the almost total lack of in-depth interest shown by the motoring press. However, it does appear that we must continue to wait for the full development of new batteries before we see large scale production of electric cars for the private motorist.

The second point might prove to be invalid but it does underline the fact that simply because a new system is clean and efficient it does not follow that we can afford to forget any possible changes it may cause. This point is particularly valid in the area of electronics and thankfully there are many individuals and bodies that act as a sort of "doomwatch" and place such possibilities in the public eye.

It is quite possible that electric vehicles will enhance our environment but this should not be accepted willy-nilly just because many believe it to be true. We are all in favour of development but it is essential to try to realise the total ramifications of the goal. Our old friend the microprocessor will have much to answer for if some of the predictions are true, wide-spread unemployment being the worst shot fired at it so far—only time will tell.

Mike Kenward

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

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

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

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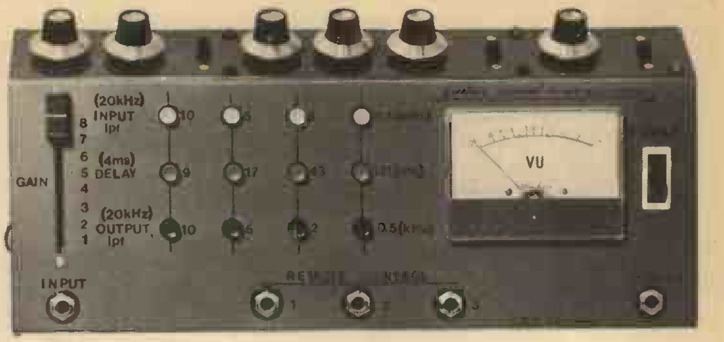
GUITAR SOUND MULTIPROCESSOR



Mark A. Sawicki M.Sc.(Eng.) **Alex. Kowalewski**

Part 2

IN PART ONE we dealt with the structure of the pre-amplifier, delay block and summers, presenting them all in a block diagram to which we will refer many times. In this part we shall deal with the clock system and both input/output low pass filters with their associated switching techniques.

In Fig. 2 we can see the filter and clock control layout. As mentioned earlier both inputs and outputs low pass filters are electronically identical. The clock and filter main controls are arranged into banks of 3 × 4 pushbuttons. On the front panel the top four are the input filter cut off frequency controls, the second row determines the clock frequencies and hence their respective delay times. The third row determines the output filter cut off frequencies.

At the bottom of the panel are five jack sockets, on the extreme left and right are the input and output sockets from the processor. The middle three are specially provided sockets designed for footswitch remote control. These quite simply bypass the three slider switches on the sloping section of the front panel. This remote control capability will prove very useful for guitar work.

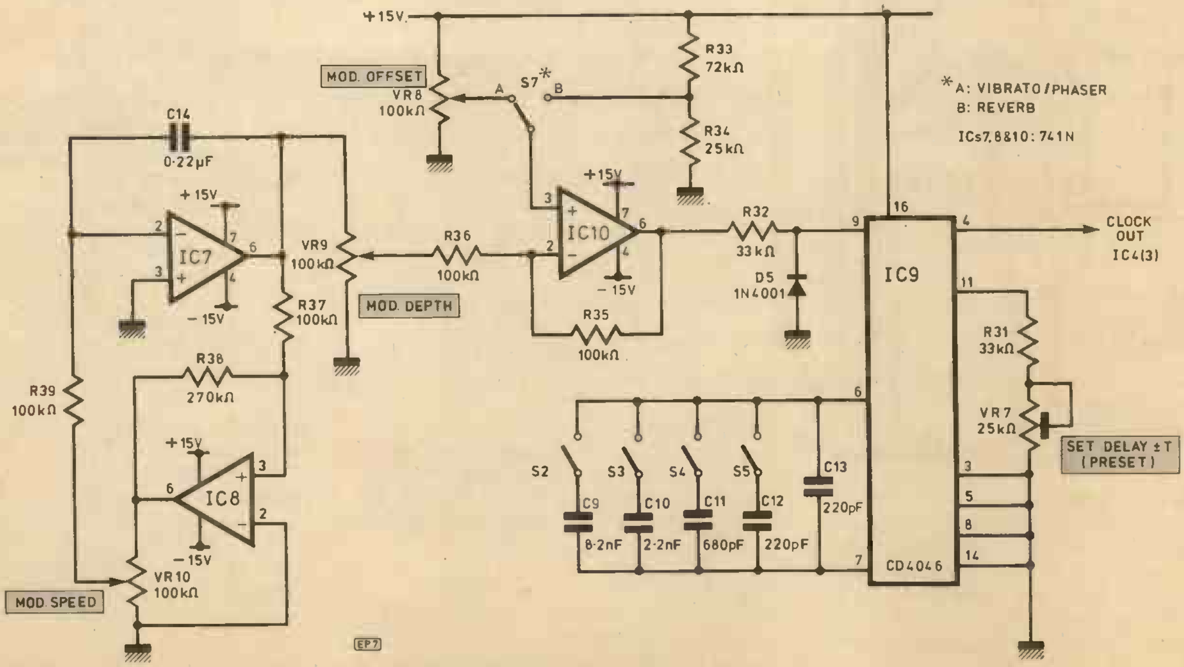


Fig. 8. Circuit diagram of clock system

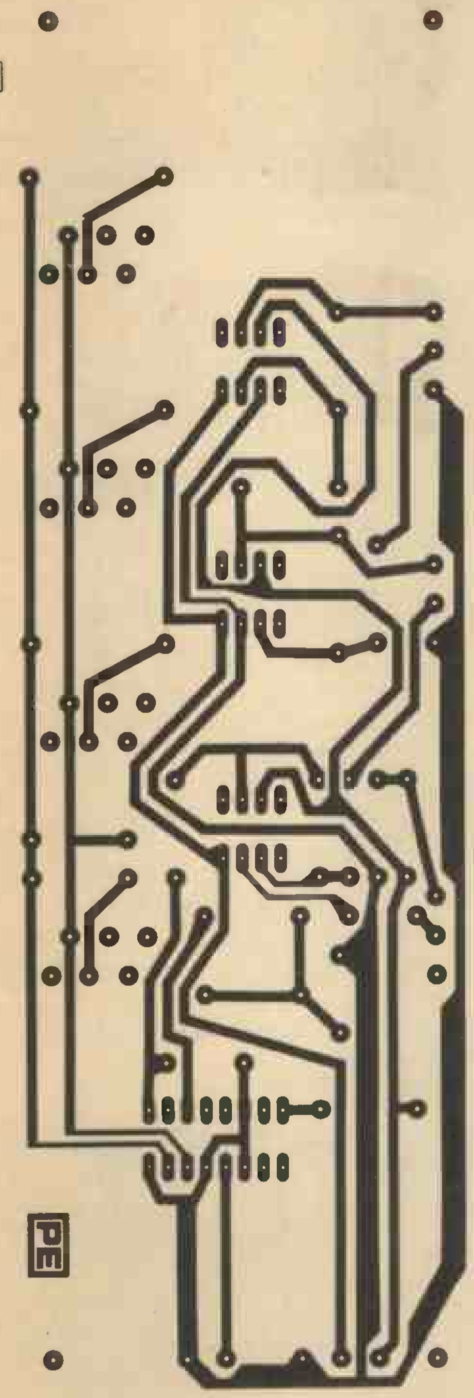


Fig. 9. Clock system p.c.b.

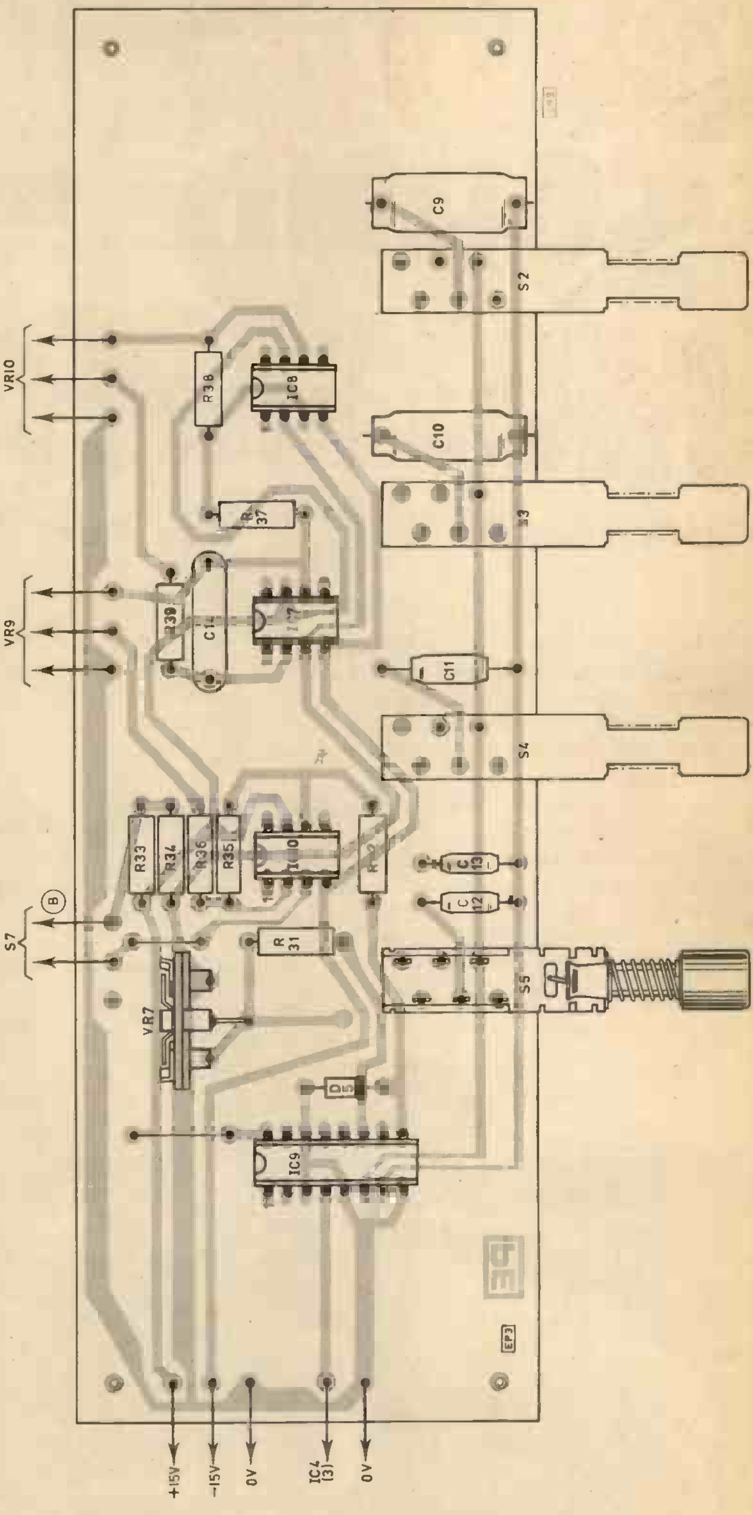


Fig. 10. Component layout

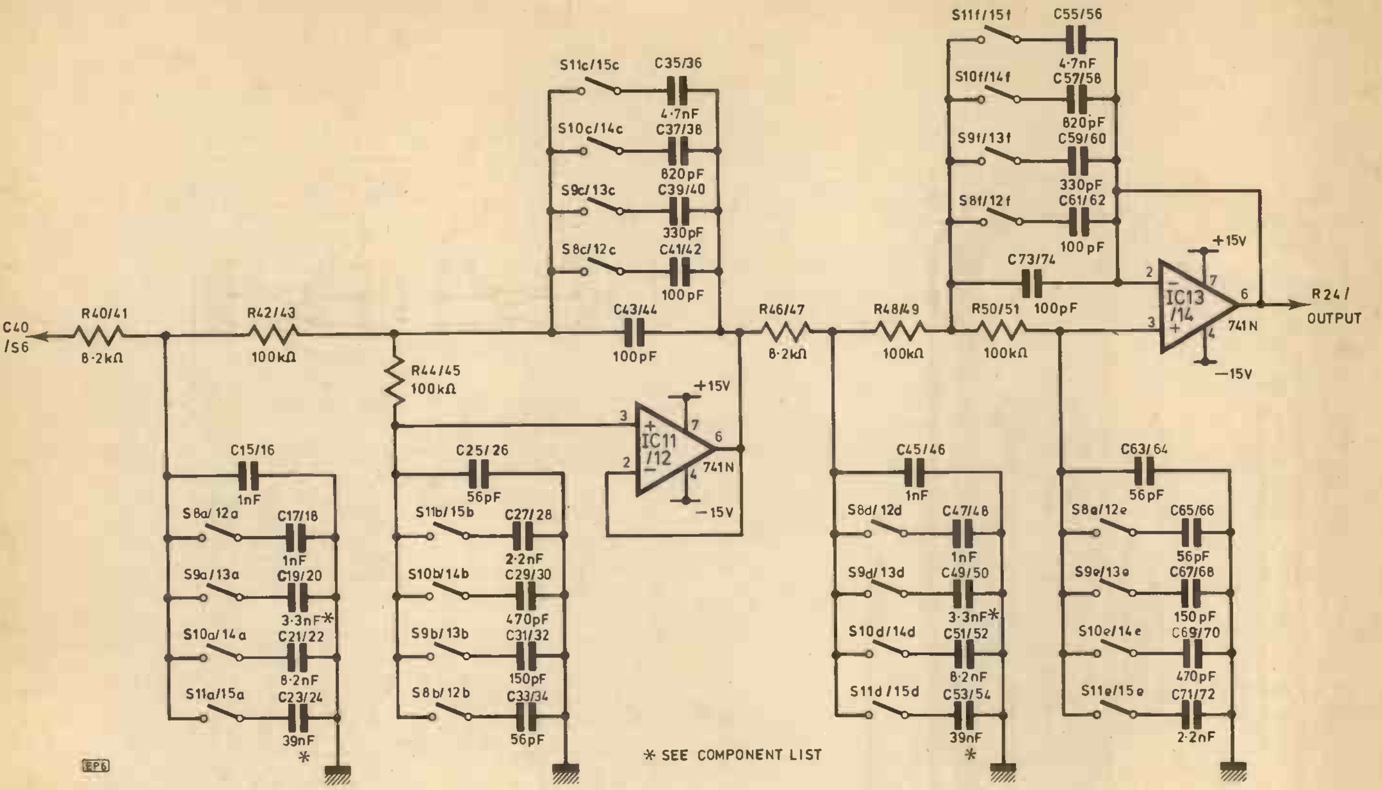
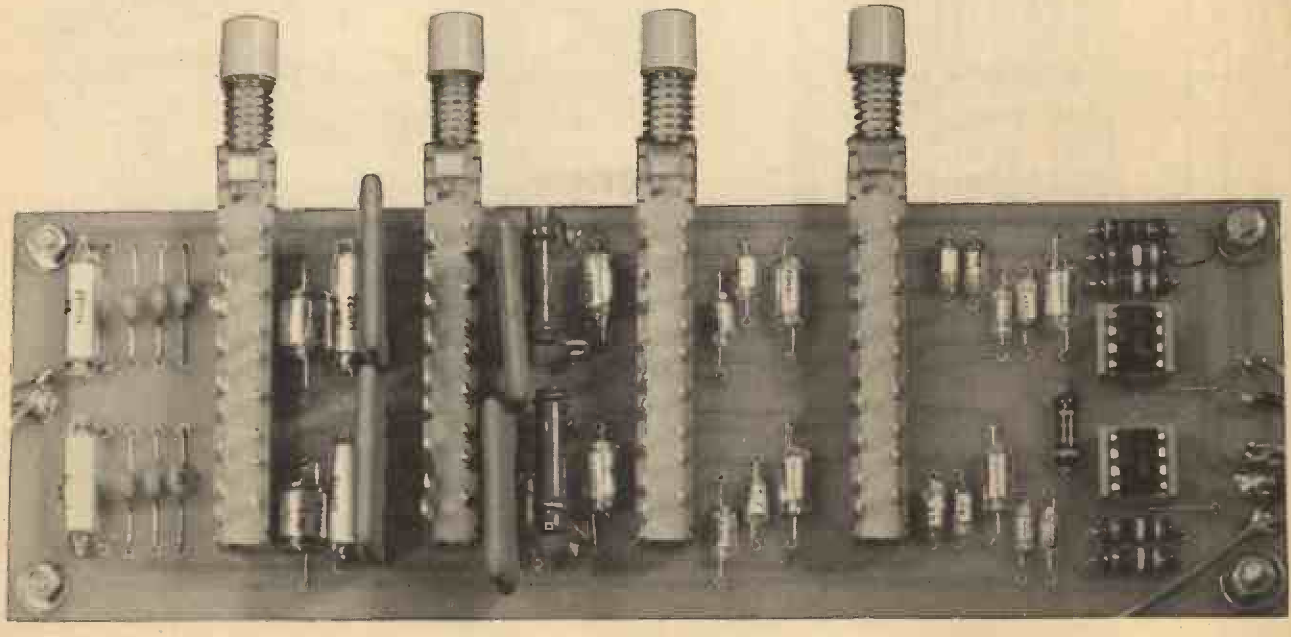


Fig. 11. Circuit for input and output low pass filters



A single low pass filter board. Two are required (Boards 2 and 4)

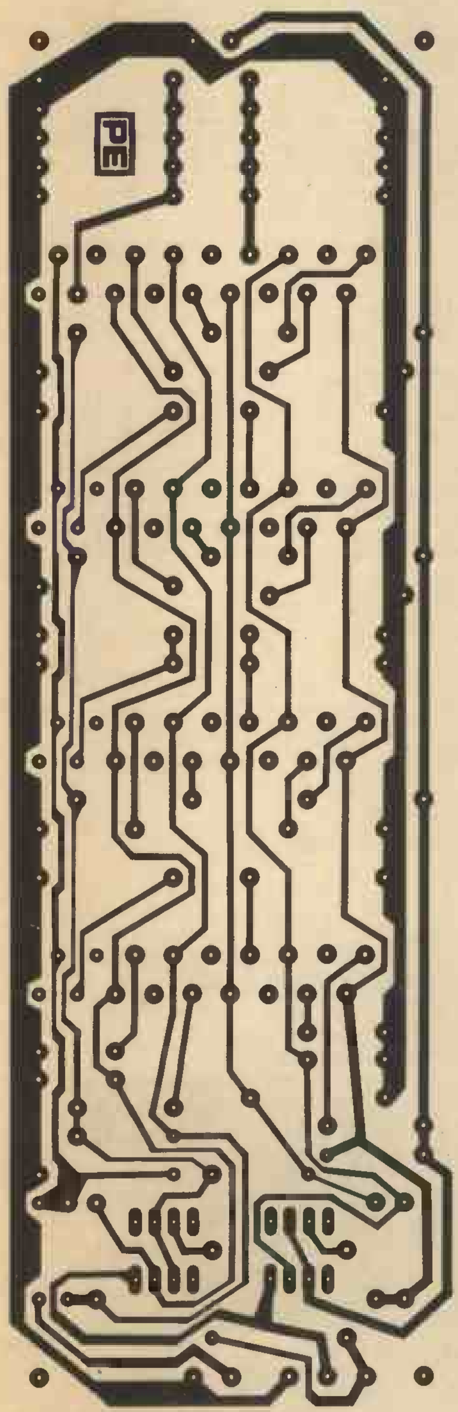


Fig. 12. Low pass filter p.c.b.

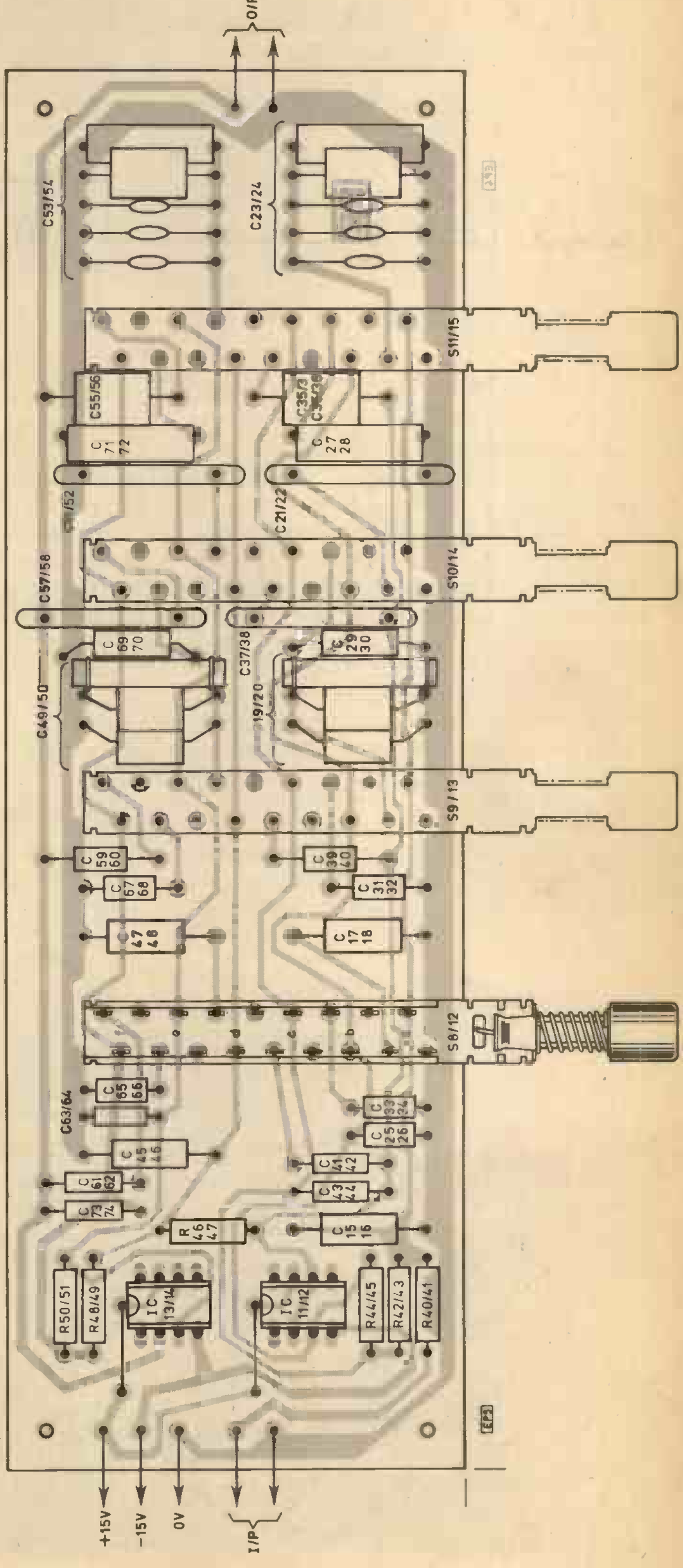
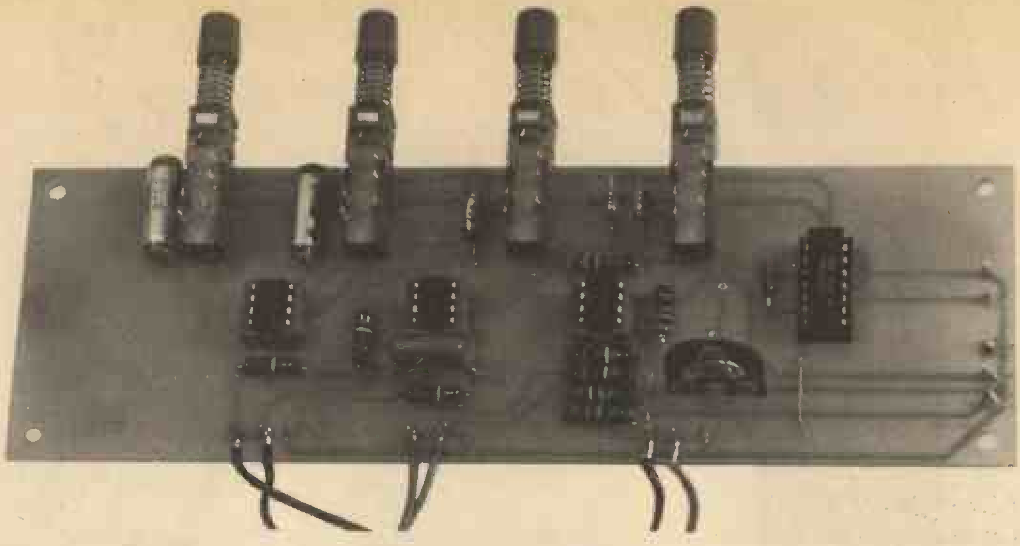


Fig. 13. Component layout



A completed board (Board 3)

CLOCK SYSTEM

Fig. 8 shows the complete circuit diagram of the clock system, block 5 on the main block diagram. The design incorporates a CD 4046 phase locked loop device of which only the voltage controlled oscillator is used. A triangle wave oscillator is constructed on ICs 7 and 8 both of which are common 741 op-amps. IC10, also a 741 type, acts as a buffer/summer device incorporating the following functions:

Modulation Depth (VR9)
Modulation Offset (VR8)

Here the required effect can be selected as a variable level by means of VR8 for Vibrato/Phaser, position A (S7) or fixed by means of R33/34 for reverb effects; position B (S7).

The VCO from the CD4046 chip provides the various, continuosly adjustable frequencies (by means of VR10) which are required to drive the delay block. This i.c. as most of the other components associated with this block, is mounted on the p.c.b. shown in Figs. 9 and 10.

SWITCHED FREQUENCIES

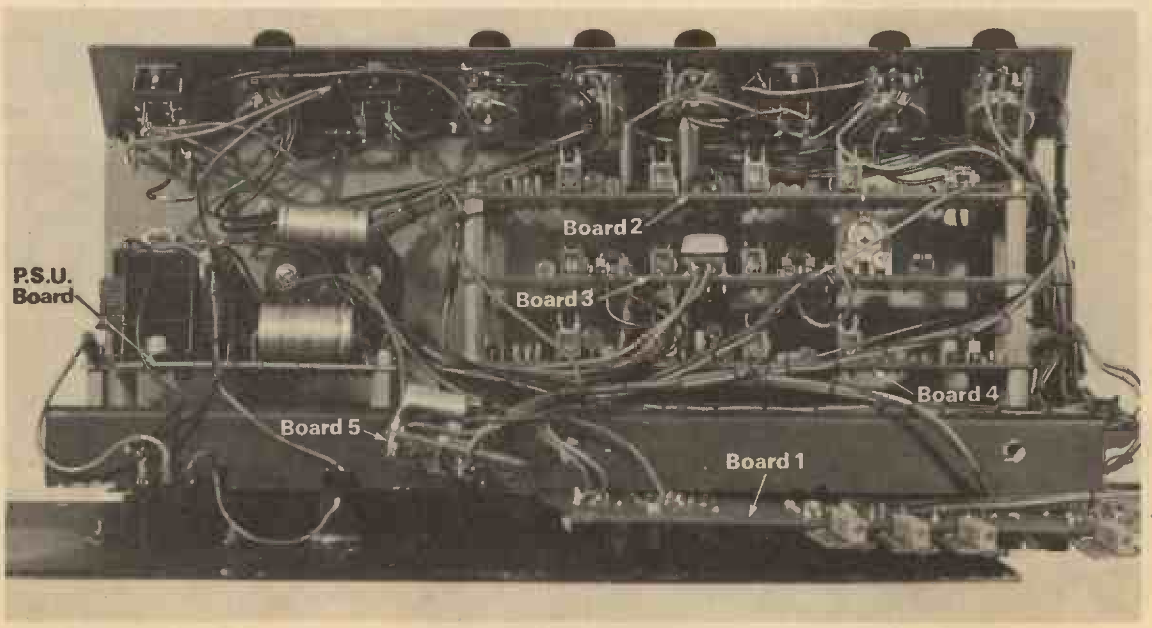
Connected across pins 6 and 7 are a series of individually switchable timing capacitors which determine the frequencies of the VCO. If no delay buttons are depressed the unit is set in a preset VCO frequency mode with a corresponding delay of 4ms. The buttons must be depressed singly and individually since no switch latching assembly is used. Similar reasoning applies to the low pass filters.

When no cut off frequency is selected the system is tuned to cut off at 20 kHz. For details of frequency/delay settings see Table 1.

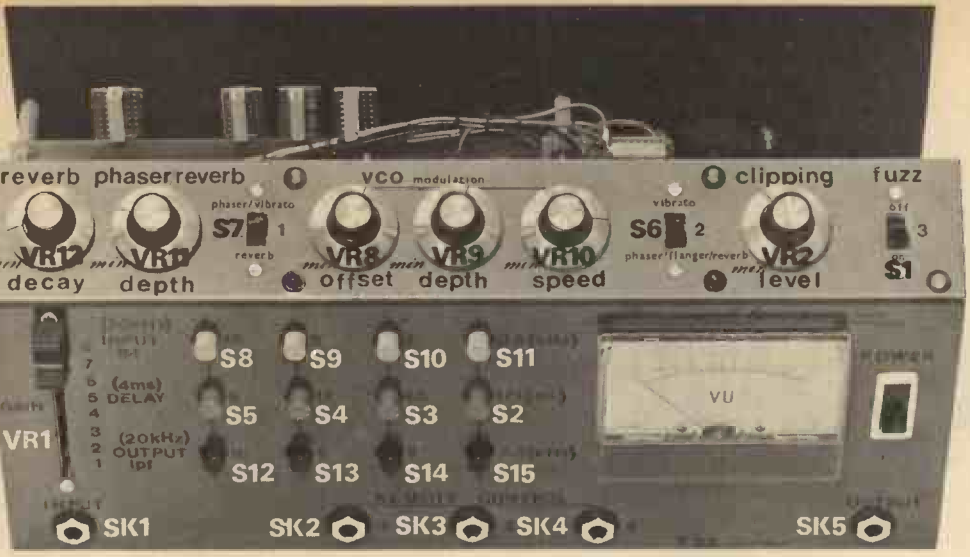
The input to the VCO via pin 9, is connected to the triangle oscillator/driver circuit. Thus triangular wave modulation is applied to the VCO when required. When using the CD4046 CMOS chip take the standard precautions.

LOW PASS FILTERS

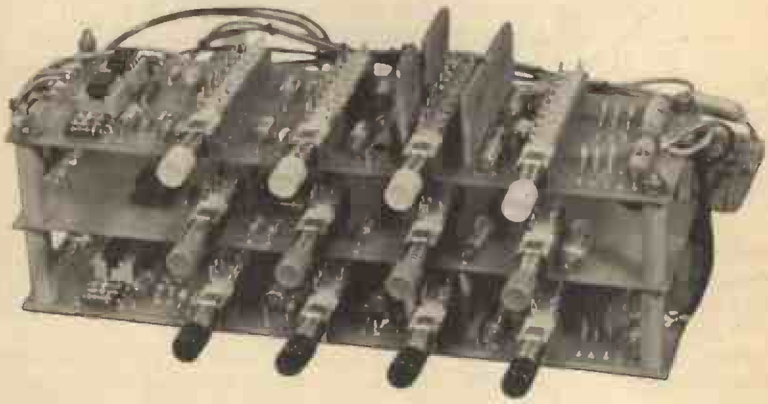
Fig. 11 shows a complete circuit diagram of the low pass

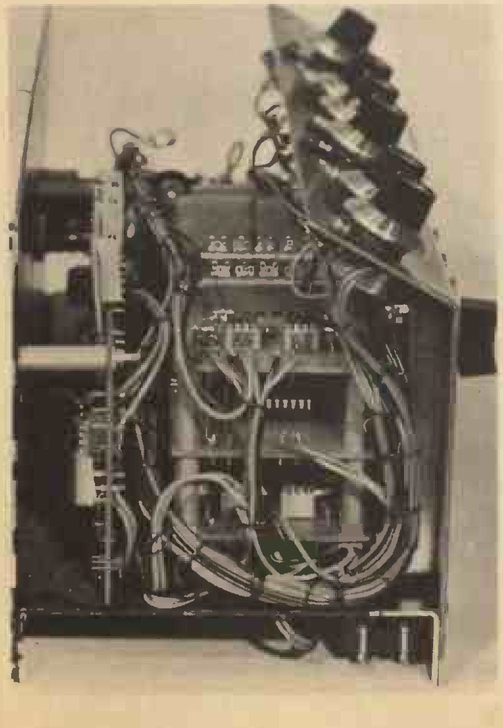


Showing board assemblies using mounting pillars



(Above) Showing control panel component numbering. Note the outrider presets on Main Board 1. (Right) Perspective view of Boards 2 to 4 which consists of the clock system sandwiched between the input and output filters. (Below) End view. Note neat umbilicals.





filters. Both filters have cut offs at 10kHz, 5kHz, 2kHz and 500Hz. However when no buttons are depressed the cut off frequency is defined at 20kHz.

By definition a wave filter is one having a single transmission band extending from a minimum frequency up to some cut off frequency which is not infinite. The filter frequencies are adjusted by means of a series of pushbutton switches and corresponding capacitors. These are connected in the order depicted in the circuit (Fig. 11) where all the switch sub-sections (S8, b, c, etc.) are ganged together. This applies to both the input and output filters. It is highly recommended to use close tolerance capacitors in order to achieve accurate cut offs (not less than $\pm 3\%$).

Figs. 12/13 shows the component side and the original artwork used by the authors to construct the processor.

Both input and output filters are stacked to form a sandwich with the clock board in the centre. This will be referred to as the pushbutton control module. All constructional details will be given in the next part of the series.

The vertical board in the photograph is the main board which was fully described in part one. The three horizontal boards comprise the pushbutton control module, the top and bottom boards being the input and output filters and the central one being the clock board.

Next Month: VU driver, p.s.u. and switch control module.

Market Place

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

by Alan Turpin and David Shortland

NOVA CHAIR

This single seater, anechoic chamber type chair, has been designed to offer a comfortable and very suitable centre for listening to binaural recordings and transmissions. The designers claim that traditional stereo is also enhanced.

An existing hi-fi system is all that is needed to drive the chair's pair of high power transducers, continuous handling capacity 60W.

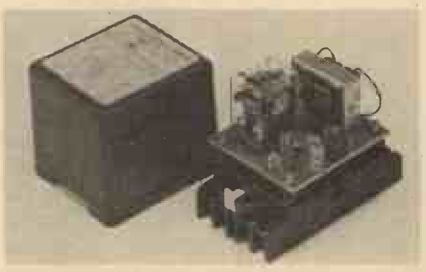
Full details from **Sound Seating Systems, Tape City Limited, 13 The Market, Wrythe Lane, Carshalton, Surrey, SM5 1AG. (01-644 4455).**

LEVEL CONTROLLER

A new electronic liquid level controller, the 61FGP from Farnell Electronics, offers two alternative modes of operation: control of levels between high and low level probes; single point level control around a single, fixed probe.

These controllers can be used for controlling levels in tanks, reservoirs, sewerage plants and mixing plants, and can also be used for flow detection in pipes and channels.

The low voltage (8V a.c.) applied to the probes ensures inherent safety and, being an alternating voltage, eliminates electrolytic corrosion of the probes.



Apart from the probes the unit is completely self-contained and is housed in a plug-in module allowing easy replacement.

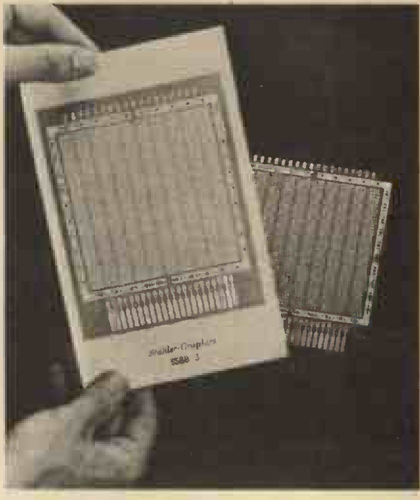
Output is a single changeover relay with contacts rated at 230V a.c. 5A, which is sufficient to directly control solenoid valves and/or small motors.

A special version, the 61FGPH, is capable of sensing liquids with a very high specific resistance such as condensed water in boiler systems or distilled water.

The price of the 61FGP is £14·45 plus VAT and post and packing. For further details contact, **Farnell Electronics, Canal Road, Leeds.**

BREADBOARD PLUS

Carel Components have just announced that a sheet of Stahler-Graphics, used in the design and layout of prototype printed circuits, will be supplied free with each of the three types of Stahler breadboards.



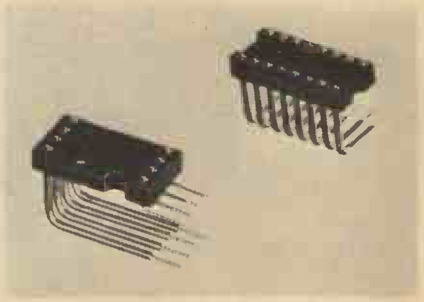
The Stahler Graphics produced on translucent vellum allow the designer to see the location of parts on both sides of the breadboard simultaneously. Also, with the help of a simple rubber, the material lends itself to making quick and easy corrections. Once satisfied with the layout, the designer can drill the holes and pads on the circuit board using the co-ordinate locations as a guide.

Extra sheets together with a comprehensive range of breadboard components are available from **Carel Components, 40-44 The Broadway, Wimbledon, London SW19 1SQ.**

STAND UP AND BE COUNTED

These strange looking devices are sockets which offer easy mounting of seven segment displays. They do away with using a holder on a piece of circuit board and then mounting the whole assembly behind a front panel with screws.

Very simply, they go straight down onto a board, near the edge, then, after a 90 degrees turn, present a socket to the front panel.



The configuration shown will accept displays made by Monsanto, Texas, Hewlett-Packard, Fairchild, Litronix. Another configuration is available to cope with displays where the sockets run vertically.

They come in units to hold from one to five displays, at about £2 each, in packs of ten.

Full details from **Astralux Dynamics Limited, Brightlingsea, Colchester, Essex CO7 0SW. Telephone, Brightlingsea 2571.**

PROM ERASER

The Prombox 12 is a new ultraviolet eraser which can handle up to 12 proms. Its erase time is variable from five to 50 minutes in five minute steps. A sliding tray carries the proms on conductive foam. It has "Mains On" and "Tube On" indicators and a safety interlock switch which prevents the tube being switched on while the tray is open. Complete instructions are supplied and the unit is fitted with two metres of flex plus a mains plug. Price, inc. VAT, p&p, and insurance, is £59·00.

Available from GP Industrial Electronics Ltd., Skardon Works, Skardon Place, North Hill, Plymouth, PL4 8EZ. (0752 28627).

NIPPON DISPLAYS

Plasma display panels, l.e.d.s and fluorescent indicator panels made by Nippon Electric are available from sole UK agents Lock Distribution. Lock are also suppliers of electronic components and microprocessor equipment.

Their plasma displays are gas discharge devices with an orange neon colour. Display voltages required are 145–155V a.c. Logic supplies are +5V and −12V.

Panels made range from simple two digit 7-segment units to one with a 256 character capability (32 digit × 8 line), using a 5 × 7 dot matrix unit.

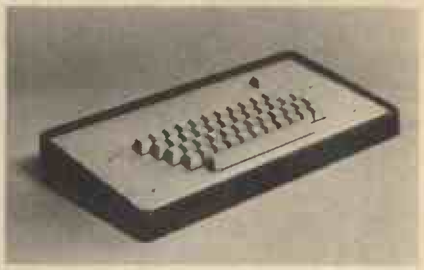
Not only are alphanumeric characters easily readable but many other patterns or ideograms are possible as is shown in the photograph.

The panels are designed to give life expectancy of 100,000 hours or longer with no discernable variation in brightness.

Lock Distribution, Neville Street, Oldham, Lancs. OL9 6LF (061-652 0431).

KEYBOARD CONSOLE

The recently introduced lightweight, vacuum formed keyboard console from Vero Electronics is supplied in kit form and comprises a black ABS enclosure, anodised aluminium cover plate, self adhesive feet and all the necessary fixings. The console will house individual keys or a standard keyboard as required.



The price of the unit (code 75—2867G) is £7·15 including VAT and it is available from **Vero Electronics Limited, Industrial Estate, Chandler's Ford, Eastleigh, Hampshire. (042-15 2956)**

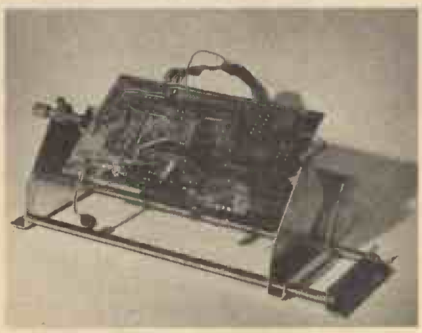
TV ACCESSORY

The CM7042 Combiner, available through high street TV dealers has been specifically designed to overcome the inconvenience of having to disconnect the TV aerial to plug a video game into the aerial socket everytime the game is used.

Using the CM7042 the aerial and game can both be permanently wired to the TV and either signal selected by means of a two way switch.

P.C.B. JIG

This useful jig for holding p.c.b.s or panels when fitting or soldering components can be adjusted to hold boards up to 280mm in length. When fitted in position the workpiece can be rotated and locked in any position.

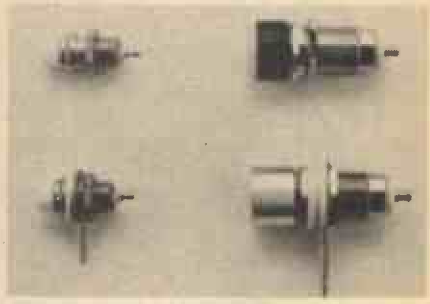


The unit which is supplied in an easily assembled kit form costs £11·00 including VAT and p&p. For further information contact **Precision Petite Limited, 119A High Street, Teddington, Middlesex, TW11 8HG.**

SUBMINIATURE LAMPHOLDERS

These new 100 series subminiature lampholders are intended for use with IMO subminiature T1 flanged base filament lamps which are available in voltage ratings from 1·25 to 28V.

The $1\frac{3}{4}$ series is a larger version of the 100 series and accepts IMO T$1\frac{3}{4}$ flanged base filament lamps. Voltage ratings for the latter extend from 1·35 to 48V and should be ordered separately.



Wide ranges of lens colours for both types of lampholder are available in transparent or translucent materials.

Both types of holders can be supplied in either earthed or insulated forms.

Large numbers of these lampholders may be fitted into a small panel area where high mounting density is required.

A unique pressure pad system on the centre contact ensures excellent contact pressure between lamp and lampholder, even under the most arduous vibration conditions.

Small quantity orders are referred to one of IMO's franchised distributors.

IMO Electronics Limited, 349 Edgware Road, London W2 1BS (01-402 7333).

PUT IT AWAY—NEATLY

She's holding a "Cord Tidy", a moulded plastic frame designed to carry electric cable (50 metres), or clothes line, kite cord, tow rope, even sheets for sailors.

There are two holes in the frame for temporary or permanent wall mounting.

The recommended VAT inclusive price is £1·49, and the "Cord Tidy" is being launched on the British market this autumn by the Ariel Group of Nottingham.

LCD DMMs

Two new digital multimeters from Fluke International are suitable for both field and laboratory applications.

The 8010A and the 8012A both incorporate liquid crystal displays of 3½ digits, and have six functions with 31 current, voltage and resistance ranges. These include a conductance function, which enables noise-free leakage measurements of up to 10,000 megohms and permits the measurement of transistor beta; true r.m.s. measurement on all a.c. ranges; autoranging; autopolarity; and a diode test facility. The basic d.c. accuracy is +0·1 per cent of reading plus one digit, a specification which holds for one year at 23 deg C ±5 deg C, while the instrument's 3dB bandwidth to 200kHz permits accuracy to be specified to 50kHz.

An important feature of the new instruments is that they are protected against transient overloads of up to 6kV, and 600V applied to their current terminals.

The main differences between the two instruments is that the 8010A has a high current range of 10A, while the 8012A has two low-resistance ranges of 20 ohms and 2 ohms, with a resolution of 0·001 on the 2 ohm range. Additionally, the 8012A incorporates a front panel control which enables the nulling of test lead resistance.

Another feature of the new models is the Y8008 "touch-hold" probe. This enables the user to concentrate full attention upon the probe tip when making delicate measurements: once the test point is contacted, a button on the probe can be pressed which "freezes" the instrument's LCD until the button is released.

The price of the 8010A is £159·00 and the 8012A is £199·00; both prices exclude VAT and post and packing. For further information contact **Fluke International Corporation, Colonial Way, Watford, Hertfordshire WD2 4TT.**

CATALOGUES

The latest edition of Ace Mailtronix catalogue which is now available covers a wide range of components, kits, tools, test equipment and audio accessories. The company will also supply any R.S. item subject to a minimum order of £2·00.

Another service offered by Ace is for special components. They will quote a price for any item not covered by their catalogue and can obtain many transistors and i.c.s given a reasonable time scale.

The cost of the catalogue is 30p which is refundable with an order of £5·00 or over. For further information contact **Ace Mailtronix Ltd., Tootal Street, Wakefield, West Yorkshire, WF15 JR.**

GREENWELD

Also available is the new Greenweld catalogue which has been increased in both size and content with a new test gear section featuring digital multimeters and oscilloscopes. To cater for schools, colleges and many constructors who prefer to buy their components in bulk, quantity prices for many components are quoted.

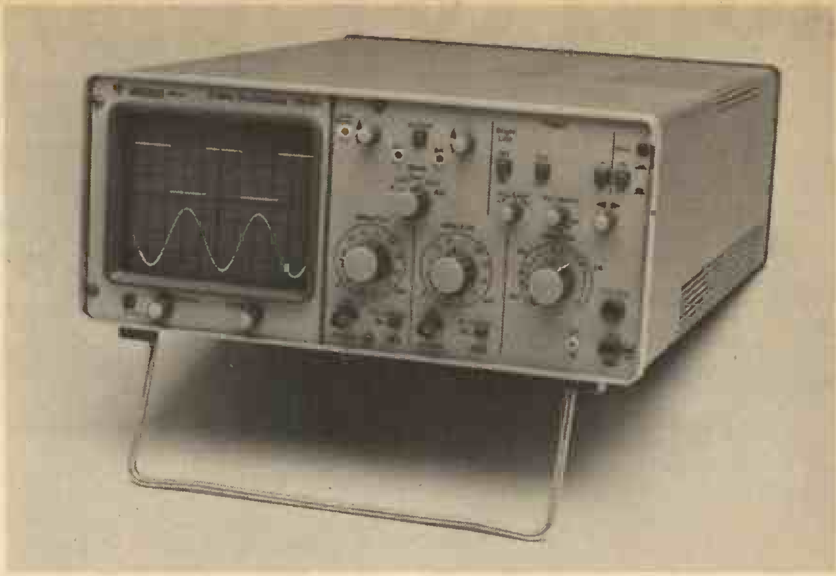
The price of the catalogue is 30p plus 15p for p&p from **Greenweld, 443 Millbrook Road, Southampton SO1 0HX.**

DORAM

In the new Doram catalogue the kit, tool, audio and test equipment ranges have all been extended whilst the component side has now been discontinued.

The kits, many of which can be purchased ready built, are rated using one, two or three stars depending on their ease of construction. Also included in this range are N.S. kits which require no soldering and are therefore ideal for the complete beginner to electronics.

The catalogue can be obtained, by sending 25p to cover p&p, from **Doram Electronics Limited, P.O. Box TR8, Wellington Road, Industrial Estate, Wellington Bridge, Leeds.**



GENERAL PURPOSE SCOPE

The OS253 is the second new instrument in the Gould Advance 25 Series of general-purpose oscilloscopes. While offering the user a low-price 12MHz dual-channel oscilloscope the OS253 maintains a useful and versatile specification.

The vertical amplifiers feature 2mV/cm sensitivity with d.c. ground and a.c. coupling, sum and difference of the two channels with channel 2 inversion and X-Y modes. Horizontal sweep rates are fully adjustable over 18 ranges from 0·5μs/cm to 0·2s/cm, with an X5 expansion giving a fastest sweep rate of 100ns/cm with no loss of accuracy.

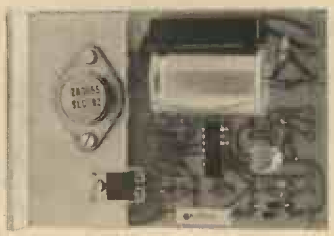
Triggering is a.c. coupled from an internal or external source, positive or negative slope and variable manual level control. Bright-line operation is available to give a trace in the absence of signal or when the selected level is outside the range of the input signal.

Additional facilities include d.c. coupled Z-modulation input, calibrator output and a front-panel trace-rotate control.

For further information including the price contact **Gould Instruments Division, Roebuck Road, Hainault, Essex.**

BI-PAK MODULES

Bi-Pak have recently introduced five new modules in their audio range; a low distortion 50W power amplifier (AL120), a stereo preamplifier (PA200) which is a variation of the popular PA100, a ten channel graphic equaliser (GE100 MKII) with a frequency range of 31Hz to 20kHz and a stabilised power supply (SPM120) which is available with a fixed output voltage of either 45V, 55V or 65V and an output current variable up to 2·5A.



The fifth module is the VPS30 power supply (shown above) which is a regulated, variable power supply with both short circuit protection and current limiting. The unit only requires a suitable shunt, transformer, meter and two potentiometers for a complete bench p.s.u. The output voltage is adjustable from 2V–30V with current limiting available from 0–2A.

Bi-Pak, Dept. PE11, P.O. Box 6, Ware, Herts.

LISTEN TO THE SECRET WORLD OF PLANTS

As featured on Horizon, Nationwide, Radio & Worldwide Press

First time in the U.K. in Kit Form, the revolutionary concept of a Biological Amplifier & Sound Synthesiser in one unit, the *Amazing*

Bio Activity Translator™.

* Experience the unique Musical Form of Plants
* Hear the beautiful patterns of sound – created by their natural response
* Compare house plants' reactions to people – with the distinct tunes of those outside
* Easy to operate, internal speaker & batteries

The naturally generated Bio Electric potential across a plant leaf is picked up by 2 carbon foam electrodes. When amplified and filtered, a VCO, VCA and other exclusive synthesiser circuits are programmed by the control voltage from the plant to produce tracking sequences of notes. These follow in pitch, rhythm and volume the ever changing signal from the plant.
The kit includes 6 I.C's, 3 transistors, all high quality components, tinned and drilled fibre glass P.C.B., loudspeaker and comprehensive assembly instructions. Also included is a free case, ready punched, with wooden end cheeks and stick on silkscreened front panel for a really professional finish.
Runs on 2 x 4½ volt batteries (not supplied).

SPECIAL INTRODUCTORY OFFER INCLUDES FREE CASE
KIT £19.90 ASSEMBLED AND TESTED £27.50 PRICE INCLUDES P & P AND VAT

Allow 14 days for delivery. Offer ends 31st December 1978.

JEREMY LORD SYNTHESISERS, (Dept PE2)
52 Becmead Avenue, London SW16 1VQ

STORAGE CABINETS

Type 1118

Metal cabinets with transparent plastic drawers. Ideal for components, small parts, nuts, bolts etc. Many other uses in the home, workshop, laboratory etc.

Choose from the following range to suit your own needs:

Type	Height (ins.)	No. of Drawers: Total	Small	Medium	Large	Price
1118	11	18	15	2	1	£8.65
1838	18	38	35	2	1	£12.95
1633	16	33	30	2	1	£10.95
2236	22	36	30	4	2	£14.75
2260	22	60	60	—	—	£14.95

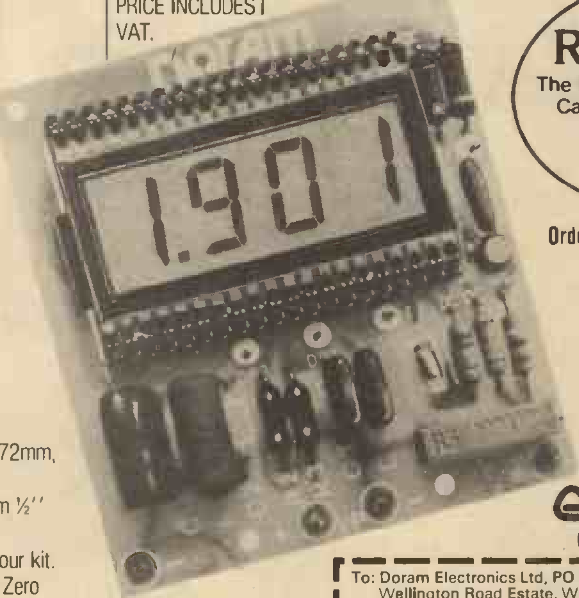
All cabinets are finished Blue, 12" wide x 5¾" deep. Prices include VAT and Post. Satisfaction or money refunded. Cheque/P.O. to:

MILLHILL SUPPLIES (TOOLS)
35 PRESTON CROWMARSH, BENSON, OXON. OX9 6SL

'We have hidden the most important part'

L.C.D.Voltmeter Kit for only £29·50 + P&P

PRICE INCLUDES VAT.



It's the way we 'hide the chip' that makes this Voltmeter such a space-saver. At 66mm × 72mm, it's small enough to replace many analogue movements, yet gives crystal-clear read-out from ½" 'black-on-silver' digits.

Full building instructions are supplied with your kit.

Automatic polarity indication and automatic Zero are big-value features, yet this compact unit comes at a very compact price and can be used as a basis for your own Digital Meter design.

TECHNICAL SPECIFICATION

- Full scale reading 200mv d.c.
- On board decimal point generation
- Supply required 7-15v d.c.
- Will work from PP3 type battery (not supplied)
- Very low current consumption (1mA @ 9 Volt)
- Accuracy ±1 digit
- Transflective display
- Measures DC Volts

REMINDER
The DORAM Electronic Hobbies Catalogue is now available.
FREE

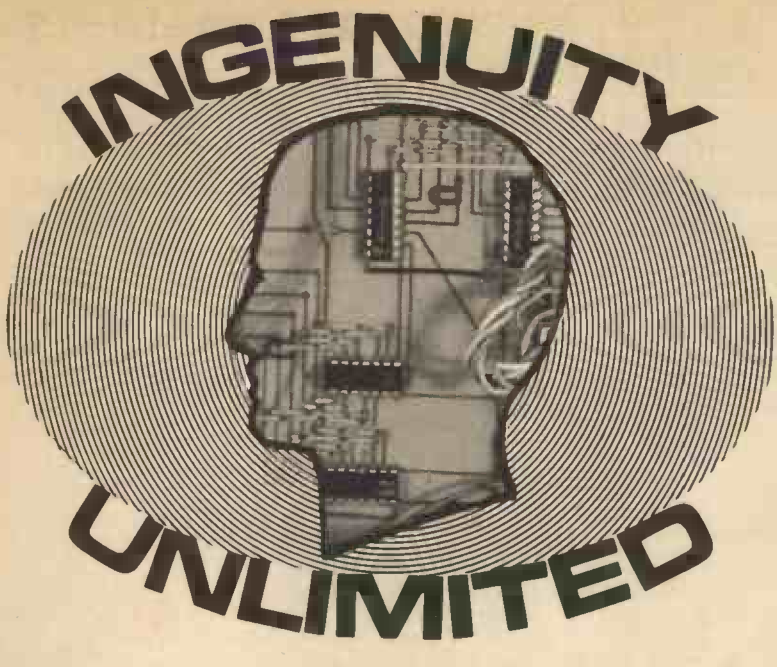
Order now. Guarantee of Satisfaction. Send the coupon immediately. Your Kit will be delivered within 21-28 days. If you are not completely satisfied you may return your purchase within 30 days for a full refund.
Doram Electronics Ltd, PO Box TR8, Wellington Road Estate, Wellington Bridge, Leeds LS12 2UF.

An Electrocomponents Group Company

OFFER CLOSES 14th February 1979.

To: Doram Electronics Ltd, PO Box TR8,
Wellington Road Estate, Wellington Bridge, Leeds LS12 2UF.
Please send.................. Kit/s at £29.95 (£29.50 + 45p P&P)
Please send me a free Hobbies Catalogue ☐
I enclose cheque/PO for £
I am paying via National Giro Centre, Bootle, Lancs to your Account Number 00/643/7257
Please debit my ACCESS Card No ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐
I expect delivery within 21-28 days
Signature ....
Name .... (BLOCK LETTERS)
Address..........................

Doram Electronics Ltd Reg London 1155856 P.E.12



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

Why not submit *your* idea? Any idea published will be awarded payment according to its merits.

Articles submitted for publication should conform to the usual practices of this journal, e.g. with regard to abbreviations and circuit symbols. Diagrams should be on separate sheets, not inserted in the text.

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

A SIMPLE THERMOMETER

THE attraction of the thermometer about to be described is its economy in the use of components, its simplicity in design, and its easy calibration.

Section A of the circuit shows a high performance reference voltage circuit, whose output changes by something less than 1mV, for an input change from 10V to 30V.

Now the Zener used is a 5·6V type, and if a similar circuit were used to oppose the output, but had eight silicon diodes, which would be 8 × 0·7V = 5·6V, in place of the Zener diode, then the voltage output from the latter device would be dependent on the temperature coefficient of the forward biased diodes as shown in Section B, and as this coefficient is a Kelvin constant which is equal to approximately 0·0024V per C°, and as eight diodes are used, then there is a hefty change of 0·0192V per C°. These can be encapsulated in epoxy resin prior to any calibration.

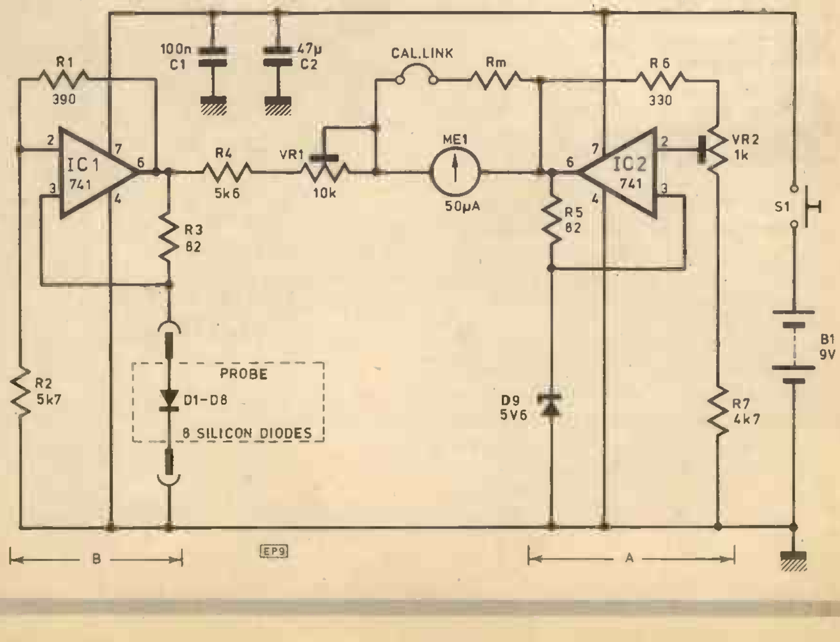
The prototype circuit was designed to read between −5°C, through zero, to +40°C (24°F to 104°F), and the scale of a 50μA meter, which was to hand, was calibrated accordingly. This was not very difficult, as the meter needle swing of 90° lent itself admirably to the nine main divisions required for the scale. The final scale reading −5°C to +40°C f.s.d.

To calibrate the thermometer after its completion, a little dodge is used, a shunt is placed across the meter such that it reads only half of the finalised value, and it is considered that the scale reads from 0°C to 100°C during the calibration.

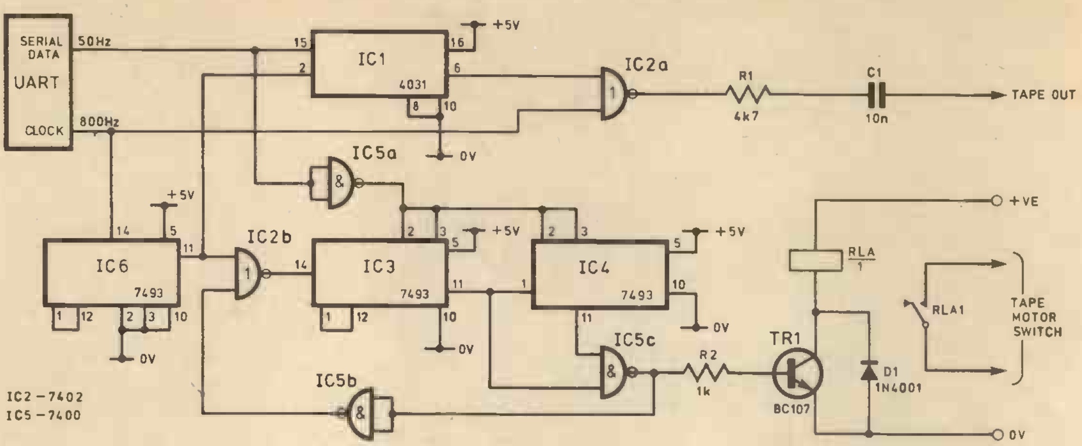
With the probe in a thermos of melting ice, VR2 is adjusted for zero meter reading (this is a balancing act ensuring that both outputs are the same at freezing). The second stage is to adjust VR1 for f.s.d. whilst the probe is immersed in boiling water, check again and re-adjust if required.

Finally VR2 is adjusted to read the zero mark on the scale, i.e. advanced one division with respect to −5°C, whilst retesting the calibration for freezing point, with R_m out of circuit.

J. D. Berryman,
Basildon.



AUTO TAPE SWITCH



When using a cassette recorder for recording ASCII data a large amount of tape is wasted during non-data transmission periods. Commercial systems use stepper motors and block memory transfer systems to combat tape wastage; these systems are expensive to implement so an alternative system was devised as shown.

The 64 bit shift register provides approximately 1 second delay at a 50 baud rate, the shift register clock pulses are obtained by dividing the UART clock by sixteen in IC6; the audio signal for recording is obtained by gating the UART clock and the shift register output.

During non-data periods the UART data output is high, IC3 and 4 are enabled via the inverter (IC5a) and count at the bit rate to a count of 72. Upon reaching 72 the tape motor is switched off and the count input to IC3 is inhibited by the NOR gate.

When serial data is available from the UART the low outputs will cause IC3 and 4 to reset, the tape motor switches on and stays on for the duration of the data plus approx 72 bits to allow the data to be clocked through the shift register.

When using higher data rates the length of the shift register must be increased to allow time for the motor to reach governed speed, the terminal count of the counter must also be increased to correspond to the length of the shift register plus the number of bits in the code group.

By omitting the NOR gate at the output of the shift register, and using a heavy duty relay circuit, this same system could be used for automatic printer operation.

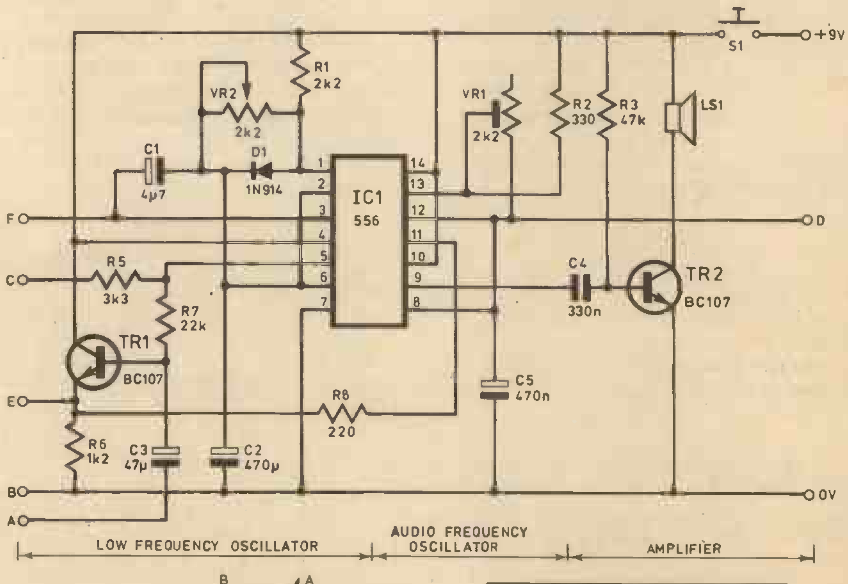
A. Glover,
Braunston,
Northants.

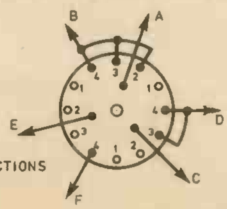
TV ALERTS

THIS circuit provides a fair simulation of three well-known TV series call signs: Z-Cars, Kojak, Red Alert (of Starship Enterprise) and a pulsed tone of no particular source. The sounds, perhaps with further amplification, are suitable for adding realism to games or stage productions.

The tones are produced by coupling together two square wave oscillators based on 555 timer i.c.s, the one producing a low frequency square wave which is doctored in various ways to modulate an audio frequency. A three-pole four-way rotary switch selects the call sign and a push switch applies power to the circuit to operate the chosen signal. Diode D1 in the low frequency oscillator circuit ensures a 1:1 mark to space ratio—about two seconds on and off. Adjustment of VR1 and VR2 are required to obtain the intended tones. A dual 555 timer has been used to simplify circuitry. The circuit will operate off a PP6 battery.

M. Plant,
Nottingham.

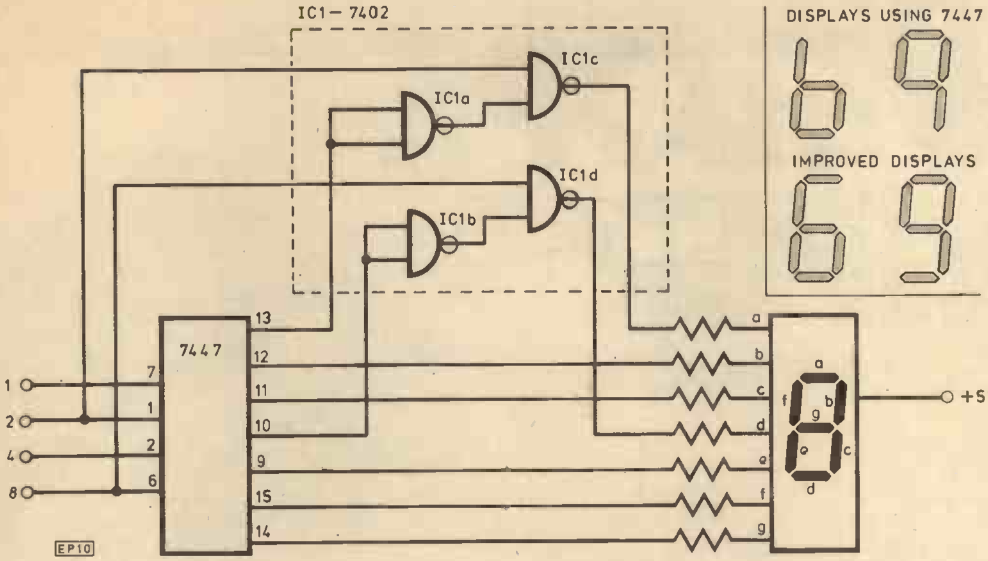




3POLE, 4WAY SWITCH CONNECTIONS (REAR VIEW)

ALERT	SWITCH STATE
Z-CARS	A,B,C,D,E,F ALL OPEN
KOJAK	A,B CLOSED
RED ALERT	A,B CLOSED C,D CLOSED
PULSED	A,B CLOSED C,D CLOSED E,F CLOSED

TOPS AND TAILS



HAVE you ever noticed that the TTL i.c. 7447 that most of us use to drive 7-segment displays, gives sixes without tops and nines without tails? On the other hand my calculator does put the tops and tails on and this set me wondering how hard it would be to generate them.

A glance through the manufacturer's catalogue revealed that the 74143 counter gave the desired display: which is fine if you want a counter; and the 74247 would do the job exactly: but few retailers stock any TTL beyond 74199.

I began to think that I should have to decode the 4-line BCD input int 10 lines with a 7442, or use several gates, just to detect the input of a 6 or 9, but when I examined the segments lit for the other numbers I found a far simpler solution.

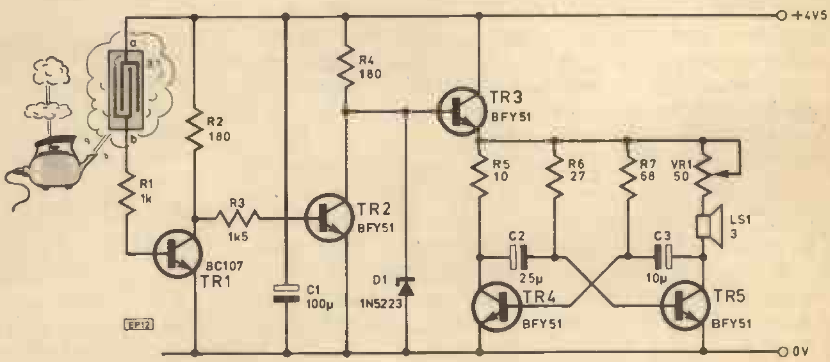
All that is needed is to force segment 'a' on when the BCD '2' bit is true, and to force segment 'd' on when the BCD '8' bit is true. This adds the tops and tails without changing any of the other numbers; and it can all be achieved with a mere 7402 quad NOR i.c.! The circuit is shown above.

The "test" and "blanking" facilities of the 7447 will still work correctly and the circuit can still be multiplexed between several digits if required. But beware! The 7402 can only drive 5-volt l.e.d.s.

Terry Froggatt,
York.

KETTLE WHISTLE

THIS circuit was developed to detect when an electric kettle of the type which does not switch itself off was boiling. It does this in a very simple way, making use of a piece of 0·1in pitch Veroboard of any convenient size with alternative strips connected to form two interlacing grids. This is placed close to one of the vents in the lid of the kettle, where it detects the steam from the boiling kettle.



When the copper strips are dry they open circuit the base of TR1 causing its collector to be high which turns on TR2 resulting in its collector being low and shorting DI cathode and TR3 base to zero volt line which results in the emitter of TR3 and hence the supply to TR4 and 5 being at zero. Therefore TR4 and 5 which form an astable multivibrator will cease to oscillate and there will be no output from LS1. However, when the kettle boils the steam will condense on the grids of X1 causing it to develop a resistance in the order of 15 kilohms which will result in base current flowing in TR1 which will turn on, the collector of which falls turning TR2 off, its collector rises and is clamped at about 2·23V by D1; this results in a voltage of about 1·4V at TR3 emitter hence a supply to TR4 and 5 resulting in the multivibrator oscillating and a whistle tone being emitted.

R. Wilds,
Aylesbury,
Bucks.

ADSR ENVELOPE SHAPER

D. J. STEPHENSON

Attack

Decay

Sustain

Release

FOR synthesis of the natural amplitude/time envelopes of conventional musical instruments, the common Attack-Sustain-Release (ASR) shapers are insufficiently accurate, and lack percussive effects at short attack settings. These shortcomings are overcome by using the Attack-Decay-Sustain-Release (ADSR) envelope shaper.

This unit incorporates a low cost voltage controlled amplifier, so that any existing VCA (which would otherwise have been required) can be used elsewhere. Fig. 1 shows the block diagram.

At short attack and decay times, percussive sounds can be generated on closing S1. At longer attack times a sort of touch sensitive playing technique can be acquired when keyboard triggered. At maximum settings of attack, decay and release the cycle will take several seconds to complete, thus producing incredible sound effects with imaginative inputs. Realistic envelopes for a wide range of conventional musical instruments can also be synthesised.

ATTACK PERIOD

Referring to Fig. 2, closing the switch contacts S1 causes the inverter output IC1a to fall sharply; this isolates the release pot VR4 via IC2d, and because of the differentiating action of C1 and R3, drives a momentary negative going spike to IC1b. This sets the bistable formed by cross-strapped nand gates IC1b IC1c, and turns on IC2a. Providing the contacts S1 remain closed, IC2c is also on, and a charging path is established for C2 via VR1 (the attack time). The rising voltage across C2, after buffering by the voltage follower IC4, is applied to one of the comparator inputs of IC3. The limit to which this voltage can rise is fixed by the divider R6, R7 which holds the positive reference at half the supply voltage.

DECAY PERIOD

At the instant when C2 voltage reaches half of Vcc, the comparator switches over and drives the output towards ground. This resets the bistable and:

(i) turns IC2a off which breaks the charging circuit.

(ii) turns IC2b on which starts the decay action.

Capacitor C2 now discharges at a rate, set by VR2 (decay time) down to a voltage determined by VR3 (sustain level).

SUSTAIN PERIOD

A stable condition now exists, during which C2 voltage remains fixed at the sustain level for as long as S1 contacts remain closed.

RELEASE PERIOD

When S1 contacts are released, the inverter output goes high, turning on IC2d which then discharges C2 from its sustain level down to a minimum set by R5. The rate of discharge is controlled by VR4 (the release time).

ANTI-LOCK UP

At first, IC2c may appear superfluous, but if not included a "circuit jam" could occur under the following conditions: If S1 contacts are released before C2 has charged up to the comparator threshold voltage, potential division at some settings or VR1 and VR4 would occur because IC2a and IC2d would both be on simultaneously. IC2c ensures this cannot happen by isolating the two potentiometers on premature key release.

SUPPLY MODIFICATIONS

The release potentiometer is returned to the junction of R5 and VR3 which lies at 2V positive rather than ground, because of the reluctance of IC4 output to sink lower than 2V on single supply operation. This techique eliminates the

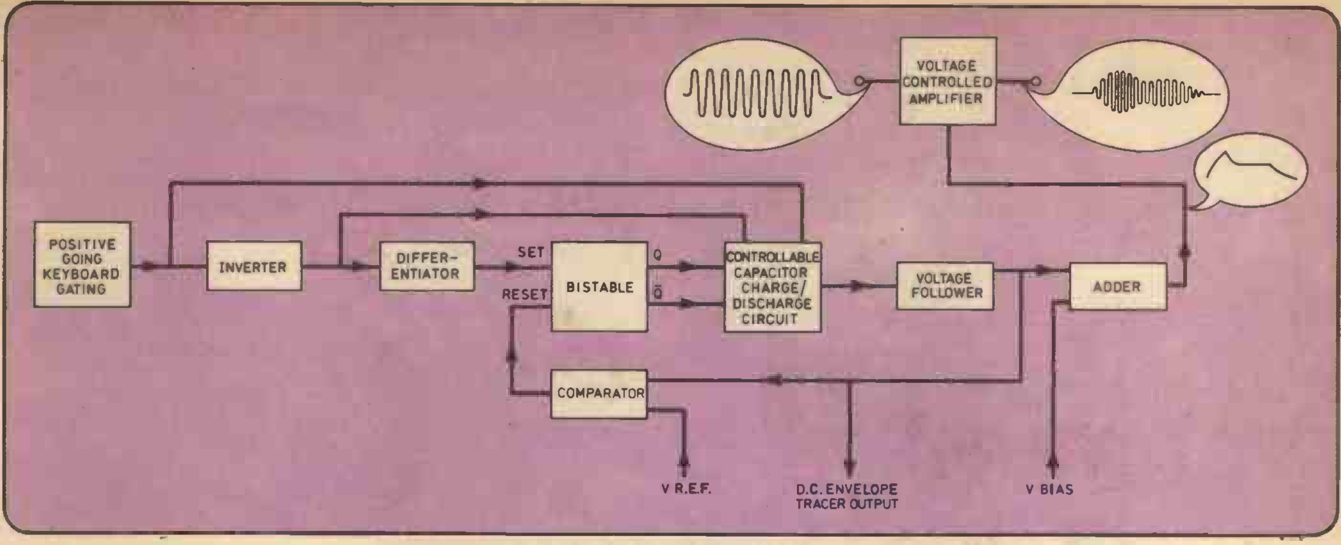


Fig. 1. Block diagram

time delay IC4 would introduce while C2 was charging to 2V.

For installation into synthesisers with a dual balanced power supply the lock-up protection is not necessary, and with the added advantage of an extended tracer voltage starting from 0V instead of 2V, the following modifications are given:

Leave the circuit as shown connected between the 0V line and the positive line, but

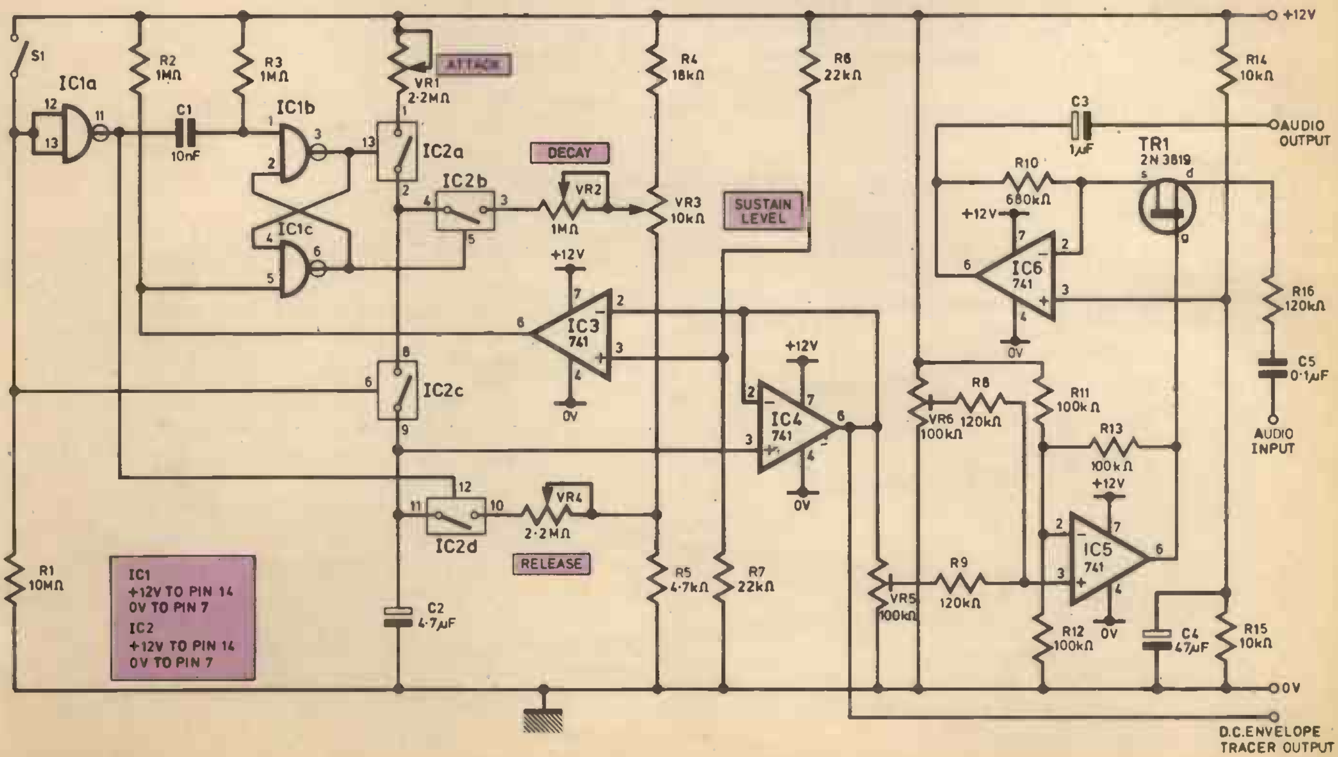
(a) replace R5 with shorting link
(b) change R4 to 10kΩ
(c) connect pin 4 of IC4 to the *negative* line.

This allows IC4 to act as a true voltage follower sinking to within a millivolt or so of the voltage across C2, which would have a minimum value of 0V.

VOLTAGE CONTROLLED AMPLIFIER

The ADSR envelope voltage is available at the output of IC4. One output is used directly as a d.c. envelope tracer, Fig. 4, the other output is amplitude controlled by preset VR5 and after passing through the non-inverting summing amplifier IC5, is applied to the gate of the junction FET (TR1). IC6 is a class A amplifier used in the inverting mode. The FET in conjunction with R16 form the "input resistance" and R10 the feedback resistance. As the envelope voltage varies, the effective resistance of the FET varies and consequently the amplifier gain. Unfortunately, the gate parameters of junction FETs are notoriously unpredictable both in their control ratio and their voltage "bandwidth". Both of these variables can be compensated for by the following:

Fig. 2. Circuit diagram of the envelope shaper



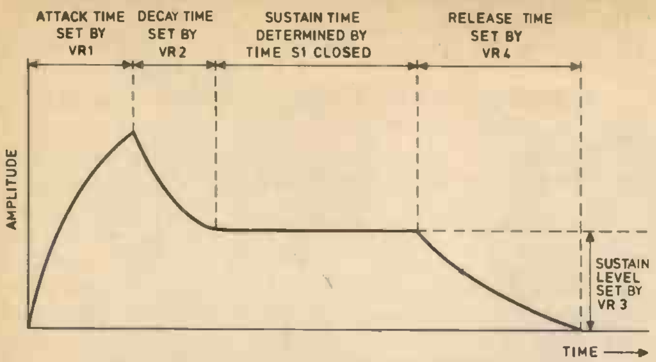


Fig. 3. VCA output amplitude against time

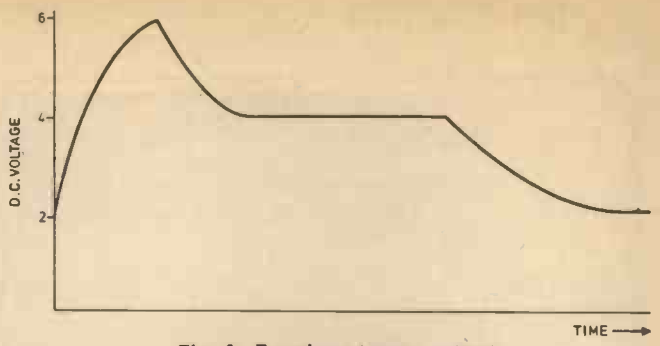


Fig. 4. Envelope tracer output

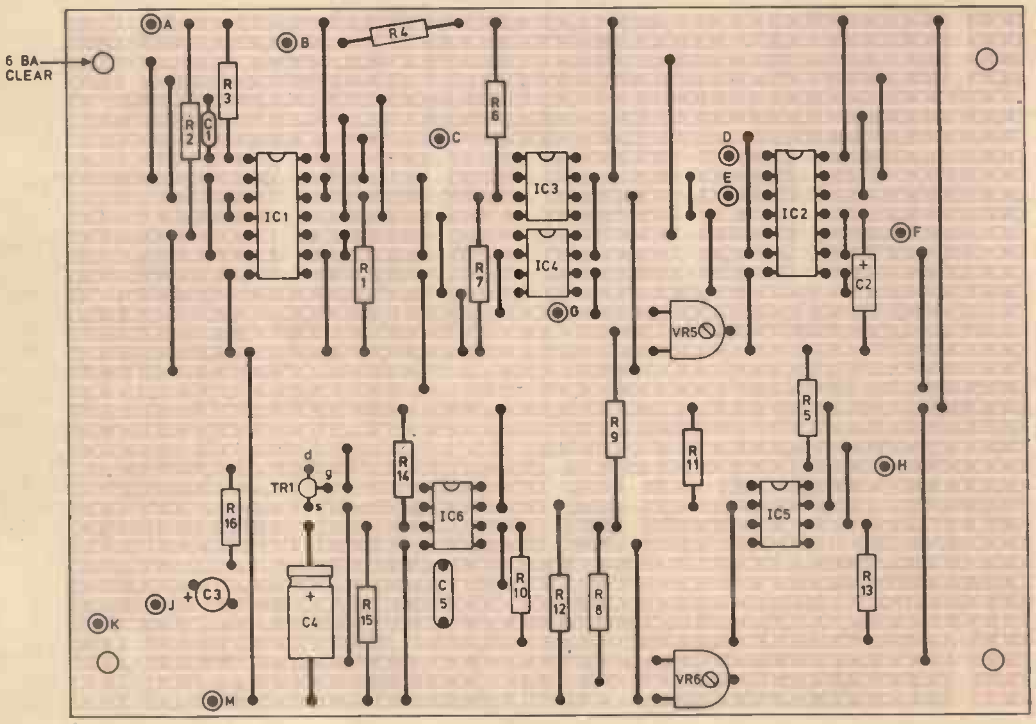
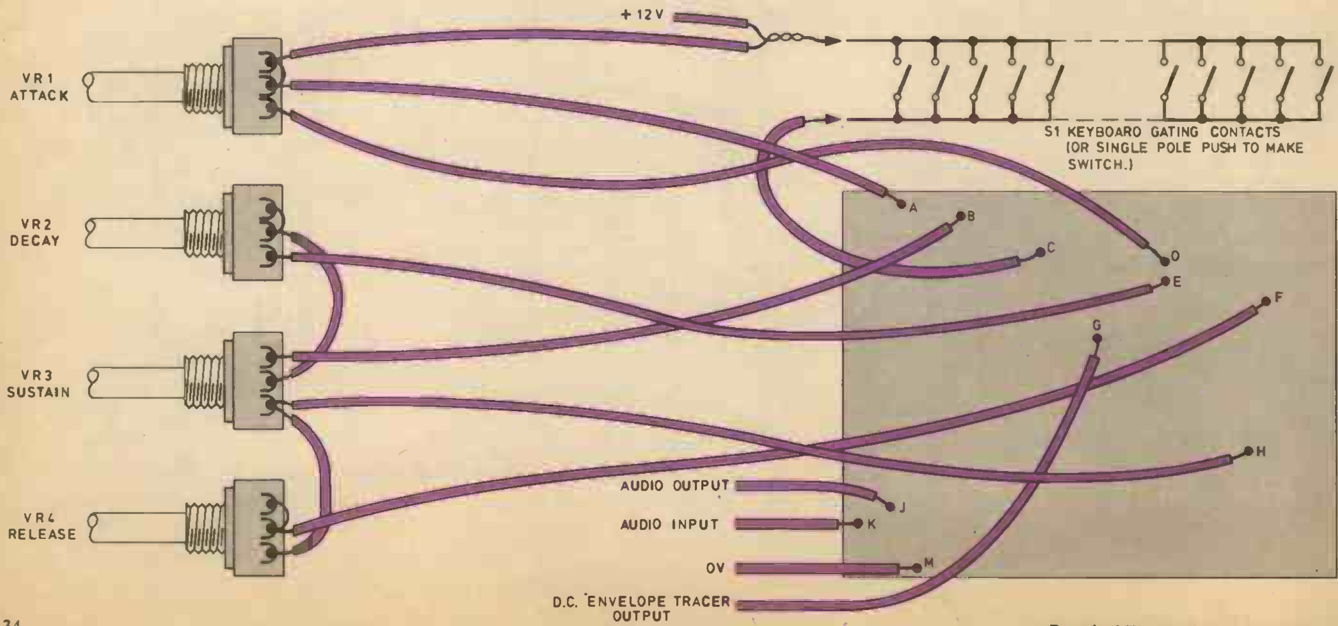


Fig. 5. Stripboard layout

Fig. 6. Interwiring diagram



COMPONENTS . . .

Resistors

R1	10MΩ
R2, R3	1MΩ (2 off)
R4	18kΩ
R5	4·7kΩ
R6, R7	22kΩ (2 off)
R8, R9, R16	120kΩ (3 off)
R10	680kΩ
R11, R12, R13	100kΩ (3 off)
R14, R15	10kΩ (2 off)

Capacitors

C1	0·01μF mylar
C2	4·7μF/25V Electrolytic
C3	1μF/25V Electrolytic
C4	47μF/25V Electrolytic
C5	0·1μF Polyester

Potentiometers

VR1, VR4	2·2MΩ lin. (2 off)
VR2	1MΩ lin.
VR3	10kΩ log.
VR5, VR6	100kΩ lin. horizontal preset (2 off)

Semiconductors

IC1	74C00 (CMOS) Quad 2 input Nands
IC2	4016 (CMOS) Quad Bilateral switches
IC3, IC4, IC5, IC6	741 Operational amplifiers (4 off)
TR1	2N3819 or similar

Miscellaneous

0·1in matrix Veroboard 36 strips × 50 holes
Veropins or component wire offcuts
Strip of 28 soldercon pins
4 potentiometer knobs
S1 s.p. push-to-make switch (if required)

(a) VR5 which adjusts the output swing of IC5 and hence the FET gate swing.

(b) VR6 applies some d.c. to the adder IC5, and hence controls the operating region of the swing.

Both these controls can be adjusted to suit any particular FET.

The maximum gain of the VCA can be set by the feedback resistor R10 since gain is approximately:

$$\frac{R10}{R16}$$

Although 680kΩ is used in the prototype (for a maximum gain of 15dB) the value can be altered to individual requirements, for the purposes of level setting. This VCA can be built as a separate module for other synthesiser applications (i.e. tremolo, if driven by a slow speed oscillator). It is very cheap to construct and effective in use; circuit layout is not critical.

CONSTRUCTION

Construction is straightforward using the component layout Fig. 5. The 741 i.c.s can be directly soldered, but the two CMOS i.c.s should be fitted last to avoid static damage.

Soldercon pins are recommended for these, rather than direct soldering. The junction FET TR1 is susceptible to damage by overheating, so swift soldering is advised. Potentiometer connections are given in Fig. 6.

A case was considered unnecessary as the potentiometer would be remotely mounted on a synthesiser front panel and the module fixed elsewhere within the system. Screened wire should be used to connect the input and output if leads over a couple of inches prove necessary on installation. The switch, S1, can be a single pole push-to-make of a paralleled keyboard contact bus. Alternatively some form of automatic switching could be devised for repetitive uses, such as a slow speed astable.

SETTING UP

Apply an audio waveform to the input and connect the output to an audio amplifier. Set VR1 and VR3 to maximum and VR2 and VR4 to minimum. Adjust VR6 until audio is just heard when S1 contacts are open and back off very slightly. Adjust VR5 to give a smooth attack from zero to maximum volume when S1 is closed. This trimming procedure should be repeated a few times to get the best results.

When set up, envelopes similar to Figs. 3 and 4 should be obtained depending on control settings. ★

Strictly Instrumental

by K. Lenton-Smith

Mention of Signetics' TDA 1008 in the September issue seems to have been the signal for a number of letters from readers asking for assistance. Incidentally, this device is available from franchised Signetics distributors: Gothic Electronic Components, PO Box 301, Beacon House, 8 Hampton Street, at Birmingham B19 3JU is one firm that can supply the i.c. at the prices mentioned in September's edition. In case of price changes before we publish, prospective purchasers should ring Gothic on 021-236 5060.

PEDAL CLAVIER

I have been asked if the TDA 1008 would be suitable for a pedalboard, which I assume is to be used by an organist reader who practices at home on a piano. Most separate pedal units use a single RC oscillator, so that the clavier is monophonic. This point is of no consequence to the average light organist, of course, but the serious performer sometimes needs to play more than one pedal at a time.

In this respect, the TDA 1008 will provide polyphony, but rather expensively: the point here is that a full set of 12 divider/keyers must be used, plus a top octave synthesiser, to provide even one octave of frequencies. The TDA 1008 is provided with five keying inputs, so that the 12 devices will service a five octave manual. Thus, half of the keying inputs will not be employed if this generator system is used with a 30 or 32 note pedal clavier.

Despite this wastage, the flexibility of the envelope control afforded by this device would still make it a good choice. Alternatively, a top octave synthesiser might be followed by strings of 7493 TTL 4-bit binary counters—along the lines of the P.E. 'Joanna'—to provide the required pitches. Though perhaps a cheaper method yet still polyphonic, keying would be more complex and probably need to be based on diodes.

Even for home practice use, the output stage should be rated at 10W at least, as the signal will often be a sustained sine wave after it has been through stop filters.

STOP SWITCHING

Another reader is building a very comprehensive organ with three manuals, 30 note pedal and 50 stop tabs. His dealer had designed the circuitry but, when asked if thumb pistons could be incorporated, gave his opinion that relay switching would give rise to considerable noise. As the aim is to simulate a cathedral organ faithfully, even to double touch, such switching interference would be intolerable.

There seem to be two possible avenues to explore here. The first would be inexpensive reed switches, using a mechanical system. A number of small permanent magnets could be attached to an extension rod behind the thumb piston, each with its associated reed switch nearby. Operating the thumb piston would thus close all the reed switches simultaneously. Apart from cost saving, no additional power supply would be required and there should be no noise problem because the contacts keep clean in their hermetically-sealed glass tubes. The magnet should approach the switch at a point which is off-centre for the most positive result. Reed switches can be operated by placing them in the centre of a coil wound with, say, 40 guage enamelled copper wire and of a suitable length to match the glass tube. Whilst this does not require a heavy current, returning to electro-magnetic methods might reintroduce switching noise.

The other approach would be to use some form of electronic switch. Many types of switching are satisfactory only for square wave signals—distorting other signals—and, as stop switches often carry complex wave signals, the choice here is critical. Devices which could be useful in this respect are Mullard's TDA 1028 and 1029: both are op. amps connected as impedance convertors.

TDA 1028 is a quad op. amp., each section having two switchable inputs, whilst TDA 1029 is a dual op. amp each with four switchable inputs. Both i.c.s. are of the 16-pin d.i.l. type with input currents independant of switch positions and outputs short-circuit protected. Mullard have designed these devices for switching from stereo to quadrophony, or four-channel signal sources. Both require a single supply of +6V to +23V and cost £3·00 at the 1-24 rate,

In both cases, eight signal inputs can be accepted, but switching is ganged electronically so that several devices might be required for combination switching: earthing out a given pin alters the mode. The basic switching for each device is relatively easy to visualise in principle, but I would suggest close study of the relative data sheet to see how either device might be used with the reader's particular project.

OPTO IDEAS

Light dependent resistors have never been as inexpensive as one could wish, whilst there is always the bother of fitting both the light emitting diode and the light dependent resistor into a light-tight box. Such a combination is often used in electronic music for "chopping", tremulant or for swell control.

The BX504 Opto Isolator is a four lead encapsulated device, looking similar to a small bridge rectifier. It contains both l.e.d. and photocell and is well worth the 25p asked by Progressive Radio of Liverpool (whose advertisements appear in this magazine). Polarity of the pins is indicated on top of the device and it should be noted that the cell is sensitive in this respect.

Another component oddity is the light activated thyristor—available from Proops Brothers of Tottenham Court Road. Supplied on a small printed circuit board with its associated gate to cathode resistor, the G.E. L9F will switch 1·6A r.m.s. at up to 50V by means of a pulse of light. The device costs 50p and might be used to switch in a rhythm unit by means of a keying pulse applied to a lamp. This "latching relay" will require a manual switch off, however, as is normal with thyristors and d.c. supplies.

8′ PEDAL

The owner of a Hammond M-100—surely one of the best of Hammonds small organs, but sadly now out of production—recently remarked that it would be nice to have the choice of either 8′ or 16′ pedal, as on the Hammond T series.

The M series organs used tone wheels throughout, the pedal generators employing a very strange shaped disc to provide a complex tone. Against this, the T series use bistable divider stages fed from other parts of the organ, so there is no problem in supplying two pitches for the pedal.

However, by applying full-wave rectification to a 16′ signal it should be possible to provide 8′ pitch. With power supply units for example, the secondary winding of the mains transformer supplies a.c. at 50Hz, full wave rectification converting this to 100Hz to make it easier to smooth. I have in mind using an op. amp. with single supply and some form of output level adjustment so that both 8′ and 16′ signals are matched. As yet, this scheme has to be tried and tested but I will report on the outcome in due course as there may be other readers with M series organs and 'T' leanings.

GIVE THEM THE BIRD

In the late autumn, flocks of migrating starlings often use the same rallying points year after year and become a complete nuisance owing to the noise and mess they create.

Some humans are driven to distraction by pop: on this basis I would suggest that British Rail considers using cascaded frequency doubling techniques to beam supersonic versions of the worst of the Top Twenty at high power levels across the station roof. It should frighten the life out of the birds!

FRANK W. HYDE

PROPOSED VERY LARGE RADIO TELESCOPE BY INDIA

A large radio telescope which would be built by international co-operation between India and the developing nations, was described by Prof. Menon at the conference of the European Physical Society. Prof. Menon is adviser on electronics to the Indian government. He was formerly head of the Tata Institute of Fundamental Research in Bombay and well known for his activity in the advancement of Science in India.

The new telescope is based on a proposal put forward some two years ago by a distinguished radio astronomer Prof. G. Swarup who returned to India after a long period of research in the United States. He was responsible for the large telescope built in Ootacamund in South India.

The new telescope will be nearly four times the length of the Ootacamund installation. It is proposed that its activities will be centred on the use of the Lunar Occultation method of study. Data is obtained by this method when the Moon passes between the telescope and the source. This provides a means of detailed study of hundreds of radio galaxies within the range of the telescope. It will be possible to study the fine structure of the radio emission.

FINE RESOLUTION

Under these conditions the resolution could range between 0·1 and 1 second of arc at metre and decimetre wavelengths. Though it is in fact possible to obtain resolutions of this order in long baseline interferometers these are only really effective at frequencies of one centimetre or less. With the addition of this new telescope it would be possible to obtain corroborative data of great value.

The new Radio Telescope will be a parabolic cylinder two km in length and 50m wide. It is to be built on the equator, making maximum use of the rotation of the Earth in order to increase the area from which to collect data. This poses the problem of its place of erection. Three areas only qualify: Africa, Indonesia and South America.

The cost of the telescope is estimated to be about eight million dollars with a further two million dollars for equipment. This is a small cost compared with the benefits to be obtained not only in technical and scientific knowledge but also in the expertise afforded the developing countries that are associated with the venture.

Profs. Menon and Swarup have already visited Tanzania, Nigeria and Kenya to enlist support. They are of the opinion that the telescope could be started in about a year and that it could be ready for operation in four years. The next step after this would be to add a 14km by 8km interferometer which could be ready two years later.

MARS AND LIFE

It is now two years since the Viking missions to Mars began their active search for life on the planet. During the intensive research over those years there have arisen two schools of thought as to the presence of life; one that contends that the apparent life is in fact the result of inorganic chemical processes, the other postulates that the biological explanation was the most likely. It does now seem that the leaning is toward the biological explanation although it would seem that a final decision needs another Mars visit.

That the biological life was taken to Mars by the mission is ruled out because of the report by the Committee on Planetary Biology and Chemical Evolution. The report says that the possibility of the effects of the oxidants and ultra violet radiation together with absence of organic compounds on Mars suggests that microbial life could not be supported. This is based on the examined strata. It is also pointed out that the majority of any micro-organisms would not have survived the journey to Mars.

SPACE DEBRIS

The number of satellites and other vehicles in local space continues to increase. While some will stay intact for periods varying from a few years to several million years it is inevitable that before long a collision will occur. This situation has been highlighted by D. Kessler and B. Cour-Palais from the Johnson Space Centre. They expect the first major collision to occur during the next 10-20 years. This would produce a band of small fragments all round the Earth in 50 years. At the present time there are more bodies heavier than a gramme than there are natural meteorites in a band 100 kilometres above the Earth. If this situation continues it will mean the zoning of Earth Space to avoid collisions and maintain effective communication.

There would appear to be the need for imposing a definite limit to the life and condition of bodies sent into space. It would of course be possible to do this by controlled be-entry or perhaps better still to gather up sufficient "dead" units and send them toward the Sun. One could of course consider a special vehicle as a space refuse collector. However it is a matter now to be seriously considered before the increasing number of launchings take the problem to alarming proportions.

NOBEL PRIZE

A Nobel prize has gone to Arno Penzias and Robert Wilson for the discovery of the cosmic microwave background. It seems a pity that Dicke, Roll, Peebles and Wilkinson were not included since they in fact were the original discoverers. It is true that when Penzias and Wilson first heard the background hiss they could not understand its origin nor had they known of work of Dicke and his team, though they were near neighbours in their respective laboratories.

FOUR HUNDRED MILLION YEARS AGO

Four hundred million years ago the Moon was nearer to the Earth. This has been determined from the growth ridges on the shell of fossil cuttle fish. Now the length of the lunar month known to vary, and indeed a figure is given for this by astronomers. It can be shown that during the past few thousand years the Moon has been receding from the Earth at the rate of 5·8cm a year.

The changes in the ridges of the cuttle fish shell suggest that a greater variation of up to 17 times that figure was the norm 400 million years ago. It is also the case that this could have varied by a factor of three. It has been generally accepted by astronomy and other disciplines that evolution tended to be more rapid when the Moon was closer to the Earth, since the tidal forces were greater. This implies that the Moon was closest to the Earth about a billion years ago.

Lunar geology makes it virtually impossible for the Moon to have been closer at that time. Thus the orbit must have been slower, at a time of 400 million years ago. This has been set out in a paper by Peter Khan and Stephen Pompea of Colorado State University in a letter to *Nature*.

SHUTTLE ENGINE

The recent tests of the Shuttle Main Engine (SSME) have now made it possible to give a firm date for the first test launch of the shuttle. This is now 28 September 1979. The Space Shuttle is launched by a combination of two solid fuel boosters and three liquid hydrogen/liquid oxygen main engines. The boosters fall away after two minutes and descend by parachute for recovery. The main engines carry the vehicle into orbit but just before it reaches orbit the main fuel tank is jettisoned to fall into the Indian Ocean.

PE MICROPRINTER Part 1

MARK SIMON

40 COLUMN, 5 × 7 DOT MATRIX, ELECTROSENSITIVE FOIL PRINTER.

SINCE the microprocessor has made home computing a reality a lot of effort has gone into creating cheaper peripherals. The household television can be transformed into a visual display unit (VDU), and inexpensive bulk storage can be realized by use of a cassette tape recorder. Unfortunately no readily available hard copy device exists in most households, which can be adapted, and yet there is a definite need for some way of permanently recording text and programs.

Commercially available printers and printer systems are usually very expensive, but a recent arrival on the printer scene is the aluminium foil printer, which costs significantly less, especially if bought *without* its associated electronics.

This series of articles will describe the electronics and software required to turn this stand-alone printer into a microcomputer compatible printing system.

The system will accept ASCII code (American Standard Code for Information Interchange), and will be capable of printing 64 different characters and symbols at a rate of around 100 characters per second. The printer can print 40 columns (i.e. 40 characters per line) onto a special metallized paper, one roll of which should be good for around 6,800 lines.

The components to build the −24V power supply and interface come to around £35, and the print-head mechanism is a further £55. Whilst this is a considerable sum for a hobbyist's project, it is still cheap compared to commercially available hard copy systems of similar capability.

The project itself is very interesting as it involves using the constructor's own microcomputer system to run software that will control the interface electronics. The electronics in turn control the action of the electromechanical/thermal printer. In short it's got a bit of everything!

The software enables the printer to print out the contents of your microcomputer memory in one of two ways. Firstly, if the memory contains text (for example a program listing in mnemonic form), and the stored characters are in ASCII code, then the locations will be read sequentially and printed directly.

If, however, it is required to perform a memory dump, that is to print the actual hexadecimal contents of memory locations, then the software will convert the contents of the memory into their corresponding ASCII code and then print them. The relevant memory address will be placed at the start of each line. The front cover picture gives examples of both modes.

Part 1 will look at the printer itself and then give an overall view of the printer system. Following parts will describe the operation and construction of the interface, the −24V power supply, general mechanical construction, and the software and system testing.

THE PRINTER

The printer produces characters based on a 7 × 5 dot matrix. The printing head is comprised of a vertical column of seven electrodes, which when pulsed cause dots to be etched onto the metallized paper. The paper is basically black, but is covered by a very thin layer of aluminium, and the pulsing of the electrodes melts the aluminium allowing the black paper to show through as a dot (see Fig. 1.1).

By pulsing various combinations of the seven electrodes as they horizontally traverse the paper, characters can be formed (see Fig. 1.2).

To maintain even spacing between the columns of dots, the electronics controlling the pulsing of the electrodes must be synchronized to the movement of the printing head. This is realised by using a gear wheel, driven by the printer motor, to induce a sinusoidal wave in a pick up coil (see Fig. 1.3). Obviously any variation in the speed of the head will be "paced" by the generated waveform.

A short time after the head has started to move, a reed switch on the printer closes. This indicates when the head is in a position to accept printing pulses. The switch opens again just before the head finishes its horizontal traverse.

This reed switch is energised by a fixed magnet whose effect on the reed is normally inhibited by a shield plate. When the printer is in a position to print, a cam pushes the shield plate aside leaving the magnet free to switch the reed. Fig. 1.4 shows the printer sequence.

The source of mechanical movement in the printer is a 24V d.c. motor; this drives the magnetic pickup tooth-wheel and a mangle gear via reduction gearing. The mangle gear drives the print head using a wire system. The cam to actuate the reed shield plate is incorporated onto the same shaft. To enable the printer to produce characters, the printer's elements must be used in the following way:

The motor must be switched on and off at the correct times, to traverse the print head and to operate the reed.

The reed switch closing must enable printing. The opening of the switch is used to switch the motor off.

The pickup coil waveform must be used to synchronize the pulsing of the electrodes.

The electrodes must be pulsed in the correct combinations at the right time to produce characters.

THE PRINTER SYSTEM

Fig. 1.5 shows a block diagram of the major parts of the system and their interconnecting signals.

The microcomputer system presents 6 bits of ASCII code (which is sufficient to encompass the characters we are concerned with) to the interface along with the print command ($\overline{PC}$) signal to initiate the printing of a line. The DATA REQ signal from the interface informs the microcomputer system when the printer is ready for another character.

The action of the microcomputer system is (a), to initiate printing ($\overline{PC}$ active), then (b), to sequentially present the required characters to the interface when requested to do so,

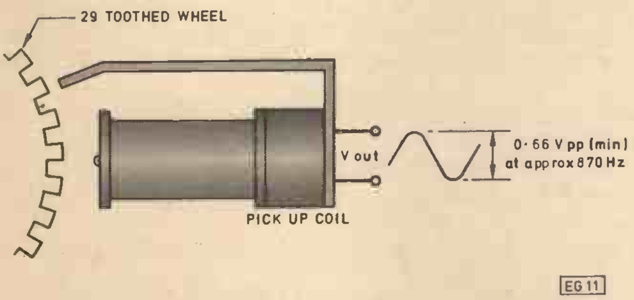
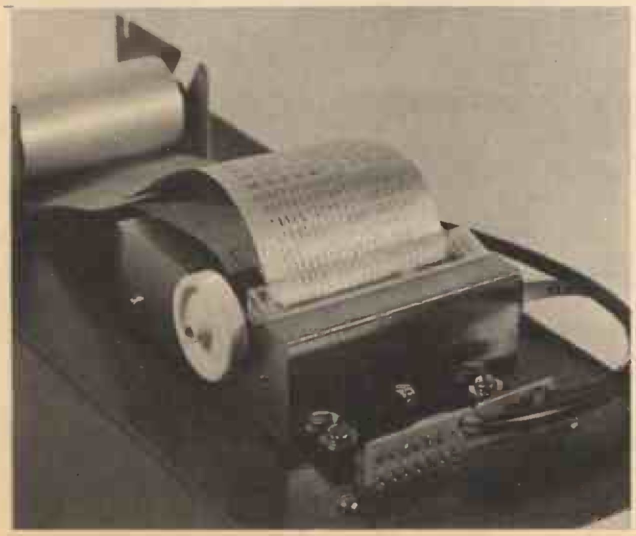


Fig. 1.3. A toothed wheel completes the permanent magnet's flux circuit. Teeth produce flux pulses; flux pulses produce e.m.f. pulses



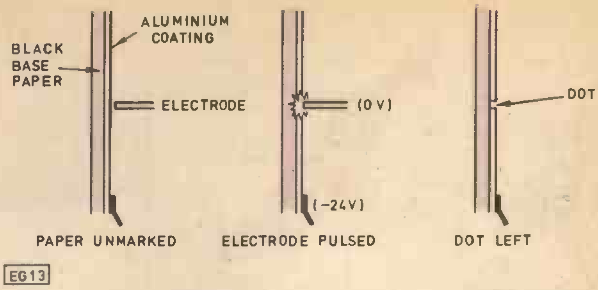


Fig. 1.1. The point contacts formed by the print-head electrodes cause concentrated points of heat which vapourise the metal film

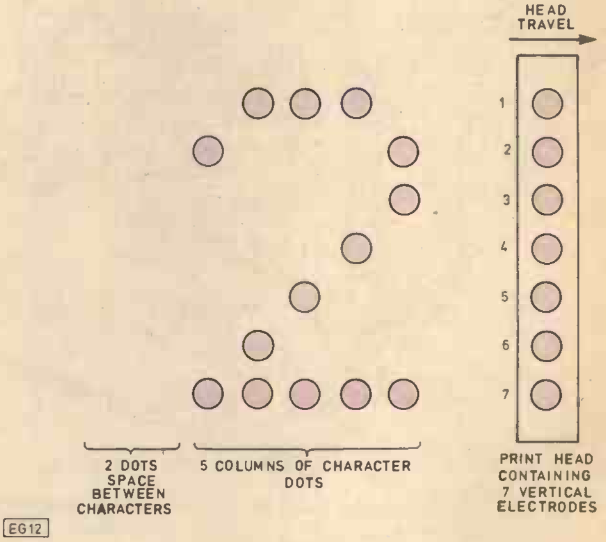
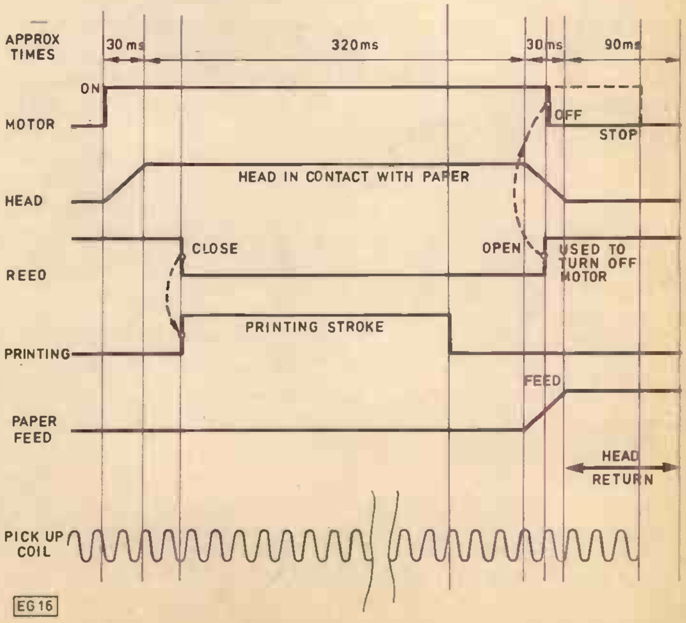


Fig. 1.2. The character generator ROM remembers the electrode pulsing sequence for each character called up

Fig. 1.4. Printer sequence. A reed switch, operated by a permanent magnet, provides feedback for the sequence control



until a line has been printed.

The interface has to convert the ASCII character codes into the 7 x 5 matrix previously mentioned and drive the electrodes in the correct combinations to produce characters. This operation must be synchronised to the movement of the printing head. This is done using the pickup coil waveform.

The printer system requires +5V, −24V, −12V and 0V supply rails. But as CMOS logic is used and the 5V current requirement is low (typically 70mA) this can be obtained from the microcomputer's 5V supply. The −24V supply is used to drive the printer motor and the electrodes (via drive circuits on the interface) and is required to supply an average current of about 200mA. The −12V supply is required as a "Vgg." supply rail by the printer's MOS character generator chip. A Zener diode will be sufficient for this requirement.

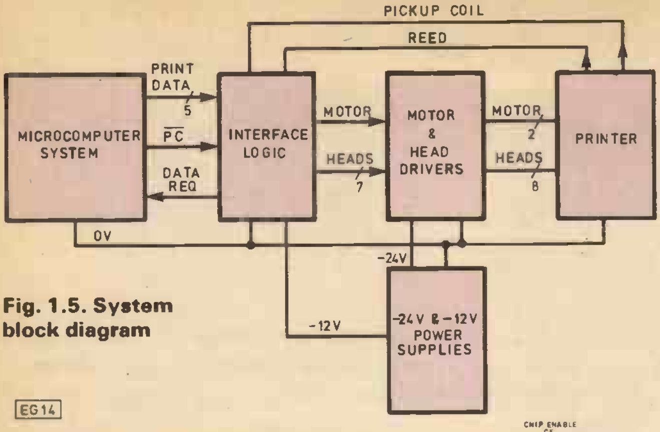


Fig. 1.5. System block diagram

CHARACTER GENERATOR

The function of the interface is to receive ASCII data from the microcomputer and convert it to 5 x 7 matrix pulses capable of driving the printer electrodes. It must also take care of the timing and synchronisation of this operation.

The heart of the interface is the character generator chip, the 3257. The following, along with Fig. 1.6 and Fig. 1.7, describe its operation.

Within, the character generator chip is a 2240 bit read only memory organised as 64 character "cells", each having five columns of 7 bits. The ASCII code presented to the inputs A0 to A5 will select the character "cell". The clock pulses entering the divide by 7 counter sequentially select the five columns of the character "cell", then outputs them from pins O1 to O7. It is useful to note at this stage that outputs O1 to O7 remain inactive (high) unless chip enable (CE) input is active (high).

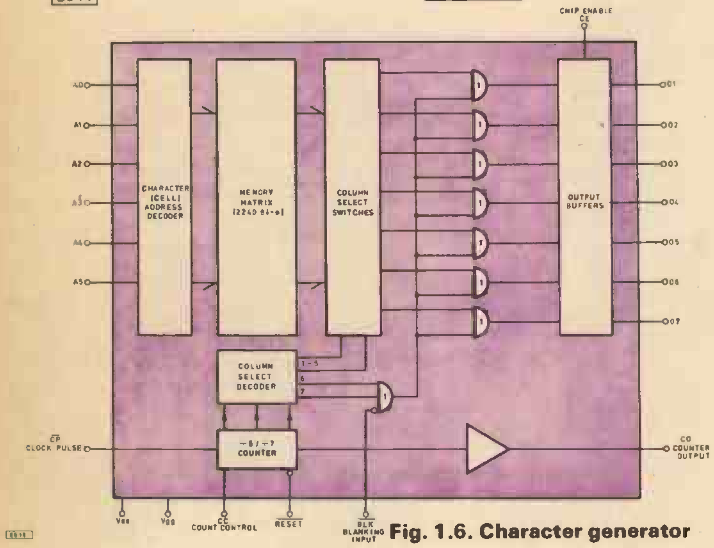


Fig. 1.6. Character generator

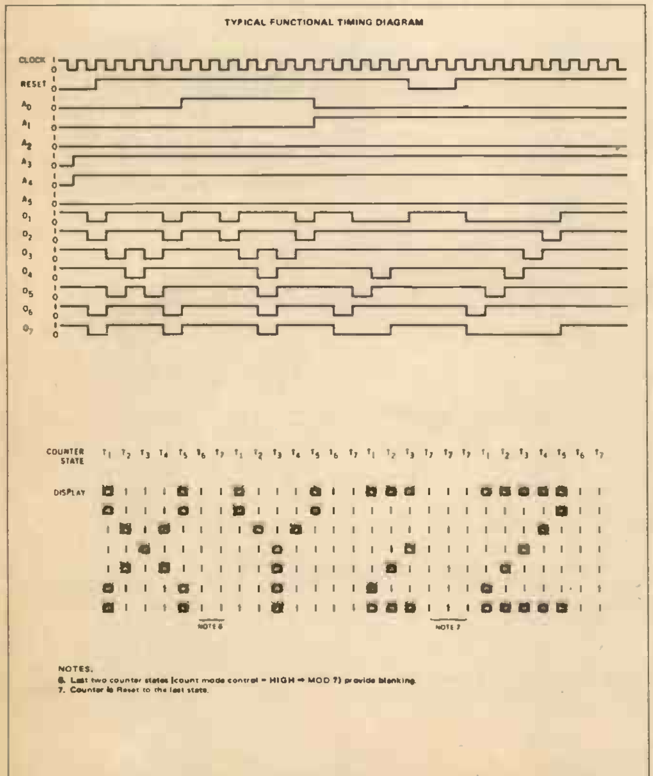
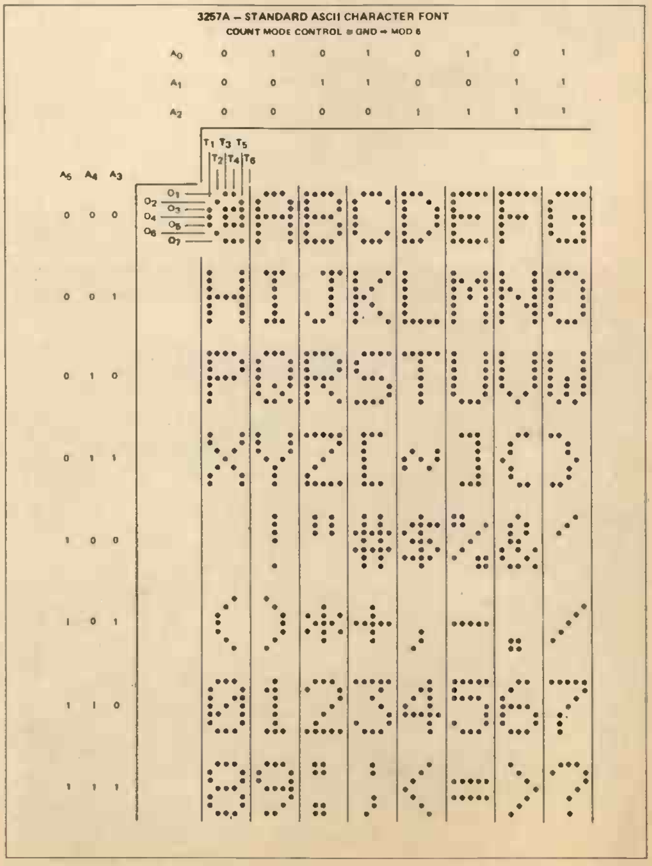


Fig. 1.7. This diagram shows how the seven drive lines are pulsed, for a sample group of characters *(Fairchild)*

Fig. 1.8. ASCII characters available *(Fairchild)*



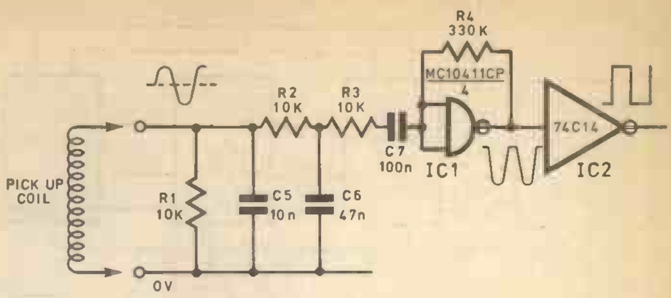
After the five columns have been clocked out and the character has been printed, output O1 to O7 all go high (inactive) for two further clock pulses. This is to give space between characters. It is during that time that the counter out (CO) output goes active (high) indicating that the character generator chip is ready to receive the next ASCII character from the microcomputer. The characters available and their configuration are shown in Fig. 1.8.

CLOCK CIRCUIT

Before we see how the rest of the interface is built around the character generator chip, it is worth looking at the clock circuit separately.

When the motor is running the gearwheel and pickup coil generate a sine wave of around 1V peak to peak. The pickup coil/clock circuit (Fig. 1.9) filters this waveform and then amplifies it using a CMOS NAND gate with feed-back. A CMOS Schmitt trigger (MM74C14) converts the amplifier output to a clean rectangular wave.

As the period of this waveform is obviously dependent upon the operation of the printer, it is used to clock the interface circuit and thus synchronize its operation with the printer.



EG 18

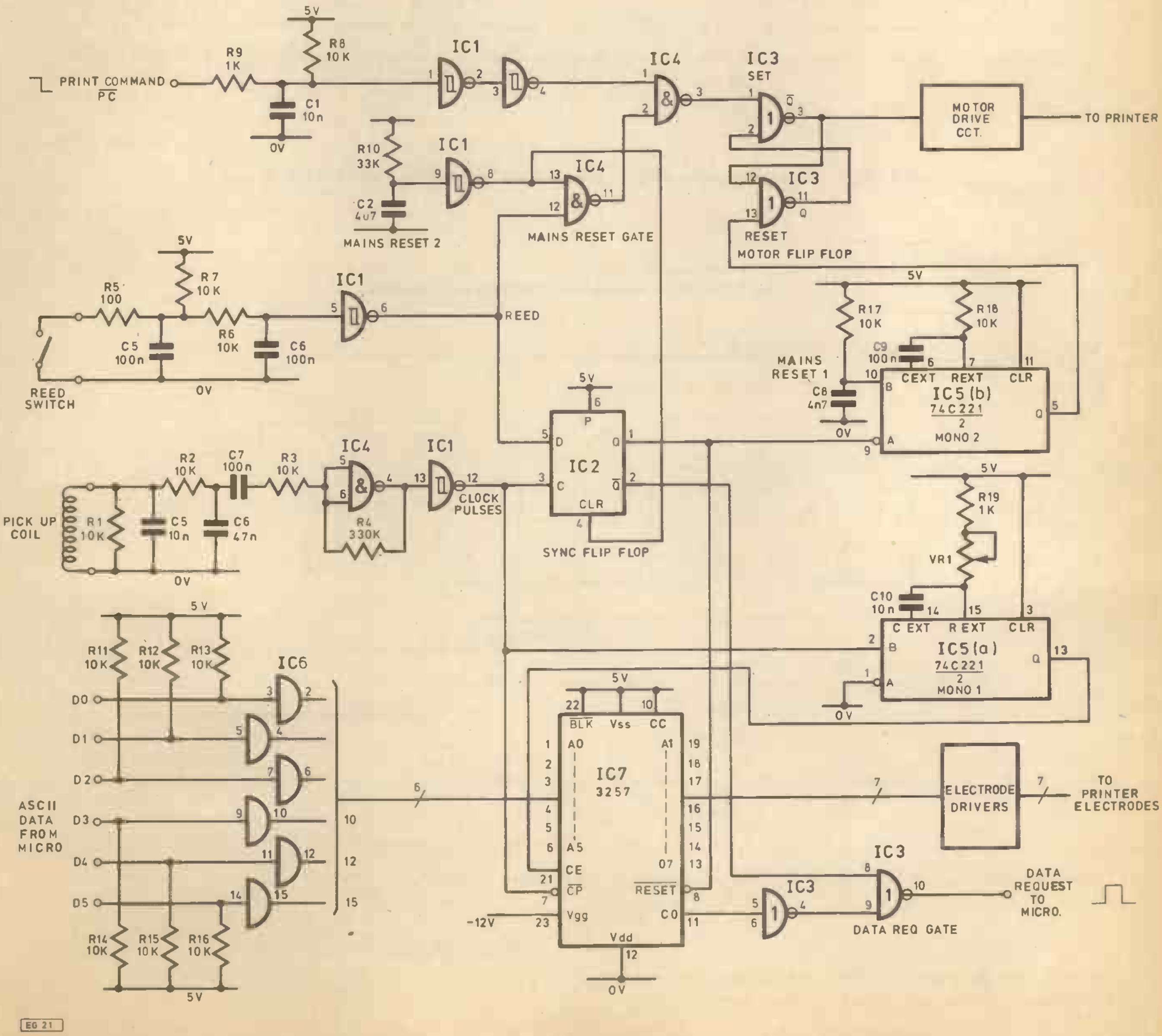
Fig. 1.9. Clock generator (amplifier) circuit

INTERFACE

The rest of the interface circuitry operates as follows:

The computer activates PRINT COMMAND ($\overline{PC}$). This sets the motor flip flop (see Figs. 1.10, 1.11, 1.12), the motor starts, the print head traverses and the pickup coil generates

Fig. 1.10. Interface circuit diagram



EG 21

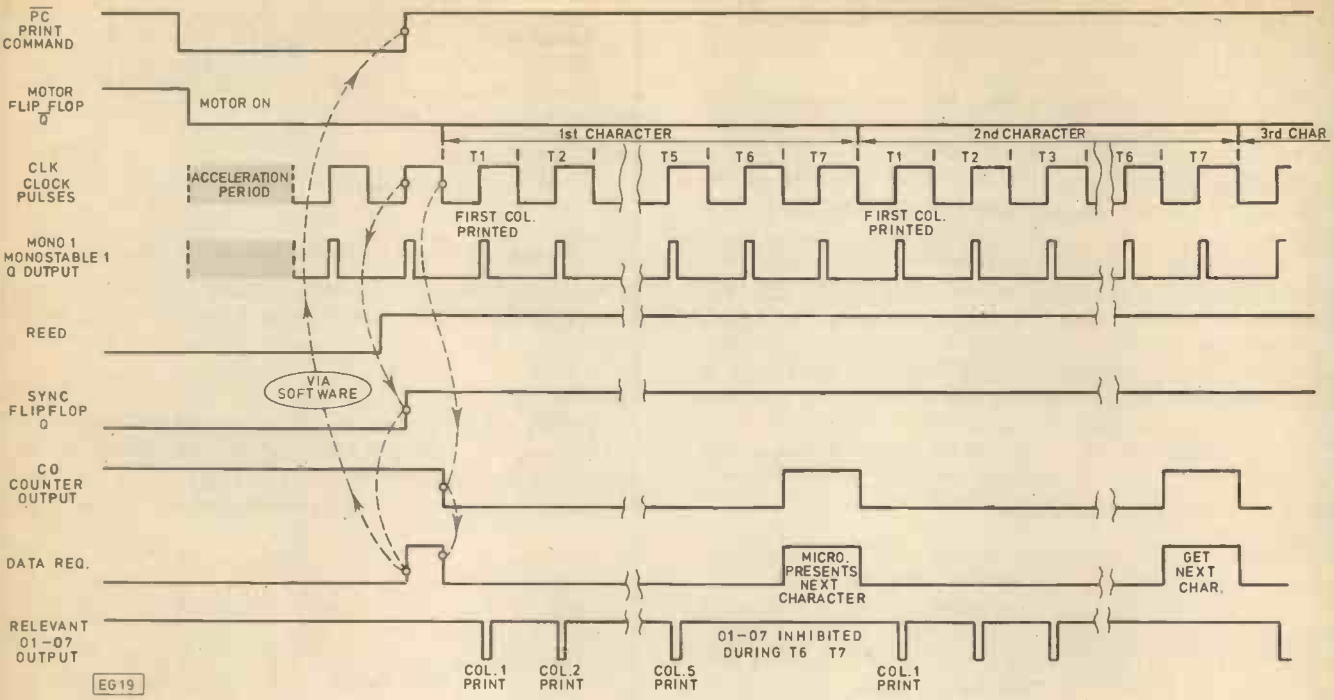
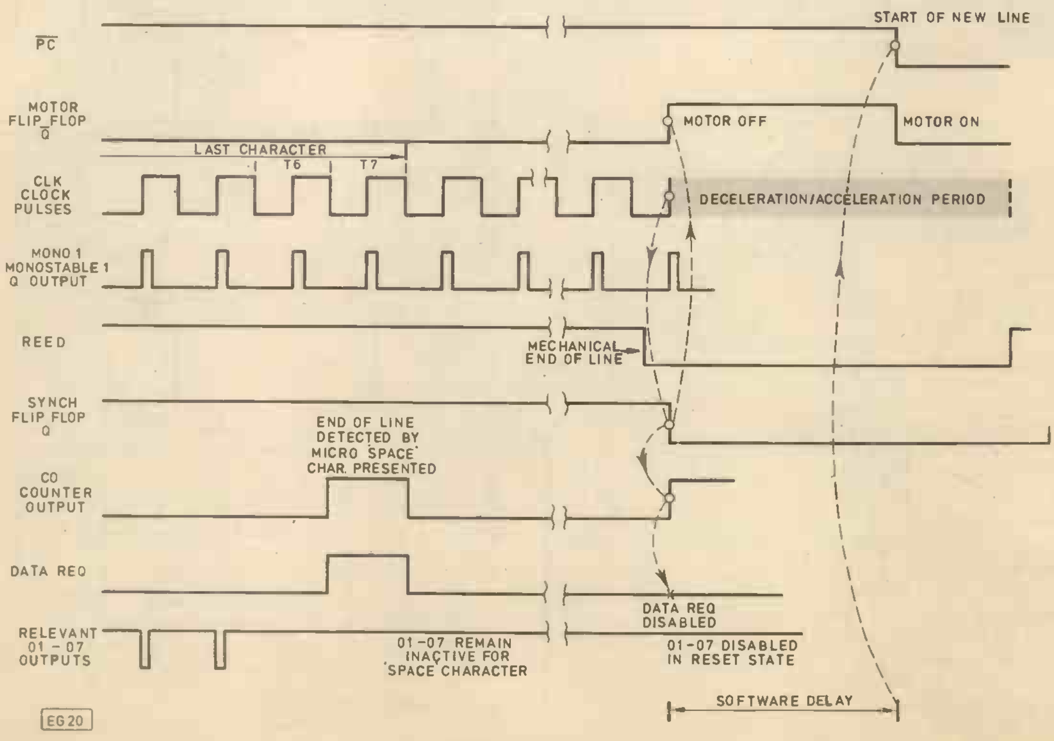


Fig. 1.11. Print sequence starting up waveforms for various points in the circuit

Fig. 1.12. Print sequence finishing waveforms



the sine wave which is converted to clock pulses.

When the print head is in a position to print, the reed closes. The resulting change of level is presented to the SYNC flip flop and clocked through on the next clock pulse.

SYNC FFQ going to 1 frees the character generator chip from its reset state.

SYNC FFQ going low enables the data request gate, which requests data from the microcomputer, allowing the software to deactivate print command (PC).

The microcomputer presents the ASCII character to the character generator chip inputs via the non-inverting CMOS buffers.

The character generating chip sequentially outputs the five matrix columns to the electrode drivers over the next five clock pulses.

During the sixth and seventh time periods, the character generator chip's outputs O1-O7 remain inactive (high) to allow intercharacter spacing to occur.

For the duration of the seventh clock period the character generator counter output (CO) goes high. As the "Data Request" gate is enabled its output also goes high. Signalling to the microcomputer that the interface is ready for another character.

At the end of the seventh period, the character generator's internal divide by seven counter returns to its original state. It is now ready for the next character which the computer will have already presented to the interface.

The next seven clock pulses will clock out this character plus two spaces. DATA REQ will cause another character to be presented; this will also be printed and so on until the end of the line.

As soon as the software decides that the last character of a line has been printed, the computer outputs an ASCII

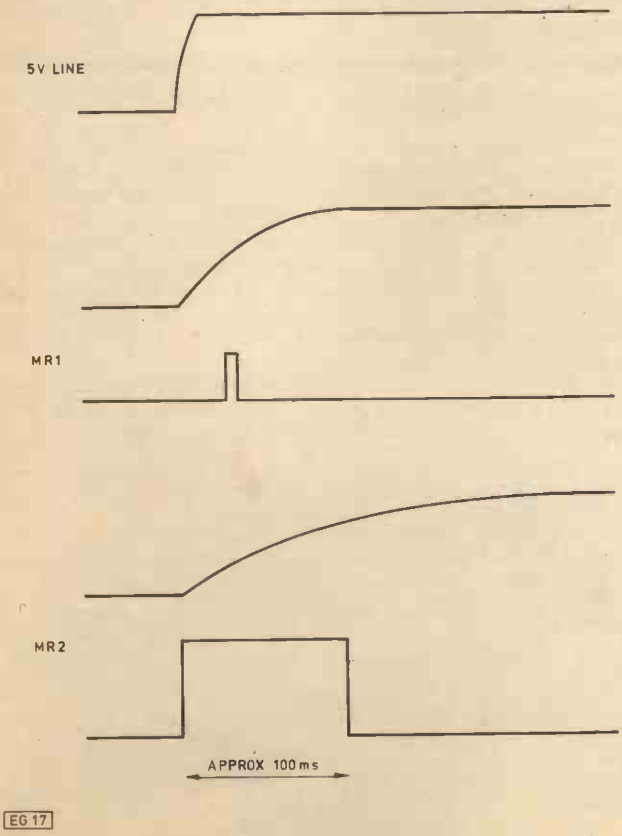


Fig. 1.13. Mains reset waveforms

COMPONENTS . . .

Resistors

R1-R3, R6-R8, R11-R18, R34-R47, R55	10k (29 off)
R4	330k
R5	100R
R9, R19, R58	1k (3 off)
R10	33k
R20-R26	4k7 (7 off)
R27-R33	2k0 (7 off)
R48-R54	470R (7 off)
R56, R57	2k7 (2 off)
R59	2k2
R60	330R

All $\frac{1}{4}$W 5%

Capacitors

C1, C10	10n polyester (2 off)
C2, C8	4µ7/16V tant (2 off)
C3, C4, C13-C15	100n disc ceramic (5 off)
C5	10n disc ceramic
C6	47n polyester
C7, C9	100n polyester (2 off)
C11, C18	10µ/63V electrolytic (2 off)
C12, C19	470µ/16V electrolytic (2 off)
C16	1µ/63V polyester
C17	4700µ/63V electrolytic

Diodes

D1-D4	ZS174 (4 off)
D5	13V 400mW Zener
D6	11V 400mW Zener
D7	1N472A 12V Zener

Transistors

TR1-TR7, TR15	BC212 (8 off)
TR8-TR14	BD189 (7 off)
TR16	2N3053
TR17	2N4037
TR18	TIP42

Integrated Circuits

IC1	MM74C14N
IC2	MC14013CP
IC3	MC14001CP
IC4	MC14011CP*
IC5	MM74C221N
IC6	MC14050BCP
IC7	3257ADC Character Generator (Fairchild)

*Must not be a B series (buffered O/P) device

Miscellaneous

14 pin d.i.l. socket (4 off)
16 pin d.i.l. socket (4 off)
24 pin d.i.l. socket (1 off)
Panel mounting mains fuse holder (1 off)
Mains d.p.s.t. switch (S1)
2-pole 3-way switch
Mains neon indicator
Stripboard 95 × 228mm, and 63 × 63mm (1 off each)
Mains cable grommet (1 off)
240V transformer with 0-25V sec (4VA min)
Printer: Matsushita type 245/L/40 (Datac Ltd)
Box of electrosensitive paper (4 rolls)
Clamp for C17 (35mm)
15-way plug (free) and socket (chassis mounting), capable of at least 2 amps

"space", character. When decoded by the character generator chip this does not cause any electrode action. The system remains in this mode outputting spaces until the switching of the REED signifies the "mechanical" end of the line. When this transition is clocked through the SYNC flip flop, the motor flip flop is reset via Mono-2. The character generator chip is held in the reset state by SYNC FFQ and the "Data Req" gate is inhibited.

If another line has yet to be printed, the software allows the printer to settle, then reactivates print command and the process is repeated.

MAINS RESETS

At switch-on the motor flip flop is required to be in the reset position so that the motor does not continually run. This is realised by the RC combination charging up at the positive transition input of Mono-2. When the voltage on the B input goes over the threshold, a reset pulse will be sent to the motor flip flop.

However, if for some reason the print head was in the middle of its traverse when power was switched on, resetting the motor flip flop would leave it stuck, and cause erroneous printing when operation started.

Mains Reset-2 generates a pulse which lasts much longer than the period before Mains Reset-1 generates its reset pulse. If the head is positioned midway, the reed will be closed (Reed = 1). This will enable the "Mains Reset" gate, allowing the Mains Reset-2 pulse to set the motor flip flop despite the Mains Reset-1 pulse (see Fig 1.13). The head will traverse until it is in its correct position and the circuitry resets itself due to the closing of the REED in the normal way.

INTENSITY OF PRINT

Intensity can be controlled by varying the *burn* time of the electrodes. The electrodes are driven by the counter-

The P.E. Microprinter is shown here with the Z80 based Micros system

generator chip outputs O1–O7. These outputs are strobed active, by Monostable-1 pulsing the chip enable input (CE). By adjusting VR1 the "active" time for O1–O7 can be varied, hence the burn time, and print intensity can thus be controlled.

As the bulk of the circuitry has now been described, the full components list is included in this part of the article.

Well, if you found detailed explanation of the circuitry heavy going, you will be relieved to hear that Part 2 will deal with the more basic driver circuits, power supplies and construction.

News Briefs

MICRO' EXTENSION

ONE of Commodore's microprocessor distributors, G.R. Electronics of Newport, Gwent, have announced several major extensions for the Commodore Kim 1 microcomputer.

Kim 1, which is manufactured by MOS Technology, a division of Commodore Systems, sells for less than £150 and is a ready-to-use microcomputer requiring only a POWER SUPPLY (price £27) to be fully operational. The new extensions, however, make the system more versatile, giving more peripherals, larger memory, and ready-made software.

A Video Board, designed by G.R. Electronics, allows KIM 1 to use a domestic television set as a visual display unit, with a capacity of 16 lines of 64 characters. (Available at £150).

Memory can be expanded with the addition of the new Memory Plus Board, which contains 8K bytes of RAM, and has provision for up to 8K of EPROM. (G.R. Electronics are now supplying a 240 volt power unit which has been specially designed for the KIM 1). (The price for the Memory Plus Board is £199).

Input to the basic KIM 1 system is by a key-pad which allows hexadecimal code and control functions to be keyed in. Although any standard ASC11 keyboard can be connected, G.R. Electronics have introduced a pocket terminal which can be plugged into the KIM 1 system for easy input of data. The terminal is a hand-held communications unit and allows input of the full ASCII characters set from its 40 dual purpose keys. (Price £240).

Now available is a wide range of powerful software for the KIM 1. To help the system run more efficently, a series of systems software packages are now available from G.R. Electronics. An Assember/Disassember/Editor called the MICRO-ADE package allows the user to program in mnemonic instructions rather than in machine code, and also offers several features to facilitate programming.

An information retrieval package gives the KIM with cassette tape peripherals some sophisticated file handling capabilities. G.R. have also developed a mailing list program for business use called HELP, available at £12.

In addition to these, a *chess playing program* is available as is PLEASE, a package which incorporates a number of games and demonstration programs. The average price for the software is £12.

News Briefs

by Mike Abbott

ELECTRIC CHARIOT RACE

It's hard to think of ingenuity as a resource in the way that oil is to the Middle East, or copper is to Central Africa, but surely it is, and Britain has it. So it's nice to see some encouragement, because although ingenuity doesn't run out like oil, it could well stagnate due to lack of incentive or reward.

Lucas Industries (who are heavily engaged in electric vehicle development), in association with the Institute of Mechanical Engineers, are launching a £2,000 challenge to the amateur and professional engineer alike, to design a manned electric vehicle. The idea being, to see whose machine can transport its driver the farthest in two hours, powered only by two standard Lucas 12V batteries.

The competition is in two parts; the first asks entrants for design submissions, and the best will be awarded prizes. Then the prizewinners, together with other entrants whose design concepts are approved by the judges, will be invited to construct their vehicles and prove them in competition during a distance trial which forms the second part of the challenge.

The winner of the second (Application) Section will be the entrant whose vehicle travels the greatest distance in a two hour period according to the rules, and the outright winner of this section will receive a £1,000 prize.

Before you decide whether to electrify a pram, tricycle, or build your own contraption, the lure of the prizes should be felt.

£1,000—Outright winner
£100—Highest placed four (or more) wheeled vehicle
£100—Highest placed three wheeled vehicle
£100—Highest placed entrant under 18 years' of age receiving full time education
£125—Leader at 60 minutes

The trial will take place during the summer or Autumn of 1979 at a venue in the Midlands.

The closing date for Design Section submissions will be February 1, 1979, and the closing date for Application Section submissions will be July 1, 1979. Some extracts of the rules which apply are listed below:

(1.4) The battery pairs may be used in series or in parallel or alternately.
(1.5) Regenerative braking will be permitted.
(1.7) The maximum dimensions of the vehicle to be powered by the Battery will be 4ft wide × 8ft long.
(1.9) The vehicle will have a minimum of three wheels.
(1.10) In the interests of fairness, driver weight will be a minimum of 10 stone. Where a driver weighs less, provision must be made on the vehicle for carrying sand ballast.
(1.11) Each vehicle shall be fitted with an effective mechanical braking device on no less than one wheel.
(1.14) Those who wish to compete as a team can do so merely by nominating a "team leader" who will become the entrant for administrative purposes. Prizes will be awarded to the first person named on the application form.
(2.6) Vehicles will be propelled by no means other than The Battery and no re-charging except by means of regenerative braking will be allowed during the competition.
(2.9) All entries shall submit to scrutiny before the contest to ensure the rules are observed, and all drivers will present themselves to be "weighed in".
(2.11) The judges, at their discretion, shall be able to award penalties (deduct laps) or disqualify competitors for dangerous driving, bumping and/or obstruction.

Details from: How Far Can You Travel? Lucas Industries, Great King Street, Hockley, Birmingham B19 2XF.

SUBSTITUTE 741

Two new operational amplifiers, NE/SE535 and 538, from Mullard, are high slew rate plug-in alternatives for 741 types. The 535 features a guaranteed unity gain slew rate of 10V/µs with 2mV maximum offset voltage whilst the 538 features 40V/µs minimum with 2mV offset. These figures show improvements in slew rates of 30 times, and 120 times respectively over the slew rate of a standard 741.

The 535 and 538 also offer the attraction of improved input characteristics, such as lower offset voltages and offset current, as well as higher input resistances. The 535 is internally compensated for unity gain whilst the 538 is internally compensated for gains of five or larger.

Both amplifiers are short circuit protected, feature an offset null capability, and have large common mode and differential voltage ranges.

WHEN THE BLOOD FLOWS

The incidence of heart disease and subsequent heart failure among males in their early thirties, and among women in general is increasing at an alarming rate. A by-product of our modern age.

Medical science is largely unable to prevent people from developing heart trouble but once a condition is known there is a great deal that can be done. Open heart surgery, for example, is now a well-practised and fairly common form of treatment.

One of Britain's leading heart surgeons is Mr Bryn T. Williams, Consultant Cardiothoracic surgeon to the Department of Cardiothoracic Surgery at St Thomas' Hospital in London. This Cardiothoracic unit performs between seven and nine open heart operations each week, with remarkable success. For coronary artery surgery the mortality rate can be as low as 2 per cent whilst around 85 per cent of patients recover completely (without side effects), and are able to resume their full-time employment within two to three months.

Open heart surgery can be a lengthy business. Replacing a valve, for example, takes approximately three hours, whilst the more complicated by-pass graft operation can last for up to five hours. During this type of operation, the measure of bloodflow in the by-pass graft is vital. For this, most hospitals use purpose-designed flow meters.

Mr Bryn Williams also uses a *Scopex* single beam oscilloscope, together with an electromagnetic flow probe which he has designed in conjunction with a colleague Mr C. A. Barefoot. The Scopex oscilloscope indicates the quality of the bloodflow by signalling peaks and troughs. It also signals reverse flow which indicates any abnormal situation. The flow meter shown in the picture measures bloodflow in ml/min.

To provide an indication of the success, or otherwise, of the operation the Williams-Barefoot probe is inserted in the patient's chest and remains in place whilst the patient recovers in the intensive care unit. Thus Mr Bryn Williams and his team can accumulate valuable data on long-term bloodflow in grafts. The Williams-Barefoot probe is removed from the patient without re-operation.

The Scopex instrument used by Mr Bryn Williams at St Thomas' is the model 4S6-LS single beam oscilloscope with a sensitivity range of 10mV/cm to 50mV/cm (16 range timebase) and accuracy of ±5 per cent. The 4S6-LS has been tailored to meet the needs of low frequency applications; the trigger circuit will perform reliably down to 1Hz.

Noughts and Crosses Game

KENNETH AMOR

THE electronic version of this well known game uses nine light emitting diodes laid out in the usual noughts and crosses format. On each side of the playing board there is a touch keypad. When a touch switch on either keypad is pressed its corresponding l.e.d. on the board will be illuminated. The l.e.d. will either, flash (indicating a cross) or remain static (indicating a nought). There is an l.e.d. over each keypad to indicate which keys are for the noughts and which are for the crosses. A touch switch is also fitted on the front panel to reset the board after each game.

COMPONENTS . . .

Resistors

R1-R10, R41-R49	10M (20 off)
R11-R19, R31-R40	4K7 (20 off)
R20-R30	470 (10 off)
R50, R53	1K (2 off)
R51, R52	47K (2 off)

Capacitors

C1, C2 4μ7 16V tant (2 off)

Transistors

TR1-TR21 BC108 (21 off)

Semiconductors

IC1-IC10 CD4011 (10 off)

Miscellaneous

11 off l.e.d. TIL209
1 off battery holder
4 off PP7 battery
1 off s.p.s.t. switch
1 off 162 × 97 × 40mm case (RS type 507-737)
Holders for i.c.s (if req).

CIRCUIT DESCRIPTION

The complete circuit diagram of the Noughts and Crosses game is shown in Fig. 1. The ten i.c.s used in the game are CMOS CD4011 quad, two input NAND gates which are cross coupled in pairs as bistable multivibrators to form eighteen memory elements. Nine memories (IC1 to IC5) are used for the "crosses" and another nine memories (IC6 to IC10) are used for the "noughts".

The input to each memory element is connected to a pad on the keyboard together with a 10 megohm resistor which is connected to the supply rail. When a player touches a keypad the input of that particular gate is grounded and the output of the memory element is switched low, turning off its respective transistor (TR1 to TR18). As the transistor turns off its collector voltage rises and the corresponding l.e.d. on the playing board is turned on.

The astable multivibrator formed by TR20 and TR21 produces a square wave output which repeatedly switches TR19 causing D10 (the indicator above the "cross" keypad) to constantly flash. When TR19 pulses its collector voltage and the emitters of TR10 to TR18 also pulse, turning the transistors (TR10 to TR18) on and off and causing the l.e.d.s turned on by the "cross" keyboard to flash.

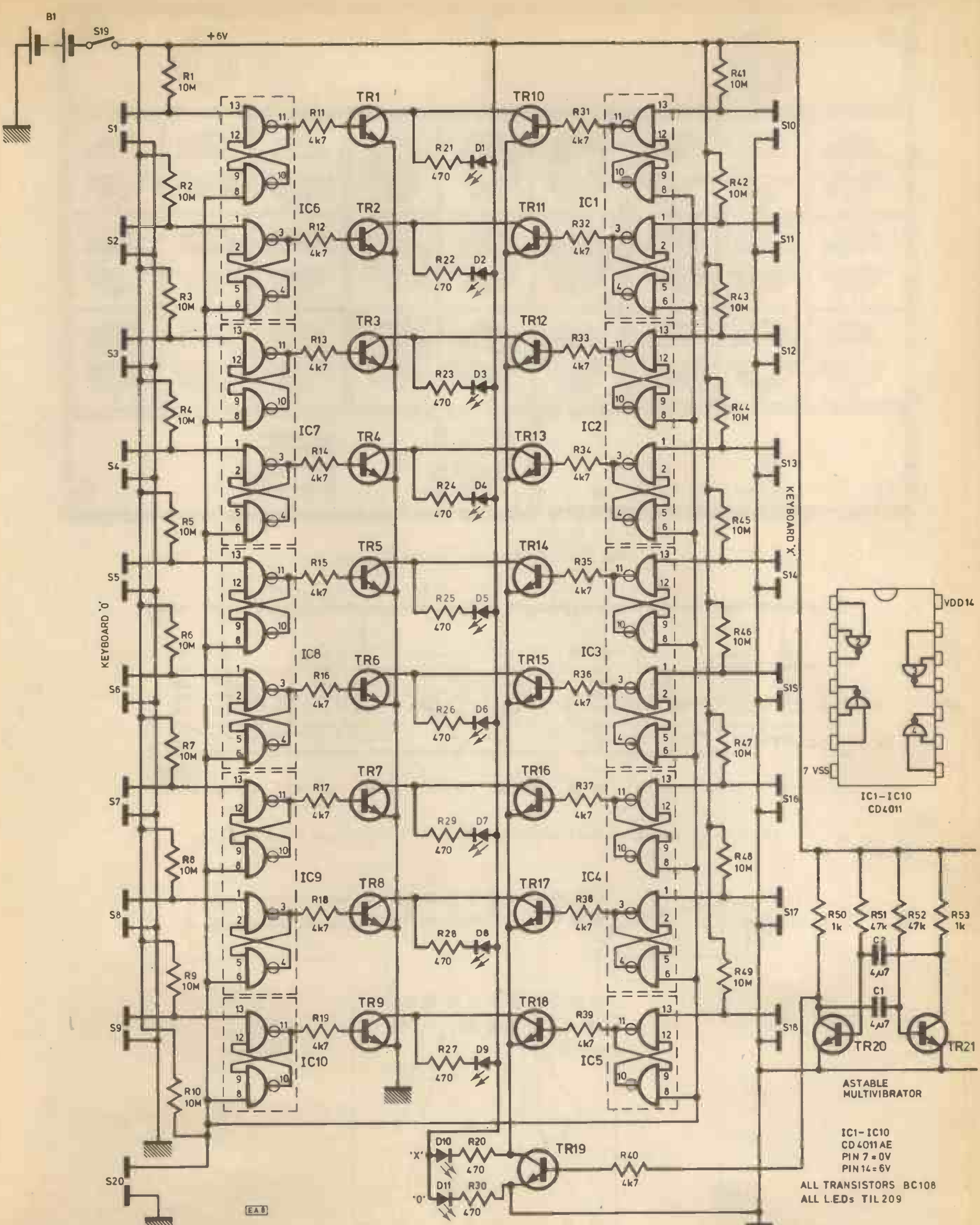


Fig. 1. Complete circuit diagram of the Noughts and Crosses Game

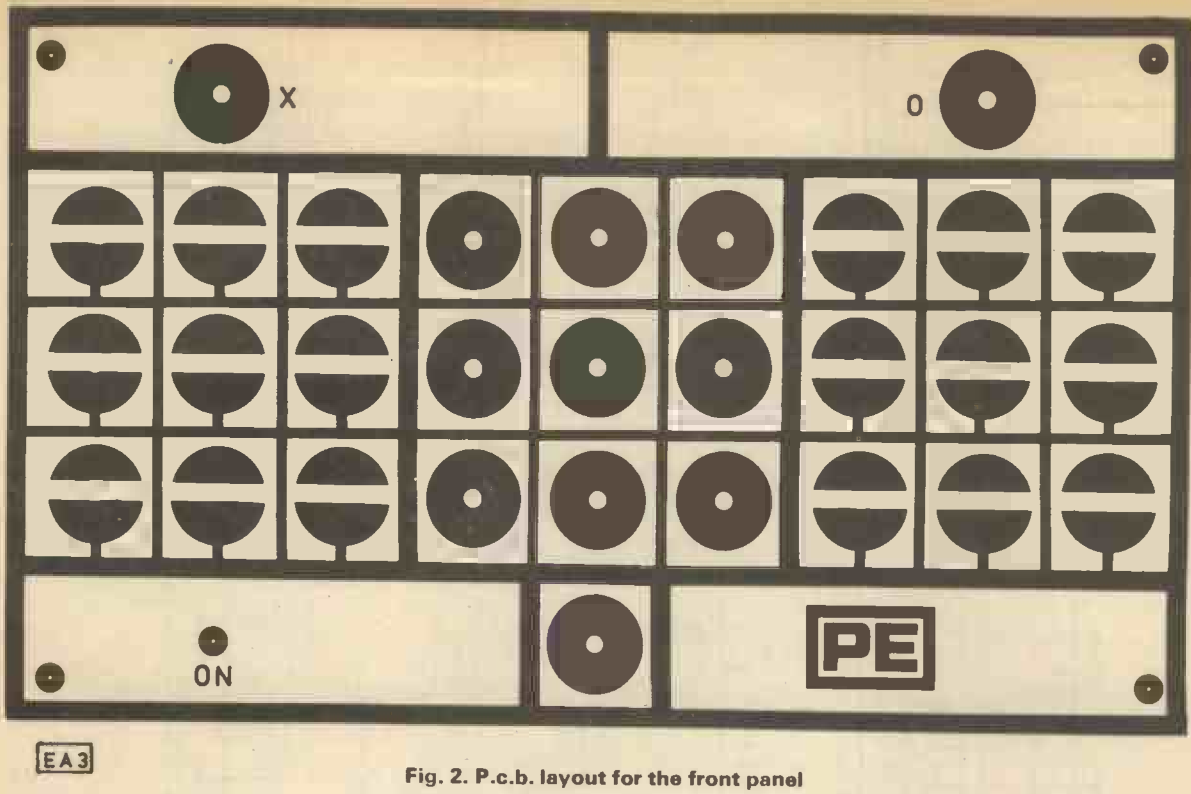


Fig. 2. P.c.b. layout for the front panel

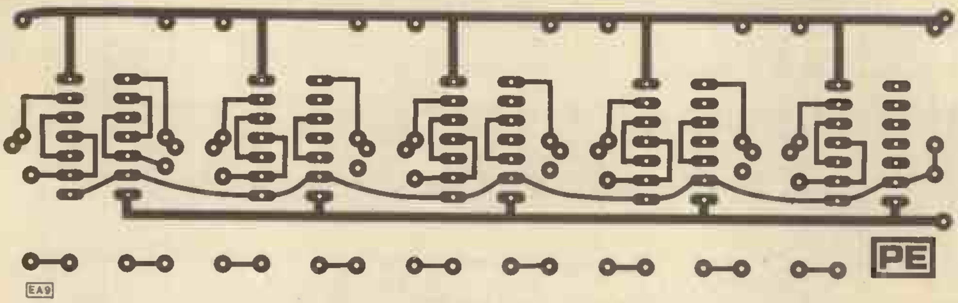


Fig. 3. P.c.b. layout for the memory boards (two of these boards are required)

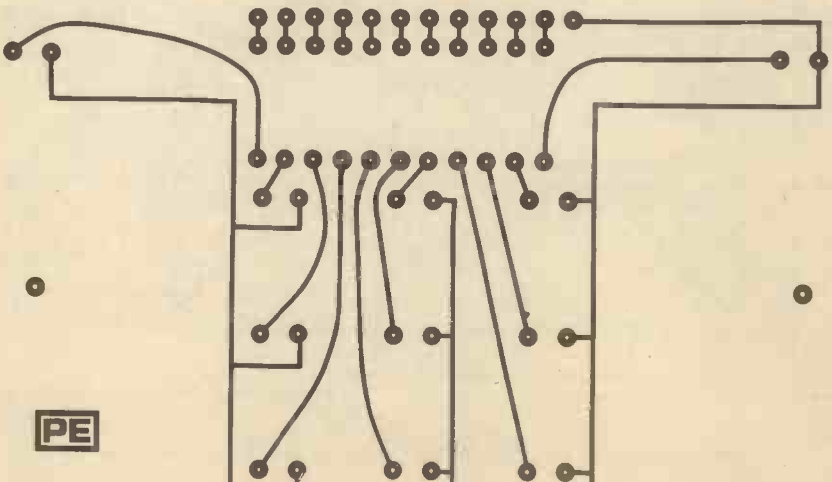


Fig. 4. P.c.b. layout for the l.e.d. board

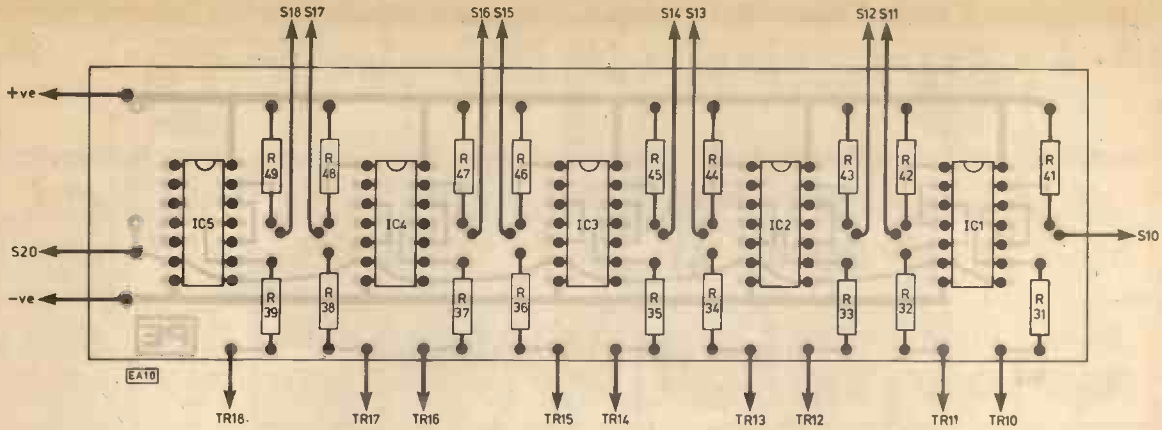


Fig. 5. Component overlay for memory board (crosses)

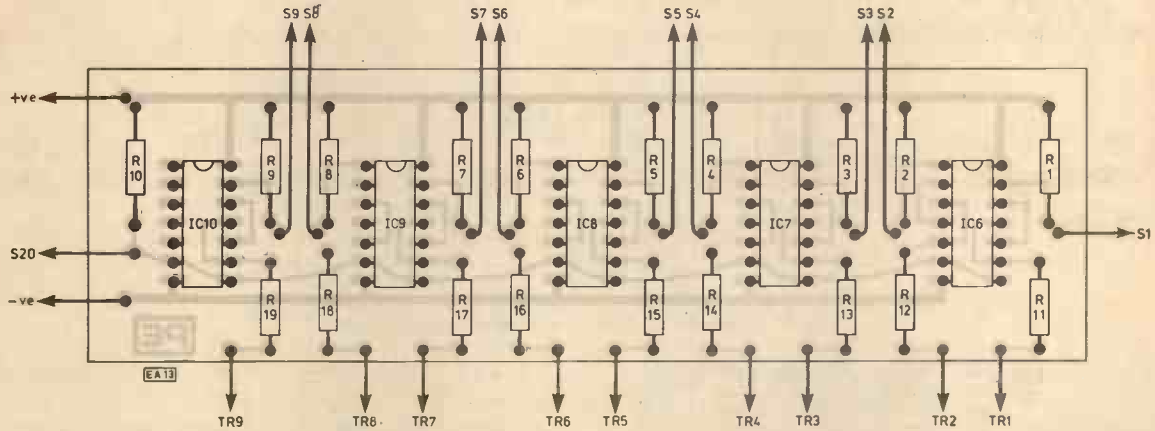


Fig. 6. Component overlay for memory board (noughts)

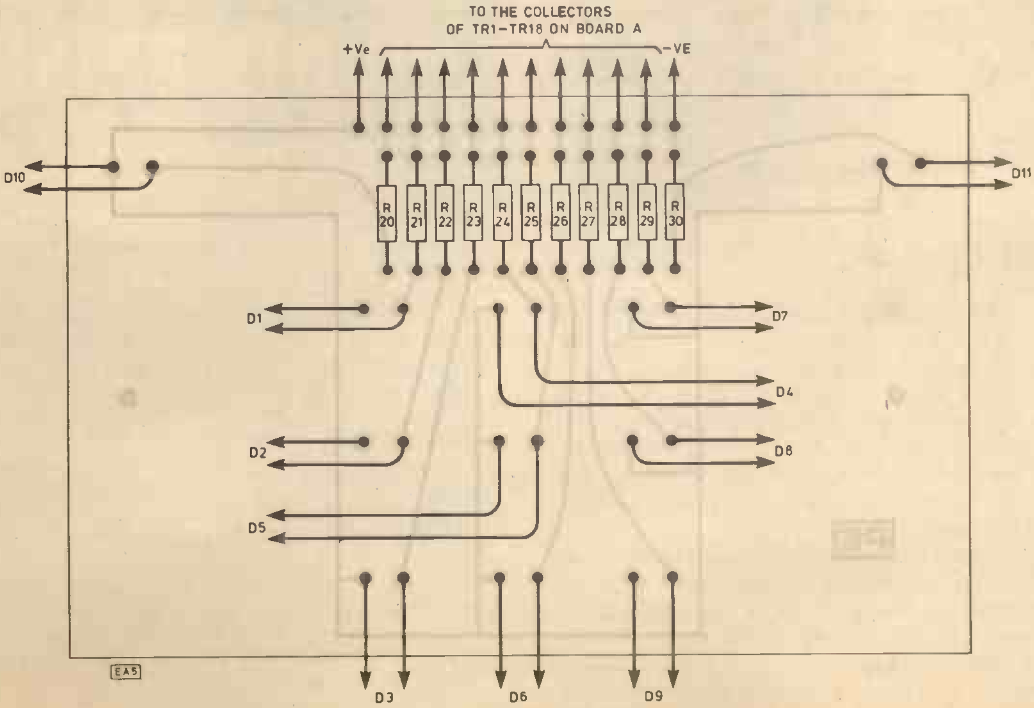


Fig. 7. Component overlay for l.e.d. board

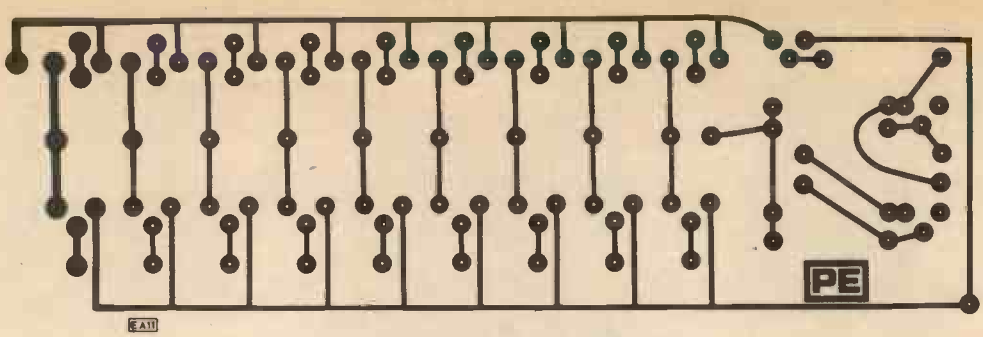


Fig. 8. P.c.b. layour for l.e.d. driver board

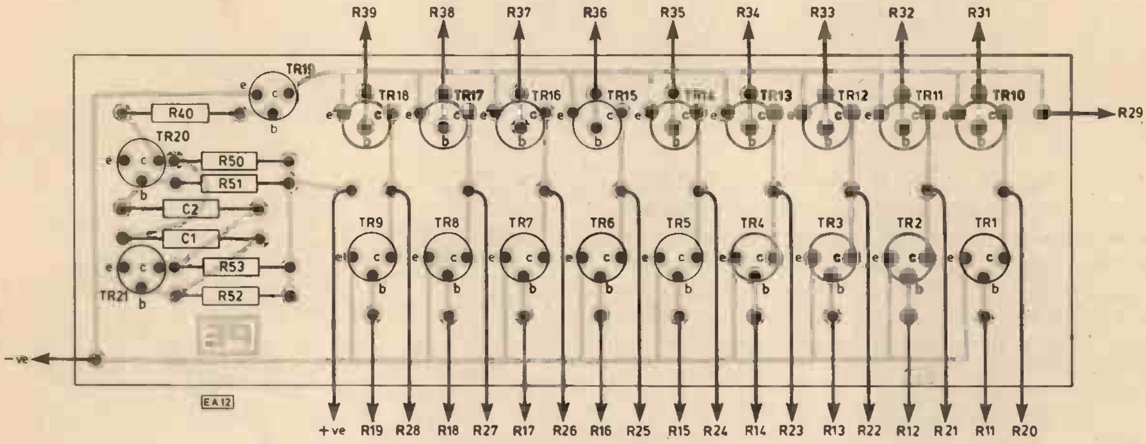


Fig. 9. Component overlay for l.e.d. driver board

CONSTRUCTION

The complete game has been designed to fit onto five p.c.b.s and these are shown together with their respective component overlays in Fig. 2 to Fig. 9.

When all the p.c.b.s have been etched, tinned and drilled the components can be mounted and soldered into position. It is recommended that i.c. holders are used to prevent the CMOS devices from being damaged during soldering. The eleven l.e.d.s should have their leads cut to $\frac{1}{4}$in before they are soldered into position.

After the five boards have been wired together the l.e.d. board can be mounted underneath the front panel p.c.b. as shown in the photograph. The two boards are held in position by two pieces of 20 s.w.g. tinned copper wire which are soldered to the centre touch switches of both keypads. These wires pass through the two holes drilled in the l.e.d. board and are then bent at right angles and soldered to the wires from R6 and R45.

The two memory boards and the l.e.d. driver board are mounted into two slotted guides fitted at the bottom of the case with the battery holder located alongside them.

After the boards have been mounted into the case and the front panel fitted into position the game is ready for use. ★

POINTS ARISING

POWER SUPPLY UNIT *(October 1978)*

The maximum output voltage and current of the supply depends on the transformer and heatsinking. For 2A 30V continuous operation T1 should be a 2A d.c. (post rectification and smoothing) rating, and 25V a.c. output.

It should be stressed that the higher quality 44V type of 741 should be used for IC1-3 (not the 741C).

R10 should be connected to the line connecting the positive side of C3 and the cathode of D5 etc. and not to the negative output terminal as shown. This is correct on the p.c.b.

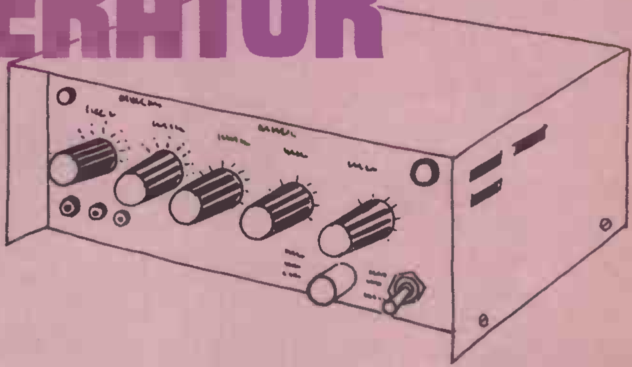
R18 should be 33kΩ and the equation relating to current metering should read $R_y = \frac{(I \text{ f.s.d.} \times 0{\cdot}3}{I} - R_m)$ ohms

for I f.s.d. full scale. (This value is up to the constructor). The equation for R_x is for 30V f.s.d.

S1 is the mains on/off switch, and S2 the meter changeover switch. The fuse should be on the mains side of S1 and is a 1A "Slo-Blo" type.

NEXT MONTH...in PE!

PULSE GENERATOR



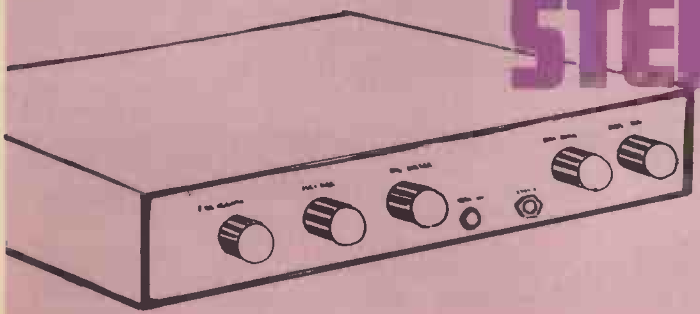
This pulse generator is capable of providing output waveforms with known characteristics over a wide range of frequencies and pulse widths. The unit has independent control over both the pulse width and repetition frequency and is ideal for slowing down the operation of circuits to allow tests to be carried out using a conventional multimeter.

HOME COMPUTERS

The Microprocessor Miracle...

In this new series R. W. Coles takes a general look at home computers together with the main types of peripherals and software currently available.

STEREO MIXER



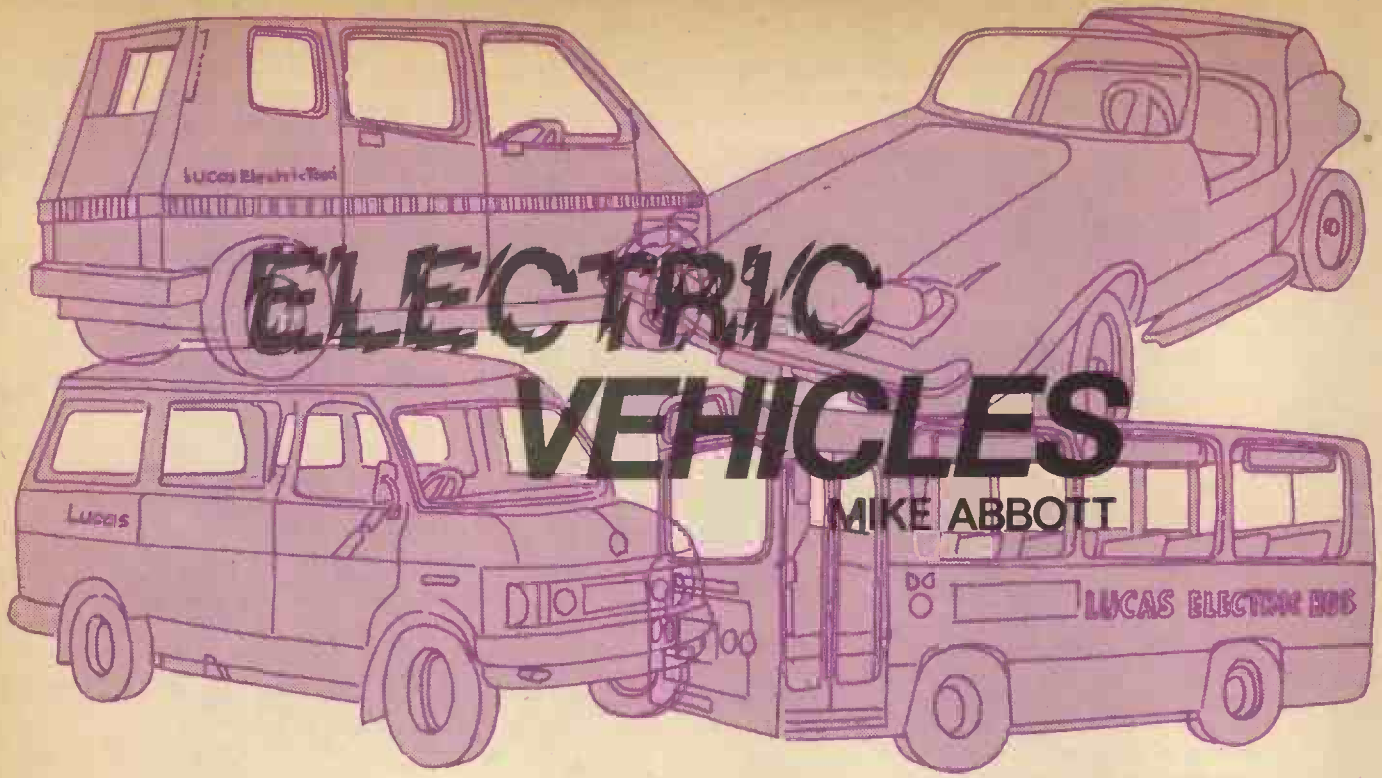
Many owners of hi-fi cassette or reel-to-reel tape recorders cannot use their machines to full creative capacity for want of a good mixer. This simple design will enable many options as it will accept both line and dynamic microphone inputs over three channels for a stereo image.

PRACTICAL
ELECTRONICS

OUR FEBRUARY ISSUE WILL BE ON SALE FRIDAY, 12 JANUARY 1979

ELECTRIC VEHICLES

MIKE ABBOTT



In the fight against noise and exhaust pollution, electric vehicles can surely make a contribution, but what effect would they have on the national fuel bill? Shall we *ever* see electric cars, and is anything being done in the UK?

COMMERCIAL VEHICLES

When fossil fuel runs out do we return to horses (whose pollution was a danger to public health in their day), or do we pin our hopes on electric vehicle development?

Your daily "pinta" has probably been arriving with the aid of an electric milk float for a long time now, and when you look at electric vehicles you tend to think of other "half-pint" machines, such as the forklift truck and the golf-course buggy. It is therefore tempting to think that battery-electric power is more suitable for small vehicles, starting with toy cars and working up to milk floats, and that advancing technology will *in time* allow bigger vehicles to go electric. This is wrong! The common denominator is not size, but predictability of terrain and route, and for this reason we shall most likely see electric buses swishing past before we see electric cars. And more probably still, electric delivery vans. There are a number of electric vans on London's roads already (see News Briefs, February 1978).

Heavily involved in electric commercial vehicle development is Joseph Lucas Ltd., whose first such van was a converted Bedford CA pick-up. Powered by standard polypropylene starter batteries, the van gave sufficient initial data on performance in traffic, and electrical drive systems, to allow the design of the traction motor and control system used in two British Leyland 250 JU vans, the next conversions to take place. They were used for further testing only, since the battery packs occupied the loading floors.

In 1974 the decision was taken to build a considerable number of development vehicles to be put into service with fleet operators, and when the concept for the trials had been determined, willing operators were found. There had to be mutual understanding here, since development vehicles by definition have shortcomings, if only at the outset, and these could lead to embarrassing disappointments. Assurances that problems will be ironed out can quickly wear thin, resulting in the test vehicle being left forgotten.

In this new generation of converted Bedford CF vans, engines, gearboxes, radiators, and much ancillary equipment gave way to electric motors, controllers, combustion heaters and battery units in the two new models. In the CF1 and CF2, higher rated rear axles and road springs from the standard CF range of parts were substituted.

In the CF2 version the batteries are accessible only from within the vehicle, but the CF1's batteries are withdrawn on a sliding tray (see photo) for exterior access. Both these models of CF van had battery packs occupying about 10 per cent of the loading floor, and so a CF3 conversion was embarked on, in which the batteries (all 1 tonne of them) could fit under the floor, and which also used the improved drive technique developed on an electric taxi (of which more later). The diagram of Fig. 1 shows the CF3 layout and the position of the Morse Hyvo chain reduction system employed.

The CF3 specification is:

Acceleration 0–48 k.p.h. in 14 sec.
48–64 k.p.h. in 10 sec.

Top speed 80 + k.p.h.

Min. working range 112km.

Range at constant 48 k.p.h. 224km.

Motor: 216V d.c. 37kW (50bhp) series wound.

Speed: 4,600rpm at 80 k.p.h.

Controller: Lucas designed SCR chopper.

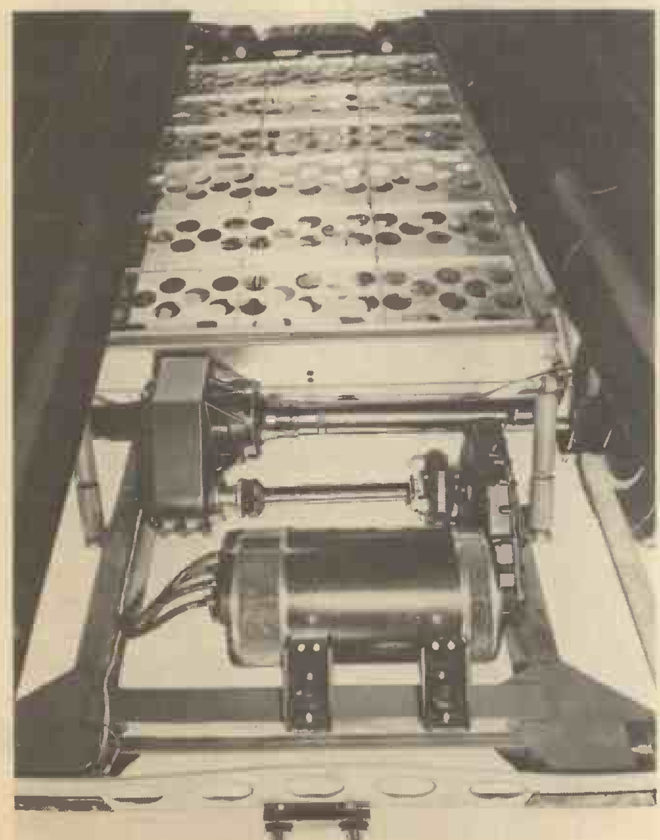
Power Pack: Thirty-six 6V lightweight lead-acid traction batteries in series. 12V type for remaining vehicle electrics.

Braking: Regenerative braking is brought into operation by initial brake pedal movement. The kinetic energy of the vehicle

Developed by Lucas, this nifty sliding tray battery pack

(photographs courtesy of Lucas)

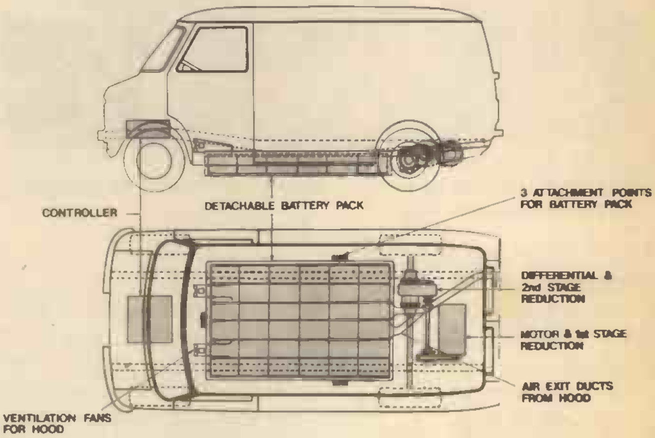
You would never know the difference—not, that is, until the CF began to roll. No smoke, no noise!



Pull up the loading floor of a CF3 and this is what you've got. Motor and chain reduction drive system in foreground; battery pack towards the front of the vehicle

drives the motor as a generator which puts charge back into the batteries, and this loading causes braking. Maximum braking effort from this is around 20 per cent g (sufficient for normal circumstances). The system drops out below 6 k.p.h. The conventional servo assisted brakes remain, powered by an electric vacuum pump. The "engine braking" effect found on conventional vehicles is simulated by controlled amounts of regenerative braking when the accelerator pedal is released.

Fig. 1. The Lucas CF3 electric van layout



Other manufacturers of electric vans are Crompton Electricars, who produce a 2 tonne payload vehicle of minimal 37 k.p.h. speed capability, effective range of up to 64km, and powered by a 35kW 26V motor. Harbilt Electric Vehicles Ltd. who produce an urban service van with an 80km range, capable of speeds up to 53 k.p.h. Its 72V series wound motor is controlled by Cableform's Pulsomatic Mark 10 thyristor controller. The payload is 409kg, which according to the specification includes the driver, so presumably only seven stone weaklings get the job.

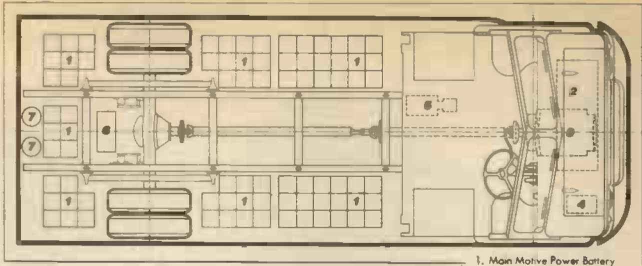
The Crompton Electricars FL85/36 2 tonnes electric delivery van

(courtesy Crompton Electricars)

One would be surprised if Chloride were not mentioned. Their efforts in conjunction with Chrysler have produced a battery electric 1·7 tonne urban delivery van. The proof of the pudding is in the eating, and this vehicle, called the Silent Karrier is employed on a strictly commercial basis in London, Birmingham and other big cities by Fleet operators. Chloride say about the Silent Karrier: "Lets explode the myth once and for all that electric vehicles have to crawl along the kerb", and with a vehicle that can travel at 72 k.p.h. they stand a reasonable chance.

Based on the Chrysler Dodge KC 6055 chassis and powered by Chloride's high energy density batteries (with single-point topping up), Silent Karrier has acceleration comparable with diesel vehicles. It has a range up to 80km minimum powered by a 37kW 160V motor (compound). Armature and field currents are controlled independently, and of course regenerative braking is included. Fig. 2 shows the Silent Karrier's layout.

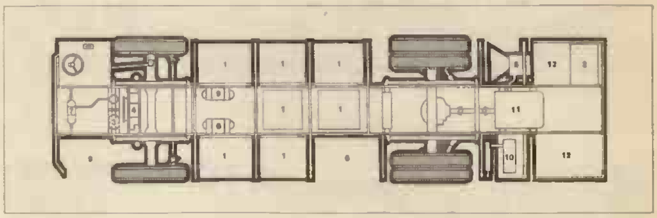
The Silent Karrier in service, jointly developed by Chloride, Chrysler UK and N.F.C.



1. Main Motive Power Battery
2. Electronic Power Controller
3. Main Drive Electric Motor
4. Heater (Cab & Demisting)
5. Hydraulic Brake Pump & Motor
6. Auxiliary Battery
7. Heater Gas Storage Bottles

Fig. 2. Dodge Silent Karrier electric van layout (protoype)

Chloride Silent Rider



1. Main 330 Volt Battery.
2. Auxiliary 24 Volt Battery.
3. Power Steering Pump and Motor Assembly.
4. Air Compressor and Motor Assembly.
5. Motor Cooling Fan
6. Main Air Tanks
7. Auxiliary Air Tank
8. Exit
9. Entrance
10. Bus Heater.
11. Motor.
12. Control Panels

Fig. 3. The Chloride Silent Rider electric bus layout

ELECTRIC BUS

Of course we have had electric buses before now; you don't have to be very old to remember the trolley-buses, and recall their twanging wires and spritely acceleration. It could all come back (without the twangs), for the beginnings have been realised by Chloride's Motive Power Projects Group in the shape of the Silent Rider, pictured right. The first Silent Rider which started carrying passengers some while ago, was developed in co-operation with Greater Manchester P.T.E. (Passenger Transport Executive). It cannot claim to be the first battery powered bus, since they ran in the 1920's, but it does use today's technology and has a place in the future.

The body is a Seddon aluminium alloy shell with steel sub-frame, on a modified Seddon RU33 chassis. The batteries are Chloride's tubular 330V 329Ah/5h motive power type, and with nearly four and a half tonnes of them, someone at the depot must be glad they have single-point topping up. How does that work? Well, the cells are of sealed construction such that when distilled water is introduced through a tube in the cell top, the electrolyte level rises to meet the tube, thus cutting off further inflow. A vacuum pump sucks distilled water from the reservoir and distributes it to each cell in the battery pack. These batteries have a life of 1,600 cycles, and have to drive a 72kW series wound motor, with another 1kW shunt motor to force air cool it. The controller to handle all this is a thyristor pulse width system capable of keeping its hair on for five minutes at 1,000A. It can manage 300A continuously and has a current limit set to 800A. Again, the controller features regenerative braking.

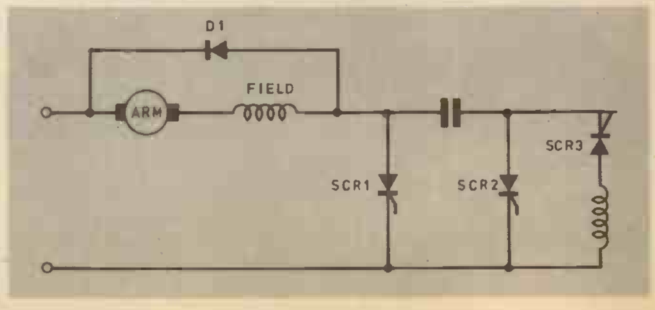
All this adds up to a bus with a maximum speed of 64km/h and an acceleration on the level of 1m/s/s. Chloride are the first to admit that these characteristics, coupled with a range of 64km and maximum gradient of 1 in 8, are not those of a bus which will *totally* replace the diesel alternative. But survey figures reveal that the average speed of buses engaged in city centres (the target area for Silent Rider) at peak times is only 13·7 k.p.h. Also, approximately 45 per cent of the fleets are used for less than 7 hours in every 24, and when in use 90 per cent of those which pass through the town centres, cover less than 64km.

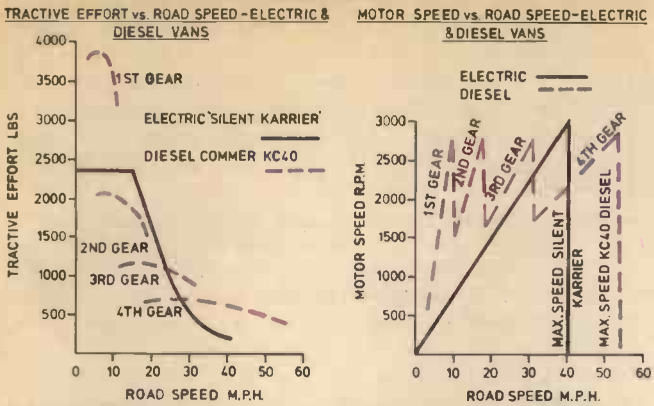
Manufacturers are not keen to divulge circuit details, but Fig. 4 shows the basic principle of the Sevcon controller. It can be seen how the current in SCR1 is interrupted in order to switch it off at the appropriate point in the cycle. Figs. 5(a) and 5(b) show the current multiplication effect produced by the thyristor controller.

The specially designed d.c. motor is capable of a peak power output of 160kW, and increased efficiency is achieved by a split pole design with laminated yoke (see Fig. 6). Extra inductance is supplied by series chokes. Thermistors are strategically positioned to activate the involute cooling fan motor, and if overheating occurs, shut off power completely to the drive motor.

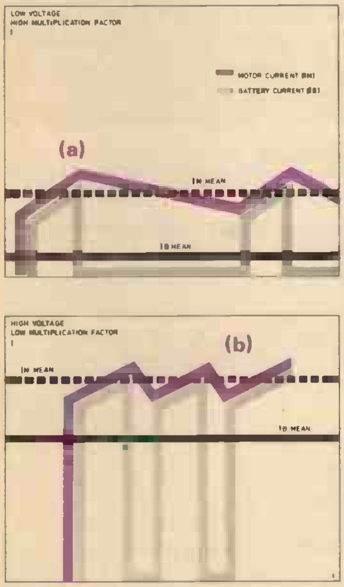
The non-drive end of the motor shaft is fitted with a tachogenerator, which apart from providing speed indication, applies a small feedback voltage to the controller for control of acceleration and maximum speed. Final drive to the 6·21:1 single speed rear axle couples via a prop shaft with two rubber bonded universal joints. Fig. 8 shows the discharge characteristics of the Chloride battery pack, and Fig. 7 shows the performance of the drive motor.

Fig. 4. Basic circuit of original Sevcon controller used in Silent Rider





Graphs supplied by Chloride for Silent Karrier show how the performance of an electric vehicle can compare with its diesel counterparts



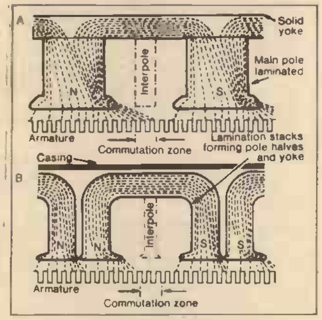
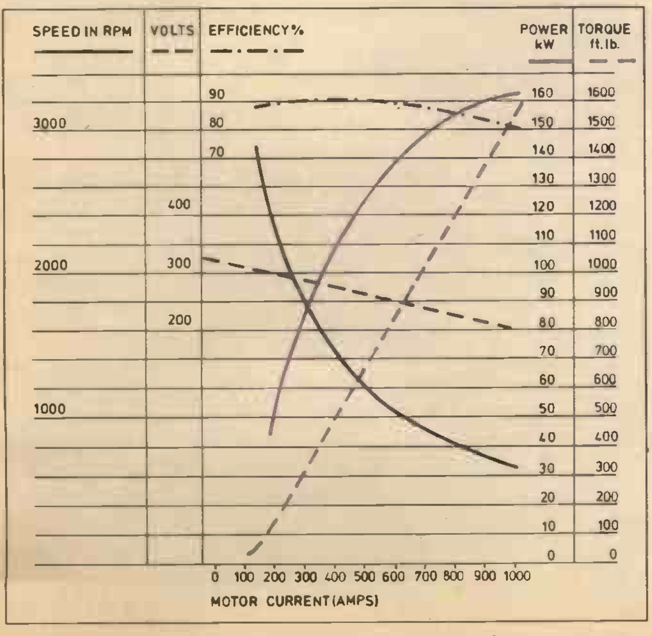


Fig. 6. Advantages of split pole system

Fig. 5 (left). Chopped waveforms produced by the SCR system

Fig. 7. Drive motor performance curves



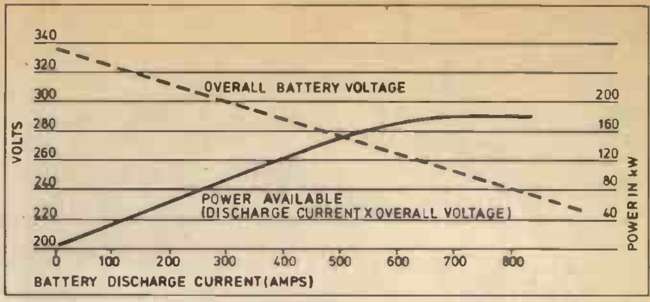


Fig. 8. Discharge characteristics of Chloride battery pack used in Silent Rider (Photographs and diagrams courtesy of Chloride)

MIDI-BUS

Back in 1975, the RAC officially observed the Lucas midi-bus as it became the first battery electric vehicle to be driven non-stop between two major English cities. The Lucas-modified Seddon Pennine 4 midi-bus, travelling at an average of 48 k.p.h. did the depot to depot run between Birmingham and Manchester, all 148km, on one charge (although favourable influencing factors undoubtedly prevailed). Like other electric vehicles, its purpose in life is that of clocking up miles *doing for real what it was intended to do,* as an evaluation exercise.

Its composite light alloy/glass fibre body can accommodate 34 passengers. A 360V d.c. CAV 97kW motor developing 130 b.h.p. sits in the centre of the chassis to drive a conventional prop' shaft, and is controlled by the Lucas developed solid state SCR chopper. There is a pack of 60 batteries on board, producing 360V and the bus has a range of 181km under *ideal* conditions, but is more than adequate for Manchester's congested Centreline service of 64km of intensive stop-start operation. Acceleration is from 0 to 48 k.p.h. in 15 seconds, with the vehicle laden to its gross weight of 9·87 tonnes. Unladen, the bus can sweep along at a brisk 80 k.p.h. Winter passengers are warmed by the front and rear paraffin heaters, and have the benefit of the bus being warmed up *before* going into service.

The Lucas Electric Midi Bus between operations on Manchester's Centreline service

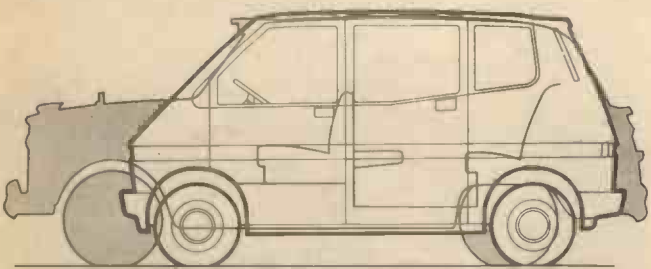
PERSONNEL CARRIERS

On a smaller scale are the three electric personnel carriers by Lucas, based on the Bedford CF van. The electric pullman is a luxury passenger vehicle for up to eight people, who gain entry through rear doors, and sit in a comfortable "horseshoe" seating arrangement. This vehicle has been used for transporting visitors to and from motor shows in London and Paris.

The Limousine is similar, but fitted with bench seats on both sides, capable of seating four people each (three with the folding armrests down). The luxury Crewbus takes up to nine passengers in individual seats positioned diagonally to face the front.

An Electric Limousine is seen outside the Hilton Hotel

The Lucas Electric Taxi



The **Lucas** Electric Taxicab compared with a conventional London cab. Five electric taxis could park in a rank which four London cabs would normally occupy.

ELECTRIC TAXI CAB

A dilemma which faces any would-be manufacturer of electric vehicles, is that of deciding which course to steer in terms of the vehicle's origin. If you design a vehicle specifically to be electric. you can take advantage of so much that will increase the range and performance, such as styling for low wind resistance, using low friction transmission and bearing arrangements, constructing out of lightweight materials, etc. but all this will result in a custom vehicle of tremendous expense in low volume production. Low volume production doesn't become high volume production until you *really* start selling, and at the "kick-off" price not many people will buy. A vicious circle!

The alternative is to find the nearest suitable vehicle already in production, and modify it to become electric. You end up with batteries in less convenient positions, and performance characteristics derated by weight and other factors less important to i.c.e. (internal combustion engine) vehicle design criteria, but at least more people can afford to purchase it, and that's the name of the game!

Nevertheless, as an exercise Lucas, in conjunction with David Ogle Ltd., purpose built an electric taxi. The design of the taxi was based specifically on the requirements of an electric vehicle, modified only to meet the regulations which apply to London cabs by the Public Carriages Office of the Metropolitan Police. See below, left.

The electric taxi achieved a drive system efficiency of some 10 per cent better than the Lucas CF Type vehicles, and has a range of 160km in heavy traffic conditions. Its length is about one metre shorter than the conventional London taxi-cab, but it is considerably heavier with batteries. The design included an inventive transmission system, which incorporates a two-stage Morse HY-VO chain drive mechanism giving a total reduction of 5·63:1. A short quill shaft between the reduction chain drives provides some shock absorption between the road wheels and the motor. This system proved so successful that, with a little rearranging it was made possible to include it in the electric CF vehicles.

The electric cab has front wheel drive and can turn full circle in 8·5m. There is a 12V auxiliary battery for the normal electrical system and the low tension supply to the controller, and this is kept charged by a converter unit powered by the traction batteries. A combustion heater is used to warm the inside of the taxi, but when the roads are clear you may not be inside it long enough to get cold, for the vehicle can manage a speed of 96 k.p.h.

ELECTRIC CARS

It would have been a misnomer to call this article "Electric Cars", because in this particular domain of the electric vehicle front there is least to report on. The limitations imposed by a machine of battery-electric propulsion are precisely those which would be least tolerated by the private motorist. That is, the short range, aggravated by the absence of widespread recharging facilities available for public use; and the lack of space within such a vehicle, which might otherwise only demote it to "second car" or "commuter car" were it not for the high capital cost involved.

How far we must be from substantial battery-electric roadside refuelling facilities, when you realise that today's five pump petrol station can dispense power at a rate equivalent to Battersea Power Station.

In Amsterdam an imaginative electric car system has been put into operation, called the "Amsterdam White Car Scheme" which is intended to partially alleviate the noise and pollution problems which all cities suffer from. The cars, designed by Luud Schimmelpennink, look rather like upright ice cream kiosks on wheels, and four of them can be parked in the space occupied by one conventional car.

Electric cars can of course be found elsewhere, but are so often for fun only, such as "buzzing" around holiday villages, etc. A company recently engaged in the production of leisure resort electric cars was Electraction Ltd. who produced "Rickshaw" pictured across. It is powered by 12 lightweight 6V batteries, with thyristor control over a 7·5h.p. motor. There is a sliding battery pack at the rear, and its role in life becomes clear when you read the list of accessories. It has a surfboard rack, golf club carriers, and what is described as ample picnic basket space.

Another vehicle from the same manufacturer is Tropicana, a rugged two-seater sports car with a maximum speed of 58 k.p.h. and a range of 95 km. It can climb a 1 in 5 gradient, and has virtually the same electrical system as the Rickshaw. At the time of writing this article the company went into receivership, leaving the future of these fun cars rather uncertain, although it seemed possible that they might continue to be manufactured by another company.

Top: Rickshaw

Above: The Tropicana 2-seater electric sports car (Courtesy Electraction Ltd)

An Amsterdam White Car

HYBRID VEHICLE

Primitive electric vehicles existed before 1890; so when you consider the time it took to evolve from the early flying machines to the hardware which puts men on the moon, maybe we should all be bouncing to work inside electromagnetic bubbles by now.

The range problems to be overcome with battery powered vehicles are put into perspective when you realise that if the present lead-acid battery was made ten times better, it would still be twenty-five times worse than petrol!

One solution, being investigated by an electronic engineering company, Lee-Dickens Ltd., is the "series hybrid" vehicle. It might sound like a lunatic formula for perpetual motion to say that there is a generator charging the batteries as the car goes along, but it makes good sense. The Lee-Dickens racing car being used as a test bed for the hybrid principle, has revealed that a petrol primary engine of a mere 500cc capacity can achieve short bursts of up to 1,600cc performance.

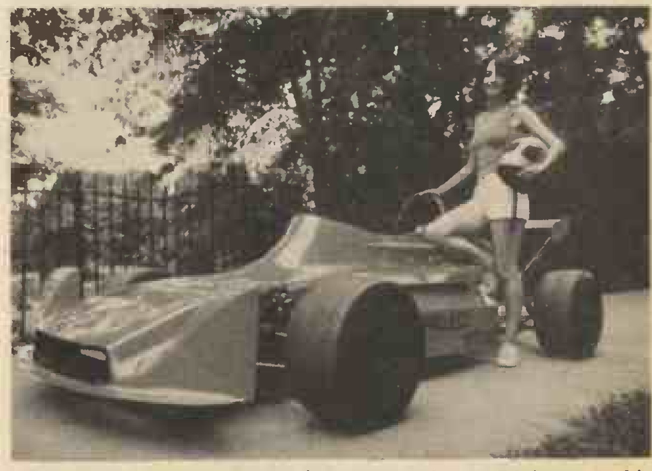
Imagine you are driving a 1,600cc i.c.e. vehicle, cruising along at 50 k.p.h. when you have to slow down to turn right. Soon you are up again to 50 k.p.h. for a while, until your foot is hard down on the accelerator to overtake a bus. Finally, you hit the brake pedal as the lights turn red: A typical urban (or suburban) sequence of events. Only once did you really need the full 1,600cc pulling power, and the rest of the time the engine rev's were going up and down repeatedly.

A 500cc engine could cope with the mean demand of these rather typical conditions, and if coupled to a generator, the surplus power could be "dumped" into storage batteries whilst the vehicle was idle or cruising. When overtaking (or climbing a hill), many minutes of high energy would be drawn from the batteries to give effective 1,600cc performance from the electric motors. With the small primary engine constantly working at optimum r.p.m., remarkable efficiency can be achieved, particularly in conjunction with regenerative braking. A hybrid mini, converted by a retired Dorset engineer, is claimed to have managed 100 miles on one gallon of petrol, and that's without the assistance of a sophisticated electronic controller.

Lee-Dickens opted for the racing car because this vehicle, which is based on the conventional Terrapin single seater, would be uncomplicated by lights, horn, heater, licencing, or even a handbrake. Intrac, as it is called, is at present geared for hill-climb and short sprint circuits, and compared to its BMC-engined counterpart has proved viable, with better traction and weight distribution. Indeed Intrac weighs 27kgms (60lbs) less.

Improved weight distribution stems from the elimination of a large heavy engine, mechanical transmission and differential unit, achieved through both drive wheels having their own motor (Lucas CAV type), each capable of producing a peak of 11·8 h.p., giving maximum power at 4,000 r.p.m.

Individual controllers for each motor, working from a single accelerator pedal, can give the ability to balance the power to each drive wheel when cornering. For extra drive, the Intrac motors are safely pressed to four times their rated power for up



Photograph shows Intrac (courtesy of Lee-Dickens Ltd.), the series hybrid racing car with a wheelbase of 200cm (6ft. 7in.). Fascia instrumentation includes Motor/Road Speed, Motor Brushgear Temp, Transistor' Heatsink Temp, and Mean Power/Mileage. The motors drive fixed 4:1 reduction duplex chain drives running dry

to three minutes, and are force cooled by fans and an airscoop.

In the original controller width modulated pulses of 44V were generated at a repetition rate of 250Hz, and limited to 200A. Cascaded Darlington power transistors (2N3055) were used in the drive circuitry, which simplified control techniqes and allowed continued running at reduced power in the event of a transistor failure. Emitter equalising resistors provided a voltage feedback to the timing portion of the control unit to limit the maximum mean current to each motor even when working into stall load. Voltages developed across the two motors could also be measured differentially so that loss of adhesion on one drive wheel could be detected for power withdrawal or adjustment.

Attempts to *increase* the performance capability of Intrac, using much higher power (and very expensive) transistors, proved unsuccessful, leaving Lee-Dickens to reluctantly concede to thyristor control. Consequently Intrac was fitted with Sevcon's latest controller, allowing development of new design twin disc motor to get ahead. At least transistor control had been explored.

The four 12V 96Ah batteries used in Intrac each have a maximum discharge capability of 385A for three minutes, and are charged by a constant voltage source through a step-down transformer. This is powered by the on-board petrol/electric generator working at 240/50Hz. The batteries can thus be charged directly from the mains, and mains powered test equipment can operate from the vehicle itself.

Lee-Dickens are keen to produce a road car which can demonstrate (perhaps by a tour of Britain) that electric cars *can* out-perform and outrange milk floats. The Microdot town car, designed by William Towns (who designed the Aston-Martin Lagonda) was considered suitable for conversion, subject to a position being found to accommodate the generator set without spoiling weight distribution and other characteristics. The alternative to this is, as always, to build a vehicle specifically for the job.

Intrac's next test bed, a rolling road at Warwick University, will provide computer data for further development, the results of which will help shape their hybrid electric car of the future.

WIDER CONSIDERATIONS

Like a capacitor, the Earth has been trickle-charging it's oil deposits throughout the ages, but now the "load" of Man's mechanisation is discharging it rapidly. The universe is not short of energy, *it is* energy! But the question is, in what form is it available, and from where? If we switch from fossil fuel to mains electricity to power a large portion of road vehicles, can the demand be met from this new quarter?

Figures presented by experts in the field indicate that the drop in electricity demand in England and Wales during the early hours each morning (Summer or Winter) should accommodate the overnight charging needs for *at least* a 50 per cent electrification of delivery type vehicles. In fact, the consequent cost-effective improvement from round-the-clock load factor balancing would benefit all electricity consumers. Not all recharging would necessarily be done overnight, however, and the power stations would still have to burn more fuel to produce this extra electricity *whenever* it was required.

Do electric vehicles actually consume less energy per mile than their i.c.e. counterparts, when you equate their fuel consumption to the same units? A test to establish a comparison of this nature was conducted by Joseph Lucas Ltd., whereby an electrified Bedford CF van was run on the same test route as a petroleum powered version, separated by some hundred metres of so. Four laps along a stretch of roads considered to present typically urban driving conditions were covered, totalling 86km, with an average speed of about 29 k.p.h. The conventional vehicle made no cold starts in the test, which gave it more favourable odds than in real conditions. Even so, the electric vehicle showed a slight advantage, with a consumption of 1·46kWh/km related to crude oil at the refinery, over a consumption of 1·53kWh/km of crude oil for the i.c.e. vehicle. Certain assumptions had to be made, such as, that the energy content for a gallon of petrol is 45kWh, with a refinery efficiency of 87 per cent for its production; and for the electric vehicle, a refinery efficiency for the production of the fuel oil used in power stations of 97 per cent. The conversion factors used are of course subject to variation, as indeed are many electric and i.c.e. vehicles in their efficiency of fuel consumption, but a guide is achieved. The general concensus of opinion is that, overall, the difference is negligible. As far as electric vehicle owners and operators are concerned, the savings are made on servicing and maintenance, and as far as the country is concerned, battery power facilitates independence from diminishing fossil fuel.

It is interesting to note that data provided by the Transport and Road Research Laboratory points to a larger ultimate energy consumption from the use of advanced lead-acid battery powered vehicles than that of today's inefficient i.c.e. machines, that is, when you lump together all energy expenditure inclusive of manufacture. The bar graph compares the alternatives for propulsion and their respective energy requirements for an assumed 25 million car and light goods vehicle fleet in the year 2025.

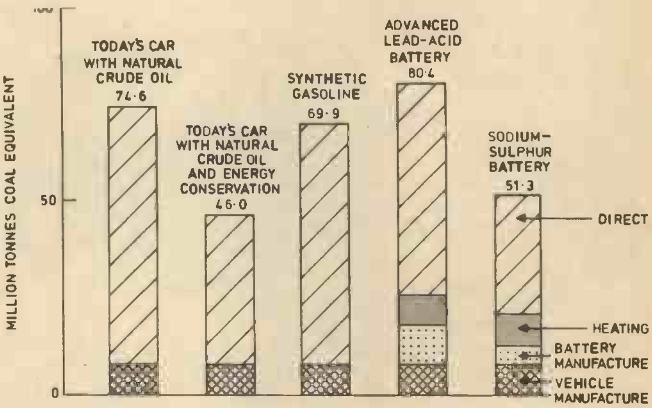


Fig. 9. Energy requirements for a 25m car and light goods vehicle fleet, inclusive of manufacture, in the year 2025

Electric vehicles are not without their hazards either, with attention drawn, by the manufacturers, to the fact that hydrogen can form an explosive mixture with oxygen over a wide range of concentrations. Therefore, precautions in design are required, as both running and charging produce hydrogen. Although the gas is reluctant to ignite from heat alone, the danger of pockets of hydrogen forming in a vehicle employing brush motors and contactors is self evident. And in the evolutionary context, who is to say that in a civilisation mobilised by battery-electric transportation, the new danger to the atmosphere is no longer aerosol propellant, but the build-up of hydrogen?

Attention is also drawn to other dangers which may accompany the electric traction era (if there is to be one), such as the possibility of accidents involving pedestrians due to the silence of these vehicles, perhaps through sudden reversing. The presence of an inadequately screened (or tampered with) controller might prove fatal to someone dependent on medical micro-electronics such as a cardiac pacemaker.

A new generation of vehicles of this kind might also be accidentally victimised through legislation as a result of a lack of appreciation of some subtle operating feature, by the powers that be. An example suggested is militation against regenerative braking because it retards one axle only, or because its effect is not constant for a given pedal pressure at all speeds.

AUXILIARY DEVELOPMENTS

Efforts in battery, charger and motor development are widespread now, with the result that the state of the art is "nudging" forward continuously. Even companies like Sinclair (of calculator fame) are taking an interest in the field. The company would reveal no more than that they are at a very infant stage in the development of a new type of d.c. motor for electric vehicles, which they hope will offer greater efficiency than the conventional type.

Another recent development is the transcalent semiconductor (utilising inherent heat pipes) which might be employed to carry heat from the controller devices to the vehicle chassis.

A more promising development by far is the sodium sulphur battery, because it has nearly emerged from the uncertainty stage of development to gain an accepted influence in calculations for the future, and has the kind of high energy density which will award electric vehicles greatly improved capabilities.

These new batteries employ relatively cheap and plentiful chemicals housed in a tubular cannister, and have the curious combination of solid electrolyte with liquid electrodes. These electrodes are *molten* at the operating temperature of 350°C and have to be separated by a special ceramic material. The sodium sulphur battery will give an electric vehicle a range of up to three times that of a lead acid powered one.

Conventional methods, and their governing economics, gain formidable momentum, and it is therefore not surprising that the electric vehicle is undergoing a slow birth, but despite this, the birth is taking place, which is very encouraging, particularly as the added weight of such new techniques as the sodium sulphur battery have yet to be felt.

readout

... a selection from our postbag

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

Standards

Sir—Your otherwise excellent article in the October edition of P.E. is likely to cause great confusion amongst students of electrical engineering. I refer of course to "Impedance" by Messrs. Bailey and Whitaker which has obviously been written in the pure mathematics context.

It has long been accepted that in electrical terms the complex number "i" is given the symbol "j" in order to avoid confusion with the use of "i" for small a.c. current values. Perhaps you would like to correct this error for the benefit of those of us that teach this particular topic in colleges of further education.

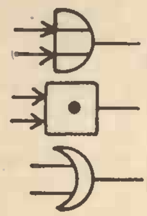
Whilst writing I would also like to comment on the use of non-standard circuit symbols in P.E. Students are usually taught to B.S.3939 as these are the symbols used in examinations set by City & Guilds of London. In particular the resistor and logic symbols are likely to cause confusion and I would only hope that the technical press could adopt the B.S. standards in the very near future. I would add that nearly all the service data for British radio & television equipment conforms to B.S.3939. Why not let P.E. start the ball rolling in 1979? I feel sure that this move would score 10 out of 10 as far as the student readership is concerned.

R. A. Bravery,
Brighton,
Sussex.

I believe it is important to appreciate that the methods of circuit analysis which we are treating are really just an application of the theory of complex numbers to electronics. As this theory can also be applied to many other branches of science and engineering I think it is a good idea to present it separately from the arcane terminology and methodology adopted by electrical engineers: "j-operators", "phasors" (beam us up Scottie?) and similar oddities.

If students are horrendously confused by this approach I think it is an indication of pedagogical failings; surely after all, if you are going to teach people to use complex numbers in electronics then you should make it clear what you are really doing so that they can apply the theory to other situations. Further, I believe that it is better to make simple mathematics and physics based texts accessible, rather than the somewhat strange electrical engineering treatments.

Many of the same comments apply to your suggestions about logic symbols. In particular, though standardisation may be desirable, if you fanatically avoid exposure to heterodox symbols are students going to be able to understand such eclectic combinations as



(Siemens handbook)

(General Electric transistor manual)

(T. I. handbook)

as my bookshelf provides on a random sampling?

As far as drawing little boxes to signify resistances, I find it difficult to believe that any self-respecting amateur will use one of these instead of the time honoured squiggle. The new symbol is awkward to draw and a fine example of change for its own sake. I wonder if the people responsible had to find some change to implement in order to justify their existence, or whether they enjoy fomenting rebellion, trouble and discontent. I fully support P.E. in their ignoring of this silly regulation.

To return to the subject, I am glad Mr. Bravery found the article "otherwise excellent" and trust that the need he felt for the global substitution of "j" for "i" did not appreciably hinder his enjoyment of it.

Toby Bailey.

(For new P.E. standards see page 64)

Postal Automation

Sir—I was very sorry indeed to read the comments under "Postal Automation" (Industry Notebook, October) which continued the errors of others in misrepresenting the facts.

The proportion of letters posted into offices with mechanised equipment is in excess of 17 per cent and even more pass through offices equipped with machinery.

A further 13 offices, some in major cities, are now in various stages of being equipped; when these are fully in operation the proportion of letters posted into mechanised letter offices will then be 40 per cent with many more passing through en route to their destination. When equipment now being manufactured is installed over the next two years the number of mechanised letter offices will rise to 48, handling 60 per cent of posted mail.

The programme to mechanise the postal service is planned for completion in the mid-1980s but the aim is to improve on this timetable if at all possible.

What is absolutely essential to the success of the programme is the fullest use of postcodes by everyone and it is an act of public service to encourage this practice both by example and exhortation. That is one easy way for everyone to help us hold down prices and improve efficiency, an end desired by all inside and outside the Post Office.

Peter H. Young,
Director, Public Relations,
Post Office.

Semiconductor UPDATE...

FEATURING : TMS 4164 AM 9511 AD 590

R. W. Coles

THANKS FOR THE MEMORY

We have heard a lot lately, via the mass media, about the microprocessor "chip" and the far reaching effect it is going to have on all our lives. Less emotive, but in my view equally revolutionary, are the giant strides being made in semiconductor memory technology. Micros are helpless without memory, yet the more they get of it, the more powerful they become, and it seems silly not to acknowledge this fact when discussing the so called "microprocessor revolution".

Only a few years ago, computer memories used tiny ferrite magnetic cores to store each bit, and memory arrays were stitched together in a manner which called for manual dexterity and a lot of skill. These memories were expensive, and if you had a 4K-word main store on your machine, that was considered a *big* memory! In the early 1970's, semiconductor memories began to replace magnetic cores, and now core memory is used only in military and other special applications. The first really successful semiconductor RAM was the PMOS 1103 which had a 1K bit capacity and was infernally awkward to drive. This was followed by the 4K bit NMOS chips which are in wide use today. More recently, we have seen the 16K bit RAM which in some applications can be used as a plug-in replacement for the 4K chips to quadruple memory size. The 16K chip has proved so popular that even today the demand for them outstrips the supply.

You can see from the foregoing that each new chip generation means four times the memory, and so now we eagerly await the 64K device. We will not have to wait long. Already, Texas Instruments and Mostek have unveiled their respective contenders for the 64K crown, and it won't be long before others do the same.

The 64K RAM has a special magic of its own. Most micros such as the 8080 or the 6800 use a sixteen bit address bus, and $2^{16} = 64K$. In other words, with just *eight* sixteen pin d.i.l. packages you can give a microprocessor all the memory it can handle, and with that much memory even a modest micro will be able to run the most sophisticated software so far obtainable. But that's not all, as the memory chips have grown in capacity, so they have become easier to use. The new Texas 64K RAM, the **TMS 4164,** has taken this to the limit by requiring only a single 5 volt supply and yet having a *lower* power requirement than its 16K predecessor. At the moment the 4164 is expensive, but it seems likely that in a few short years it will be inexpensive enough to take a giant part in the "microprocessor revolution".

Thanks for the memory, Texas!

SPEEDY SUMS

Doing useful arithmetic with a micro is not as easy as some people may have you believe. There is a world of difference between the basic 8 bit add and subtract instructions in most microprocessor chip instruction sets, and the floating point arithmetic we expect a packaged microprocessor system to handle via the keyboard. The difference is usually made up with a large software program known as a Floating Point Arithmetic Package which may need several kilobytes of memory. This sort of package can be obtained separately for most micros, and also comes as a standard feature of a BASIC interpreter or other high level language package. Trouble is, these floating point arithmetic routines are *slow*, taking perhaps 5ms for a multiplication and over 100ms to sort out SIN x. This may not sound too bad, but anyone who has done any BASIC programming will know that having to wait for a sophisticated program to deliver the goods is a perfectly normal part of the job. Of course, having to wait may not be a problem for some applications, but in others, particularly those which respond to events in real time, spare time is just not available.

If *you* don't want to stuff *your* memory with a slow old floating point package, or if you are building a system which needs to do sums quickly, what you need is an **AM 9511** from A.M.D. This new wonder-chip does all the work in hardware in a fraction of the time taken by software, e.g. multiply—200µs, SIN x—2ms. It'll work on 16 and 32 bit fixed point numbers and 32 bit floating point numbers with a range of plus or minus $2{\cdot}7 \times 10^{-29}$ to $9{\cdot}2 \times 10^{18}$. You tell it what to do with single byte instructions, and in addition to normal arithmetic you get square roots, common and natural logs, sine cosine, tangent, and their inverses together with fixed-to-floating point and floating-to-fixed point conversion routines.

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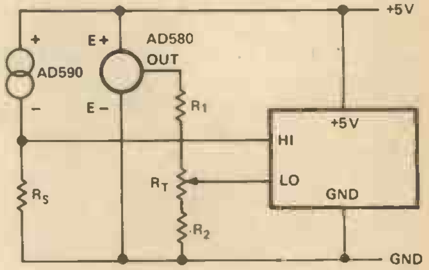

	R_S	R_1	R_2	R_T
°K	1kΩ	OPEN	SHORT	SHORT
°C	1kΩ	9.09kΩ	1kΩ	200Ω
°R	1.8kΩ	OPEN	SHORT	SHORT
°F	1.8kΩ	9.53kΩ	1.95kΩ	500Ω

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By teaming the AD 590 with an AD 580 voltage reference and a digital panel meter, you can make an excellent thermometer which can be scaled in Celsius, Fahrenheit, or Kelvin, by the appropriate selection of fixed resistors.

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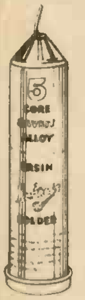

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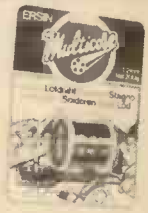

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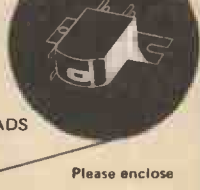

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7402	13	7427	27
7404	14	7430	15
7405	14	7440	15
7408	17	7445	80
		7472	25
		7473	30
		7474	27
		7476	30
		7480	45
		7482	69
		7483	72
		7490	33
		7491	75
		7495	60
		7496	57
		74100	95
		74107	29
		74121	25
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Logic Circuit Tester

N.D. JONES

THIS TTL test probe which uses l.e.d.s to display logic levels will also provide other useful information about the circuit under test:

1. A simple input buffer which reduces the loading on a TTL input indicates whether or not connecting an additional input will exceed the fan-out of the gate under test.
2. When the input to a gate is unconnected the tester will indicate an open circuit.
3. Any narrow pulses which could pass undetected are displayed by an l.e.d. that changes state (from on to off or vice versa) with each input pulse.

CIRCUIT DESCRIPTION

The complete circuit diagram of the Logic Circuit Tester is shown in Fig. 1.

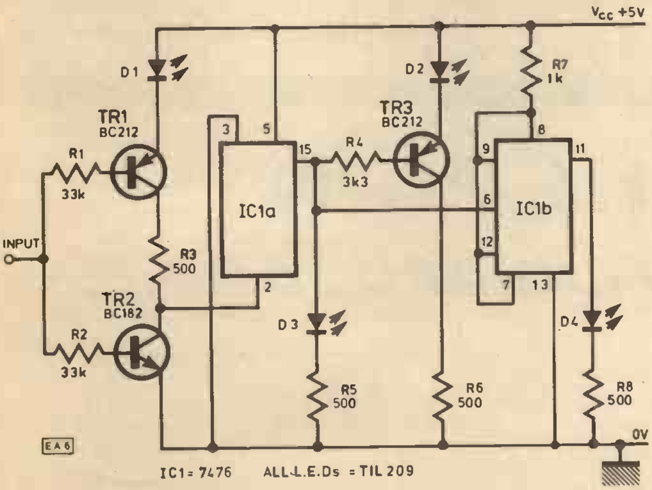


Fig. 1. Complete circuit diagram of the Logic Circuit Tester

TR1 and TR2 act as an inverting buffer to reduce loading on the gate to which the probe is connected and D1 indicates if a valid logic level is present on the input. If the input is at logic level 0 (about 0·3V) TR2 will be turned off and TR1 turned on, so that no current will pass through D1. Similarly, if the input voltage is higher than about 2·55V [Vcc–(Vbe of TR1 + about 1·75V across D1)], corresponding to a valid logic 1, TR1 will be off and TR2 on. If the input voltage is anywhere between these two limits then both TR1 and TR2 will be on and D1 will light to show an incorrect or open circuit input.

The input state is indicated by the use of half a 7476 dual J-K flip flop. If the "clear" input (pin 3) of the 7476 is 0 the "Q" output (pin 15) will be the inverse of the "preset" input. D3 which is connected directly to this output lights when the probe is at logic 1. TR3 acts as an inverter to drive D2 which lights to indicate a 0 input.

The other half of the 7476 is used to display pulses; if the "J" and "K" inputs (pins 9 & 12) are 1 then the "Q" output (pin 11) will change state once for every complete pulse on the "clock" input, even if it is too short to produce a visible change in D2 and D3. The current consumption of the whole circuit is only about 20mA and its power is obtained from the 5V supply of the circuit being tested.

CONSTRUCTION

The prototype unit was constructed using the printed circuit board layout shown in Fig. 2 with the component overlay shown in Fig. 3.

The finished unit was mounted into a diecast case which was drilled as shown in Fig. 4.

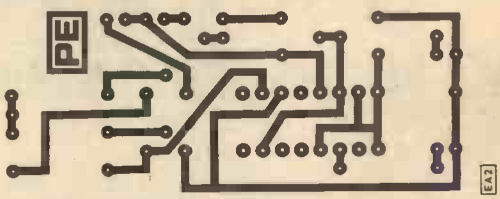


Fig. 2. P.c.b. layout for the Logic Tester

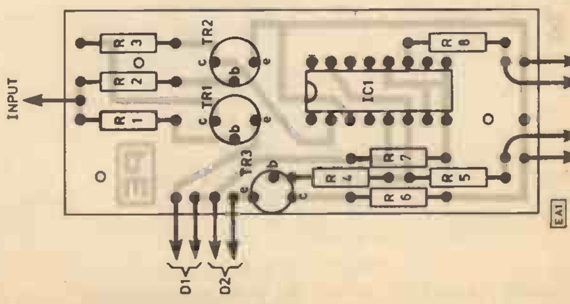


Fig. 3. Component layout for the Logic Tester

After the p.c.b. has been soldered and mounted into the case the four l.e.d.s can be fitted into the case top and wired to the board. Labelling for the l.e.d.s is shown in Table 1.

Table 1	
D1	Open Circuit
D2	Zero
D3	One
D4	Pulsed Input

The probe which can be made from a piece of plastics tube 8mm dia. (e.g. a ballpoint case) should have a small brass contact fitted in the end. Before fixing the contact into position the input lead should be soldered to it.

Finally the probe can be mounted into the case and Araldited into position.

COMPONENTS . . .

Resistors

R1, R2	33k (2 off)
R3, R5, R6, R8	500 (4 off)
R4	3k3
R7	1k
All $\frac{1}{4}$W 5% carbon	

Semiconductors

TR1, TR3	BC212 (2 off)
TR2	BC182
IC1	7476 dual J-K flip flop
D1–D4	TIL209 (4 off)

Miscellaneous

2 off crocodile clips (insulated) 1 red, 1 black
Diecast box 89 x 35 x 30mm RS type 509–923

It may be necessary to alter the values of some of the 500 Ohm resistors used to limit the l.e.d. currents so that all

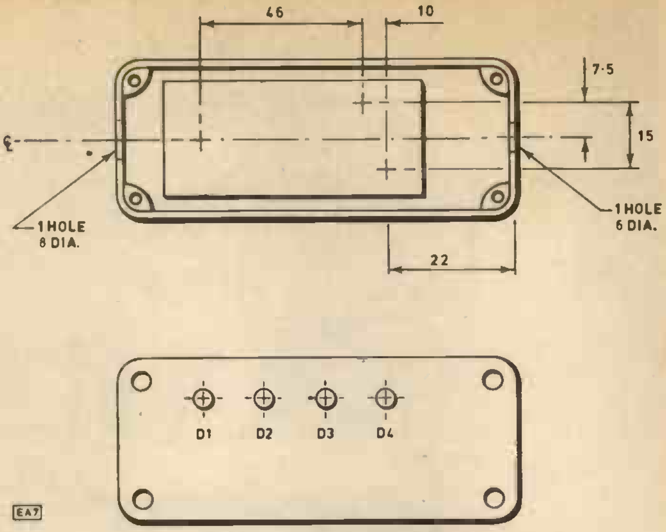


Fig. 4. Case drilling details

l.e.d.s shine equally brightly; this is particularly likely if different coloured l.e.d.s are used.

USING THE LOGIC TESTER

To operate the logic tester, the power leads are connected using crocodile clips to the +5V and 0V lines of the circuit to be tested. D1, D3 and possibly D4 will then light. When connected to a correct logic level D1 will go out and D2 or D3 will indicate the input's state. If the input is oscillating with a mark/space ratio of about 1 then D2, D3 and D4 will light. If D4 changes state without any visible alteration to D2 and D3 then a narrow pulse has been detected.

The tester is also useful in detecting wiring errors in logic circuits as a single gate input, if unconnected, to any output, will float at about 2V and so D1 will indicate it as not connected. However, it must be remembered that some devices such as a flip flops have several gate inputs internally connected to the same pin, and such multiple inputs will, if not connected, float at a somewhat higher voltage and cannot be distinguished from a valid logical 1. ★

MORE TO THE POINT

NEW COMPONENT STANDARD FOR P.E.

Apart from current constructional series this issue sees the commencement of a new house style of assigning component values. This means that in future large numbers of zeros and decimal points will be avoided.

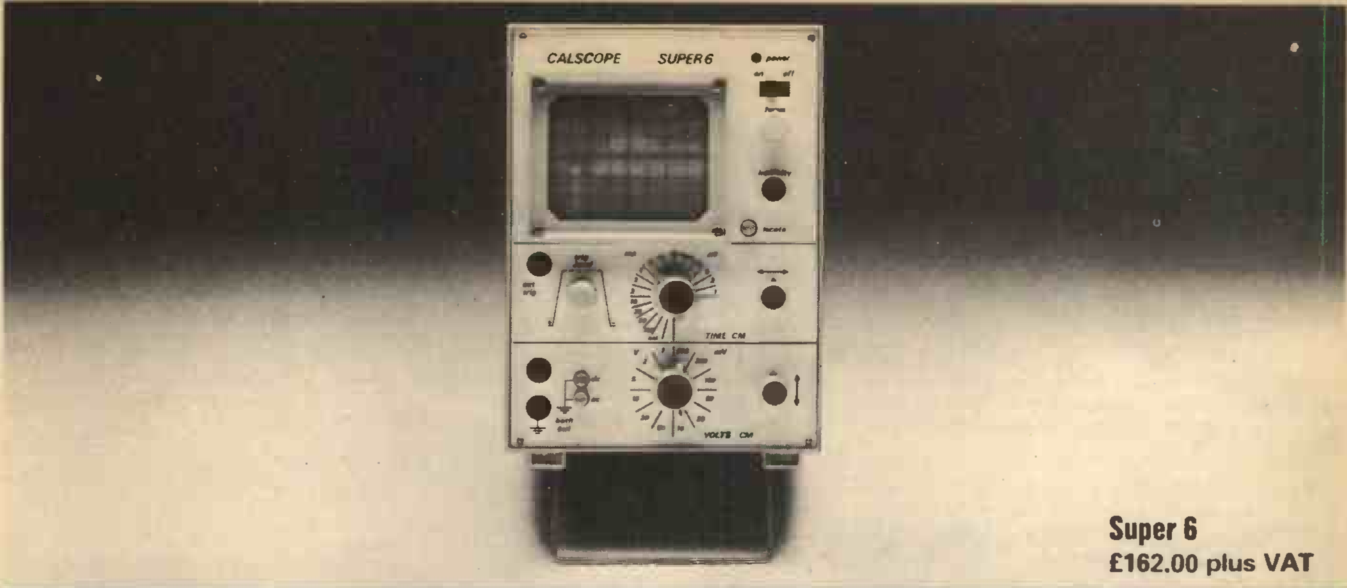
With resistance, inductance and capacitance values the reductions

p (pico –) = 10^{-12}
n (nano –) = 10^{-9}
µ (micro –) = 10^{-6}
m (milli –) = 10^{-3}
k (kilo –) = 10^{3}
M (mega –) = 10^{6}
G (giga –) = 10^{9}

will replace the decimal point where appropriate.

To illustrate this some typical component changes are given:

	Now	Before
Resistance	3k9	3·9kΩ
	1M5	1·5MΩ
	470	470Ω
	2Ω2	2·2Ω
Capacitance	680µ	680µF
	4µ7	4·7µF
	470n	0·47µF
	47n	0·047µF
	4p7	4·7pF
Inductance	3H4	3·4H
	800m	800mH
	2m6	2·6mH
	1m	1mH



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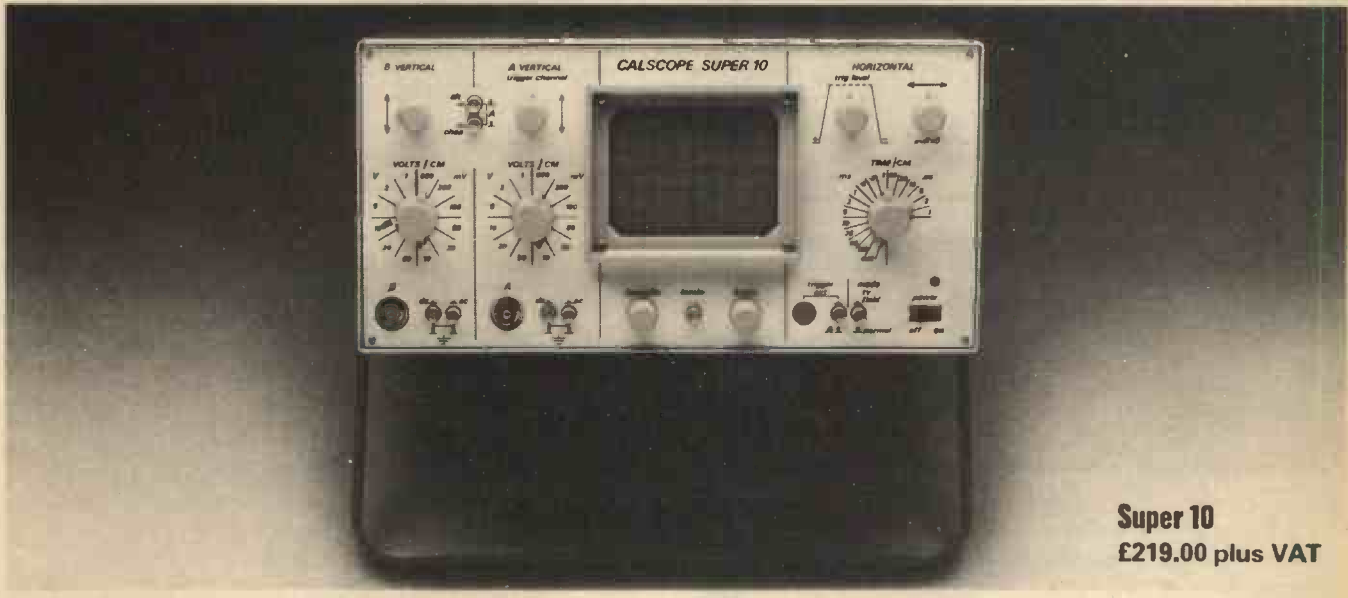

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CALSCOPE

INDUSTRY NOTEBOOK

By Nexus

Pioneer

Most of the "greats" in electronics started their businesses in their garage at home or in other non-business premises. Hewlett and Packard started their partnership in a garage in the USA. Tom Jermyn in the UK started part time manufacture in his garage. Honeywell UK started in a room in London over a pub. Arthur William Stapleton, who died recently, mourned by the whole industry, started his business in a poultry shed. That was way back in 1922 but it was not until ten years later that he registered his company as Advance Components Ltd., later to become Advance Electronics and since 1974 two divisions of Gould Inc., USA.

Stapleton's speciality both before and after the 1939-45 war was low-cost signal generators. Good knock-about instruments, never claiming to be in the top class but always in demand and giving years of service. You saw them everywhere, in professional laboratories as well as in radio dealers' workshops. When I first met him he had some 300 staff, all of whom he knew by name. He stimulated interest by running staff competitions and used to hand out fivers from his own wallet to meritorious performers on the shop floor. One big happy family.

I am not saying that today's Gould Instrument Division is better or worse, only that it must be different in character if only because of a vigorous product policy, leadership by new-style business-school trained professionals, efficiency the top priority for survival in a fiercely competitive market. But I doubt if it is a happier ship than when Stapleton was at the helm.

Nearly all the top men in the industry I have had the privilege of meeting, some of them millionaires, tell me that the best time of their lives was not the ultimate success but the early struggle to achieve it. Nostalgia? Rubbish? Take your choice.

Carve-up

All the big companies are now busy planning their positions as far ahead of the mid 1980s. The Americans and the Japanese are consolidating their markets in Europe by establishing new operations or forming joint ventures with European-based companies. The Japanese and the Europeans in their turn are starting up, buying in, or getting into bed with companies in America.

This is especially true in microcircuits. I note that Motorola and Harris are both said to be doing deals with French companies, Thomson CSF and Matra respectively, new elements in technology exchange, possibly in manufacture and marketing, too. The fear of trade protection (banning or restricting imports) encourages the Americans and Japanese to move more positively into Europe—to be on the inside, to become, in effect, a British or French or German company, just as Standard Telephones & Cables and other US ITT companies in the UK are regarded as purely British in trade terms and are in fact run by British management with British workers and enjoy all the subsidies for setting up new plants in depressed areas.

New anxieties are now being expressed on the impact of imported colour TV tubes in Europe. Latest figures are that 47 per cent of all colour tubes used in Europe are of foreign manufacture, mainly from Japan. This, clearly, is a threat to the European tube manufacturers and the possibility of import restriction is very real. So the Japanese would like to establish their own plants in Europe but this, of course, represents an internal threat to established European manufacturers. Readers will recall that Hitachi wanted to start a plant in Britain but permission was refused. This sort of struggle is destined to continue.

The 64K Race

The 64K Random Access Memory (RAM) market is already hotting up. Hard on the heels of Texas Instruments now comes news that Mostek is second in the field with production samples for the trade. The Mostek device is pin-compatible with the TI product but claims a faster access time although at the expense of higher power dissipation. There is also news of a 64K RAM built in-house at IBM and already being used in the 8100 Information System, though this RAM is apparently not being offered in the open market.

The 64K RAM was, of course, supposed to be the way into the market for the new British i.c. company INMOS. After the initial flurry of excitement of the first announcements, further stimulated by well-publicised litigation in the United States to prevent Mostek "trade secrets" being exploited in Britain by former Mostek employees, everything has gone relatively quiet.

Except, that is, for an extended interview with INMOS founder-member Ian Barron published in the IEE journal "Electronics and Power". Barron does not preclude the possibility that INMOS may one day be in the 64K RAM business but he is wisely non-commital on the proposed product range, only that it will "achieve the complexity level necessary for the 64K RAM". This, of course, leaves everything wide open, perhaps as it should be for a company still virtually on the drawing board and some two years away from production, and even that assessment could be optimistic.

Scanner Saga

The golden year for the EMI Scanner, which revolutionised medical diagnosis, was 1975 when turnover on their great product was £20·4 million, showing a profit of £9·2 million. By 1977 turnover had shot up to a magnificent £93·2 million on which profit, as a percentage of turnover, had slumped to £14·7 million, but still a useful gain. Cut-backs in US medical spending depressed turnover to £66·5 million in 1978 with an accompanying loss of £13·2 million. So in the last two years with a turn-over of £160 million the profit has been a miniscule £1·5 million, less than 1 per cent.

After EMI's big initial breakthrough the competition got to work and there are now plenty of rival products. As EMI sales are nearly all overseas the company had to set up a world-wide and costly service network to support the Scanner in the field. Then came the US cut-backs in spending plus the natural attraction in the USA of buying a locally made machine.

But EMI could still reap a rich harvest from claimed patent infringements, especially by wealthy US competitors. EMI is said to hold some 500 patents on the Scanner and if successful in the courts there could be substantial arrears of royalties due some time in the future. Meantime, the US sales slump is to some extent offset by greatly increased sales elsewhere in the world and the new EMI 7070 System, said to be the most advanced machine ever, should help Scanner sales back into the black.

Videotex

France, as chauvinistic as ever, is going her own way with Viewdata (now known as Prestel in the UK). They are to call their system Videotex, as is the Bell Canada system, and it is scheduled for market trials in 1980 and a full service by 1982/83. Will Videotex be the odd-man-out in Europe as was the French Secam CTV system in the 60s and the 819-line system before that?

Car Electronics

A few years ago the idea of putting computers into production cars was open to question. Now, it seems, that the inroads of electronics to this area could contribute to 10 per cent of car cost by the 1980s and 30 per cent by the year 2000. In the U.S. models of the 1980s are expected to incorporate computerised engine control and this will inevitably appear in European models.

PATENTS REVIEW...

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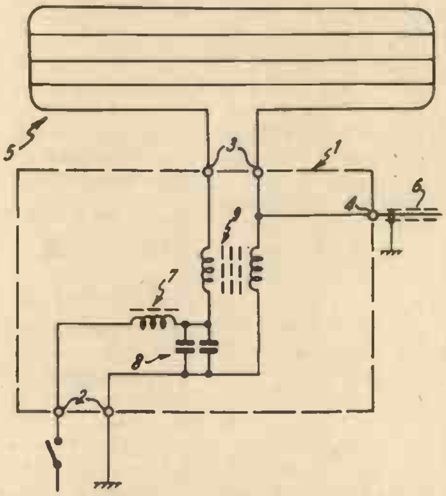
SCREEN HEATER AERIAL

In BP 1 520 030, B.S.H. Electronics (Manchester) Ltd. suggest simple circuitry for enabling the heating element of an electrically heated motor car window to be used as a radio aerial. This is not a new idea, but according to the patent, previously proposed solutions have relied on large air-cored chokes between the element and the car d.c. supply to provide a low resistance path for the d.c. power and a high impedance path for the radio signal to avoid loss of signal strength and reduce interference breakthrough. One disadvantage attributed to past designs is that the chokes degrade signal strength due to coil capacitance.

The allegedly new idea is described and sketched in the patent and preferred circuit component values suggested. Essentially the heating element 5 is connected to the car battery and car radio aerial input by means of a "black box" blocking circuit which can be sold as an accessory. The d.c. battery input 2 is routed to the connector 3 for the heater 5 via choke 7 and coils 9 bridged by a pair of ceramic filter capacitors 8. The aerial 6 connects direct to heater terminal 3.



In use heating current flows unimpeded from the car battery to the heating element via the choke and coils which provide a low impedance path to d.c. At the same time radio signals received by the heating element 5, and which are in phase at terminals 3, flow to the radio aerial input. The coils 9 provide a high Impedance blocking path for r.f. thereby preventing loss of signal strength. The coils 9, along with the filter capacitors and choke 7, prevent interference from the heating power circuit reaching the radio aerial.

It is suggested that a number of tuned inductance-capacitance circuits can be connected in series between the aerial terminal and earth, each circuit being tuned to a frequency in the middle of a different broadcast band, e.g. VHF FM, AM MW and AM LW. Each circuit thus presents a high impedance in its own tuned band.

It is also suggested that the choke 7 may be wound from twenty turns of 10 s.w.g. wire on a pot core of 36mm diameter and 23mm height, the winding of the core air-gapped to give an optimum inductance of between 60 to 100µH and a current rating of 10A. The filter capacitors 8 may be 1µF ceramics and between 10 and 25µF tantalum electrolytics. The coils, 9, may be formed by bifilar winding of 18 turns of 19 s.w.g. wire on a pot core of 30mm diameter and 19mm height with no air gaps to give an inductance of around 2mH.

LOG POT

Indesit of Turin Italy in BP 1 497 418 patent a potentiometer with a logarithmic function which, the company claims, is far easier to manufacture than a log pot of conventional type. Conventionally a non-linear law is obtained by distributing the resistive material of the potentiometer in a non-uniform manner or by varying its geometrical cross section. Indesit claim to achieve a reasonably accurate logarithmic law from a linear potentiometer by loading its output with an additional fixed resistor.

Indesit start from the premise that an ideal logarithmic potentiometer should have a resistance variation R plotted against the position of the wiper, the resistance R being proportional to:

$$y = \frac{a^{kx} - 1}{a^{k} - 1}$$

Where x is the position of the wiper represented as a percentage of its total range of movement, and a and k are two prefixed constants, Figs. 1 and 2 show how an additional resistor 6 is bridged between the pot wiper and one of its two other terminals. In each case the output is attenuated. The transfer function between output (V_u) and input (V_i) is equal to:

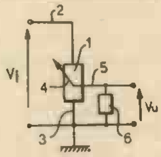


Fig-1

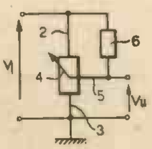
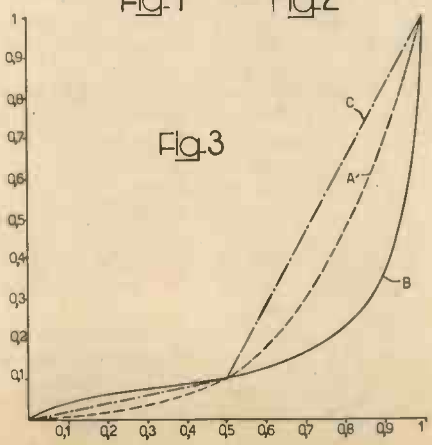


Fig-2

$$\frac{x}{1 - cx\,(x - 1)}$$

Where x is again the wiper position and c is the ratio between potentiometer and additional resistances.

Clearly the manner of choosing the constant c is the essence of the invention and a string of calculation steps are given. One suggested value is $c = 16$. Fig. 3 shows graphically the ideal logarithmic curve A, and a compromise curve B obtained with the circuit of the invention after selection of the constant as $c = 16$.



Also shown is a curve C obtained from a commercially available logarithmic potentiometer. Clearly curve B (of the invention pot) does not have the discontinuities present in curve C (conventional log pot).

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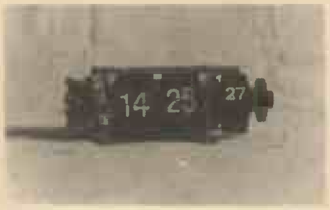

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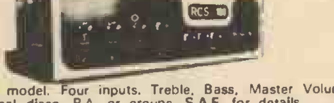

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Flux Density	16,500 gauss
Useful response	20–17,000 c/s
8 or 16 ohms models	

"AUDITORIUM" £22.68
12in 35 watt Post £1 60

A full range reproducer for high power Electric Guitars, public address, multi-speaker systems, electric organs. Ideal for Hi-Fi and Discotheques.

Bass Resonance	35 c/s
Flux Density	15,000 gauss
Useful response	25–16,000 c/s
8 or 16 ohms models.	

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TRANSISTORS

TYPE	PRICE
AC107	0.23
AC125	0.17
AC126	0.17
AC127	0.16
AC127K	0.23
AC128	0.14
AC128K	0.25
AC128/176	0.42
AC142	0.18
AC153	0.55
AC15B	0.50
AC176	0.16
AC187	0.50
AC187K	0.55
AC188K	0.55
ACY20	1.02
ACY22	1.02
AD142	0.87
AD143	0.87
AD149	0.65
AD161	0.35
AD161/162	0.70
AD162	0.35
AD262	0.36
AD263	0.36
ADY26	4.74
ADZ11	4.05
AF106	0.45
AF109R	0.36
AF124	0.25
AF125	0.25
AF126	0.25
AF127	0.25
AF139	0.32
AF178	0.30
AF179	0.30
AF200	0.36
AF201	0.39
ASY73	0.30
ASZ15	0.60
ASZ16	0.60
ASZ17	0.60
AU103	0.90
AU107	1.00
AU110	0.90
AU210	0.90
BC107	0.06
BC107A	0.07
BC107B	0.07
BC108	0.06

BC108A	0.07
BC108	0.07
BC109	0.06
BC109B	0.07
BC109C	0.07
BC113	0.12
BC114	0.15
BC116	0.13
BC117	0.15
BC118	0.12
BC119	0.25
BC125	0.15
BC125B	0.16
BC126	0.15
BC136	0.15
BC137	0.15
BC138	0.30
BC140	0.27
BC141	0.29
BC142	0.20
BC147	0.06
BC147B	0.07
BC148	0.06
BC148A	0.07
BC148B	0.07
BC149	0.06
BC157	0.06
BC157A	0.07
BC158	0.07
BC158A	0.08
BC158V1	0.09
BC159	0.06
BC159A	0.07
BC159B	0.07
BC161	0.25
BC167	0.06
BC168	0.06
BC169	0.06
BC170B	0.07
BC170C	0.07
BC171	0.06
BC171A	0.07
BC171B	0.07
B172	0.06
BC172A	0.07
BC172B	0.07
BC172C	0.07
BC173	0.06
BC173B	0.07
BC174B	0.07
BC177A	0.12

BC177B	0.12
BC178B	0.12
BC179	0.12
BC182A	0.09
BC182B	0.09
BC183A	0.09
BC183LA	0.09
BC183LB	0.10
BC184	0.08
BC184L	0.09
BC184LB	0.10
BC186	0.19
BC187	0.19
BC204	0.08
BC204B	0.09
BC206	0.10
BC206B	0.11
BC207	0.10
BC209B	0.09
BC212A	0.10
BC213L	0.10
BC214L	0.10
BC237	0.15
BC237A	0.16
BC237C	0.21
BC238	0.15
BC238B	0.16
BC238C	0.18
BC251A	0.15
BC251B	0.17
BC252A	0.15
BC252B	0.17
BC252C	0.20
BC258	0.20
BC261A	0.10
BC262	0.20
BC267A	0.21
BC267B	0.22
BC268	0.21
BC304	0.25
BC307	0.15
BC307A	0.15
BC307B	0.15
BC308	0.15
BC309A	0.15
BC317B	0.15
BC322	0.10
BC327	0.16
BC328	0.16
BC337	0.16
BC338	0.16

BC348A	0.15
BC350A	0.17
BC441	0.20
BC461	0.24
BC546	0.10
BC547	0.11
BC547A	0.11
BC547B	0.11
BC547C	0.11
BC548A	0.11
BC548B	0.11
BC548C	0.11
BC549A	0.11
BC549B	0.11
BC550	0.11
BC557	0.11
BC557A	0.11
BC557B	0.11
BC557C	0.11
BC558	0.11
BC558A	0.11
BC558B	0.11
BC559B	0.11
BCY42	0.55
BCY58	0.20
BCY71	0.13
BCY72	0.13
BD115	0.30
BD116	0.30
BD123	0.60
BD128	1.02
BD131	0.35
BD133	0.40
BD135	0.30
BD136	0.30
BD137	0.30
BD138	0.30
BD139	0.30
BD140	0.30
BD144	0.30
BD168	0.50
BD178	0.72
BD181	1.32
BD183	1.50
BD232	0.60
BD233	0.60
BD234	0.60
BD235	0.40
BD236	0.40
BD237	0.40
BD238	0.40
BD434	0.40
BD507	0.50

BD508	0.50
BD518	0.50
BD537	1.02
BD587	1.40
BDX32	1.90
BDY16	0.50
BDY20	0.50
BF115	0.35
BF121	0.20
BF123	0.20
BF125	0.20
BF127	0.20
BF137	0.21
BF152	0.15
BF154	0.15
BF157	0.37
BF158	0.15
BF167	0.25
BF173	0.20
BF174	0.20
BF177	0.25
BF178	0.25
BF179	0.25
BF180	0.20
BF181	0.20
BF182	0.20
BF183	0.20
BF184	0.20
BF185	0.20
BF194	0.06
BF194A	0.07
BF195	0.06
BF195D	0.07
BF195G	0.07
BF196	0.06
BF197	0.06
BF198	0.06
BF224	0.18
BF253	0.18
BF254	0.18
BF255	0.18
BF257	0.16
BF258	0.28
BF259	0.28
BF324	0.20
BF335	0.25
BF338	0.45
BF457	0.60
BF523	0.22
BF594	0.10
BFR91	5.00
BFT43	0.54
BFX29	0.20

BFX43	0.70
BFX84	0.20
BFX85	0.20
BFX88	0.20
BFY18	0.50
BFY19	0.50
BFY33	0.50
BFY34	0.50
BFY46	0.50
BFY51	0.12
BFY52	0.12
BFY81	4.00
BRY39	0.35
BSX20	0.18
BSX52	0.33
BSY20	0.21
BSY25	0.30
BSY26	0.30
BSY27	0.30
BSY29	0.54
BSY39	0.15
BSY52	0.33
BSY54	0.39
BSY56	0.36
BSY60	0.36
BSY84	0.30
BU105	1.08
BU105-04	1.08
BU108	1.80
BU126	1.00
BU133	1.75
BU204	1.30
BU205	1.30
BU208	1.50
BU208-02	1.75
BU406	3.60
BUY69A	6.75
BUY69B	2.00
BUY69C	7.00
BUY70A	5.00
BUY71	4.50
MPS6517	0.48
MPS6523	0.27
MPSA06	0.90
MV5053	0.72
NKT214	0.25
NKT224	0.25
OC22	1.40
OC26	1.40
OC29	0.85
OC36	1.00
OC44	0.12
OC45	0.12

OC71	0.09
OC74	0.10
OC75	0.10
OC82	0.48
OC139	0.50
OC203	2.50
OC207	2.70
OC1072	2.50
OC1074	2.50
R2008B	2.10
TIP30	0.35
TIP31	0.45
TIP31A	0.45
TIP32	0.45
TIP33	0.60
TIP42	0.60
TIP2955	0.65
TIS90	0.18
2N344B	0.30
2N404	0.45
2N524	0.48
2N526	0.48
2N527	0.48
2N685	3.50
2N705	0.10
2N706	0.10
2N706A	0.11
2N708	0.12
2N1039	0.15
2N1059	0.15
2N1101	0.15
2N1102	0.15
2N1132	0.20
2N1304	0.50
2N1305	0.50
2N1307	0.50
2N1309	0.50
2N1613	0.18
2N1671	1.10
2N1671B	2.20
2N1711	0.20
2N1893	0.25
2N1905	0.25
2N1990	0.25
2N2060	1.00

2N2188	0.20
2N2218A	0.22
2N2222	0.18
2N2222A	0.20
2N2270	0.39
2N2368	0.10
2N2484	0.18
2N2904	0.18
2N2906	0.18
2N3053	0.15
2N3117	1.00
2N3440	0.70
2N3638	0.15
2N3638A	0.16
2N3643	0.24
2N3692	0.24
2N3705	0.06
2N3706	0.06
2N3707	0.06
2N3711	0.06
2N3819	0.20
2N3899	3.00
2N3904	0.06
2N3905	0.06
2N3906	0.06
2N4037	0.25
2N4058	0.10
2N4222A	0.65
2N4348	2.00
2N4448	1.50
2N4914	3.50
2N5172	0.25
2N5245	0.30
2N5296	0.40
2N5458	0.25
2N5496	0.60
2N5670	0.65
2N5926	0.55
2N6123	0.65
2S003	0.75
2S303	0.90
2S304	0.90
2S305	0.90
2S323	1.00
2S732	1.00

TTL

7400	.12
7401	.12
7402	.12
7403	.12
7404	.13
7405	.13
7406	.29
7407	.29
7408	.14
7409	.14
7410	.13
7411	.18
7412	.21
7413	.25
7414	.54
7416	.27
7417	.27
7420	.13
7421	.28
7423	.25
7425	.22
7426	.25
7427	.25
7428	.34
7430	.13
7432	.24
7433	.32
7437	.24
7438	.24
7440	.13
7441	.52
7442	.55
7444	.90
7445	.70
7446	.70
7447	.66
7448	.60
7450	.13
7451	.13
7452	.13
7454	.13
7460	.13
7470	.28
7472	.22
7473	.26
7474	.20
7475	.28

7476	.13
7483	.75
7484	.90
7485	.90
7486	.26
7489	2.00
7490	.35
7491	.65
7492	.45
7493	.36
7494	.80
7495	.55
7496	.62
7497	2.40
74100	.95
74105	.40
74107	.28
74109	.45
74110	.46
74111	.70
74116	1.60
74118	.82
74119	1.30
74120	.82
74121	.26
74122	.40
74123	.55
74125	.45
74126	.46
74128	.62
74132	.70
74141	.58
74142	2.02
74143	2.02
74144	2.02
74145	.65
74147	1.35
74148	1.20
74150	1.00
74151	.60
74153	.60
74154	1.06
74155	.63
74156	.63
74157	.63
74158	1.70
74160	.80

74161	.80
74163	.80
74164	.90
74165	.90
74166	1.00
74167	2.70
74170	1.70
74172	4.00
74173	1.20
74174	.90
74175	.70
74176	.90
74177	.90
74178	1.20
74179	1.10
74180	.70
74181	1.95
74182	.75
74184	1.20
74185	1.20
74186	7.20
74188	5.40
74190	1.10
74191	1.00
74192	1.00
74193	1.10
74194	.92
74195	.85
74196	.92
74197	.92
74198	1.60
74199	1.50

CMOS

4000	.15
4001	.15
4002	.20
4006	.95
4007	.20
4008	.94
4009	.46
4010	.50
4011	.15
4012	.15
4013	.35
4014	.85
4015	.80
4016	.45
4017	.55
4018	.90
4019	.45
4020	.60
4021	.85
4022	.85
4023	.20
4024	.68
4025	.20
4026	1.35
4027	.35
4028	.70
4029	.90
4030	.50
4033	1.40
4035	1.10
4040	.90
4041	.80
4042	.75
4043	.85
4044	.85
4049	.28
4050	.45
4051	.88
4052	.88
4053	.88
4055	1.00
4060	1.00
4066	.35
4068	.20
4069	.20
4070	.20
4072	.20

4073	.20
4075	.20
4076	1.10
4078	.20
4081	.20
4082	.20
4502	.90
4507	.52
4508	2.30
4510	1.10
4511	.70
4512	.95
4516	.70
4518	.65
4520	1.10

DIODES

AA119	0.17
AA121	0.11
AA129	0.08
AA143	0.15
AA144	0.09
BA102	0.30
BA111	0.98
BA115	0.25
BA145	0.15
BA148	0.12
BA154	0.10
BA155	0.12
BA156	0.12
BA157	0.45
BA158	0.66
BA159	0.75
BA182	0.46
BA201	0.15
BA243	0.85
BAX13	0.06
BAX16	0.07
BAX17	0.10
BB105B	0.35

BB105G	0.35
BB110G	0.48
BB142	1.25
BR100	0.20
BR101	0.30
BY100	0.20
BY103	0.35
BY118	1.45
BY126	0.15
BY127	0.10
BY130	0.15
BY133	0.10
BY134	0.45
BY142	0.48
BY164	0.50
BY176	3.45
BY179	0.90
BY182	1.85
BY184	0.70
BY187	1.30
BY198	0.75
BY199	0.56
BY201-2	0.40

BY201-3	0.40
BY201-4	0.45
BY201-5	0.56
BY201-6	0.56
BY203-12	0.60
BY203-16	0.66
BY203-20	1.00
BY204-4	0.46
BY204-8	0.66
BY204-10	0.75
BY206	0.30
BY210-400	0.46
BY210-600	0.50
BY210-800	0.55
BYX10	0.36
BYX55-350	0.45
BYX55-600	0.55
BYX71-350	0.90
BYX71-600	1.15
BZX61 series	0.18
BZY88 series	0.08
DK13	0.45
ITT44	0.10

ITT210	1.36
ITT827	2.36
ITT921	0.20
ITT923	0.36
ITT1075	0.25
ITT2001	0.25
ITT2002	0.20
MR502	0.75
MR813	0.90
MR854	1.80
MR856	2.10
MR992A	1.56
MV2203	1.60
MV5460	0.66
OA47	0.07
OA70	0.07
OA71	0.36
OA81	0.12
OA85	0.12
OA86	0.20
OA90	0.07
OA91	0.06
OA95	0.06

OA202	0.07
ST2	0.14
1N4001	0.04
1N4002	0.06
1N4003	0.05
1N4004	0.06
1N4005	0.06
1N4006	0.07
1N4007	0.08
1N4148	0.04
1N4150	0.46
1N4448	0.25
1N5401	0.12
1N5402	0.15
1N5403	0.15
1N5404	0.16
1N5405	0.25
1N5406	0.20
1N5407	0.19
1N5408	0.20
1N5450A	6.75
1N5761	0.60

LINEAR INTEGRATED CIRCUITS

CA3020	1.75
CA3046	0.80
CA3048	2.50
CA3065	1.58
CA3089E	7.88
CA3090Q	4.50
ETT6016	4.95
ETTR6016	4.95
MC1303L	1.50
MC1304P	2.00
MC1306	5.15
MC1307P	2.85
MC1310P	1.00
MC1327P	2.75
MC1327PQ	2.50
MC1330P	1.25
MC1339P	3.95
MC1349	3.35
MC1351P	1.25
MC1352P	1.45
MC1358PQ	3.85
SAA570	4.20
SAA7008	10.15
SAS560	2.75
SAS570	2.75
SBA750B	8.75
SC9503P	2.00

SC9504P	2.00
SL414A	4.88
SL415A	6.30
SL9C18	8.50
SL917B	10.70
SL1310	5.65
SL1327	2.75
SL3046	2.60
SN76003N	2.50
SN76003NQ	2.15
SN76013N	1.80
SN70613ND	2.15
SN76023N	1.80
SN76023ND	2.15
SN76033N	2.40
SN76110N	1.50
SN76131N	2.00
SN76226N	3.15
SN76226NQ	3.15
SN76227N	2.50
SN76532N	3.15
SN76533N	2.70
SN76544N	1.80
SN76550N	1.80
SN76660N	0.80
SN76666N	1.60

TAA300	3.75
TAA310	3.15
TAA320	2.60
TAA350A	3.00
TAA435	3.40
TAA550	0.50
TAA550B	0.40
TAA570	2.85
TAA621	6.95
TAA630	8.55
TAA630S	6.10
TAA661A	1.70
TAA661B	1.80
TAA700	3.60
TAA840	4.50
TAD100	1.35
TBA120A	3.05
TBA120AS	1.80
TBA120S	2.70
TBA120SB	1.80
TBA120SQ	1.80
TBA281	4.70
TBA350A	3.00
TBA396	1.80
TBA440	3.60
TBA440S	3.86
TBA480Q	2.50

TBA400	2.25
TBA510	2.40
TBA510Q	2.80
TBA520	2.80
TBA520Q	2.80
TBA530	2.80
TBA530Q	2.80
TBA540	2.80
TBA540Q	2.25
TBA550	3.80
TBA550Q	3.80
TBA560	8.45
TBA560C	4.60
TBA560Q	7.38
TBA560CQ	3.00
TBA570	2.00
TBA570Q	2.00
TBA641A12	6.20
TBA641B11	6.65
TBA673	5.00
TBA700	3.85
TBA700Q	2.25
TBA720	5.10
TBA720A	5.10
TBA720AQ	2.10
TBA750	2.40

TBA750Q	2.60
TBA800	0.90
TBA800Q	2.85
TBA810A	3.40
TBA810S	1.10
TBA820	0.80
TBA915	7.35
TBA920	3.00
TBA920Q	3.50
TBA950-2	5.40
TBA950-2X	5.04
TBA990	4.95
TBA990Q	3.75
TCA160	5.10
TCA270	3.00
TCA270B	3.90
TCA270Q	3.80
TCA270S	2.25
TCA270SQ	3.40
TCA800	5.40
TCA800Q	12.40
TCA830	3.10
TDA440	6.75
TDA1327	2.88
TDA1327B	2.88
TDA1330	1.60
741	0.25

BRIDGE RECTIFIERS

CURRENT	VOLTAGE	ORDER CODE	PRICE
1A	50V	B1/50	0.26
1A	100V	B1/100	0.28
1A	200V	B1/200	0.28
1A	400V	B1/400	0.30
1A	800V	B1/800	0.34
2A	50V	B2/50	0.40
2A	100V	B2/100	0.46
2A	200V	B2/200	0.55
2A	400V	B2/400	0.65
2A	800V	B2/800	0.70
3A	200V	B3/200	0.70
3A	600V	B3/600	0.80
4A	100V	B4/100	0.90
4A	400V	B4/400	0.96
6A	50V	B6/50	0.88
6A	200V	B6/200	1.10
6A	400V	B6/400	1.20
10A	400V	B10/400	2.80
25A	50V	B25/50	4.00
25A	200V	B25/200	4.20
25A	400V	B25/400	4.30

I. C. SOCKETS

NO. OF PINS	ORDER CODE	PRICE
8	D8	0.10
14	D14	0.11
16	D16	0.13
20	D20	0.30
22	D22	0.36
24	D24	0.40
28	D28	0.46
40	D40	0.60

PANEL METERS

Size 2" x 2" x 1 3/8"; requires 1¾ cut-out.

F.S.D.	ORDER CODE	PRICE
1mA	M1	5.50
500mA	M500	5.50

THYRISTORS

CURRENT	VOLTAGE	CASE	ORDER CODE	PRICE
80mA	30V	TO18	S08/30	0.22
80mA	60V	TO18	S08/60	0.24
80mA	200V	TO18	S08/200	0.28
1A	50V	TO220	S1/50	0.25
1A	100V	TO220	S1/100	0.28
1A	200V	TO220	S1/200	0.28
1A	400V	TO220	S1/400	0.35
3A	50V	TO220	S3/50	0.25
3A	100V	TO220	S3/100	0.28
3A	200V	TO220	S3/200	0.30
3A	400V	TO220	S3/400	0.40
4A	50V	TO220	S4/50	0.35
4A	100V	TO220	S4/100	0.40
4A	200V	TO220	S4/200	0.50
4A	400V	TO220	S4/400	0.65
5A	400V	TO220	S5/400	0.65
7A	50V	TO220	S7/50	0.46
7A	100V	TO220	S7/100	0.50
7A	200V	TO220	S7/200	0.56
7A	400V	TO220	S7/400	0.60
8A	400V	TO220	S8/400	0.70

TRIACS

CURRENT	VOLTAGE	CASE	ORDER CODE	PRICE
3A	100V	TO220	T3/100	0.75
3A	200V	TO220	T3/200	0.80
3A	400V	TO220	T3/400	0.86
6A	200V	TO220	T6/200	1.00
6A	400V	TO220	T6/400	1.08
8A	400V	TO220	T8/400	1.35
10A	400V	TO220	T10/400	1.40
15A	400V	TO220	T15/400	2.00

ALL ITEMS OFFERED SUBJECT TO AVAILABILITY

RESISTORS

¼W Values available in E12 series from 10R to 1M Price 0.03 each

¼W Values available in E 12 series from 1R0 to 10M Price 0.03 each.

1W Values available in E12 series from 2R2 to 10M Price 0.08 each.

2W Values available in E12 series from 10R to 10M Price 0.11 each.

5W Values available in E6 series from 1R0 to 6K8.
Prices 1R0 to 1K0 0.19 each.
1K5 to 3K3 0.22 each.
4K7 to 6K8 0.24 each.

7W Values available in E12 series from R47 to 22K.
Prices R47 to R82 0.25 each.
1R0 to 1K0 0.26 each.
1K2 to 12K 0.27 each.
15K to 22K 0.28 each.

11W Values available in E6 series from 1R0 to 22K.
Prices 1R0 to 1K0 0.29 each.
1K5 to 12K 0.30 each.
15K to 22K 0.36 each.

17W Values available in E6 series from 1R0 to 22K.
Prices 1R0 to 4K7 0.38 each.
6K8 to 22K 0.41 each.

½W Single turn cermet potentiometer. Values available 100R, 200R, 500R, 1K0, 2K0, 5K0, 10K, 20K, 50K, 100K, 200K, 500K, 1M
Price 0.87 each.

¾W Multiturn cermet potentiometer. Values available 20R, 50R, 100R 200R, 500R, 1K0 2K0, 5K0, 10K, 20K, 100K, 500K.
Price 1.40 each.

1W Potentiometer with 2" spindle. Values available 10R, 25R, 50R, 100R, 250R, 500R, 1K0, 2K5, 5K0, 10K, 20K.
Prices 10R to 5K0 1.61 each.
10K & 20K 1.62 each.

1.5W Convergence preset potentiometer. Values available 5R0, 7R0, 10R, 15R, 20R, 100R, 500R.
Price 0.50 each.

2W 10 Turn potentiometer. Values available 100R, 200R, 500R, 1K0, 2K0, 5K0, 10K, 20K, 50K, 100K.
Price 7.34 each.

CAPACITORS

Tantalum Bead		
6.3V	47uF	0.32 each
	100uF	0.50 each
16V	10uF	0.24 each
	22uF	0.30 each
	47uF	0.50 each
25V	22uF	0.41 each
35V	0.1uF	0.22 each
	0.22uF	0.22 each
	0.47uF	0.22 each
	1.0uF	0.22 each
	2.2uF	0.22 each
	4.7uF	0.24 each
Disc Ceramic		
8kV	150pF	0.27 each
	180pF	0.27 each
	200pF	0.27 each
	220pF	0.27 each
	250pF	0.40 each
	270pF	0.40 each
	300pF	0.40 each
Mixed Dielectric		
600V	1uF	1.01 each
1kV	0.01uF	0.26 each
	0.033uF	0.32 each
	0.047uF	0.35 each
	0.1uF	0.39 each
	0.22uF	0.58 each
	0.47uF	0.89 each
1.25kV	0.1uF	0.50 each
1.5kV	0.001uF	0.24 each
	0.0022uF	0.24 each
	0.0047uF	0.24 each
	0.22uF	0.28 each
Single Ended Electrolytic		
16V	10uF	0.11 each
	22uF	0.11 each
	47uF	0.11 each
	100uF	0.11 each
	220uF	0.14 each
	470uF	0.28 each
	1000uF	0.32 each
63V	1uF	0.11 each
	2.2uF	0.11 each
	4.7uF	0.11 each
	10uF	0.13 each
	22uF	0.16 each
	47uF	0.22 each
	100uF	0.32 each
	220uF	0.46 each
Double Ended Electrolytic		
10V	22uF	0.14 each
	100uF	0.14 each
	220uF	0.17 each
	470uF	0.36 each
	1000uF	0.40 each

25V	10uF	0.14 each
	22uF	0.14 each
	47uF	0.17 each
	100uF	0.17 each
	220uF	0.36 each
	470uF	0.47 each
	1000uF	0.72 each
63V	1uF	0.14 each
	2.2uF	0.14 each
	4.7uF	0.14 each
	10uF	0.17 each
	22uF	0.17 each
	47uF	0.29 each
	100uF	0.40 each
	220uF	0.65 each
	470uF	0.66 each
	1000uF	1.01 each
	2200uF	1.44 each
100V	10uF	0.20 each
	22uF	0.25 each
	47uF	0.36 each
	100uF	0.61 each
	220uF	0.68 each
450V	1uF	0.27 each
	4.7uF	0.45 each
	10uF	0.53 each
	22uF	1.07 each
	33uF	1.22 each
Silvered Mica		
500V	3.3pF	0.18 each
	5pF	0.18 each
	10pF	0.18 each
	39pF	0.18 each
	100pF	0.18 each
	150pF	0.18 each
	180pF	0.18 each
	220pF	0.18 each
	330pF	0.36 each
	470pF	0.36 each
	680pF	0.38 each
	820pF	0.36 each
	1000pF	0.42 each
	2200pF	0.50 each
	8200pF	1.58 each
	10000pF	1.62 each
Multi-sectional Electrolytic		
30V	2500/2500uF	1.94 each
70V	2500/2500uF	2.70 each
300V	150/150/100uF	2.81 each
350V	200/300uF	2.46 each
	200/200/100/32uF	3.80 each
	150/100/100/100/150uF	4.75 each
	400/400uF	4.75 each
	300/300/150/100/80uF	6.18 each

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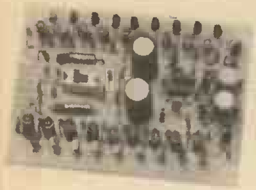
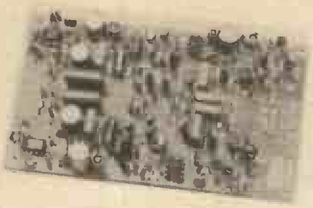
MC 1



CPR 1



CPR 1 – THE ADVANCED PRE-AMPLIFIER

The best pre-amplifier in the U.K. The superiority of the CPR 1 is probably in the disc stage. The overload margin is a superb 40dB, this together with the high slewing rate ensures clean top, even with high output cartridges tracking heavily modulated records. Common-mode distortion is eliminated by an unusual design. R.I.A.A. is accurate to 1dB; signal to noise ratio is 70dB relative to 3.5mV; distortion < .005% at 30dB overload 20kHz.
Following this stage is the flat gain/balance stage to bring tape, tuner, etc. up to power amp. signal levels. Signal to noise ratio 86dB; slew-rate 3V/uS; T.H.D. 20Hz – 20kHz < .008% at any level. F.E.T. muting. No controls are fitted. There is no provision for tone controls. CPR 1 size is 130 x 80 x 20mm. Supply to be ±15 volts.

MC 1 – PRE-PRE-AMPLIFIER

Suitable for nearly all moving-coil cartridges. Sensitivity 70/170uV switchable on the p.c.b. This module brings signals from the now popular low output moving-coil cartridges up to 3.5mV (typical signal required by most pre-amp disc inputs). Can be powered from a 9V battery or from our REG 1 regulator board.

REG 1 – POWER SUPPLY

The regulator module, REG 1 provides 15-0-15v to power the CPR 1 and MC 1. It can be used with any of our power amp supplies or our small transformer TR 6. The power amp kit will accommodate it.

POWER AMPLIFIERS

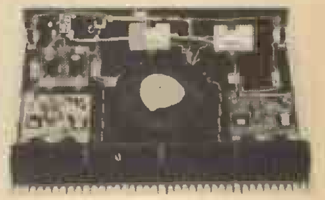
It would be pointless to list in so small a space the number of recording studios, educational and government establishments, etc. who have been using CRIMSON amps satisfactorily for quite some time. We have a reputation for the highest quality at the lowest prices. The power amp is available in five types, they all have the same specification: T.H.D. typically .01% any power 1kHz 8 ohms; T.I.D. insignificant; slew rate limit 25V/uS; signal to noise ratio 110dB; frequency response 10Hz-35kHz, -3dB; stability unconditional; protection drives any load safely; sensitivity 775mV (250mV or 100mV on request); size 120 x 80 x 25mm.

POWER SUPPLIES

We produce suitable power supplies which use our superb TOROIDAL transformers only 50mm high with a 120-240 primary and single bolt fixing (includes capacitors/bridge rectifier).

POWER AMPLIFIER KIT

The kit includes all metalwork, heatsinks and hardware to house any two of our power amp modules plus a power supply. It is contemporarily styled and its quality is consistent with that of our other products. Comprehensive instructions and full back-up service enables a novice to build it with confidence in a few hours.



POWER AMPLIFIER MODULES

CE 608 60W/8 ohms 35-035v	£16·30
CE 1004 100W/4 ohms 35-0-35v	£19·22
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TOROIDAL POWER SUPPLIES

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CPS4 for 1 x CE 1008	£15·31
CPS5 for 1 x CE 1708	£22·68
CPS6 for 2 x CE 1704 or 2 x CE 1708	£23·98

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Fan mounted on two drilled 100mm heatsinks, 2 x 4°C/W, 65°C max. with two 170W modules.	£29·16

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POWER AMP KIT . . . **£32·40**

PRE-AMPS:
These are available in two versions – one uses standard components, and the other (the S) uses MO resistorts where necessary and tantalum capacitors.

CPRI	£29·49	CPRIS	£39·98
MCI	£18·50	MCIS	£29·49

POWER SUPPLY:

REGI	£6·75	TR6	£1·75

BRIDGE DRIVER, BDI
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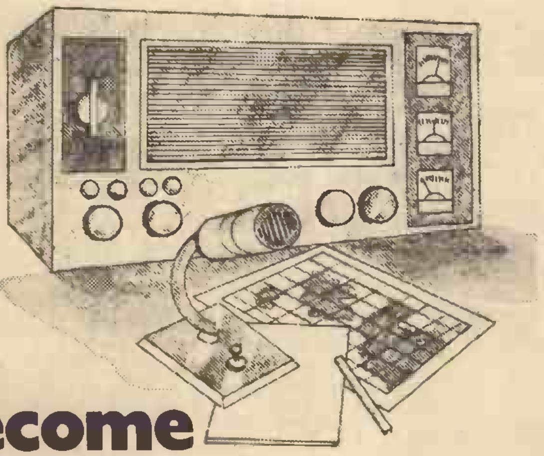

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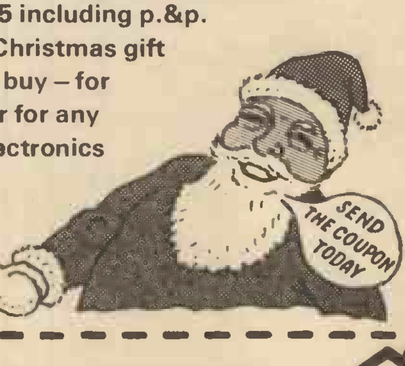

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AC125	0·20	BD124	1·30	NKT404	1·73	1N4005	0·08	7413	0·32
AC126	0·20	8D131	0·35	OA5	0·95	1N4006	0·08	7416	0·32
AC127	0·20	8D132	0·38	OA7	0·55	1N4007	0·09	7417	0·32
AC128	0·20	BD135	0·34	OA10	0·60	1N4009	0·06	7420	0·17
AC141	0·25	BD136	0·34	OA47	0·14	1N4148	0·06	7422	0·20
AC141K	0·35	BD137	0·35	OA70	0·30	1N5400	0·13	7423	0·32
AC142	0·20	BD138	0·40	OA79	0·30	1N5401	0·13	7425	0·30
AC142K	0·30	BD139	0·43	OA81	0·30	1S44	0·04	7427	0·30
AC176	0·20	BD140	0·44	OA85	0·30	1S920	0·07	7428	0·43
AC187	0·20	BD144	2·00	OA90	0·08	1S921	0·07	7430	0·17
AC188	0·20	BD181	1·10	OA91	0·08	2G301	1·00	7432	0·30
ACY17	0·85	BD182	1·18	OA95	0·08	2G302	1·00	7433	0·36
ACY18	0·80	BD237	0·40	OA200	0·09	2G306	1·10	7437	0·32
ACY19	0·75	BD238	0·55	OA202	0·09	2N404	1·00	7438	0·32
ACY20	0·70	BDX10	0·91	OA211	1·00	2N696	0·25	7440	0·18
ACY21	0·75	BDX32	2·00	OAZ200	1·00	2N697	0·25	7441AN	0·85
ACY39	1·50	BDY20	1·25	OAZ201	1·00	2N698	0·30	7442	0·72
AD149	0·70	BDY60	1·50	OAZ206	1·00	2N705	1·20	7447AN	0·90
AD161	0·45	BF115	0·25	OAZ2D7	1·00	2N706	0·15	7450	0·18
AD162	0·45	BF152	0·18	OC16	2·00	2N708	0·20	7451	0·18
AF106	0·45	8F153	0·20	OC20	2·50	2N930	0·20	7453	0·18
AF114	0·35	BF154	0·17	OC22	2·50	2N1131	0·26	7454	0·18
AF115	0·35	BF159	0·23	OC23	2·75	2N1132	0·26	7460	0·18
AF116	0·35	BF160	0·16	OC24	3·00	2N1302	0·35	7470	0·35
AF117	0·35	8F167	0·20	OC25	0·90	2N1303	0·35	7472	0·33
AF139	0·40	BF173	0·20	OC26	0·90	2N1304	0·45	7473	0·36
AF186	1·20	BF177	0·24	OC28	2·00	2N1305	0·45	7474	0·40
AF239	0·45	BF178	0·24	OC29	2·00	2N1306	0·50	7475	0·54
AFZ11	2·75	BF179	0·25	OC35	1·50	2N1307	0·50	7476	0·40
AFZ12	2,75	BF180	0·30	OC36	1·50	2N1308	0·55	7480	0·55
ASY26	0·40	BF181	0·30	OC41	0·80	2N1309	0·56	7482	0·75
ASY27	0·40	BF182	0·30	OC42	0·75	2N1613	0·25	7483	0·90
ASZ15	1·25	BF183	0·25	OC43	2·25	2N1671	1·50	7484	1·00
ASZ16	1·25	BF184	0·26	OC44	0·60	2N1893	0·25	7486	0·35
ASZ17	1·25	BF185	0·25	OC45	0·55	2N2147	1·75	7490	0·52
ASZ20	1·50	*BF194	0·09	OC71	0·55	2N2148	1·65	7491AN	0·80
ASZ21	2·00	*BF195	0·09	OC72	0·55	2N2218	0·25	7492	0·60
*AU110	1·70	*8F196	0·10	OC73	1·00	2N2219	0·24	7493	0·60
*AU113	1·70	*BF197	0·12	OC74	0·65	2N2220	0·18	7494	0·80
*AUY10	1·70	BF200	0·27	OC75	0·65	2N2221	0·18	7495	0·72
*BA145	0·13	*BF224	0·20	OC76	0·55	2N2222	0·18	7496	0·80
*8A148	0·13	BF244	0·28	OC77	1·20	2N2223	2·75	7497	3·00
BA154	0·09	BF257	0·24	OC81	0·65	2N2368	0·17	74100	1·50
BA155	0·10	BF258	0·26	OC81Z	1·20	2N2369A	0·21	74107	0·45
BA156	0·09	BF259	0·32	OC82	0·65	2N2484	0·20	74109	0·70
BAW62	0·05	BF336	0·30	OC83	0·65	2N2646	0·55	74110	0·50
BAX13	0·06	BF337	0·30	OC84	0·65	2N2904	0·25	74111	0·70
BAX16	0·09	BF338	0·31	OC122	1·50	2N2905	0·25	74116	1·75
BC107	0·12	BFS21	3·96	OC123	1·75	2N2906	0·21	74118	1·00
8C108	0·12	BFS28	2·23	OC139	2·25	2N2907	0·21	74119	1·50
BC109	0·13	*BFS61	0·20	OC140	2·75	*2N2924	0·21	74120	0·83
*BC113	0·12	*BFS98	0·20	OC141	3·25	*2N2925	0·22	74121	0·40
*BC114	0·13	BFW10	0·65	OC170	1·00	*2N2926	0·14	74122	0·60
*BC115	0·14	BFW11	0·65	OC171	1·00	2N3053	0·25	74123	1·00
*BC116	0·15	BFX84	0·22	OC200	1·50	2N3054	0·50	74125	0·55
*BC117	0·17	8FX85	0·23	OC201	1·75	2N3055	0·70	74126	0·55
*BC118	0·10	BFX87	0·21	OC202	1·75	2N3440	0·60	74128	0·60
BC125	0·16	BFX88	0·21	OC203	1·75	2N3441	0·80	74132	0·70
*BC126	0·20	BFY50	0·26	OC204	2·50	2N3442	1·10	74136	0·55
*BC135	0·14	BFY51	0·26	OC205	2·50	2N3525	0·80	74141	0·80
*BC136	0·15	BFY52	0·26	OC206	2·50	2N3614	1·50	74142	2·30
*BC137	0·15	BFY64	0·26	OC207	1·75	*2N3702	0·11	74143	2·50
*BC147	0·09	BFY90	1·25	OCP71	1·25	*2N3703	0·13	74144	2·50
BC148	0·08	BSX19	0·21	ORP12	0·75	*2N3704	0·13	74145	0·90
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*BC158	0·08	BT106	1·25	*R20108	1·75	*2N3707	0·13	74150	1·60
*BC159	0·10	BTY79/4	3·19	T1C44	0·30	2N3708	0·10	74151	0·85
*BC167	0·12	*BU205	1·75	T1C226D	1·20	2N3709	0·13	74154	1·75
BC170	0·11	*BU206	2·25	T1L209	0·20	2N3710	0·10	74155	0·85
BC171	0·10	*BU208	2·00	*T1P29A	0·41	2N3711	0·10	74156	0·85
BC172	0·10	BY100	0·45	*T1P30A	0·44	2N3771	1·75	74157	0·75
BC173	0·12	BY126	0·14	T1P31A	0·45	2N3772	2·00	74159	2·10
BC177	0·15	BY127	0·15	T1P32A	0·48	2N3773	3·00	74170	2·30
BC178	0·14	BZX61	0·18	T1P33A	0·69	2N3819	0·36	74172	4·40
BC179	0·16	Series		T1P34A	0·73	2N3820	0·45	74173	1·40
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*BC338	0·17	MJE370	1·17	*ZTX302	0·15	*2N5457	0·35	74199	2·25
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8CY31	1·00	MJE520	0·52	*ZTX304	0·19	*2N5459	0·35		
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BCY33	0·90	MJE2955	1·25	*ZTX314	0·20	**INTEGRATED**			
BCY34	0·90	MJE3055	0·75	*ZTX500	0·13	**CIRCUITS**			
BCY39	3·00	*MPF102	0·30	*ZTX501	0·14	7400	0·16	Plugs in socket	
BCY40	1·00	*MPF103	0·30	*ZTX502	0·16	7401	0·16	—low profile	
BCY42	0·25	*MPF104	0·30	*ZTX503	0·17	7402	0·16	8 pin DIL	0·15
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Section 5

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6500 .... £10.60N
Spare bulb 35pN

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ERSA solder station
Temp controlled iron
with stand £59.00N

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.... £25.00N
DESOLDER TOOL
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Spare nozzle. PTFE SR3AN.. 65pN

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No 2 .094"; No 4 .187";
No 6 .047"
Iron coated bits 46pN
No. 102, 104, 106
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(low capacitance) 15W
Spare element £1.90N
Iron coated bits 46pN
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1102 .187"
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Spare element £1.60N
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2518H	120	65	40	£2.07
2520J	150	80	50	£2.35
2522K	188	110	60	£3.13

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Constructed from ABS material light grey top & dark grey bottom section. Anodised ali. front and rear panels. Internal guides for PC boards.

Type	L	H	D	
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CONNECTORS

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RA Wafers MBB
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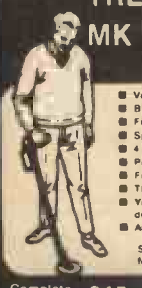

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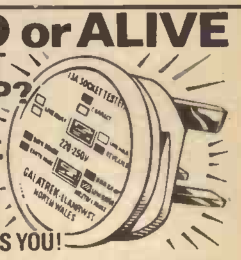

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203	500, 500	0-15-27-0-15-27	3·99	0·96
204	1A, 1A	0-15-27-0-15-27	6·04	0·96
239	50	12-0-12	2·57	0·38

MINI-MULTIMETER
DC-1000V AC-1000V DC-100mA Res-150kΩ 1000Ω/V Bargain £6·14 P & P 62p VAT 8%

20,000 ohm/V Multimeter, mirror scale. Ranges AC/DC to 1000V, DC currents to 250mA. Resistance to 3 Megs. 5" x 3½" x 1¼" £14·36 P&P £1·05 VAT 8%.

TEST METERS
U4315 Budget Meter 20KΩ/V DC 2K/V AC 1000V AC/DC 2·5A AC/DC 500K res. in robust steel case and leads £15·85.

AVO8	£81·70	TT169 incircuit transistor tester	£34·75
AVO71	£33·50	DA116 digital	£102·00
AVO73	£45·20	Megger BM7 Battery.	£45·15
EM272	£53·70	Wee Megger	£66·90
MM5	£28·66		

P&P £1·15 VAT 8%.
Full range of AVO's, Megger's and Cases.

ISOLATOR – *Special Price*
0-200-220-240V, 0-240V Centre Tap, 250VA Ref. 62 £5·20 P & P 96p

ELECTROSIL Metal oxide low noise resistors.

ELECTRONIC CONSTRUCTION KIT
Home electronics teacher. Start simply and progress to a TRF radio or electronic organ. No soldering, all parts included in presentation box. £8·29 + VAT + 96p p&p.

1 1/16" x 1 1/16" PANEL METERS 3 3/16" x 3 1/16"

0-50μA	5·50	0-50μA	6·70	Carriage
0-500μA	5·50	0-500μA	6·70	65p
0-1mA	5·50	0-1mA	8·40	VAT 8%
0-30V	5·50	0-30V	8·40	

VU Ind Panel 90mm 250μa £3·36
VU Indicator Edge 54mm x 14mm 250μa FSD £2·60

Cassette Tapes Low Noise
C60 30p P. & P. 15p
C90 42p P. & P. 15p VAT 8%.

Prices correct 17.8.78. Please add VAT after P. & P. PE1.

COMPONENT PACKS
65 High Quality Metal Oxide .5% ½w Resistors.
150 Mixed Value Capacitors
10 Read Switch.
50 Wire Wound Resistors, mixed.
25 assorted Presets.
50 Wire Wound Resistors, mixed.
washers, insulators. All **70p** each + 12½% P & P 40p.

TMK 500
30K/V Mirror Scale Meter
AC 0-2·5-10-25-100-250-500-1000V
DC 0-·25-1-2·5-10-25-100-250-1000V
Resistance 0-6K-60K-6M-60M auto o/load protection £23·30
P. & P. £1·05 VAT 8%.

AMPLIFIER MODULES

10W	(AL30)	£3·75
25W	(AL60)	£4·57
35W	(AL80)	£7·15
125W	(AL250)	£17·25
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Power Supply SPM80		£4·25
Pre-amp PA12		£6·70
PA100		£13·88

VAT 12½% P & P 35p

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PB1	80mm x 62 x 40	56p
PB2	100mm x 75 x 40	63p
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PB4	215mm x 130 x 85*	£2·54

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VAT 12½% P & P 35p.

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3A	£14·70	P & P £1·48
4A	£18·77	P & P £1·84
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PLUG IN SAVE BATTERIES
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P & P 55p. VAT 12½%.

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U Dec "B" for I.C.s etc	£6·99

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BE8 0-240 15-0-15V 2A £1·50 P. & P. 70p.

Ref 30 240-240 Isolater 200VA £4·20 P & P 96p.

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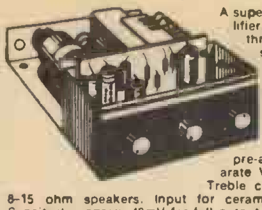
NEAREST TUBE STATIONS: ALOGATE & LIVERPOOL ST

SUPERSOUND 13 HI-FI MONO AMPLIFIER



A superb solid state audio amplifier. Brand new components throughout. 5 silicon transistors plus 2 power output transistors in push-pull. Full wave rectification. Output approx. 13 watts r.m.s. into 8 ohms. Frequency response 12Hz 30KHz ± 3db. Fully integrated pre-amplifier stage with separate Volume. Bass boost and Treble cut controls. Suitable for 8–15 ohm speakers. Input for ceramic or crystal cartridge. Sensitivity approx. 40mV for full output. Supplied ready built and tested, with knobs, escutcheon panel, input and output plugs. Overall size 3in high × 8in wide × 7½in deep. AC 200/250V.

PRICE £15·00 P. & P. £1·20.

HARVERSONIC MODEL P.A. TWO ZERO

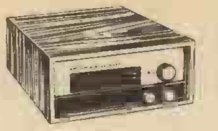
An advanced solid state general purpose mono amplifier suitable for Public Address system, Disco, Guitar, Gram., etc. Features 3 individually controlled inputs (each input has a separate 2 stage pre-amp.). Input 1, 15mV into 47k. Input 2, 15mV into 47k (suitable for use with mic. or guitar etc.). Input 3, 200mV into 1 meg. suitable for gram, tuner, or tape etc. Full mixing facilities with full range bass & treble controls. All inputs plug into standard jack sockets on front panel. Output socket on rear of chassis for an 8 ohm or 16 ohm speaker. Output in excess of 20 watts R.M.S Very attractively finished purpose built cabinet made from black vinyl covered steel, with a brushed anodised aluminium front escutcheon. For ac mains operation 200/240 volts. Size approx. 12½in. wide × 5in high × 7½in deep

Special introductory price £28·00 + £2·50 carriage and packing.

"POLY PLANAR" WAFER-TYPE, WIDE RANGE ELECTRO-DYNAMIC SPEAKER

Size 11¾in × 14¾in × 1¼in deep. Weight 19oz. Power handling 20W R.M.S. (40W peak). Impedance 8 ohm only. Response 40Hz-20KHz. Can be mounted on ceilings, walls, doors, under tables, etc, and used with or without baffle. Send S.A.E. for full details. Only £8·40 each + P. & P. (one 90p, two £1·10). Now available in either 8in round version or 4½ × 8½in rectangular. 10 watts R.M.S. 60Hz-20kHZ £5·25 + P. & P. (one 65p, two 75p.).

MAINS OPERATED SOLID STATE AM/FM STEREO TUNER



200/240V Mains operated Solid State F.M. A.M. Stereo Tuner. Covering M.W. A.M. 540–1605KHz V.H.F. F.M. 88–108MHz. Built-in Ferrite rod aerial for M.W. Full AFC and AGC on A.M. and F.M. Stereo Beacon Lamp Indicator. Built in Pre-amps with variable output voltage adjustable by pre-set control. Max o/p Voltage 600mV R.M.S. into 20K. Simulated Teak finish cabinet. Will match almost any amplifier. Size 8½in wide × 4in high × 9½in deep approx.

Limited number only at £28·00 + £1·50 P. & P.

10/14 WATT HI-FI AMPLIFIER KIT

A stylishly finished monaural amplifier with an output of 14 watts from 2 EL84s in push-pull. Super reproduction of both music and speech, with negligible hum. Separate inputs for mike and gram allow records and announcements to follow each other. Fully shrouded section wound output transformer to match 3-15Ω speaker and 2 independent volume controls, and separate bass and treble controls are provided giving good lift and cut. Valve line-up. 2 EL84s, ECC83, EF86 and EZ80 rectifier. Simple instruction booklet 25p + S.A.E. (Free with parts). All parts sold separately. ONLY £14·50 P. & P. £1·40. Also available ready built and tested £19·00 P. & P. £1·40.

STEREO MAGNETIC PRE-AMP Sens. 3mV in for 100mV out. 15 to 35V neg. earth. Equ. ±1dB from 20Hz to 20KHz. Input impedance 47K. Size 1⅝in x 2⅜in x 5⅜in H. £2·60 + 20p. P & P.

Mullard LP1159 RF-IF module 470 kHz £2·25 + P. & P. 20p. Full specification and connection details supplied.
Pye VHF FM Tuner Head covering 88-108 MHz 10·7 MHz I.F. output. 7-8V + earth. Supplied pre-aligned, with full circuit diagram with precision-geared F.M. gang and 323PF + 323PF A.M. Tuning gang only £3·15 + P. & P. 35p.

SPECIAL OFFER

Slightly shop soiled radios by well-known manufacturer for AC Mains or battery use. MW and FM bands. Dynamic M/coil speakers, telescopic aerial and internal ferrite aerial. Earpiece socket for personal listening. Finished in attractive simulated leatherette.
Size 7"H x 9½"W x 4"D approx. Fully guaranteed.
Bargain price of only £10·00 + £1·30 p&p.

MODEL FL4
Few only similar to above, but battery operation only. Twin speakers, Four wave bands, MW, FM and two VHF bands for reception of aircraft and some public services. ONLY £9·50 + £1·30 p&p.

MODEL MULTI 5
Specification as Model FL4 but with additional SW band.
Twin speakers. ONLY £11·00 + £1·30 p&p.

HARVERSONIC SUPERSOUND 10 + 10 STEREO AMPLIFIER KIT

A really first-class Hi-Fi Stereo Amplifier Kit. Uses 14 transistors including Silicon Transistors in the first five stages on each channel resulting in even lower noise level with improved sensitivity. Integral pre-amp with Bass, Treble and two Volume controls. Suitable for use with Ceramic or Crystal cartridges. Very simple to modify to suit magnetic cartridge—instructions included. Output stage for any speakers from 8 to 15 ohms. Compact design, all parts supplied including drilled metalwork, high quality ready drilled printed circuit board with component identification clearly marked, smart brushed anodised aluminium front panel with matching knobs, wire, solder, nuts, bolts—no extras to buy. Simple step by step instructions enable any constructor to build an amplifier to be proud of. Brief specification; Power output: 14 watts R.M.S. per channel into 5 ohms. Frequency response ±3dB 12–30,000Hz. Sensitivity: better than 80mV into 1 MΩ. Full power bandwidth: ±3dB 12–15,000Hz. Bass boost approx. to ±12dB. Treble cut approx. to −16dB. Negative feedback 18dB over main amp. Power requirements 35V at 1A
Overall size 12in wide x 8in deep x 2½in high.

Fully detailed 7 page construction manual and parts list free with kit or send 25p plus large S.A.E.

AMPLIFIER KIT .... £13·50 P. & P. 80p
(Magnetic input components 33p extra)
POWER PACK KIT .... £5·50 P. & P. 95p
CABINET .... £5·50 P. & P. 95p

SPECIAL OFFER—only £23·75 if all 3 items ordered at one time plus £1·25 P. & P.

Full after sales service
Also available ready built and tested £31·25 P. & P. £1·50

HARVERSONIC STEREO 44

A solid state stereo amplifier chassis, with an output of 3–4 watts per channel into 8 ohm speakers. Using the latest high technology integrated circuit amplifiers with built in short term thermal overload protection. All components including rectifier smoothing capacitor, fuse, tone control, volume controls, 2 pin din speaker sockets and 5 pin din tape rec./play socket are mounted on the printed circuit panel. Size approx. 9½in × 2½in × 1in max. depth. Supplied brand new and tested, with knobs, brushed anodised aluminium 2 way escutcheon (to allow the amplifier to be mounted horizontally or vertically) at only £9·00 + 50p P. & P. Mains transformer with an output of 17V a.c. at 500mA can be supplied at £1·50 + 40p P. & P. if required. Full connection details supplied.

STEREO DECODER
SIZE 2" · 3" · ½" ready built. Pre-aligned and tested for 9–16V neg. earth operation. Can be fitted to almost any FM VHF radio or tuner. Stereo beacon light can be fitted if required. Full details and instructions (inclusive of hints and tips) supplied. £6·00 plus 20p P. & P. Stereo beacon light if required 40p extra.

Open 9.30–5.30 Monday to Friday. 9.30–5 Saturday Closed Wednesday.
Prices and specifications correct at time of press. Subject to alteration without notice

HARVERSON SURPLUS CO. LTD.

(Dept. P.E.) 170 MERTON HIGH ST., MERTON, LONDON, S.W.19 Tel: 01-540 3985

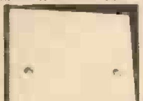
A few minutes from South Wimbledon Tube Station

(Please write clearly)

PLEASE NOTE: P. & P. CHARGES QUOTED APPLY TO U.K. ONLY P. & P. ON OVERSEAS ORDERS CHARGED EXTRA.

BAD NEWS FOR KNOB TWIDDLERS

A 300W Lightdimmer Kit with NO knob. Dimming and on/off functions are controlled by touch. Features include:



★ No mains rewiring.
★ Easy to build – uses one MOS 1C.
★ Switches on to preset brightness.
★ Can be switched and dimmed from many locations using TDE/K kit making 2-way switching easy.
★★ PRICE TD300K £9.67
TDE/K £1.62

LIGHTING CONTROL KITS (300W) TSD300K TOUCH-SWITCH & DIMMER combined. One touchplate for on/off. Small knob controls brightness. £5.62
TS300K TOUCHSWITCH. Two touchplates, ON/OFF £4.32.
TSA300K AUTOMATIC. One touchplate. Preset time delay off. £4.32
LD300K LIGHTDIMMER. £3.02

TRIAC BARGAINS

400V Plastic Case	
3A	64p
6.5A with trigger	86p
8A	80p
12A	90p
16A	113p
20A	178p
25A	205p
SCR (C106D) 5A/400V	54p
Diac	23p

COMPONENTS

0.2" L.E.D.s	
Red 13p (£1.08/10)	
Green 23p Yellow	27p
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LCD .5" 4 digit	£9.72
LDR .5" dia.	45p
NE555 31p	(4 for £1.08)
741 27p	(5 for £1.08)
LM3911 temperature control/thermometer IC	£1.08
AY-5-1224	£3.51
AY-5-1230	£5.23
ZN1034E	£1.94
ICL7106 DVM IC	£8.64
IN4001	7p
IN4148	5p
BC182L	11p
2N3819	25p

DIGITAL VOLTMETER/THERMOMETER KIT

Based on the 7106 single IC 3½ digit D.V.M. the Kit contains a PCB, resistors, capacitors, presets, I.C. and 0.5" liquid crystal display. Components are also included to enable the basic D.V.M. kit to be modified to a Digital Thermometer using a single transistor as the sensor.
ONLY £23.75

MINI MAINS TRANSFORMERS

Standard 240V mains primary 100mA secondary	
6–0–6V	92p
9–0–9V	97p
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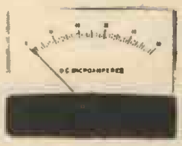
24HR CLOCK/APPLIANCE TIMER KIT

Switches any appliance of up to 1KW on and off at preset times once a day. KIT contains: AY–5–1230 Clock/Appliance Timer IC, 0.5" LED display, mains supply, display drivers, switches, LEDs, triac, complete with PCBs and full instructions. £14.85
White box (56 x 131 x 71mm) – drilled £2.70
– undrilled £2.38
Ready built with box £22.95

ABOVE PRICES INCLUDE V.A.T.
Quantity discounts on request. Add 25p postage and packing. Mail order only to:

T.K. ELECTRONICS (PE) 106 Studley Grange Road, London, W7 2LX.



4½in × 3½in METER. 30μA, 50μA or 100μA, £6.40. 19p P. & P.

2in x 2in meters 500μA, £3·65. 16p P. & P.

60 x 45mm meters 50μA, 100μA, 500μA and 1mA VU meter, £6·16. 11p P. & P.

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DM228R 200 ohm with 3·5 and 2·5mm Jack Plugs £1·30
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Model IT1-2 20,000 ohm/volt. £12·32. 33p P. & P.

CARDIOID DYNAMIC MICROPHONE

Model UD-130 Frequency response 50–15,000c/s. Impedance Dual 50K and 600 ohms, £8·02. 26p P. & P.

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6–0–6V	100mA	£0·75
9–0–9V	75mA	£0·75
12–0–12V	50mA	£0·85
12–0–12V	100mA	£1·05
Post on above transformers 30p.		
9–0–9V	1A	£1·80
12–0–12V	1A	£2·15
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Post on above transformers 45p.		

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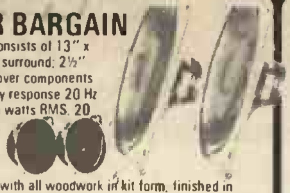
...SPEAKER BARGAIN



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.

£14.95 Per stereo pair + £3.40 p&p

★ As above but complete with all woodwork in kit form, finished in simulated teak veneer, with instructions. Size approx 20" x 11" x 9½" **£28.00** Per stereo pair + £5.00 p&p.

EASY BUILD RECORD PLAYER KIT

for the D-I-Y man who requires a stereo unit at a budget price, comprising ready assembled stereo amp. module. Garrard auto/manual deck with cueing device, pre-cut and finished cabinet work. Output 4 watts per channel, phones socket and record/replay socket including 2 SPHERICAL HIFI speakers. **£19.95** p&p £4.05

BARGAINS FOR PERSONAL SHOPPERS

PORTABLE STEREO RADIO CASSETTE RECORDER UNREPEATABLE MW, LW, SW and Stereo VHF. 6 watts output Battery/Mains operation. **£69.95**

16o 16 **VOLT MAINS TRANSFORMER**, 2½ amp. **£2.50**

BSR Record auto deck on plinth with stereo cartridge ready wired. **£11.95**

LED 5 function men's digital watch stainless steel finish **£5.95**

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LCD 8 Function **CHRONOGRAPH** men's digital watch, stainless steel finish. **£13.95**

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£11.95

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PORTABLE RADIO/CASSETTE RECORDER. AM/FM with clock. LW, MW, SW, VHF mains/battery operation. **£41.95**

7" TAPE TRANSPORT Mechanism—a selection of models from **£8.95**

SANYO Nic/cad. battery, with mains charger equivalent in size and replaces 4 SP11 type batts. Size 3¾" x 1¼" x 2" approx.

£7.50 p+p £1.50p

AM/FM STEREO TUNER AMPLIFIER CHASSIS ***COMPLETE***

Ready built. Designed in a slim form for compact, modern installation.
Rotary Controls Vol On/Off, Bass, Treble, Balance.
Push Buttons for Gram, Tape, VHF, MW, LW and 5 button rotary selection switch.
Power Output 5 watts per channel Sine at 2% THD into 15 Ohm 7 watts speech and music.
Tape Sensitivity Playback 400mV/30K OHM for max output Record 200mV/50K output available from 25KHz (150mV/100K) deviation
FM signal Frequency Range (Audio) 50Hz to 17KHz within ± 1dB
Radio FM sensitivity for 3dB below limiting better than 10 uV
AM sensitivity for 20dB S/N MW 350 uV/Metre LW 1mV/Metre
Size approx length 16" x height 2⅜" x depth 4¼"
240 Volts AC Complete with Circuit diagram. **£19.95** p&p £2.25

Mullard

AUDIO MODULES IN BARGAIN PACKS

CURRENT CATALOGUE PRICE £25 AT OVER PER PACK

SEE OUR PRICES

1 PACK 1. 2 x LP1173 10w. RMS output power audio amp modules, + 1 LP1182/2 Stereo pre amp for ceramic and auxiliary input. OUR PRICE p+p £1.00 **£4.95**

2 PACK 2. 2 x LP1173 10w. RMS output power audio amp modules + 1 LP1184/2. Stereo pre amp for magnetic, ceramic and auxiliary inputs. **illus.** OUR PRICE p+p £1.00 **£7.45**

3 PACK 3. 1 x LP1179/2 FM Tuning head with AM gang, 1 x LP1165/1 AM/FM IF module, 2 x LP1173/10w. RMS output power audio amp modules + 1 LP1182/2 Stereo pre amp for ceramic and auxiliary input. OUR PRICE p+p £1.00 **£9.95**

ACCESSORIES

Suitable power supply parts including mains transformer, rectifier, smoothing and output capacitors. £1.00 p+p **£1.95**

Recommended set of rotary stereo controls comprising BASS, TREBLE, VOLUME and BALANCE. p+p 50p **95p**

THIS MONTHS OFFER
added to our bargain packs
When you buy Pack 3 at £9.95, together with a mains transformer at £1.95 and a set of controls for 95p you receive FREE a Mullard LP1400 Decoder to match Listed at £11.90 p & p £2.50 **£12.85**

20 x 20 WATT STEREO AMPLIFIER

Viscount IV unit in teak finished cabinet. Silver fascia with aluminium rotary controls/pushbuttons, 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. **£29.90** + £2.50 p&p

SPECIAL OFFER
FOR PERSONAL SHOPPERS ONLY

FREE. 4 dimensional stereo sound adaptor, when purchasing the 20x20 Viscount amplifier.

30x30 WATT AMPLIFIER IN KIT FORM

For the experienced constructor complete in every detail, same facilities as Viscount IV, but with 30x30 output. 60x60 watts peak. For use with 4-15 ohms speakers. £23.00 without cabinet. £29.00 complete with cabinet. p&p £2.50 in each case.

£23.00 + £2.50 p&p without cabinet. (NOTE Cabinet not available separately.) **£29.00** + p&p £2.50 complete with cabinet.

SPECIAL OFFER
Complete with Case **30x30 WATT AMPLIFIER IN KIT WITH SPEAKERS**

2 Goodman compact 12" bass woofers with cropped size 14,000 Gauss magnet. 30 watt RMS handling + 3¼" approx. tweeters and crossovers. **£49.00** + p&p £4.00

BUILT AND READY TO PLAY **39.00**
30x30 Viscount. Available fully built and tested. + p&p £2.50

50 WATT MONO DISCO AMP
£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

70 & 100 WATT MONO DISCO AMP

Size approx. 14" x 4" x 10½"
Brushed aluminium fascia and rotary controls.
Five vertical slide controls master volume, tape level, mic level, deck level, PLUS INTER DECK FADER for perfect graduated change from record deck No 1 to No 2, or vice versa. Pre fade level control (PFL) lets YOU hear next disc before fading it in. VU meter monitors output level.
Output 100 watts RMS 200 watts peak.
70 watt 140 watt peak **£57** p & p £4.00
100 watt **£65**

STEREO CASSETTE TAPE DECK ASSEMBLY

Consisting of ready built tape transport system/mechanism, mated to the electronics Unit is ready built for installing into cabinet of own choice Features include pause control, solenoid assisted auto-stop, 3 digit tape counter, belt driven balanced fly wheel by DC motor with electronic speed control, twin VU meters. Specification Power Output, more than 0.5v, mic –65dB 10KΩ, DIN –47dB 100KΩ
Track-2 channel stereo record play-back, Tape speed 4.8cm/sec Freq. response 50 1200 Hz signal to noise ratio 42dB Recording system AC bias Erasing system AC erase Bias freq 57KHz. Compatible for both normal and chrome dioxide tapes Size of mechanism only 4½" x 6¼" x 11½" approx., included a moulded top-plate as illustrated

13⅜" x 9¼" approx with circuit diagram **£25.00** P&P £2.50

Opt. extras Mains transformer to suite £2.50 + £1 p & p.

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