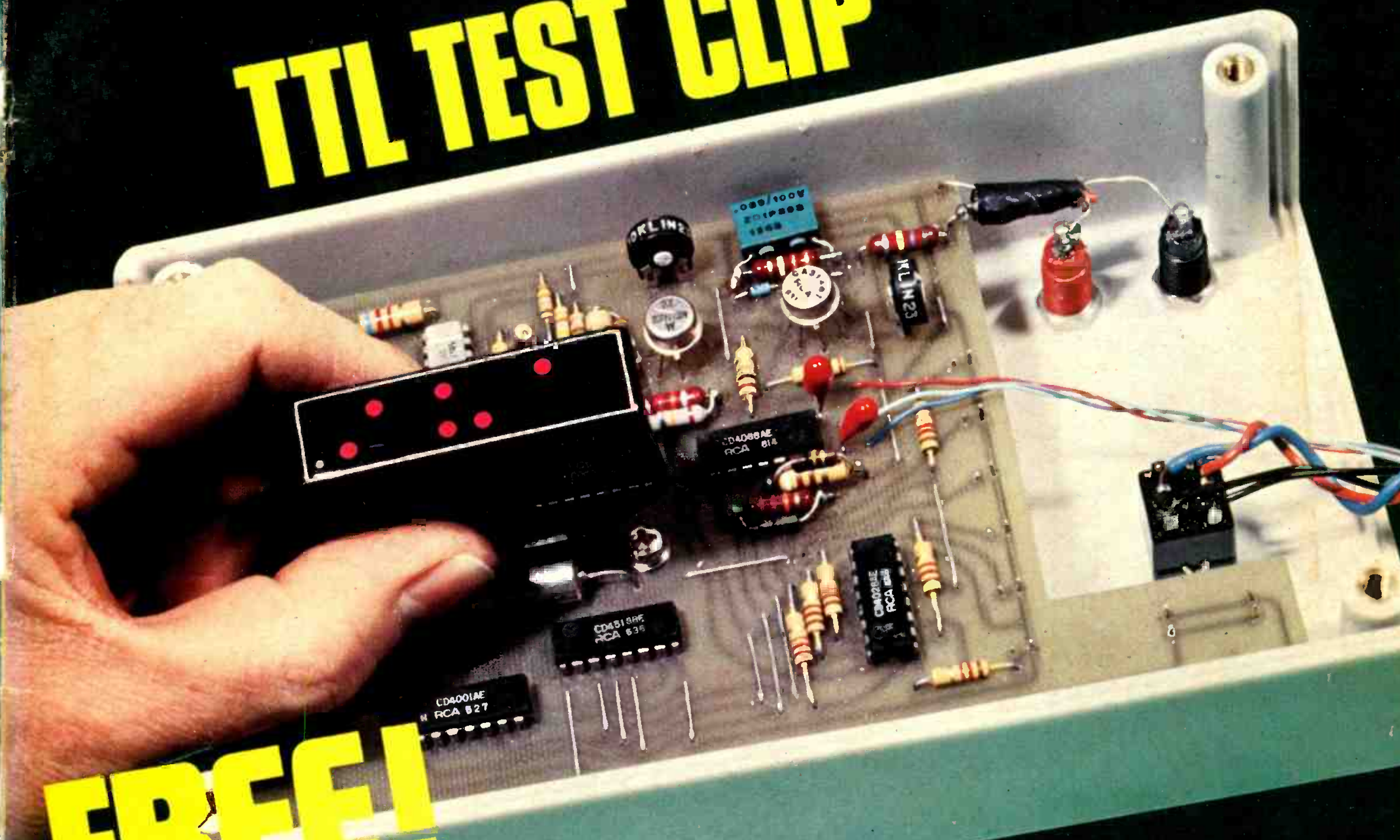
PRACTICAL

ELECTRONICS

MAY 1978

45p

TTL TEST CLIP



FREE!

PRESENTED FREE WITH PRACTICAL ELECTRONICS MAY 1978

A Guide to the Language of MICROCOMPUTERS

...with this issue

Also inside...

WORKSHOP POWER SUPPLY UNIT

Plus Regular Features

WATFORD ELECTRONICS

35 CARDIFF ROAD, WATFORD, HERTS., ENGLAND
MAIL ORDER, CALLERS WELCOME. Tel. Watford 40588/9

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 **8p**; 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**: 0.039, 0.15, 0.22 **13p**; 0.33, 0.47 **22p**; 0.68, 1.0 **29p**; 1.5 **33p**; 2.2 **38p**; 4.7 **47p**. **DUBILIER**: **1000V**: 0.01, 0.015 **16p**; 0.022 **18p**; 0.047 **16p**; 0.1 **34p**; 0.47 **43p**.

POLYESTER RADIAL LEAD (Values in μF) **250V**:
0·01, 0·015 **6p**; 0·022, 0·027 **7p**; 0·033, 0·047, 0·068, 0·1 **8p**; 0·15 **12p**; 0·22, 0·33 **14p**; 0·47 **16p**; 0·68 **20p**; 1·0 **24p**; 1·5 **27p**; 2·2 **31p**.

FEED THROUGH CAPACITORS
100μF 350V **8p**

ELECTROLYTIC CAPACITORS: Axial lead type (Values are in μF)
63V: 0.47, 1.0, 1.5, 2.2, 2.5, 3.3, 4.7, 6.8, 8, 10, 15, 22 **9p**; 47, 32, 50 **12p**; 63, 100 **27p**; **50V**: 1.0 **7p**; 50, 100, 220 **25p**; 470 **50p**; 1000, 2200 **68p**; **40V**: 22, 33 **9p**; 100 **12p**; 3300 **62p**; 4700 **64p**; **35V**: 10, 33 **7p**; 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, 470 **16p**; 1000, 1500 **20p**; 2200 **34p**; **10V**: 4, 100 **6p**; 640 **10p**; 1000 **14p**.
TAG-END TYPE: **70V**: 2000 **98p**; 4700 **121p**; **50V**: 3000 **75p**; **40V**: 4000 **70p**; 2500 **65p**; **25V**: 4700 **48p**; 2000 **37p**; **40V**: 2000 + 2000 **95p**; **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, 47 **6V**: 47, 68, 100, **3V**: 68, 100μF. **20p** each

MYLAR FILM CAPACITORS
100V: 0.001, 0.002, 0.005, 0.01μF **5p**
0.015, 0.02, 0.04, 0.05, 0.056μF **6p**
0.1μF, 0.15, 0.2 **7p**. **50V** 0.47μF **10p**

CERAMIC CAPACITORS: 50V
0.5pF to 10nF **3p** each
15nF, 22nF, 33nF, 47nF **4p** each
0.1μF **6p**

POLYSTYRENE CAPACITORS
10pF to 1nF **6p**; 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

CERAMIC TRIMMER CAPACITORS
2–7pF, 4–15pF, 6–25pF, 8–30pF **20p**

MINIATURE TYPE TRIMMERS
2.5–6pF, 3–10pF, 10–40pF **22p**
5–25pF, 5–45pF, 60pF, 88pF **30p**

COMPRESSION TRIMMERS
3–40pF, 10–80pF, 25–190pF **25p**
100–500pF, 1250pF **38p**

POTENTIOMETERS (AB or EGEN)
Carbon Track, ¼W Log & ¼W Linear values
500Ω, 1K & 2K (lin only). Single **26p**
5KΩ-2MΩ single gang **26p**
5KΩ-2MΩ single gang D/P switch **55p**
5KΩ-2MΩ dual gang stereo **70p**

SLIDER POTENTIOMETERS
0·25W log and linear values 60mm
5KΩ-500KΩ single gang **70p**
10KΩ-500KΩ dual gang **80p**
Self Stick Graduated Bezels **20p**

PRESET POTENTIOMETERS
Vertical & Horizontal
0.1W 50Ω–5MΩ Miniature **8p**
0.25W 100Ω–3.3MΩ Horiz **10p**
0.25W 200Ω–4.7MΩ Vert **10p**

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 5Ω-1M			8p	

100 + price applies to Resistors of each type not mixed values

PE String ENSEMBLE
Components now available.

OPTO ELECTRONICS★
LEDs + clip
TIL209 Red 13
TIL211 Grn 24
TIL212 Yellow 27
T110 20
2" Red 17
2" Yellow Green 21
OCP70 40
ORP12 68
2N5777 54
7 Seg Displays
TIL312 C An 3 125
TIL313 C Cth 3 125
TIL321 C An 5 130
TIL322 C Cth 5 130
DL704 C Cth 99
DL707 C A 99
DL747 C A 180
FND 357 140
LCD 3½ digit 975
LCD 4 digit 975

SWITCHES★
TOGGLE 2A 250V
SPST **26p**
DPDT **35p**
4 pole on off **58p**
SUB-MIN TOGGLE
SP changeover **59p**
SPST on off **54p**
DPDT 6 tags **78p**
DPDT Centre off **92p**
DPDT Biased **115p**
SLIDE 250V:
1A DPDT **14p**
1A DP c/over **16p**
½A DPDT **13p**
4 pole c over **24p**
PUSH BUTTON
Spring loaded
SPST on/off **55p**
SPDT c/over **65p**
DPDT 6 Tag **85p**

JACK PLUGS	Screened chrome	Plastic body	SOCKETS: 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, 3, 4, 5 Pin Audio	13p	8p	20p
CO-AXIAL (TV)	14p	14p	14p
PHONO		5p single	15p
assorted colours	9p	8p double	—
Metal Screened	12p	10p 3-way	—
BANANA 4mm	10p	12p	—
2mm	10p	10p	—
1mm	8p	8p	—
WANDER 3mm	9p	9p	

SWITCHES ★ Miniature Non-Locking
Push to Make **15p** Push to Break **25p**
ROCKER (white) 10A 250V
SP changeover centre off **28p**
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 **42p**

DIL SOCKETS★ (Low Profile – Texas)
8 pin **10p**; 14 pin **12p**; 16 pin **13p**; 18 pin **20p**; 20 pin **26p**; 24 pin **30p**; 28 pin **42p**; 40 pin **58p**.

TANK BATTLE

Build this fantastic TV **GAME** with realistic battle sounds – Steerable Tanks – Controllable Shell trajectory and Minefields to avoid.

A really exciting and skilful game simply constructed with our easy to follow instructions.

IC AY-3-8710 **£9.78★**
Basic Kit (just add controls)
Price: Only **£17.98★**
(p&p 30p)

Complete Kit incl. cases & controls
Price: Only **£24.30★**
(p&p 30p)

RHYTHM GENERATOR

Build this PE (Jan. '78) Easi-build Low cost Rhythm Generator. We are the sole suppliers of the complete Kit including the case, pre-drilled printed front panel and the printed Circuit Boards.

Complete Kit price incl. VAT **£49.95** only. P & P £1.10 insured. Ready Built Units available in limited quantities at **£65.00** plus P & P. Send S.A.E. for descriptive leaflet.

DALO ETCH Resist Pen + Spare Tip **75p★**

COPPER BOARDS★
Fibre Glass
Single Sided
6 x 6 **75p**
6 x 12 **130p**
SRBP
8 x 10 **70p**

VOLTAGE★ REGULATORS
723C **45p**
TBA625B **95p**
TO3 Can + Ve
1A 5V **140p**
1A 12V **145p**
1A 15V **145p**
1A 18V **150p**
LM323K **625p**
1A –5V **220p**
1A –12V **220p**
Plastic + Ve
1A 5V, 12V, 15V, 18V, 24V **99p** each
0.1A 5V, 6V, 8V, 12V, 15V **51p** each
LM320-12 **145p**
LM320-15 **155p**
LM341-15 **145p**
LM325N **240p**
LM326N **240p**
LM327N **260p**

TTL 74★

7400	14	7494	85	7486	36	74185	146
7401	14	7495	70	7489	320	74188	65
7402	16	7496	82	7490	36	74190	140
7403	16	7497	262	7491	80	74191	140
7404	20	74100	125	7492	53	74192	140
7405	22	74105	62	7493	35	74193	140
7406	38	74107	33	74194	140		
7407	38	74109	54	74195	95		
7408	20	74110	54	74196	118		
7409	20	74111	70	74197	118		
7410	15	74112	90	74198	250		
7411	24	74116	198	75150	110		
7412	23	74118	90	75491	75		
7413	37	74119	90	75492	80		
7414	74	74120	115				
7416	35	74121	28				
7417	39	74122	48				
7420	16	74123	70				
7421	33	74125	65				
7422	24	74126	60				
7423	32	74128	77				
7425	30	74132	73				
7426	36	74136	73				
7427	36	74141	72				
7428	38	74142	280				
7430	18	74143	314				
7432	32	74144	314				
7433	40	74145	85				
7437	30	74147	175				
7438	33	74148	143				
7440	17	74150	118				
7441	74	74151	75				
7442	68	74153	75				
7443	115	74154	140				
7444	112	74155	82				
7445	94	74156	80				
7446	94	74157	80				
7447	82	74159	225				
7448	78	74160	116				
7450	17	74161	116				
7451	17	74162	116				
7453	17	74163	116				
7454	17	74164	121				
7460	17	74165	130				
7470	30	74166	141				
7472	28	74167	198				
7473	32	74170	240				
7474	32	74172	625				
7475	42	74173	175				
7476	30	74174	113				
7480	50	74175	90				
7481	97	74176	120				
7482	82	74177	116				
7483	95	74178	102				
7484	95	74180	142				
7485	110	74181	299				
		74182	126				
		74184	225				

CMOS★

4000	15	4056	134	4513	206
4001	17	4057	2570	4514	265
4002	17	4059	480	4515	299
4006	105	4060	115	4516	125
4007	18	4061	2380	4517	382
4008	92	4062	999	4518	102
4009	58	4063	110	4519	59
4010	58	4066	58	4520	108
4011	19	4067	380	4521	268
4012	18	4068	22	4522	199
4013	55	4069BE	22	4526	199
4014	99	4070	32	4527	152
4015	93	4071	21	4528	99
4016	52	4072	21	4529	165
4017	99	4073	21	4530	85
4018	99	4075	23		
4019	60	4076	129		
4020	102	4077	40		
4021	99	4078	21		
4022	90	4081	22		
4023	20	4082	21		
4024	76	4085	74		
4025	19	4086	73		
4026	180	4089	150		
4027	55	4093	85		
4028	90	4094	190		
4029	108	4095	105		
4030	58	4096	105		
4031	230	4097	372		
4032	100	4098	110		
4033	145	4099	190		
4034	196	4160	109		
4035	120	4161	109		
4036	325	4162	109		
4037	100	4163	109		
4038	108	4174	110		
4039	320	4175	99		
4040	105	4194	108		
4041	86	4408	720		
4042	81	4409	720		
4043	96	4410	720		
4044	95	4411	995		
4045	145	4412F	1650		
4046	130	4412F	1380		
4047	99	4415F	795		
4048	58	4415V	795		
4049	52	4419	280		
4050	52	4422	545		
4051	89	4433	1225		
4052	89	4435	825		
4053	89	4440	1275		
4054	120	4450	295		
4055	134	4451	295		
		4490F	695		
		4490V	525		
		4501	17		
		4502	120		
		4503	69		
		4506	51		
		4507	55		
		4508	298		
		4510	135		
		4511	168		
		4512	98		

LINEAR IC'S

702	75	MC1303L	148
709C 14 pin	35	MC1304P	260
710★	48	MC1310P	185
741C★ 8 pin	22	MC1312PQ	195
747C	70	MC1458P★	90
748C	36	MC1496	101
753	150	MC14433L	1250
810	159	MC1710CG	79
8038CC★	355	MC3401	69
AY-1-0212	580	MC3340P	150
AY-1-1313	660	MC3360P	89
AY-1-5051	145	MFC4000B	85
AY-1-6721/6	195	MFC6040★	97
AY-3-8500★	450	MK50253★	550
AY-3-8710★	978	MK50362★	650
AY-5-1224★	349	MM2102-2	190
AY-5-1230★	490	MM2112-2N★	310
CA3011★	82	NE518A	210
CA3018★	82	NE555★	36
CA3020	170	NE556DB★	90
CA3023	170	NE560★	325
CA3028A★	95	NE561★	410
CA3035	140	NE562★	410
CA3036	180	NE565A★	185
CA3043	190	NE566★	180
CA3046	80	NE567★	157
CA3048	200	NE571	450
CA3075	175	RAM2102-2★	210
CA3080E	80	RC4136D★	120
CA3081	190	ROM2513★	700
CA3089E	210	SG3402★	255
CA3090AQ	390	SN72733N	125
CA3123E	200	SN76003N	211
CA3130★	94	SN76013N	140
CA3140	95	SN76023N	140
ICL7106Ev★	975	SN76033N	211
ICM7205★	1150	SN76115N	215
LM300H	170	SN76227N	175
LM301A	39	TAA621AX1	228
LM308	140	TAA661A	155
LM318	195	TAA700	353
LM324	98	TAA960	300
LM339	55	TBA120S	90
LM348	120	TBA540Q	220
LM379	398	TBA550Q	356
LM380	95	TBA641BX11	250
LM381	170	TBA651	180
LM381AN	241	TBA800	90
LM382	125	TBA810S	105
LM1459	425	TBA820	80
LM3900	65	TBA920Q	350
LM3909N	70	TDA1022★	595
LM3911	125	TDA2020	320
M252AA★	750	UAA170	198
M253AA★	795	ZN414	110
		ZN424	130

TRANSISTORS

AC117	35	BC168C	12	BF195	10	OC43★	65	ZTX501	15	2N3614★	169
AC125★	19	BC169C	14	BF196	12	OC44★	35	ZTX502	19	2N3615★	135
AC126★	19	BC170	13	BF197	15	OC45★	35	ZTX503	19	2N3663	26
AC127★	18	BC171	11	BF198	18	OC46★	35	ZTX504	25	2N3702	10
AC128★	18	BC172	10	BF200	30	OC70★	30	ZTX531	28	2N3703	11
AC141★	24	BC177★	18	BF224A	18	OC71★	30	ZTX550	25	2N3704	10
AC141K★	38	BC178★	16	BF256★	50	OC72★	30	2N526★	58	2N3705	11
AC142★	24	BC179★	18	BF257★	29	OC77★	76	2N696★	35	2N3706	10
AC142K★	38	BC182	10	BF258★	29	OC79★	76	2N697★	21	2N3707	10
AC176★	18	BC182L	13	BF259★	30	OC81★	28	2N698★	39	2N3708	11
AC187★	20	BC183	10	BF394	22	OC82★	45	2N699★	50	2N3709	11
AC188★	20	BC183L	12	BF594	40	OC82D★	35	2N706A★	19	2N3710	16
ACY17	35	BC184	11	BF595	38	OC83★	48	2N707★	50	2N3711	12
ACY18★	40	BC184L	14	BFR39	25	OC84★	44	2N708★	19	2N3715★	250
ACY19★	40	BC186	24	BFR40	28	OC123★	115	2N914★	32	2N3772★	170
ACY20★	40	BC187★	28	BFR79	28	OC139★	140	2N916★	27	2N3773★	288
ACY21	35	BC212	11	BFR80	28	OC140★	125	2N918★	30	2N3819	22
ACY22★	40	BC212L	13	BFX29★	28	OC141★	157	2N920★	51	2N3820	38
ACY28★	40	BC213	11	BFX81★	130	OC170★	40	2N930★	18	2N3823★	65
ACY39	78	BC213L	14	BFX84★	24	OC171★	40	2N961★	61	2N3824★	70
ACY40★	48	BC214	14	BFX85★	28	OC201★	125	2N1131★	22	2N3866★	90
ACY44	39	BC214L	15	BFX86★	28	OC202★	140	2N1132★	22	2N3903	20
AD140	69	BC307B	20	BFX87★	23	OC203★	150	2N1302★	35	2N3904	18
AD149★	70	BC328	15	BFX88★	26	OC204★	150	2N1303★	50	2N3905	18
AD161★	42	BC338★	15	BFY18	50	TIP29	43	2N1304★	50	2N3906	17
AD162★	42	BC441★	45	BFY50★	17	TIP29A	44	2N1305★	28	2N4037★	52
AF114★	20	BC461★	38	BFY51★	17	TIP29C	60	2N1306★	35	2N4058	17
AF115★	20	BC462★	45	BFY52★	17	TIP30	52	2N1307★	50	2N4061	17
AF116★	20	BC547	12	BFY71	47	TIP30A	52	2N1308★	46	2N4064★	120
AF117★	22	BC548	12	BSX20	18	TIP30B	64	2N1613★	20	2N4236★	145
AF118★	55	BC549C	13	BSX20★	18	TIP30C	70	2N1671★	190	2N4289	20
AF121★	48	BC557	15	BSY65★	30	TIP31★	50	2N1671B★	195	2N4859	65
AF124★	55	BC558	15	BSY95A★	18	TIP31A★	50	2N1893★	28	2N5135	42
AF125★	35	BCY30★	57	BU105★	140	TIP31B★	58	2N1986	60	2N5136	42
AF127★	35	BCY34★	75	BU205★	190	TIP31C★	66	2N2160★	105	2N5138	20
AF139★	35	BCY39★	78	BU208★	225	TIP32★	55	2N2217★	48	2N5179★	60
AF178★	70	BCY40★	75	E5567	65	TIP32A★	60	2N2218A★	35	2N5180★	60
AF180★	70	BCY59★	90	MD8001★	158	TIP32B★	75	2N2219A★	22	2N5191★	65
AF186★	50	BCY70★	15	MJ400★	90	TIP32C★	77	2N2220A★	26	2N5305★	40
AF239★	42	BCY71★	20	MJ491★	160	TIP33★	85	2N2221A★	25	2N5457	35
ASY26★	40	BCY72★	15	MJ2955★	120	TIP33B★	100	2N2222★	20	2N5458	36
ASY27★	45	BD115★	62	MJE340★	45	TIP33C★	110	2N2297	45	2N5459	36
BC107★	9	BD121★	78	MJE370★	80	TIP34★	95	2N2303★	50	2N5485	38
BC107B★	10	BD123	98	MJE371★	80	TIP34A★	95	2N2368	25	2N5777	56
BC108★	9	BD124★	115	MJE520★	65	TIP34B★	120	2N2369★	15	2N6027	40
BC108B★	12	BD131★	38	MJE521★	74	TIP35★	219	2N2476	125	40311★	56
BC108C★	12	BD132★	38	MJE2955★	115	TIP35A	225	2N2483★	28	40313★	125
BC109★	9	BD133★	43	MJE3055★	80	TIP35C★	270	2N2484★	30	40316★	95
BC109B★	12	BD135	38	MPF102	36	TIP36A★	280	2N2646★	48	40317★	52
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BC114	20	BD138	50	MPF105	36	TIP41B★	73	2N2894	30	40347★	99
BC115	20	BD139	34	MPF106	50	TIP42A★	72	2N2904A★	22	40348★	116
BC116	20	BD140	36	MPF107	50	TIP42B★	82	2N2905A★	20	40360★	43
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BC135	20	BDY17★	195	MPSA70	34	TIS46	45	2N2926O	8	40576★	190
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ELECTRONICS

VOLUME 14 No. 9 MAY 1978

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

Our June issue will be on sale Friday, 12 May, 1978
(for details of contents see page 657)

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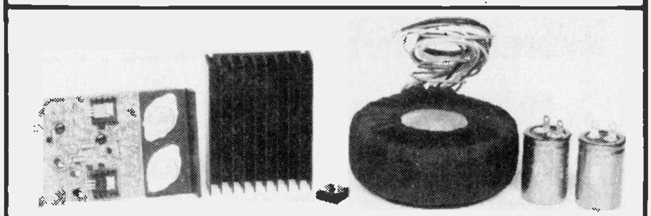

By popular demand we have designed higher powered versions of our well known modules. The CE 1704 which gives 170W into 4 ohms and the CE 1708 which gives 170W into 8 ohms are physically similar to the original types and have the same combination of compatible performance features which makes CRIMSON amplification audibly superior to the competition and the only choice if you have an ear for music. We have also produced suitable power supplies which again use our superb TOROIDAL TRANSFORMERS, only 50mm high, with a 120-240 primary and single bolt fixing.

Write or phone for more information and biased opinions.

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CE 1004 100W/4 ohms 35-0-35V	£19.22	£19.30
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CE 1704 170W/4 ohms 45-0-45V	£29.12	£28.46
CE 1708 170W/8 ohms 60-0-60V	£31.90	£31.04
TOROIDAL POWER SUPPLIES		
CPS 1 for 2 x CE 608 or 1 x CE 1004	£14.47	£18.40
CPS 2 for 2 x CE 1004 or 2/4 x CE 608	£16.82	£20.57
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Recommended for improved reliability		
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T.H.D.	: TYPICALLY <·02% ANY POWER, 1kHz, 8 OHMS
T.I.D.	: INSIGNIFICANT
SLEW RATE LIMIT	: 20V/μS
S/N RATIO	: 110dB
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STABILITY	: UNCONDITIONAL
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SENSITIVITY	: 775mV (250mV or 100mV ON REQUEST)
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Ref	Amps 12V	Amps 24V	£	P & P
111	0·5	0·25	2·20	0·45
213	1·0	0·5	2·64	0·78
71	2	1	3.51	0·78
18	4	2	4·03	0·96
70	6	3	5·35	0·96
108	8	4	6·98	1·14
72	10	5	7·67	1·14
116	12	6	8·99	1·32
17	16	8	10·39	1·32
115	20	10	13·18	2·08
187	30	15	17·05	2·08
226	60	30	26·82	OA

50 VOLT RANGE
Prim 220/240V Sec 0-20-25-33-40-50V 20V-0-20V or 25V-0-25V available by connection to appropriate taps.

Ref	Amps	£	P & P
102	0·5	3·41	0·78
103	1·0	4·57	0·96
104	2·0	6·98	1·14
105	3·0	8·45	1·32
106	4·0	10·70	1·50
107	6·0	14·62	1·64
118	8·0	17·05	2·08
119	10·0	21·70	OA

MAINS ISOLATING (SCREENED)
PRIM 120/240 SEC 120/240 CT TAPPED

Ref	VA (Watts)	£	P & P
07*	20	4·40	0·79
149	60	6·20	0·96
150	100	7·13	1·14
151	200	11·16	1·50
152	250	12·79	1·84
153	350	16·28	1·84
154	500	19·15	2·15
155	750	29·06	OA
156	1000	37·20	OA
157	1500	45·60	OA
158	2000	54·80	OA
159	3000	79·05	OA

*Please specify 115 or 240V required

HIGH VOLTAGE MAINS ISOLATING
Prim 200/220V 400/440V
Sec 100/120V or 200/240V

Va	Ref	£	P & P
60	243	5·89	1·32
350	247	14·11	1·84
1000	250	35·65	OA
2000	252	54·25	OA

30 VOLT RANGE
Prim 220/240V Sec 0-12-15-20-24-30V 12V-0-12V or 15V-0-15V available by connection to appropriate taps.

Ref	Amps	£	P & P
112	0·5	2·64	0·78
79	1·0	3·57	0·96
3	2·0	5·27	0·96
20	3·0	6·20	1·14
21	4·0	7·44	1·14
51	5·0	8·37	1·32
117	6·0	9·92	1·45
88	8·0	11·73	1·64
89	10·0	13·33	1·84

60 VOLT RANGE
Prim 220/240V Sec 0-24-30-40-48-60V 24V-0-24V or 30V-0-30V available by connection to appropriate taps.

Ref	Amps	£	P & P
124	0·5	3·88	0·96
126	1·0	5·58	0·96
127	2·0	7·60	1·14
125	3·0	10·54	1·32
123	4·0	12·23	1·84
40	5·0	13·95	1·64
120	6·0	15·66	1·84
121	8·0	20·15	OA
122	10·0	24·03	OA
189	12·0	27·13	OA

AUTO TRANSFORMERS

Ref	VA (Watts)	Volts	£	P & P
113	15	0-115-210-240	2·48	0·71
64	75	0-115-210-240	3·95	0·96
4	150	0-115-200-220-240	5·35	0·96
67	500	0-115-200-220-240	10·99	1·64
84	1000	0-115-200-220-240	18·76	2·08
93	1500	0-115-200-220-240	23·36	OA
95	2000	0-115-200-220-240	34·82	OA
73	3000	0-115-200-220-240	48·00	OA

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VA	£	P & P	Ref
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150	8·48	1·14	4W
200	9·92	1·45	65W
250	10·49	1·45	69W
500	15·73	1·64	67W
750	18·55	1·76	83W
1000	22·68	OA	84W
1500	26·02	OA	93W
2000	37·65	OA	95W

SCREENED MINIATURES

Ref	mA	Volts	£	P&P
238	200	3-0-3	1·99	0·55
212	1A, 1A	0-6, 0-6	2·85	0·78
13	100	9-0-9	2·14	0·38
235	330, 330	0-9, 0-9	1·99	0·38
207	500, 500	0-8-9-, 0-8-9	2·59	0·71
208	1A, 1A	0-8-9, 0-8-9	3·53	0·78
236	200, 200	0-15, 0-15	1·99	0·38
214	300, 300	0-20, 0-20	2·56	0·78
221	700 (DC)	20-12-0-12-20	3·41	0·78
206	1A, 1A	0-15-20-0-15-20	4·63	0·96
203	500, 500	0-15-27-0-15-27	3·99	0·96
204	1A, 1A	0-15-27-0-15-27	5·39	0·96
S112	500	12-15-20-24-30	2·64	0·78
239	50	12-0-12	1·99	0·38

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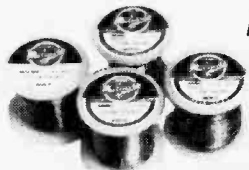

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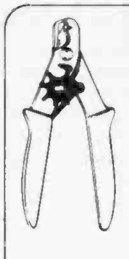

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Prices shown are recommended retail, inc. VAT. From electrical and hardware shops. In difficulty send direct, plus 20p P. & P. Prices and specifications subject to change without notice.

More power per £ from Stirling Sound

READY BUILT

OR BASIC MODULES

4 CHANNEL MIXER/CONTROL UNIT & POWER SUPPLY

By designing and manufacturing in our own Essex factory and selling direct to YOU the customer, we believe we have produced just about the best value ever in mixer/control equipment. You can buy the Disco 2 Unit assembled, tested and ready to connect up and use at once, or build your own unit using Stirling Sound Basic Modules. Either way you stand to save – and look at the advantages you get – sensibly arranged controls (on the built unit), proper DJ/PA facilities and RELIABILITY.

- INPUTS – Left deck, right deck, mic. and aux.
- INPUT IMPEDANCE – 47K ohms
- POWER SOURCE – 220-240V. A.C. Mains
- CONTROLS – Mains on-off, master volume, base ±15db, treble ± 15db, L and R mixing, L and R motor switches, selector switch for P.F.L. (Pre-Fade Listening), headphone volume, mic, vol., aux. vol., LED indicators on main and decks on/off switches.
- HEADPHONE AMPLIFIER – Powerful 2 watts into 8 ohms; separate vol. contol.
- TERMINATIONS – Five ¼" jack sockets – 2 input, 2 output, headphones.
- SIZE – 23¼" x 3¾" x 2½" max. depth to rear (plus separate power unit). Panel in matt black with controls sensibly grouped for easy handling.

Suggested Stirling Sound power amps with heat sinks and power supply units – 140PH £18. 160PH £22. 1100PH £26.75.

Built, tested and guaranteed,
£39.95
POST FREE in U.K. and INC. V.A.T.

Kit of basic modules less power pack, pots, 5 jack sockets, and 3 mains switches, but with front panel
£21.00
POST FREE in U.K. and INC. V.A.T.

READY BUILT OR D.I.Y. MODULES

READY BUILT

(Prices inc. V.A.T. but NOT cost of carriage)

SOUND-LIGHT UNITS

SSTL 3/250B – 3 channels, 250w. each	£22.95
SSTL 3/1000B – 3 channels, 1000w. each	£25.95

INTEGRATED POWER AMPS

In strongly made metal cases, complete

POWER AMP 40 – 40w. r.m.s./4 ohms, 2 ch. mixer	£43.00
POWER AMP 60 – 60w. r.m.s./4 ohms, 2 ch. mixer	£48.00
POWER AMP 100 – 100w. r.m.s./4 ohms, 4 ch. mixer	£85.00
100w. SLAVE AMP	£50.00

LOUDSPEAKERS

Disco 25 – 25w. r.m.s. in cabinet, 20' lead	£23.95
Disco 50 – 50w. r.m.s. in cabinet 20' lead	£39.95
Disco 100 – 100w. r.m.s. in cabinet, 20' lead	£55.95
Ampower 50 – 50w. amp & speaker in cabinet	£60.00
Ampower 100 – 100w. amp & speaker in cabinet	£80.00

Complete Disco with Disco 2 console and Ampower 50	£155.00
ditto with Disco 2 console & two Ampower 50s	£210.00
ditto with Disco 2 console & one Ampower 100	£175.00
ditto with Disco 2 console & two Ampower 100s	£250.00

Carriage in U.K. please add for sstl unit £1; for power Amps 40 & 60 £1.50; for power Amp. 100 & 100w slave amp disco 25 or 50 £2.00. Ampower 50 and 100: Disco Console, disco 25 or 50 £5.00. Complete discos. £10.

EVERYTHING RIGOROUSLY TESTED AND GUARANTEED

BASIC MODULES

For constructors wishing to build systems to their own requirements. As their description implies, these modules will require control knobs, pots in some cases, etc. Each module is supplied assembled on its own PCB.

SSB4	Phase splitter (for two SS.105s in bridge formation)	£2.75
SS104/2	Two channel mixer stage	£3.75
SS104/4	Four channel mixer stage	£7.00
SS.DTM	Output control stage Master vol., 30dB variation on both treble and bass; 3mV in for 2V out, 18V working voltage	£6.75
SSTL3/250	Sound/light, 3 ch., 250w. ea.	£9.25
SSTL3/1000	Sound/light, 3 ch., 1000w. ea.	£11.50

POWER AMPS.

Ready assembled on P.C.Bs., tested and guaranteed. Easy to connect. With instructions. Output ratings ±1dB.

SS.103	I.C. amp. 3 watts R.M.S. using 20V/8Ω or 14V/4Ω. Input 100mV.	£2.85
SS.103-3	Stereo version of above, 2 I.C.s	£5.00
SS.105	5 watts R.M.S. into 3Ω using 13·5V. Sensitivity – 30mV. THD – 0·3%. 3½" x 2" x 1"	£3.95
SS.110	10 watts R.M.S. into 4Ω using 24V. Sensitivity – 60mV. THD – 0·3%. 3½" x 2" x 1"	£4,65
SS.120	20 watts R.M.S. into 4Ω using 34V. Sensitivity – 80mV. THD – 0·3%. 3½" x 2" x 1"	£5.15
SS.125	25 watts R.M.S. into 8Ω using 50V. Sensitivity – 140mV. Distortion – Less than 0·05% into 8Ω S/N better than 70dB.	£7.25
SS.140	40 watts R.M.S. into 4Ω using 45V. Sensitivity – 300mV. Distortion typically 0·1%. 5" x 3½" x 1½"	£6.50
S.160	64 watts R.M.S. into 4Ω using 50V. Sensitivity – 350mV. Distortion typically 0·1%. 5" x 3½" x 1½"	£8.50
SS.1100	100 watts R.M.S. into 4Ω using 70V/2A. Input sensitivity – 500mV. Distortion at half-power, typically 0·1%. 5" x 3½" x 1½"	£10.50
HS.160	Multi-finned heatsink for SS.140 or SS.160	75p
HS.1100	Ditto for SS.1100	£1.50

POWER SUPPLIES

Every Stirling Sound Power Unit is tested and guaranteed under working conditions before despatch. All units except SS.312 include a stabilised low voltage take-off point (13-15V) for pre-amp, tone control, radio tuner, etc. Outputs quoted are minimal unloaded ratings.

SS.312	12V/1A	£6.60
SS.318	18V/1A	£6.95
SS.324	24V/1A	£7.65
SS.334	34V/2A	£8.75
SS.345	45V/2A	£10.75
SS.350	50V/2A	£11.75
SS.360	60V/2A	£12.75
SS.370	70V/2A	£14.75

SS.310/50 Stabilised power supply unit with variable output from 10V to 50V/2A. Short circuit protected £17.75

SS.300 Power stabilising unit variable from 10 to 50V/8A for adding to unstabilised supply units £5.50

CONTROL/PRE-AMPS.

UNIT ONE
Combined stereo pre-amp & active tone control unit 50mV in for 200mV out 10 16V operation Bass ±15dB; Treble ±15dB; Balance control; Volume control. Ceramic P.U., radio or tape inputs. WITH FREE CONTROL PANEL FASCIA £9.00

UNIT TWO
Controls as UNIT ONE but for magnetic cartridge input. 5mV in for 200mV out. R.I.A.A. corrected. WITH FREE CONTROL PANEL FASCIA £12.43

CONTROL PANEL FASCIA
For above 50p

SS.100
Basic active stereo tone control module to provide ±15dB on bass at 30Hz and on treble at 10KHz £3.00

SS.101
Stereo pre-amp suitable for ceramics, tape, radio, etc. £2.75

SS.102
Stereo pre-amp for mag. pick-ups £4.45

STIRLING SOUND PRODUCTS ARE MADE IN OUR OWN ESSEX FACTORY AND SOLD DIRECT TO YOU, THE CUSTOMER. SEND NOW FOR YOUR FREE CATALOGUE SHEETS.

MAIL ORDERS

WHEN ORDERING. All goods sent post free in U.K. (except certain heavy ready built items) and ALL INCLUDE V.A.T. Prices subject to alteration without notice. E. & O.E. S.A.E. with enquiries, please.

Dept. PE3, 37 VANGUARD WAY, SHOEBURYNESS, ESSEX.
Telephone: (03708) 5543.

SHOP & SHOWROOMS

220-224 West Road, Westcliff-on-Sea,
Telephone: Southend (0702) 351048.

Stirling Sound

ACCESS OR BARCLAYCARD – JUST LET US KNOW YOUR No.

To STIRLING SOUND, 37 VANGUARD WAY, SHOEBURYNESS, ESSEX.

Please send ....

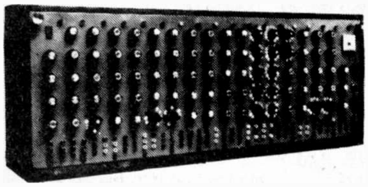
(or as list attached) for which I enclose £ ....

NAME ....

ADDRESS ....

.... PE5

KITS FOR SYNTHESISERS, SOUND EFFECTS



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

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

PHOTOCOPIES of all P.E. texts for most of the kits are available—prices in our lists.

PHONOSONICS

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

P.E. MINISONIC Mk. 2 SYNTHESISER
A portable mains-operated Miniature Sound Synthesiser, with keyboard circuits. Although having slightly fewer facilities than the large P.E Synthesiser the functions offered by this design give it great scope and versatility. Consists of 2 log VCOs, VCF, 2 envelope shapers, 2 voltage controlled amps, keyboard hold and control circuits, HF oscillator and detector, ring modulator, noise generator, mixer, power supply.

Set of basic component kits	from £62·23
Set of printed circuit boards	£9·71

P.E. SYNTHESISER (P.E. Feb. 73 to Feb. 74)
The well acclaimed and highly versatile large-scale mains-operated Sound Synthesiser complete with keyboard circuits. Other circuits in our lists may be used with the Synthesiser to good advantage.

The Main Synthesiser: PSU, 2 linear VCOs, 2 ramp generators, 2 input amps, sample hold, noise generator, reverb amp, ring modulator, peak level circuit, envelope shaper, voltage controlled amp.

Set of basic component kits	£83·03
Set of printed circuit boards	£13·20

The Synthesiser Keyboard Circuits (can be used without the Main Synthesiser to make an independent musical instrument): 2 logarithmic VCOs, divider, 2 hold circuits, 2 modulation amps, mixer, 2 envelope shapers and PSU.

Set of basic component kits	£48·18
Set of printed circuit boards	£7·66

GUITAR EFFECTS PEDAL (P.E. July 75)
Modulates the attack, decay and filter characteristics of an audio signal not only from a guitar but from any audio source, producing 8 different switchable effects that can be further modified by manual controls. Possibly the most interesting of all the low-priced sound effects units in our range. Circuit does not duplicate effects from the Guitar Overdrive Unit.

Component set with special foot operated switches	£7·59
Alternative component set with panel switches	£4·96
Printed circuit board	£1·43

SOUND BENDER (P.E. May 74)
A multi-purpose sound controller, the functions of which include envelope shaper, tremolo, voice-operated fader, automatic fader and frequency-doubler.

Component set for above functions (excl. SWs)	£7·84
Printed circuit board	£1·81

Optional extra—additional Audio Modulator, the use of which, in conjunction with the above component set, can produce jungle-drum rhythms.

Component set (incl PCB)	£2·88

PHASING UNIT (P.E. Sept. 73)
A simple but effective manually controlled unit for introducing the 'phasing' sound into live or recorded music.

Component set (incl. PCB)	£2·87

PHASING CONTROL UNIT (P.E. Oct. 74)
For use with the above Phasing Unit to automatically control the rate of phasing.

Component set (incl PCB)	£4·48

SOPHISTICATED PHASING AND VIBRATO UNIT
A slightly modified version of the circuit published in "Elektor", December 1976, and includes manual and automatic control over the rate of phasing and vibrato.

Component set	£17·69
Printed circuit board	£2·33

WAH-WAH UNIT (P.E. Apr. 76)
The Wah-Wah effect produced by this unit can be controlled manually or by the integral automatic controller.

Component set (incl. PCB)	£3·55

AUTOWAH UNIT (P.E. Mar. 77)
Automatically produces Wah-pedal and Swell-pedal sounds each time a new note is played

Component set, PCB, special foot switches	£7·27
Component set and PCB, with panel switches	£4·83

P.E. JOANNA PLUS ORGAN VOICING
The basic five octave electronic piano (P.E. May/Sept 75 and Sound Design) has switchable alternative voicings for Honky-Tonk, ordinary piano, and Harpsichord or a mixture of any of these three, together with facilities including fast and slow tremolo, loud and soft pedal switching, and sustain pedal switching. The modification retains all the circuitry associated with the piano but in addition provides an organ-voice envelope facility with 5 switchable pitches, variable attack and sustain, phasing and vibrato.

Set of components (excl switches) for PSU, Frequency generator, Pitch and Note Divider, Envelope Shapers, Voicings, and Control circuitries. (Order as KIT 71-5)	£109·75
Set of PCBs (Order as PCB SET 71-6)	£29·18

SYNTHESISER TUNING INDICATOR (P.E. July 77)
A simple 4-octave frequency comparator for use with synthesisers and other instruments where the full versatility of the P.E. Tuning Fork is not required.

Component and PCB (but excl sw.)	£7·45

GUITAR FREQUENCY DOUBLER (P.E. Aug. 77)
A modified and extended version of the circuit published.

Component set and PCB	£4·22

GUITAR SUSTAIN (P.E. Oct 77)
Maintains the natural attack whilst extending note duration.

Component set, PCB and foot switches	£4·90
Component set, PCB and panel switches	£3·48

WIND AND RAIN UNIT
A manually controlled unit for producing the above-named sounds.

Component set (incl. PCB)	£3·72

GUITAR OVERDRIVE UNIT (P.E. Aug. 76)
Sophisticated, versatile Fuzz unit, including variable and switchable controls affecting the fuzz quality whilst retaining the attack and decay, and also providing filtering. Does not duplicate the effects from the Guitar Effects Pedal and can be used with it and with other electronic instruments.

Component set using dual slider pot	£6·86
Component set using dual rotary pot	£6·20
Printed circuit board	£1·62

FUZZ UNIT
Simple Fuzz unit based upon P.E. "Sound Design" circuit.

Component set (incl. PCB)	£2·05

TREMOLO UNIT
Based upon P.E. "Sound Design" circuit.

Component set (incl. PCB)	£3·64

TREBLE BOOST UNIT (P.E. Apr. 76)
Gives a much shriller quality to audio signals fed through it. The depth of boost is manually adjustable.

Component set (incl. PCB)	£2·40

P.E. TUNING FORK (P.E. Nov. 75)
Produces 84 switch-selected frequency-accurate tones. A LED monitor clearly displays all beat note adjustments. Ideal for tuning acoustic or electronic musical instruments.

Main component set (incl. PCB)	£15·59
Power supply set (incl. PCB)	£7·03

SEE OTHER PAGE FOR KEYBOARDS, AND OUR LISTS FOR OTHER COMPONENTS AND ACCESSORIES STOCKED

P.E. SYNCHRONOME (P.E. Mar. 76)
An accented-beat electronic metronome, providing duple, triple and quadruple times with full control over the beat rate. Can also be used as a simple drum-beat rhythm generator. Includes power supply

Component set (incl. loudspeaker)	£11·62
Printed circuit board	£2·04

TAPE NOISE LIMITER
Very effective circuit for reducing the hiss found in most tape recordings. All kits include PCBs

Standard tolerance set of components	£2·96
Superior tolerance set of components	£3·76
Regulated power supply (will drive 2 sets)	£4·69

ENVELOPE SHAPER WITHOUT VCA (P.E. Oct. 75)
Provides full manual control over attack, decay, sustain and release functions, and is for use with an existing voltage controlled amplifier.

Component set (incl PCB)	£4·66

ENVELOPE SHAPER WITH VCA (P.E. Apr. 76)
This unit has its own voltage controlled amplifier and has full manual control over attack, decay, sustain and release functions.

Component set (incl. PCB)	£6·68

TRANSIENT GENERATOR (P.E. Apr 77)
An envelope shaper, without VCA, having the usual attack, decay, sustain and release functions, and in addition it also provides a 'Repeat Effect' enabling a synthesiser to be programmed to imitate such instruments as a mandolin or banjo

Component set	£4·52
Printed circuit board	£1·82

WAVEFORM CONVERTER
Slightly modified from a circuit published in "Elektor". Converts a saw-tooth waveform into four different waveforms: sine-wave, mark-space saw-tooth, regular triangle form, and squarewave with an externally variable mark-space ratio.

Component set (incl. PCB but excl. sw/s)	£8·19

VOLTAGE CONTROLLED FILTER (P.E. Dec. 74)
Part of the P.E Minisonic now released as an independent kit for use with other synthesisers.

Component set (incl PCB) (Order as Kit 65-1)	£8·22

RING MODULATOR (P.E Jan 75)
Part of the P.E. Minisonic now released as an independent kit for use with other synthesisers

Component set (incl. PCB) (Order as Kit 59-1)	£5·50

NOISE GENERATOR (P.E. Jan. 75)
Part of the P.E. Minisonic now released as an independent kit for use with other synthesisers.

Component set (incl. PCB) (Order as Kit 60-1)	£3·35

SOPHISTICATED POWER SUPPLIES
A wide range of highly stabilised low noise power supply kits is available—details in our lists.

MICROPHONE PRE-AMP (P.E Apr. 77)

Component set (incl. PCB)	£3·78

VOICE OPERATED FADER (P.E Dec. 73)
For automatically reducing music volume during 'talk-over'—particularly useful for Disco work or for home-movie shows.

Component set (incl. PCB)	£3·97

DYNAMIC RANGE LIMITER (P.E. Apr. 77)
Automatically controls sound output to within a preset level.

Component set (incl. PCB)	£4·58

POST AND HANDLING
U.K. orders—under £15 add 25p plus VAT, over £15 add 50p plus VAT. Keyboards £2·00 plus VAT.
Optional Insurance for compensation against loss or damage in post, add extra 50p for cover up to £50, £1·00 for £100 cover, £2·00 for £200 cover.
Eire, C.I., B.F.P.O., and other countries are subject to Export postage rates.

DON'T FORGET VAT!
Add 12½% (or current rate if changed) to full total of goods, post and handling. (Does not apply to export orders).

EXPORT ORDERS are welcome, though we advise that a current copy of our list should be obtained before ordering as it also shows Export postage rates. All payments must be cash-with-order, in Sterling and preferably by International Money Order or through an English Bank. To obtain list send 50p.

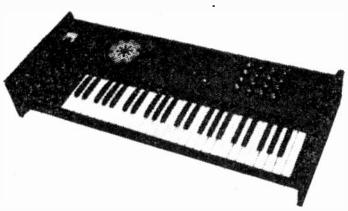
PHONOSONICS · DEPT. PE65 · 22 HIGH STREET · SIDCUP · KENT DA14 6EH MAIL ORDER AND C.W.O. ONLY SORRY BUT NO CALLERS PLEASE

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 24p
Type GB: 2 pairs of contacts, each pair normally open	each 27p
Type GC: 3 pairs of contacts, each pair normally open	each 36p
Type GE: 4 pairs of contacts, each pair normally open	each 45p
Type GH: 5 pairs of contacts, each pair normally open	each 57p
Type 4PS: 3 pairs of contacts plus single-pole changeover	each 53p

Printed Circuit Boards for use with CJ, 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)	£12·90
10-Instrument Effects circuits	£13·56
PCB for Effects circuits	£4·25
Power Supply incl. PCB	£12·00

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)	£20·60
Power Supply (KIT 76-3)	£6·05
Trigger Inverter and Alt. Output (KIT 76-2)	£1·35
LED Counter (KIT 76-4)	£2·45
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 (P.E. commencing Mar 78)

The new keyboard string-instrument synthesiser.

Power Supply Basic component set	£9·22
Tone Generators (incl. Test components)	£14·93
PCB for PSU and Tone Generator	£3·40

Details of further kits and PCBs in our list.

FORMANT SYNTHESISER (Elektor 1977/78)

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

3-CHANNEL SOUND-TO-LIGHT (P.E. Apr. 76)

A simple but effective sound-to-light controller capable of operating 3 lamps each of approximately 700 watts. Includes power supply, thyristors, and by-pass switches.

Component set (incl. PCB)	£11·95

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)	£4·22
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 (PE65)

TERMS: Correctly costed, C.W.O., U.K. orders over £40 goods value. Valid until end of month on cover of P.E. This voucher must accompany order.

TRANSISTORS

AC128	26p
AC176	26p
BC107	14p
BC108	14p
BC109	14p
BC109C	15p
BC177	14p
BC184	12p
BC187	25p
8C204	14p
BC209C	14p
BC213	15p
BC214	15p
BC262	25p
BC415	16p
BC478	29p
BD131	44p
BD132	54p
BF244A	24p
8F245A	24p
8SY95A	22p
MD8001	172p
OC71	20p
OC72	30p
RPY58A	48p
TIS43	50p
ZTX108	9p
ZTX301	13p
ZTX384	16½p
ZTX501	13p
2N2219	27p
2N2646	50p
2N2905	35p
2N2905A	36p
2N2906	22p
2N2907	22p
2N3054	66p
2N3055	60p
2N3702	12p
2N3704	12p
2N3819	35p
2N3820	64p
2N3823E	39p
2N5459	45p

INTEGRATED CIRCUITS

301 8-pin DIL	48p
318 8-pin DIL	230p
320-15	58p
324 14-pin DIL	87p
341-15	195p
709 8-pin DIL	48p
723 TO5	106p
723 14-pin DIL	56p
726 TO5	980p
741 8-pin DIL	32p
748 8-pin DIL	63p
4024 14-pin DIL	46½p
4069 14-pin DIL	18p
4136 14-pin DIL	126p
7805 TO220	205p
7806 TO220	205p
7808 TO220	205p
7812 TO220	205p
7815 TO220	205p
7818 TO220	205p
AY10212 16-pin DIL	650p
AY16721/6	195p
CA3046 14-pin DIL	90p
CA3080 8-pin DIL	82p
CA3084 14-pin DIL	209p
M252 16-pin DIL	680p
MC3340 8-pin DIL	150p
MCM6810 24-pin DIL	870p
SG3402N 14-pin DIL	262p
STK025	595p
TDA1022 16-pin DIL	672p
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

TRAIN FOR SUCCESS

in Radio, Television & Electronics

ICS have helped thousands of ambitious people to move up into higher paid more secure jobs in the field of electronics - now it can be your turn. Whether you are a newcomer to the field or already working in the industry, ICS can provide you with the specialised training so essential to success.

Personal Tuition and Guaranteed Success

The expert and personel guidance by fully qualified tutors, backed by the ICS guarantee of tuition until successful, is the key to our outstanding record in the technical training field. You study at the time and pace that suits you best and in your own home. In the words of one of our many successful students: "Since starting my course, my salary has trebled and I am expecting a further increase when my course is completed."

City and Guilds Certificates

Excellent job prospects await those who hold one of these recognised certificates. ICS can coach you for:

Telecommunications Technicians
Radio, T.V. Electronics Technicians
Technical Communications
Radio Servicing Theory
Radio Amateurs
Electrical Installation Work
Also MPT Radio Communications Certificate

Diploma Courses

Colour T.V. Servicing
Electronic Engineering & Maintenance
Computer Engineering and Programming
Radio, T.V. and Audio, Engineering & Servicing
Electrical Engineering, Installations & Contracting

Other Career Courses

A wide range of other technical and professional courses are available including GCE.

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To ICS, Dept. 273 T, Intertext House, London SW8 4UJ or telephone 01-622 9911 (all hours)

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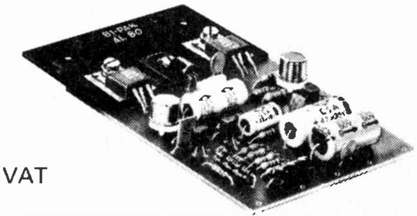

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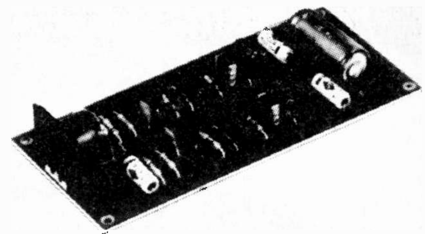

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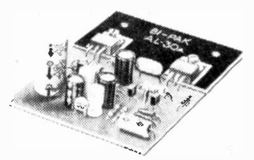

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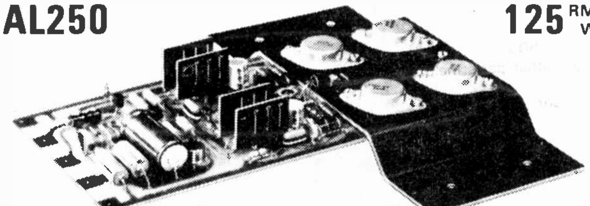

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PE VOLUME 14 No. 9 MAY 1978

SPECIAL

THIS month we bring you yet another special issue—the third in as many months. We have enclosed a *Guide to the Language of Microcomputers* in this issue and feel sure that this will be of interest to virtually all readers. The booklet contains over 120 words allied to microcomputers and gives a concise meaning to each. Even those with little or no interest in the field at present will, we are sure, soon find it necessary to keep up with the language as these devices enter into our everyday lives from all directions at an increasing rate.

The next two issues of P.E. will also be rather special as they contain details and entry coupons for a "free entry" competition. This is special because it could result in financial backing for a reader's idea. Some inventive readers could thus be financially rewarded as well as win a couple-of-hundred pounds worth of oscilloscope.

This competition is the result of an exclusive arrangement between P.E. and a Venture Capitalist. The aim is to attract ideas that could be developed to form commercial products. The presenter of such an idea will be involved in the development and will reap the benefit in the form of a stake in any company set up to handle the product or in the form of a royalty or other payment.

The competition is also open to companies, who could thus win backing for their prototype designs. We think you are an inventive lot and remember—it is often the simple ideas that are the best ones. So put your thinking caps on and watch out for full details in the next two issues of **P.E. only.**

SAVING

In this day and age it seems that one thing is becoming more and more important—that is the best possible use of available finances. For the electronics man this often means the construction of a piece of equipment rather than its purchase and also means the use of electronics to save energy by providing automatic control of such things as central heating, etc.

It is probably true to say that it is now easier to get into electronic construction than ever before—the tools for the job are readily available as are the necessary components. Most construction can be carried out with the minimum of metal bashing and the use of readily available plastic cases, knobs and finishing materials can result in a very professional end product.

So, all those regular readers who enjoy the theory, or just reading all about it, perhaps now is the time to get stuck in! If you want further encouragement there's an item under *Strictly Instrumental* that tells you how to save about £4,500!

SUBSCRIPTIONS

As some alert readers may have noticed we have recently reinstated the subscription service for P.E. Although this may not interest many "home" readers, we know that a large number of overseas readers have problems in getting regular issues. This should no longer be the case as you can now have them posted to you each month with the minimum of fuss—see the foot of this page for details.

The subscription service is of course also available to British readers; if you have problems getting issues this service should guarantee you a copy. The next best thing is to place an order with your local newsagent.

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Copies of most of our recent issues are available from: Post Sales Department, IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 0PF, at 65p each including Inland/Overseas p & p.

Binders for PE are available from the same address at £2·85 each to UK addresses, £3·45 overseas, including postage and packing, and VAT where appropriate. Orders should state the year and volume required.

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

Letters
Queries regarding articles published in PE should be addressed to the Editor, at the Editorial Offices, and a stamped, addressed envelope enclosed. We cannot undertake to answer questions regarding other items, nor to answer technical queries over the telephone.

MOVING LIGHTS DISPLAY

C. J. BOWES

FOR some years advertising signs have used strings of lights wired up and controlled in such a way as to make lights appear to move in a continuous movement along the string. Such effects are also fairly popular as backgrounds in television shows and on the stage. Smaller units are also used to create the same effects in discos.

The device to be described is designed to provide the same effect using either three strings of low voltage pygmy lights or up to a 3kW total power loading of mains voltage bulbs wired in three circuits.

The movement effect is obtained by wiring the lamps as three circuits so spaced out that every third bulb in the series of bulbs is wired to the same circuit. The three circuits are switched on and off in sequence and the effect created is that of a moving point of light if one circuit is on at a time and the other two off.

If the circuits are so arranged that two circuits are on and one is off at any one time the effect is the opposite in that a moving gap in a string of lights is created.

Here, both possibilities can be obtained, depending on the position of a selector switch. A sprint facility is included which, if switched into operation, will make the speed of change of the output circuits increase for a short period at regular intervals in the cycle.

POWER SUPPLIES

Two voltages are required to power the circuitry; +5V stabilised which is used to power the TTL circuits and the lamp changing multivibrator and +12V which is used to power the relay driver circuitry and to provide part of the output for the sprint circuit.

The power supply is shown at the left of Fig. 1. The two voltages are derived from the secondary of a single 9V transformer the output of which is rectified by a bridge rectifier and smoothed.

This circuit gives 12V, the negative connection of which is grounded. The +5V stabilised supply is derived from the smoothed 12V rail by IC1. This device is a 100mA stabiliser mounted in a TO92 case and only requires the addition of C2, C3 and R1 to form a complete stabilisation circuit.

TR1, TR2, C4, C5, R2, R3, R4, R5 and VR1 form a conventional multivibrator circuit. The speed of the lamp change is governed by the frequency of the output, which is set by VR1.

SELECTION AND OUTPUT CIRCUITS

The output sequence is obtained by counting the output pulses from the multivibrator and decoding the numerical sequence obtained to switch the lamp circuits.

This circuit uses TTL logic and is shown in Fig. 2.

In this an input to a gate is logic 1 when a voltage of more than 2·4V is present and at logic 0 when less than 0·4V is present. As most logic circuits require a clean transition between these two states the output from the multivibrator circuit is cleaned up by means of a Schmitt trigger which gives a clean square waveform.

This is achieved by using half of a 7413 (IC2a).

As any unused TTL input automatically floats to the logic 1 condition it is customary to tie any unused input to a used input on the same gate so the used inputs of IC2a are connected to the output of the multivibrator.

The square wave output from IC2a passes to IC3 which is a 7492 divide-by-twelve counter. The truth table for this is given in Table 1.

Table 1

Count (Pin 14)	Output			
	D (Pin 8)	C (Pin 9)	B (Pin 11)	A (Pin 12)
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	1	0	0	0
7	1	0	0	1
8	1	0	1	0
9	1	0	1	1
10	1	1	0	0
11	1	1	0	1
12	1	1	1	1

After 12 the counter resets to 0 and runs through the sequence again.

Outputs A and B are used to drive relays 1 and 2 respectively each of which controls one circuit of lamps. The third circuit of lamps needs to be on when neither

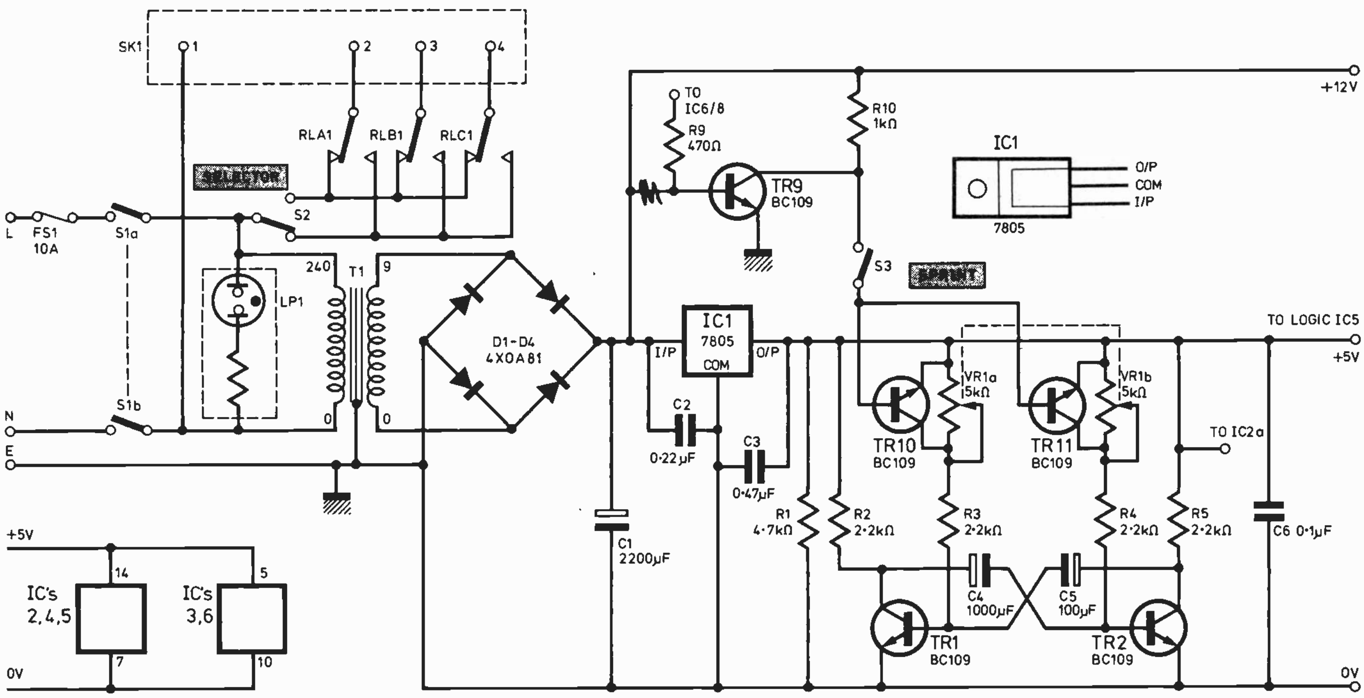


Fig. 1. Power supply and lamp changing multivibrator

A or B is at logic 1. This would be most easily obtained by using a NOR gate, but to do so would require an additional i.c. To implement this an alternative circuit using three inverters from unused gates are used.

A two input NAND gate has a truth table as shown in Table 2.

Table 2

B	A	Output
0	0	1
1	0	1
0	1	1
1	1	0

Although this circuit gives us the required output at logic 1 when both A and B are at logic 0, it gives us the same output when either of the inputs are at logic 0 and the other is at logic 1. However, we can make use of the fact that the gate gives us an output of logic 0 when both of the inputs are at logic 1. By inverting outputs A and B of the counter and connecting the inverted outputs to the inputs of the NAND gate we can obtain an output from the gate which changes from logic 1 to logic 0 when the counter outputs are both at logic 0. This output is the opposite of what we wanted but this can easily be rectified by inverting the output of the gate.

If we allowed the 7492 counter to continue further through its cycle after it had reached the count of two we would obtain a very strange light display and we therefore need to return the counter to zero when it would normally go onto a count of three. This is achieved by making use of the reset line connected to pins 6 and 7. When both of these pins are connected to logic 0 the circuit counts but if the reset pins are taken to logic 1 the counter resets all outputs to logic 0.

COMPONENTS . . .

Resistors
- R1 4·7kΩ
- R2–8 2·2kΩ
- R9 470Ω
- R10 1kΩ
- ½W 10% carbon

Potentiometer
- VR1 5kΩ dual linear potentiometer

Capacitors
- C1 2,200μF 25V electrolytic
- C2 0·22μF 250V polyester
- C3 0·47μF 250V polyester
- C4 1,000μF 10V electrolytic
- C5 100μF 10V electrolytic
- C6 0·1μF disc ceramic

Semiconductors
- TR1–11 BC109 (11 off)
- IC1 7805 regulator
- IC2 7413
- IC3, IC6 7492
- IC4 7404
- IC5 7400
- D1–7 OA81 (7 off)

Miscellaneous
- T1 240V primary 9V secondary 6VA
- S1 D.p.s.t. rocker switch with neon indicator
- S2 S.p.d.t. rocker switch
- S3 S.p.s.t. rocker switch
- FS1 10A fuse
- RLA–C 12V 110Ω. Contacts rated 10A, 240V according to requirement
- SK1 5 way output socket with plug to match. Each pin rated 5A 240V

Double sided printed circuit board 140mm × 102mm
Metal case 204mm × 152mm × 76mm

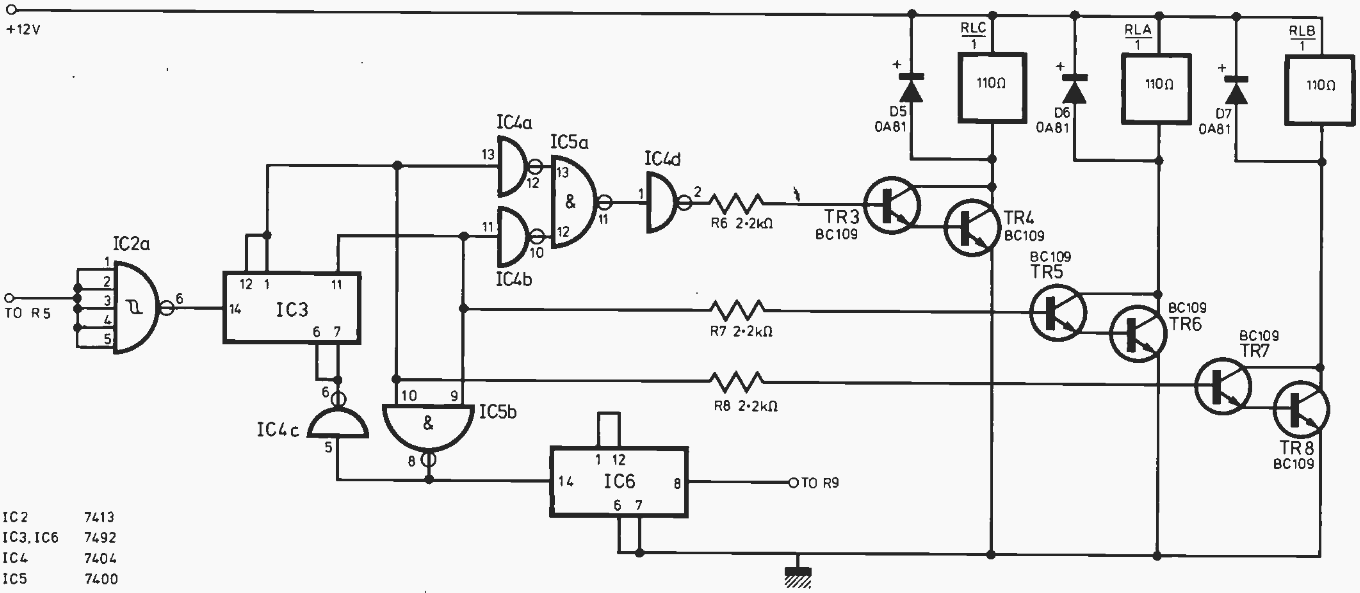


Fig. 2. Logic and drive circuit

A two input NAND gate, IC5b, is connected with its inputs to the outputs A and B of the counter. When both of these inputs are at logic 1 (when the counter goes to a count of three) the gate gives an output of logic 0; this is inverted so that the counter is reset to zero every time it goes to a count of three. As the reset only takes about 8ns the unwanted display never appears and the counter appears to count 0, 1, 2, 0, 1, 2. . . .

SPRINT CIRCUIT

A sprint circuit can be engaged so that the speed of the display will increase for eighteen counts and then continue at the set speed for a further eighteen counts before speeding up again.

The circuit takes an output from the reset circuit to a 7492 counter. The output of this counter at pin 8 (output D) goes to logic 1 for counts 6 to 12 and as the counter is incremented every time the first counter is reset this corresponds to 18 counts in all. This output is used to drive TR10 and TR11 which are arranged to form saturated transistor switches which short out the variable resistance VR1 of the multivibrator circuit.

When the collector voltage of the transistor is lower than the base voltage the transistor saturates and the emitter collector path behaves as a short circuit. R3 and R4 are therefore in effect connected to the +5V line and set the frequency of the multivibrator.

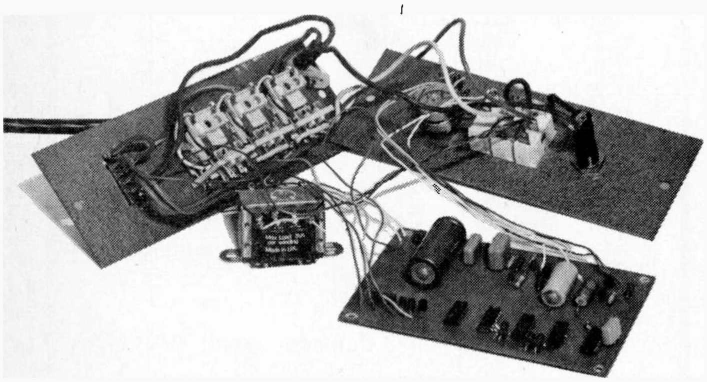
In order to operate the transistor switches the output voltage of the 7492 is used to lift the base voltage of the two transistors to be above the collector voltage. Unfortunately the logic 1 voltage of TTL gates is typically only +2·4V and so voltage amplification is required. TR9, R9 and R10 form a simple voltage amplifier.

This single stage amplifier inverts the output from the 7492 in the process of amplifying the voltage and therefore the circuit sprints when the output of IC6 is at logic 0.

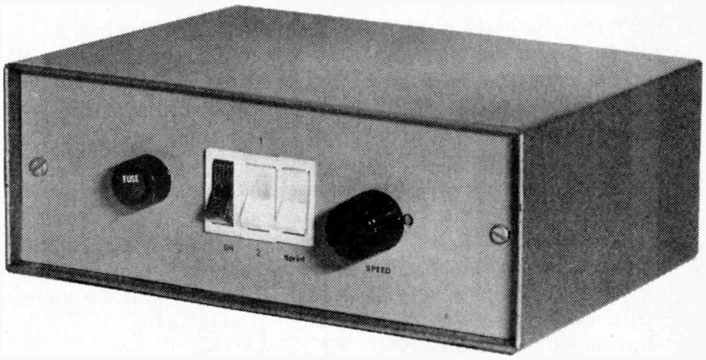
Switch S3 disengages the output of TR9 from the bases of TR10 and TR11 and when this switch is in the off position the sprint circuit is inoperative.

OUTPUT RELAY DRIVE

The use of s.c.r.s as the output elements of this device was considered but was abandoned in order to reduce the



Showing component assembly to front and back panels with p.c.b. and transformer which fixes to box base panel



Control panel layout

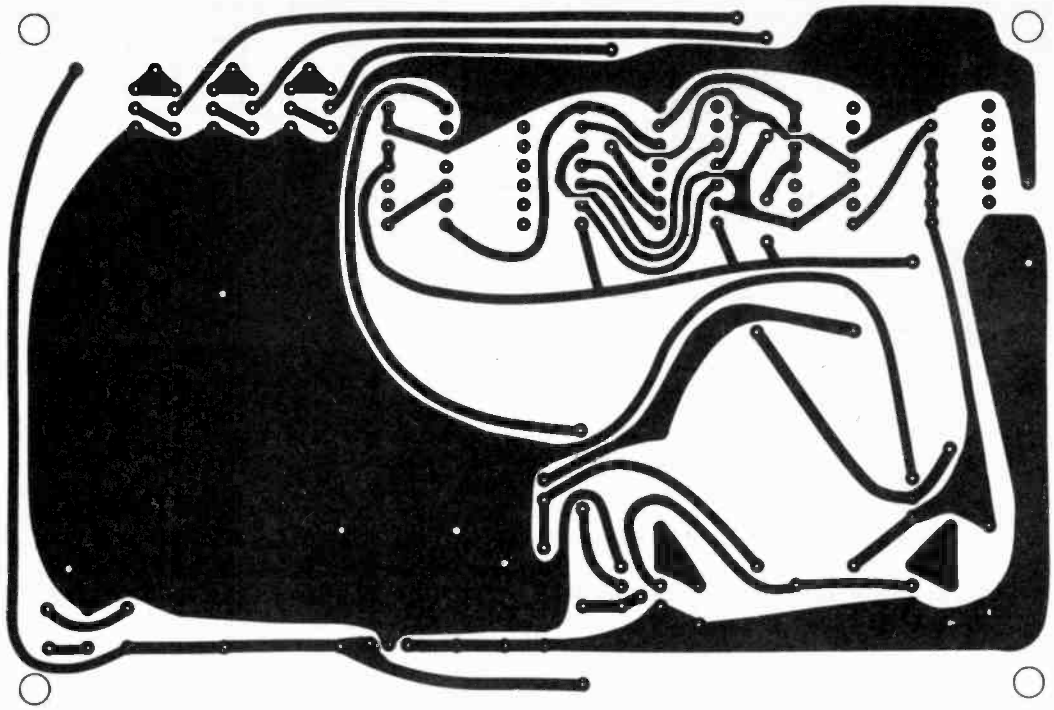


Fig. 3. Etching details shown full size for p.c.b.

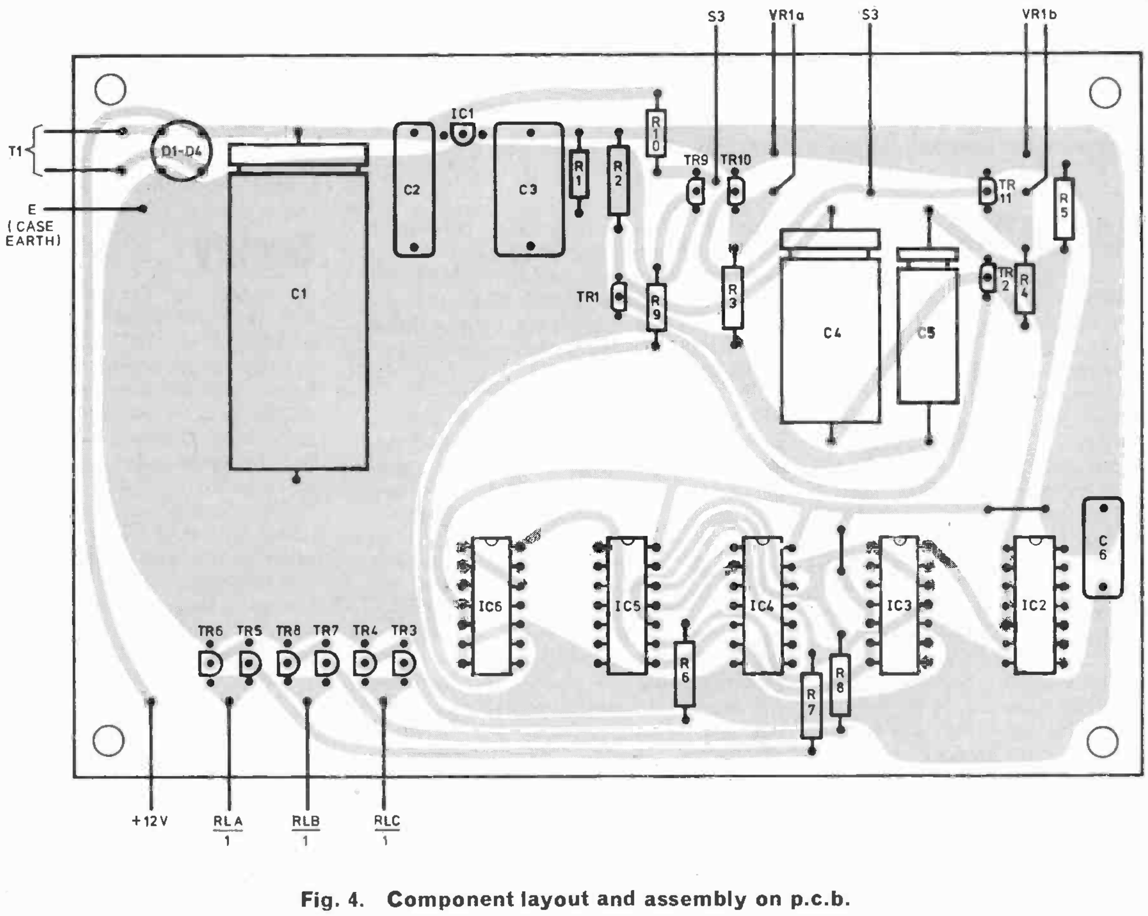


Fig. 4. Component layout and assembly on p.c.b.

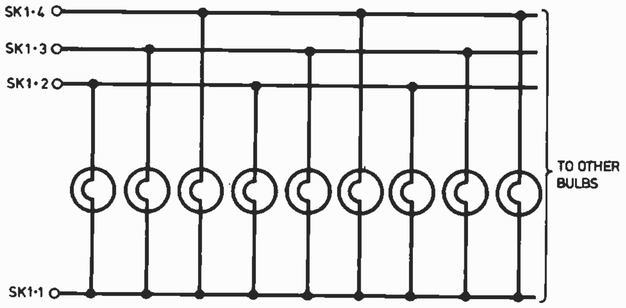


Fig. 3. Wiring for a large display

cost of the device since relay drives are easily inverted to give the two light or one light circuit operative at a time.

The output from the TTL logic circuits is insufficient to drive the relays directly and the relays are driven by transistors connected in the standard Darlington pair configuration, controlled by the output from the TTL circuits. The drive circuits for each relay are identical.

In order to provide the option of one light circuit or two light circuits active at a time the relays are wired with the common terminal connected to the lamps and the normally closed contacts of each relay wired together. If two lamp circuits are required to be on at any one time and the third circuit off (giving a moving gap effect) the mains connection is made to the normally closed contacts of each relay so that the selection by the TTL logic circuits switches off the required circuit. If one light circuit is required to be on and the other two circuits off, giving a moving light effect, the mains is connected to the normally open contacts of the relays and the TTL logic circuits activate the relay to switch the required lamp on.

LIGHT DISPLAY

An easy way to obtain the necessary light display is to use three strings of low voltage bulbs connected with a common wire from each string to the neutral connection of the output socket and the live connection to the appropriate output pin of the output socket. The strings should be taped together so that the lamps of each string are interleaved to give the correct impression of movement. If a bigger display is required this could be obtained by wiring mains bulb holders together as shown in Fig. 3. ★

Readout—
A SELECTION FROM OUR POSTBAG

Readers requiring a reply to any letter must include a stamped addressed envelope. We regret that we cannot answer any technical queries on the telephone.

CHAMPing at The Bit

Sir—I have read the first parts of the CHAMP project with great interest, but am somewhat reluctant to spend, to me, a fair amount of money on the system shown for the following reasons:

(1) The seemingly poor availability of the Intel devices, in fact, all the i.c.s not in the 74 range. I have noticed that in the past, a project has been published, and, next month, the retailers adverts are full of "complete kit of parts for . . . project" but not for CHAMP.

(2) The fact that the 4040 is a 4-bit device as opposed to the 8-bit devices of which there seem to be more types available at the moment. Coupled with this the 4040 is an "old" device—will there be spares available for this 4-bit device in the years (months?) to come amid all the parts for 8-bit and now 12-bit (16-bit? 20-bit?) devices on the market?

I am very keen to learn more about microprocessors and thought that CHAMP might provide a good start.

P. C. Chamberlain,
Anglesey.

Point 1:— *The "chip kit" mentioned in part II of CHAMP contains all the necessary Intel i.c.s and is available for a very reasonable price. These i.c.s are also available separately from Rapid Recall, G.E.C. Semiconductors, Jermyn, and several other suppliers.*

Point 2:— *The Intel 4040 has been a very successful microprocessor, and has been incorporated in a very wide range of commercial equipment which guarantees its availability for many years to come. I would urge Mr Chamberlain not to be misled by current advertising which concerns the "latest and the greatest" microprocessor chips. It has been the trend to "push" these chips often before they are available in useful quantities, and this can cause frustration for intending users. I would also point out that to use a sixteen bit microprocessor for example, a considerable investment in equipment and software is necessary before anything like full use can be made of its admittedly powerful facilities.* CHAMP *does not, and will not, require teletypes, VDUs, bulk memory, assembler software or high level compilers for its effective employment.*

The writer is currently using the 4040 in a number of applications which involve the control of printers, paper tape stations, and keyboards, all of which involve binary arithmetic, B.C.D. arithmetic and binary to B.C.D. conversion along with other tasks such as time measurement and analogue output. All these applications were programmed directly in hexadecimal and involve the simplest basic 4040 hardware. I have the highest regard for the more powerful microprocessors, but believe me, they are only worth having if you invest in a powerful memory, software, and input output environment to do them justice.

R W Coles.

Quality

Sir—I feel that the quality of projects in P.E. is not as good as a year ago. For instance Dec. 1977 three out of four projects were continuations of projects from previous months. Jan. 1978 had six projects in, one of which was a continuation and another three were suitable only for (your usually excellent) *Ingenuity Unlimited!*

P.E. Champ is all very nice and educational but, at the cost indicated not very many people can afford to build it. For this reason I think that *Champ* should be a General Features/Project, rather than just a project. This would allow for four projects plus *P.E. Champ.*

R. A. Austin,
Brentwood.

Although we endeavour to present a varied selection of constructional projects each month we cannot promise to please "all of the people all of the time". It is also necessary to give a good selection of additional news and features as we are sure most readers would not like a purely constructional magazine.—Ed.

Strictly Instrumental

by K. Lenton-Smith

There is a case on record of the businessman who visited his doctor, to be told that he was suffering from strain, hypertension and was likely to have heart trouble. The treatment prescribed was not the usual course of drugs: instead, he was advised to buy an electronic organ. Perhaps a bit expensive, but good advice as a method of unwinding from the effects of the rat-race.

HATH CHARMS

It appears that the treatment worked, though learning to play from scratch demands a good deal of concentration and co-ordination of mind and limbs. For the perfectionist in particular, this will be hard going at first but before long the tiro can become completely absorbed. As a large percentage of organ sales are to first-time owners, manufacturers compete with each other to offer aids to the beginner—from a special pedal Legato to illuminated keys. Many of these features can also be put to good use by the skilled player, Arpeggiators and A.O.C. as two examples. Aside from organ features, specialist magazines and sheet music scored for electronic keyboard instruments are more common than hitherto.

WERSI D.I.Y.

Klaus Wunderlich, who records for Telefunken, has many best selling records to his name. One of his more recent discs is "In the Miller Mood", played on the Wersi "Helios" organ and multi-tracked to obtain an orchestral effect (Selecta 6-23026AS). Though many of his past records were made using Hammond or Lowrey organs, he appears to be confining his attentions to Wersi at present and, although he would not claim to be an electronics engineer, I am certain that the Wersi design team have taken heed of his suggestions.

Since Wersi organs were mentioned in "Market Place" last October I have had a chance of hearing and examining a "Helios" W2T assembled from a kit. There is no doubt that this is an outstanding instrument, embodying the latest state-of-the-art circuitry. The Wersi concern is some eight years old, comprising an enthusiastic team of engineers and musicians: it provides both assembly kits and the complete instrument.

Readers of practical magazines need no reminder that it is usually cheaper to construct than buy a ready-made product. Organ building is one of the more complex projects, especially where the shopping list is concerned, so that buying a kit really makes sense. In the case of the "Helios" W2T the saving is very considerable as the finished product costs over £7,000, whilst the kit retails for about £2,500. If even the kit price sounds expensive, I would point out that this is a very comprehensive instrument and that Klaus Wunderlich's opinion of it may be verified by hearing the record previously mentioned.

Keying is fully electronic, the Transposer allows brilliant key changes while the special effects include auto-Wah, Repeat, Contracussion and Second Voice. There are three outstanding features of the W2T, in my opinion. "Wersivoice" is an electronic doppler-effect superior to any I have heard, based on several "bucket brigade" devices: two speeds at three intensities provide a perfect rotating baffle effect. "Wersidatal" is a system for programming preset sounds, each of the 20 programs having random access: thus, favourite combinations may be memorised and altered if superseded. Lastly, the "Wersimatic" rhythm unit is one of the best in its field. Based on 24 patterns and 15 instruments, it can produce alternating bars, stereo effects, drum breaks and has touch and automatic control.

Despite the complexity of the "Helios", it can easily be disassembled into three parts—top, base and chrome legs. Perhaps the only musical criticism is that the pedal section consists only of 13 notes, though a larger clavier is available in the "Zenith" series, if required. Potential constructors can obtain further information on the kits from Aura Sounds, Copthorne Bank, Crawley, West Sussex.

Building from a kit or published design has the advantage that the circuitry will have been proven beforehand, though the shopping list will call for careful planning in the latter case. By carefully following instructions and taking care to *understand* what is being assembled at each stage, this option should prove both successful and educational in familiarising the organist with the routing and processing of signals. Once the instrument is playable, he will not be deterred from changing component values—especially in the formant stages—to suit his taste and musical requirements. In this respect, a commercial organ under guarantee tends to preclude getting to work with an iron and sidecutters!

For most owners, the professionally built instrument will tend to be the natural choice but, because organs are happily obeying the cost of living graph, a great deal of thought is required before parting with one's money.

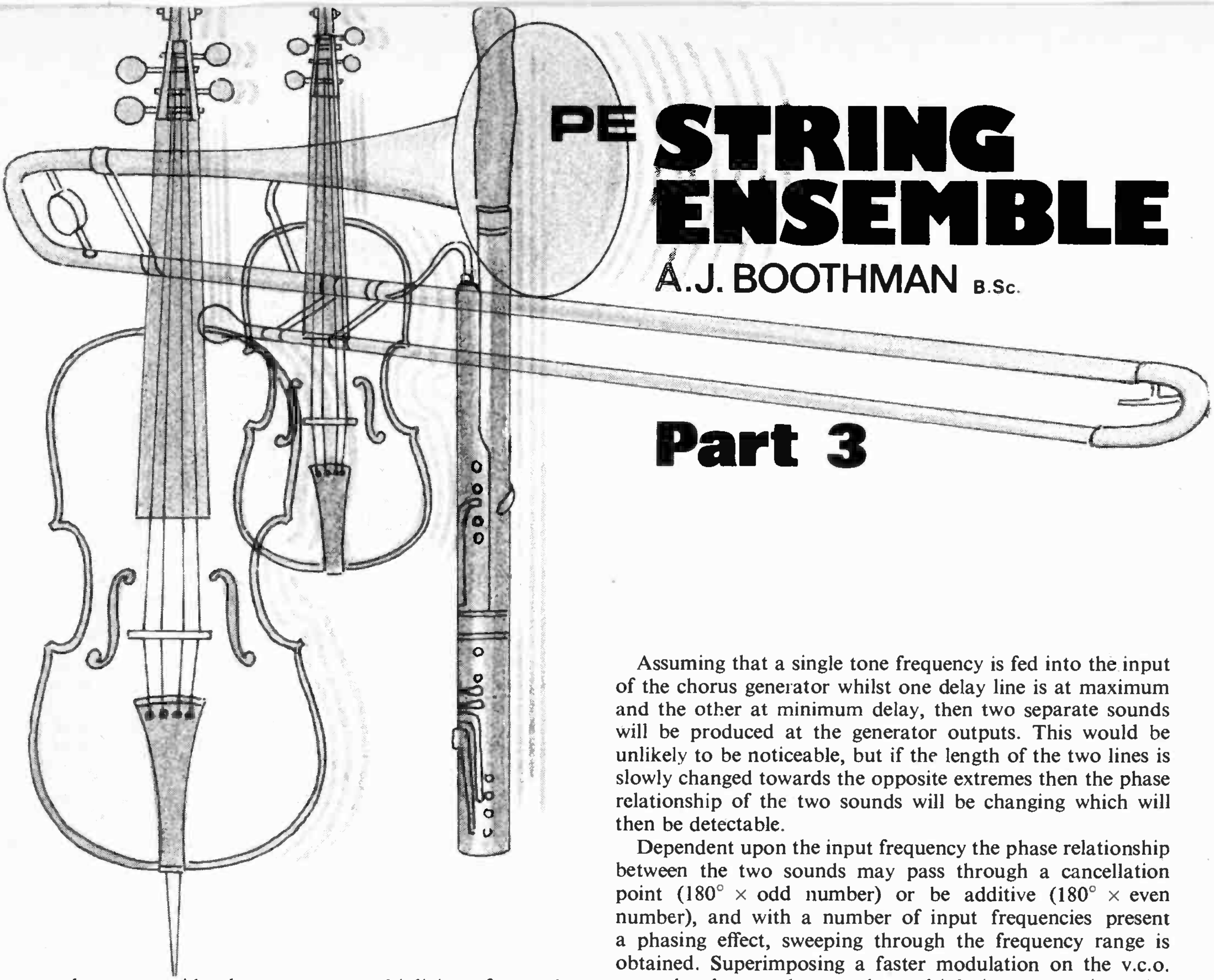
CAVEAT

The buyer must beware of himself, so *se ipsum caveat emptor* would be more appropriate! Whether a new or used model is in prospect, a few guidelines may not be out of place in this column.

The amount of money available will narrow the field and, having decided on what the bank balance can stand, a specification commensurate with the musical requirements should be aimed for. In this respect, salesmen are not only helpful but extremely honest as they know that you will recommend the firm if satisfied—or perhaps buy a more expensive model at a later date.

Arrange for a demonstration of the models within the range that can be afforded and, having heard them, ask for detailed brochures of those that lived up to expectations. Then take these home and study them carefully, with time no object: after all, having been without an instrument for years, what does another week matter? By all means take advice from a musical friend but remember that *your* money is involved and that the final decision lies with you. Look at the accompaniment manual in particular: the solo manual may offer a number of pitches, but the lower manual is often threadbare—perhaps one pitch only—and could begin to sound monotonous. Check the dimensions of the instrument against the available room space and confer with the "household management" as to the appearance of the cabinet as a piece of furniture.

Those who are classically inclined will look for fewer trimmings and more "straight" organ in the specification. A spinet organ, with short manuals and 13 stub pedals, will not suit anyone aspiring to Widor and Bach.



PE STRING ENSEMBLE

A.J. BOOTHMAN B.Sc.

Part 3

In order to provide the apparent multiplicity of sound sources, producing similarly pitched notes, required to simulate the orchestral string section effect, a Chorus Generation System is described which relies on the use of bucket brigade analogue delay lines for its fundamental operation.

CHORUS GENERATION SYSTEM

The system is shown in block schematic form in Figure 3.1. For reasons described later the input is processed by a low pass filter thus reducing the maximum frequency fed into the delay lines. Two active low pass filters follow each of the delay lines to complete the signal paths, extracting the clock frequency break through, and reconstituting the sampled waveform.

The two-phase clock circuits produce square waves in anti-phase from v.c.o.s A and B (see inset example of waveforms associated with Delay Line A), and both v.c.o.s are controlled in frequency by the combination of slow and fast modulator outputs which have been amplified to a suitable drive level. The two v.c.o.s work in an opposing manner in that as the control voltage increases, the frequency for one v.c.o. increases whilst the frequency for the other v.c.o. decreases, and vice versa.

Since the delay in each line is inversely proportional to the clock frequency, the delay in one line reduces whilst the delay in the second line increases and vice versa. When the control voltage is in the mid position the two delay lines have equal delays of approximately 3·5ms, varying between approximately 2·5ms and 5ms at the extremes.

Assuming that a single tone frequency is fed into the input of the chorus generator whilst one delay line is at maximum and the other at minimum delay, then two separate sounds will be produced at the generator outputs. This would be unlikely to be noticeable, but if the length of the two lines is slowly changed towards the opposite extremes then the phase relationship of the two sounds will be changing which will then be detectable.

Dependent upon the input frequency the phase relationship between the two sounds may pass through a cancellation point (180° × odd number) or be additive (180° × even number), and with a number of input frequencies present a phasing effect, sweeping through the frequency range is obtained. Superimposing a faster modulation on the v.c.o. control voltage enhances the multiple image, causing relatively rapid changes in phase relationship which when combined with the slow sweep give a complex pattern of relative phase simulating more than two sources and resulting in a rich chorus sound. The sweep rates of the slow and fast modulators are approximately 0·5Hz and 10Hz respectively.

BUCKET BRIGADE

The term "Bucket Brigade Delay Line", is derived from the anology of a number of people, each with a bucket, forming a chain along which it is desired to transmit water.

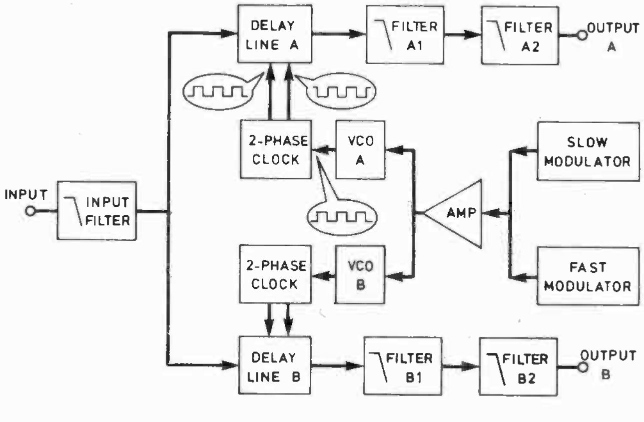


Fig. 3.1. Schematic of Chorus Generation system

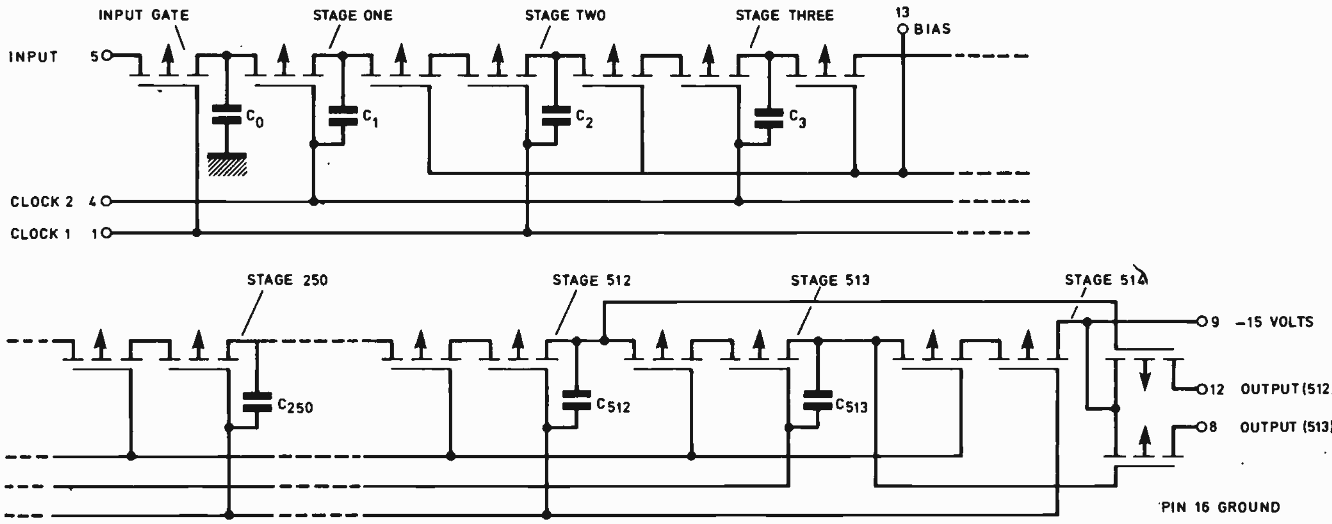


Fig. 3.2. Circuit of TDA1022 analogue delay line

Assuming that the first person has a full bucket, and all others are empty, it is possible to pour the water from bucket one into bucket two, then bucket two into bucket three, and so on until eventually all the water from the first bucket, excluding spillage, is transferred to the last bucket.

This description infers a delay which is dependent on both the speed at which each person reacts in filling his neighbour's bucket, and the number of buckets in the chain. In the String Ensemble it is fundamental that this delay line is controllable at will, and since the number of buckets, or stages in the device, is constant it is necessary to instruct each person how quickly to react before pouring the contents of their bucket into the next bucket, thus controlling the overall delay. The reaction time is quoted since in the electronic version the speed of pouring is very high such that variation in the "stage delay" is controlled by introducing a pause before the instruction to pour. Electronically the pause is created by an instruction to pour constituting the leading edge of a square wave which is known as the "clock". An increase in clock frequency corresponds to shouting "pour" at greater frequency thus shortening the stage and overall delay.

Carrying the analogy further, two instructions are used, which equate to two clocks, where one can visualise one male and one female instructor each instructing persons of their own sex in a line where the sexes are alternated. This is only a matter of electronic convenience and in future generations of bucket brigade delay line i.c.s one can expect that the required conversion from a single clock will be carried out in the same package.

ANALOGUE DELAY

The system described above can be digital or analogue, in the first case either full or empty buckets would always be concerned and in the second case the amount of water in the last bucket would directly relate to the amount contained in the first bucket as it commenced its journey.

In order to fully understand the electronic analogue delay line, sometimes called the analogue shift register, an alternative method of operation within our chain of bucket carriers and water pourers should be considered. Since we are not concerned with the actual transfer of water along the chain, but simply require to know how much water was in the first bucket when the chain commenced its sequence of operation, we can start with all buckets full apart from the first one which will be filled to the amount (analogue) of interest. On the first instruction (leading edge of Clock 1) the first person (male) puts the required amount of water into his bucket, which is equivalent to the level of the input signal at that moment, and on the second instruction the second person (female) fills up the first bucket leaving her with the same quantity of water previously contained in the first bucket. On the next instruction the third person fills up the second bucket and this continues down the line until the last bucket contains the same quantity of water as was present in the first bucket at the commencement of the sequence.

This can of course be a continuous process such that whilst the third person is topping up the second bucket, the first person is correcting the quantity in his bucket to match the new analogue or signal level.

BUCKET BRIGADE DEVICES

Many of the earliest instruments incorporating analogue delay line i.c.s used an ITT device, the TGA350, which contains 185 stages of delay in the package, but since that time Reticon, Matsuchita and Phillips (Signetics) have produced devices in various configurations ranging from a single 512 stage line in a package to 2 × 512 stage lines, tapped lines, and now rumours of considerably longer lines in a package. The potential application for A.D.L.s are numerous including echo, reverberation, double tracking, flanging and phasing, vibrato, chorus generation, speech delay matching in P.A., signal scrambling, time compression, pseudo-stereo, voice threshold switching and test equipment circuitry particularly associated with oscilloscope storage displays.

THE CHORUS MODE

Circuits have been proposed in which chorus is achieved by mixing a direct signal with the output of one delay line and the output of a second line fed from the first, both lines using the same changing clock frequency, but for the greatest effect the outputs from two or more lines should be mixed using clock frequencies modulated in an out of phase relationship—e.g. 180° for two lines, 120° for three lines. In practice this poses a problem for dual packaged lines in that on-chip intermodulation occurs in the form of both audio frequency tones and high noise. It is therefore necessary to use a separate package for each line, although noise advantages can be gained by using parallel dual lines in each position providing only one clock frequency is fed to the package.

FREQUENCY CONSIDERATIONS

The bucket brigade principle described earlier relies on sampling the input waveform at discrete moments in time, and since a bucket cannot be involved in both filling and emptying operations at the same time, Bucket 1 must wait for the transaction between Buckets 2 and 3 to be completed before it can again be involved with Bucket 2, and half the information from the input is automatically lost. This imposes a relationship between the bandwidth (DC to maximum input frequency) and the clock frequency, such that the input bandwidth should be limited to less than one-half of the clock frequency, and normally to less than one-third. The resulting sampled waveform at the output of the delay line requires heavy filtering to recover the original waveform and remove the clock frequency content.

TDA1022

The internal circuitry of the Signetics A.D.L. is shown in Fig. 3.2, using MOS technology f.e.t.s to switch the charge in the required manner between capacitors at each stage. The supply required is a nominal –15 volts, and at the clock frequencies used in the Ensemble (50–100kHz), the average delay for the 512 stages totals approximately 3·5ms, and for a distortion level of less than $\frac{1}{2}$ per cent the input level can slightly exceed 2V r.m.s., with a band width of 12–15kHz, and attenuation through a line will be typically 4dB.

Fig. 3.3(a)–(h) indicate the operation of the delay line in conjunction with Fig. 3.2. Clocks 1 and 2 are in anti-phase, odd number stages linked to Clock 2 and even number stages, together with the input gate, connected to Clock 1.

Taking a waveform as shown in Fig. 3.3(b), the voltage present whilst Clock 1 is up is transferred direct to C_0 in Fig. 3.2. When Clock 2 rises the charge in C_0 is topped up reducing the charge in C to that which was previously present on C_0. Thus in Fig. 3.3(c) the voltage on C_0 rises to V and in Fig. 3.3(d) the voltage at the output of Stage 1 falls to the value at the input immediately prior to the rise of Clock 2. This situation now prevails until Clock 1 rises again at which time C is topped up reducing the charge on C_2 to that which was previously on C_1.

With the rise of Clock 1 again C_0 continues to monitor the input voltage such that when Clock 2 rises again the new voltage level (second sample) at the input, immediately prior to the rise of Clock 2, is transferred to the output of Stage 1, whilst the voltage at the output of Stage 2, which is equal to the first sample, is transferred to the output of Stage 3.

Thus it can be seen that the time taken for each sample to move from one stage to the next is half a clock period, and input samples are taken once per clock cycle with the input blocked for one half of each clock cycle.

When stage 512 is reached, a further stage (513) is used to fill in the half of the clock cycle during which a sample has not been passed through the delay line giving the stepped waveform shown in Fig. 3.3(h) which is then filtered to reconstitute the input waveform.

CHORUS GENERATOR CIRCUITRY

The complete circuit of the Chorus Generator is given in Fig. 3.4. The bandwidth of the incoming signal is first limited by the low pass filter associated with IC19, and parallel connections taken to Channels A and B incorporating TDA1022 delay lines IC25 and IC26 respectively. The delay lines in each channel are followed by two low pass active filters based on IC20 and IC21 in Channel A and IC22 and IC23 in Channel B.

Clock frequencies are generated in IC28 and IC30 for Channel A and IC29 and IC31 for Channel B using the conventional v.c.o. configuration based on the CMOS 4007. In Channel A the variable resistance with voltage of the *n*-channel f.e.t. (pins 3, 4 and 5) is used to control the frequency of the oscillator comprising two gates of IC28 by virtue of its effect on the value of R59 which in combination with C45 determines its frequency of operation.

Two gates within IC30 are used to shape the waveform and produce an inverted version for the second phase of the clock.

In Channel B the *p*-channel f.e.t. (pins 1, 2 and 3) is used to control the oscillator comprising two gates in IC29, such that for the same modulation waveforms as pin 3 of IC30 and IC31, the oscillators work in anti-phase with respect to frequency variation.

Some gate wastage occurs in IC28 and IC29 due to the necessity to provide good decoupling of clock frequencies between the two channels, without which clock intermodulation would occur leading to a high noise level and swept audio frequencies at the output of the delay lines.

The modulation signals at pin 3 of the 4007's are generated by IC27 and amplified by IC24. IC27 is connected as two oscillators, similar to the clock oscillation but without voltage control, one operating at approximately 0·5Hz and the other at approximately 10Hz.

Filters, consisting of R47, C36, R48 and C37 for the slow modulator and R52, C40, R53 and C41, provide smooth modulation waveforms the level of which is controlled by VR9 and VR10 for slow and fast modulations respectively.

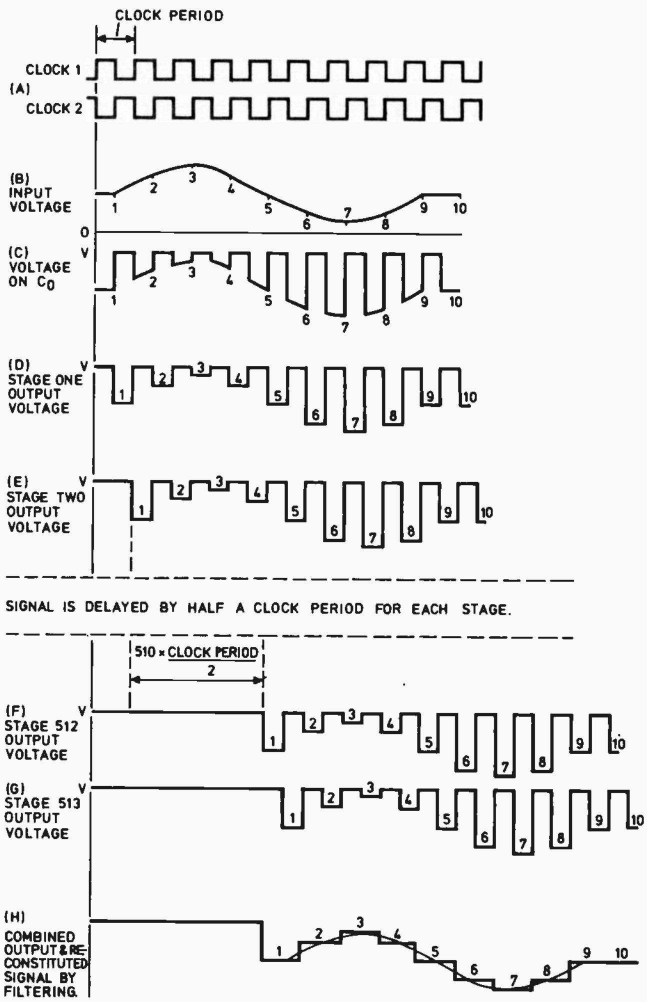


Fig. 3.3. Waveshapes showing operation of delay line

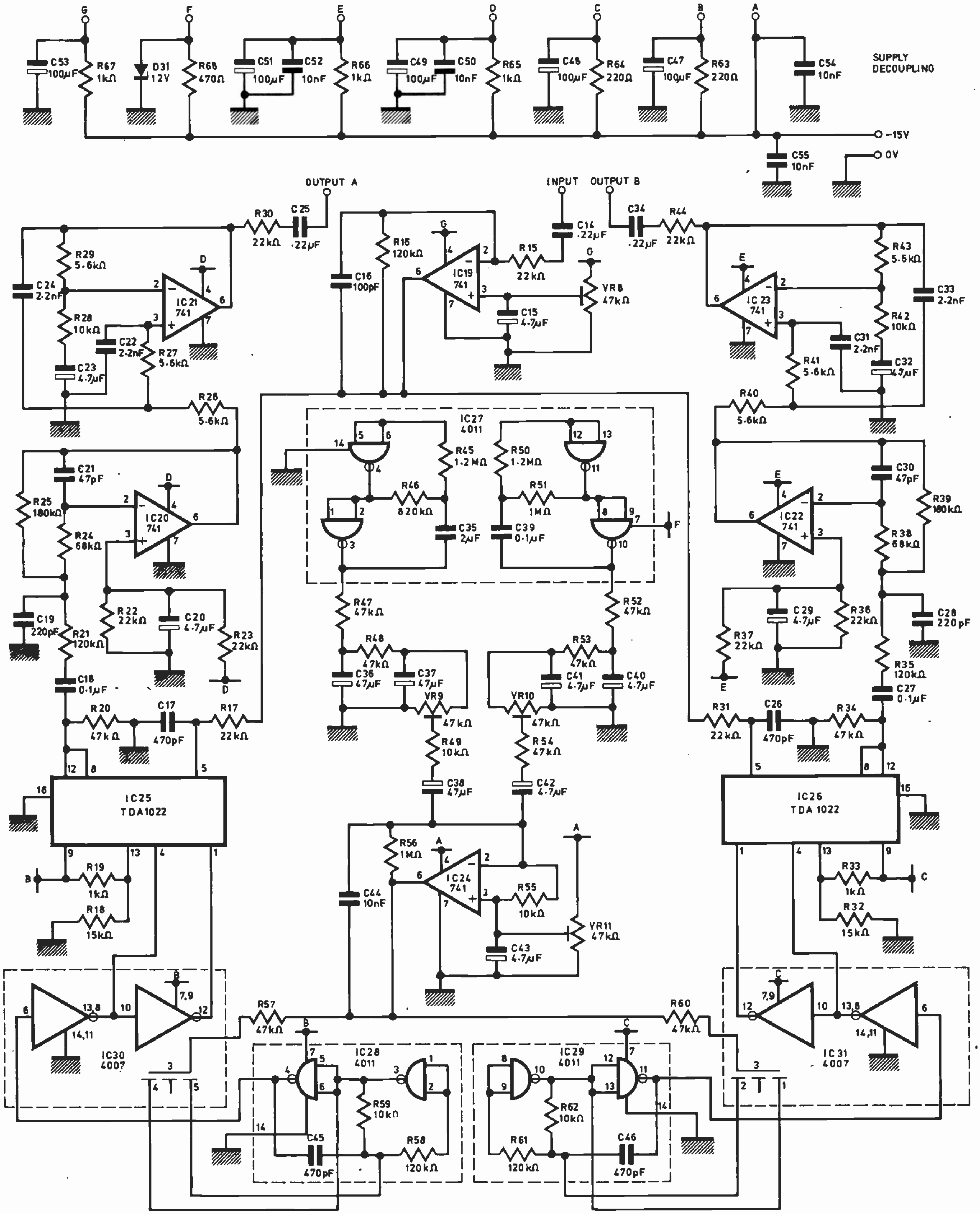


Fig. 3.4. Circuit of Chorus Generator

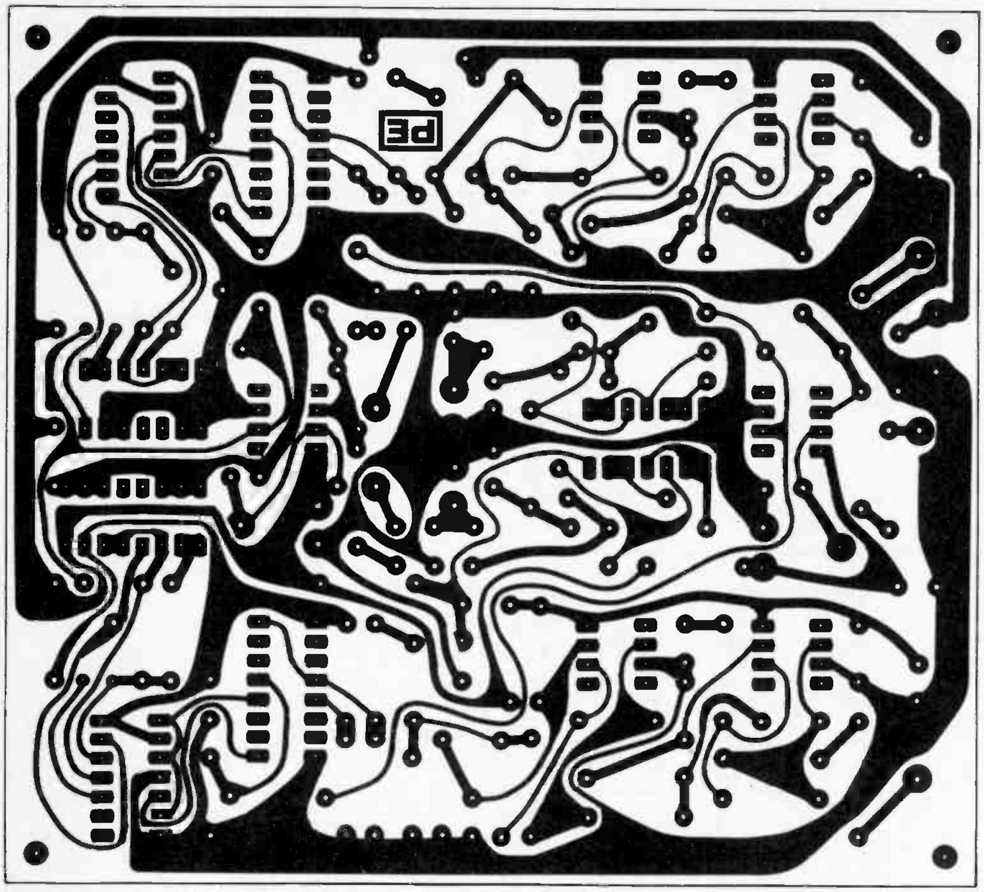


Fig. 3.5. Etching and drilling details of the Chorus Generation printed circuit board

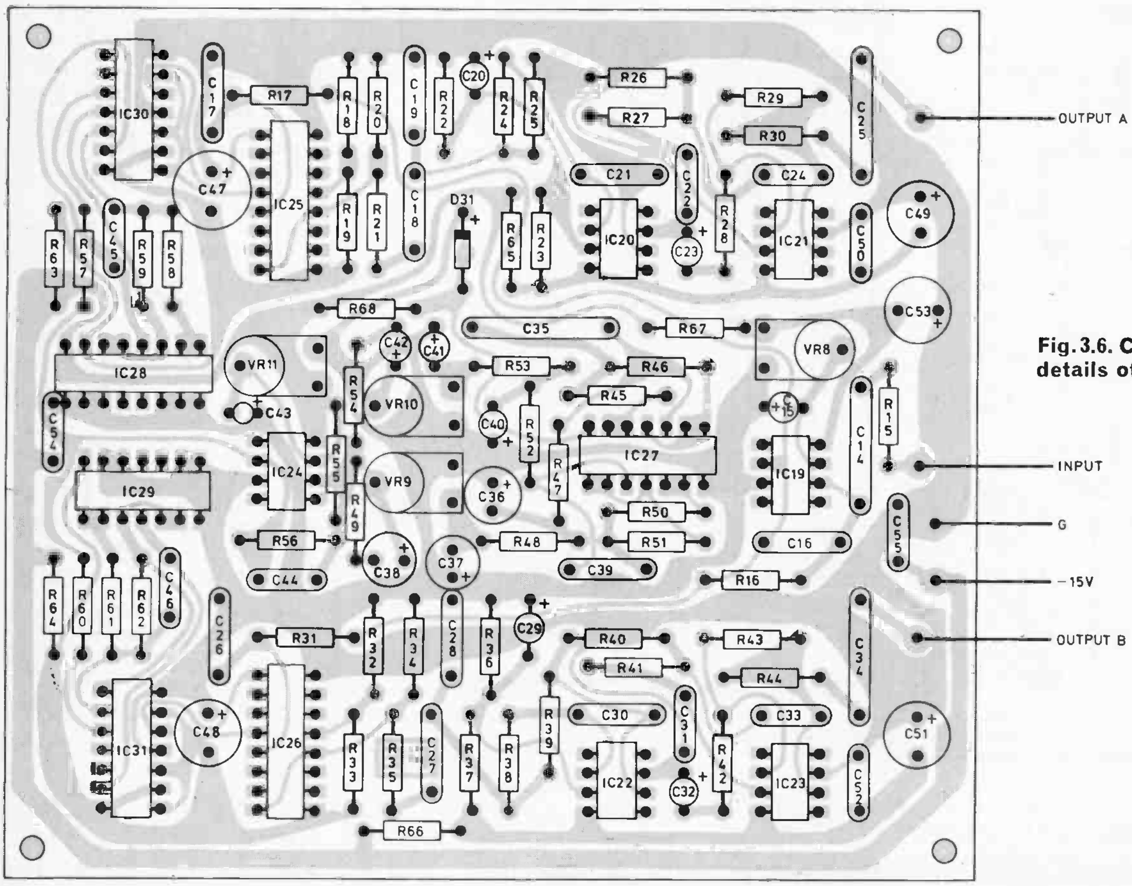


Fig. 3.6. Component assembly details of p.c.b.

COMPONENTS . . .

CHORUS GENERATOR

Resistors

R15	22kΩ	R32	15kΩ	R49	10kΩ		
R16	120kΩ	R33	1kΩ	R50	1·2MΩ		
R17	22kΩ	R34	47kΩ	R51	1MΩ		
R18	15kΩ	R35	120kΩ	R52–54	47kΩ		
R19	1kΩ	R36–37	22kΩ	R55	10kΩ		
R20	47kΩ	R38	68kΩ	R56	1MΩ		
R21	120kΩ	R39	180kΩ	R57	47kΩ		
R22–23	22kΩ	R40–41	5·6kΩ	R58	120kΩ		
R24	68kΩ	R42	10kΩ	R59	10kΩ		
R25	180kΩ	R43	5·6kΩ	R60	47kΩ		
R26–27	5·6kΩ	R44	22kΩ	R61	120kΩ		
R28	10kΩ	R45	1·2MΩ	R62	10kΩ		
R29	5·6kΩ	R46	820kΩ	R63–64	220Ω		
R30–31	22kΩ	R47–48	47kΩ	R65–67	1kΩ		
¼ watt 5% carbon film				R68	470Ω		

Capacitors

C14	0·22μF polyester
C15	4·7μF —V electrolytic
C16	100pF polystyrene
C17	470pF ceramic
C18	0·1μF polyester
C19	220pF polystyrene
C20	4·7μF 16V electrolytic
C21	47pF polystyrene
C22	2·2nF ceramic
C23	4·7μF 16V electrolytic
C24	2·2nF ceramic
C25	0·22μF polyester
C26	470pF ceramic
C27	0·1μF polyester
C28	220pF polystyrene
C29	4·7μF 16V electrolytic
C30	47pF polystyrene
C31	2·2nF ceramic
C32	4·7μF 16V electrolytic
C33	2·2nF ceramic
C34	0·22μF polyester
C35	2μF non polarised
C36–38	47μF 16V electrolytic
C39	0·1μF polyester
C40–43	4·7μF 16V electrolytic
C44	10nF ceramic
C45–46	470pF ceramic
C47–49	100μF 16V electrolytic
C50	10nF ceramic
C51	100μF 16V electrolytic
C52	10nF ceramic
C53	100μF 16V electrolytic
C54–55	10nF ceramic

Potentiometers

VR8–11 47kΩ presets 100mW subminiature

Diodes

D31 12 volt 300mW Zener

Integrated Circuits

IC19–24	741
IC25–26	TDA1022
IC27–29	4011
IC30–31	4007

Miscellaneous

1 Printed circuit board; 2–16 lead d.i.l. sockets; 5–14 lead d.i.l. sockets; 5 terminal pins

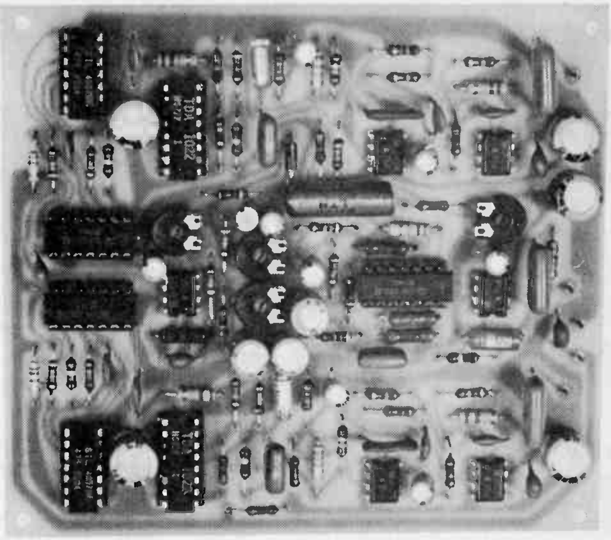


Photo of Chorus Generation board

SETTING UP THE CHORUS GENERATOR

VR8 provides a d.c. control to the input filter which sets the input bias on both delay lines. This preset potentiometer should be adjusted such that with a signal present at the input, the combined A+B outputs will move from zero, through a distorted period, through a clear range, a further distorted period and back to zero. VR8 should be finally set for the centre of the clear transmission range to give maximum signal handling capacity for the delay lines.

With VR9 and VR10 at minimum, VR11 adjusts the centre frequency of the two v.c.o.s to approximately the same value. This is achieved by initially setting VR11 near its midpoint and VR9 slowly increased. The combined A and B output signals should be subject to a phasing effect with a smooth sweep and sweep turn-around characteristic. If the sweep appears to pause at one end, VR11 should be adjusted to recover the even sweep. VR9 should then be reduced and VR10 increased to mix in the fast modulator, the levels of both being adjusted to taste.

All the adjustments associated with the clock modulation are slow to take effect due to the long time constants associated with the slow modulator filters. This time constant also produces a turn on delay of a few seconds, before the chorus modulation commences, after switching on the instrument. Rapid adjustment will stop the chorus modulation which will then recover after a few seconds.

CHORUS GENERATOR CONSTRUCTION

All the chorus generation circuits are mounted on a single printed circuit board, the etching and drilling details of which are given in Fig. 3.5 with the component assembly details in Fig. 3.6.

To assemble the board the previously recommended order of terminals, pins, resistors, Zener (D31), i.c. sockets, preset potentiometers, small capacitors, and finally large capacitors may be used. Sockets are recommended for the 14 and 16 lead i.c.s which are all of MOS type and therefore sensitive to handling, but these are not necessary for the 741 type i.c.s.

Careful attention should be paid to correct orientation of the i.c.s.

Note—the track cutting amendment given finally last month refers to IC3

NEXT MONTH: Voice/preamp board construction

PATENTS REVIEW...

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

SOUND CONTROL BP 1 476 516

Patents continue to give an interesting insight into the areas under research by Sony in Tokyo. In BP 1 476 516, Sony describe how a.g.c. circuits in a stereo amplifier must act on both channels if image swing from left to right, through one channel level dipping in volume while the other remains untouched, is to be avoided.

However, there is a difficulty with this approach, because a high level transient in one channel can dip the level of both channels and in so doing push quiet sounds down to inaudible levels. Sony have patented a circuit which is claimed to overcome this problem. The block diagram, Fig. 1,

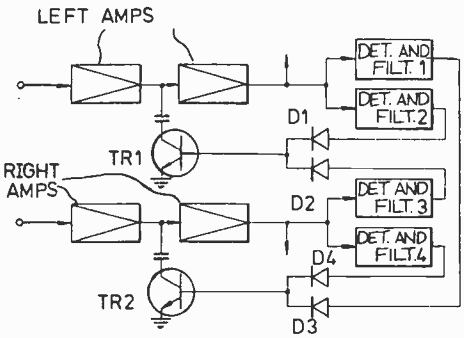


Fig. 1

shows left channel amplifiers feeding detector and filter circuits to produce gain control signals. Diode D1 connects the output of the detector circuit 2 to the base of gain control transistor TR1. A right channel is arranged in corresponding fashion, with the output of detector circuit 4 connected to gain control transistor TR2 via D4. There is also, however, a cross-feed of the outputs of detector circuits 1 and 3 between channels, via further blend diodes, D2 and D3.

In action, control signals of high amplitude applied to the base of the gain control transistors reduce the collector-emitter impedance and thus reduce the gain of the signals passing between the amplifiers. The attack time of both detector circuits 2 and 4 is made small (around 0·1 second) and their recovery time is made large (between 20 and 30 seconds). Thus the circuits are capable of passing relatively short transient signals which control the gain of their own respective left and right channels.

The attack time of the cross-channel circuits 1 and 3 is however approximately 5 second, i.e. substantially longer than the attack time of circuits 2 and 4. The recovery time of the cross-channel circuits is also much shorter, for instance, around 5 seconds.

When a transient of high amplitude is applied to one channel only, the a.g.c. function of that channel begins to operate in less than 0·1 second; but the gain control of the other channel transistor will not be affected. During normal operation, the a.g.c. functions of both channels are controlled by the average voltage. In this way there is overall a.g.c. and a transient peak in one channel should cause neither an image swing nor inordinate depression of the other channel's level.

HIGH VOLTAGE SWITCH BP 1 486 804.

Siemens AG, in BP 1 486 804, suggests a clever way of controlling high voltage remote switching, for instance in the order of 1MV, without corona discharge.

A series of thyristors, each suited to control a voltage of 1kV, are arranged in a circle. A second series of similar thyristors are arranged in a second, smaller circle, spaced from the first, so that the two circles lie as if on the exterior of an imaginary cone (see Fig. 1). To enable remote operation, the thyristors are associated with light or other electromagnetic radiation-sensitive circuitry. A radiation source, "s" is arranged at the focal point of a parabolic reflector "r", with a firing control signal "z" supplied to a radiation generator "e". The emitted signal "h" is beamed towards the two rings of thyristors, which by virtue of their arrangement (as if on an imaginary cone) all receive similar amounts of radiation, with no one thyristor and its sensor shielding another.

The individual thyristors are connected in series with each thyristor switching the next-higher potential, so that in the first circle t1 switches 1kV, t2 switches 2kV relative to 1kV, and so on, up to t8, which switches 8kV relative to 7kV. A similar arrangement is obtained in the lower circle of thyristors, so that there is between two adjacent group planes no greater potential than 8kV, and between the neighbours of a group plane no more than 1kV. In this way corona discharge and flash-over are avoided, with the single safe firing signal "z" remotely switching a voltage of level governed only by the number of thyristors placed on the notional cone.

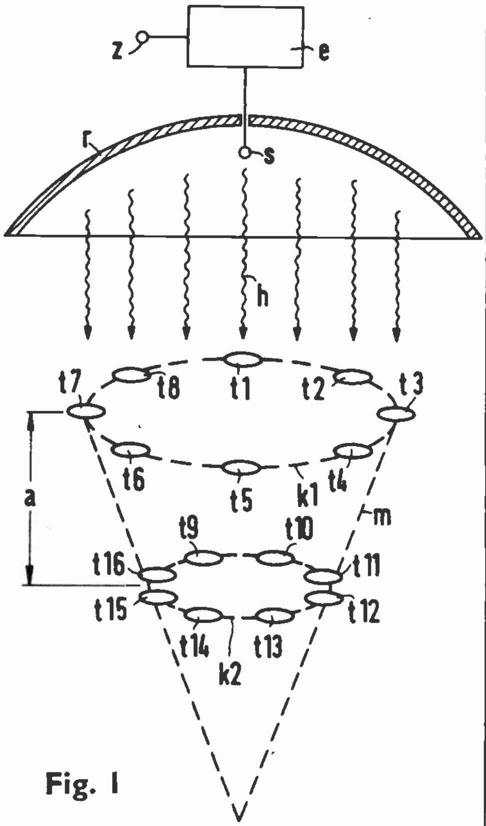


Fig. 1

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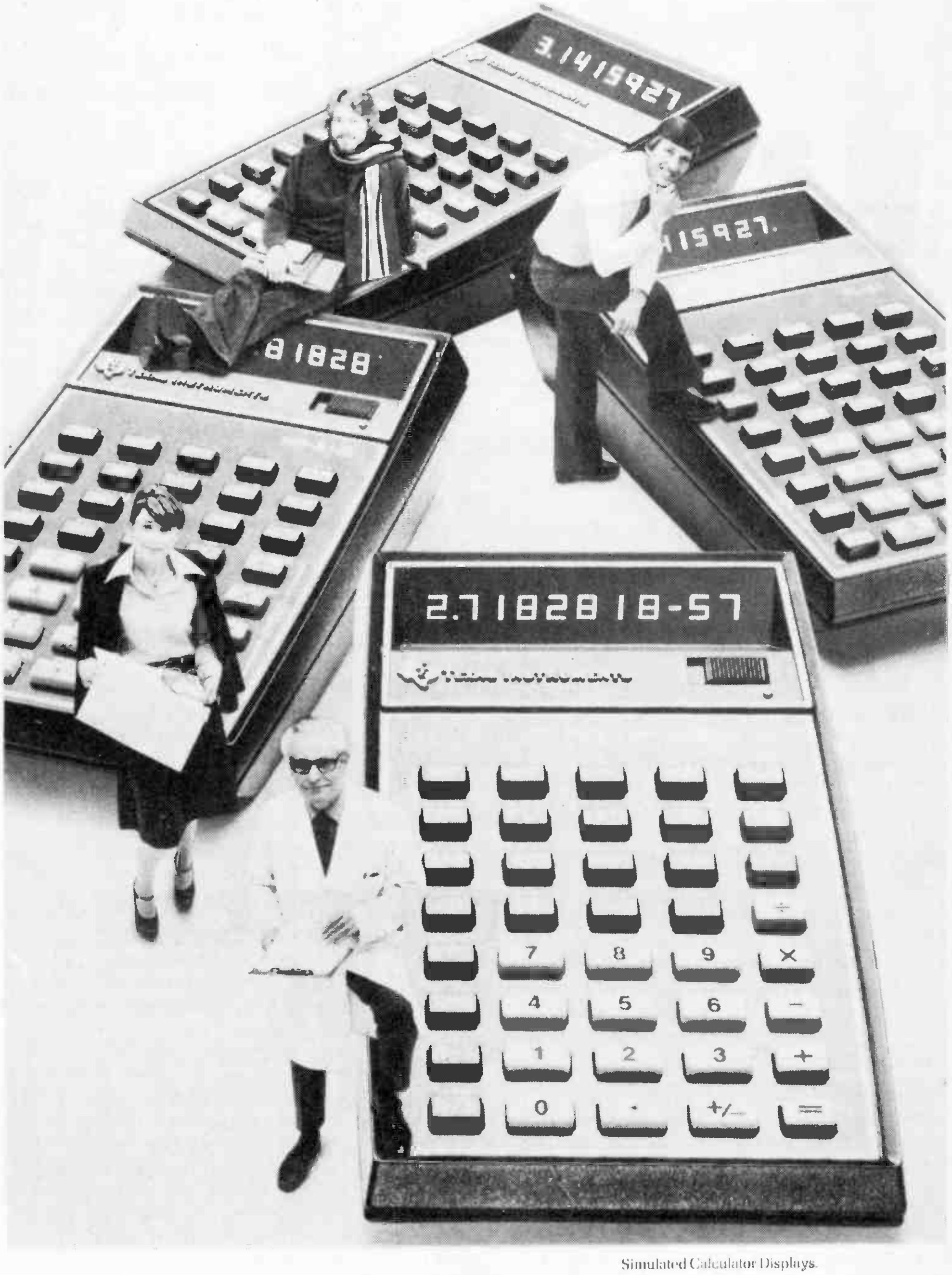

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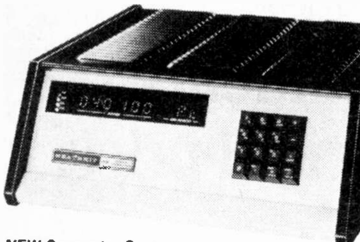

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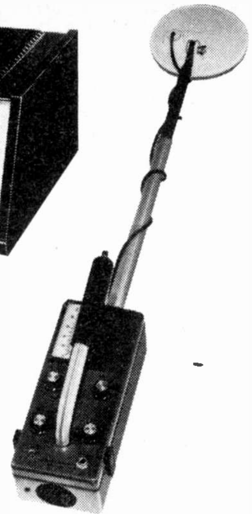

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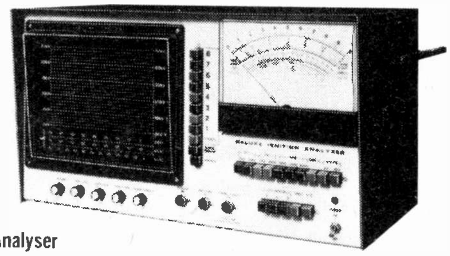

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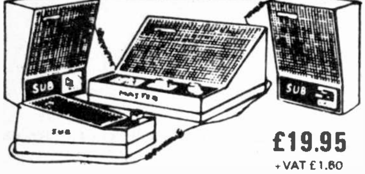

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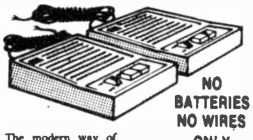

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4 7	04½p	05p	05½p	06p
6 8	05p	05½p	06p	07p
10	05p	06p	07p	09p
22	06p	07p	09p	13p
33	07p	08½p	10p	15p
47	08p	10p	12p	19p
68	09p	12p	16p	23p
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next month

FREE ENTRY Competition...

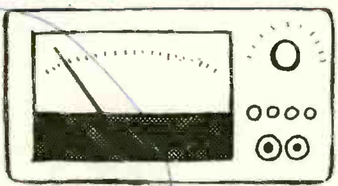
Your Ideas in Production! Plus £490 worth of Test Gear TO BE WON!

If you enter our competition you could see your design in production, reap the financial reward and win yourself some test gear.

We feel that many of the projects devised by readers and contributors are suitable candidates for commercial products and, with this in mind, P.E. has made an exclusive arrangement with a venture capitalist to provide backing.

The competition is open to almost everyone and, in addition to the chance of winning this backing, there will be £490 worth of Scopex 'scopes to be won!

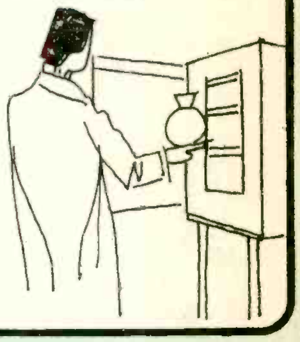
LINEAR CAPACITANCE METER



With eight decade ranges it is possible to read capacitance from 300pF to 3,000μF on a linear scale, due to integrator circuit operating techniques. An absolute accuracy $\pm 2{\cdot}5$ per cent can be attained if suitable components are used, and for matching, comparative measurements can be made to an accuracy of as little as $\pm 0{\cdot}25$ per cent.

KILN CONTROLLER

Pottery is now a popular hobby and many amateur potters, schools, etc. possess small kilns. Most kilns are only supplied with an indicating pyrometer and have no temperature control; this can be provided by our project, described next month.



PRACTICAL
ELECTRONICS

OUR JUNE ISSUE WILL BE ON SALE FRIDAY, 12 MAY, 1978

MARKET PLACE

Items mentioned in this feature 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.

TUNE SEQUENCER

To the numerous electronics kits for the home constructor available from **Phonosonics**, has been added the 128 Note Sequencer of *P.E.* November and December 77.

This programmable sequencer was designed with the *P.E.* Minisonic in mind, for which Phonosonics can provide the various kits, and Kimber-Allen Keyboard.

A kit comprising components for the Sequencer Main Board (Kit 76-1) is now available. Control switches and p.c.b.s are not included. Kit 76-2 provides the components for three "Optional Trigger Inverters" and one "Alternative Output Circuit".

The same company are also able to supply kits for the *P.E.* String Ensemble.

Details of the above component kits, p.c.b.s, and prices can be obtained by sending a s.a.e. to **Phonosonics, 22 High Street, Sidcup, Kent, DA14 6EH.**

TOMORROW'S TECHNICAL LANGUAGE

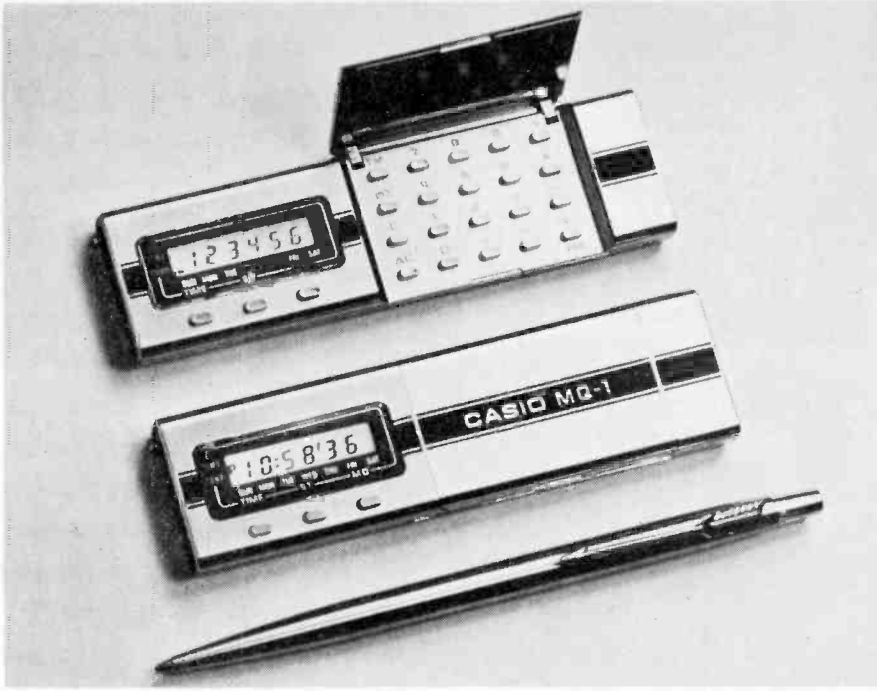
The International Electrotechnical Commission, the organisation responsible for the preparation of world-wide standards in the electrical and electronic fields announces the publication of the 1978 edition of their International Electrotechnical Vocabulary (IEV).

The purpose of the IEV "dictionary" is for there to be one common technical language for the scientists and engineers of tomorrow.

Containing originally some 2,000 terms, today the IEV, in line with the unparalleled growth in electrotechnology, accounts for more than seventy thousand internationally agreed terms.

The International Electrotechnical Commission comprises member countries representing 80 per cent of the world's population consuming 95 per cent of electrical energy. At present there are some twenty thousand pages of IEC standards in each of the official languages of the Commission, the largest set of international standards existing in the world.

Details from **IEC, 1 Rue de Varembé, 1211 Geneva 20, Switzerland.**



BEAUTIFUL AND CLEVER

A slim and elegant accessory (present) for the modern woman. That's the Casio MQ-1 multi-function micro-computer.

Its time display is constantly visible even in bright light and quartz accuracy is plus or minus fifteen seconds per month.

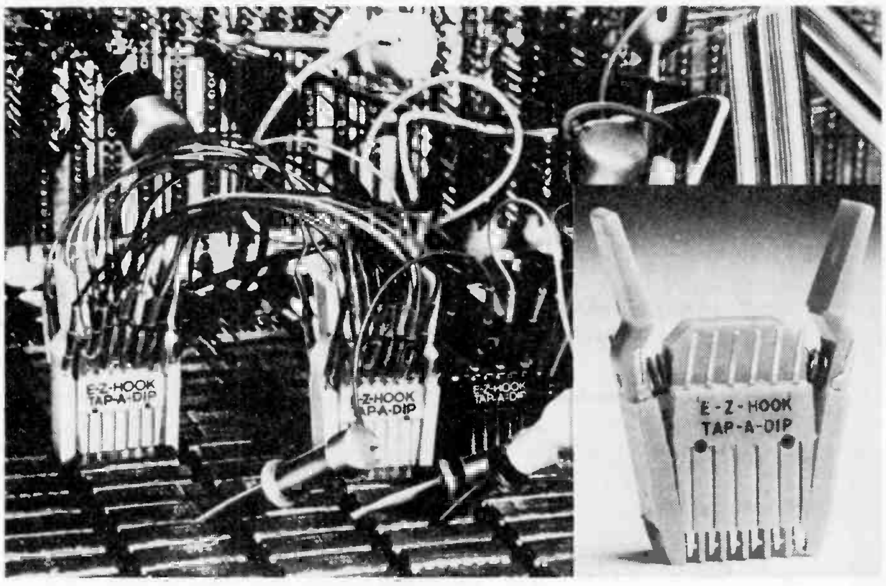
The calendar function is capable of helping the busy female to be in the right place on the right day up until 31st December 2099. If she wishes to compute whether a friend was born "full of grace", the same function can do calculations back to 1st January 1901.

A genuine stopwatch allows a full 24 hours of continuous timing of one tenth of a second accuracy.

The timer function can count down enabling, say, remaining parking time to be seen at a glance. Also, by setting the timer to count up from a set origin a continuous read out of an overseas time zone can be run without altering home time.

Finally, the four basic mathematical functions are possible on the petite calculator panel which is beautifully designed for a slim feminine finger.

£34·95, including leatherette wallet available from **Tempus, 19-21 Fitzroy Street, Cambridge, CB1 1EH.**



An American test clip which doubles as an insertion and removal tool for 14 and 16 d.i.l. packages is available, priced £9·04 (14 pin) and £9·38 (16 pin), from **BCE Ltd., Briticent House, New Street, Ringwood, Hants.**

IIY ALARM SYSTEM

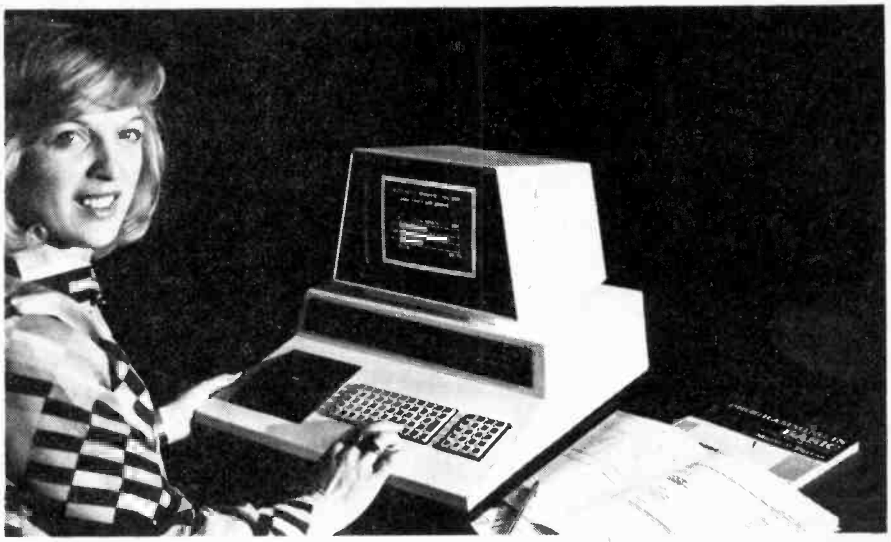
Motor vehicle alarms fitted by garages tend to be expensive. These systems usually consist of switches fitted to the doors, bonnet and boot or operate with a trembler switch.

An install it yourself (IIY) alarm by Photain Controls operates on an entirely new current sensing principle. This unit monitors the outflow of current from the battery of a vehicle. Current flow can be caused by anyone attempting to start the vehicle or when a lamp is illuminated by the opening of a door, the bonnet or the boot. The alarm can operate the existing vehicle horn or a separate siren from Photain.

When activated the horn will sound for a period of sixty seconds and the unit will then automatically reset for the next operation. To enable the owner to leave and enter the vehicle quietly two time delays are incorporated.

The easily installed unit operates from the 12 volts DC vehicle battery (negative earth) and has a current consumption of only 1mA in the set condition. The complete unit measures 55mm × 100mm × 64mm, weighs 227 grams and will operate over a temperature range of minus 20 degrees to plus 60 degrees centigrade.

Price complete with on/off switch, mounting brackets, fixing screws and connecting cable is £20 plus 12½ per cent VAT. Siren costs £12 plus VAT. **Photain Controls Ltd., Unit 18, Hangar No. 3, The Aerodrome, Ford, Arundel, West Sussex.**



A NEW PET FOR YOUR HOME

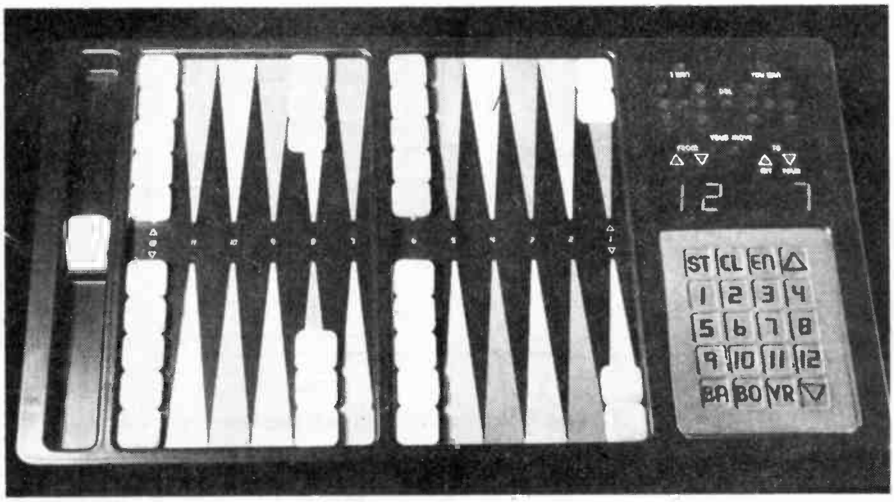
The Commodore PET is now available in the U.K. although you will have to wait at least 30 days to get one—provided of course you have £695. The PET is a "low priced" all-in-one microcomputer designed with the user in mind. The package incorporates a 9 inch CRT which will accommodate 25 lines of 40 characters, and a standard cassette system for program storage and entry. A keyboard containing 73 alpha numeric keys plus 64 additional graphic characters for plots, games or "artwork", lower case letters is also available.

PET operates in BASIC and comes with 8k of RAM and 14k of ROM which includes 4k operating system and 1k diagnostic routine.

Commodore will be marketing PET from office/showroom premises in London and they will also be setting up a PET Owners Club. They hope to offer such items as extra RAM (24k we believe), floppy disks, printers etc., at a later stage.

We also hear from Commodore that they have been able to reduce the price of KIM1 to £149.00 plus VAT.

More details from **Commodore Systems, 446 Bath Road, Slough, Berkshire.**



BACKGAMMON COMPUTER

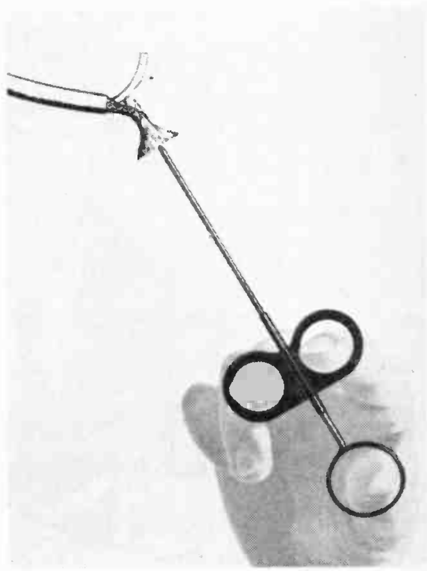
The latest microprocessor-based game now available from Gemini Electronics is backgammon. The unit which is called the Gammon Master II is based on the Motorola 6800 microprocessor and is designed to change its strategy depending on the type of game you choose: running block and hit, back games, it is capable of playing them all.

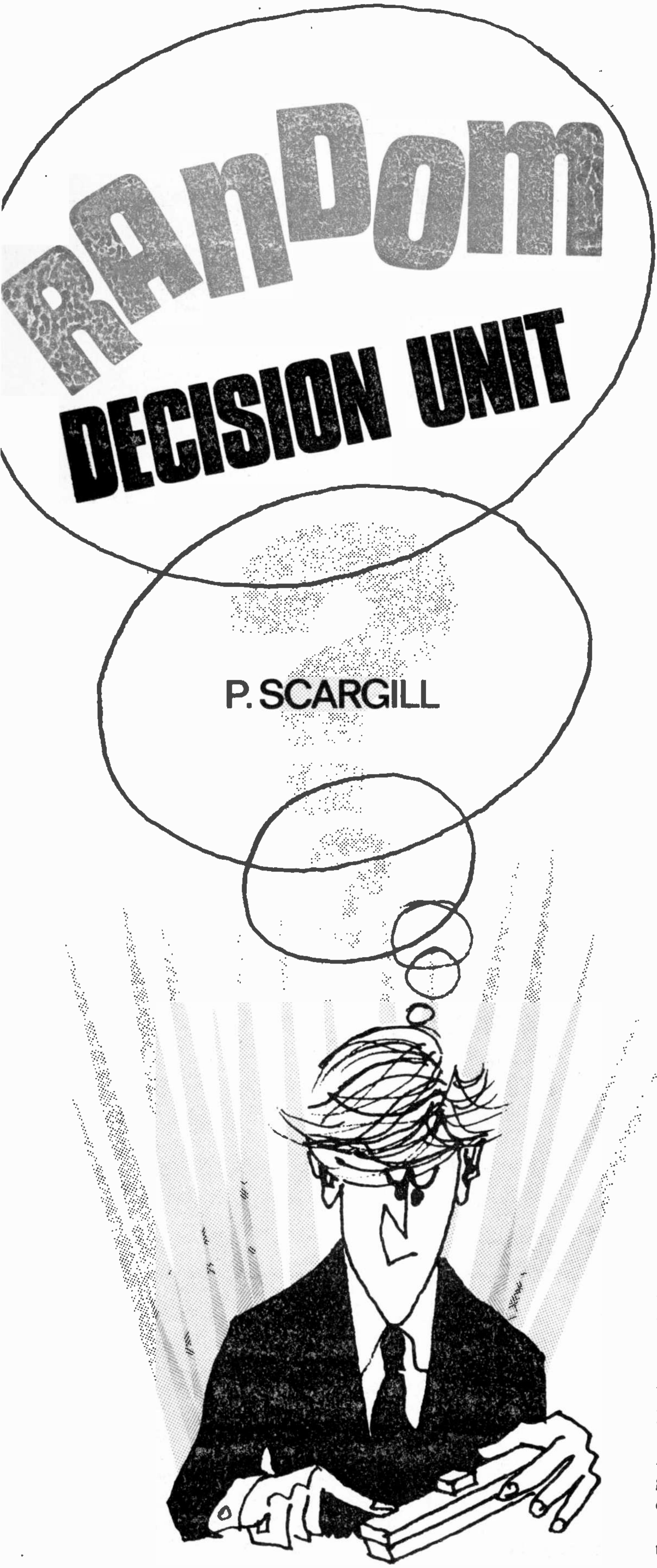
It is claimed that the unit will on average defeat an intermediate player and compete evenly with experts. Each game is "charted" with regular pieces and the location of every man on the board can be verified by the touch of a button. The dice is also electronically "rolled" ensuring each game is different.

The total cost of the game including VAT and post and packing is £175·00. It is available by mail order only from **Gemini Electronics, 3 Branksome Avenue, Prestwich, Manchester.**

MAINLINER

Co-axial cable de-braiding tools handling cables from 3·3mm to 13·5mm and having the memorable name of "Mainliner" are available at £5·58 plus VAT from **Eraser International Ltd, 2/3 Hampton Court Parade, East Molesey, Surrey, KT8 9HB.**





RANDOM DECISION UNIT

P. SCARGILL

THE circuit to be described has several advantages over previously published designs, in that most have used mechanical switches. If the unit is carried in a pocket, this is a major disadvantage as it can be switched on accidentally during movement, leading to shortened battery life. The touch switch alternative used here obviates this.

The circuit has no tendency towards biasing the outcome, and as the i.c.s are CMOS and the indicators are l.e.d.s, it is a gadget that will probably last for years.

The use of CMOS means that standby current is so low that an on-off switch is not necessary.

The whole unit including battery is built into a box of, in the case of the prototype, 120 × 30 × 20mm.

CIRCUIT

In Fig. 2. IC1a and b form an oscillator whose frequency is controlled by R1, R2, C1 and C2. The output of this oscillator feeds IC2a, a JK flip flop. The $\overline{Q}$ output of IC2a connects to the clock input of IC2b, another flip flop. As each flip flop has two possible output states, there are four possible output conditions in total. The four outputs are fed to IC3, a quad NAND package, which acts not only as an inverting buffer to the outputs (although in this case the inversion feature has no relevance) but also it acts to gate the outputs hence acting as an on-off switch for the display.

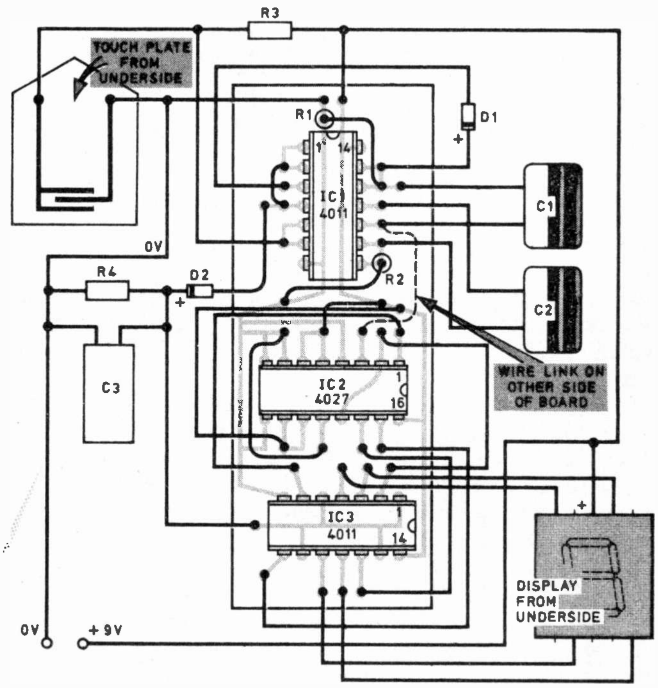


Fig. 1. Wiring diagram of Random Decision Unit.

The outputs of IC3 feed the l.e.d. segments of the display.

To be safe, 100Ω resistors should be inserted in series with the four cathode leads to the display, however, in the prototype these were not used as all the i.c.s tried appeared to limit their own output current without the inclusion of these resistors. They have not been shown in the diagram nor in the layout drawing but can be included if it is desired to play safe.

IC1c and D1 serve to gate the oscillator (IC1a and b). Attempts were made to use one of the spare inputs of these gates, but in two of the i.c.s tried, this made start up of the oscillator unreliable so the present method was adopted.

When the junction of IC1c and D2 is taken high, C3 charges through D2 and hence the display is activated, also IC1c goes

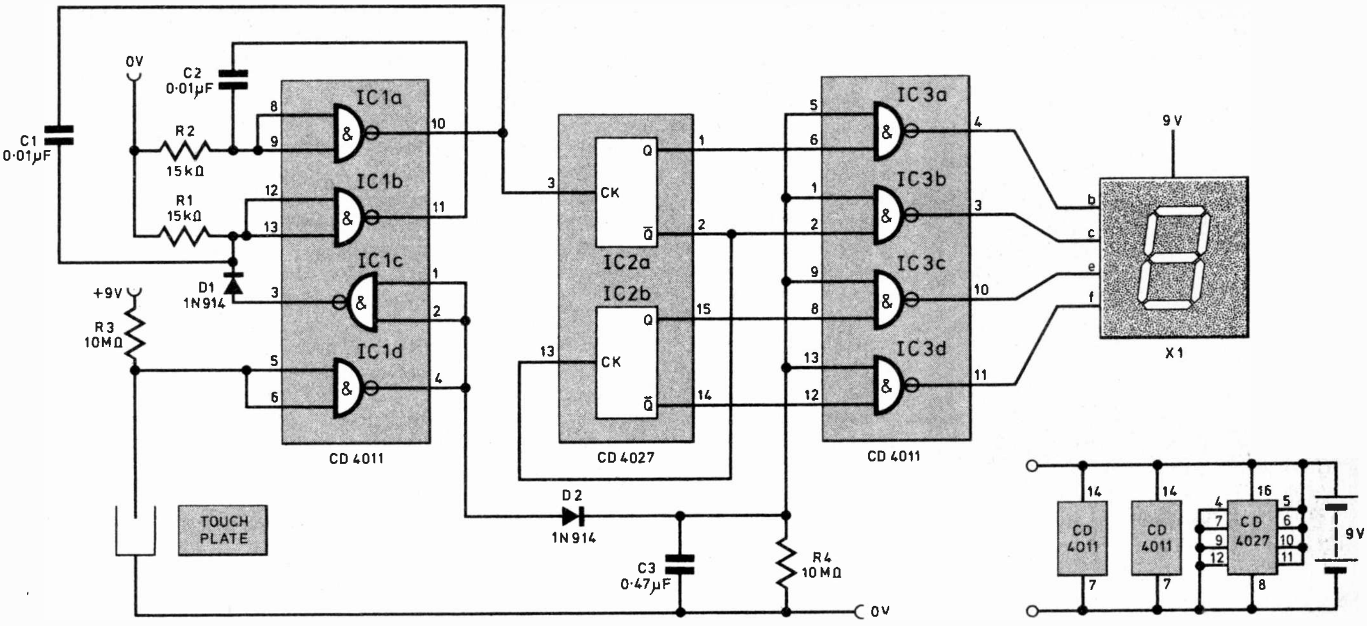


Fig. 2. Circuit diagram.

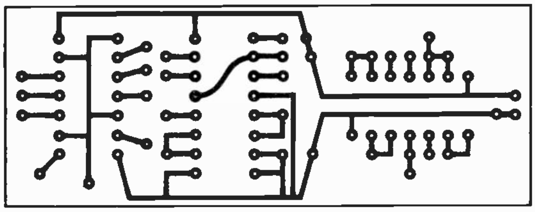
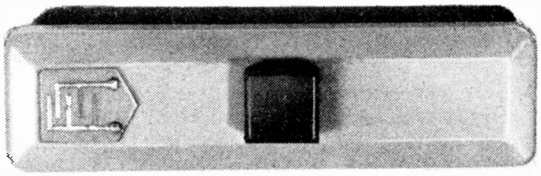


Fig. 3. Printed circuit board design



low and the oscillator starts up. As the above mentioned junction goes low, the oscillator stops immediately, however the display remains active until C3 has discharged through R4, hence sufficient time is given (5–6 seconds) to read the resulting display. IC1d serves as a buffer with its input normally kept high via R3.

Touching the plate takes IC1d input low (due to skin conductivity) and the above explained process occurs.

In the quiescent state, the i.c.s take virtually no current, and the only real flow is that through D1 and R1, this amounting to around ½mA. Hence an on-off (mechanical) switch is not really justified.

CONSTRUCTION

The touch plate is shown full size and the copper lines should not be made any closer than that shown, otherwise dampness caused by breathing near the plate could lead to shortened battery life. If trouble is experienced, the value of R3 can be reduced slightly without significantly affecting the sensitivity of the touch plate. See Fig. 1.

Construction methods will vary depending on the type of case available, however in the prototype construction of both the p.c. board and the touch plate was on copper coated p.c. board. An excellent system to use for etch resisting is the Alfac range of electronic symbols (lines, bends, etc), however these are expensive, but if a professional looking finish is desired, this system is excellent. The i.c.s should be mounted on sockets if space permits and they should be mounted last, and must not be handled until you are ready to use them as they are liable to damage by static, and the more often handled, the greater the chance of damage. The battery should not be fitted until all parts and all connections have been checked.

COMPONENTS . . .

Resistors
R1–R2 15kΩ ¼W 10% (2 off)
R3–R4 10MΩ ¼W 10% (2 off)

Capacitors
C1–C2 0·01µF polyester
C3 0·47µF 35V tantalum

Integrated Circuits
IC1/IC3 4011 (2 off)
IC2 4027
XI FND 507 (common anode)

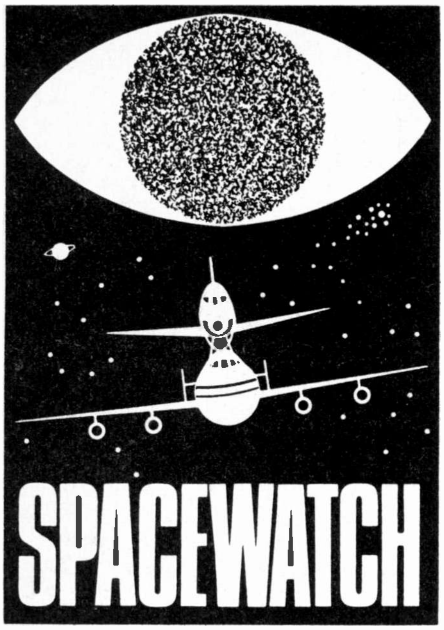
Diodes
D1–D2 1N914 (2 off)

Miscellaneous
Printed circuit board, sockets for i.c.'s (if req.), PP3 battery, suitable battery press studs.

OPERATION

In use, the plate is touched and all 4 segments will light up, appearing to be all on at once due to the high oscillator speed used. On release of the plate, 2 of the 4 segments will remain alight. Which two is *totally* random and there should be *no* bias toward any particular combination (of the four possible alternatives). If segments bce and f are used as in the prototype, it could be said that a straight line represents "EVENS" and a staggered line represents "ODDS".

Keep the unit in a reasonably dry atmosphere and the battery should last for many months. ★



THE SAGA OF SALYUT, SOYUZ AND PROGRESS

The year 1978 will mark a special place in the history of Soviet space progress. On Valentine's day Yuri Rmanenko and Georgi Grechko began using equipment brought up to them by the cargo spacecraft Progress 1.

They began erecting an electric heating chamber in a special lock compartment. Photographic and other monitoring equipment was set up also. Part of the programme included the photography of Earth and space phenomena. Optical instruments for navigation were tested in the new mode where operation can be automatic or manual depending whether the station is with or without crew. This facility can be operated whether the vehicle is on the dark side or the light side of the Earth.

The furnace was brought up by Progress 1 and assembled by the two cosmonauts. This furnace, whose temperature is in excess of 1,000°C is controlled by a computer. An accuracy of plus or minus five degrees can be maintained. The unit is installed in the lock compartment which is arranged so that the rear end of the furnace faces into space.

The first experiment in smelting was to study the diffusion process of molten metals in weightless conditions. A capsule of aluminium-magnesium, copper-indium and indium-antimonide was introduced into the heating chamber. The airlock was depressurised and the heating switched on. At the same time the control of the spacecraft for orientation was switched off to allow the vehicle to drift. The process of crystallization was completed and the control engines took over again. The materials obtained during the experiment will be brought back to Earth for study.

A second experiment was carried out; research materials were aluminium-tungsten, molybdenum-gallium and semiconductor materials. These results will also be examined when they are returned to Earth. Information about the interaction between liquid and solid metals will show what reaction occurred under weightless conditions. The aim of these experiments is to gain knowledge of welding and soldering and also the possibility of the creation of new composite materials.

Optical observations have also been carried out particularly with regard to silver clouds, which may provide information about the state of the atmosphere. These clouds tend to appear at about 80 kilometres above the poles. Many drawings have been made as well as photographs. It is clear that these clouds are in distinct layers. Three of these layers have been observed between −130° and −150°C. During this time the Aurora was very prominent and reached a height of about 500 kilometres.

In the mission there was a programme for the study of biological effects involving drosophila, micro-organisms and tissue culture. Two day larvae of drosophila were taken aboard the spacecraft in a nutrient medium, contained in a special thermostatically controlled container, Biotherm-4. The temperature was held constant at 24°C. The first flies appeared in December 1977 and the reproduction cycle began again. This time it was in the condition of weightlessness. The object of this experiment is to determine effect of weightlessness on the insects' hereditary systems.

An important phenomenon was confirmed regarding the productivity level of the cosmonauts. There was an increase in their output of 10 per cent. This was noticed with the activity of the previous long term team, Sevastyanov and Klimuk, which lasted 63 days. It would appear that prolonged weightlessness is like getting second wind.

Another point which is being closely watched is the calcium loss in the bone structure. It would seem that as the skeleton is no longer needed to support the body the amount of calcium reduces. This was of course also noticed with the American teams.

RADIO TELESCOPE

The largest telescope of its kind has been installed in the Salyut-Soyuz space station and is to operate in the 1·5 millimetres band. The detector, which consists of crystals, is cooled in a closed circuit using liquid helium at a temperature of −269°C: The liquid helium is made on board and the final cooling is by an expanding throttle valve.

The telescope is being used to detect radiation in the infrared part of the spectrum. This particular wavelength is not observable from Earth because of the cut-off caused by the atmosphere. The instrument will be turned towards Earth to examine the upper layers which are important in weather forecasting. The control system uses Jupiter and Sirius as test locations.

Also included in this programme are observations of the centre of the galaxy, the Orion nebulosity and interstellar clouds.

THE PROGRESS 1 DESIGN

The development of Progress 1 was based on economy and reliability. Both these parameters were best served by making use of existing tried materials and units. For example the carrier was similar to that of an ordinary manned Soyuz. Only the emergency rescue system was removed. Since there were no crewmen this was redundant.

The main re-design was on the spacecraft itself. In order that the maximum payload might be carried it was decided that the Progress 1 should be non-recoverable. This decision enabled the heavy heat protection shield to be discarded.

Progress 1 weighed 7,020 kilogrammes and could carry 2,300 kilogrammes of cargo. This amounted to 30 per cent of the lift-off weight, a very high proportion for a spacecraft. Progress was 2·2 metres in diameter and 8 metres long. Without solar panels the flight time was for eight days, in independent operation. However its design was such that it could have remained a month in space if linked to the space station. The vehicle was indeed a tanker for it carried upwards of half a ton of fuel, plus 1,300 kilogrammes of dry cargo.

In order that the dynamic characteristics should not be affected a new power scheme was developed.

A number of frames supporting the hull were removed to make economical use of the space. These were replaced by a structural framework supporting shelves to which containers were attached by quick release locks.

New systems in the craft included a pumping installation to transfer the fuel to the space station. Control systems were extended to ensure reliability in the absence of manual control.

It took the cosmonauts twelve trips to unload Progress 1 on its arrival and docking with the space station. Before the re-fuelling operation, the cosmonauts had replenished the air supplies from that brought up by the cargo craft. Stock air had been depleted by the disposal of waste and the space walk.

While still locked to the space station another series of 'resonance' experiments were carried out. No doubt the cosmonauts enjoyed using the cargo ship as a trampoline.

The Progress engines were used to make a correction to the orbit of the space station. After that the cosmonauts set about the separation of the two craft.

Before the Progress 1 was allowed to enter the atmosphere it performed one more task. One orbit after separation, when it was 12 to 15 kilometres away, the back-up automatic and approach systems were tested. This had never been tried before.

Semiconductor UPDATE...

FEATURING: 8086, Z8000, MC6809, TL170C, 355 **R. W. Coles**

THE 16 BIT CHALLENGE

You may remember that I was less than enthusiastic about the Texas Instruments announcement that the ... "end of the two-bit eight bit" was imminent. There is still no doubt in my mind that the eight bit micros, such as the 6800, the 8080 and the Z80, will be with us for many years yet, as indeed will the four bit chips such as the 4040 and the TMS 1000.

Certainly the current sixteen bit contenders, represented by the Texas TMS 9900, the General Instrument CP1600, and the Ferranti F100L, are hardly taking the micro world by storm, and have so far proved to be of little interest to computer hobbyists who still have plenty of elbow room left in their existing eight bit systems.

But time marches on, and the sixteen bit challenge is soon to be reinforced by the three giants in microprocessor technology, who have at last decided that the market, and their own technology, are now ready. First of the giants on the scene will be Intel with its new **8086**, a powerful 16 bit design which is software compatible with its 8080 and 8085 predecessors and yet offers on-chip multiply and divide, a one megabyte address range and internal clock rates of up to 8Mhz. Close on the heels of Intel are Zilog with their new **Z8000** chip which, like the 8086, offers software compatibility with its eight bit predecessors. Rumour has it that one version of the Z8000 will be able to address eight megabytes of memory!

FROM MOTOROLA

Last but not least come Motorola with their **MC6809** device which has the interesting distinction of being at an "in-between" stage in microprocessor development because, while it uses 16 bit internal architecture, externally it interfaces with the eight bit data bus common to all current 6800 systems. This "best of both worlds" design, while not as powerful as the Intel or Zilog chips, has the advantage that existing hardware and memory investment can be carried through into the more capable sixteen bit arena.

If you relish the thought of a powerful home computer based on a sixteen bit chip, then this news from the three giants will please you, because confident predictions of price erosion are already being made. Before throwing your old micro away though, try calculating the cost of eight megabytes of RAM!

HALL SWITCH

Becoming increasingly popular in the professional electronics market these days, and looking extremely attractive for amateur applications are the new generation of magnetic sensors, the Hall effect switches.

These useful devices have been mentioned once before in this column, but at that time they were difficult to obtain. Now Texas Instruments have introduced the **TL170C** which is likely to become freely available at a very low price, and so there are no longer any excuses for not sampling the delights of this robust and useful switching device!

Hall effect switches like the TL170C are basically silicon integrated circuits which include a Hall sensor able to sense the presence or absence of steady state magnetic fields, and a transistor switching stage which provides a logic type output. The TL170C itself is packaged in a tiny plastic three lead transistor package and operates from standard five volt supplies. The output switching stage is a base-collector transistor with a 30 volt rating so that the output voltage swing can be tailored with the aid of a pull-up resistor and a suitable supply rail to suit most applications. Output sink current is a respectable 20mA.

EASILY INFLUENCED

Magnetic sensitivity is rated in milli-Teslas, with a positive threshold of about 35mT and a negative threshold of about minus 35mT. If, like me, you do not have much of a feel for milli-Teslas, suffice to say that the TL170C can be reliably operated with quite a small magnet! To prevent erratic switching or threshold oscillations the new chip has a built in hysteresis of 20mT.

Applications for these devices must be legion, and are surely not limited to the main commercial use which is as contactless keyboard switches for high quality teletypes and VDUs. All kinds of clever, perhaps concealed, magnetic switches are possible, and how about a solid state magnetic replacement for the mechanical or reed switch car contact breakers used with electronic ignition systems? And don't forget model train layouts, and slot cars, and ... well I am sure you can see that it really is amazing how you have been able to manage without these devices for so long!

SPIKELESS TIMER

No doubt everyone will have used that great little 555 timer integrated circuit by now, probably with great success. You may have used it as a monostable, an astable, a voltage controlled oscillator, a long period timer or any number of the other jobs at which it excels, but if you used it on a board with TTL flip-flops, you may have come unstuck.

The trouble is that the 555 generates a large current spike in the supply lines when it switches to the high output state, a spike which can be as large as 300mA and last for 100 nanoseconds or more. This sort of spike can cause glitches in the Vcc line which will have unfortunate effects on TTL or other flip-flops, particularly if the decoupling arrangements are not of the best.

The only way out of this problem until now has been to hang a few hundred microfarads of capacitance across the 555 supply pins so that it could guzzle current from its own personal supply during a spike, without communicating its bad habits to the other occupants of the board!

But now a rather more elegant solution has appeared from Teledyne Semiconductor in the shape of their **355** timer.

Yes, that's right folks! It's a pin for pin replacement for the 555 chip *without* the current drinking problem! Actually, the 355 *does* take a tiny *sip* when it switches but the current spike generated is only about 1mA.

The 355 not only tackles the 555's drinking problem, but also solves another couple of problems on the side. The 555 has a tendency not to reset reliably on command, and can get too hot on 15 volt supplies. The goody-goody 355 never puts a foot wrong. Personally my sympathies are with my red-faced, overheated, intemperate, 555's who sometimes forget to reset. I think it's an identity problem!

TTL TEST CLIP

P.A. BIRNIE

This unit gives a usual indication of the logic states of any 14 or 16 pin i.c. in the 74 family

THIS tester was designed for use on all 14 and 16 pin integrated circuits in the 74 TTL series. It is powered from the circuit under test and uses TTL hex inverters with light emitting diodes to indicate the logic states of the i.c. under test.

POWER SOURCE

As the tester is powered from the circuit under test and because in the 74 series the pins used for the power supply connections vary from device to device, it was necessary to ensure that the tester received a voltage of the correct polarity irrespective of the i.c. being tested.

This was achieved by listing all the pins used to supply power in the 74 series and then designing a diode circuit capable of providing the correct voltage.

CIRCUIT OPERATION

The complete circuit diagram of the tester is shown in Fig. 1 with the four hex inverters enclosed within the dotted lines.

Under typical operating conditions with output voltages over 0·6V the 74L04 hex inverter acts as a 13mA constant current generator. This current is sufficient to illuminate an l.e.d. and so indicate a "logic 1" state.

When the tester is applied to an i.c. its positive and negative supply rails are obtained by two of the diodes D18 to D23 being forward biased from the supply pins of the i.c. under test. If for example a 16 pin i.c. with its +5V and earth connected to pins 5 and 12 respectively is to be tested, then diodes D18 and D23 will be forward biased establishing the supply rails.

If any inverter senses a logic 1 input its output is switched low and the l.e.d. connected to it is illuminated. When a logic 0 is sensed by an inverter its output is switched high and the appropriate l.e.d. turned off.

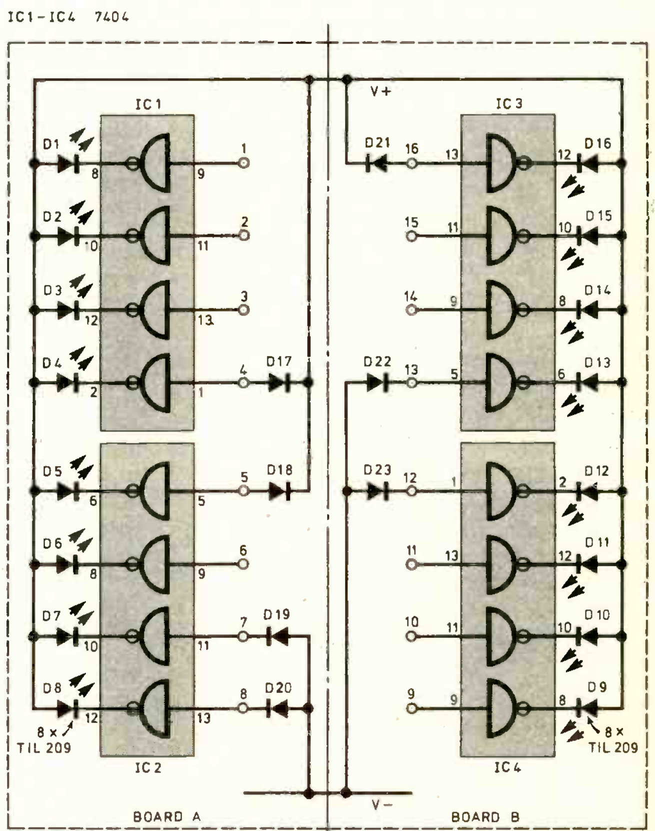


Fig. 1. Circuit diagram of the Test Clip. Pins 14 and 17 are used as the positive and negative connections of the 7404

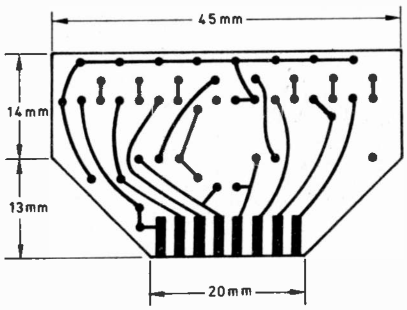


Fig. 2. Printed circuit board pattern

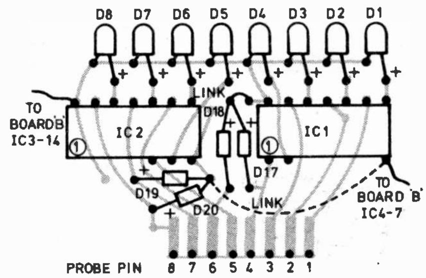


Fig. 3. Component layout for Board A

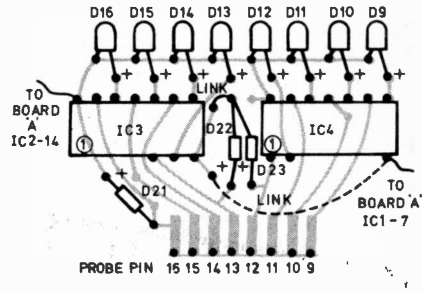


Fig. 4. Component layout for Board B

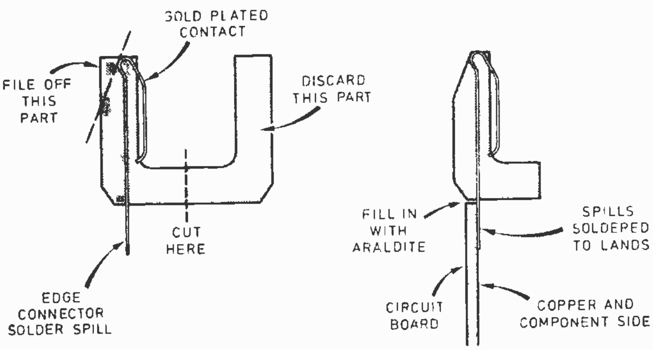


Fig. 5. Modifications and mounting details for the edge connectors

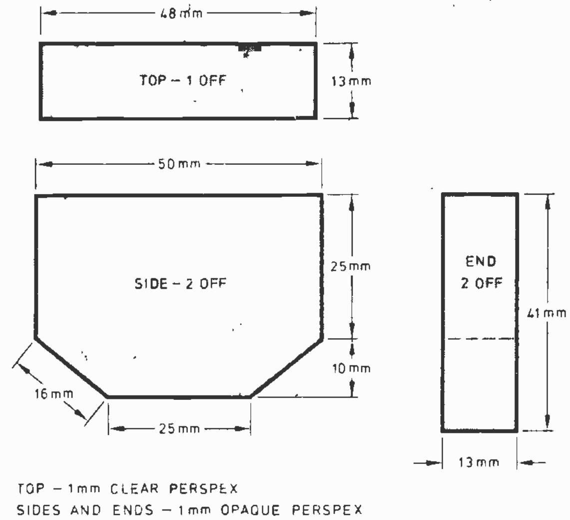


Fig. 6. Case cutting details

COMPONENTS . . .

Diodes
D1–D16 TIL 209 (16 off)
D17–D23 OA47 (7 off)

Integrated Circuits
IC1–IC4 74L04 (4 off)

Miscellaneous
Printed circuit board, 4in length of 0·1in pitch edge connector for probe, clear and opaque Perspex, Araldite, Tensol No. 6 cement

CONSTRUCTION

The two printed circuit boards (Fig. 2) used in the tester are identical and their respective component layouts are shown in Figs. 3 and 4. The components should be soldered as close as possible to the p.c.b.s to allow easy mounting of the boards into the case.

The unused pins of each i.c. should be cut off before the i.c. is soldered into the p.c.b.s.

Each l.e.d. should have its cathode lead cut to about ¼in and its anode lead to about ⅜in. A piece of sleeving should be fitted over the cathode lead to prevent it shorting out to the positive supply line.

When soldering the l.e.d.s in place care should be taken to keep the spacing between them even to ensure neat indicator rows in the finished tester.

TEST CLIP

The test clip was made using 0·1in edge connector which was modified as shown in Fig. 4. One side of the connector was carefully cut off, leaving a strip of 8 contacts with convenient "spills" which were used to solder the connectors to the p.c.b.s. Araldite was then used to securely hold the connectors in place.

TESTING

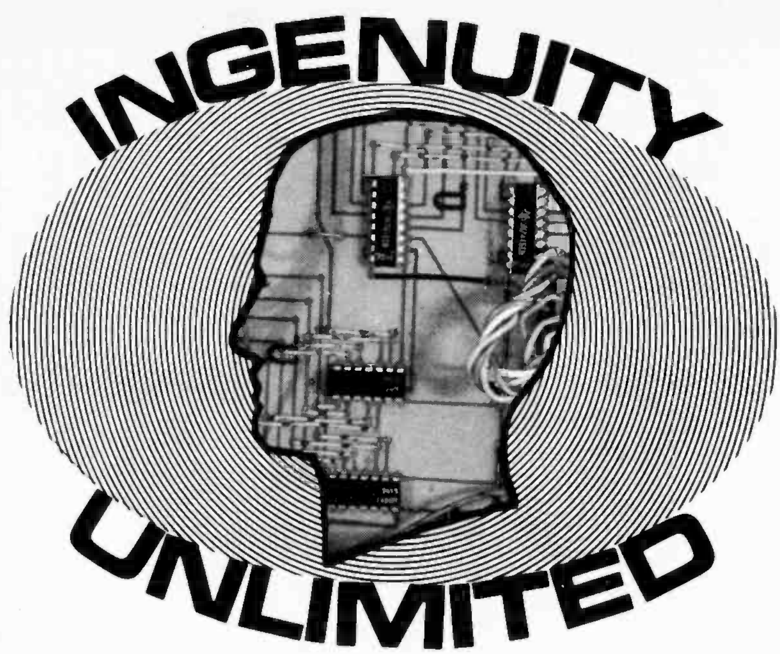
The tester should be checked before it is fitted into the case to ensure that it is working correctly. A +5 volt supply should be connected to the positive and negative supply lines of the boards and all the l.e.d.s should light up. If a lead is taken from the negative supply to each inverter input in turn the corresponding l.e.d. should be turned off.

CASE ASSEMBLY

The case was constructed using 1mm Perspex (Fig. 6). A special solvent is available for fixing Perspex and this should be used rather than an adhesive.

The two p.c.b.s are first Araldited to the sides taking care to align the connectors in the centre of the case. The top of the case, which should be made of clear Perspex, may then be fitted to one side.

The two ends of the case can be curved by warming them over a hot soldering iron and gently bending them until they match the curves of the sides. These may now be fitted to the top and side of the test clip. The other side can now be fitted and all the corners rounded off with wet and dry sandpaper. The Perspex can be restored to its original finish using Brasso. Finally the top of the tester should be marked with a spot of white paint to indicate the position of pin 1. ★



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.

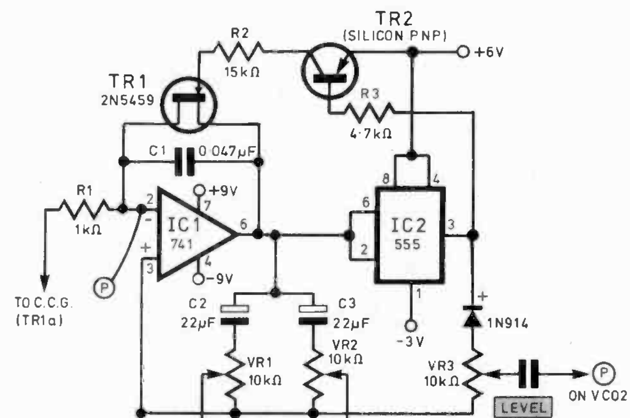
Each idea submitted must be accompanied by a declaration to the effect that it is the original work of the undersigned, and that it has not been accepted for publication elsewhere.

Here are a number of circuits contributed by E. F. Flint which should be of interest to constructors of the Minisonic 2 synthesiser

Copies of *Sound Design* containing this are still available from Post Sales Dept., IPC Magazines Ltd., Lavington Street, London SE1 0PF at £1·20 each including Inland/Overseas p. & p.)

VOLTAGE CONTROLLED OSCILLATORS

Fig. 1



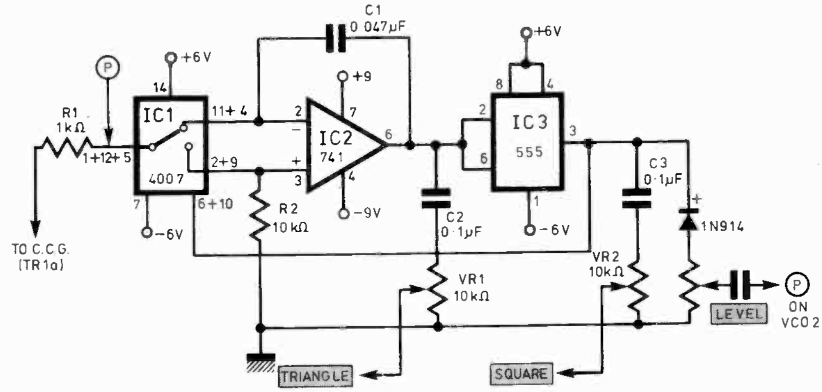
One of the modifications incorporated in Minisonic 2 was in the design of the v.c.o.s. The new circuit used an LM318 N op-amp as a comparator on the grounds that this device has a much faster slewing rate than the 741—70µV/sec. It is however both expensive and hard to obtain, and an alternative approach is to use a 555 timer, which contains two comparators with slewing rates comparable to the 318, and is cheap and readily available. Two designs are possible, the second being more complex and having two output waveforms.

This version (see Fig. 1) provides only a ramp waveform as in the original design. The two comparators in the 555 have thresholds of $\frac{1}{3}$ and $\frac{2}{3}$ of V_{cc}, so that by operating the device with supplies of -3 volts and $+6$ volts the thresholds become zero volts and $+3$ volts.

The mode of operation is as follows: the 741 integrator ramps in a positive direction as before until the ramp level reaches $+3$ volts. At this point the output of the 555 goes rapidly to the negative supply rail; this switches on TR2, connecting the gate of the f.e.t. to $+6$ volts and discharging the integrating capacitor. When the ramp output reaches zero volts, the 555 output goes positive, switching off the f.e.t., and integration begins again. Thus the oscillator produces a ramp of 3 volts amplitude, rising from zero volts.

The synchronisation network is slightly different from the published design; since the 555 produces negative-going pulses the gating diode must be reversed, and the sync. pulses are fed to the inverting input of the integrator.

Fig. 2



This version provides triangle and square wave outputs; in addition to the 555 and 741 it uses a CMOS chip 4007 as a two-way switch. The switch works as follows: the 4007 contains two complementary pairs of f.e.t.s and an inverter. The two complementary pairs are wired as a pair of bilateral switches with one common terminal, and the inverter controls their on/off state so that when one is on the other is off, and vice versa. (Fig. 2).

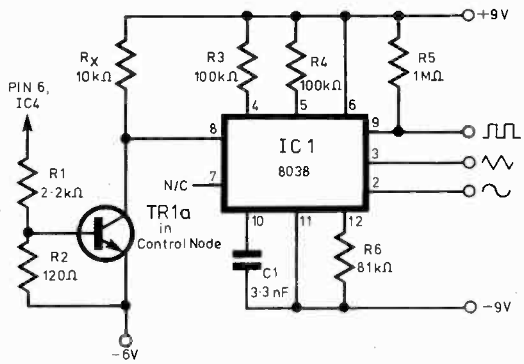
The 4007 is used in this application to switch the constant current generator between the inverting and non-inverting inputs of the 741 integrator, so that it can ramp both positively and negatively. The 555 is connected to ±6 volts, so the threshold levels are +2 and −2 volts.

If we consider first the ramp rising positively, the 555 output is also positive and the 4007 is in position 2 + 9. When the ramp reaches +2 volts, the output of the 555 swings to −6 volts, the 4007 switches to position 11 + 4, and the integrator begins to ramp negatively. When the ramp reaches −2 volts the 555 output swings back to +6 volts, the 4007 switches back to position 2 + 9, and the integrator once more ramps in a positive direction.

This oscillator uses only negative-going sync pulses so the gating diode is reversed and the pulses are routed to the common terminal of the switch; this means that when the ramp is positive-going the spikes from the sync pulses are too, and when the ramp is negative-going, the spikes are again in the same direction as the ramp, i.e. the sync pulses always augment the ramp voltage to induce triggering of the comparators at a sub-threshold voltage.

THE 8038 V.C.O.

Fig. 3



A completely different approach to v.c.o. construction is to use the 8038 (Fig. 3), a 14 d.i.l. package which contains a v.c.o. with sine, square and triangle outputs, having variable symmetry, adjustable harmonic distortion on the sine-wave output, and an extremely wide frequency range of 0·001Hz to 1MHz (by changing the component values in the timing network then in the voltage controlled mode the sweep range is 1,000 : 1).

The internal workings of the package are far too complex to describe in detail but it can be considered as a black box whose output frequency depends on the values of R3, R4, C1 and the voltage between pin 8 and the positive supply rail. It is the last of these variables with which we are concerned. The frequency is a linear function of this voltage, but a logarithmic function can be introduced using a modified version of the well-known Minisonic v.c.o. control node.

Here the constant current generator (c.c.g.) instead of working from an integrator draws its current from the positive rail via resistor R_X. Since the collector current of the transistor is a logarithmic function of the voltage on its base, it follows from Ohm's Law that the voltage across R_X follows the same log function, and therefore the frequency of the oscillator becomes a log function of the voltage on the transistor base.

The control node works exactly as before, and setting up therefore follows the established procedure. Symmetry is adjusted by varying either R3, R4 or both, but note that this also affects the frequency. This is best done using an oscilloscope to monitor the square wave output.

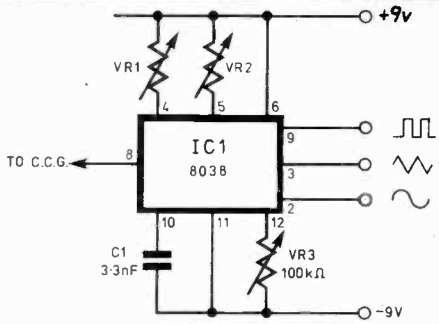


Fig. 4

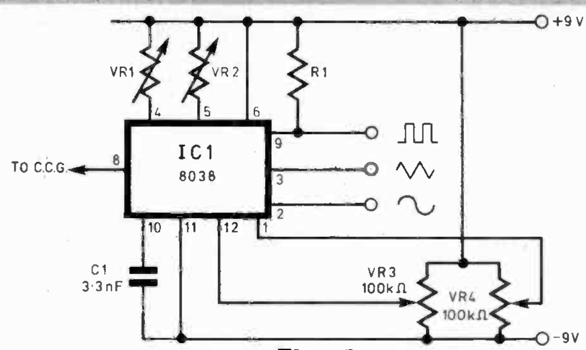


Fig. 5

Sine wave distortion can be adjusted in two ways—the first is simpler and should be used where it may be desired to introduce some harmonics during use, for example in simulating flutes etc. A variable resistor is connected from pin 12 to the negative rail (Fig. 4) and adjusted for the required purity of waveform or harmonic content.

Where a pure sine wave is required the circuit of Fig. 5 is used and the two potentiometers adjusted for minimum distortion—this requires an oscilloscope and a sine wave generator for comparison, and distortion as low as 0·5 per cent can be achieved.

REPEAT/PERCUSSION CIRCUIT

The circuit of Fig. 6 produces a train of pulses of variable width and repetition frequency, for so long as a key is pressed. These can be used to repeatedly trigger an envelope shaper so as to produce an effect like a banjo, mandolin or xylophone (all of these require an ADSR envelope shaper).

The circuit uses a 741 in the astable mode, with a few alterations from the usual design. It is basically a comparator, with R1 and R2 added to allow operation from a single supply.

The two diodes allow the charging and discharging times of C1 to be adjusted independently. TR1 connects R1 to the negative supply when a key trigger pulse is present, allowing the multivibrator to oscillate. VR2 controls the charging time of C1, and therefore the width of the output pulses, and VR1 controls the discharging time and therefore the width of the spaces between the pulses.

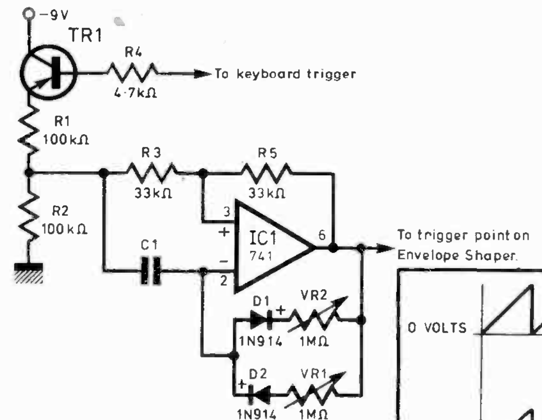


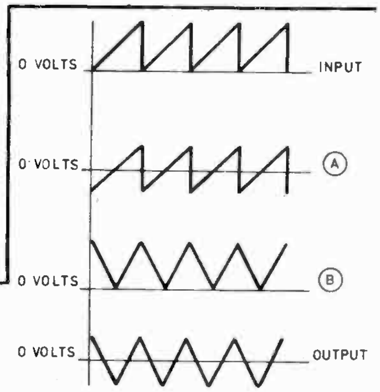
Fig. 6

SAWTOOTH TO TRIANGLE CONVERTER CIRCUIT

The circuit of a sawtooth to triangle converter is shown as Fig. 7 with examples of waveforms produced (Fig. 7a). The sawtooth wave first passes through a d.c. blocking capacitor so that it is symmetrical about zero volts. A pair of diodes then gate the signal so that positive half waves are applied to the non-inverting input of a differential amplifier, and negative halves to the inverting input. As shown, this produces an output train of alternate positive and negative-going ramps, i.e. a triangle wave.

Since this rectification process effectively halves the signal amplitude, the resistor values in the amplifier are chosen to give a gain of two. A second d.c. blocking capacitor in the output again makes the output symmetrical about ground.

The same circuit can also be used as a frequency doubler for triangle wave signals, as shown in Fig. 7b.



(7a)

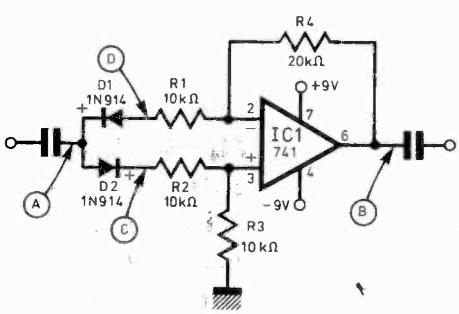
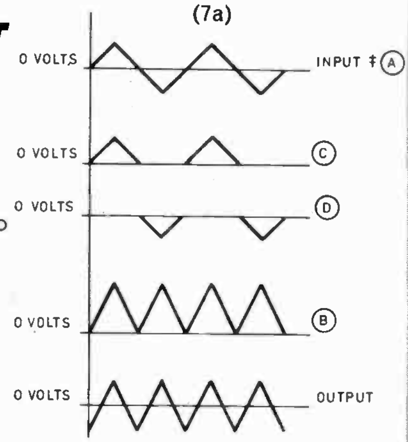


Fig. 7



(7b)

ELECTRIFYING TIME

M.E.THEAKER B.Sc.

The technology of today's watches is relatively new but electro-assisted time-keeping has been progressing for 150 years through electrostatic, electromagnetic and mains frequency to quartz drive

READERS of this magazine who have observed the sudden rise of digital clocks and quartz watches over the last few years may be surprised to learn that electric timekeeping goes back over 150 years. Last year an exhibition at the Science Museum, "Electrifying Time", commemorated the centenary of the death of the Father of Electric Horology, Alexander Bain. The exhibition surveyed electric timekeeping from its infancy at the beginning of the 19th Century through to the atomic clocks of the present day.

ELECTROSTATIC

Zamboni and others in Europe experimented with electrostatically maintained clocks at the start of the 19th Century. They relied on the repulsion between a charged ball at the end of a pendulum and two oppositely charged plates at each end of the pendulum's swing. A high voltage battery such as a Zamboni pile maintained the potential difference between the ball and the plates. As the ball swung to one plate it would be electrostatically repelled to the other and so on, thereby maintaining the pendulum. This system was so highly temperature sensitive that Zamboni concluded that it was a better thermometer than a clock and this approach was soon abandoned.

In 1819 Oersted had demonstrated the principle of electromagnetism and in 1841 a Scotsman, Alexander Bain, produced the first successful electric clock using an electromagnetically maintained pendulum. One of the difficulties associated with these early electric clocks was the temperature dependence of the cell driving the clock, usually a Daniell cell. In 1843 Bain hit on the idea of the Earth Cell in which copper and zinc electrodes were buried several feet down in the soil which acted as the electrolyte. At a depth of six or more feet the temperature of the soil is constant and so Bain managed to eliminate at least one of the causes of poor electric timekeeping.

SYNCHRONISATION

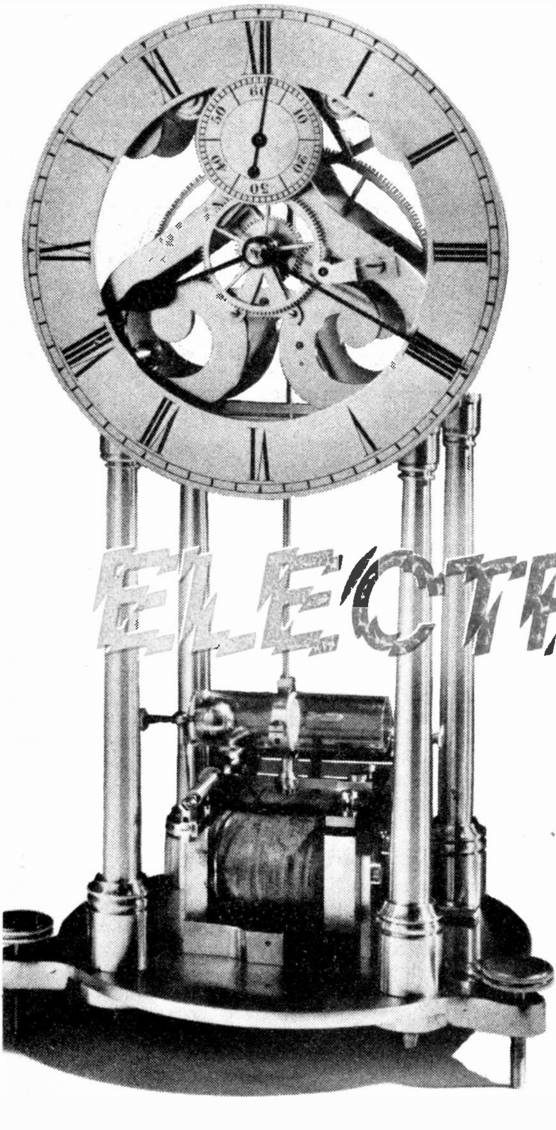
One of the great virtues of electric clocks is that the pulses of electrical energy which maintain the pendulum swinging may also be used to synchronise other clocks in the same building or at greater distances. Bain demonstrated such a system with a master clock in Edinburgh synchronising a slave clock in Glasgow, the synchronising pulses being transmitted over telegraph wires.

Despite Bain's innovations, it appears that he did not meet with any great commercial success. He installed an electric turret clock in St. John's Church, Loughton, Essex, in 1846, but within four years it was replaced by a mechanical clock. A similar fate befell Shepherd's electric clock for the 1851 Great Exhibition in Hyde Park.

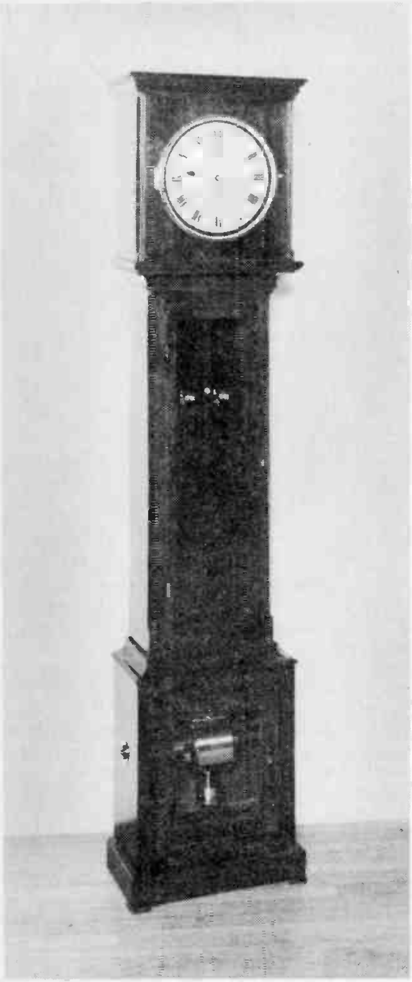
By the end of the 19th Century new methods of electrifying time were being evolved. In 1881 Chester H. Pond of the U.S.A. produced the first electrically maintained spring driven clock in which the spring mechanism was wound every hour by an electric motor. The "Synchronome" master clock using a dead-beat escapement was patented in 1895, but was not practically realised until 1905–7 by F. Hope-Jones and G. B. Bowell. In this clock a gravity arm falls every half minute to give the pendulum a push. This done, the gravity arm is restored to its original position by an electromagnet. At the same time as the elecromagnet is energised, a pulse is sent to move the slave clocks. The great advantage of this scheme over all previous ones is that the master pendulum itself does not have to provide the synchronising pulses.

William Hamilton Shortt carried this principle further in 1921. Shortt's master pendulum was placed in a vacuum and did not even have to turn a counting wheel. A slave clock carries out the counting and every half minute releases a light arm carrying a jewel which falls on to a small wheel mounted on the master pendulum. In rolling off this wheel it imparts a light impulse to it and after transmits a synchronising signal to the slave clock. The master pendulum runs completely free except for this impulse every half minute and maintains an accuracy of 1 part in 10^7. This type of clock was in use at the Greenwich Observatory until 1942, when it was replaced by a quartz clock.

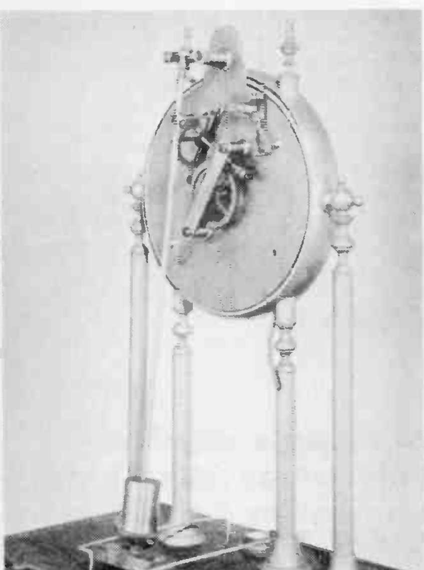
Alexander Bain 1810–1877
(Photo courtesy Science Museum)



Rolling ball clock attributed to Wheatstone
(Photo courtesy Science Museum)



Electric clock of the type patented by Bain in 1845
(Photo courtesy Science Museum)



Rear view of Scott clock
(Photo courtesy Science Museum)

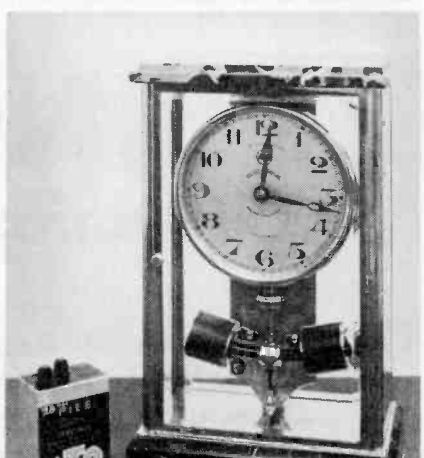
The idea of using the mains to distribute time occurred to Ferranti in 1895 when the first alternating current generator was installed at Deptford. At that time, however, there was no means of controlling the mains frequency with sufficient accuracy and the idea had to wait until 1916 when H. E. Warren of the Warren Telechron Company devised a method of precision frequency measurement and a low power-consumption synchronous motor which led to the first mains driven electric clock.

Quartz oscillators were first constructed in the early 1920s and in 1927–30 Warren Alvin Morrison of the Bell Telephone Laboratories produced the first quartz clock. The reliability of electronics at that time was low and consequently three such independent clocks were used to confirm the time. The accuracy of these quartz clocks was improved and now accuracies of better than 1 part in 10^8 are achievable, ten times better than the best pendulum clock.

The quartz oscillator which is the timekeeping element of the quartz clock relies upon the vibration of a quartz crystal between two metal electrodes. This high frequency vibration, which usually takes place above 100kHz, is amplified by an active device, originally a valve but nowadays a semiconductor device, and a portion of this amplified output is fed back to the quartz crystal to maintain its oscillation. The high frequency signal is then divided to provide a low frequency signal (between 50Hz and 1Hz) to drive a synchronous or stepping motor to provide an analogue display of time or a digital display via counter and decoder circuits.

ATOMIC CLOCK

Up until the early 1950s the method of timekeeping had always relied on the oscillation of a solid body whether it be a pendulum, a balance wheel or quartz crystal. These are calibrated with respect to the rotation of the Earth on its axis which is irregular. In 1955, Dr Louis Essen and Mr Parry of the National Physical Laboratory in England produced the first atomic clock. This essen-



A typical domestic electric clock of the 1920's
(Photo courtesy Science Museum)

Hamilton electric analogue watch
(Photo courtesy Science Museum)

tially was a quartz clock controlled by the vibration of cæsium atoms and was accurate to within 1 second in 300 years (1 part in 10^{10}). As a result, in 1967, the second was re-defined in terms of the cæsium vibrations and in 1971 the International Atomic Time Scale was adopted. Currently cæsium clocks are accurate to within 1 second in 100,000 years (3 parts in 10^{13})—a quite mind-boggling accuracy which, if it surprises us, would have shaken Alexander Bain. Rubidium clocks which rely on the vibrations of rubidium atoms are used as secondary standards and are at present accurate to within 1 second in 1,000 years (3 parts in 10^{11}).

DIGITAL

On the domestic scene Max Hetzel devised a clock employing an electrically maintained tuning fork. This was the forerunner of the Bulova Accutron, a wristwatch in which the tuning fork was maintained by a transistor circuit. The first domestic quartz clock was manufactured by Junghan's in 1967. Only two years later, Seiko introduced the world's first electronic watch and later that same year Longines introduced their electronic watch. All three of these timepieces used a motor driving the hands of an analogue display. In 1972 Hamilton produced the first quartz watch with a digital l.e.d. display and, in the same year, a Swiss Company, Societe des Gardes-Temps, produced a quartz watch using a liquid crystal digital display.

All of these brings us just about up to date. The accuracy of even a cheap quartz watch is beyond the dreams of watchmakers of a hundred years ago. Although it is improbable that atomic clocks will ever be used domestically, their accuracy can be tapped by receiving and decoding the radio clock signals transmitted by MSF, Rugby. Such radio clocks and designs for the experienced constructor are available, so if you ever feel the need for a clock with an accuracy of 1 second in 100,000 years, that's the way to achieve it.

INDUSTRY NOTEBOOK

By Nexus

CB RADIO

Last year's clamour from pressure groups advocating Citizens Band Radio is now somewhat muted, perhaps because the problems of introducing a CB "service" in a smallish country like the UK have now been more fully examined and debated.

An interesting sidelight on CB in the United States is that Texas Instruments has been working with the FCC on developing a high-performance TV receiver which is less susceptible to interference from CB radios, the implication being that interference is a major problem to viewers. Improving front-end performance of mass-produced TV receivers is a worthy end in itself but it costs money.

Ninety-five per cent of Britain's 20 million households have a TV receiver and the average viewing time is 18 hours per week. The great mass of the population would not take kindly to interruption of their principal recreation and even less kindly to having to spend more to overcome the difficulties caused by enthusiastic chatterers on CB.

PRELUDE

Project Prelude, now running on a trial basis in the United States could be the shape of things to come in Business Communications. Big companies need to talk from their headquarters to their factories and offices at remote locations and often to each other. The modern way to do this is by communications satellite which can provide high-speed data, facsimile and teleconference transmission, all over the same links. In the teleconference mode, for example, you can have large-screen projection colour TV for group discussions and even person-to-person viewphones.

Three big businesses are involved in the trials, Texaco, Rockwell International and Montgomery Ward. Using small transportable earth terminals they are currently operating through the Communications Technology Satellite (CTS) which operates on the same frequencies as a proposed Satellite Business Systems (SBS) satellite.

LUCAS ELECTRICAL

Lucas seldom gets in the news as an electronics company but the company is strong in thick film technology and has large semiconductor manufacturing operations in Birmingham to supply devices for alternators, electronic ignition and other automotive electronic applications. Lucas has now increased its shareholding in Ducellier, France, from 49 per cent to 100 per cent, having bought out DBA (the American Bendix Automotive subsidiary) for a reported 26 million dollars.

Ducellier has 7,000 employees in four factories. Lucas-France already has 4,300 employees in six factories as well as a 49 per cent share in Thomson-Lucas which serves the aerospace market, making Lucas a major company in France. The Lucas move appears to be following the trend of investment overseas into areas where the industrial climate is less restrictive than in Britain under the present regime.

DISTRIBUTION

The Association of Franchised Distributors of Electronic Components (AFDEC) have forecast a total component market this year worth £531 million of which about 16 per cent will be served through distributors, the balance being bulk direct supplies from manufacturers.

Despite talk of overcrowding in the distribution business there are still some eager entrants. One such is Jack Evans Electronic Distribution Ltd, scheduled to start up in April near London Airport, an area already heavily populated with distributors. JEE Distribution, as the company will be called, is to concentrate on electronic hardware which, according to company hand-outs, is a neglected area.

Jack Evans is a familiar name in the business. He was the prime mover in setting up ITT Electronics Services and was general manager there from 1964 to 1970. Most new companies in distribution start off with one or two good franchises as the foundation of the business. Evans is starting with over 30.

JEE's hardware catalogue is said to be a real engineering manual rather than a list of products and is expected to be a prime addition to the equipment design engineer's technical library. The first edition has some 150 pages of products and technical data.

HEWLETT-PACKARD

John A. Young, newly elected president and chief operating officer of Hewlett-Packard has inherited a strong financial and technological position. He is only 45 so has many years ahead of him to seek further growth in what is one of the most powerful and respected companies in world electronics. He heads up over 35,000 H-P people of whom 10,000 are outside the United States. The two founders of the company who started up in a backyard garage are continuing to exercise influence on long-term policy.

Ten years ago H-P was still the classical test and measurement company with 86 per cent turnover in that field out of a total turnover of less than 300 million dollars. Today the company is approaching 1·5 billion dollar turnover and test and measurement activities are only 42 per cent of the total, having now been overhauled by an equal share in electronic data products which was only 4 per cent of the total 10 years ago.

It's now full speed ahead on computational technology in H-P, which means "smart" instruments, computers, terminals and analytical tools. To keep the whole effort moving H-P has invested in component technology, one example being H-P's silicon-on-sapphire microprocessor which has over 10,000 circuit elements on one chip. But above all H-P invests in people. Graduate student intake last year totalled nearly 400, and over 10,000 employees took advantage of educational programmes to develop technical and management skills. R and D spend last year was running at the rate of about £1 million a week. Nothing succeeds like success.

BIG BATTERIES

With so much emphasis on micromin in electronics we tend to overlook that some things get bigger. In contrast to the tiny cells which power our watches and calculators, Chloride Industrial Batteries have recently roped in £4 million of orders for submarine batteries. Individual cells are said to be nearly as tall as a man and weigh about half a ton. A complete set for a submarine can weigh as much as 250 tons.

AVO's DMM

AVO, the oldest name in multimeters, is having another crack at the digital multimeter market with a unit, the DA116, with liquid crystal display and a price tag of £99. An important feature is high-speed resistance measurement, claimed to be ten times faster in response than conventional dmms. A single i.c. is used for analogue-digital conversion.

WORKSHOP POWER SUPPLY UNIT

I. HICKMAN

Provides a variable power source up to 25V at 1·5A. Completely stabilised and with an adjustable over-current limit

An essential piece of equipment for any home lab is a power supply as batteries come extremely expensive—particularly the high power types.

This design is stabilised and has a performance which vies with a number of much higher priced commercial designs.

The maximum power available is 25V at 1·5A. The voltage output is continuously variable and the protection offered by an adjustable over-current limit is very reassuring—especially when experimenting with breadboards that have been inadvertently wired with shorts.

To cut cost, meters have been deliberately excluded but the ingenious use of l.e.d.s compensate in part for this omission.

STABILISER

Transistors TR1, 6, 7 and 8 constitute the constant voltage stabiliser. The reference voltage for TR1 is provided by D3 with the decoupling components C3 and R2 removing any hum that could be fed back.

Assuming S2 in the B switched position then TR8 is providing current to the load. For a full rated 1·5A the base input to this comes via R11, R14 and R16.

The output voltage seen at the terminal is sampled by the preset VR5 and R18 and if too negative (dependent on VR1 setting) switches on TR1. As a result of this TR6 and TR7 are turned on so that some of the base current available to TR8 is shunted.

This feedback ensures that the output voltage will be such that the base of TR1 is always just negative with respect to the slider of VR1, the voltage setting potentiometer.

Returning TR6 collector to a tapping on the divider chain feeding TR8 base ensures that dissipation in this transistor is kept low. Note that R16 cannot be omitted, otherwise TR7 would be unable to bottom sufficiently to control TR8 base current.

Stability in the feedback loop is ensured by the roll off provided by C6 and C5, although the main role of the latter is to maintain a low output impedance at high frequencies. C4 provides this additional h.f. roll off when the output is switched off.

CURRENT LIMITING

The active components in the current limit loop are TR2, 6, 7 and 8. To understand the working, assume calibration has been made—VR2, VR3 adjusted—and a current limit value has been set on VR6. If the volt drop across D4 and R3 is such as to turn on TR2 then TR6 and TR7 will turn on, subtracting base current from TR8 and preventing any further increase in load currents.

If the whole of the volt drop across R3 were fed to TR2 base, it would be necessary to vary R3 to adjust the current limit and to obtain a wide control range—say 20mA to full load—requiring a low value non-linear wirewound potentiometer. This has been done in some commercial stabilised supplies, but such a specialised component is hard to come by. Therefore, a power diode D4 is included and this still drops an appreciable voltage even at low currents, enabling front panel control VR6 to be calibrated directly in current down to low values.

VR2 sets the maximum current the stabiliser can supply (with VR6 fully clockwise) and VR3 is set to make the anticlockwise position of VR6 correspond to virtually zero short circuit output current.

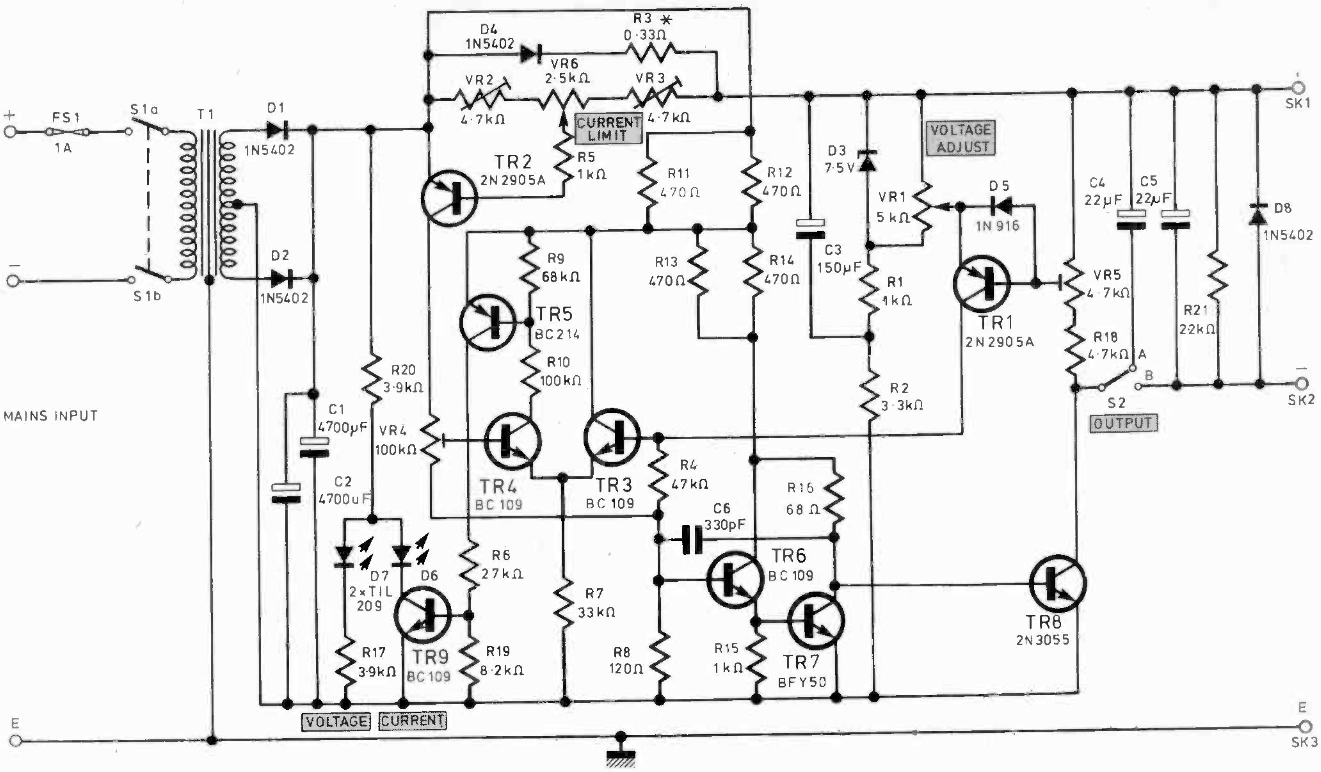


Fig. 1. Circuit of Power Supply Unit

R21 ensures that C5 discharges when the output is turned off at S2. Consequently, when S2 is switched on again, the charging current into C5 momentarily takes the power supply into current limit, causing the output voltage to ramp up linearly from zero. This feature in conjunction with the adjustable current limit provides complete protection of any circuit connected to the stabiliser.

L.E.D. INDICATORS

Whilst the omission of meters saves a considerable amount of money, one needs to know if the output voltage set by front panel control VR1 is really appearing across the load or whether the supply is in current limit. TR3 and 4 detect whether TR1 or TR2 is controlling the output and light an appropriate l.e.d. Thus, if the output voltage really is as

COMPONENTS . . .

Resistors

R1	1kΩ	
R2	3·3kΩ	
R3	0·33Ω.	7in of 24 s.w.g. Eureka wire may be used. Eureka wire is obtainable from The Scientific Wire Co., PO Box 30, London E4 9BW.
R4	47kΩ	
R5	1kΩ	
R6	27kΩ	
R7	33kΩ	
R8	120kΩ	
R9	68kΩ	
R10	100kΩ	
R11–14	470Ω ½W	
R15	1kΩ	
R16	68kΩ	
R17	3·9kΩ	
R18	4·7kΩ	
R19	8·2kΩ	
R20	3·9kΩ	
R21	2·2kΩ	

(¼W 5% Hi stab except where stated otherwise)

Potentiometers

VR1	5kΩ linear
VR2, 3	4·7kΩ vertical miniature skeletal
VR4	100kΩ vertical miniature skeletal
VR5	4·7kΩ vertical miniature skeletal
VR6	2·5kΩ linear

Capacitors

C1, C2	2 × 4,700µF 40V
C3	150µF 15V
C4, C5	2 × 22µF 40V
C6	330pF

Semiconductors

TR1, 2	2N2905A (2 off)
TR3, 4	BC109 (2 off)
TR5	BC214
TR6	BC109
TR7	BFY50
TR8	2N3055 with mica insulating set
TR9	BC109
D1, 2	1N5402 (2 off)
D3	BZY88 C7V5
D4	1N5402
D5	1N916
D6, 7	TIL209 (2 off)
D8	1N5402

Miscellaneous

T1 MT104AT pri. 240V; sec. 25–0–25V 1½A, FS1 1A, S1 On/off switch, S2 S.P.C.O. switch, Heatsink 401-807 (Radiospares). LK301 Side Plate No. 1 (2 off) LK211 Chassis rail (4 off) LK431 Front panel LK521 short perforated plate (3 off) (Home Radio)

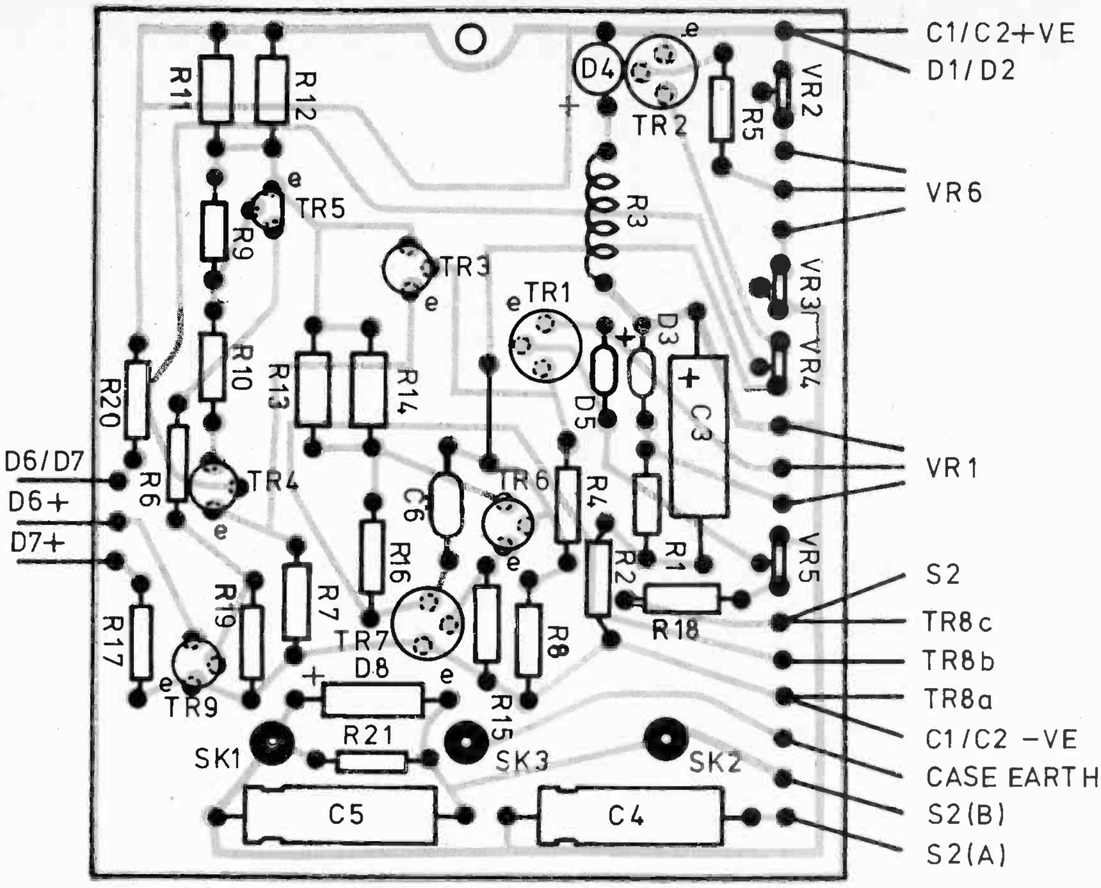


Fig. 3. (above) Component layout and wiring details for p.s.u. board

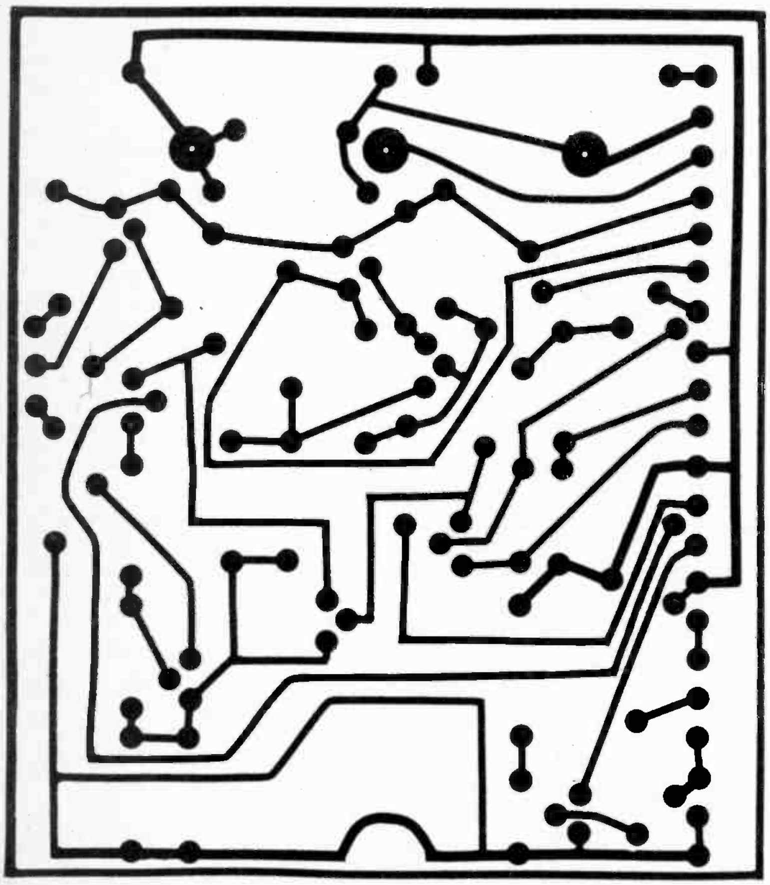
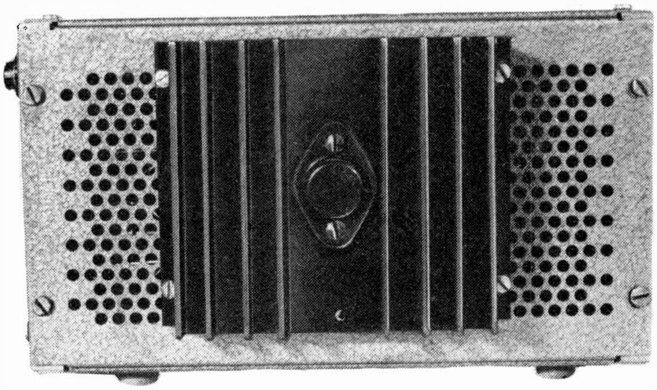
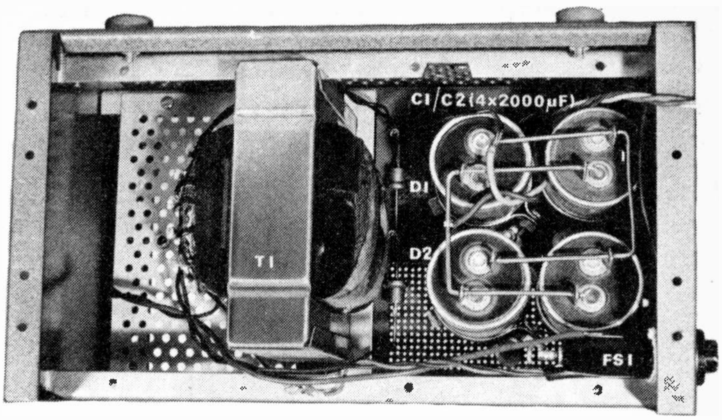
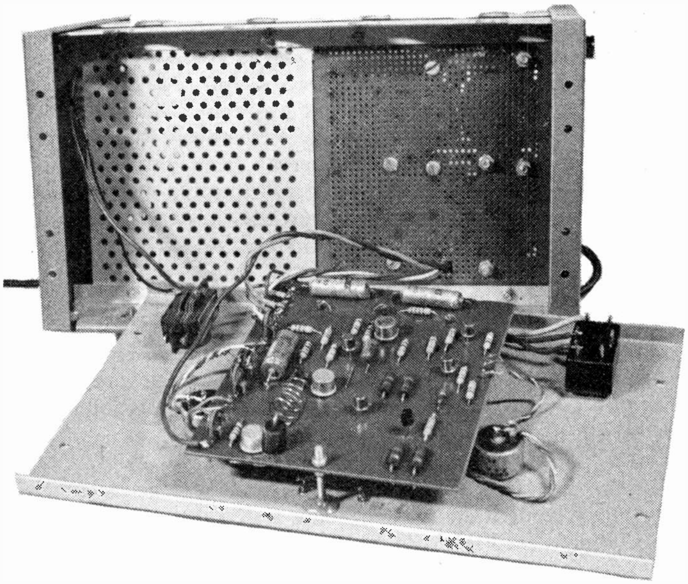


Fig. 2. (left) Printed circuit board layout. Holes should be drilled to conform with the component wire inserts as shown above







Various views showing p.s.u. prototype assembly. Four lower value reservoir capacitors were used in this

indicated by VR1 setting, TR1 is controlling the loop and the volt drop across R4 due to its collector current will ensure that TR3 is on and TR4 is off. Therefore TR5 and TR9 will be off and D7 lit. In current limit TR2 takes over control of the loop, so the drop across VR4 will cause TR4 and hence TR5 and TR9 to turn on and l.e.d. D6 will light, extinguishing D7.

S2 enables the output to be turned off and R19 ensures that even with little or no load the output voltage will then collapse to zero within a second or so. If the mains switch were used instead, then the output voltage could hold up for several seconds when lightly loaded, leading to possible damage to a circuit being worked on whilst still connected to the supply. D8 protects the stabiliser when switching off a highly inductive load and also when the supply is being used in series with another to obtain a higher voltage. Under these circumstances, if the stabiliser goes into current limit, the voltage at its terminals could reverse if it were not for D8.

CONSTRUCTION

Figs. 2 and 3 show the track layout and component assembly of the main board. In the prototype a Lektrokit chassis system was used for the case with TR8 heat sink mounted to the rear. A free air circulation must be ensured around this.

The sink specified will cope with the dissipation in TR8 at 1·5A output current into a short circuit at ambient temperatures in excess of 50 degrees centigrade if heat sink compound is used on both sides of the insulating mica washer.

As D4 can get rather warm on full load it should be mounted with its body away from the board.

CALIBRATION

On completion, set VR1, 2, 3, 4 and 5 midway, VR6 fully clockwise and check the raw supply voltage across C1. Off load it should be 37V. With S2 on, monitor the output voltage. Increase it to maximum by rotating the voltage control VR1 fully clockwise and set VR5 to give 25V output. VR1 may now be calibrated directly in output volts.

With output voltage control VR1 set fully anti-clockwise, the minimum output voltage is about 1·75V. Next set VR1 fully clockwise and current limit control VR6 fully anti-clockwise and measure the short circuit output current. Adjust VR3 to set this to 1 or 2mA. Now adjust VR6 clockwise until the short circuit current reaches 1·5A. Adjust VR2 so that 1·5A short circuit current occurs with VR6 fully clockwise. As the settings of VR2 and 3 will interact somewhat, readjust them alternately so that the short circuit current with the current limit control VR6 fully anti-clockwise and clockwise is 2mA and 1·5A respectively. VR6 may now be calibrated directly in short circuit current.

Next connect a suitable load to draw 1·25A at 25V and adjust current limit control VR6 so that the output voltage just begins to fall. Adjust VR4 so that l.e.d. D6 just takes over from D7. The l.e.d.s now indicate the mode of operation, i.e. if D7 is lit the output voltage is as indicated by the setting of voltage control VR1, whilst if D6 is lit the power supply is in current limit. The current limit control VR6 can thus be used as indication of the current drawn by the load, by noting its reading at the point where the current limit l.e.d. D6 just lights.

USE

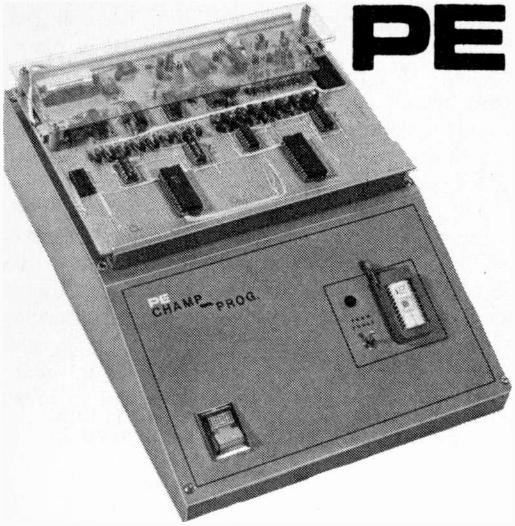
Whilst the power supply can look after itself, with 25V at 1·5A available, care is needed to avoid damage to low power circuits being run from the supply. Always connect up with S2 switched off and check the voltage and current limit settings before switching the output on. Set the current limit at about 50 per cent more than the current you expect the circuit to take and you will then seldom damage it even if it has been assembled wrongly.

Note that the current limit control has been calibrated in terms of the short circuit output current. Of course, when the output is short circuited, R21 draws no current, but at 25V output it will draw about 11mA. Consequently, if the current limit is set to less than 11mA, even though the voltage control VR1 is set to maximum, the output voltage will be less than 25V. At high current limit settings, the 11mA difference between current at the onset of limiting at 25V and the current at short circuit is of course barely perceptible. ★

PE CHAMP

R.W. COLES B. CULLEN

PART NINE



With the circuit details of CHAMP-PROG behind us, this month we can move on to consider the construction of the main board, power supply and plinth, and to an examination of the PROMPT firmware program. Anyone who has already built CHAMP itself should have no problems with CHAMP-PROG, because the techniques required will have already become familiar.

CIRCUIT BOARD

Most of the CHAMP-PROG circuitry is mounted on a piece of Veroboard measuring 165mm by 225mm, and this has to be cut from a larger sheet, of the same type as was used for the CHAMP main board. When the board has been cut to size, the three unperforated copper strips which run along the two long edges should be removed by easing up each of their ends with a sharp knife and then carefully pulling them away from the board along their entire length. The removal of these strips makes for easier insertion of the board into the card guide supports, and insertion can be further eased by chamfering the four board corners with a fine file.

The required track cuts and component positions are detailed in Fig. 9.3 and it is a good idea to study the component layout at this stage so that when construction starts you will "know-your-way-around". There are three distinct circuit areas on the board, the top quarter being occupied by the regulator components, the next quarter by the timing generator and the lower half by the CHAMP interface and the data and address circuits. The layout chosen provides plenty of room in which to work and makes fault finding fairly easy.

Track cuts can be made right at the start, which makes life easier later but requires great care initially to prevent errors creeping in. Alternatively they can be incorporated as construction proceeds so that some layout flexibility is retained.

CONNECTING UP

The circuitry on the CHAMP-PROG board is a fair mixture of digital and analogue integrated circuits and discrete components, and of course high voltages will be present during operation. Needless to say, great care must be taken during wiring-up to avoid expensive mistakes. A wiring error on the prototype caused a transistor to quite literally "blow its top" when power was first applied! One consolation though, faults on this kind of circuitry are usually easy to locate, just watch out for the smoke signals!

As with the CHAMP main board, Soldercon pins are recommended for every integrated circuit, but not for the 16 and 24 way connector socket positions where standard or low-profile sockets are best. Remember to leave the bandolier attached to the Soldercon pins until construction is complete, and be sure not to plug in the 4265 MOS chips until the debugging process is over.

Using the Soldercon pins and sockets as a reference framework, wiring up is carried out using Fig. 8.2. Kynar wire is highly recommended for the interconnection of all logic circuitry address and data drivers, although sturdier single core PVC covered wire is better for the +5V, −10V and +80V interconnections because of its higher current rating and higher voltage insulation.

TESTING

The complex timing generator and voltage regulator circuitry lends itself well to being tested in isolation without benefit of PROMPT software or 4265 interface chip. Before testing can take place, +5V and −10V supplies must be connected, and the 80V supply will have to be built using the circuit of Fig. 9.1 and the layout shown in Fig. 9.2.

To start the testing procedure, first connect pin 1 of IC1 to 0V temporarily to enable the timing generator to free-run (this can be achieved by grounding pin 11 of the vacant IC8 socket if desired). Next apply the +5V and −10V power, but *not* the +80V supply and examine the timing generator waveforms at the Q and $\overline{Q}$ outputs of the 74123 using an oscilloscope set to measure pulse amplitudes of a few volts and pulse durations of a few milliseconds.

At IC1 pin 13 you should be able to see narrow pulses with a 15ms separation. If the pulses you see are separated by much more or less than this, the value of fixed resistor R3 should be changed to compensate. A timing accuracy of ±10 per cent should be the target.

On IC2 pin 13 a series of 3·25ms wide pulses should be obtained, and of course the width of these pulses can be accurately set using VR1. On IC3 pin 12 the pulses should be set to a width of 3·0ms using VR2, and on IC2 pin 12 pulses about 60μs wide should be observed. Finally on IC3 pin 13, pulses of about 155μs width should be visible.

REGULATOR OUTPUTS

If the monostable circuits are operating correctly and VR1 and VR2 have been properly adjusted, the next step is to set VR3 to its mid-travel position (Remember that all three adjustment pots are of the 10 turn variety) and connect up the +80V supply. Providing that the fuse does not blow (and that no wisps of smoke are observed!), the next step is to examine the 7405 outputs, IC4 pins 2, 4, 8, and 10 and compare these with Fig. 8.5 published last month.

If these drive pulse outputs are correct switch the 'scope probe to the junction of D7 and D8 in the regulator area and decrease the 'scope sensitivity to show pulses of about 50V. The waveform at this point should consist of a steady +4·5V level with pulses 3·25ms wide superimposed every 15·0 ms. The amplitude of these pulses can be set by means of VR3, and this should be adjusted to give a peak of +47V. (Note that the +47V should be measured with respect to 0V and *not* with respect to +4·5V.)

At this point you can relax a little, because the worst is over! All that remains is to check the remaining Cs, Vbb, Vgg, Prgm and Vdd outputs and to ensure that they all conform to the timing and amplitudes specified in Fig. 8.5 last month. The Prgm pulse must have the characteristic "two-eared" shape and you will find that final trimming of this pulse can be achieved using VR1 and VR2. The high voltage programming waveforms can all be found on the board-mounted 24 pin socket as well as on the regulator transistors themselves of course.

CASE CONSTRUCTION

The CHAMP-PROG case, or plinth, is made of plywood and aluminium and is relatively easy to construct using the techniques described in part four for the CHAMP case. The plywood framework should be pinned and glued together, and mated carefully with the aluminium top cover and the separate aluminium back

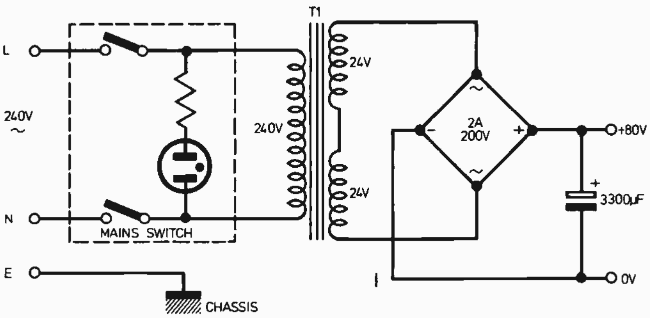


Fig. 9.1. Circuit diagram of 80V supply

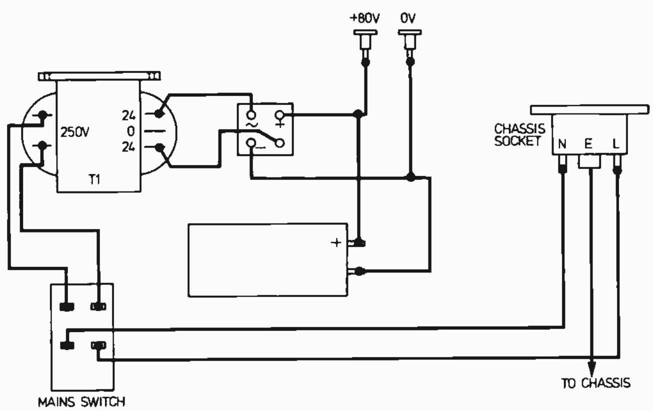


Fig. 9.2. Component layout of 80V Supply

panel. When the overall fit is satisfactory all necessary holes can be drilled in accordance with Fig. 9.4 and the board runners made up and pop riveted or bolted in place on the cover.

It is of course essential at this stage to ensure that the board runners are positioned so as to provide a satisfactory sliding fit on the CHAMP-PROG circuit board. A great deal of care was taken to ensure that the CHAMP-PROG prototype finish matched that of CHAMP itself, and again the process of applying several coats of primer, sanding it smooth and finishing off with a couple of colour coats, was followed. After allowing the paint to harden for a couple of days Letraset lettering was applied along with outlines drawn with a spirit based pen. Finally a coat or two of polyurethane clear varnish was applied to bring out a high gloss and to protect the lettering.

ZERO INSERTION FORCE SOCKET

With the plinth hardware completed, overall assembly can begin with items such as the ON/OFF rocker switch and the zero insertion force socket mounted on the front panel section of the cover.

If an economy CHAMP-PROG is required, the zero insertion force socket *could* be left out, and PROMS programmed directly in the 24-pin socket on the board, but levering expensive PROMS in and out of this type of socket is less than satisfactory, and the sheer convenience of the lever action type is well worth the few pounds it costs. If used, the front panel socket can be mounted either by adhesive, or more securely by first removing the two small Phillips screws from the socket, and with the socket lever in the upright position removing the face of the socket so that two holes can be drilled at the top and bottom of the socket. These should clear the two Phillips screw holes to take two 8BA countersunk screws. Using the socket as a template, two 8BA clear holes can be drilled in the plinth cover so that the socket can be mounted securely and its faceplate replaced.

EIGHTY VOLT SUPPLY

The programming voltages are derived from a simple power supply which consists of a transformer with a 25-0-25V 2A secondary, a 200V 2A bridge rectifier, and a 3,300μF, 100V electrolytic capacitor. These bulky components are mounted inside the plinth using the separate aluminium back panel as a support and as a heat sink for the transformer and the rectifier. Mains input is via a three pin connector and, of course, the rocker switch on the front panel. The 80 volt output is routed to two wander sockets on the back panel, and the CHAMP-PROG board connects to these via a couple of flying leads.

The 80V generated by this circuit is of course sufficient to give the unwary quite a tingle, and caution is advisable when making the back panel connections! A fully insulated connector could of course be used instead of the Wander plugs and sockets if required. Since the 80V is also present on the CHAMP-PROG circuit board some protection against prying fingers has been provided by mounting a tailored sheet of perspex over the parts of the board where danger exists. Five 4BA plastic mounting pillars were cut to size and cemented to the Veroboard using cyanoacrylate adhesive. The perspex safety cover is screwed to these pillars when construction is complete.

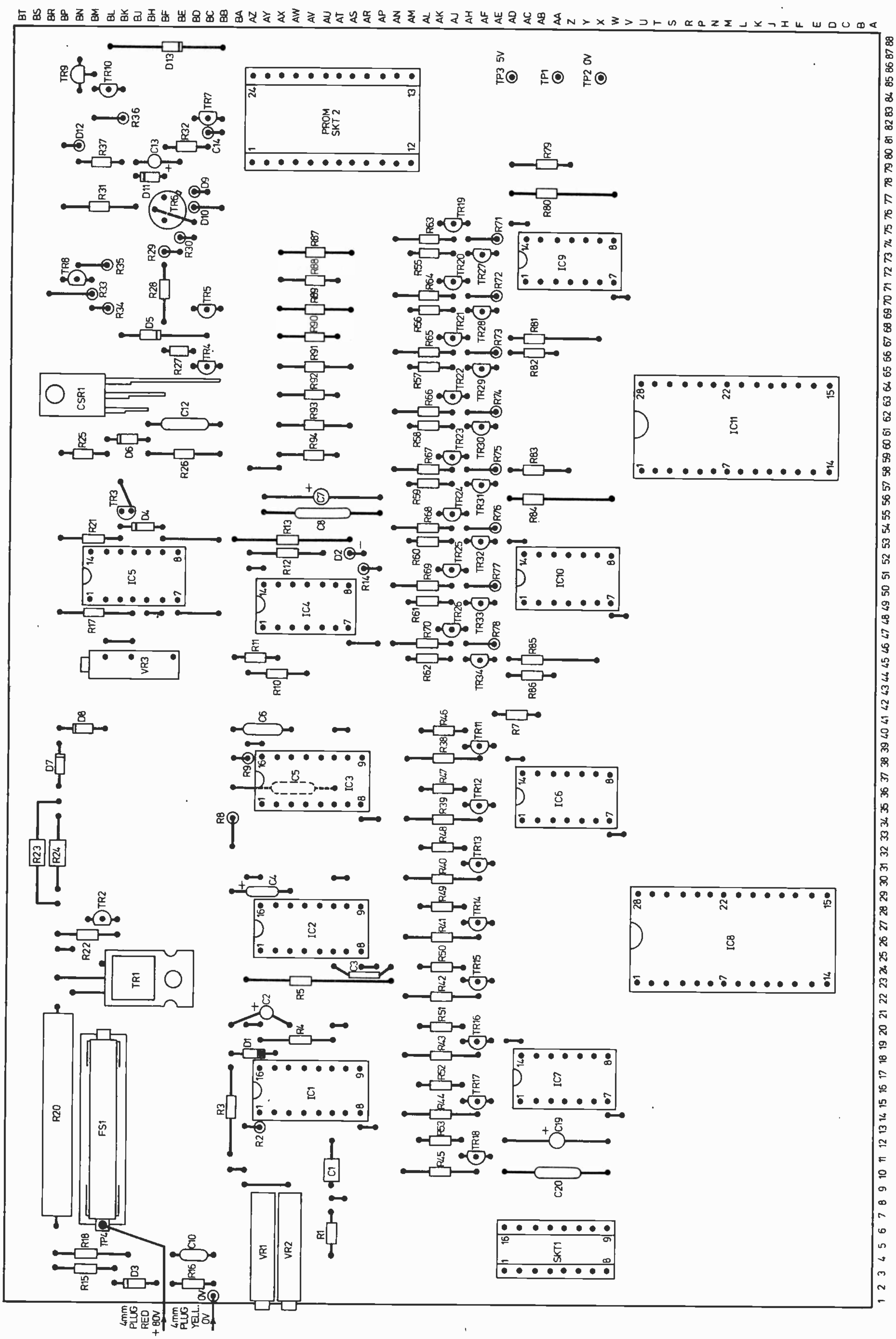


Fig. 9.3. CHAMP-PROG component layout. For interconnections see Fig. 8.2.

Row	Positions
4	X, Y, Z, AA, AB, AC, BK
5	AT, AV, AX
9	X, Y, Z, AA, AB, AC
11	AS, AT, AU, AV, AW, AX
12	BA
13	AF, AH, AL, BP
16	AR-AY
17	W, X, Y, Z, AA, AB, AC, AF
20	BL
21	AF, AH, AL
22	AN, AR-AY, BA
24	BK, BL, BM, BP
25	AF, AH, AL
26	D-Z, AA, AB, AC
27	AR-AY
28	AN, BN
29	AF, AH, AL, BJ, BK
30	BL
31	AR-AY, BA
33	AF, AH, AL, BA, BP
35	W-Z, AA, AB, AC, BE, BF, BH, BJ
37	AF, AH, AL, AR-AY, BA
39	BM
42	AR-AY
43	D-U, W-Z, AA, AB, AC, BA, BE-BN
44	AF-AK
47	BL, BM
48	AF-AK, AN, AR-AY
50	W-Z, AA, AB, AC
51	BE-BJ, BM
52	AF-AK, AN
56	AF-AK, AN, BE, BH-BN
57	AR-AY
60	AF-AK, AN, AT, BC, BD
61	D-U, W-Z, AA, AB, AC
63	AS, BJ
64	AF-AK, AN, AT
65	BN
66	AS, BA
68	AF-AK, AN, AT, BD
70	AS, BE, BF
72	W-Z, AA, AB, AC, AF, AH, AJ, AK, AN, AT, BD
74	BN
75	AN-AZ
76	BF, BK
79	BC, BD, BF
81	BN
82	AM-AZ
84	X, AA

Table of track cut positions on CHAMP-PROG Veroboard

TWENTY-FOUR WAY CONNECTOR

The zero insertion force socket on the front panel is connected via a flying lead to the socket on the circuit board, and in addition to the 24 wires required for the PROM three others are needed for the "PROM POWER" switch and l.e.d. On the prototype a 27-way wiring loom was made up with the three extra wires being terminated at the board end with individual sleeved Soldercon sockets which provided a very convenient means of connection to terminal pins soldered to the Veroboard (Fig. 9.5).

The 24-pin plug required was actually made using a "header plug with top" which is available from Doram. Fine flexible wire was used for the interconnection, and this was soldered to the plug pins and brought out through a hole cut in the right hand side of the header plug top. When fully wired the header plug pins were potted in quick-set Araldite and the top clamped in position until the epoxy hardened. This method of construction has provided a satisfactory and trouble free plug which is a less expensive but more time consuming alternative to the flat-strip cable connectors used on CHAMP itself.

PROMPT FIRMWARE

When construction is complete, and the timing circuits and voltage regulator outputs have been set up correctly, you are ready to plug in the 4265 chips and run the PROMPT firmware program using the control sequence detailed last month. The 4702A containing PROMPT must be in the Chip One socket on the CHAMP main board, and arrangements have been made to enable CHAMP-PROG constructors to get their own devices programmed with PROMPT by using the CHAMP PROM programming service. Of course, once CHAMP-PROG is operating with PROMPT, CHAMP programmers will be totally independent and will never again have to rely on outsiders for programming facilities. The full listing of PROMPT is given in Fig. 9.7 and as you can see there is no wasted space in the 256 line PROM. All users of CHAMP will find it useful to study the operation of the PROMPT software, and to make this easier to follow, some words of explanation might be helpful.

DESIGN AIMS

A prime objective of the software design was that it should make CHAMP-PROG simple to use and preferably self explanatory. To this end the program has been made "interactive" with the programmer. PROMPT issues a prompting message via the keyboard display and waits for a response from the programmer, this process is repeated three times for address entry. At the termination of a programming run, CHAMP-PROG will issue the message "done" or "fail".

For address entry the CHOMP keyboard interrupt routine is "borrowed", and for the display of messages and keyboard entries the CHOMP DDRV subroutine is used. Here is a good example of why it pays to make software routines as general-purpose as possible from the outset, and to code them as subroutines callable from anywhere in program memory! The DDRV subroutine is segment, rather than BCD based and so it is quite capable of refreshing a display of alphanumeric characters when required. The generation of text messages is of course a new facility, and PROMPT includes a new subroutine, TEXT, to handle this job.

MAIN FLOWCHART

Referring to Fig. 9.6 PROMPT is entered at the top via a JUN instruction, from CHOMP. Since CHOMP itself was unaware of the presence of CHAMP-PROG during CHAMP initialisation, the first job here is to set the modes of the two new 4265 chips via WMP instructions (box 1). Next, (box 2) the prompt message "Adr 1" is loaded into the display RAM buffer register by the subroutine TEXT, and then an interruptible display loop is entered to await keyboard response (boxes 3 and 4). The continuous looping automatically refreshes the display via DDRV, while accepting up to three hexadecimal digits via the INTER routine.

An exit from the loop is made via box 4 by pressing the ENTER DATA button. At this time, a three digit hexadecimal address should be resident in 4040 registers C, D and E, and of course visible on the left of the display. The next job is to store Adr 1 away in its appointed storage locations (box 5) and to change the display message to Adr 2 (box 6). In this case it is not necessary to change the message radically, and so rather than employ TEXT once more, the display buffer is modified directly to save program lines. Boxes 7 and 8 are of course identical to boxes 3 and 4 also boxes 11 and 12 further down, and this makes them ideal subroutine candidates. (In fact a subroutine ENTERL *does* contain this pair of boxes, but for the purposes of our flow chart these activities have been included individually, to clarify program action.)

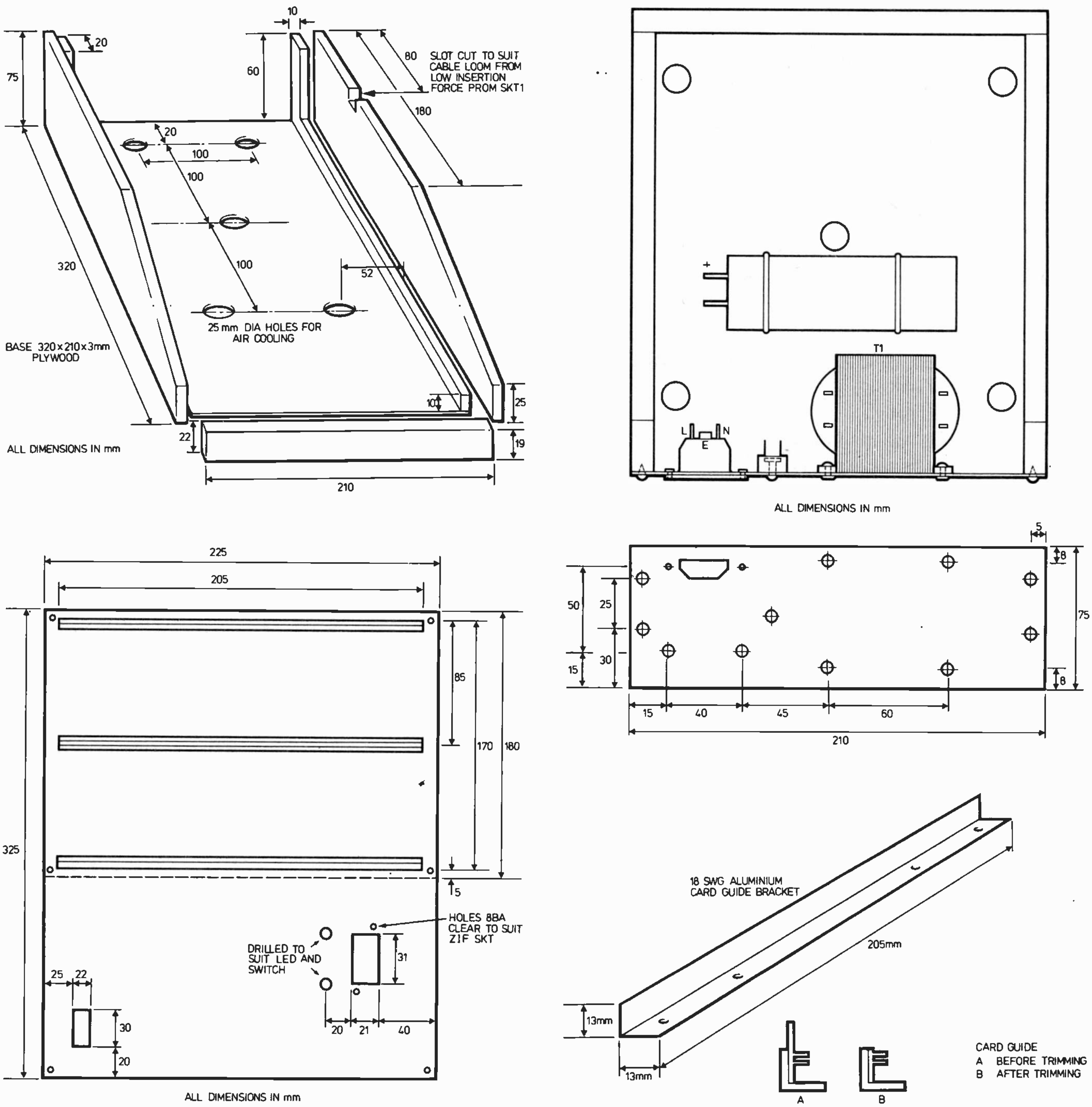


Fig. 9.4. Physical dimensions of CHAMP-PROG chassis

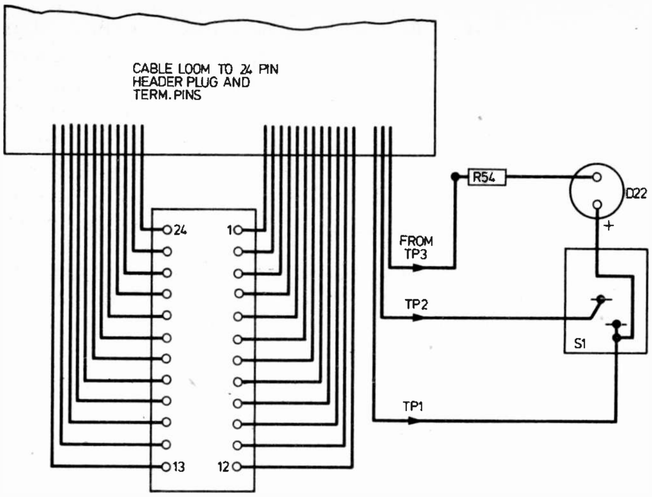


Fig. 9.5. Cable loom arrangement for z.i.f. socket

With three new hexadecimal digits entered, ENTER DATA is pressed once more and the Adr 2 data stored away in RAM register 2 where it will later be needed for comparison with Adr 1 (box 9). The display is now modified to show Adr 3, and the interruptible display loop again used for address entry. Adr 3 data is left in the 4040 registers C, D and E, and so box 13 does not so much represent an *action* but rather it is a reminder that no action takes place in this case.

Next the keyboard display is blanked by writing OOH to ports X and Y of the CHAMP 4265 so that in the absence of a refresh loop, a single display digit does not remain on continuously.

Box 15 represents a largish subroutine called WUNBYTE which has the job of programming a single PROM location each time it is called. This subroutine reads data from the appointed area in program RAM, sends it out together with Adr 3 to the CHAM-PROG 4265 chips, initiates a program cycle via 4265 number 1 port Z3, and waits during a software delay of about 540 milliseconds before reading the results of its programming and storing them away in RAM register 2 before returning to the main program.

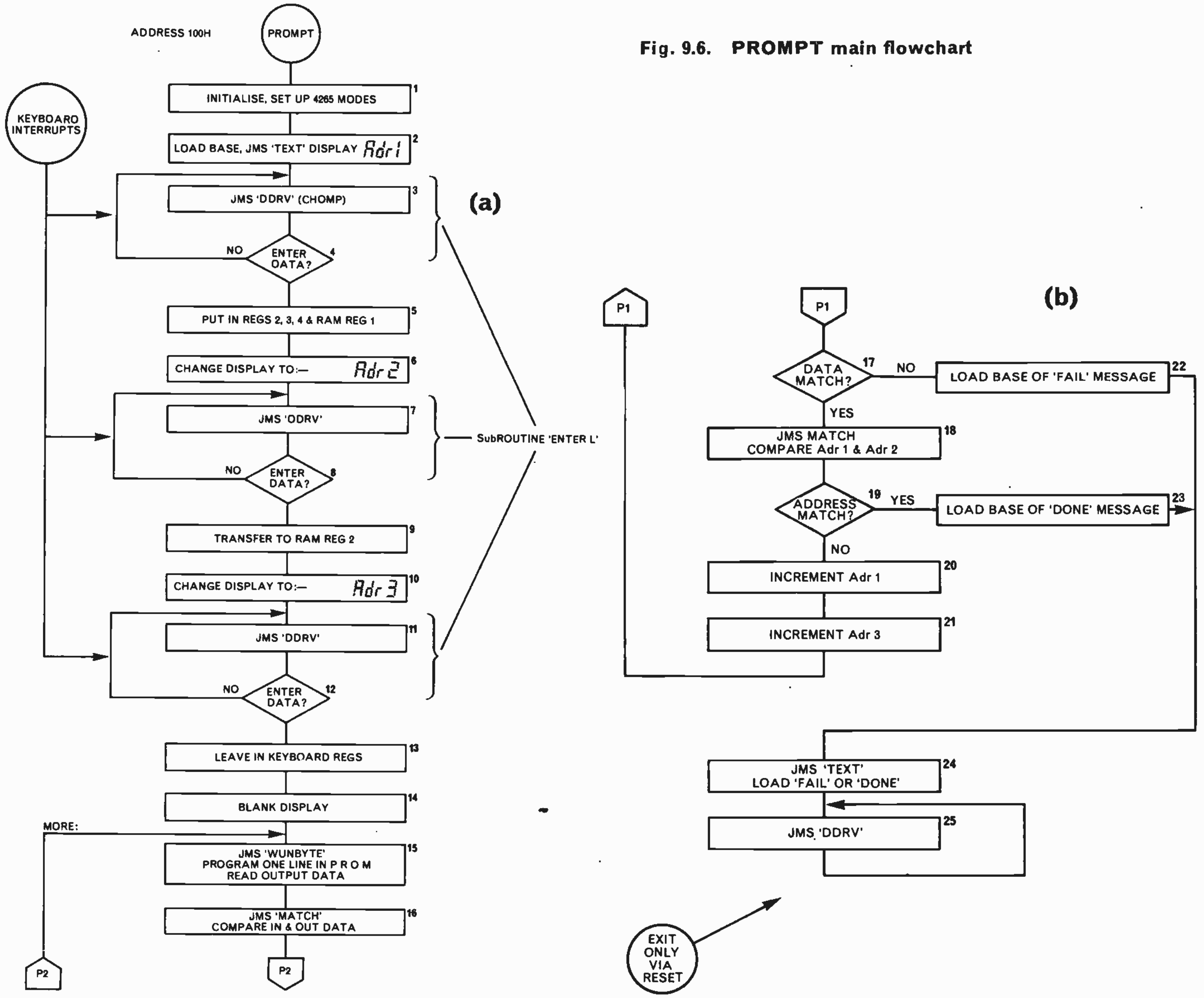


Fig. 9.6. PROMPT main flowchart

In box 16 a subroutine called MATCH is used to compare a copy of the PROM input data stored in RAM with the output data read by WUNBYTE after its cycle. MATCH returns a flag which is tested in box 17, where a conditional jump (JCN) either aborts operations if the output is bad, or passes on to an address compare operation using MATCH (box 18) if the output is good.

Address comparison is needed to check whether all necessary locations have been programmed. In this case further programming is suspended if a *good* comparison results. If on the other hand Adr 1 and Adr 2 are not yet the same, then Adr 1 and Adr 3 are incremented to point to the next source address and the next destination (PROM) address respectively, before a JUN loop to the label MORE is carried out (boxes 20 and 21).

Boxes 22 and 23 load the base addresses of text messages stored in PROM before jumping to a routine which loads the message into the display using TEXT

PROMPT

PAGE	LINE	ROM CODING	LABEL	OPERATION	OPERAND	COMMENTS
1	0 0	D9	PROMPT	LDM	9	LOAD DCL & SRC CODE
	1	FD		DCL		SELECT RAM BANK 1
	2	B8		XCH	8	9H → R8
	3	29		SRC	9	SELECT 4265 CHIP
	4	D4		LDM	4	
	5	E1		WMP		SET TO MODE 4
	6	DF		LDM	F	BIT SET PORT Z3
	7	E0		WRM		
	8	D2		LDM	2	
	9	FD		DCL		SELECT RAM BANK 2
	A	29		SRC	9	SELECT 4265 CHIP
	B	D6		LDM	6	
	C	E1		WMP		SET TO MODE 6
	D	D0		LDM	0	
	E	FD		DCL		SELECT RAM BANK 0
	F	0B		SB1		SELECT REG. BANK 1
1	1 0	20		FIM	0	SET UP BASE ADDRESS
	1	F4		F	4	OF MESSAGE "Adr-1"
	2	51		JMS		LOAD MESSAGE INTO
	3	E1		TEXT		DISPLAY
	4	51		JMS		LOOP FOR Adr-1 KEYBOARD
	5	C0		ENTERL		ENTRY & 'ENTER DATA'
	6	AD		LD	D	GET Adr-1 LEAST SIG
	7	B3		XCH	3	PUT IN R3
	8	AC		LD	C	GET Adr-1 MID
	9	B2		XCH	2	PUT IN R2
	A	AE		LD	E	GET Adr-1 MOST SIG
	B	B4		XCH	4	PUT IN R4
	C	51		JMS		COPY LEAST SIG & MID
	D	D0		LADR1		OF Adr-1 TO RAM
	E	20		FIM	0	CODE FOR TEXT
	F	6B		6	B	OF "2"
1	2 0	51		JMS		CHANGE DISPLAY TO
	1	B6		ADNO		"Adr 2"
	2	51		JMS		LOOP FOR Adr-2 KEYBOARD
	3	C0		ENTERL		ENTRY & "ENTER DATA"
	4	28		FIM	8	SET UP Adr-2 RAM
	5	22		2	2	ADDRESS
	6	29		SRC	9	
	7	AD		LD	D	LEAST SIG Adr-2 TO RAM
	8	E0		WRM		
	9	69		INC	9	
	A	29		SRC	9	
	B	AC		LD	C	MID Adr-2 TO RAM
	C	E0		WRM		
	D	20		FIM	0	GET CODE FOR TEXT
	E	E9		E	9	OF "3"
	F	51		JMS		CHANGE DISPLAY TO
1	3 0	B6		ADNO		"Adr 3"
	1	51		JMS		LOOP FOR Adr-3 KEYBOARD
	2	C0		ENTERL		ENTRIES & ENTER DATA
	3	28		FIM	8	
	4	80		8	0	
	5	29		SRC	9	SELECT CHAMP 4265
	6	F0		CLB		
	7	E5		WR1		} BLANK
	8	E6		WR2		} DISPLAY
1	3 9	51	MORE	JMS		PROGRAM ONE PROM
	A	5A		WUNBYTE		LOCATION
	B	20		FIM	0	SET UP ADDRESS OF
	C	10		1	0	'IN' DATA FOR MATCH
	D	22		FIM	2	SET UP ADDRESS OF
	E	20		2	0	'OUT' DATA FOR MATCH.
	F	51		JMS		COMPARE 'IN' & 'OUT'
1	4 0	A6		MATCH		
	1	20		FIM	0	SET UP BASE ADDRESS
	2	F8		F	8	OF TEXT MESSAGE "FAIL"
	3	1C		JNZ		STOP & DISPLAY "FAIL"
	4	DA		FINIS		IF AC NOT ZERO.
	5	20		FIM	0	SET UP ADDRESS OF Adr-1
	6	12		1	2	FOR MATCH.
	7	22		FIM	2	SET UP ADDRESS OF Adr-2
	8	22		2	2	FOR MATCH.
	9	51		JMS		COMPARE CURRENT Adr-1
	A	A6		MATCH		WITH Adr-2
	B	20		FIM	0	SET UP BASE ADDRESS
	C	FC		F	C	OF TEXT MESSAGE "donE"
	D	14		JZ		STOP & DISPLAY
	E	DA		FINIS		"donE"
	F	0A		SB0		SELECT REG. BANK 0
1	5 0	73		ISZ	3	}
	1	53		PAST		} INCREMENT Adr-1
	2	62		INC	2	}
1	5 3	51	PAST	JMS		NEW Adr-1 TO RAM
	4	D0		LADR1		}
	5	7D		ISZ	D	}
	6	39		MORE		} INCREMENT Adr-3
	7	6C		INC	C	}
	8	41		JUN		} LOOP BACK FOR NEXT BYTE
	9	39		MORE		} END OF MAIN PROG.
1	5 A	28	WUNBYTE	FIM	8	SUBROUTINE PROGS 1 BYTE
	B	00		0	0	
	C	29		SRC	9	SELECT PROGRAM MEMORY
	D	A4		LD	4	SOURCE CHIP.
	E	E1		WMP		
	F	23		SRC	3	SEND OUT Adr-1
1	6 0	0E		RPM		READ FIRST NIBBLE.
	1	F4		CMA		COMPLEMENT IT.
	2	B1		XCH	1	PUT IT IN R1
	3	0E		RPM		READ SECOND NIBBLE.
	4	F4		CMA		COMPLEMENT IT
	5	B0		XCH	0	PUT IT IN R0
	6	28		FIM	8	}
	7	10		1	0	}
	8	29		SRC	9	} PUT 'IN' DATA IN
	9	A1		LD	1	} RAM FOR USE
	A	E0		WRM		} WITH MATCH
	B	69		INC	9	} LATER.
	C	29		SRC	9	}
	D	A0		LD	0	}
	E	E0		WRM		}
	F	D2		LDM	2	
1	7 0	FD		DCL		SELECT RAM BANK 2
	1	28		FIM	8	}
	2	80		8	0	} SELECT 4265 No 2
	3	29		SRC	9	}
	4	A1		LD	1	}
	5	E6		WR	2	} 'IN' DATA TO PORTS
	6	A0		LD	0	} Y & Z.
	7	E7		WR	3	}
	8	D1		LDM	1	}
	9	FD		DCL		} LOAD Adr-3 TO PORTS
	A	AD		LD	D	} W & X 4265 No 1
	B	E4		WR0		}
	C	AC		LD	C	}
	D	E5		WR1		}
	E	DE		LDM	E	TURN ON PROGRAM
	F	E0		WRM		PULSES.

Fig. 9.7. PROMPT program listing

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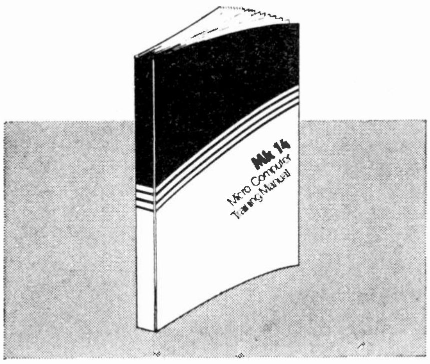

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4007	·19*	4060	1·16*	7451	·16*
4009	·62*	4068	·22*	7470	·27*
4010	·62*	4070	·22*	7472	·22*
4011	·18*	4071	·22*	7473	·27*
4012	·21*	4081	·22*	7474	·27*
4013	·53*	4082	·22*	7475	·40*
4014	1·00*	4510	1·24*	7476	·30*
4015	·97*	4511	1·54*	7485	·76*
4016	·58*			7486	·27*
4017	·97*	**TTL**		7489	2·32*
4018	·97*			7490	·38*
4019	·58*			7492	·41*
4020	1·08*	7400	·16*	7493	·41*
4021	·97*	7401	·16*	74107	·27*
4022	·88*	7402	·16*	74121	·27*
4023	·19*	7403	·16*	74123	·49*
4024	·78*	7404	·17*	74141	·65*
4025	·19*	7408	·19*	74145	·65*
4026	1·76*	7410	·16*	74151	·49*
4027	·58*	7413	·27*	74154	·85*
4028	·87*	7420	·16*	74174	·72*
4029	1·18*	7427	·28*	74192	·86*
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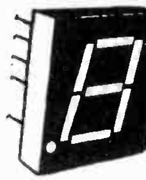

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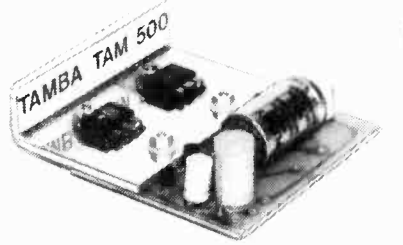

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(box 24) and then enters a display loop using DDRV (box 25). From the foregoing you can see that the program always terminates with one of the two messages "fail" or "done" displayed, and that return to CHOMP must be carried out by use of the RESET button.

SUBROUTINE FLOWCHARTS

The flowchart of the ENTERL or "interruptible loop" subroutine is shown in Fig. 9.8, note the use of EIN and DIN to control interrupts, and the way that the ENTER DATA flag is read using RDR and tested using JCN; the WRR before the BBL is used to reset the ENTER DATA flag. Fig. 9.9 shows the TEXT subroutine and its look-up tables. This subroutine is passed the base address of a text message table in register pair O,1 so that the FIN command can be used to fetch the message a byte at a time.

In PROMPT only four-character messages are per-

PROMPT

PAGE	LINE	ROM CODING	LABEL	OPERATION	OPERAND	COMMENTS
1	8 0	0B		SB1		
	1	22		FIM	2	
	2	19		1	9	PRESET DELAY
	3	24		FIM	4	COUNTER.
	4	9A		9	A	
1	8 5	72	WAIT	ISZ	2	
	6	85		WAIT		
	7	73		ISZ	3	
	8	85		WAIT		540 M.S. DELAY
	9	74		ISZ	4	
	A	85		WAIT		
	B	75		ISZ	5	
	C	85		WAIT		
	D	DF		LDM	F	TURN OFF
	E	E0		WRM		PROGRAM PULSES.
1	8 F	74	DELAY	ISZ	4	
	0	8F		DELAY		DELAY BEFORE
	1	75		ISZ	5	READ 36 M.S.
	2	8F		DELAY		
	3	D2		LDM	2	
	4	FD		DCL		SELECT 4265 No 2
	5	29		SRC	9	
	6	EC		RD0		
	7	B5		XCH	5	READ FROM 'OUT' DATA
	8	ED		RD1		PUT IN R5, R4.
	9	B4		XCH	4	
	A	D0		LDM	0	
	B	FD		DCL		SELECT RAM BANK 0
	C	28		FIM	8	CHIP 0 REG 2
	D	20		2	0	
	E	29		SRC	9	
	F	A5		LD	5	
1	A 0	E0		WRM		
	1	69		INC	9	PUT 'OUT' DATA INTO
	2	29		SRC	9	RAM.
	3	A4		LD	4	
	4	E0		WRM		
	5	C0		BBL	0	END OF WUN BYTE.
1	A 6	FA	MATCH	STC		SUBROUTINE COMPARES 2 BYTES.
	7	DE		LDM	E	PRESET NIBBLE COUNTER.
	8	B5		XCH	5	
1	A 9	F3	LOOP2	CMC		
	A	21		SRC	1	
	B	E9		RDM		READ FIRST NIBBLE.
	C	23		SRC	3	
	D	E8		SBM		SUBTRACT SECOND NIBBLE.
	E	61		INC	1	INCREMENT RAM
	F	63		INC	3	ADDRESSES.
1	B 0	14		JZ		
	1	B3		SKIP		
	2	C1		BBL	1	IF AC. NOT 0 BBL 1
1	B 3	75	SKIP	ISZ	5	NEXT PAIR OF
	4	A9		LOOP2		NIBBLES ?
	5	C0		BBL	0	IF AC STILL 0 BBL 0.
1	B 6	28	ADNO	FIM	8	SUBROUTINE MODIFIES DISPLAY
	7	0E		0	E	SELECT RAM BANK 0,
	8	29		SRC	9	CHIP 0, CHAR E.
	9	A0		LD	0	PUT FIRST NIBBLE IN
	A	E0		WRM		CHAR E.
	B	69		INC	9	NEXT CHAR
	C	29		SRC	9	
	D	A1		LD	1	PUT SECOND NIBBLE
	E	E0		WRM		IN CHAR F.
	F	C0		BBL	0	END OF ADNO

PAGE	LINE	ROM CODING	LABEL	OPERATION	OPERAND	COMMENTS
1	C 0	0C	ENTERL	EIN		SUBROUTINE: KEY ENTRY LOOP
	1	28		FIM	8	
	2	40		4	0	READ SWITCH FLAGS.
	3	29		SRC	9	
	4	EA		RDR		
	5	F6		RAR		PUT 'ENTER DATA' IN CY
	6	0D		DIN		DISABLE INTERRUPTS.
	7	50		JMS		DISPLAY NEXT DIGIT.
	8	B1		DDRV		
	9	12		JC		IF 'ENTER DATA' NOT
	A	C0		ENTERL		PRESSED THEN LOOP.
	B	28		FIM	8	NOW PRESSED SO
	C	50		5	0	CLEAR SWITCH FLAGS.
	D	29		SRC	9	
	E	E2		WRR		
	F	C0		BBL	0	END OF ENTERL
1	D 0	28	LADR1	FIM	8	SUBROUTINE: Adr1 TO RAM.
	1	12		1	2	SELECT RAM BANK 0
	2	29		SRC	9	CHIP 0, REG 1, CHAR 2.
	3	A3		LD	3	
	4	E0		WRM		LEAST SIG TO RAM.
	5	69		INC	9	
	6	29		SRC	9	NEXT CHAR.
	7	A2		LD	2	
	8	E0		WRM		MID TO RAM.
	9	C0		BBL	0	END OF LADR1.
1	D A	51	FINIS	JMS		SUBROUTINE: END OF PROG.
	B	E1		TEXT		LOAD TEXT TO DISPLAY
1	D C	0A	LOOPX	SB0		
	D	50		JMS		DISPLAY NEXT DIGIT.
	E	B1		DDRV		
	F	41		JUN		LOOP UNTIL RESET.
1	E 0			LOOPX		END OF FINIS.
1	E 1		TEXT	FIM	2	SUBROUTINE: LOADS TEXT.
	2			0	8	SELECT RAM BANK 0, C0, R0, C8
	3			LDM	C	PRESET BYTE COUNT.
	4			XCH	5	
1	E 5		LOOP1	FIN	6	LOOK UP IN TEXT TABLE.
	6			INC	1	NEXT TABLE LINE
	7			SRC	3	RAM SRC
	8			LD	7	FIRST NIBBLE TO RAM
	9			WRM		DISPLAY BUFFER.
	A			INC	3	NEXT RAM CHAR
	B			SRC	3	
	C			LD	6	SECOND NIBBLE TO
	D			WRM		RAM DISPLAY BUFFER.
	E			INC	3	NEXT RAM CHAR.
	F			ISZ	5	
1	F 0			LOOP1		NEXT BYTE ?
	1			SB0		
	2			BBL	0	END OF TEXT.
	3			NOP		
1	F 4		ADR1	E	E	TEXT TABLE: A
	5			B	C	d
	6			A	0	r
	7			0	C	I
1	F 8		FAIL	E	2	F
	9			E	E	A
	A			6	0	I
	B			7	0	L
1	F C		DONE	B	C	d
	D			B	8	o
	E			A	8	n
	F			F	2	E

ENTERL SUBROUTINE FLOW CHART

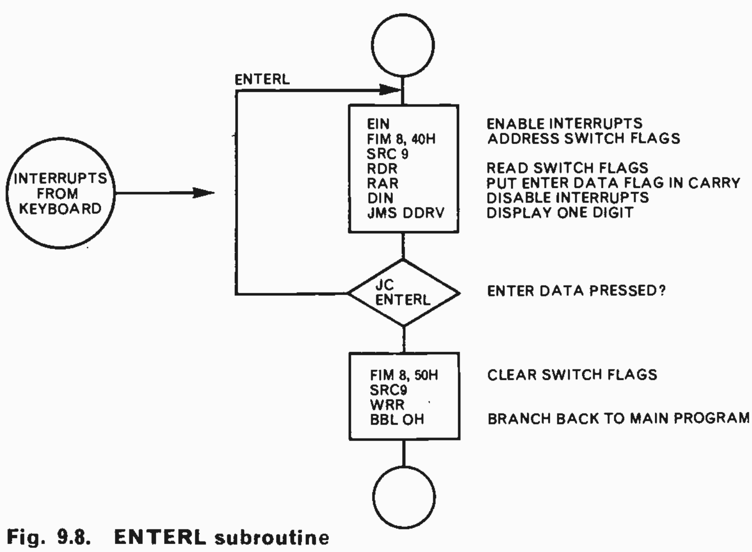

Fig. 9.8. ENTERL subroutine

TEXT SUBROUTINE

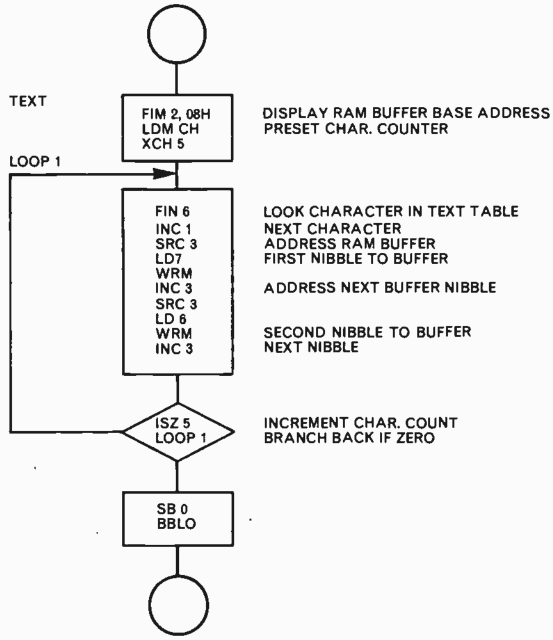

Fig. 9.9. TEXT subroutine

SUBROUTINE MATCH

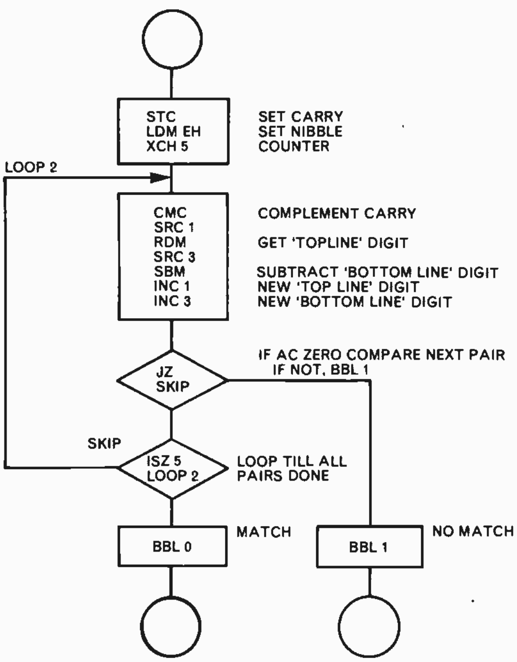

Fig. 9.10. MATCH subroutine

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mitted to save program space, but any message of up to eight characters could be used in other applications, with appropriate table entries and a different preset for the byte counter, register 5. The messages themselves were worked out to give the most pleasing display within the restrictions of a seven segment format.

The MATCH subroutine is shown in Fig. 9.10, and here the ploy is to subtract one byte of data from the other and check if the result is zero. The result of the comparison is flagged to the main program via alternative BBL exits, BBL 0 means match, BBL 1 means no match. The addresses of the data to be compared are passed to MATCH in register pairs 0,1 and 2, 3 by the main program.

There is not sufficient room to fully detail WUNBYTE, but since this subroutine is so important, readers may like to draw up their own flowchart using the listing in Fig. 9.7. Fortunately WUNBYTE *is* relatively straightforward and should pose few problems.

Note that source data is complemented using CMA before programming to compensate for the 74L00 inversion. Notice also the way the registers 2, 3, 4, 5 are preset using FIM instructions to give a 16 bit counter which produces a delay of 540 milliseconds. For further details see page 2.17 of the MCS40 manual.

PROMPT LISTING

For PROMPT we have chosen to list the program code in the format introduced in Part 7 for the TONE program. This format differs from the cross assembler listing given in Part 6, and is used to demonstrate to all budding CHAMP programmers that hand-coding of long programs is perfectly feasible! No facilities other than CHAMP itself were used in the development of the PROMPT firmware.

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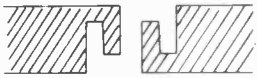

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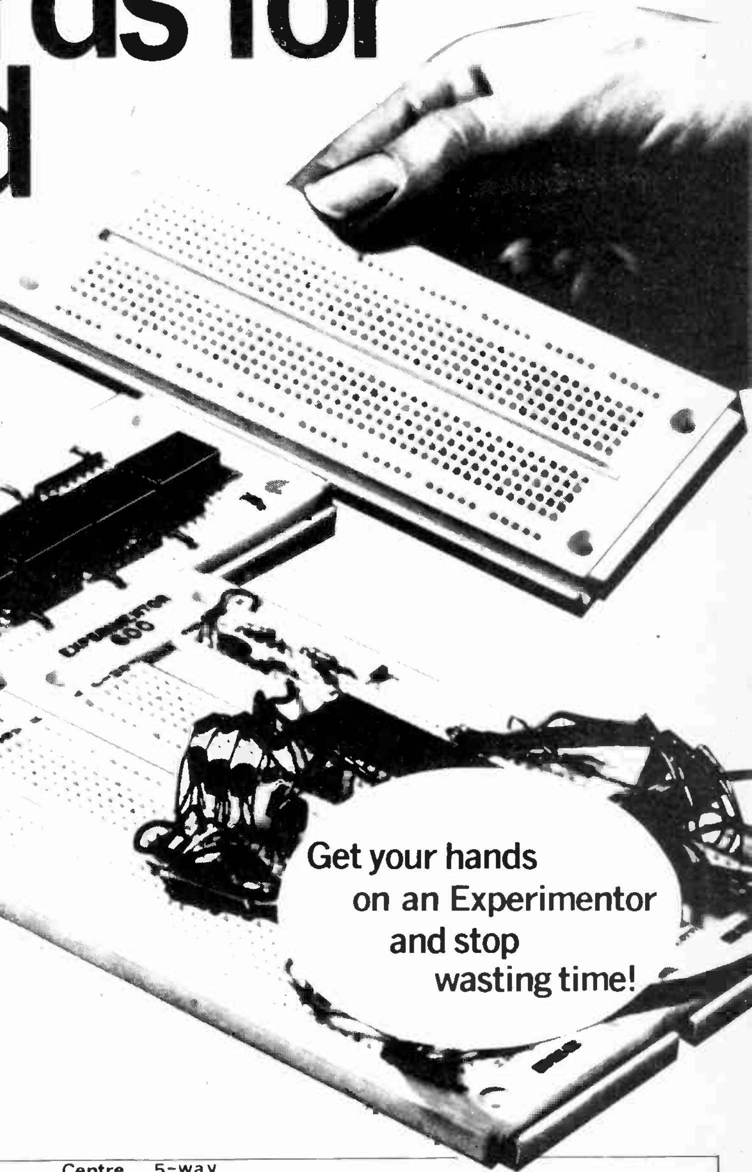

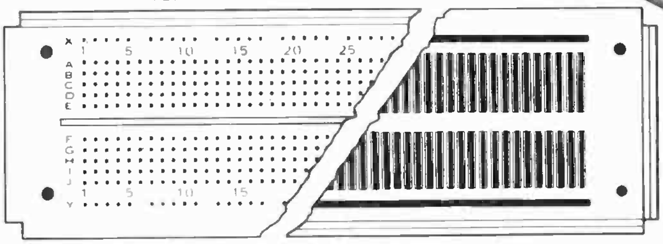

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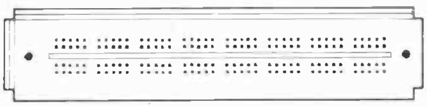

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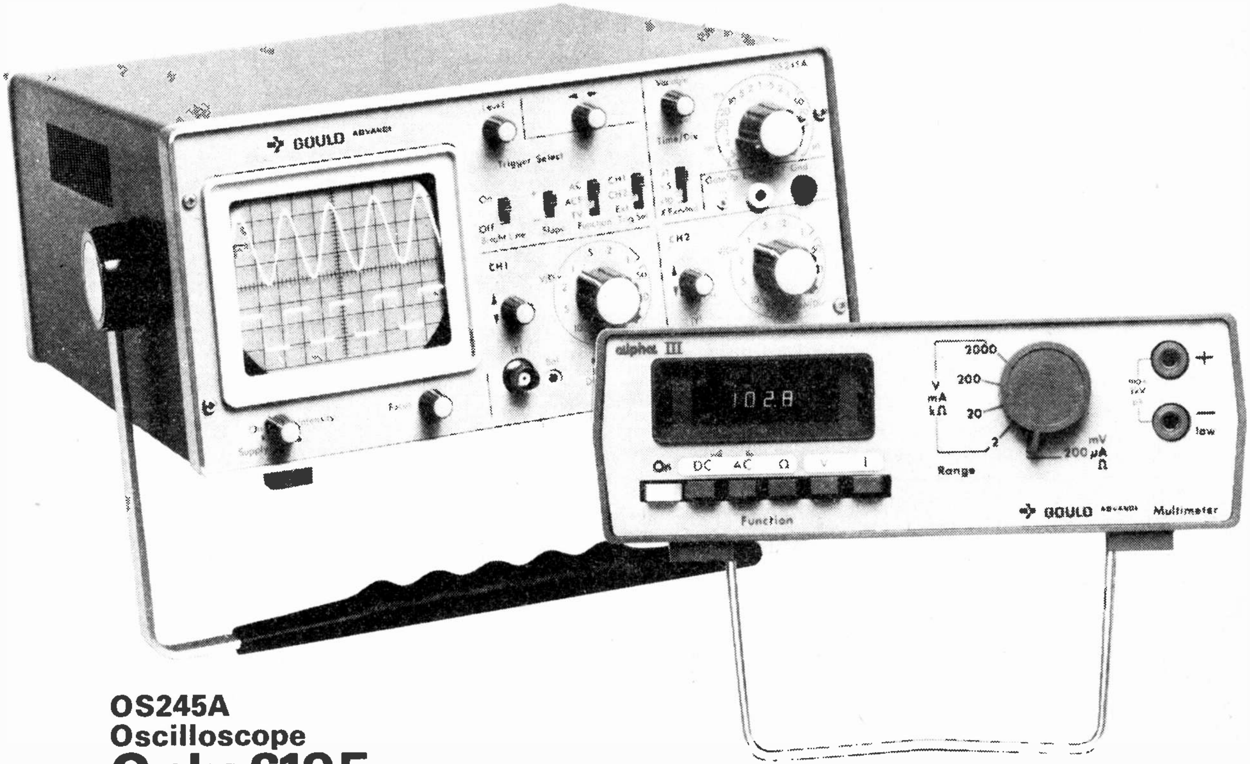

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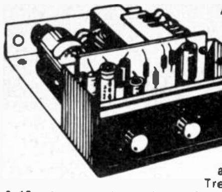

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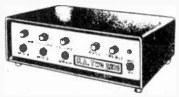

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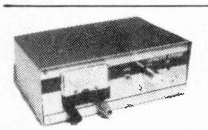

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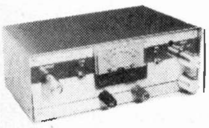

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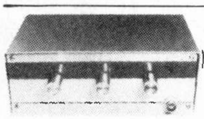

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2N917	0.38	2N2905	0.31	2N3709	0.12	2N4347	2.20	2N5485	0.40	AC176	0.54
2N918	0.45	2N2905A	0.31	2N3771	2.16	2N4348	2.65	2N5486	0.40	AC187	0.59
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2N929A	0.37	2N2906A	0.25	2N3773	3.15	2N4919	0.70	2N5492	0.64	AC188	0.54
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2N1893	0.30	2N2926	0.17	2N3903	0.20	2N5086	0.30	2N6109	0.55	BC107	0.16
2N2102	0.50	2N3053	0.25	2N3904	0.18	2N5087	0.30	2N6111	0.49	BC107A	0.16
2N2192	0.58	2N3054	0.72	2N3905	0.18	2N5088	0.30	2N6121	0.41	BC107B	0.16
2N2193	0.50	2N3055	0.75	2N3906	0.18	2N5089	0.30	2N6122	0.44	BC108	0.16
2N2193A	0.52	2N3390	0.50	2N4031	0.55	2N5190	0.65	2N6123	0.48	BC108A	0.16
2N2194	0.42	2N3391	0.40	2N4032	0.65	2N5191	0.75	2N6124	0.45	BC108B	0.16
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2N2218A	0.38	2N3396	0.19	2N4061	0.19	2N5246	0.38	40409	0.82	BC141	0.32

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BC149C	0.15	BC183B	0.13	BC238C	0.13	BD115	0.88	BD435	0.46	BF198	0.19	BSX20	0.35	MPSA05	0.27
BC157A	0.15	BC183C	0.13	BC239B	0.16	BD131	0.55	BD436	0.46	BF199	0.19	BSX21	0.35	MPSA06	0.27
BC158A	0.15	BC183L	0.15	BC239C	0.17	BD132	0.75	BD437	0.55	BF224J	0.22	BU104	1.80	MPSA12	0.44
BC158B	0.15	BC183LA	0.15	BC257A	0.18	BD135	0.40	BD438	0.55	BF225J	0.27	BU105	1.55	MPSA14	0.33
BC159A	0.17	BC183LB	0.15	BC258B	0.19	BD136	0.40	BD529	0.49	BF244A	0.38	BU126	1.08	MPSA55	0.27
BC159B	0.17	BC183LC	0.15	BC259B	0.19	BD137	0.41	BD530	0.55	BF244B	0.33	BU204	2.20	MPSA56	0.27
BC160	0.38	BC184	0.12	BC300	0.43	BD138	0.41	BD535	0.70	BF245A	0.44	BU205	2.40	R2008B	2.45
BC161	0.38	BC184B	0.13	BC301	0.43	BD139	0.43	BD536	0.70	BF245B	0.44	BU206	2.70	R2010B	2.15
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BC169B	0.13	BC212A	0.15	BC308	0.16	BD235	0.46	BDX18	1.90	BF338	0.52	ME0414	0.22	TIP31C	0.72
BC169C	0.13	BC212B	0.15	BC308B	0.16	BD236	0.44	BDY20	1.10	BFR39	0.30	ME4001	0.16	TIP32A	0.59
BC177	0.22	BC212L	0.18	BC3D9A	0.16	BD237	0.44	BDY55	1.90	BFR40	0.29	ME4002	0.16	TIP32C	0.82
BC177A	0.22	BC212LA	0.18	BC309B	0.16	BD238	0.44	BDY56	2.10	BFR41	0.30	ME4003	0.16	TIP41A	0.76
BC177B	0.25	BC212LB	0.18	BC309C	0.16	BD239A	0.44	BF115	0.39	BFR79	0.30	ME4101	0.11	TIP41C	0.97
BC178	0.22	BC213	0.15	BC327	0.22	BD239C	0.59	BF160	0.33	BFR80	0.30	ME4102	0.11	TIP42A	0.86
BC178A	0.25	BC213A	0.15	BC328	0.20	BD240A	0.49	BF161	0.65	BFR81	0.30	ME4103	0.11	TIP42C	1.08
BC178B	0.35	BC213B	0.15	BC337	0.20	BD240C	0.59	BF167	0.37	BFX29	0.34	ME4104	0.11	TIP2955	0.70
BC179	0.25	BC213C	0.15	BC338	0.23	BD241A	0.49	BF173	0.37	BFX30	0.34	ME6101	0.22	TIP3055	0.59
BC179A	0.25	BC213L	0.17	BC547	0.13	BD241C	0.65	BF177	0.27	BFX84	0.30	ME6102	0.22	TIS34	1.05
BC179B	0.25	BC213LA	0.17	BC547A	0.13	BD242A	0.55	BF178	0.27	BFX85	0.38	MJ2955	1.35	TIS42	0.50
BC179C	0.26	BC213LB	0.17	BC547B	0.13	BD242C	0.62	BF179	0.33	BFX86	0.30	MJE340	0.62	TIS43	0.47
BC182	0.12	BC213LC	0.17	BC548	0.13	BD243A	0.65	BF180	0.37	BFX87	0.35	MJE370	0.62	TIS90	0.22
BC182A	0.12	BC214	0.17	BC549	0.14	BD243C	0.87	BF181	0.37	BFX88	0.30	MJE371	0.86	TIS91	0.27

LINEAR CIRCUITS

CA3018	0.75	LM379S	4.25	LM324	0.75	TAA930B	1.45
CA3018A	1.10	LM380N8	0.96	LM7815K	1.75	TAD100	2.00
CA3020	2.20	LM380N14	1.08	LM7824K	1.75	TBA120	0.80
CA3020A	2.50	LM381AN	2.70	LM78L0802	0.30	TBA500	2.24
CA3028A	0.90	LM381N	1.69	LM78L1202	0.30	TBA500Q	2.34
CA3028B	1.25	LM382N	1.32	LM78L15C2	0.30	TBA510	2.35
CA3030	1.50	LM384N	1.55	MM5314	4.60	TBA510Q	2.48
CA3030A	2.20	LM386N	0.88	MM5316	4.60	TBA520	2.60
CA3038	2.90	LM387N	1.10	NE555	0.33	TBA520Q	2.70
CA3038A	4.10	LM388N	1.00	NE556	0.85	TBA530	2.35
CA3045	1.55	LM389N	1.00	NE558N	1.98	TBA530Q	2.45
CA3046	0.77	LM702C	0.81	NE560	4.50	TBA540	2.60
CA3048	2.45	LM709	0.70	NE561	4.50	TBA540Q	2.70
CA3052	1.78	LM7098	0.50	NE562	4.50	TBA550	3.60
CA3080	0.85	LM70914	0.49	NE565	1.39	TBA550Q	3.80
CA3080A	2.10	LM710	0.67	NE566	1.75	TBA5600Q	3.00
CA3086	0.50	LM71014	0.64	NE567	1.90	TBA570	2.10
CA3088B	1.87	LM711CN	0.72	NE571N	4.95	TBA570Q	2.20
CA3089B	2.90	LM723C	0.75	SAS60	2.70	TBA700Q	2.20
CA3090Q	4.40	LM723C14	0.45	SAS70	2.70	TBA720AQ	2.06
CA3130	1.05	LM726	5.80	SAJ110	2.10	TBA750	2.36
CA3140	1.04	LM741C	0.70	S041P	1.35	TBA750Q	2.45
LM301	0.30	LM741C8	0.30	S042P	1.35	TBA800	1.30
LM307N	0.50	LM741C14	0.30	SN76001N	1.30	TBA810S	1.30
LM308N	0.95	LM747CN	0.99	SN76003N	2.38	TBA820	0.80
LM309KC	1.95	LM7488	0.50	SN76013N	1.50	TBA920	2.99
LM317K	3.35	LM74814	0.90	SN76023N	1.50	TCA160C	2.36
LM318N	2.45	LM1303N	1.15	SN76033N	2.35	TCA160B	2.55
LM32015	2.15	LM1304N	1.52	TAA263	1.35	TCA270	2.99
LM320112	2.15	LM1305N	1.52	TAA300	3.70	TCA730	4.50
LM320115	2.15	LM1307N	1.22	TAA320A	1.15	TCA740	4.50
LM320124	2.15	LM1310N	2.10	TAA350A	3.00	TCA750	3.00
LM320P5	1.15	LM1351N	1.30	TAA521	1.10	TCA760	2.00
LM320P12	1.15	LM1458N	0.45	TAA522	2.10	TCA105	1.49
LM320P15	1.15	LM1496N	0.97	TAA550	0.48	TCA440	1.65
LM320P24	1.15	LM1808N	2.10	TAA560	2.10	TDA1022	7.50
LM323K	6.95	LM1812N	6.20	TAA570	2.20	TDA1024	1.24
LM339N	0.60	LM1820N	1.16	TAA370A	5.45	TDA1034	4.75
LM34015	0.88	LM1828N	1.90	TAA630	2.40	TDA2020AD	4.50
LM340115	0.88	LM1830N	1.90	TAA960	3.90	UAA170	2.15
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LM341P5	0.80	LM1845N	1.50	TAA611B	2.50	TL080CP	1.25
LM341P12	0.80	LM1848N	1.98	TAA621	2.50	TL081CP	0.90
LM341P15	0.80	LM1850N	1.90	TAA661A	1.65	TL082CP	1.10
LM341P24	0.80	LM1889N	4.90	TAA661B	1.45	TL083CN	1.40
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LM360N	3.00	LM3401N	0.55			LF356N	0.80
LM370N	3.30	LM3900N	0.68			LF357N	0.80
LM371H	2.35	LM3905N	1.15			LF13201N	3.00
LM350K	6.45	LM3909N	0.78			LF13331N	3.00
LM373N	3.35	LM3911N	1.10			LF13741H	0.80
LM374N	3.36	LM7805K	1.75			LF13741N	0.55
LM377N	1.80	LM7812K	1.75				
LM378N	2.40						

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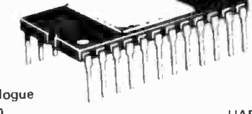

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4001B	0.22	4017B	1.05	4031B	2.25	4051B	0.85	4069B	0.24	4089B	2.10
4002	0.22	4018B	1.05	4035B	1.30	4052B	0.86	4070B	0.85	4093B	1.00
4006	1.25	4019B	0.52	4037	1.20	4053B	0.98	4071B	0.24	4094	2.30
4007	0.22	4020B	1.15	4041B	0.85	4054	1.48	4072	0.27	4095	1.30
4008B	0.99	4021	1.05	4042B	0.86	4055	1.65	4073B	0.24	4096	1.30
4009	0.58	4022B	1.00	4043	1.05	4056	1.65	4075B	0.24	4097	4.85
4010	0.58	4023B	0.22	4044	1.00	4059	6.00	4076B	0.99	4098	1.00
4011B	0.22	4024B	0.76	4045	1.76	4060B	1.15	4077	0.70	4510B	1.20
4012	0.22	4025B	0.22	4046B	1.50	4063	1.35	4078	0.27	4511	1.75
4013B	0.52	4027B	0.55	4047B	0.96	4066B	0.75	4081B	0.24	4516	2.10
4014	1.00	4028B	0.92	4049	0.96	4067	4.85	4082	0.27	4518B	1.20
4015	1.05	4029B	1.10					4085	0.89		

TTL & CMOS

74LS00N	0.26	74LS154N	1.45	74C173N	0.90	7485N	1.36
74LS01N	0.26	74LS155N	1.20	74C174N	0.90	7486N	0.38
74LS02N	0.26	74LS156N	1.20	74C175N	0.90	7489N	2.45
74LSD3N	0.26	74LS157N	0.60	74C192N	1.11	7490AN	0.45
74LS04N	0.29	74LS158N	0.65	74C193N	1.11	7491AN	0.85
74LS08N	0.26	74LS160N	1.43	74C195N	1.04	7492N	0.45
74LS10N	0.26	74LS161N	0.85	7400N	0.17	7493N	0.45
74LS12N	0.26	74LS162N	1.43	7401N	0.17	7494N	0.90
74LS13N	0.58	74LS163N	0.85	7402N	0.17	7495N	0.76
74LS14N	1.43	74LS164N	1.43	7403N	0.17	7496N	0.70
74LS20N	0.26	74LS168N	2.43	7404N	0.17	7497N	1.95
74LS26N	0.39	74LS169N	2.43	7405N	0.22	74100N	1.40
74LS27N	0.50	74LS174N	1.33	7406N	0.56	74107N	0.35
74LS28N	0.42	74LS175N	1.26	7407N	0.55	74118N	0.95
74LS30N	0.26	74LS181N	3.95	7408N	0.22	74119N	1.40
74LS32N	0.27	74LS189N	3.74	7409N	0.22	74121N	0.28
74LS37N	0.32	74LS190N	1.00	7410N	0.20	74122N	0.55
74LS38N	0.32	74LS191N	1.00	7411N	0.26	74123N	0.55
74LS40N	0.29	74LS192N	1.98	7412N	0.20	74125N	0.45
74LS42N	1.07	74LS193N	1.98	7413N	0.36	74141N	0.86
74LS47N	1.09	74LS196N	1.28	7414N	0.80	74148N	1.35
74LS48N	1.09	74C00N	0.24	7416N	0.36	74145N	0.86
74LS49N	1.09	74C02N	0.24	7417N	0.36	74150N	1.20
74LS51N	0.26	74C04N	0.24	7420N	0.22	74151N	0.76
74LS54N	0.26	74C08N	0.24	7423N	0.32	74153N	0.76
74LS73N	0.42	74C10N	0.24	7425N	0.32	74154N	1.20
74LS74N	0.42	74C14N	1.41	7427N	0.32	74155N	0.70
74LS75N	0.58	74C20N	0.24	7430N	0.22	74157N	0.78
74LS76N	0.42	74C30N	0.24	7432N	0.30	74160AN	1.10
74LS78N	0.42	74C32N	0.24	7437N	0.35	74161AN	1.10
74LS83AN	1.20	74C42N	0.92	7438N	0.32	74162AN	1.10
74LS85N	1.10	74C48N	1.38	7440N	0.20	74163AN	1.10
74LS86N	0.44	74C73N	0.54	7441AN	0.84	74164N	1.36
74LS90N	1.10	74C74N	0.56	7442N	0.76	74165N	1.36
74LS91N	1.20	74C76N	0.54	7445N	1.40	74167N	2.50
74LS92N	0.86	74C83N	1.30	7446AN	0.90	74174N	1.60
74LS93N	1.10	74C85N	1.30	7447AN	0.80	74175N	1.00
74LS95AN	1.10	74C86N	0.64	7448N	0.80	74176N	0.90
74LS96N	1.35	74C89N	4.39	7450N	0.22	74177N	0.90
74LS107N	0.42	74C90N	0.85	7451N	0.22	74180N	1.00
74LS109N	0.42	74C93N	0.85	7453N	0.22	74181N	2.00
74LS122N	0.80	74C95N	1.04	7454N	0.22	74182N	0.80
74LS123N	0.83	74C107N	1.22	7460N	0.22	74184N	1.50
74LS124N	2.70	74C150N	4.14	7470N	0.48	74185AN	1.50
74LS125N	0.50	74C151N	2.47	7472N	0.30	74188AN	3.25
74LS126N	0.50	74C154N	3.68	7473N	0.44	74189N	2.60
74LS132N	0.85	74C157N	2.21	7474N	0.32	74190N	1.40
74LS136N	0.44	74C160N	1.11	7475N	0.80	74191N	1.20
74LS138N	0.65	74C161N	1.11	7476N	0.45	74192N	1.20
74LS139N	0.65	74C162N	1.11	7480N	0.60	74193N	1.20
74LS145N	1.30	74C163N	1.11	7481N	1.00	74196N	1.20
74LS151N	1.07	74C164N	1.04	7482N	0.90	74197N	1.00
74LS153N	0.58	74C165N	1.04	7483N	1.05	74198N	2.00
				7484N	1.20	74199N	2.00

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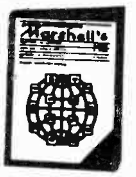

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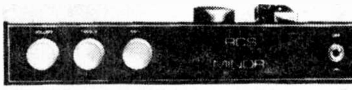

This kit is suitable for record players, tape play back, guitars, electronic instruments or small P.A systems. Two versions are available. The mono kit uses 13 semiconductors. The stereo kit uses 22 semiconductors. Both kits have printed front panel and volume, bass and treble controls. Spec. 10W output into 8 ohms, 7W into 15 ohms. Response 20c/s to 30kc/s, input 100M.V. high imp. Size 9½ × 3 × 2in A/C mains operated.

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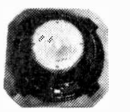

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R.C.S. BOOKSHELF complete with speakers. Size 14 × 9 × 6in. approx. Response 50 to 14,000 cps 12 watt rms 8 ohms **£19 pair** Post £1.50
ACOUSTIC WADDING 18in. wide, **20p** ft.

MONO PRE-AMPLIFIER

A mains operated solid state pre-amplifier unit designed to compliment amplifiers without low level phono and tape input stages. This free standing cabinet incorporates circuitry for automatic R.I.A.A. equalisation on magnetic phono input and N.A.B. equalisation for tape heads. Power ON/OFF, PHONO/TAPE switches and pilot lamp are on the front panel; phono socket input and output are rear located. AC mains 240V. Size 6 × 3½ × 2in.

£4·50 ea. – 2 for £8. Post 50p.

BAKER MAJOR 12 INCH £15

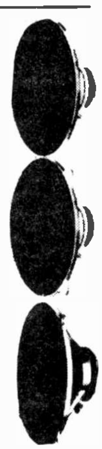
Post £1 00

30–14,500 c/s. 12in double cone, woofer and tweeter cone together with a BAKER ceramic magnet assembly having a flux density of 14,000 gauss and a total flux of 145,000 Maxwells. Bass resonance 40 c/s. Rated 25W.
NOTE 4 or 8 or 16 ohms available

Module kit, 30–17,000 c/s with tweeter, crossover, baffle, 19 × 12½in. instructions. As illustrated. **£19**

Please state 4 or 8 or 16 ohms Post £1 60

"BIG SOUND" BAKER SPEAKERS



Robustly constructed to stand up to long periods of electronic power As used by leading groups and discos. Useful response 30–13,000 c s Bass Resonance 55 c/s

GROUP "25" 12in 30W 4, 8 or 16 ohms. **£12** Post £1

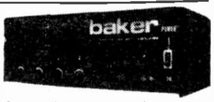
GROUP "35" 12in 40W 4, 8 or 16 ohms **£14** Post £1

GROUP 50/12in 12in 60W 4 or 8 or 16 ohms with aluminium presence dome **£21** Post £1 60

GROUP 50/15in 15in 75W 8 or 16 ohms **£26** Post £1 60

Disco, Group - PA Cabinets in stock. Send for Leaflet. Cabinet Fittings, Handles, Corners, Feet, Covering Material all in stock.

BAKER 150 WATT ALL PURPOSE TRANSISTOR AMPLIFIER



Ideal for Groups, Disco, P A and Musical Instruments 4 inputs speech and music 4 way mixing Output 4/8/16 ohm. a.c. Mains 240V. Separate treble and bass controls. **£75** Carr £1 50

NEW "DISCO 100 WATT" £59

Carr £1

ALL TRANSISTOR AMPLIFIER
2 inputs 4 outputs separate volume treble and bass controls Ideal disco or slave amplifier chassis Made by Jennings

R.C.S. SOUND TO LIGHT DISPLAY MK II

Complete kit of parts with R.C.S. printed circuit. Three 1000W channels. Will operate from 20mV signal source. CABINET extra £4. KIT **=£17.00**

GOODMANS CONE TWEETER

18,000 c/s 25W 8 ohm
E.M I 5in mid range 25W £4·95. Price **£3·25**

R.C.S. 100 WATT VALVE AMPLIFIER CHASSIS

Professional model Four inputs Treble, Bass, Master Volume Controls Ideal disco, P.A. or groups S.A E for details 5 speaker outputs 3 or 8 or 15 ohm 100V line to order Suitable carrying case £16·50. **£94** plus £2 50 carr

LOW VOLTAGE ELECTROLYTICS
1 2 4 5, 8 16, 25, 30, 50, 100 200mF 15V **10p.** 500mF 12V **15p;** 25V **20p;** 50V **30p.** 1000mF 12V **17p;** 25V **35p;** 50V **47p;** 100V **70p.** 2000mF 6V **25p;** 25V **42p.** 2500mF 50V **62p;** 3000mF 25V **47p;** 50V **65p.** 3900mF 100V **£1·60.** 4700mF 63V **£1·20.** 5000mF 6V **25p;** 12V **42p;** 25V **75p;** 35V **85p;** 5600mF 76V **£1.60;** 1200/76V **80p.**

R.C.S. LOW VOLTAGE STABILISED POWER PACK KITS

All parts and instructions with Zener diode, printed circuit rectifiers and double wound mains transformer Input 200/240V a c. Output voltages available 6 or 7·5 or 9 or 12V d.c. up to 100mA or less Size 3 × 2½ × 1½in. Please state voltage required **£2·95** Post 45p

ROBUST BLACK PLASTIC BOX

Size 6¼ × 3¾ × 2in with brushed aluminium facia. Ideal for constructional projects. **£1·50** Post 30p

R.C.S. GENERAL PURPOSE TRANSISTOR PRE-AMPLIFIER—BRITISH MADE £1·45

Ideal for Mike Tape, P U , Guitar Battery 9–12V or H T line 200–300V d c operation. Size 1½ × 1½ × ½in 25 c/s to 25 kc/s 26 dB gain For valve or transistor equipment Instructions supplied

ELECTRO MAGNETIC PENDULUM MECHANISM 95p Post 30p

1 5V d.c operation over 300 hours continuous on SP2 battery, fully adjustable swing and speed Ideal displays, teaching electro magnetism or for metronome, strobe, etc.

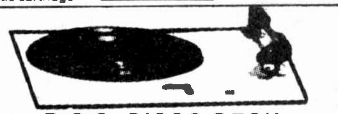
BSR HI-FI AUTOCHANGER

Plays 12in, 10in or 7in records Auto or Manual A high quality unit backed by BSR reliability with 12 months guarantee a c 200/250V Size 13½ × 11¼in. Above motor board 3¼in Below motor board 2½in.
With STEREO/MONO CARTRIDGE **£12·95** All Post 75p

Single Player version £15.50.	
BSR P128 with Magnetic Cartridge	£24·50
GARRARD MINICHANGER plays all records	£9·95
BSR P163 BELT DRIVE DECK, less cartridge	£27.50
GARRARD AP76 Single Player less cartridge	£27.50

BSR DE LUXE AUTOCHANGER

Features balanced arm. Cueing device, stylus pressure gauge, 3 speed – plays all size records. Fitted with stereo ceramic cartridge. Size: 13 × 12ins. Post £1. **£17.50**
Or with Sonotone V100 magnetic cartridge **£21.50**



R.C.S. DISCO DECK SINGLE RECORD PLAYER

Fitted with auto stop, stereo compatible cartridge. **Baseplate.** Size 11 × 8½in Turntable Size 7in diameter a c mains 220/250V 3 speeds plays all size records
Two for £15. Post 75p. **£7.95** Post 45p

HEAVY METAL PLINTHS

With P V C. Cover Cut out for most B.S R or Garrard decks Silver grey finish **£6·50** Post £1 30
Model 'A' Size 12¼ × 14¾ × 7½in
Model 'B' Size 16 × 13¾ × 7in £7·50.
Extra Large Plinth and Cover. For transcription decks Size 20 × 17⅞ × 9in uncut board Callers only **£18·50.**

TINTED PLASTIC COVERS ONLY
Sizes: 14½ × 12½ × 4½in, **£3.** 14 × 12¼ × 2½in, **£3.50.** 16⅜ × 14½ × 3in, **£3.75.** 16¼ × 14 × 4in, **£4.** 19 × 14⅜ × 4½in, **£4.** 15 × 13½ × 3in, **£3.50.** 17¼ × 9½ × 3½in, **£3.** 14½ × 14¾ × 2½in, Rosenwood sides **£4.**
Ideal for record decks, tape decks, etc. Post 75p.

BAKER HI-FI SPEAKERS

HIGH QUALITY—BRITISH MADE

SUPERB £22
12in 25 watt Post £1 60

Quality loudspeaker low cone resonance ensures clear reproduction of the deepest bass Special copper drive and concentric tweeter cone Full range reproduction with remarkable efficiency in the upper register.

Bass Resonance	25 c/s
Flux Density	16,500 gauss
Useful response	20–17,000 c/s

8 or 16 ohms models

AUDITORIUM £21
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

AUDITORIUM £26
15in 45 watt Post £1 60

BLANK ALUMINIUM CHASSIS, 18 s.w.g. 2½in. sides, 6 × 4in. **95p;** 8 × 6in. **£1.40;** 10 × 7in. **£1.55;** 14 × 9in. **£1.90;** 16 × 6in. **£1.85;** 12 × 3in. **£1.20;** 16 × 10in. **£2.20;** 12 × 8in. **£1.70.**
ALUMINIUM PANELS, 18 s.w.g. 6 × 4in **20p;** 8 × 6in. **40p;** 10 × 7in. **50p;** 12 × 5in. **50p;** 12 × 8in. **50p;** 16 × 6in. **75p;** 14 × 9in. **80p;** 12 × 12in. **80p;** 16 × 10in. **95p.**
ALUMINIUM ANGLE BRACKET, 6 × ¾ × ¾in **15p.**
ALUMINIUM BOXES, MANY SIZES IN STOCK.
4 × 2 × 2in, **55p;** 3 × 2 × 1in, **55p;** 6 × 4 × 2in, **65p;** 8 × 6 × 3in, **£1;** 9 × 4 × 4in, **£1·20;** 12 × 4 × 4in, **£1·50**

THE "INSTANT" BULK TAPE ERASER & HEAD DEMAGNETISER.
Suitable for cassettes, and all sizes of tape reels a c mains 200/240V
Leaflet S A E **£4·95** Post 50p

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The most MODERN, RAPID, ECONOMIC way to master space age electronics. Starting even from ZERO by performing over

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and creating more than 20 practical applications

You learn all about the most up to date electronic circuits: how to calculate, repair, and design them, while pursuing your favorite hobby. Start from scratch, or improve your present knowledege. Train and ear money in your spare time turn your pastime into valuable job opportunities. Compare our price: you receive the entire course, "mini laboratory" and components for LESS than the price of the components alone.

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you get:

- instruction manual : over 200 pages of detailed step-by step instructions -starting from scratch, explains basic laws and physics of Electricity, semiconductor principles and operation electronic circuits : from diodes (including diac, zener) transistors, triacs to integrated circuits (C.MOS, operational amplifiers) etc...
- Over 200 Electronic components : aerospace technologie printed circuit experiment board, phototransistor, triac, thyristor I.C.S Transistors (including FET, MOSFET) LEDS + résistors , capacitors, speaker, milliameter, potentiometers, variable capacitor, etc... etc... etc...
- measuring instruments (you assemble yourself from among components furnished in kit.)

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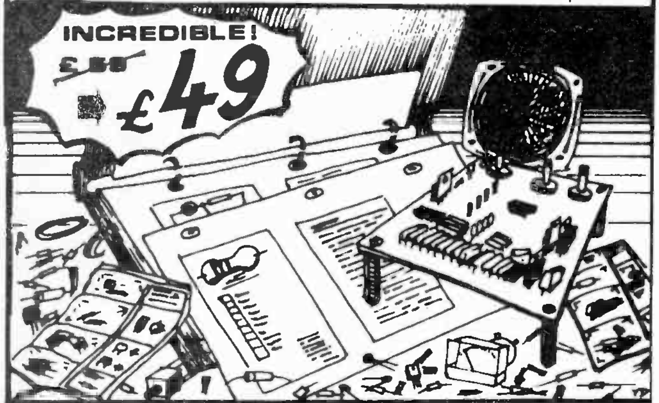
you construct

-more than 20 complete fonctional systems : light modulator, high fidelity amplifier, radio control set, radio receiver and transmitter, electronic gadgets and games and many, many more.

*Hand tools not provided.



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Spring Loader hook grip Probe
50p pair.

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7400	13p
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7402	18p
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7407	44p
7408	23p
7409	23p
7410	18p
7411	24p
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7413	38p
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7417	33p
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7432	28p
7437	20p

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7441	74p
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7480	48p
7482	81p
7483	90p
7485	108p
7486	38p
7489	300p
7490	57p
7491	82p
7492	57p
7493	57p
7494	83p
7495	70p
7496	83p
74100	130p
74107	38p
74118	125p
74121	30p
74122	55p
74123	103p
74144	340p
74145	83p
74153	62p
74154	138p
74165	115p
74174	132p
74175	78p
74180	85p
74181	295p
74190	142p
74191	131p
74192	131p
74193	131p
74196	130p
74198	195p

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CD4000	18p
CD4001	18p
CD4002	18p
CD4006	110p
CD4007	20p
CD4008	87p
CD4009	62p
CD4010	62p
CD4011	18p
CD4012	20p
CD4013	50p
CD4015	97p
CD4016	50p
CD4017	90p
CD4018	90p
CD4019	85p
CD4020	110p
CD4021	90p

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CD4022	84p
CD4023	21p
CD4024	83p
CD4025	20p
CD4026	190p
CD4027	50p
CD4028	90p
CD4029	118p
CD4030	62p
CD4035	130p
CD4041	87p
CD4042	85p
CD4043	90p
CD4044	90p
CD4045	150p
CD4046	131p
CD4047	85p
CD4049	85p

CD4050	60p	CD4082	23p
CD4054	120p	CD4086	24p
CD4055	140p	CD4088	POA
CD4056	140p	CD4501	POA
CD4060	117p	CD4502	130p
CD4066	70p	CD4507	50p
CD4067	410p	CD4510	132p
CD4068	24p	CD4511	173p
CD4069	22p	CD4516	132p
CD4070	60p	CD4518	114p
CD4071	22p	CD4520	114p
CD4072	23p	CD4522	POA
CD4076	167p	CD4526	POA
CD4077	65p	CD4528	POA
CD4078	24p	CD4572	POA
CD4081	23p	CD4583	POA

D.I.L. Sockets

8	10p	16	14p
14	13p	28	30p

LINEAR I.C.s

CA3028	85p	MC1496	78p
CA3046	90p	NE555	33p
CA3052	152p	NE556	78p
CA3078	138p	NE561	385p
CA3080	57p	NE562	385p
CA3089	238p	NE565	138p
CA3090	327p	NE566	126p
CA3130	113p	NE567	175p
CA3140	74p	SN76003	185p
CA3160	140p	SN76013	165p
LM301	38p	SN76023	180p
LM308	54p	SN76033	258p
LM380	100p	TAA621	257p
LM381	120p	TAA661	175p
LM710	41p	TBA540	238p
LM741	24p	TBA641	281p
LM747	73p	TBA800	102p
LM748	38p	TBA810	113p
LM3900	73p	TBA820	80p
MC1304	282p	µA723	57p
MC1310	197p		
MC1351	78p		
MC1458	78p		

DIODES

BY127	18p
OA47	9p
OA70	9p
OA79	14p
OA81	15p
OA85	14p
OA91	7p
OA95	9p
OA200	9p
OA202	9p
IN914	4p
IN916	6p
IN4001	6p
IN4002	6p
IN4003	6p
IN4004	7p
IN4005	10p
IN4006	10p
IN4007	11p

VU Meter	£1.95
Balance Meter	£1.95
Long Nose Pliers	£1.95
Side Cutters	£1.95
Goodman's 6 x 4 5 ohm speaker	£1.95

3 amp 50 PIV	18p
3 amp 100 PIV	18p
3 amp 200 PIV	18p
3 amp 400 PIV	20p
3 amp 600 PIV	25p
10 amp 50 PIV	25p
10 amp 100 PIV	25p
10 amp 200 PIV	28p
10 amp 400 PIV	30p
10 amp 600 PIV	42p

BRIDGE RECS

1 amp 50 PIV	22p
1 amp 100 PIV	24p
1 amp 200 PIV	27p
1 amp 400 PIV	30p
1 amp 600 PIV	34p
2 amp 50 PIV	34p
2 amp 100 PIV	30p
2 amp 200 PIV	38p
2 amp 400 PIV	40p
2 amp 600 PIV	42p

TRIACS

2 amp 100 PIV	28p
2 amp 200 PIV	42p
2 amp 400 PIV	71p
6 amp 100 PIV	50p
6 amp 200 PIV	56p
6 amp 400 PIV	81p
10 amp 100 PIV	64p
10 amp 200 PIV	100p
10 amp 400 PIV	113p
10 amp 400 Plastic	130p
15 amp 400 PIV	420p
30 amp 400 PIV	430p

D32 Diac	20p
BR100 Diac	20p

S.C.R.

1 amp 50 PIV	28p
1 amp 100 PIV	30p
1 amp 200 PIV	38p
1 amp 400 PIV	40p
1 amp 600 PIV	58p
1 amp 800 PIV	68p
3 amp 50 PIV	34p
3 amp 100 PIV	38p
3 amp 200 PIV	38p
3 amp 400 PIV	51p
3 amp 600 PIV	60p
3 amp 800 PIV	80p
5 amp 200 PIV	50p
5 amp 400 PIV	58p
5 amp 600 PIV	75p
7 amp 200 PIV	68p
7 amp 400 PIV	75p
7 amp 600 PIV	123p
10 amp 200 PIV	67p
10 amp 400 PIV	70p
10 amp 600 PIV	83p

ZENERS

Range 2 2-35 volts 400m watts	10p
1 3 watts	20p

TRANSISTORS

AC126	21p	BC148	10p	BC547	14p	BF183	37p	MJ2955	99p	2N1305	21p
AC127	21p	BC149	10p	BC548	14p	BF194	13p	MJE340	64p	2N1306	27p
AC128	21p	BC157	11p	BC549	27p	BF195	13p	MJE2955	99p	2N1711	21p
AC176	21p	BC158	11p	BC557	14p	BF196	13p	MJE3055	68p	2N2219	21p
AC187	23p	BC159	11p	BCY34	74p	BF197	16p	OC28	108p	2N2904	21p
AC188	23p	BC168	12p	BCY70	17p	BF200	38p	OC35	108p	2N2905	21p
AD149	65p	BC169	12p	BCY71	20p	BF224	16p	OC71	18p	2N2906	17p
AD161	50p	BC171	12p	BCY72	17p	BF257	37p	OC84	48p	2N2926G	9p
AD162	50p	BC172	12p	BD115	58p	BF258	40p	TIP29C	50p	2N2926R	9p
AF114	30p	BC173	12p	BD124	87p	BF259	44p	TIP30	52p	2N2955	130p
AF115	27p	BC177	18p	BD131	47p	BFR39	30p	TIP31A	47p	2N3053	17p
AF116	25p	BC178	18p	BD132	47p	BFX29	34p	TIP32A	51p	2N3054	54p
AF117	23p	BC179	18p	BD135	43p	BFX30	38p	TIP33	90p	2N3055	54p
AF118	30p	BC182L	13p	BD136	50p	BFX84	27p	TIP34	195p	2N3702	10p
AF124	42p	BC183L	11p	BD137	50p	BFX85	34p	TIP35	282p	2N3703	10p
AF125	42p	BC184L	13p	BD138	51p	BFX86	31p	TIP36	389p	2N3704	10p
AF126	25p	BC212L	13p	BD139	51p	BFX87	31p	TIP41A	54p	2N3705	10p
AF139	40p	BC213L	13p	BD140	52p	BFX88	31p	TIP42A	54p	2N3706	10p
AF239	53p	BC214L	14p	BF173	30p	BFY50	17p	TIP2955	128p	2N3708	10p
BC107	9p	BC238	14p	BF179	37p	BFY51	17p	TIP3055	64p	2N3709	10p
BC108	9p	BC303	30p	BF180	37p	BFY52	17p	ZTX108	12p	2N3711	10p
BC109	9p	BC328	15p	BF181	37p	BSX20	21p	ZTX300	13p		
BC147	10p	BC338	15p	BF182	37p	BU105	191p	ZTX500	15p		

SWITCHES

Toggle Large	SPST	27p
	DPST	29p
	DPDT	35p
STD	SPST	66p
	SPDT	70p
	DPDT	75p
MIN	SPST	54p
	SPDT	58p
	DPDT	70p
	DPDT c off	90p
SUB MIN	SPST	48p
	SPDT	52p
	DPDT	60p

Push Button SPST Locking	60p
Push Button SPDT Locking	69p
Push Button DPDT Locking	91p
Bias push to make	15p
Bias push to break	20p
Slide DPDT SUB MIN	13p
Slide DPDT STD	13p
Slide DPDT c off	15p

ROTARY SWITCHES

1 Pole 12 way	46p
2 Pole 2 way	46p
2 Pole 4 way	46p
2 Pole 6 way	46p
3 Pole 3 way	46p
3 Pole 4 way	46p
4 Pole 2 way	46p
4 Pole 3 way	46p
Mains DPDT	45p
BULGIN Foot Switch DPDT	160p
SPST	115p

OPTO

TIL 209 Red	14p
TIL 209 Green	24p
TIL 209 Yellow	24p
2 Red	18p
2 Yellow	30p
2 Green	30p
TIL 209 Clip	4p
2 Clip	5p

TRANSFORMERS (Mains prim 220-240V)

LT44		60p	6-0-6	1 5A	345p
LT700		60p	9-0-9	1A	280p
6-0-6	100MA	93p	9-0-9	2A	398p
9-0-9	74MA	87p	12-0-12	1A	317p
12-0-12	100MA	99p	15-0-15	1A	350p
0-6-0-6	280MA	140p	20-0-20	2A	544p
0-12-0-12	150MA	150p	25-0-25	2A	585p
6 3V-1 5a		284p	30-0-30	2A	625p

12-15-20-24-30 Tapped 1 amp	455p
12-15-20-24-30 Tapped 2 amp	657p
Pulse TRX 1 1	170p

Potentiometers

1K—2MΩ Single gang LIN or LOG	27p
5K—2MΩ Single gang D P switch LOG	55p
5K—2MΩ Dual gang stereo LIN or LOG	70p

SLIDERS

5K—500K Single Gang LIN or LOG	73p
5K—500K Dual Gang Stero LIN or LOG	88p
Presets sub. min. vert. Horiz. 100Ω-1MΩ	10p
Slider Bezzels 21p Slider Knobs	10p

LOUD SPEAKERS

1½in	8Ω	72p
1¾in	8Ω	72p
2in	8Ω	72p
2½in	8Ω	64p
2¼in	8Ω	64p
2½in	64Ω	72p
2¾in	8Ω	76p
2¾in	80Ω	118p

ENAMELLED COPPER WIRE
2 onz reel

16	44	26	54	34	70
18	45	28	62	36	72
20	46	30	65	38	73
22	48	32	66	40	78
24	52				

Solder Wick	87p.
Desoldering Gun	640p.
Spare Nozzle	95p
Degee 25 Watt	2.95p.
Antex X25 Watt Iron	387p
Antex C 2 15 Watt Iron	387p
Antex CX 15 Watt Iron	387p
PP3 Battery Clips	6p
PP9 Battery Clips	10p
Battery Holder 4 pen Cells	20p
Etching Pen	81p
Ferric Chloride	95p
Etching Kit	245p
Telephone Pick-Up Coil	70p
Ear Piece 2 5mm or 3 5mm	16p
Ear Piece Crystal	33p

RESISTORS

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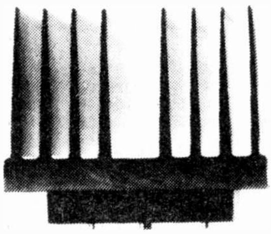

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FEATURES: very low distortion; integral heatsink, load line protection, thermal protection, five connections, no external components.
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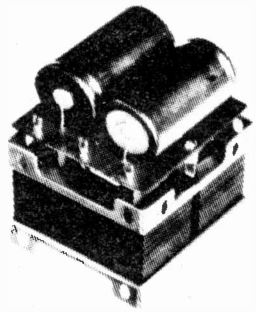

The HY400 is I.L.P.'s "Big Daddy" of the range producing 240W into 4Ω! It has been designed for high power disco or public address applications. If the amplifier is to be used at continuous high power levels a cooling fan is recommended. The amplifier includes all the qualities of the rest of the family to lead the market as a true high power hi-fidelity power module.

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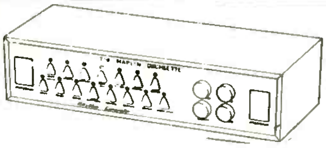

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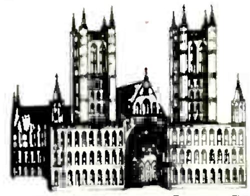

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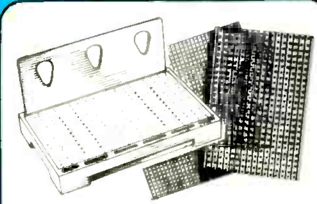

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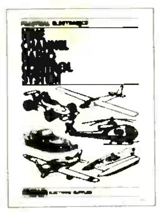

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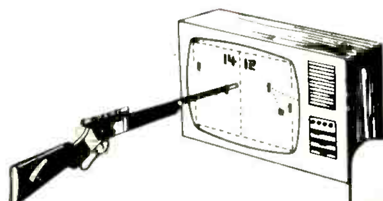

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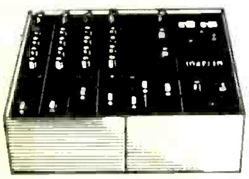

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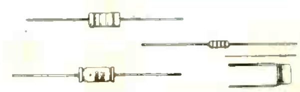

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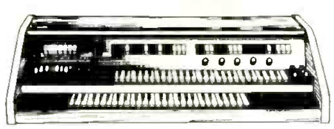

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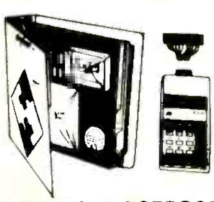

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