Easy to build projects for everyone

Everyday ELECTRONICS

FEB. 80
50p

SLIDE/TAPE SYNCRONISER

MICRO MUSIC BOX

SPECIAL OFFER
Mini 20 MULTIMETER

SIMPLE S.W. RECEIVER
MORSE PRACTICE OSCILLATOR

Australia 85c South Africa 85c New Zealand 95c Malaysia $3·50

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.

VAT Export orders no V.A.T. Applicable to U.K. Customers only. Unless stated otherwise all prices are exclusive of V.A.T. Please add 15% to total cost including P & P.

We stock many more items. It pays to visit us. We are situated behind Watford Football Ground. Nearest Underground/BR Station: Watford High Street. Open Monday to Saturday 9.00 am-6.00 pm. Ample Free Car Parking space available.

POLYESTER CAPACITORS: Axial lead type (Values are in μF)
400V: 1nF, 1n5, 2n2, 3n3, 4n7, 6n8, 10m, 15n 9p; 18n 10p; 22n, 33n 11p; 47n, 68n 14p; 100n 17p; 150n, 220n, 24p; 330n, 470n 41p; 680n 52p; 1μF 64p; 2μ 82p.
160V: 39μF, 100n, 150n, 220n 11p; 330n, 470n 19p; 680n, 1μF 22p; 1μ5, 2μ2 32p; 4μ7 36p.
1000V: 10nF, 15n, 20p; 22n 22p; 47n 26p; 100n 38p; 470n 53p; 1μF 175p.

POLYESTER RADIAL LEAD CAPACITORS (250V)
10nF, 15n, 22n, 27n, 5p; 33n, 47n, 68n, 100n 7p; 150n 10p; 220n, 330n 13p; 470n 17p; 680n 19p; 1μF 22p; 1μ5 30p; 2μ2 34p.

FEED THROUGH CAPACITORS
1000pF 350V 8p

ELECTROLYTIC CAPACITORS: Axial lead type (Values are in μF) 500V: 10 40p; 47 68p; 250V: 100 65p; 63V 0·47, 1·0, 1·5, 2·2, 2·5, 3·3, 4·7, 6·8, 8 10, 15, 22 8p; 47, 32, 50 12p; 63, 100 27p 50V 50, 100, 220 25p; 470 32p; 1000 50p; 40V: 22, 33, 9p; 100 12p; 2200, 3300 85p; 4700 98p; 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 45p; 3300 62p; 4700 85p; 16V: 10, 40, 47, 68 7p; 100, 125 8p; 220, 330 14p; 470 16p; 1000, 1500 20p; 2200 34p; 10V: 100 6p; 640 12p; 1000 14p.
TAG-END TYPE: 450V: 100μF 180p; 70V: 4700 165p; 64V: 3300 130p; 2500 98p; 50V: 3300 105p; 2200 99p; 00V: 15,000 399p; 4700 120p; 4000 92p; 3300 93p; 2500 85p; 2200 85p; 2000 + 2000 120p; 30V: 4700 90p; 25V: 6400 105p; 4700 85p; 3300 80p; 2200 60p.

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 20p 6V: 47, 68, 100, 30p 3V: 68, 100μF. 20p

MYLAR FILM CAPACITORS
100V: 0·001, 0·002, 0·005, 0·01μF 6p
0·015, 0·02, 0·04, 0·05, 0·056μF 7p
0·1μF, 0·2 9p 50V: 0·47 12p

MINIATURE TYPE TRIMMERS
2-5·6pF, 3-10pF, 10-40pF 22p
5-25pF, 5-45pF, 60pF, 88pF 30p

COMPRESSION TRIMMERS
3-40pF, 10-80pF 30p; 25-190pF 33p
100 500pF 45p 1250pF 58p.

POLYSTYRENE CAPACITORS
10pF to 1nF 8p; 1·5nF to 10nF 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, 180 9p each
220, 250, 300, 330, 360, 390, 600, 820 16p each
1000, 1200, 1800, 2000 20p each

CERAMIC CAPACITORS: 50V 0·5pF to 10nF 4p; 22n to 100n 6p.

EURO BREADBOARD £5·30.

POTENTIOMETERS: (ROTARY) Carbon Track. 0·25W Log & 0·5W Linear Value.
500Ω, 1K & 2K (Lin. only) Single 27p
5K-2 MΩ single gang 27p
5K-2 MΩ single with DP switch 65p
5K-2 MΩ double gang 78p

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

PRESET POTENTIOMETERS
Vertical & Horizontal
0·1W 50Ω—5MΩ Miniature 7p
0·25W 100Ω—3·3MΩ Horiz 10p
0·25W 200Ω—4·7MΩ Vert 10p

RESISTORS: Carbon Film, High Stability, Low Noise, Miniature Tolerance 5%.

Range	Val.	1-99	100+
¼W 2Ω2–4M7	E24	2p	1p
½W 2Ω2–4M7	E12	2p	1p
1W 2Ω2–10M	E12	5p	4p
2% Metal Film 10Ω–1M		6p	4p
1% Metal Film 51Ω–1M		8p	6p

100+ price applies to Resistors of each value not mixed.

S–Dec 350p T–Dec 400p
U–Dec 'A' 465p U–Dec 'B' 699p

OPTO ELECTRONICS
LEDs plus clips

TIL209 Red	13
TIL211 Grn	17
TIL212 Yellow	18
·2" Red	15
2" Yellow Green	18
Square LED	36
ORP12	63
2N5777	45

7 Seg Displays

LS400	255
TIL312 C An 3"	105
TIL313 C Cth 3"	105
TIL321 C An 5"	115
TIL322 C Cth 5"	115
DL704 C Cth ·3"	99
DL707 C.A. ·3"	99
DL747 C.A. ·6"	180
FND357	120
MAN3640	175
LCD 3½ digit	875
TIL307	675

SWITCHES

TOGGLE 2A 250V	
SPST	28p
DPDT	38p
4 pole on/off	54p

SUB-MIN TOGGLE

SP changeover	59p
SPST on/off	54p
DPDT 6 tags	70p
DPDT c/off	79p
DPDT Biased	115p

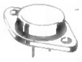
SLIDE 250V:

1A DPDT	14p
1A DP c/off.	15p
½A DPDT	13p
4 pole c/over	24p

PUSH BUTTON Spring Loaded

SPST on/off	65p
SPDT c/over	70p
DPDT 6 Tag	85p

VOLTAGE REGULATORS*



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

1A	TO220 Plastic Casing			
5V	7805	65p	7905	75p
12V	7812	65p	7912	75p
15V	7815	65p	7915	75p
18V	7818	65p	7918	75p
24V	7824	65p	7924	75p

100mA	TO92 Plastic Casing			
5V	78L05	30p	79L05	65p
6V	78L62	30p		—
8V	78L82	30p		—
12V	78L12	30p	79L12	65p
15V	78L15	30p	79L15	65p

CA3085	95	LM323K	625	MVR5	150
LM300H	170	LM325N	240	MVR12	150
LM305H	140	LM326N	240	TAA550	50
LM309K	135	LM327N	270	TBA625B	95
LM317K	350	LM723	39	TDA1412	150

EE TEACH-IN
Complete kit of parts now available £20·95.

SWITCHES Miniature Non-Locking
Push to Make 15p Push to Break 25p
ROCKER: SPST on/off 10A 250V 23p
ROCKER: Illuminated (white) Lights when on: 3A 240V 70p
ROTARY: (ADJUSTABLE STOP) 1 pole/ 2-12 way 2p/2-6W, 3p/2-4W, 4p/2-3W. 41p
ROTARY: Mains 250V AC, 4 Amp 45p

DIL SOCKETS ★ (Low Profile – Texas)
8 pin 10p; 14 pin 12p; 16 pin 13p; 18 pin 16p; 20 pin 22p; 24 pin 25p; 28 pin 39p; 40 pin 50p.

JACKSONS VARIABLE CAPACITORS
Dielectric 0 2 365pF with slow motion
100/300pF 175p Drive 325p
500pF 205p 00 208/176 285p
6 1 Ball Drive ,, ,, with slow
4511/DAF 125p motion drive 325p
Dial Drive 4103 C804-5pF 10 15
6 1/36 1 650p 25 50 pF 175p
Drum 54mm 40p 100, 150pF 275p
0-1·365pF 245p 'L' 3 x 310pF 550p
00 2 365pF 275p 00·3 x 25pF 430p

DENCO COILS
'DP' VALVE TYPE
Range 1 to 5 Bl., Rd., Yl. Wht. 92p
6–7 B.Y.R. 85p
1·5 Green 99p
'T' 1 to 5 Bl., Yl., Rd., Wht. 1·05p
B9A Valve Holder 28p

RDT2	98p
RFC 5 chokes	98p
RFC·7(19mH)	102p
I FT 13; 14; 15; 16; 17	92p
I FT 18/1·6	104p
I FT 18/465	109p
TOC 1	92p
MW5FR	112p
MW/LW 5FR	120p

VEROBOARD

	0·1	0·15	0·15
	(copper clad)		(plain)
2½ × 3¾	46p	39p	24p
2½ × 5	55p	50p	31p
3¾ × 3¾	55p	50p	—
3¾ × 5	62p	67p	43p
2½ × 17	169p	135p	92p
3¾ × 17	218p	180p	120p
4¾ × 17	280p	—	183p
Pkt of 35 pins			22p
Spot face cutter			85p
Pin insertion tool			120p

DIODES

AA119	25
AA129	20
BA100	10
BY126	12
BY127	12
CRO33	148
OA9	75
OA47	12
OA70	12
OA79	15
OA81	15
OA85	14
OA90	7
OA91	6
OA95	8
OA200	9
OA202	8
IN914	4
IN916	5
IN4001/2	5
IN4003	6
IN4004/5	6
IN4006/7	7
IN4148	4
IS44	20
3A/100V	18
3A/400V	20
3A/600V	27
3A/1000V	30

We stock a wide selection of Electronic Books and Magazines

ZENERS
Range 2V7 to 39V 400mW 8p each
Range 3V3 to 33V. 1·3W 15p each

NOISE
25J 160

BRIDGE RECTIFIERS
(plastic case)

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

SCRs Thyristors

0·6A/200V	30p
0·8A/100V	30p
0·8A/200A	35p
1A600V	70
5A300V	35
5A600V	43
8A300V	48
8A500V	58
8A600V	85
12A300V	59
12A500V	92
15A/700V	195p
2N4444	140p
BT106	150
C106D	38
TIC44	25
TIC45	45

TRIACS

3A100V	48
3A200V	49
3A400V	50
8A100V	54
8A400V	64
8A800V	108
12A100V	60
12A400V	70
12A800V	130p
16A100V	95
16A500V	150
25A800V	295
25A1000V	480p
T28000D	120

DIAC
ST2 25

TTL 74

7400	11	74126	57
7401	11	74128	74
7402	11	74132	73
7403	12	74136	65
7404	12	74141	56
7405	18	74142	209
7406	28	74143	314
7407	38	74144	314
7408	17	74145	65
7409	17	74147	175
7410	11	74143	109
7411	20	74150	99
7412	17	74151	64
7413	30	74153	64
7414	45	74154	96
7416	30	74155	53
7417	30	74156	80
7420	16	74157	67
7421	29	74159	185
7422	17	74160	82
/423	27	74161	92
7425	27	74162	92
7426	36	74163	92
7427	27	74164	105
7428	35	74165	105
7430	17	74166	140
7432	25	74167	200
7433	40	74170	185
7437	30	74172	625
7433	33	74173	120
7440	15	74174	87
7441	74	74175	87
7442	68	74176	75
7442	115	74177	78
7444	112	74178	153
7445	94	74180	85
7446	94	74181	165
7447	57	74182	88
7443	51	74184	135
7450	17	74185	135
7451	17	74188	275
7453	17	74190	95
7454	17	74191	95
7460	17	74192	98
7470	23	74193	98
7472	25	74194	98
7473	32	74195	98
7474	25	74196	93
7475	38	74197	80
7476	36	74198	150
7480	48	7150	175
7481	86	75491	92
7482	69	75492	92
7483	72		
7484	95	**74LS***	
7485	75	74LS00	11
7486	31	74LS01	11
7489	140	74LS02	12
7490	30	74LS03	12
7491	75	74LS04	14
7492	38	74LS05	23
7493	32	74LS08	22
7494	78	74LS09	22
7495	65	74LS10	20
7496	57	74LS11	22
7497	189	74LS12	23
74100	119	74LS13	38
74105	62	74LS14	75
74107	29	74LS15	30
74109	54	74LS20	20
74110	54	74LS21	22
74111	68	74LS22	22
74112	125	74LS26	48
74116	198	74LS27	28
74118	83	74LS28	48
74119	149	74LS30	22
74120	115	74LS32	27
74121	25	74LS33	39
74122	46	74LS37	39
74123	48	74LS38	39
74125	38	74LS40	28
		74LS42	98

74LS47	63	74LS365	65
74LS51	24	74LS366	65
74LS54	28	74LS367	65
74LS55	30	74LS368	66
74LS63	150	74LS373	180
74LS73	46	74LS375	160
74LS74	41	74LS374	155
74LS75	48	74LS378	184
74LS76	40	74LS670	248
74LS78	40	74LS673	1050
74LS83	115	74LS674	1450
74LS85	118		
74LS86	43	**CMOS**	
74LS90	38	4000	13
74LS91	104	4001	13
74LS92	89	4002	15
74LS93	89	4006	87
74LS95	116	4007	18
74LS96	116	4008	82
74LS107	44	4009	33
74LS109	55	4010	38
74LS112	55	4011	18
74LS113	50	4012	18
74LS114	50	4013	45
74LS123	70	4014	80
74LS124	180	4015	82
74LS125	60	4016	45
74LS126	60	4017	82
74LS132	95	4018	87
74LS136	55	4019	48
74LS138	85	4020	99
74LS139	85	4021	95
74LS151	96	4022	85
74LS153	76	4023	22
74LS155	96	4024	66
74LS156	96	4025	19
74LS157	76	4026	180
74LS158	96	4027	45
74LS160	128	4028	81
74LS161	98	4029	99
74LS162	138	4030	58
74LS163	102	4031	205
74LS164	114	4032	100
74LS165	75	4033	145
74LS168	155	4034	116
74LS169	150	4035	111
74LS170	288	4036	325
74LS173	105	4037	100
74LS174	106	4038	108
74LS175	110	4039	320
74LS181	398	4040	105
74LS183	298	4041	80
74LS189	430	4042	75
74LS190	140	4043	94
74LS191	140	4044	95
74LS192	132	4045	145
74LS193	130	4046	128
74LS194	166	4047	87
74LS195	136	4048	58
74LS196	100	4049	48
74LS197	100	4050	48
74LS221	96	4051	72
74LS240	236	4052	72
74LS241	231	4053	72
74LS242	232	4054	110
74LS243	232	4055	123
74LS244	155	4056	134
74LS245	270	4059	480
74LS247	190	4060	115
74LS251	134	4061	1425
74LS253	142	4062	999
74LS257	110	4063	110
74LS258	110	4066	58
74LS259	160	4067	380
74LS261	450	4068	22
74LS266	52	4069BE	20
74LS273	244	4070	32
74LS275	250	4071	21
74LS279	66	4072	21
74LS280	250	4073	21
74LS299	468	0475	23
74LS323	468	4076	85
74LS324	240	4077	40

4078	21	CA3123E	200
4081	20	CA3130	85
4082	21	CA3140	70
4085	74	ICL7106E	795
4086	73	ICL7107	975
4089	150	ICM7205	1159
4093	85	ICM7217A	790
4094	190	ICM7555	89
4095	105	LD130	452
4096	105	LM300H	170
4097	372	LM301A	30
4098	110	LM308	110
4099	145	LM318	205
4160	109	LM324	68
4161	109	LM339	70
4162	109	LM348	90
4163	109	LM379	375
4174	110	LM380	80
4175	99	LM381	145
4194	108	LM381AN	248
4408	720	LM382	125
4409	720	LM1458	50
4410	720	LM3900	60
4411	958	LM3909N	70
4412V	1380	LM3911	125
4415F	795	M253AA	795
4415V	795	MC1304P	260
4419	280	MC1310	149
4422	545	MC1312P	195
4433	995	MC1488	85
4435	825	MC1489	90
4440	1275	MC1495	350
4450	295	MC1496	92
4451	295	MC1710	79
490F	695	MC3340P	120
4490V	525	MC3360P	120
4501	19	MC3401	52
4502	120	MC3403	135
4503	69	MFC6040	97
4506	51	MK50362	670
4507	55	MK50398	635
4508	298	MM5303	635
4510	99	MM5307	1275
4511	150	NE518	210
4512	98	NE543	210
4520	108	NE544	185
		NE555	20
LINEAR IC's		NE556	660
702	75	NE560	325
709C 14 pin	35	NE561	395
710	67	NE562	410
723	38	NE564	425
733	125	NE565	120
741C 8 pin	17	NE566	160
747C	78	NE567	170
748C	36	NE571	420
753	150	SAD1024	1350
810	159	SN76003	170
8038CC	340	SN76013	140
AY-1-0212	580	SN76023	140
AY-1-1313A	660	SN76033	175
AY-1-1320	315	SN76477	225
AY-1-5050	190	TAA621	250
AY-1-5051	145	TBA120F	70
AY-1-6721/6	195	TBA641	250
AY-3-8500	390	TCA965	120
AY-5-1224A	260	TDA1008	310
AY-5-1230	450	TDA1022	575
CA3011	100	TDA1024	105
CA3018	68	TDA2020	320
CA3020	170	TLO61	76
CA3023	170	TLO74	199
CA3028A	80	TLO81	48
CA3035	240	TLO82	96
CA3043	190	TLO83	105
CA3046	71	TLO84	130
CA3048	210	UAA170	198
CA3080E	70	UAA180	198
CA3081	190	ZN414	85
CA3805	85	ZN424E	130
CA3809E	210	ZN425E	415
CA3090AQ	398	ZN1034	200

TRANSISTORS

AC125	20	BC171	11	BF179	30
AC126	20	BC172	11	BF180	35
AC127	20	BC177	18	BF194	12
AC128	20	BC178	16	BF195	12
AC141	24	BC179	18	BF196	12
AC142K	38	BC182	9	BF197	14
AC176	24	BC182L	11	BF198	18
AC188	24	BC183	9	BF200	30
ACY17	35	BC183L	11	BF224A	18
ACY18	40	BC184	9	BF244	30
ACY19	40	BC184L	11	BF256	60
ACY20	40	BC187	28	BF257	30
ACY21	35	BC212	10	BF258	30
ACY22	40	BC212L	11	BF259	30
ACY28	40	BC213	10	BF594	30
ACY39	78	BC213L	12	BF595	38
AD140	70	BC214	10	BFR39	25
AD149	70	BC214L	13	BFR40	28
AD161	42	BC307B	11	BFR41	28
AD162	42	BC328	15	BFR79	28
AF114	50	BC338	12	BFR80	28
AF115	50	BC441	36	BFR81	28
AF116	50	BC461	36	BFX29	28
AF117	70	BC447	25	BFX81	45
AF139	35	BC547	12	BFX84	26
AF178	70	BC548	12	BFX85	28
AF180	70	BC549	13	BFX86	28
AF186	50	BC557	15	BFX87	28
AF239	42	BC558	20	BFX88	28
BC107	11	BC559	20	BFY50	20
BC107B	11	BCY70	18	BFY51	20
BC108	11	BCY71	20	BFY52	20
BC108B	11	BCY72	20	BFY71	20
BC108C	12	BD131	45	BRY39	39
BC109	11	BD132	45	BSX20	18
BC109B	12	BD133	43	BSY65	18
BC109C	12	BD135	38	BSY95A	16
BC117	20	BD136	37	BU105	140
BC119	23	BD137	36	BU205	190
BC137	20	BD138	50	BU208	225
BC140	35	BD139	40	MJ491	160
BC142	30	BD140	36	MJ2955	120
BC143	30	BD145	198	MJE340	54
BC147	8	BD222	75	MJE370	58
BC148	8	BD659A	65	MJE371	60
BC149	8	BD696A	65	MJE2955	99
BC153	27	BDY17	195	MJE3055	70
BC154	27	BDY60	110	MPF102	66
BC157	10	BDY61	165	MPF103	38
BC158	11	BF115	34	MPF104	40
BC159	11	BF154	25	MPF105	40
BC160	42	BF156	29	MPF106	40
BC167A	11	BF167	30	MPSA05	25
BC168C	12	BF173	25	MPSA06	25
BC169C	12	BF177	24	MPSA12	42
BC170	18	BF178	25	MPSA55	25
				MPSA56	25

MPSU06	56	ZTX302	20	2N3707	11
MPSU56	60	ZTX303	25	2N3708	11
OC26	170	ZTX304	24	2N3709	11
OC28	150	ZTX314	24	2N3710	16
OC35	130	ZTX326	40	2N3711	12
OC36	130	ZTX341	20	2N3713	215
OC41	48	ZTX500	15	2N3771	233
OC42	48	ZTX501	15	2N3772	195
OC43	55	ZTX502	19	2N3773	283
OC44	31	ZTX503	15	2N3819	22
OC45	28	ZTX504	25	2N3820	45
OC46	28	ZTX531	25	2N3882	130
OC70	28	ZTX550	25	2N3823	95
OC71	28	2N526	58	2N3866	90
OC72	42	2N696	36	2N3903	20
OC76	36	2N697	25	2N3904	18
OC77	76	2N698	44	2N3905	18
OC81	50	2N699	54	2N3906	17
OC82	50	2N706	19	2N4037	52
OC83	48	2N708	19	2N4058	17
OC84	44	2N918	40	2N4061	17
OC140	110	2N930	18	2N4859	65
OC170	85	2N961	61	2N5135	42
OC171	75	2N1131	22	2N5136	42
OC202	95	2N1132	22	2N5138	20
TIP29	43	2N1302	35	2N5179	60
TIP29C	60	2N1303	50	2N5180	80
TIP30	47	2N1304	50	2N5191	70
TIP30C	65	2N1305	28	2N5305	40
TIP31	50	2N1671B	215	2N5457	32
TIP31A	52	2N2160	350	2N5458	32
TIP31B	58	2N2219A	22	2N5459	32
TIP31C	66	2N2220A	25	2N5485	35
TIP32A	58	2N2222	20	2N5777	45
TIP32C	75	2N2369	15	2N6027	40
TIP33A	85	2N2476	125	3N128	112
TIP33C	105	2N2484	25	3N140	112
TIP34A	85	2N2646	48	40311	60
TIP34C	110	2N2894	30	40313	125
TIP35A	185	2N2904	22	40316	86
TIP35C	220	2N2905A	22	40317	52
TIP36C	255	2N2906	22	40324	85
TIP41A	63	2N2926G	10	40326	52
TIP41B	73	2N3053	20	40327	62
TIP42A	72	2N3054	55	40348	105
TIP42B	82	2N3055	48	40360	43
TIP2955	65	2N3121	40	40361	45
TIP3053	65	2N3133	43	40407	52
TIS43	34	2N3135	33	40411	295
TIS44	45	2N3250	40	40412	65
TIS90	20	2N3442	140	40467	95
TIS91	24	2N3663	26	40576	190
ZTX107	12	2N3702	11	40594	70
ZTX108	12	2N3703	11	40673	68
ZTX109	12	2N3704	11		
ZTX300	13	2N3705	11		
ZTX301	15	2N3706	11		

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BC107C	£0.09
BC108	£0.06
BC108A	£0.06
BC108B	£0.07
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BC109	£0.06
BC109B	£0.07
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BC118	£0.10
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BC147	£0.07
BC148	£0.07
BC149	£0.07
BC157	£0.09
BC158	£0.09
BC159	£0.09
BC169C	£0.09
BC170	£0.06
BC171	£0.07
BC172	£0.07
BC173	£0.08
BC177	£0.13
BC178	£0.13
BC179	£0.13
BC182	£0.07
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BC183L	£0.07
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BC261	£0.14
BC327	£0.12
BC328	£0.12
BC337	£0.12
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BC461	£0.28
BC477	£0.15
BC478	£0.15
BC479	£0.15
BC547	£0.08
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BC558	£0.09
BC559	£0.10
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BCY71	£0.13
BCY72	£0.13
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BD131	£0.30
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OC26	£0.45
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OC29	£0.55
OC35	£0.55
OC36	£0.60
OC42	£0.18
OC44	£0.20
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TIP29A	£0.30
TIP29B	£0.32
TIP29C	£0.34
TIP30	£0.30

Type	Price
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TIP30B	£0.32
TIP30C	£0.34
TIP31	£0.30
TIP31A	£0.30
TIP31B	£0.32
TIP31C	£0.34
TIP32	£0.30
TIP32A	£0.30
TIP32B	£0.32
TIP32C	£0.34
TIP41	£0.34
TIP41A	£0.34
TIP41B	£0.36
TIP41C	£0.38
TIP42	£0.34
TIP42A	£0.34
TIP42B	£0.36
TIP42C	£0.38
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ZTX109	£0.09
ZTX300	£0.10
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ZTX501	£0.10
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2N2904A	£0.17
2N2905	£0.16
2N2905A	£0.18
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2N2906A	£0.15
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2N2907A	£0.16
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2N3054	£0.30
2N3055	£0.35
2N3702	£0.07
2N3703	£0.07
2N3704	£0.06
2N3705	£0.06
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BAX16	£0.06	OA95	£0.08	IN5401	£0.13
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OA202	£0.07	IN60	£0.07	IN5404	£0.15
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LM381	£1.35	TAA550	£0.30	uA710	£0.25
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SJ57	6 100K log 40mm slider pots	0.50
SJ58	6 1K lin 40mm slider pots	0.50
SJ59	6 5K lin 40mm slider pots	0.50
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SJ61	4 100K log 60mm single	0.50
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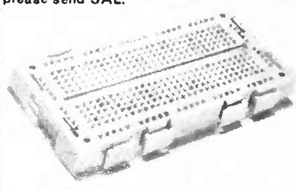

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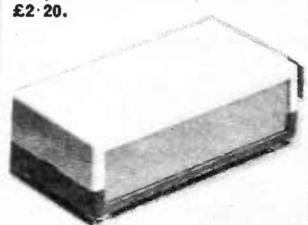

VEROCASE SALE!!

3 popular sizes of Verocase at drastically reduced prices—these were part of their standard range (75-1411 etc.) but are in GREEN and have been discontinued by Vero. We have purchased their entire stock and offer them as below:

Type No	Size	Price
21050	205×140×75mm	£2·70
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TEACH IN 80

We are again supplying all parts required for this major series which started in October. The price for all the Tutor Deck parts is **£19·50.** Also supplied *without* breadboard for **£13·50.** The price for the additional components required for Parts 1-6 is **£2·00.** All prices include VAT and Postage. Reprints of Oct & Nov parts **30p** ea.

Simply ahead . .

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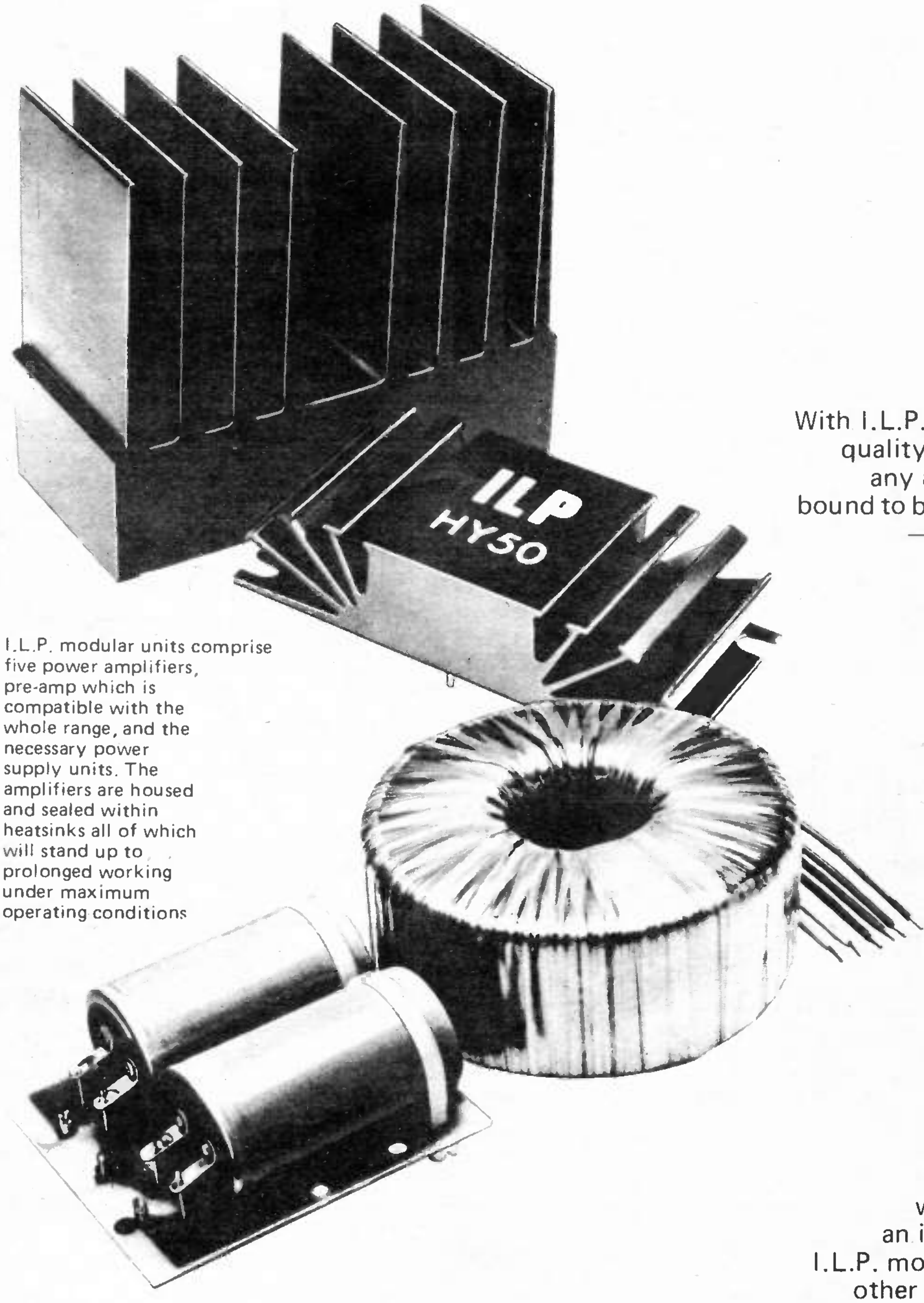

I.L.P. modular units comprise five power amplifiers, pre-amp which is compatible with the whole range, and the necessary power supply units. The amplifiers are housed and sealed within heatsinks all of which will stand up to prolonged working under maximum operating conditions

With I.L.P. performance standards and quality already so well established, any advances in I.L.P. design are bound to be of outstanding importance — and this is exactly what we have achieved in our new generation of modular units. I.L.P. professional design principles remain — the completely adequate heatsinks, protected sealed circuitry, rugged construction and excellent performance. These have stood the test of time far longer than normally expected from ordinary commercial modules. So we have concentrated on improvements whereby our products will meet even more stringent demands such, for example, as those revealed by vastly improved pick-ups, tuners, loudspeakers, etc., all of which can prove merciless to an indifferent amplifier system. I.L.P. modules are for laboratory and other specialised applications too.

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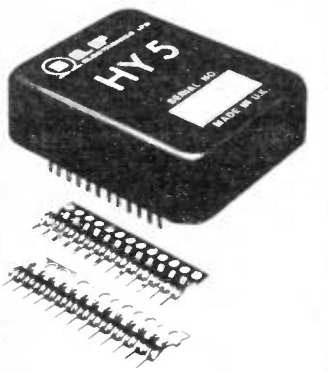

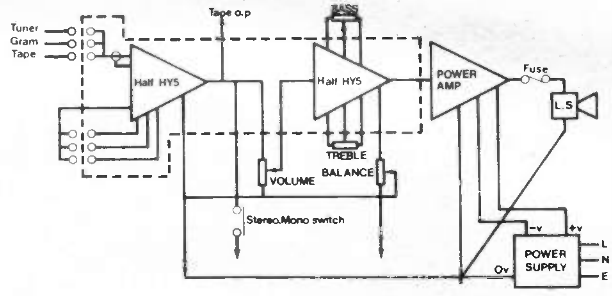

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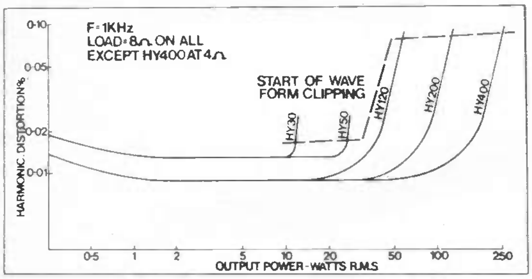
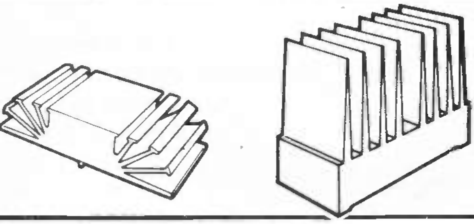
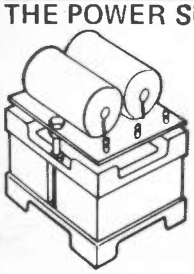


Model	Output Power R.M.S.	Distortion Typical at 1KHz	Minimum Signal/ Noise Ratio	Power Supply Voltage	Size in mm	Weight in gms	Price + V.A.T.
HY30	15 W into 8 Ω	0.02%	80dB	-20 -0- +20	105x50x25	155	**£6.34** + 95p
HY50	30 W into 8 Ω	0.02%	90dB	-25 -0- +25	105x50x25	155	**£7.24** + £1.09
HY120	60 W into 8 Ω	0.01%	100dB	-35 -0- +35	114x50x85	575	**£15.20** + £2.28
HY200	120 W into 8 Ω	0.01%	100dB	-45 -0- +45	114x50x85	575	**£18.44** + £2.77
HY400	240 W into 4 Ω	0.01%	100dB	-45 -0- +45	114x100x85	1.15Kg	**£27.68** + £4.15



Load impedance — all models 4 - 16 Ω
Input sensitivity — all models 500 mV
Input impedance — all models 100K Ω
Frequency response — all models 10Hz - 45Hz - 3dB

THE POWER SUPPLY UNITS



I.L.P. Power Supply Units are designed specifically for use with our power amplifiers and are in two basic forms — one with circuit panel mounted on conventionally styled transformer, the other with toroidal transformer, having half the weight and height of conventional laminated types.

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PSU 70	with toroidal transformer for 1 or 2 HY120's	**£13.61** + £2.04 VAT
PSU 90	with toroidal transformer for 1 HY200	**£13.61** + £2.04 VAT
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Projects... Theory... and Popular Features...

The seventies could with justice be called the decade of the digit. During the past ten years advances in semiconductor technology greatly favoured the application of digital techniques in the world of electronics.

Speed of circuit operation is the essential ingredient in electronic computing systems. Semiconductor designers and manufacturers have combined this requirement with another very important quality—that of packing a tremendous amount of circuitry inside "chips" of small size. Thus making possible, amongst other things, those personal electronic goods the digital watch and the pocket calculator.

But computing is not all. In the eighties we can expect digital or pulse code modulation (PCM) techniques to make their impact upon the recording field. Digital audio and video discs will bring about another major revolution in the hi-fi and home entertainment area.

Talking of digital techniques . . . the first practical use of electricity was to send messages over wire circuits. Samuel F. B. Morse was the inventor of the electric telegraph and also of the dot-dash code that bears his name. That was around 1838. Today it is worth remembering that the most elementary of all electric signalling methods — opening and closing a switch—is fundamental to all electronic digital computing systems.

The morse code is still in use. By this means, radio amateurs communicate regularly over thousands of miles, often using very low transmitting power. In difficult reception contions W/T (or c.w.) nearly always "gets through", unlike telephony. And there are no language problems.

Thus our *Morse Practice Oscillator* is more than a sentimental gesture to the past. It is a means for acquiring an essential skill for those aspiring to obtain the full Radio Amateur Transmitting Licence.

As a fitting complement we also include in this issue a *Simple Short Wave Receiver*. Searching around the short waves never fails to offer interest, knowledge and frequently excitement as amateur and broadcast transmissions are logged from all over the world.

And finally something else "digital" but with a difference—a certain microprocessor makes a return appearance in EE this month. This i.c. device and all its associates in circuit are shown off to the best possible advantage in our *Micro Music Box*. All of which is patently clear to see.

Fred Bennett

Our March issue will be published on Friday, February 15. See page 102 for details.

Readers' Enquiries

We cannot undertake to answer readers' letters requesting modifications, designs or information on commercial equipment or subjects not published by us. All letters requiring a personal reply should be accompanied by a stamped self-addressed envelope.

We cannot undertake to engage in discussions on the telephone.

Component Supplies

Readers should note that we do not supply electronic components for building the projects featured in EVERYDAY ELECTRONICS, but these requirements can be met by our advertisers.

Everyday ELECTRONICS

VOL. 9 NO. 2 FEBRUARY 1980

CONSTRUCTIONAL PROJECTS

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Certain back issues* of EVERYDAY ELECTRONICS are available worldwide price 70p inclusive of postage and packing per copy. Enquiries with remittance should be sent to Post Sales Department, IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 0PF. In the event of non-availability remittances will be returned.
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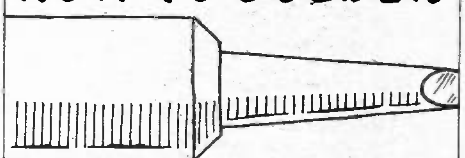
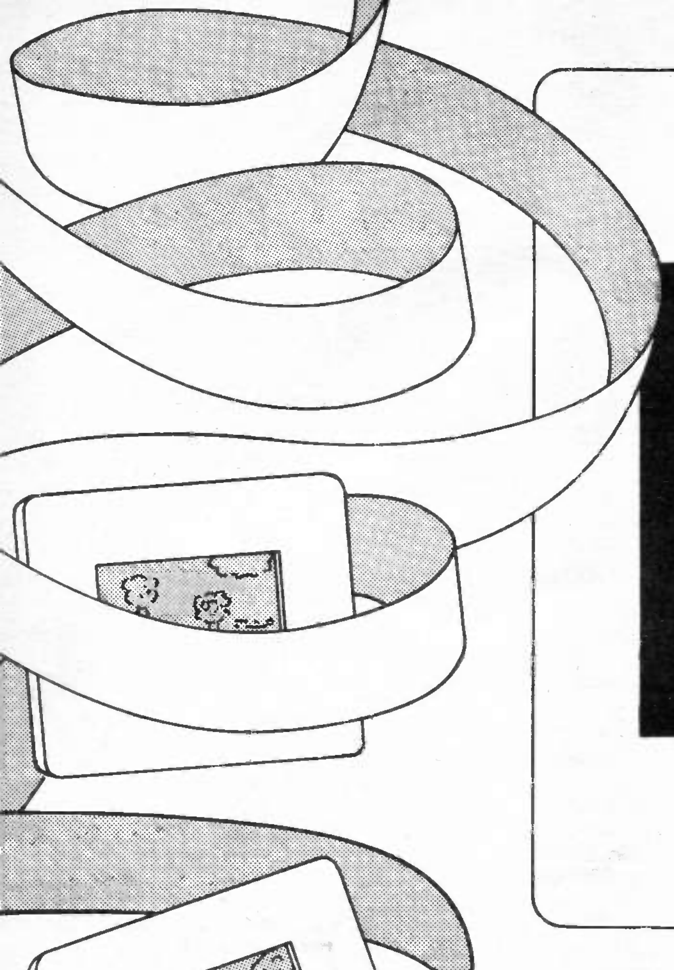
HOW TO SOLDER

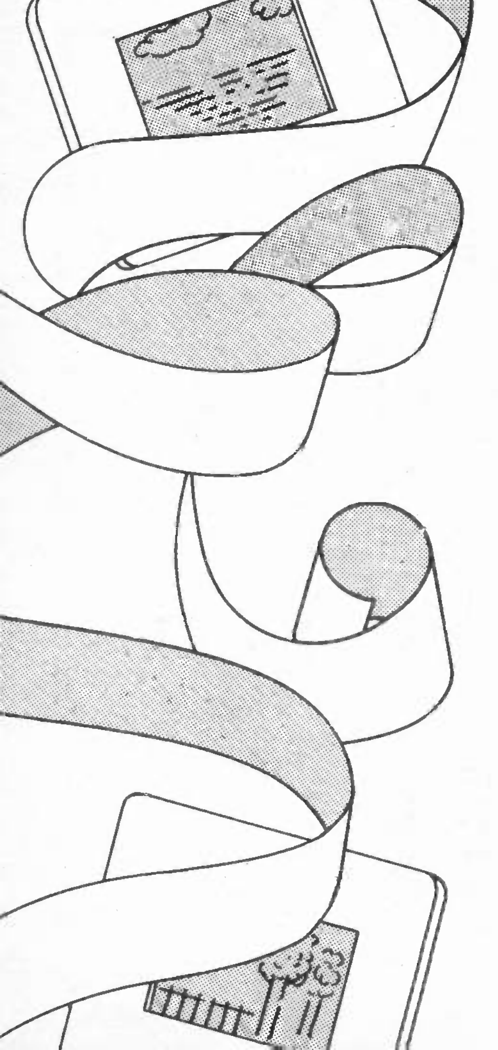


SEE SQUARE ONE PAGE 112



Slide/tape Synchroniser

BY G.N. SLEE



AFTER looking through many photographic press magazines, the author was surprised to find only one advertisement for a slide/tape synchroniser. This prompted the necessity for this design which is simple, inexpensive and effective.

A slide/tape synchroniser is a must for amateur photographers who wish to give the professional touch to their slide presentation. With such a unit connected to a stereo tape recorder, the tape is programmed to change the slides in conjunction with commentary, music, or both. Any slide projector fitted with a remote control socket, may be used with this unit.

DESIGN

The synchroniser consists of three sections—a tone generator, followed by a rectifier/smoothing section and an electronic switch. When making up a slide/tape programme the unit is used to record a tone pulse on the left-hand channel of the tape at each point where a slide change is required.

Commentary and music are recorded on the right-hand channel. When the tape is played back the pulses on the left-hand channel activate the electronic switch in the synchroniser which activates the slide change mechanism in the projector.

The entire circuit, which consumes only a small standing current, is powered by a 9V PP3 battery. The unit is sufficiently sensitive to use with the majority of reel or cassette stereo tape recorders.

In the event of the slide programme lagging behind the commentary the SYNC switch can be used as an override button when operating the unit from tape. Commentary and background music can be recorded or played back by connecting a mixer or amplifier to the audio socket.

Standard 5-pin to 5-pin 180 degree DIN recording leads are used for connections to both AMP and TAPE sockets (SK1 and 2), unless external equipment connections are different.

PULSE CIRCUIT

The tone generator stage consists of TR1, TR2, C1, C2, R1, R2, R3 and R4 and associated components wired to make up a multivibrator whose frequency f is determined by the formula.

$$f = \frac{1}{0{\cdot}7\,(C1R3 + C2R2)}$$

In this particular circuit the values of C1 and C2 are the same as those of R2 and R3. This means that the formula can be simplified to

$$f = \frac{1}{1{\cdot}4\,RC}$$

where R is R2 or R3 and C is C1 or C2.

The output is then passed through an attenuator network made up of C3, R5 and R6 before going to the SYNC switch S1. This is a momentary action d.p.s.t. type. Capacitor C3 is included to block d.c. and to shape the tone output.

The supply to the tone generator is controlled by S1b, and S1a switches the output. When this is pressed and released it provides a tone burst to the next stage and to the TAPE input/output socket SK1.

Although switch S1b is unconventionally placed in the negative supply line, this has proved advantageous in the wiring of the unit.

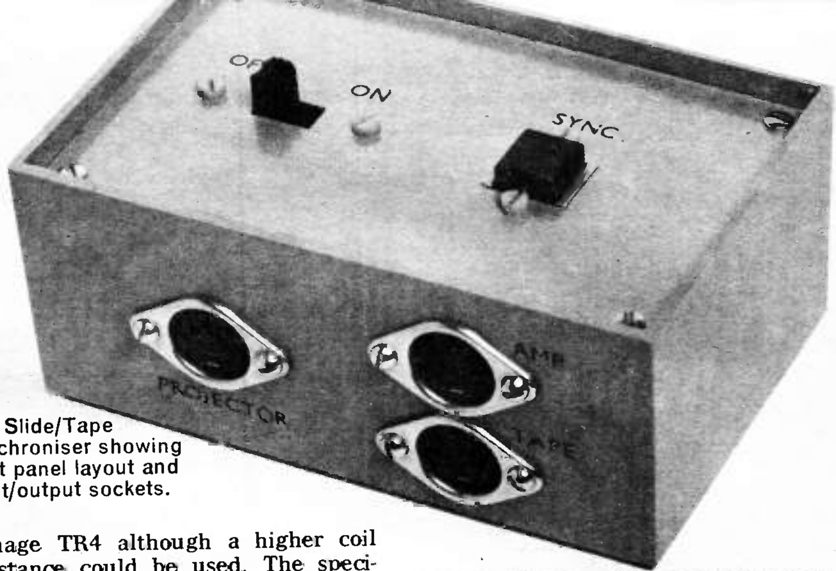
The output to the tape is taken directly from the other side of S1a to pin one of a 5-pin 180 degree DIN socket SK2.

The next stage is controlled by S1 supplying the pulse when recording, or the tape on playback.

ELECTRONIC SWITCH

On arrival at the base of TR3 the pulse is amplified and then rectified into d.c. by D1 and D2 and smoothed by C6. This voltage applied to the base of TR4 causes the Darlington pair TR4 and TR5 to turn on hard, energising the relay. Diode D3 is included to protect these transistors against any back e.m.f.

The relay chosen has a coil resistance of 185 ohms and an operating range of 5·5V to 17V (nominal 12V). A coil resistance less than this could damage TR4 although a higher coil resistance could be used. The specified relay should not be used to switch mains loads.



The Slide/Tape Synchroniser showing front panel layout and input/output sockets.

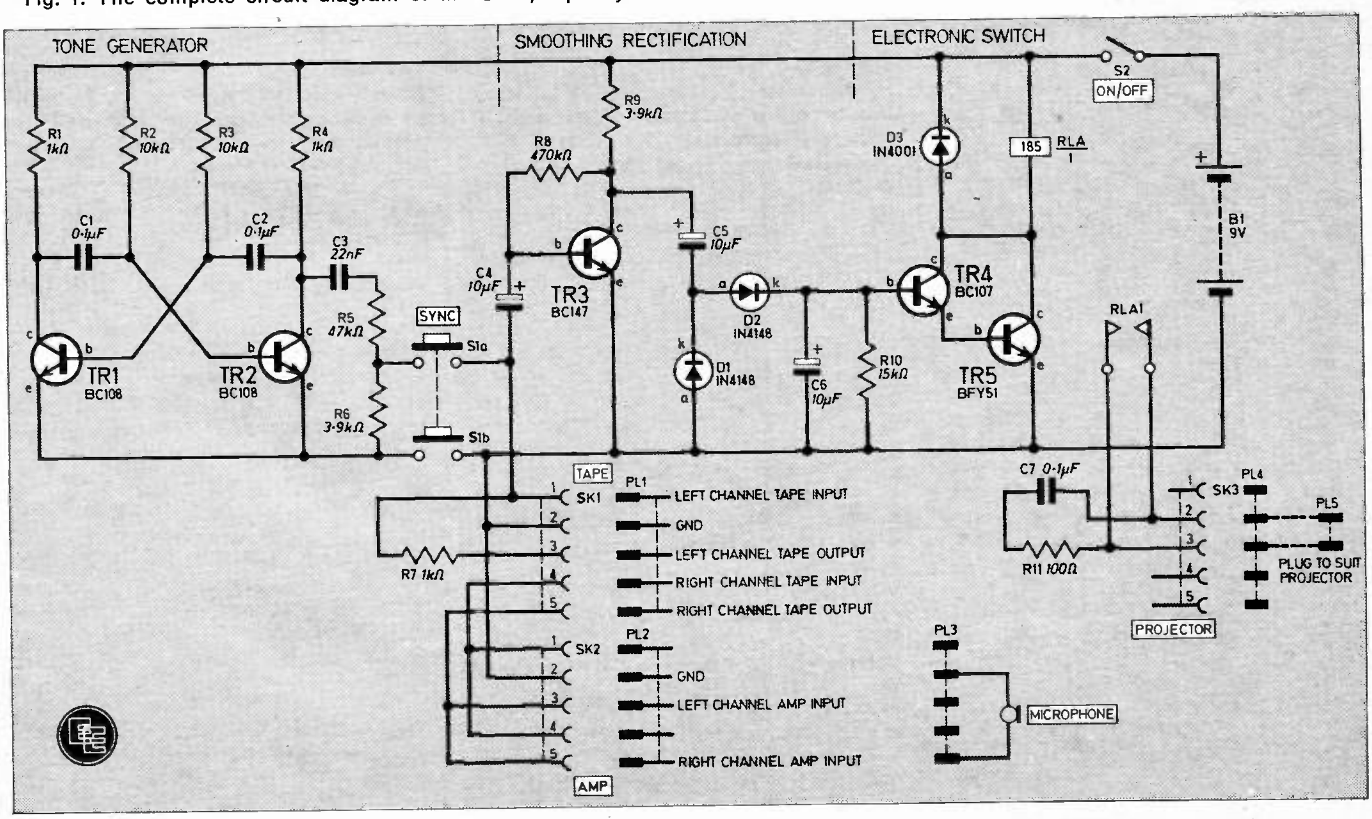
A set of normally open contacts are wired to pins 2 and 3 of the PROJECTOR socket SK3. The other end of the lead into SK3 is terminated in a suitable connector for the projector, normally a 6-pin 240 degree DIN. Two-core lighting flex is suitable for interconnecting the unit to the projector, connections being made from pin 3 to pin 3 and pin 2 to pin 2 respectively. (Check with your handbook.)

To stop relay chatter, a 100 ohm resistor R11 and a 0·1 microfarad capacitor C7 are connected in series across pins 2 and 3 of the synchroniser projector socket forming a contact arc suppressor.

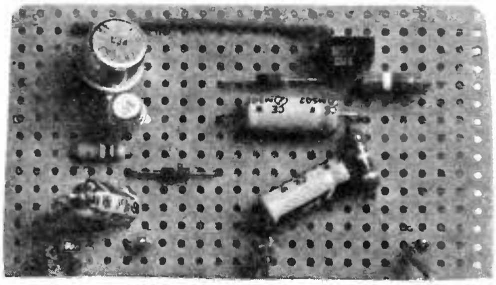
CONSTRUCTION starts here

The synchroniser is housed in a small module box. This is made of an A.B.S. plastics material with an aluminium lid, and incorporates circuit board guides, which are used to mount the two circuit boards. The tone generator circuit is built on one board (Fig. 2) which is 15 strips by

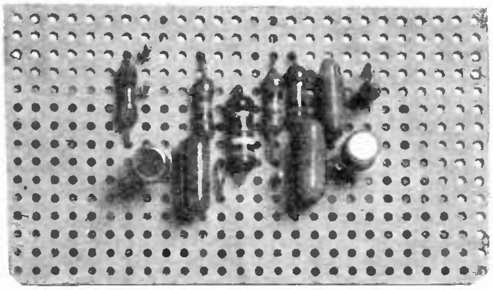
Fig. 1. The complete circuit diagram of the Slide/Tape Synchroniser showing connections to amplifier, recorder and projector.



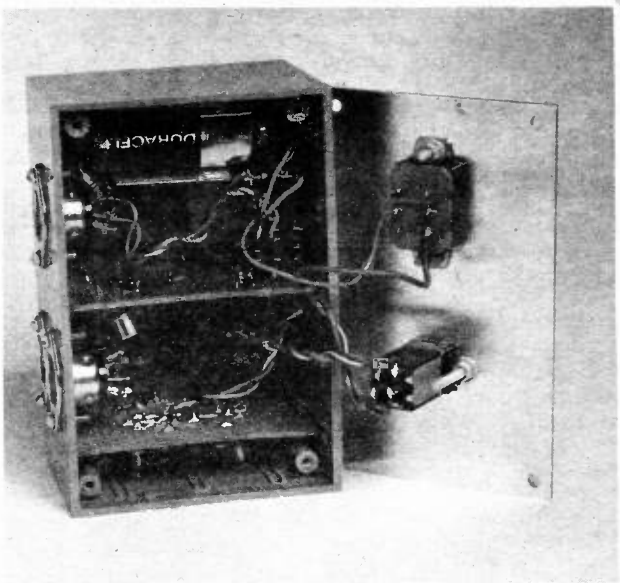
slide/tape synchroniser



Completed electronic switch circuit board.



Completed tone generator circuit board.



Front panel removed showing the circuit boards "sandwiched" in the case.

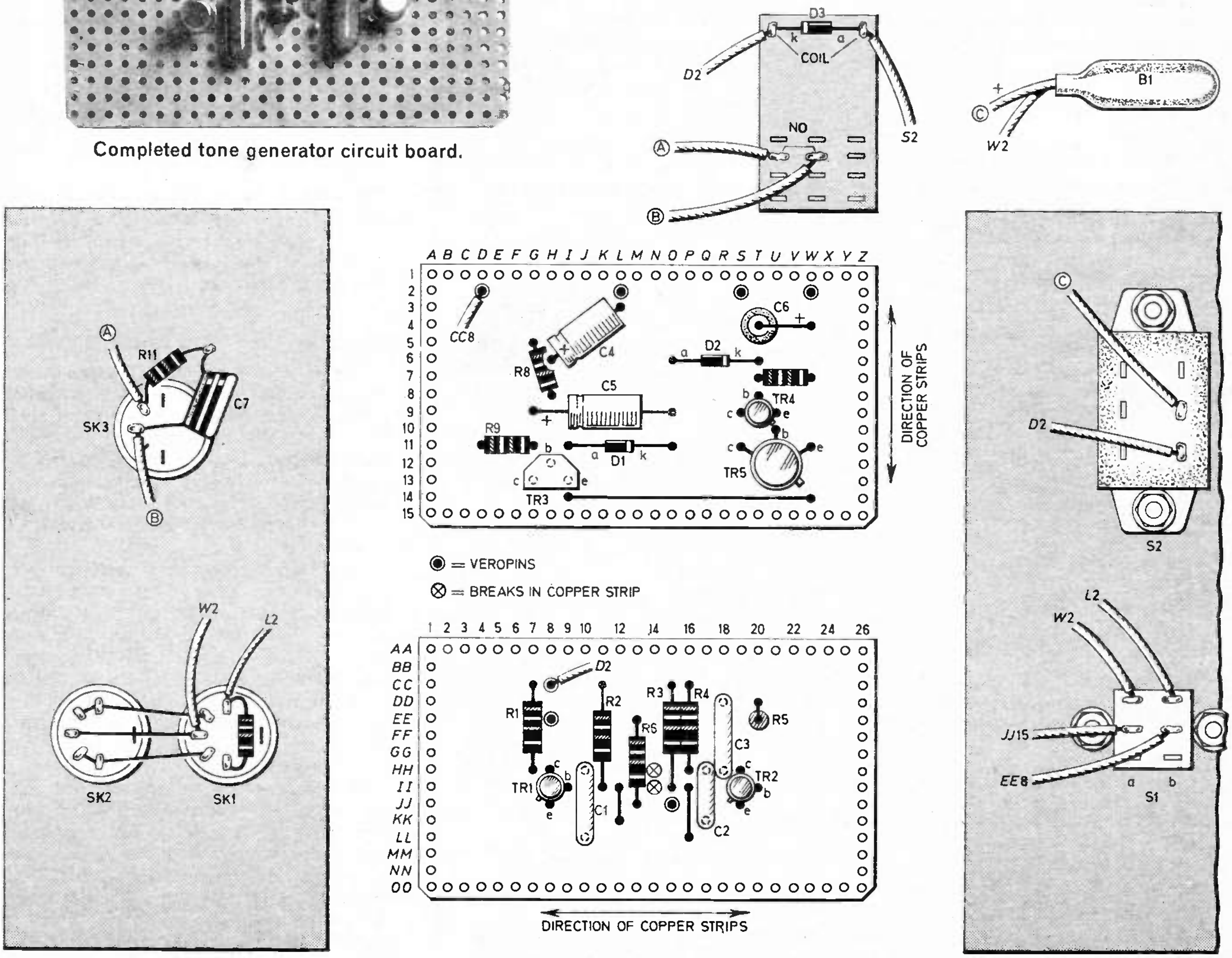


Fig. 2. Internal wiring showing circuit board layouts and interconnections.

26 holes, the sides of which are tapered to fit the guides as shown.

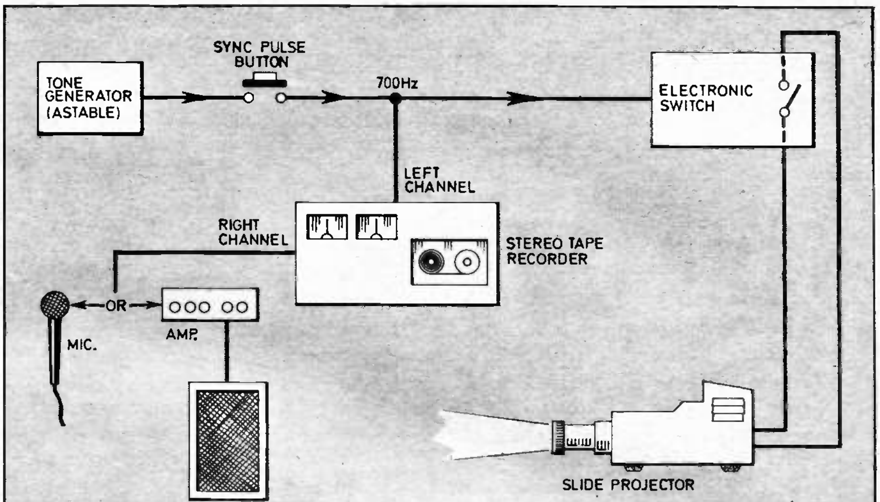
The electronic switch is built on the other board (Fig. 2) which is 26 strips by 15 holes, the sides of which are also tapered. Both boards are 0·1 inch matrix s.r.b.p. stripboard.

The breaks in the strips are made first with either a spot face cutter or a hand-held twist drill (5mm). Double-sided Veropins are recommended for lead-outs from the boards. These are soldered in position first and then the link wires followed by the rest of the components, leaving the transistors until last. Care should be taken to avoid overheating these which could cause damage.

Components should be as close to the board as possible and their physical size should also be as small as possible, especially in the case of the Astable board, otherwise this will not fit in the case.

Before mounting anything in the case, the holes for the DIN sockets are drilled as indicated in Fig. 2. Next the top panel is drilled to suit the switches. Because of the compact proportions of the box it is advisable to wire the sockets before the circuit boards are installed. Thin flexible stranded wire is used for all connections.

The relay is connected upside-down with its connections pointing upwards by means of double-sided sticky pads.



HOW IT WORKS

A tone generator provides a tone of frequency 700Hz. When the sync button on the Synchroniser is pressed, the tone is applied to the electronic switch and also to the left hand channel of the tape recorder (set on "record"). The effect of this is to activate the switch which changes the slide and also to record a tone burst on the tape.

Music and commentary are recorded on the right hand channel of the tape at the same time.

When the programme is repeated, the commentary and music are reproduced from the right hand channel of the tape whilst the tone bursts on the left hand channel activate the electronic switch and change the slide at the appropriate time.

COMPONENTS

Resistors

R1 1kΩ
R2 10kΩ
R3 10kΩ
R4 1kΩ
R5 47kΩ
R6 3·9kΩ
R7 1kΩ
R8 470kΩ
R9 3·9kΩ
R10 15kΩ
R11 100Ω
All ¼W carbon ±5%

See Shop Talk page 114

Capacitors

C1 0·1µF polyester
C2 0·1µF polyester
C3 22nF polyester
C4 10µF 25V elect.
C5 10µF 25V elect.
C6 10µF 25V elect.
C7 0·1µF polyester

Semiconductors

TR1 BC108 *npn* silicon
TR2 BC108 *npn* silicon
TR3 BC147 *npn* silicon
TR4 BC107 *npn* silicon
TR5 BFY51 *npn* silicon
D1 1N4148 small signal silicon diode
D2 1N4148 small signal silicon diode
D3 1N4001 50V 1A silicon diode

COMPONENTS approximate cost £7 excluding case

Miscellaneous

S1 d.p.s.t. momentary miniature push button
S2 s.p.s.t. miniature toggle
SK1, SK2 5-pin 180 degree DIN socket (2 off)
SK3 5-pin DIN socket
RLA 12V relay, coil resistance 185Ω with two sets of changeover contacts
B1 PP3 type 9 volt battery
PL1-4, 5-pin 180 degree DIN plug (4 off)
PL5 To suit projector
0·1 inch matrix strip board, one piece 15 strips by 26 holes, one piece 26 strips by 15 holes; battery clips; Veropins; connecting wire; sticky pads; case (R.S. type 348-908 or similar)

The battery is placed in position first and the relay is placed tightly against the battery. This forms a kind of battery clip. Make sure of course you are able to remove the battery.

IN USE

The unit is connected to a projector and a stereo recorder or cassette deck. A microphone is connected to the right-hand channel and the left-hand channel is used for the synchroniser. Alternatively a mixer can be connected to the AMP socket of the synchroniser to provide music and commentary.

The unit is then switched on and the recording level is set for the left-hand channel by holding the sync-pulse button down. The slide magazine is now set to the first slide and recording is started. Commentary is given for the first slide and then the sync button is pressed and released. This changes the slide and records a tone on the tape.

The process is repeated until the last slide is reached and then the recording is stopped. When required, the slide magazine is reset to the beginning in the usual manner, the tape rewound, and an amplifier connected to the AMP socket. The tape is started and the recorded programme is replayed automatically with the commentary synchronised to its particular slide. ☐

MORSE PRACTICE OSCILLATOR

By S. F. Gregory

THIS simple unit was built for the author's friend who is a keen short wave listener. After being on the receiving end for so long he felt that he would like to be able to transmit so he has decided to attend night school for a year's study and then attempt the Radio Amateurs Examination and the Morse examination.

The Morse exam involves the sending and receiving of Morse code characters at a speed of 12 words per minute for a period of three minutes, and the sending and receiving of 10 groups of 5 figures in each group for $1\frac{1}{2}$ minutes.

To reach this standard a generally agreed figure of about 60 to 65 hours of practice is necessary but this can vary considerably between individuals.

CIRCUIT DESCRIPTION

The complete circuit diagram of the Morse Oscillator is shown in Fig. 1.

It uses two transistors which form a complementary astable multivibrator in conjunction with R1 and C1. When the key S1 is pressed C1 will commence to charge through R1. When it has charged to approximately 0·2V TR2 will conduct. This in turn switches TR2 into conduction but C1 will now be shorted out and it will therefore lose its charge and result in TR1 and TR2 switching "off".

Capacitor C1 will now commence to charge up again, and the above process will repeat itself as long as the key is held down.

Every time TR1 and TR2 conduct, a pulse of current will flow through the loudspeaker and with the capacitor and resistor used, these pulses will be of an audio rate and result in a tone at the loudspeaker.

If it is desired, the audio output can be made variable by connecting a 10kΩ variable potentiometer, VR1 in circuit, and lowering the value of R1 to about 82kΩ. To do this, the connection at point *A* is broken and VR1 inserted in series.

CONSTRUCTION starts here

ASSEMBLY

The oscillator is constructed on a piece of 0·1 inch matrix stripboard size 24 holes × 10 strips. After cutting the board to the required size and drilling the two mounting holes, it is advisable to remove any jagged edges with a small file. The single break can now be made in the copper strip as shown in Fig. 2.

The next step is to insert R1, C1, TR1 and TR2 ensuring that a heat sink is used on the transistor leads as semiconductors are likely to be damaged due to excessive heat.

The unit is mounted in a plastics box size 80 x 115 x 35mm. It should first be prepared by drilling all mounting holes, and the aperture holes for the loudspeaker (see Fig. 2).

When all rough edges have been filed smooth, the loudspeaker can be carefully glued in position and the rest of the components mounted according to Fig. 2.

It is unnecessary to provide an on/off switch for the completed unit, as the key acts as a switch.

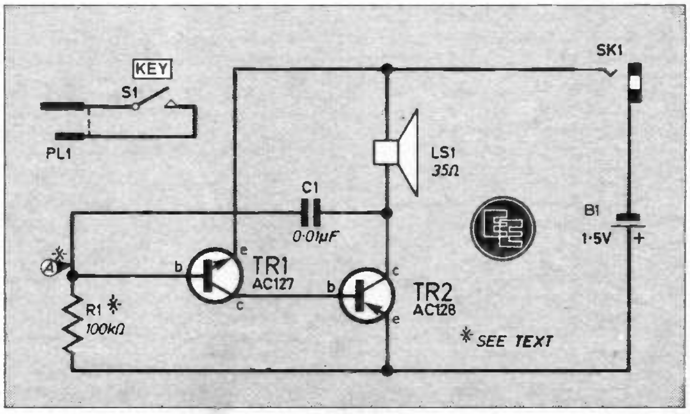
A battery holder can be fabricated using a piece of wood or circuit board guide and some pieces of foam. Connections are made using the negative connectors from two sets of PP9 battery connector clips.

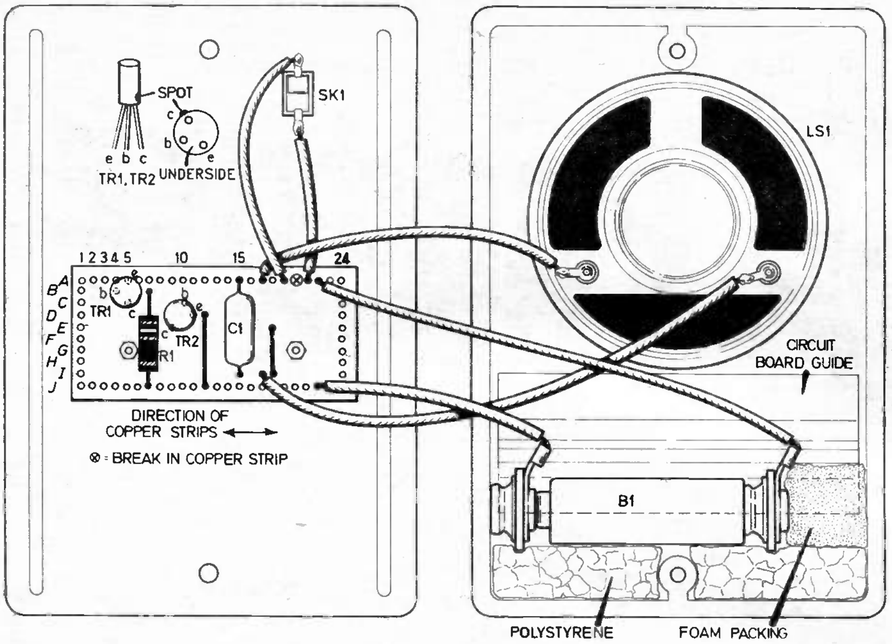
During long sessions of practice, it is advisable that the key is secured to a block of heavy wood, or similar heavy object, so as to prevent undesired movements which could result in bad sending in the long run.

LEARNING THE CODE

When a newcomer commences to learn the Morse Code he must think of each individual character in dit dah form and *not* as dots and dashes. The reason for this is that no sense of rhythm is achieved when using dots and dashes and without the sense of rhythm, the recognition of characters when listening on a receiver becomes very difficult.

Fig.1. Full circuit diagram of Morse Practice Oscillator





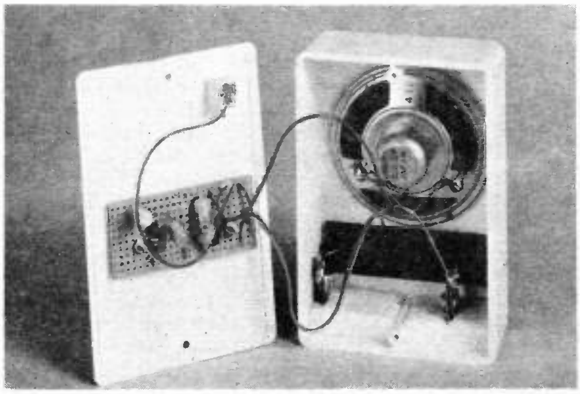


Fig. 2. (above) Assembly and layout details. Note circuit board layout and the position of the one break in the copper strips. (left) Interior layout of oscillator.

COMPONENTS approximate cost £2.50 excluding case

COMPONENTS

Resistor
R1 100kΩ (see text)
Carbon ¼W ± 10%

Capacitor
C1 0·01μF polyester

Semiconductors
TR1 AC127 germanium *npn*
TR2 AC128 germanium *pnp*

Miscellaneous
B1 1·5V type HP7 or similar
S1 Morse key with normally open contacts
LS1 miniature moving coil loudspeaker, 35 to 80 ohms impedance
SK1 3·5mm miniature jack socket
PL1 3·5mm miniature jack plug
Plastics case, 80 × 115 × 35mm; 0·1 inch matrix stripboard, 24 holes × 10 strips; 6BA nuts and bolts for stripboard mounting; interconnecting wire; battery connectors (see text); foam and circuit board guide or fillet of wood for battery clip.

THE INTERNATIONAL MORSE CODE

A di-dah
B dah-di-di-dit
C dah-di-dah-dit
D dah-di-dit
E dit
F di-di-dah-dit
G dah-dah-dit
H di-di-di-dit
I di-dit
J di-dah-dah-dah
K dah-di-dah
L di-dah-di-dit
M dah-dah
N dah-dit
O dah-dah-dah
P di-dah-dah-dit
Q dah-dah-di-dah
R di-dah-dit
S di-di-dit
T dah
U di-di-dah
V di-di-di-dah
W di-dah-dah
X dah-di-di-dah
Y dah-di-dah-dah
Z dah-dah-di-dit

1 di-dah-dah-dah-dah
2 di-di-dah-dah-dah
3 di-di-di-dah-dah
4 di-di-di-di-dah
5 di-di-di-di-dit
6 dah-di-di-di-dit
7 dah-dah-di-di-dit
8 dah-dah-dah-di-dit
9 dah-dah-dah-dah-dit
0 dah-dah-dah-dah-dah

Note
One "dah" should be equal to three "dits" in length.
The space between parts of the same letters should be equal to one "dit".

The space between two letters should be equal to three "dits".

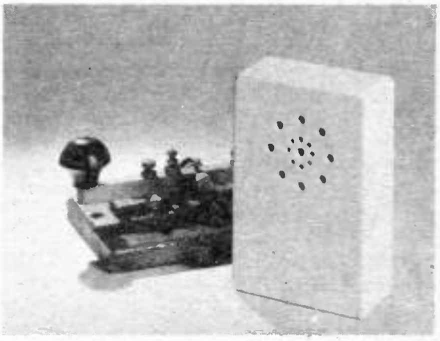
The space between two words should be equal to six "dits".

As soon as the person learning the code is capable of recognising the individual characters in dit dah form he has completed the first stage in learning the Morse Code.

The next stage is to be able to receive at the necessary speed. This will only come about by practising with a person who already knows the Morse code or if such a person is not available it is advisable that he joins a reputable amateur radio club in the area in which he lives.

The address of many amateur radio clubs in your area can be obtained by writing to the R.S.G.B. As soon as your receiving is up to standard learning to send can now be attempted. This is where this month's article comes in use.

It has often been said that a good sender is as good as his key. We therefore stress that a good rugged Morse key is used and not one of the cheap tinny tappers which are on the market at present. A good key can usually be purchased from army surplus stores for a few pounds. ⌑



Simple S.W. Receiver

By R. A. Penfold

THE short wave receiver which is described in this article has been designed to combine both simplicity and good performance. A circuit of the t.r.f. (tuned radio frequency) type is used as this avoids the complexities of a superhet circuit, including the need for any complicated alignment of the finished receiver.

The receiver is suitable for both Amateur Band and Broadcast Band listening as it is capable of resolving c.w. (Morse) and s.s.b. (single side-band) transmissions, as well as ordinary a.m. (amplitude modulation) transmissions.

A frequency coverage of about 1·67 to 31·5MHz in three ranges can be obtained, and so the set covers the entire s.w. frequency spectrum. The approximate coverage of each range is given below. The Range numbers are those used by the manufacturer of the coils employed in the unit.

Range 3 1·67 to 5·3MHz (180 to 57 metres).

Range 4 5 to 15MHz (60 to 20 metres).

Range 5 10·5 to 31·5MHz (28 to 9·5 metres).

Plug-in band changing is used, the desired band being selected merely by plugging the appropriate coil into the coil holder.

Although a proper outdoor antenna is required in order to obtain optimum results from the receiver, a large number of stations can be received using a short indoor aerial.

THE CIRCUIT

Only two transistors are used in the receiver, as can be seen by reference to the circuit diagram shown in Fig. 1. The aerial signal is coupled to the primary winding of L1. Normally the aerial is plugged into SK2 so that there is direct coupling here, but with very strong input signals present SK1 can be used instead. Losses through C2 will then prevent overloading.

TR1 is a field effect transistor (f.e.t.), and as such it has an extremely high input impedance. The tuned winding of L1 can therefore be coupled direct to TR1 gate without there being any detrimental effect on performance. The variable capacitors C3 and C4 are both forms of tuning control, and they are termed the "Bandspread" and "Bandset" controls respectively. These terms are fully explained in the section dealing with operation of the set.

Transistor TR1 is used in the common source mode, with R1 acting as the source bias resistor and C3 as its r.f. bypass capacitor. The choke L2 acts as the drain load for TR1, and the amplified gate signal appears at TR1 drain.

REACTION

Some of this signal is coupled back to the input of the circuit via the third winding of L1, and C1, the latter being used to control the amount of feedback. This feedback is usually termed "regeneration", and is also known as "reaction". It has the obvious effect of increasing the gain of the receiver, but it also boosts selectivity.

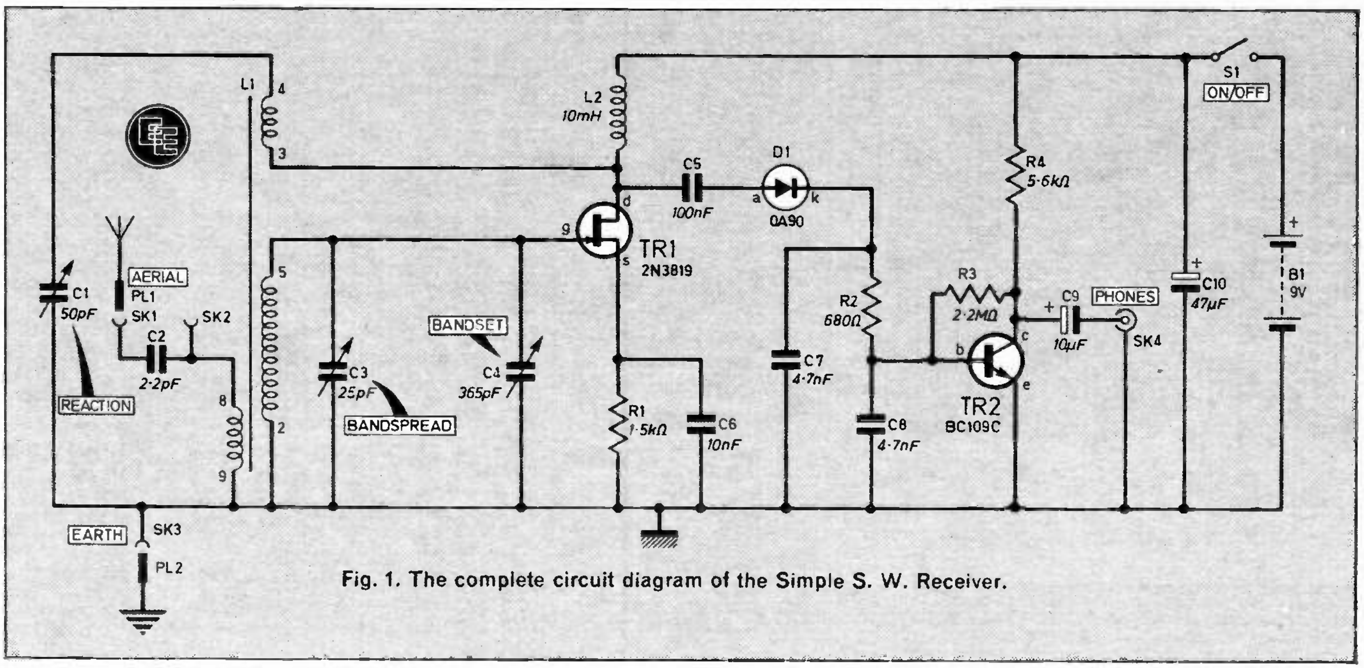
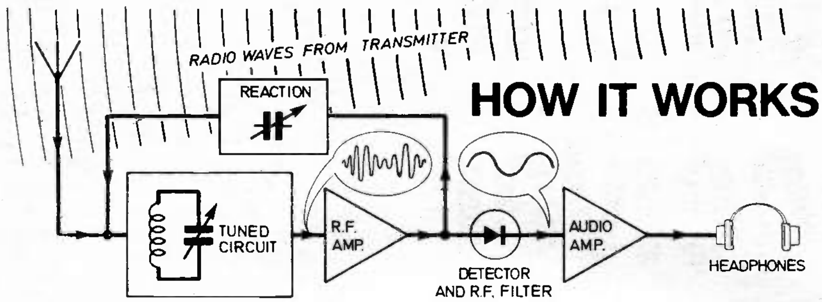


Fig. 1. The complete circuit diagram of the Simple S. W. Receiver.

HOW IT WORKS



Radio signals from the transmitter induce minute high frequency electrical signals into the aerial. These signals are fed to a resonant circuit which is adjusted to the desired frequency by means of a variable capacitor. This circuit only passes signals which are at or very close to its resonant frequency.

The selected signals are then amplified, and some of the amplified signal is fed back to the input via a reaction control. This greatly boosts the sensitivity and selectivity of the receiver. The rest of the signal is fed to a detector diode and r.f. filter and the remaining audio signal is then greatly amplified before being applied to the headphones.

Selectivity is the ability of a receiver to pick up just one of several closely spaced transmissions. Good selectivity is extremely important in a s.w. receiver as the s.w. bands are extremely crowded.

Reaction improves selectivity as it provides the greatest boost in gain towards the centre of the receiver's passband where the set will be most sensitive to the feedback, just as it would be to any other siginal.

There is a limit to the useful amount of reaction which can be applied to the circuit, as exceeding this limit will cause TR1 to oscillate. The reaction level is adjusted to just below the threshold of oscillation for a.m. reception, and just beyond this threshold for c.w. and s.s.b. reception.

DETECTOR AND AMPLIFIER

The output from TR1 is coupled to an ordinary diode detector by way of d.c. blocking capacitor C5. Components C7, R2, and C8 provide r.f. filtering at the detector output, and the remaining audio signal is fed straight into the base of TR2.

TR2 is used as a high gain common emitter amplifier, and it feeds a pair of high impedance headphones via d.c. blocking capacitor C9.

Despite its simplicity the circuit provides excellent results. The use of high gain low noise transistors plus reaction results in good sensitivity and selectivity. Unlike some t.r.f. designs this set also has a very low background noise level, this being aided by the use of a separate diode detector rather than the more usual regenerative detector.

CONSTRUCTION starts here

CHASSIS

The case is actually a 203×63·5×152mm 18 s.w.g. aluminium chassis with baseplate. This is used up-side down, so that the baseplate becomes the lid. The lid can be held in place by four self-tapping screws which fasten it to the corner pieces of the chassis, but this was not necessary on the prototype where the lid was a tight fit and simply clipped into position.

Layout details of the front and rear panels are shown in the photographs and this is quite straightforward apart from the 19mm diameter cut out in the rear panel. Ideally this should be made using a chassis punch, but in the absence of a suitable punch it can be made using a miniature round file or a fretsaw.

Variable capacitor C4 is mounted by means of a 12mm long 4BA bolt. A 4mm diameter mounting hole is drilled for this in the base panel of the case, 18mm back from the front panel, and in line behind the hole for the spindle of C4. Spacers must be used over the mounting bolt to hold the capacitor 8mm clear of the bottom of the case. The author used a couple of 2BA full nuts here.

Note that the mounting bolt should not be more than about 12mm long, as there is otherwise a risk that it will penetrate too far into the capacitor and cause damage to the sets of metal vanes. The mounting bolt fits into a ready-made 4BA threaded hole in the underside of C4.

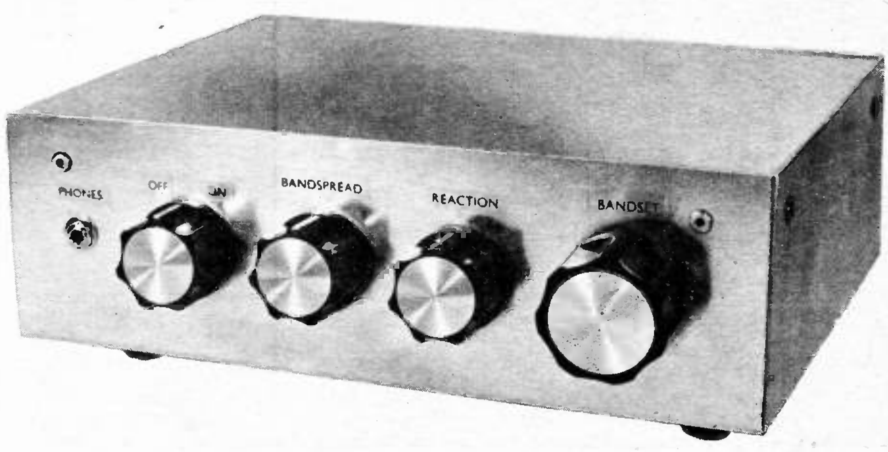
COIL MOUNTING BRACKET

The coil units have a 9-pin base which fits into a standard B9A valveholder. This enables a B9A valveholder to be used as a coil holder, with the desired range being selected by merely plugging in the appropriate coil unit.

However, the receiver has to be arranged so that there is easy access to the coil holder in order to facilitate easy band changing. In this case the coil holder is mounted vertically behind a cutout in the rear panel. It is mounted on an 18 s.w.g. aluminium bracket, and details of this are provided in Fig. 2. The positions of the two small mounting holes for the coil holder are found using the holder as a template.

Mount the coil holder so that pins 1 and 9 are uppermost. This makes it easy to give the coil the correct orientation when it is plugged in.

The bracket is positioned so that the top of the coil holder is about



Simple S.W. Receiver

COMPONENTS

Resistors
R1 1·5kΩ
R2 680Ω
R3 2·2MΩ
R4 5·6kΩ
All ¼W carbon ± 5%

See **Shop Talk** page 114

Capacitors
C1 50pF air spaced variable (Jackson type C804)
C2 2·2pF ceramic or plastic
C3 25pF air spaced variable (Jackson type C804)
C4 365pF air spaced variable (Jackson type 0)
C5 100nF polyester
C6 10nF plastic foil
C7 4·7nF polystyrene
C8 4·7nF polystyrene
C9 10µF 10V elect.
C10 47µF 10V elect.

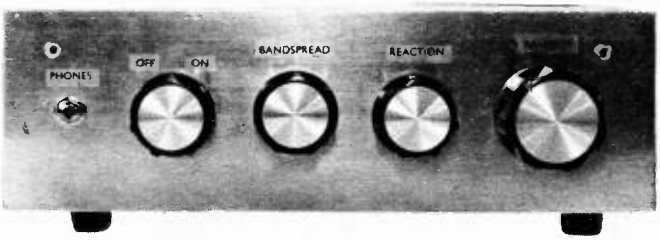
COMPONENTS approximate cost £15 including three coils

Semiconductors
TR1 2N3819 *n*-channel f.e.t.
TR2 BC109C *npn* silicon
D1 OA90 germanium small signal diode

Inductors
L1 Denco Green dual purpose coil, ranges 3, 4 and 5
L2 10mH r.f. choke Repanco type CH4

Miscellaneous
SK1, SK2 4mm sockets, red (2 off)
SK3 4mm socket, black
SK4 3·5mm jack socket
PL1, 2 4mm plugs (one red, one black)
B1 9V PP3 type
S1 s.p.s.t. rotary type

Aluminium chassis 203 × 64 × 153mm with baseplate; stripboard: 0·15 inch matrix 13 strips by 9 holes; B9A valveholder for coil; control knobs, 3 small, 1 large; PP3 battery connector; 18 s.w.g. aluminium for coil mounting bracket; interconnecting wire; 4BA nuts and bolts (4 off); 4BA spacing collars for circuit board mounting (2 off).



Front view of completed S.W. Receiver.

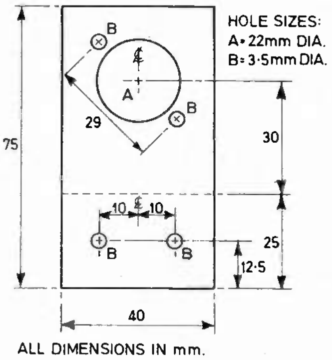


Fig. 2. Drilling details for the coil holder bracket.

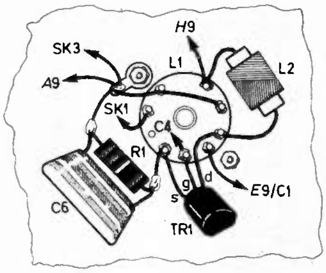
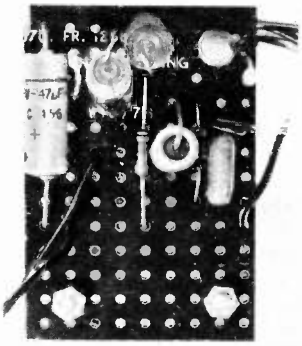
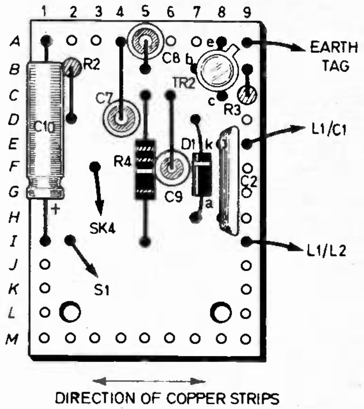


Fig. 3. Wiring of the r.f. components on the coil holder.





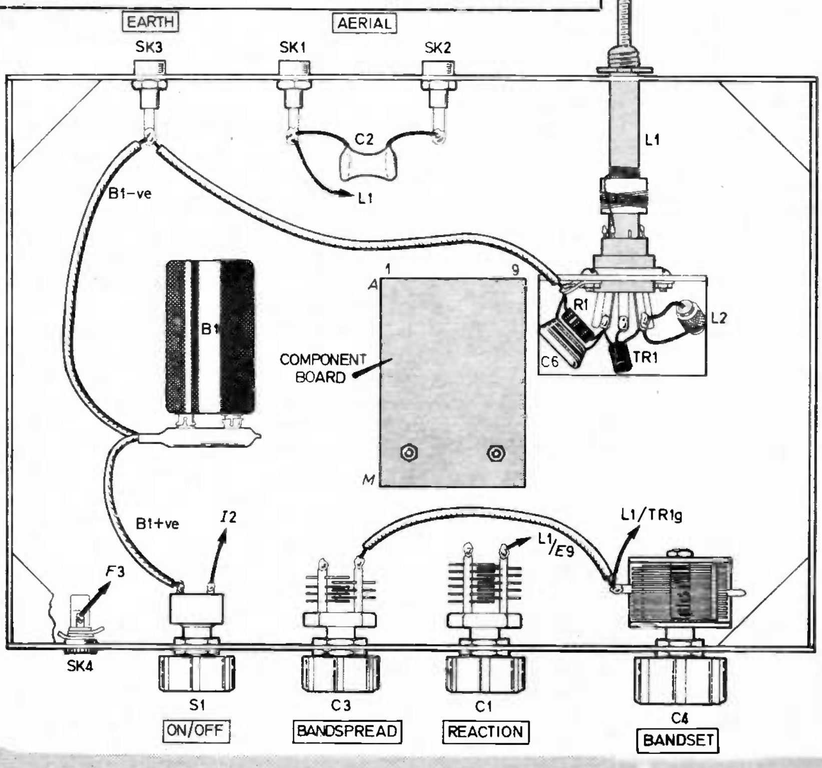
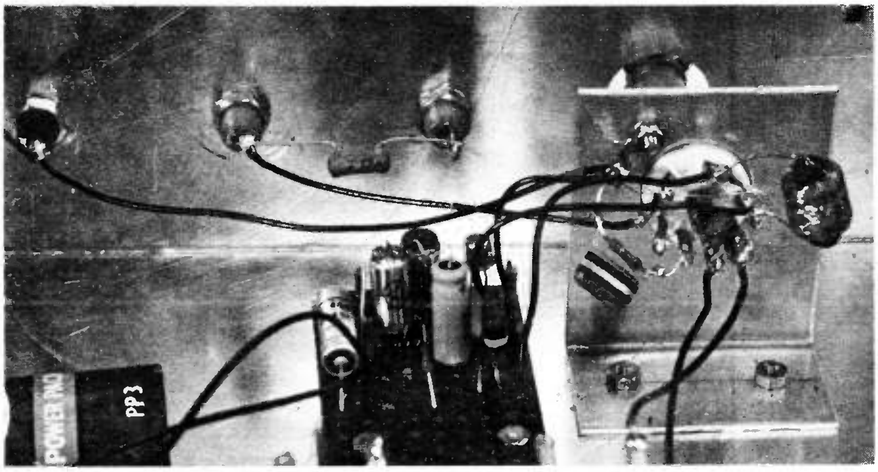


Fig. 4 (left). Interior of the receiver showing point to point wiring of the components.
Fig. 5 (above). Close up view of the top of the circuit board. Note that there are no breaks in the copper strips.



View of the inside of the receiver showing the circuit board, coil holder bracket, and rear panel.

27 to 30mm back from the rear panel of the case, and immediately behind the cutout in the rear panel. It is secured using a couple of short M3 or 6BA bolts. The coil holder is mounted on its bracket in the same way, and a soldertag is secured on the mounting bolt nearest to pins 1 and 9 of the holder.

WIRING

The audio and detector components are wired up on a piece of 0·15in matrix stripboard 13 strips by 9 holes. Details of this panel are provided in Fig. 5. The other wiring of the receiver can be seen in Fig. 4. This is all of the point-to-point type.

Construction of the panel commences with the two 3·2mm diameter mounting holes being drilled, and then the components are soldered into position.

The completed board is then wired up to the rest of the unit before it is mounted on the base of the case just to the left of L1. Spacers are used to hold the panel about 10mm or so clear of the case.

The remaining wiring can then be completed. Try to keep the r.f. wiring reasonably short and direct (see Fig. 3). The ends of component leadout wires, tags, etc., should all be generously tinned with solder prior to making a joint. There should then be no problems with dry joints.

AERIAL AND EARTH

The set is designed for use with an ordinary long-wire antenna. If possible, this should consist of about 10 to 40 metres of aerial wire mounted outside, as high as possible, and preferably clear of buildings or similar obstructions.

As mentioned earlier, a fairly short indoor aerial will provide quite good results, although reception will obviously not be as good as when using a long outdoor aerial. An indoor aerial can consist of a few metres of aerial wire fixed along a wall close to the ceiling.

An earth connection is by no means essential, and is likely to be of little or no benefit except on Range 3. An earth connection usually consists of an insulated lead connected to a metal spike or piece of thin pipe which is driven into the ground. Do not use a water pipe, gas pipe, or mains earth.

USING THE RECEIVER

Ideally the receiver should be used with a pair of good quality high impedance headphones, but inexpensive high impedance phones are also suitable, and even a crystal earpiece can be used.

Under normal circumstances the aerial should be plugged into SK2, but if this causes overloading the aerial should be connected to SK1 instead. Overloading will be made evident by an abnormally high background noise level and an apparent worsening of the selectivity.

Switch S1 is an ordinary on/off device.

The variable capacitor C1 should not be regarded as an ordinary volume control though, and it is not used in the same way. With C1 backed right off (the two sets of vanes unmeshed) very few (if any) stations will be received. As it is advanced, the sensitivity and selectivity of the set will considerably increase.

However, advancing this control too far will cause the r.f. amplifier to break into oscillation. This will be accompanied by an increase in the background noise level, and a varying tone will be heard as the set is tuned across an a.m. station. It is impossible to correctly resolve a.m. signals with the set in this condition.

For optimum results on a.m. signals the receiver should be adjusted to just below the point at which oscillation occurs. This is somewhat harder than it might at first appear as C1 will need slight readjustment each time the tuning is significantly altered. A certain amount of skill has to be acquired before the operator will obtain the best from the receiver.

Amplitude modulation (a.m.) is the mode of transmission used on the s.w. broadcast bands, and most of the popular broadcast bands fall within the coverage of the Range 4 coil (the 49, 41, 31 and 25 metre bands).

AMATEUR BANDS

The main transmission modes used on the amateur bands these days are c.w. and s.s.b. and these can be resolved by adjusting C1 slightly beyond the threshold of oscillation. Do not advance C1 any further than is necessary to cause oscillation as this will result in a loss of sensitivity.

The exception to this is when an extremely strong s.s.b. signal is being received. Such signals can overload the set unless C1 is advanced slightly more than normal.

When receiving c.w. signals the tuning controls are adjusted to produce an audio note of the desired pitch. When resolving an s.s.b. signal the tuning controls must be adjusted to produce an audio output of a realistic pitch.

The amateur bands which will provide the most interesting results are the 80 and 20 metre bands. The 80 metre band appears at the high frequency end of Range 3 (C4 adjusted almost fully anticlockwise) and the 20 metre band can best be received at about the middle of Range 5 (it also appears at the high frequency end of Range 4).

BANDSET AND BANDSPREAD

Variable capacitor C4 is the main tuning or "Bandset" control, but tuning will be difficult using this, especially on Range 5, and when tuning c.w. and s.s.b. signals. For this reason the "Bandspread" control C3 is included in the circuit.

Tuning is very cramped using C4 as it covers such a wide range of frequencies. This is not the case with C3 which has a much lower value, and therefore only covers a limited range of frequencies. Tuning is best accomplished by setting C4 to the part of the range which is to be scanned for signals, and then actually searching for signals using C3.

Finally, the coils have an adjustable core which affects the frequency coverage. As supplied, this core is fully screwed down for packing purposes. In use the core should be unscrewed slightly so that roughly 10mm of metal screwthread protrudes from the top of the coil. ⌑

NEXT MONTH

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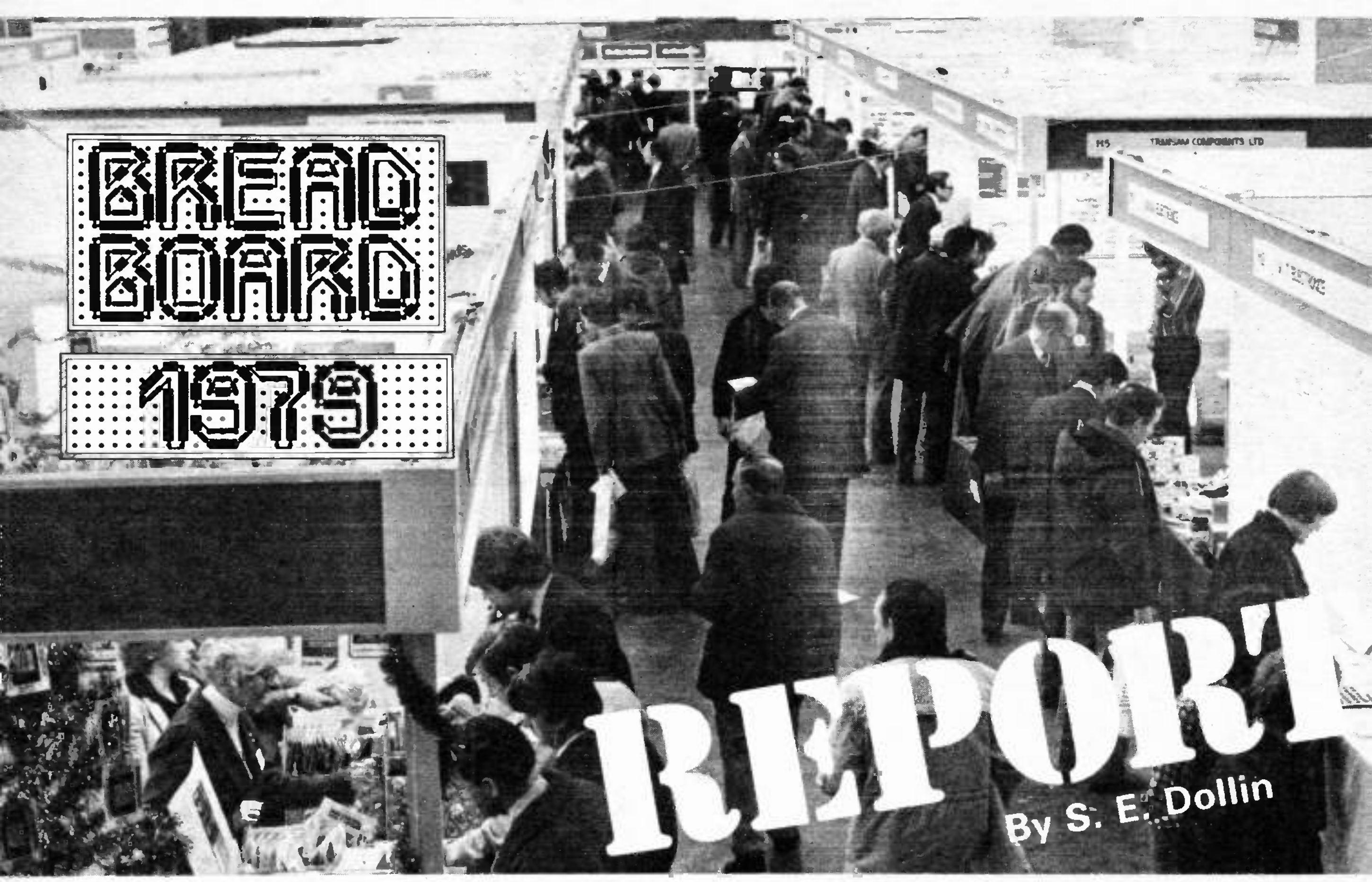


Anyone visiting the Breadboard 79 exhibition at the Royal Horticultural Halls, London, early in December last, would have at once been overwhelmed by the plethora of sound as he or she came through the door. Indeed the visitor could be forgiven for thinking that he was attending some futuristic music fair, although a quick glance round would soon belie this initial impression.

In fact there seemed to be exhibitors from just about all sectors of the electronics hobby field including most of the major component suppliers, one or two computer specialists and several magazines (including your very own Everyday Electronics of course).

BOXES AND BREADBOARDS

Of the larger industrial concerns, Vero Electronics had the most interesting stand with a full display of all their products including a new breadboard with the trade name Verobloc and a range of electronics kits called Hobbikits. Apparently the first batch of kits was only completed the day before the show opened. However Vero boast that these are the only kits to be put together and packaged in the U.K. and that they live up to the company's usual high standards.

Certainly they are well presented with full circuit descriptions and assembly details and also a separate book on such essentials as how to solder, resistor colour codes and the like. Prices range from about £6 to £18 and full details can be obtained from the company.

Although Vero seem to have a large market in factory built cases for the home constructor, Boss Industrial Mouldings were also showing an impressive range of boxes and breadboards.

Continental Specialities Corporation seemed to be pushing their own solderless breadboards, especially the new TM system, and they also had a fascinating range of test equipment for digital circuits.

MICRO COMPUTING

Microcomputers featured quite strongly this year with several specialist computer concerns taking stands as well as a predominance of computer products amongst general component suppliers and magazines.

Newbear had one of the biggest spreads with a comprehensive selection of computer hardware, including the new Sharp microcomputer, backed up by an equally comprehensive selection of books. Microdigital of Liverpool were also out to make an impact with their wide range of products and books, although of the manufacturers, only Commodore and Acorn were actually represented and neither of these had anything particularly new to see.

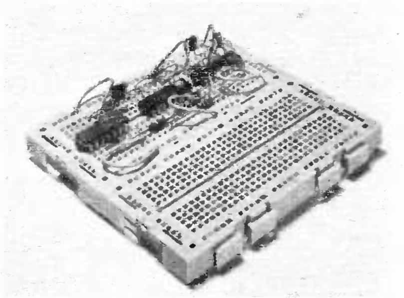
COMPONENTS AND THE LIKE

Of course no show would be complete without working models and of these there were plenty. In fact virtually every component supplier had brought along something that would at least flash a light if not make an incalculable volume of sound. Tuac were the chief culprits here having a large part of their range of disco equipment available for demonstration.

The new Hobbikit range from Vero Electronics.

However the biggest display of working models came from Maplin Electronic Supplies who had taken the best, not to mention most expansive, exhibition space and set up two large demonstration tents, one for the new 5600S synthesiser and the other for the MES50 electronic organ. The space around these was filled up with all manner of different products, nearly all in an operational state.

Watford Electronics were sticking more exclusively to computer products to catch the public's eye although they did feature their new laser project as well as a fairly large range of stock. Marshalls on the other hand preferred to stick to a more limited range of products—some at a discounted price. Bi-Pak were out



Verobloc breadboarding system showing two boards clipped together.

to make an impression with their large stand and the Bi-Kit range of high quality audio modules.

The centre-piece of T. Powell's stand was a very neat version of the E.E. Tutor Deck (like many other component suppliers, they were offering a complete kit of parts for the Teach-In 80 series). In fact, taking into account the number of smaller component shops represented, constructors should have been able to find virtually any component imaginable somewhere in the place.

AMATEUR CLUBS

It was heartening to see that a couple of amateur clubs were able to be present at the exhibition. The British Amateur Electronics Club founded in 1966 had a small display, mainly of books and pamphlets designed to attract new members.

The Electronic Organ Constructors Society were much more ambitious having several organs on display built by their own members including a certain model with the resplendent title "The Mini Minor Moveable Mk 2".

MAGAZINES

Turning to the press, most of the usual hobby magazines were represented, each with its own set of demonstrations adding to the general

The Sharp MZ80K microcomputer.

cacophony. EVERYDAY ELECTRONICS was featuring various musical sound effects (some published, some yet to be seen in print) which proved very popular, and also the Loft Alert as well as a static display of several other projects "in the flesh" as one youngster put it. These included the Radio-Control System and the Tutor Deck, both of which aroused considerable interest.

So was it all worth it? There was certainly "something for everyone" as the saying goes. The attraction for many people, it seems, lay in the fact that everything was there under the one roof, both magazines and suppliers, and where better to see that unit you were going to build or buy that transistor you couldn't find deep in furthest Ipswich?

Electronic Translation

The latest marvel to catch my eye is the electronic translator. It is pocket size, and you merely spell out the word in English, press the button and "hey presto", there is the equivalent word in French, German, Italian or whatever language you have selected.

I am not knocking the idea which is a brilliant piece of technology, but it will cost you around £150 and I am wondering if I could not do just as well with a dictionary costing a pound or so. The trouble is, that without a working knowledge of the language concerned, it is impossible to write a letter with a dictionary.

This was forcibly brought home to me a few years ago by a letter I received from the third world, Benin City to be precise. I always remember one phrase in the middle of the letter which ran "Never let failure be the result" which raised a smile and if any of my staff were in difficulty over anything someone was bound to quote it to them.

I know when I am in a strange country I shall fall back on my usual technique of pointing to my mouth when I am hungry, putting my two hands together and laying my head on them when I am tired.

All Electric

Several years ago, I decided that as my business was electronics everything in my house should be electric. I even had an electric fire lighter and very good it was too. It was about this time that I decided we ought to have central heating and it coincided with the invention of the storage heaters.

Now as I understand it, and I hope my electrical friends will correct me if I am wrong, the theory behind the storage heaters was this. At night when most of the load on the power stations is switched off, the engineers are faced with a problem.

Their machines must always run at constant speed otherwise the frequency would change with devastating results. So when the load is taken off it must be replaced with an artificial load. In other words lots of kilowatts are wasted.

Along comes a bright lad, and suggests using them to warm up fire bricks in a container and these would continue to give out heat all next day. Thus the storage heater was born.

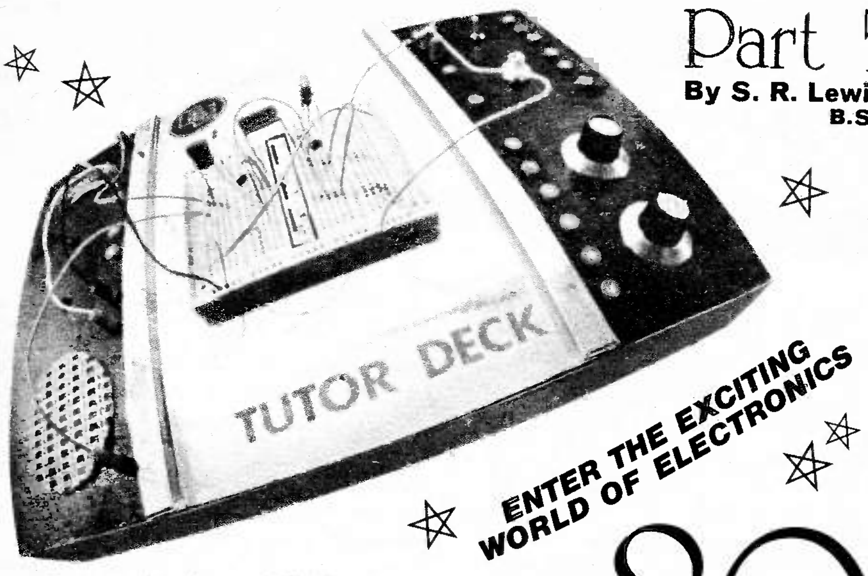
The Electricity Authority could afford to sell this night supply at a cheap rate, because in the past they had received nothing for it at all. Storage heaters had little to recommend them, they were big, heavy, ugly, and practically uncontrollable but they were cheap to run.

This was the situation up to about three years ago when some luminary on the Board decided he would put up the cost of the night supply. The results were disastrous.

Faced with astronomical bills people had to change to an alternative system overnight. Factories making storage heaters closed down, and work on two power stations was halted because of the sudden drop in demand. Added to that, the Electricity Authority were back to square one, getting nothing for their surplus which has to be shunted off as before.

Apparently even after this calamity became apparent, no one could reverse the decision and put it right. Instead the Electricity Board's remedy is to waste public money on a vast advertising campaign to try and persuade people to have a storage heater, saying that "We can supply you with one for £99!".

Pardon me while I give a hollow laugh. I have been trying to give my storage heaters away for months and I am just about to bury them in my garden and I am not joking!



Part 5

By S. R. Lewis, B.Sc.

TEACH-IN 80

In all the electronic circuits which we have looked at in previous parts of this series, the variables in which we have been interested (current and voltage) have been invariant with time; it did not matter when the measurements were made, providing the connections were the same then the variables would be the same.

We are now about to look at **capacitors** and we must now concern ourselves with a new dimension—that of **time.** It is now no longer a matter of measuring voltages and currents, we must now take the timing of the measurements into consideration.

Before looking at capacitors (as physical circuit components) we will take a look at the property which capacitors are designed to exploit: **capacitance.**

CAPACITANCE

Resistance is a property of all components: every material through which current passes produces some resistance to that flow. Capacitance is another property which all components exhibit although, like resistance, there are a large number of situations where it is so small as to be negligible.

Resistance is a property which is fairly easily visualised in terms of everyday systems. It is sometimes thought of as like a thin pipe opposing the flow of water or a narrow passage through which lots of people are trying to pass. Analogies of this sort, with all their limitations help us to comprehend in part at least a rather abstract concept.

When it comes to capacitance we have to resort to rather more complicated visual models and thus capacitance is a more difficult concept to grasp.

Capacitance arises because of the charge on a body and the field in which it exists. When a charge moves in an electric field, energy is either absorbed or released. It is similar to raising a weight in the gravitational field (which absorbs energy) or dropping a weight (which releases the stored energy).

Each charge has a potential, in other words a stored amount of energy. To go back to the analogy of gravity, the potential of the weight would depend on its distance above the object on which it was to be dropped.

Table 5.1
UNITS OF CAPACITANCE

Submultiple		Symbol
10^{-6}	micro	μF
10^{-9}	nano	nF
10^{-12}	pico	pF
10^{-12}	micro micro	$\mu\mu$F

It will be observed that pF and $\mu\mu$F are alternative ways of expressing the same thing; the first (pF) is more commonly used nowadays.

The potential of a charged body (of any sort) is proportional to its charge. The ratio of charge (Q) to potential (V) we call capacitance (C).

Thus $C=Q/V$.

THE FARAD

The charge of a body (Q) is measured in coulombs (C) and the potential of the body (V) is measured in volts. A body with a charge of one coulomb and a potential of one volt is said to have a capacitance of one **farad.** This unit is named after Michael Faraday.

One farad is rather a large unit for normal, practical electronic circuits so submultiples of the farad, such as the **microfarad** (equal to one millionth of a farad) and the **picofarad** (one millionth-millionth of a farad) are the units commonly used.

Symbols for these submultiples of the farad are given in Table 5.1.

The capacitance of a body depends on the nature of the body (its physical shape, size, etc) and the field in which it exists.

CAPACITORS

All charged bodies can be said to possess capacitance but unless the body is carefully designed and constructed it will be low.

Since capacitance is charge divided by potential, we can increase the capacitance of a given body by increasing the charge which it can hold whilst reducing the potential. This can be done by concentrating the region over which the electric field extends. Capacitors can therefore be described as components for concentrating electric field energy.

Most modern capacitors are designed around the simple **parallel plate** principle. They are constructed of two parallel metal plates with as large an area as is necessary to achieve the required capacitance, separated by a very thin insulating layer called the **dielectric.**

The dielectric is a material specially chosen to be able to support a high concentration of field energy—it must therefore be a very good insulator. The sort of materials that are used in modern capacitors for the dielectrics are **polyester, polycarbonate** and **polystyrene.** Older capacitors had **paper** or **mica** dielectrics.

CONSTRUCTION

The construction of a typical polystyrene capacitor is shown in Fig. 5.2. The metal plates are thin sheets of aluminium placed on either side of a thin sheet of polystyrene. The whole arrangement is then rolled very tightly, making sure that the two plates do not touch.

At each end of the capacitor electrical connection is made to one of the plates. The whole assembly is then covered with a coating of plastic, and the finished component looks like that shown in Fig. 5.3a.

Capacitors of this type tend to become extremely large when values over a few microfarad are required. The problem is that the distance between the plates is governed by the thickness of the dielectric. Since this can only be made as small as manufacturing processes allow, the plate area (and hence the size of the capacitor) has to be kept large to compensate.

ELECTROLYTIC CAPACITORS

It is possible to produce capacitors with high values in a small volume but the dielectric must be produced in a new way. Instead of a dry insulating material between the plates of the capacitor, a special liquid, or, more usually a liquid impregnated paper, is used. The liquid is an **electrolyte** which has the property of allowing current to pass through it. This liquid dielectric gives this type of capacitor its name: **electrolytic.**

The way that electrolytic capacitors work is that a steady (d.c.) current through the electrolyte causes a very thin film of oxide to form on one of the plates. This layer is an almost perfect dielectric as it is very thin but can withstand quite high voltages across it.

Sometimes the plates are treated in a special way to make them rougher ("corrugated") and hence increase the effective surface area of the plates.

SOME DRAWBACKS

Whilst they produce very high capacitance in a small volume, electrolytic capacitors have quite a few drawbacks.

First, there must be a d.c. current through the capacitor in order to maintain the dielectric.

Secondly, the so-called **polarising current** must be in the correct direction. If the voltage across electrolytic capacitors is accidentally reversed then the dielectric layer may be destroyed.

Some electrolytics are called **reversible** but this does not mean that they can be used in the same way as non-electrolytics as the "reversing" may not be able to take place as fast as the voltage across the capacitor is changing.

The other drawback is that electrolytics cannot work in as harsh an environment as non-electrolytics since the electrolyte requires a rather narrow range of operating temperatures.

TANTALUM CAPACITOR

Another type of capacitor which is now quite widely used is the **tantalum** capacitor. Again these capacitors need a polarising current in a specific direction in order to maintain the dielectric layer.

The dielectric layer in this type is even thinner than that in electrolytics, but the voltage that it can withstand is lower. Thus while tantalum capacitors have very high values in small volumes, the working voltage (that is the maximum voltage that can be safely placed across them) is only in the order of a few tens of volts.

Three typical types of capacitor are illustrated in Fig. 5.3.

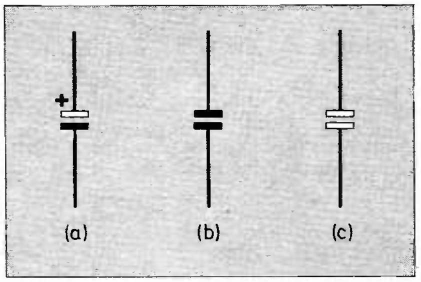


Fig. 5.1. Circuit symbols for three types of capacitor. (a) polarised or electrolytic type (b) non-electrolytic (c) reversible electrolytic.

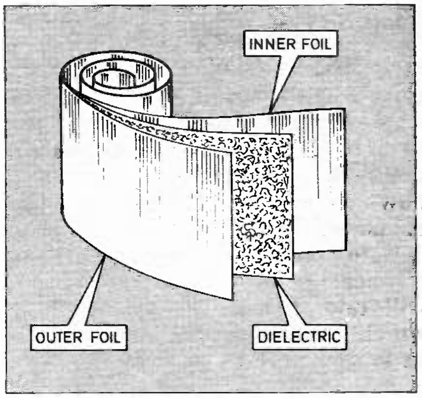
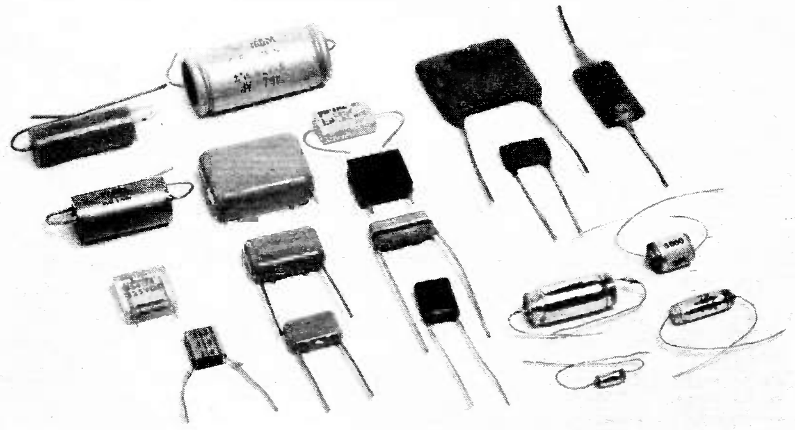


Fig. 5.2. Construction of a typical non-electrolytic capacitor.



A selection of commonly used small-value types of capacitors. Dielectrics include mica, paper and polyester film. Aluminium cans, moulded plastic cases and dipped encapsulation are all included in this group.

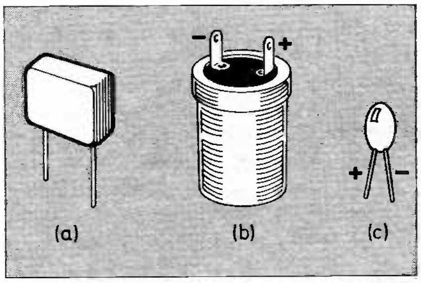


Fig. 5.3. Three different types of capacitor. (a) polyester (non-electrolytic) (b) metal can type electrolytic (c) tantalum.

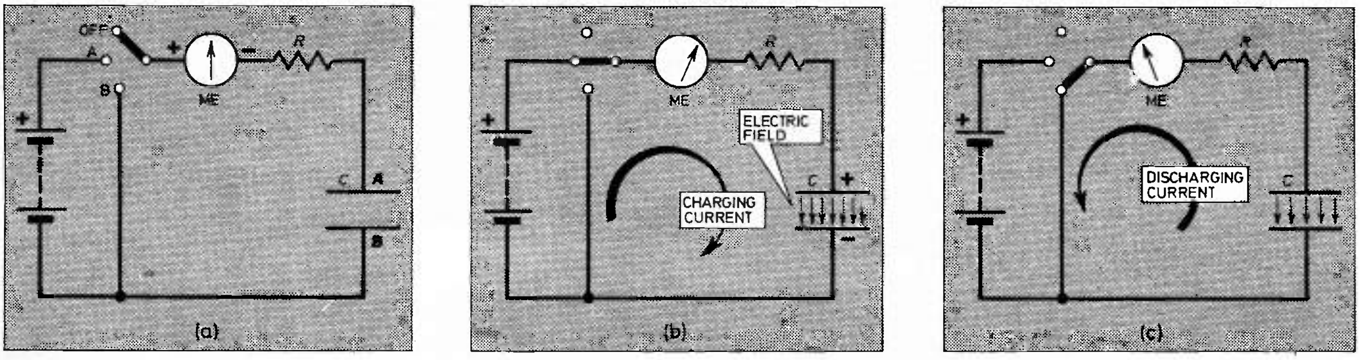


Fig. 5.4. Charging and discharging a capacitor from a battery through a resistor. (a) Switch open—no charge on the capacitor, no current through the meter. (b) Switch closed—charge accumulates on the capacitor and current flows in the meter, slowly decaying to zero. (c) Short circuit—field on capacitor drives current in opposite direction. Meter indicates flow in reverse direction.

CAPACITOR SPECIFICATIONS

When capacitors are specified for constructional projects in this and other magazines they are usually described in terms of three or sometimes four parameters: **capacitance; dielectric type; working voltage** and, sometimes, **tolerance.**

Capacitors in general tend to have much wider tolerances than resistors. It is not uncommon to use non-electrolytic types with tolerances of ± 20 per cent and electrolytics with tolerances of -50 to $+100$ per cent! This is not to say that close tolerance capacitors are not sometimes used but, on the whole, it is rare to find a circuit which relies on close tolerance capacitors.

The reason for this is that the two components (resistors and capacitors) are used for different reasons. Resistors tend to be used for setting voltage and current levels within a circuit, whilst capacitors are used for such things as d.c. isolation, smoothing pulsating voltages and decoupling power supplies (these terms will be explained later).

In short, one could say that resistors are used in a **quantitative** manner whilst capacitors are used in a **qualitative manner.**

The type of dielectric is specified since the properties of the capacitor depend on the dielectric. Certain dielectrics work better in high frequency circuits whilst others are good for use in timing circuits where one requires very low leakage current through the capacitor.

In most cases the type of dielectric is not critical and the cheapest type (usually paper or polyester) can be used.

CHARGING AND DISCHARGING A CAPACITOR

To see how a capacitor behaves in a circuit we will look at what is perhaps the most fundamental circuit containing a capacitor.

A battery, switch, meter, resistor and capacitor are connected in series as shown in Fig. 5.4. The switch is initially open and therefore no current can flow in the circuit. When the switch is closed an interesting thing occurs.

The meter swings nearly to full scale at the instant that the switch is closed but gradually the reading on the meter falls until eventually it reaches zero.

If the meter is again reading zero then no current can be flowing and thus the voltage across the resistor must be zero. The only way that this can happen is if the voltage across the capacitor is exactly the same as that of the battery.

We can understand what has happened by considering electron flow around the circuit.

As soon as the switch is closed there is a brief rush of electrons from plate *A* which is connected to the positive terminal of the battery through the battery to plate *B* where they accumulate. The meter will be showing maximum deflection at this time.

Current will keep flowing until the potential difference between the plates is equal to the voltage of the battery.

As plate *B* gathers more and more electrons it becomes harder for any more to arrive because of like charges repelling. Similarly, at plate *A* as more electrons are lost it becomes increasingly harder to lose further electrons because of the attraction of opposite charges.

Thus, as the charge on the plates increases it becomes harder and harder for the current to flow.

The two oppositely charged plates produce a field in the dielectric separating them. If the switch is now opened each plate is left charged with a certain quantity of electricity, *A* with a positive charge and *B* with a negative charge.

The sum of the charges is zero so when one sees a reference to the *"charge on a capacitor"* one should understand that it is in fact the charge on *one* of the plates.

ENERGY STORE

If the battery is now removed and replaced with a short circuit (direct connection) and the switch is again closed we see another interesting feature of capacitors: they act as stores of energy.

The field which was created by the charge from the battery flowing into the capacitor now sees no opposition since the battery is not in circuit. The electrons therefore rush back along the paths through which they arrived until the charge is evenly distributed throughout the circuit.

If we look at the meter when this is happening we see that the flow is in the opposite direction as we would expect and like the charging current it begins at a maximum and slowly decays to zero. This is because as the charge from the plates distributes itself in the circuit, the force generated by the charge on the plates becomes less and less until, when there is even distribution of charge, the current is zero.

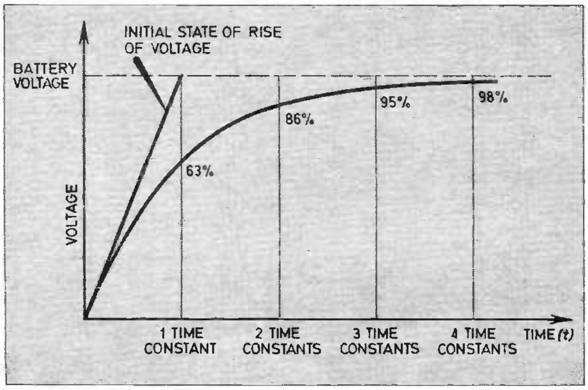


Fig. 5.5. Voltage on a charging capacitor plotted against time. It takes about 0·69 time constants for the voltage to reach 50 per cent of the battery voltage.

To use an analogy, the capacitor is like a spring which stores the energy which was used to stretch it. This energy can be released by releasing the force on the spring.

CHARGING RATE

We have said that the current through the meter starts off large and reduces to zero but we have not said anything about the *size* of the current or the *time* that it takes to reach zero.

When the capacitor is fully discharged, that is there is no potential difference between its plates, and the switch is closed the capacitor appears simply as a short circuit. The current that flows is therefore solely determined by the battery voltage divided by the value of the resistance—Ohm's Law.

Say we imagine this current flowing for a short time t. The charge which will have accumulated on the plates will be $I \times t$ (where I is battery voltage divided by resistance R). Now this charge will produce a voltage across the capacitor in an opposite sense to the battery voltage and of magnitude $(I \times t)/C$ where C is the value of the capacitor.

The current which now flows in the circuit must be less by an amount equal to the voltage on the capacitor. Therefore, in the next time period t the charge accumulated on the capacitor will be slightly smaller.

We can thus plot the voltage on the capacitor against time as series of short straight lines to obtain a graph like that of Fig. 5.5. Providing the time interval has been made small enough then the graph will be a pretty true representation of the actual voltage.

EXPONENTIAL RISE

The shape of the curve is known to mathematicians as an "exponential rise" and it can be described very accurately using calculus.

A couple of interesting features of the graph should be noted. First, the voltage on the capacitor never theoretically reaches the voltage on the battery. This is because the more charge on the plates the more difficult it is for any more charge to be added.

In a real situation, however, we need to have some way of relating the shape of the curve with the value of the circuit components. We therefore look at the angle which the initial part of the curve makes with the time axis.

TIME CONSTANT

The rate of rise of voltage is simple given by V/CR. Now since this is **rate of rise of voltage** the units of $C \times R$ must be units of time. We call the value of the capacitance multiplied by the resistance the **time constant** of the circuit.

In one time constant the voltage on the capacitor will have reached 63 per cent of the battery voltage.

In two time constants the voltage will be 86 per cent of the battery voltage. The figures for three, four and five time constants are 95, 98 and 99 per cent, respectively.

CAPACITORS IN PARALLEL

If we place two capacitors in parallel and again charge them up through the battery and resistor circuit, then we would end up with each capacitor having the same charge that the single capacitor had. If we call the charge on the single capacitor Q then the total charge on the two capacitors will be $2 \times Q$.

Since the voltage across the capacitors is still equal to the battery voltage the total capacitance in the circuit (total charge divided by total voltage) will be $2 \times Q/V$.

Since Q/V is the capacitance of the single capacitor we can deduce that two capacitors in parallel are equivalent to the sum of the capacitances of the individual components.

CAPACITORS IN SERIES

If two equal capacitances are placed in series and charged by the battery through the resistance as before, then clearly the voltage on each of them must be half the battery voltage. The total charge is still the same so that the total capacitance is $V/2 \times Q$ or $\frac{1}{2} \times Q/V$. Thus the total capacitance is half that of a single capacitor of the same value.

PART 5 QUESTIONS

5.1. To increase the capacitance for a given plate area should the plates be moved:
- a) nearer
- b) further apart

5.2. A 0·1μF and a 0·47μF capacitor in parallel have a capacitance of:
- a) 0·57μF
- b) 0·37μF
- c) 0·08μF

5.3. Two 0·22μF capacitors in series have a capacitance of:
- a) 0·44μF
- b) 0·11μF
- c) 0·22μF

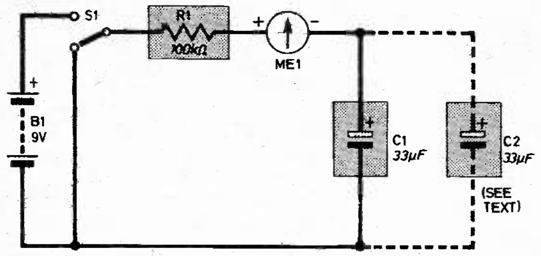
5.4. How long will it take a 10μF capacitor to charge to 99 volts from a 100V battery through 470kilohms:
- a) 23·5 seconds
- b) 2·35 seconds
- c) 4·7 seconds

5.5. A 10μF and a 5μF capacitor in series are charged to 15V. What is the voltage on the 5μF capacitor:
- a) 10V
- b) 5V
- c) 7·5V

PART 4 ANSWERS

4.1. b) 4.2. b) 4.3. b) 4.4. a) 4.5. b)

EXPERIMENT 5.1:
CHARGING AND DISCHARGING



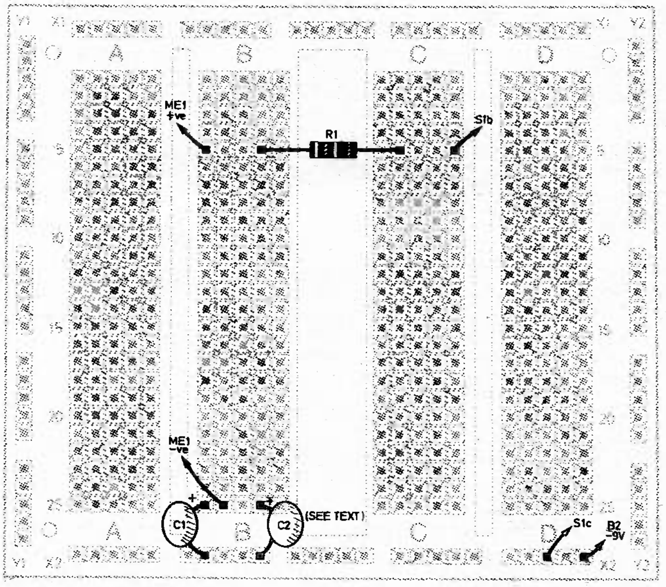


Fig.5. 7b

Fig. 5.7. Charging and discharging a capacitor are illustrated with this circuit. (a) shows the circuit diagram and (b) the Tutor Deck layout. Note these additional connections on right hand panel of Tutor Deck: link S1(a) to B2 +9V.

Components needed: 100kΩ resistor, 33μF tantalum capacitors (2 off)

The circuit of this experiment is quite simple consisting of a battery, switch, meter, a resistor and a capacitor in series. The capacitor used is of the tantalum type and the polarity markings must be observed on the body and made to match the orientation shown in the diagram Fig. 5.7.

The meter is measuring current flow, not voltage on the capacitor. When the switch is operated so that the battery is connected to the circuit the meter will swing full scale and then return to zero, rapidly at first but much more slowly as time progresses.

When the switch is placed in the other position there is again a swing to almost full scale followed by a "decay" back to zero, but now the current flow is in the reverse direction.

Note the time that the meter takes to go back to half scale and verify that it takes the same time whether the capacitor is charging or discharging.

Now put another 33μF capacitor in parallel with the first and again record the time for the meter to reach half scale. This should be twice the original time.

For identification of Tutor Deck components and their associated sockets refer to Fig. 2.8.

EXPERIMENT 5.2:
CAPACITOR BRIDGE

Components needed: 100kΩ resistor, diodes (4 off), 10kΩ resistor, 0·47μF capacitor, capacitors to test.

This circuit makes use of the calibrated scale as described in Part 2 of this series, but this time it is used with VR1.

The reference capacitor is a 0·47μF type so capacitance values from about 0·05μF to 5μF can be measured using the circuit.

Note that the voltage across the bridge is now a.c. so the meter does not give a true reading of current. However since it is simply used to null the bridge, this does not matter.

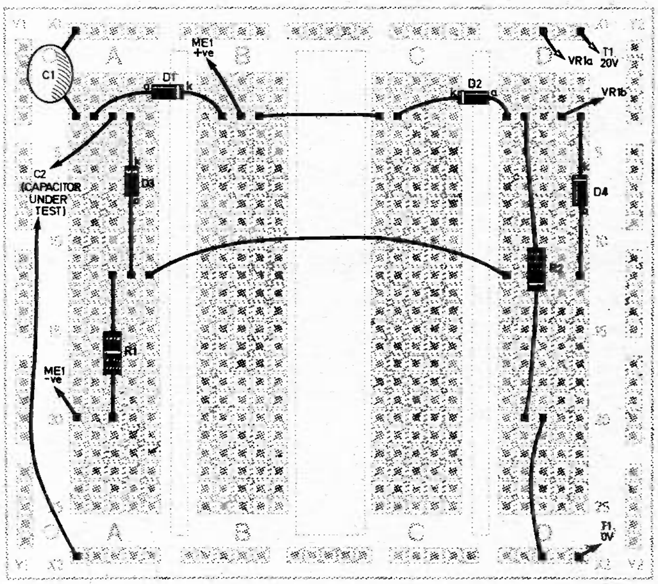
The potentiometer is simply used to adjust the meter reading until the bridge is balanced. The capacitance is then given by

$$C = (0{\cdot}47 \times R)\,\mu F$$

where R is the reading on VR1 scale (0 to 10).

Note that the meter will only swing in the positive direction since the diode bridge will only produce current in one direction through it. The null is thus when the meter reading is a minimum.

Fig.5. 8b



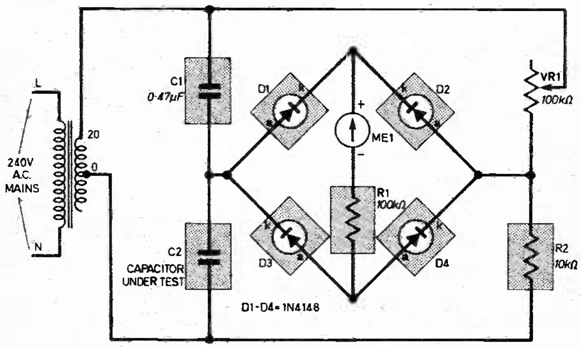


Fig. 5.8. A capacitor bridge to measure unknown capacitance between 0·05 and 5μF. (a) shows the circuit diagram and (b) the layout of the components on the Tutor Deck.

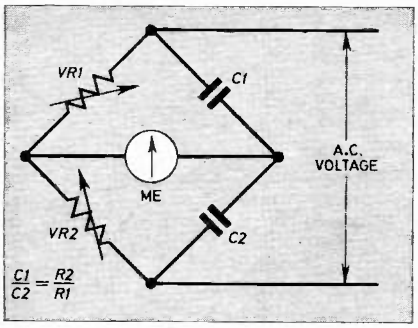


Fig. 5.6. Capacitor bridge circuit. The meter is assumed to be able to read a.c. current. The unknown capacitor can be deduced from knowledge of the resistor ratio and the known capacitor.

To generalise: the total capacitance of any number of capacitors in parallel is given by the sum of the capacitors. For capacitors in series the total capacitance is equal to the reciprocal of the sum of the reciprocals of the individual capacitors.

Parallel: $C_T = C_1 + C_2 + C_3 + \ldots.$

$$\textbf{Series: } C_T = \frac{1}{1/C_1 + 1/C_2 + 1/C_3 + \ldots}$$

CAPACITORS IN A.C. CIRCUITS

When we were looking at the charging of a capacitor one deduction that could have been made is that the current flowing in the circuit was a maximum when the *rate of change* of voltage across the capacitor was also at a maximum. In fact there is a direct relationship between the current flow into a capacitor and the rate of change of potential. The relating factor is again the capacitance.

The relationship states that the current through a capacitor is directly proportional to the rate of change of voltage across it.

This relationship is all-important when it comes to a.c. circuits for here we are dealing only with voltages that are constantly changing. The higher the frequency of a signal the greater is its rate of change of voltage and so we can deduce that the higher the frequency of an a.c. voltage applied to a capacitor, the greater will be the a.c. current through that capacitor.

To more fully appreciate how capacitors, and indeed those other components **inductors,** act in an a.c. circuit we will have to look at a.c. circuits in more detail.

CAPACITOR BRIDGE

When looking at circuits containing only resistance we looked at the way a "bridge" circuit could be used to identify unknown resistors by using a calibrated potentiometer and a meter to balance the current through the known and the unknown halves of the bridge.

A bridge circuit can also be constructed using a capacitor to replace one of the resistors. The unknown component now becomes a capacitor rather than a resistor. The circuit is shown in Fig. 5.6.

We have seen that a direct voltage flowing through a resistor will simply cause the capacitor to charge up until the force created by the field in the capacitor exactly balances the electromotive force of the battery.

To measure the unknown capacitor using direct voltage would therefore require the measurements to be made only during the charging period, for this is the only time that appreciable current flows. In order to keep current flowing in the circuit we use an alternating voltage to drive the bridge.

Because the voltage is alternating and the meter is only designed to read direct current we must have some way of converting the rapidly changing current into a direct current. We do this using a diode bridge since this will only conduct in one direction, the current flow in the reverse direction being negligible.

Because the voltage across the capacitors is constantly reversing this circuit can only be used with non-electrolytic capacitors.

Notice that with capacitors in series (as they are in the bridge) the larger the capacitor, the smaller the voltage which will be developed across it.

Next month we will look at inductance and a.c. circuits.

CORRECTION!

We are sorry for these small errors which occurred in previous parts of this series. Please mark your copies as follows:

Part 2 page 716
Second column 17th line should read: "just over 0·1A (100mA)".

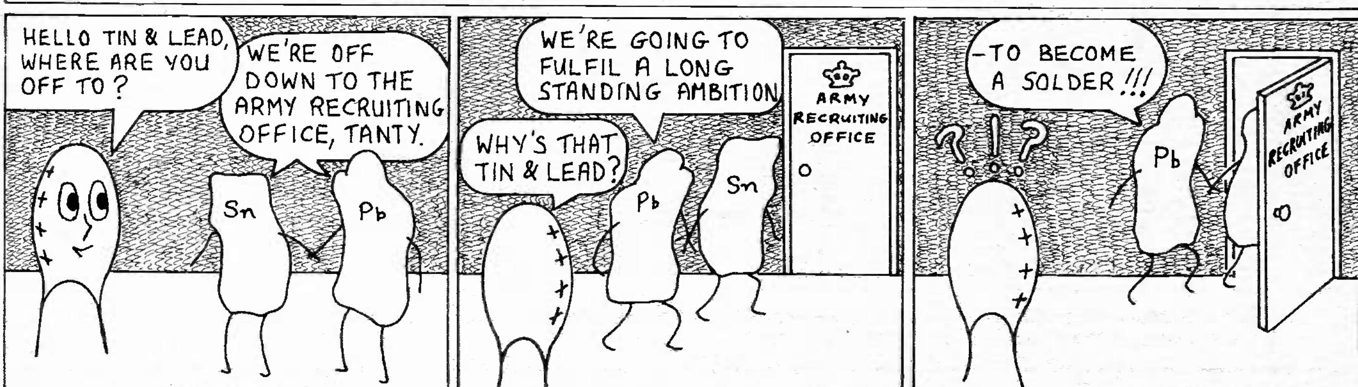
Part 3 page 796
First paragraph, lines 5 and 6, should read:
"100 × 0·005 = 0·5V and that . . . must be 200 × 0·005 = 1V."

Question 3.2. Bridge circuit referred to should read: "Fig. 3·5".

Answer to Question 2.3 should read: "a".

The Adventures of Tanty Bead

By Matthew Reed



SQUARE one FOR BEGINNERS

SOLDERING

COMPONENTS forming an electronic circuit are bonded together using "solder". This is an alloy of lead and tin, a very good conductor. The soldered joint thus provides continuity between components and produces a joint of considerable strength.

Solder is silvery in colour and wire-like in appearance, being very pliable. It is obtainable in a range of different sizes (gauges). Throughout its length are a number of cores filled with a resinous flux to "clean" the joint as it is being made.

To make a soldered joint in electronic circuits an electric soldering iron is required. This is a special tool to heat up the joint to a sufficient temperature to cause the applied solder to melt. Basically the "iron" consists of a coil of resistive wire (similar to the bar on an electric fire) which is in contact with a solid shaped metal rod called the "bit". Current through the coil causes the bit temperature to rise.

Soldering is extremely important. Every joint must be good to enable successful operation of the unit being built. If you have never carried out any soldering before it is wise to practice on scraps of circuit board and components before attempting to construct a project.

For the majority of projects published in E.E. an electric soldering iron rated between 15 and 25 watts will be most suitable. A selection of bit sizes will be useful and most jobs can be accommodated with a 1/16 in, 1/8 in, and a 3/16 in bits or their metric equivalents. On no account use an iron that is heated in a flame or electric furnace.

Use the resinous-flux-incorporated solder as described above. Never use unfluxed solder or separate flux or acid to clean joints: 18 s.w.g. or 22 s.w.g. "Multicore" solder is ideal for E.E. projects.

The bits of new soldering irons may contain a protective layer of light oil which should be removed before the iron is heated. Methylated spirit or similar solvent will remove this.

TINNING

For best results and ease of soldering the bit should be "tinned" immediately before use. This means coating the tip of the bit with a thin layer of solder. Merely melt some solder on the tip and see it flow over a clean tip.

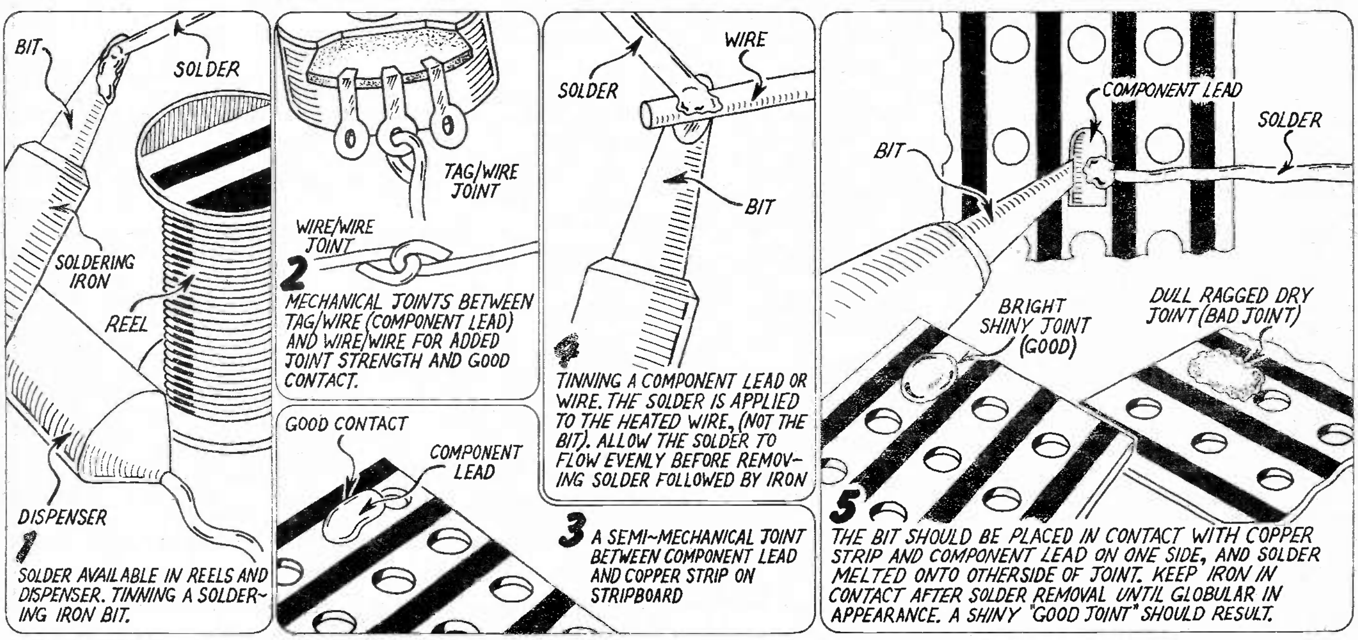
It is a good idea to have a piece of damp sponge foam available to occasionally "wipe" the bit clean from the oxide that accumulates.

Component leads in general do not require to be tinned before connection since this is carried out by the manufacturer. In some cases the leads may be gold plated for ease of connection. However, if they appear to be dirty, emery paper or steel wool can be used to clean the wires, and then preferably tinned.

With copper clad circuit boards, such as stripboard, the surface may need to be cleaned with emery paper/steel wool to remove any oxide or grease that would impair the making of a good bond.

The two items to be joined must be in good contact before soldering, preferably a "mechanical" or "semi-mechanical" connection, see below.

The solder should *not* be melted onto the iron. Instead, the iron is used to heat the two surfaces and the solder melted onto and around the contact area. When the solder is seen to flow evenly over the joint, remove the solder followed by the iron and allow to cool. A shiny, smooth globular appearance will indicate a good joint. If the joint is disturbed during cooling or insufficient heat is applied, or the surfaces are dirty in any way, a "dry joint" may result. This will be indicated by a dull ragged looking joint. Such a joint could have a high resistance or even be open circuit—components not electrically connected.



1 SOLDER AVAILABLE IN REELS AND DISPENSER. TINNING A SOLDERING IRON BIT.

2 MECHANICAL JOINTS BETWEEN TAG/WIRE (COMPONENT LEAD) AND WIRE/WIRE FOR ADDED JOINT STRENGTH AND GOOD CONTACT.

3 A SEMI-MECHANICAL JOINT BETWEEN COMPONENT LEAD AND COPPER STRIP ON STRIPBOARD

4 TINNING A COMPONENT LEAD OR WIRE. THE SOLDER IS APPLIED TO THE HEATED WIRE, (NOT THE BIT). ALLOW THE SOLDER TO FLOW EVENLY BEFORE REMOVING SOLDER FOLLOWED BY IRON

5 THE BIT SHOULD BE PLACED IN CONTACT WITH COPPER STRIP AND COMPONENT LEAD ON ONE SIDE, AND SOLDER MELTED ONTO OTHERSIDE OF JOINT. KEEP IRON IN CONTACT AFTER SOLDER REMOVAL UNTIL GLOBULAR IN APPEARANCE. A SHINY "GOOD JOINT" SHOULD RESULT.

RUMMAGING AROUND

with Keith Cadbury

WAR GAMES

FIFTEEN years ago your humble scribe was a documentary film cameraman, employed by various companies contracted to the Air Ministry to make films concerned with aspects of RAF procedure and modern warfare. The work was exciting and very, very interesting, but the very nature of film making gave the camera crew periods, sometimes quite lengthy, of inactivity.

One particular film was concerned with electronic warfare, and we were "on location" in an underground radar base, somewhere on the east coast of Britain. The camera was set ready to film a radar screen in a room just off the main operations centre.

While we waited for a Squadron Leader to come back from tea, or something, Cadbury (documentary's answer to Cecil B. de Mille) did not desert his camera. The various controls around the radar console were fun to play with, and there were no RAF personnel in the room to rap naughty fingers.

Scanning hundreds of miles across the North Sea, the screen displayed "blips" that represented all aircraft in the sector. A "joystick" control could be manœuvred, guiding a small circle across the screen. When an aircraft was thus encircled, a switch could be thrown and after a short pause, digital displays would inform height and distance of the selected aircraft.

INQUISITIVE CAMERAMAN

This electronic miracle (fifteen years ago, remember) was possible by way of the great computer, air-conditioned and temperamental, that occupied an area the size of a tennis court. An even greater aspect of the miracle was discovered by this inquisitive cameraman, as the Squadron Leader continued to stay absent, and new knobs and switches were found.

Under a hinged glass box was a large illuminated press-switch that bore the inscription "Identify." If this switch was depressed, the blip that was ringed could be identified as an aircraft that was friendly or presumably (although I never found one) as enemy.

Before the confirmation of the aeroplane's friendly intentions came through, another blip was seen to home-in on the selected blip. Presumably some other aspect of the device that I had not yet fathomed.

Over a period of about three-quarters of an hour, several aircraft blips were encircled and subsequently identified in this way. It was only after I got bored with playing with just one radar screen and thought of an interesting variation that things started to get out of hand.

I discovered that when a blip was being homed-in for identification, I could move to the next radar console and pick-out the "homing" blip, depress the appropriate controls, and another blip would be seen to enter the area also. The third console in the room seemed to be out of action, or I could have sent yet another blip scudding into the scene.

An officer with God knows how many rings round his sleeves came into the room and asked me to desist—"If you wouldn't mind, old chap, as there seems to be a bit of a flap on."

It turned out that every time I pressed the "Identify" button, I was "scrambling" a Lightning jet fighter to fly up and carry out the identification!

ON THE BLINK?

At first, the fighter stations concerned thought that all the sudden activity was merely an unannounced exercise, but when aircraft were being scrambled to "buzz" aircraft from the same base, doubts were voiced. Someone from Fighter Command had telephoned the radar station to enquire "If the computer thingy is on the blink again, what?"

The RAF "brass" never discovered, as far as I know, that the entire "flap" was my doing. I didn't find out how many thousands of pounds of the RAF's, or NATO's, or the taxpayers' money I used up that afternoon, but I consoled myself with the thought that it was jolly good practice, to keep the chaps on their toes, what?

BLOWN FUSE INDICATOR

I was recently approached by a friend who runs a sophisticated discotheque, incorporating many different circuits for a variety of purposes. Several high-power amplifiers, many different lighting effects and various other devices are banked behind the DJ's control desk, and the problem my friend had was that he needed an indication of when a fuse has blown.

With some of the combinations of sounds and lights, he had found it a long, laborious business to locate a couple of blown fuses. Perhaps some simple indication of the state of the fuses would be possible?

He had sketched out various electronic circuits that would do the job, but they all seemed to be quite complicated, and wondered if I knew of any simpler circuits. What I worked out appeared at first sight to be dangerous, but when we checked it against each and every one of his circuit diagrams, and then tried out, it has proved adequate, and I thus pass on the thought to you.

All the fuses were mains, so we simply put a neon indicator across each fuse, thus the neon remains "off" until the fuse blows. Once the fuse blows, the neon illuminates.

All the circuits I have considered would not be damaged by the neon, so long as the mains is switched-off before replacing the fuse, and it is borne in mind that the neon gives no indication as to *why* the fuse has blown. Electronics purists may well shudder at my solution to the problem, but then they would at other of my devices no doubt!

By Dave Barrington

Catalogues

A new computer products catalogue containing details of their products and specialist services offered to micro computer users has just been published by Transam Components.

Of special interest is their range of integrated circuits, memory devices and a complete range of p.c.b. and cable connectors suitable for microprocessor applications. They also offer a specialist EPROM programming service to customers and users of their own Triton Personal Computer.

Copies of the catalogue can be obtained from Transam Components Ltd., Dept EE, 12 Chapel St., London, NW1 5DH.

Just in time for their move to bigger premises comes news of the publication of Ambit International's Part Three Components Catalogue.

If you are looking for l.c.d. clock/timer modules, communications equipment, radio integrated circuits or radio control parts, there all to be found in this latest edition.

Also, the already extensive range of v.h.f. tunerheads stocked by Ambit has been extended with the introduction of the EF5804. This has been designed with synthesised control in mind and tunes over the f.m. Band II (88–108MHz) with only 2V to 8V bias.

Since the complete range of tunerheads are made in the UK by Ambit, they are able to offer a custom versions to special order.

Copies of the new Ambit International components catalogue are available from 200 North Service Road, Brentwood, Essex.

Wire and Wire Tidy

A new range of wire packs and a wire bin from OK Machine Co. will help to alleviate the frustration of trying to find suitable wire lengths and gauge when in the middle of a project.

The wire bin, wire-Tidy WB-16, consists of sixteen plastics tubes mounted in front and back end "cheeks". The front panel being numbered so that the user can easily compile an identification system for selecting suitable wires.

The wire storage tubes have adjustable depth stops to take wire lengths from 25mm to 350mm. Each wire bin can store up to 10,000 wires and can be grouped together to extend the storage capabilities.

Amongst the many wire packs and reels from OK are Kynar-insulated wire for wire-wrapping and various packs of general purpose wire with stripped ends.

For more information write to OK Machine & Tool (UK) Ltd., Dept EE, Dutton Lane, Eastleigh, Hants S05 4AA.

Storage Boxes

Although intended specially for printed circuit boards, the storage and handling boxes from Adcola Products make ideal storage cabinets for all the numerous forms of circuit boards usually found laying around the workshop.

Available in two sizes, 450 × 250 × 158mm and 450 × 250 × 82mm, the boxes are made from tough corrugated cardboard with plastics grooved liners. Similar in concept to slide-film holders, the dividers hold the boards apart one from the other and can be supplied in short and long lengths to enable several "compartments" to be made up.

The boxes are supplied with either a p.v.c. or corrugated self-stacking lid and cost approximately £5 each. Further particulars and stockists can be obtained from Adcola Products Ltd., Dept EE, Adcola House, Gauden Road, London, SW4 6LH.

Constructional Projects

The majority of components required to build this month's projects should be readily available from many sources. In the *Micro Music Box* the i.c. type TMS 1000N MP0027A is only available from Chromatronics, Coachworks House, River Way, Harlow, Essex. The cost is £4·95 inclusive of post and packing.

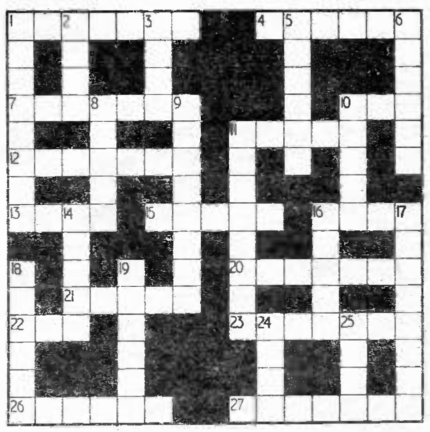
The *Morse Practice Oscillator* calls up a Morse key. These can be obtained from Watford Electronics, Maplin and Home Radio.

Coils and variable capacitors often cause supply problems for the constructor. Both are used in the *Short Wave Receiver*. The Denco coils can be obtained direct from the manufacturers Denco (Clacton) Ltd; 357/9 Old Road, Clacton-on-Sea, Essex (Tel: 22807). Jackson variable capacitors are specified and are listed in the catalogues of the three firms mentioned above.

The relay is the only component likely to cause concern in the *Tape/Slide Synchroniser*. The relay contacts should be rated to suit the projector being used. Constructors are advised to consult their handbook before ordering. The coil impedance specified should be regarded as the minimum value for the circuit. Higher values may be used that will operate from a 9V supply.

Suppliers for the more unusual components required for the *Radio Control* project are mentioned in the article.

EE CROSSWORD No 24 BY D. P. NEWTON



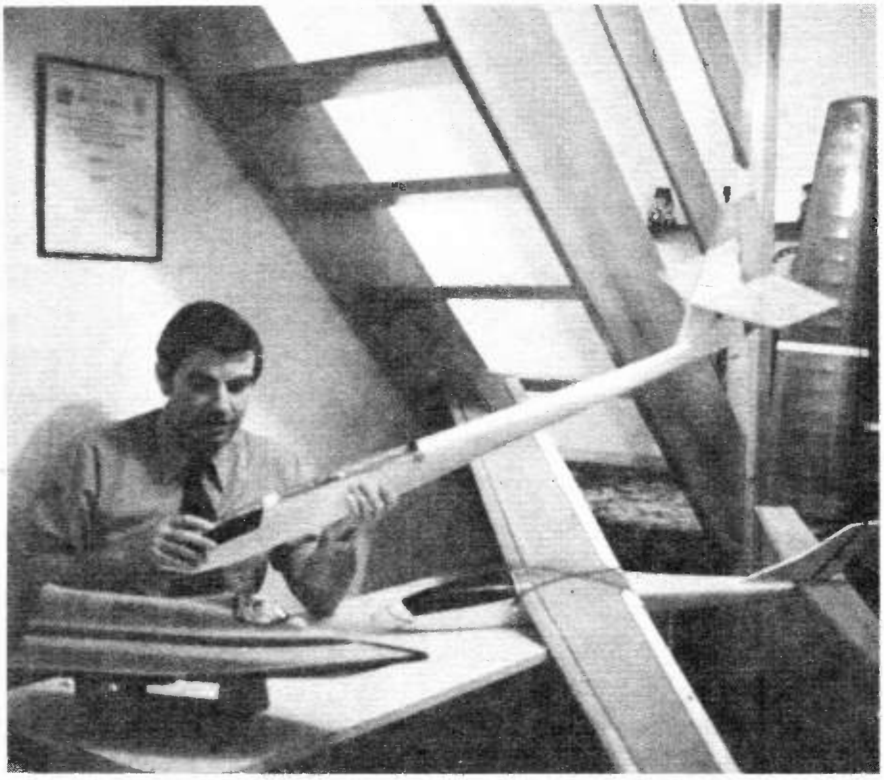
ACROSS

1 Comfort and control unit (7).
4 as forbidden meats (6).
7 Event concluding meeting with referee (4, 3).
10 Not so much a lag, more a droop (3).
11 The Mother of all at ground level (5).
12 Part of the alarm gives warm currents (7).
13 Commonly found in electrical backwaters (4).
15 Noise associated with pulse through loudspeaker (5).
16 Found at end of travel (4).
20 Rejection needed to keep things going in the home (7).
21 Electrical arena associated with the agrarian revolution (5).
22 Decays from rotor (3).
23 To oppose with a mathematical recording device (7).
26 Very short wave aerials but never need washing (6).
27 Mauve followed by two black rings (7).

DOWN

1 Small tape unit (8).
2 Rare gas gives us the red light (4).
3 Gold found on trees? (4).
5 Forceful verbal objection (6).
6 Pulsed in the power supply (6).
8 Unclean (5).
9 Working at the utmost capacity (4, 4).
10 Meter by-pass (5).
11 Operated by wired energy (8).
14 To wander as the electron (5).
16 Rejection from the addition to house wiring (5).
17 Antipodean electrical property (8).
18 Wiry London street (6).
19 Often found with 23 across, to replace both hands (6).
24 Singular occurrence (4).
25 Wafer-like (4).

Solution on page 137



By L. ARMSTRONG • H. DICKINSON • W. WILKINSON

PART FOUR

EE RADIO CONTROL SYSTEM

SERVO UNIT DESCRIPTION AND CONSTRUCTION

IN THE first part of this series we discussed and described how we make use of radio frequencies as a means of transmitting information from one place to another: in this case the movement of a stick into pulses of a width dependent upon that stick position. The final process in this system is that of converting the electrical signal back into some form of mechanical movement (servo) or into movement of an electric powered vehicle (speed controller).

This article provides full information on the servo. The proportional speed controller will be covered next month.

SERVO DESCRIPTION

The purpose of the servo is to convert the decoded electrical signal from the receiver back into a mechanical movement which corresponds to the stick position of that particular channel. A typical servo therefore consists of some form of amplifier to convert the input signal into a signal suitable to drive a motor.

This motor is connected to a gearbox to generate sufficient power to drive an output arm, which will be connected to some control function. Also connected to this output arm is the feedback device, usually a variable resistor, which is connected back to the amplifier. A schematic of this system is shown in Fig. 4.1.

I.C. AMPLIFIER

There are several amplifiers available on the market these days, all in the form of integrated circuits. Some of these are in small TO5 cans, others are in 12-pin d.i.l.s. However, the one chosen in this particular instance is the ZN419CE Precision Servo I.C. manufactured by Ferranti but also available as the SRC419P as marketed by Skyleader Radio Control Ltd. This device comes in a shortened 14-pin d.i.l. to enable it to fit into most mechanics available today.

The ZN419CE was chosen because of its good performance over other makes in terms of linearity and output drive. The output drive is attained by making use of two "on-chip" *npn* transistors and two external *pnp* transistors to form a bridge drive.

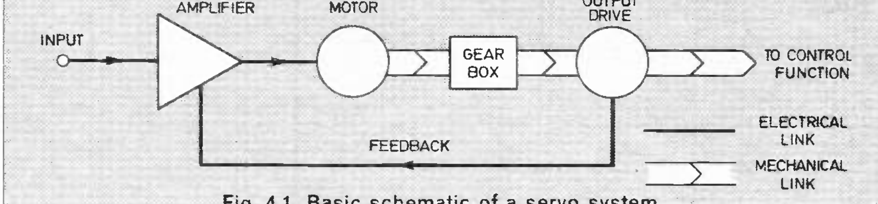


Fig. 4.1. Basic schematic of a servo system.

The use of external *pnps* gives far better saturation voltages and therefore more power under stall conditions than the equivalent i.c.s with the *pnps* "on-chip". The latter are always of a poorer quality due to the difficulty in fabricating them in most integrated circuit semiconductor processes.

FEEDBACK POTENTIAL DIVIDER

The ZN419CE also has the advantage of using the feedback pot in the potential divider mode, thus reducing the effect of pot noise to which the amplifiers using the pot as a variable resistor become prone.

SERVO CIRCUIT

The circuit diagram for the servo appears in Fig. 4.2.

The servo input from the receiver is in the form of a positive-going pulse which as explained in previous parts of this series, varies in width dependent upon the stick position.

The capacitor C1 is in the input circuit to avoid the servo "locking-up" should a permanent high level be presented to the servo from the receiver when going out of range of the transmitter; thus—in the case of aircraft—avoiding a disastrous crash.

The input signal is compared with a signal from the feedback potentiometer VR1 which produces an error signal related to the difference in position of the output arm and position of the stick on the transmitter. This error signal is then expanded to form a pulse to drive the motor in the required direction.

Depending upon the size of the error the amplifier will in turn provide an appropriate size of drive signal; that is if there is a large error the signal to the motor will be 100 per cent drive, if however, the error is small then the drive is reduced accordingly down to 20 per cent drive.

ERROR AND DRIVE RELATIONSHIP

Fig. 4.3 shows the relationship between error and output drive. As can be seen, above a certain error there will always be 100 per cent drive to set the servo arm to its approximate position as quickly as possible, then, as that position is approached, the drive will smoothly drop off. The quick drop off from 20 per cent is there so that the servo is given one last "kick" into its final position, therefore avoiding "creeping" with the servo buzzing and taking unnecessary supply current.

DEADBAND

The amount of error that is required before drive is given is called the "deadband" and is set by the capacitor C3. The value is chosen such that the servo will respond to very small stick movements but not so small that the servo is responding to jitter in the input pulse. The other components in that network R1 and C4 are the pulse expansion components and determine the point at which 100 per cent drive is reached.

The resistor R2 and capacitor C5 are the timing components and are chosen for a pulse input of 1·5 millisecond centre. R3 in turn sets the overall throw of the servo arm.

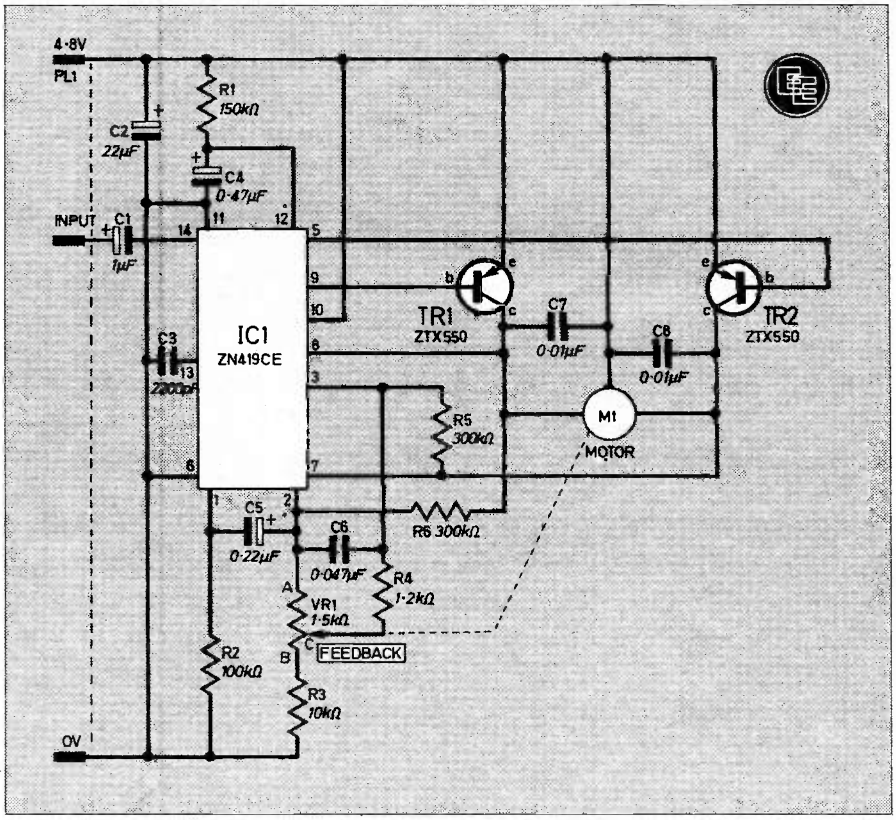


Fig. 4.2. Circuit of the EE Radio Control System Servo Unit.

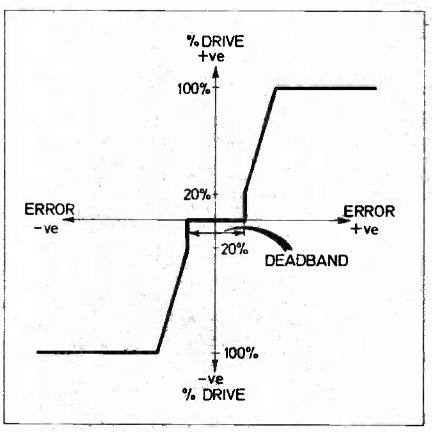


Fig. 4.3. Servo error and output drive relationship.

EE RADIO CONTROL SYSTEM

COST TO BUILD

Approximate cost for different-sized systems.

Two-channel version	*£75*
Four-channel version	*£110*
Seven-channel version	*£170*

The cost for each version includes all units specified in Part 1.

The EE Radio Control System is fully capable of expansion from two-channels to seven-channels at anytime, simply by fitting additional sticks and servos.

DECOUPLING CAPACITORS

The capacitors C2, C6, C7 and C8 are purely decoupling components. C2 is across the supply, C5 is to stop r.f. affecting the servo operation when one is stood over a model with the aerial fully extended; C7 and C8 are to stop motor noise being radiated.

EE RADIO CONTROL SERVO

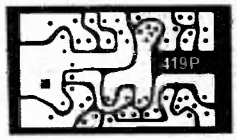


Fig. 4.4. Printed circuit board for the EE Radio Control System Servo Unit, actual size.

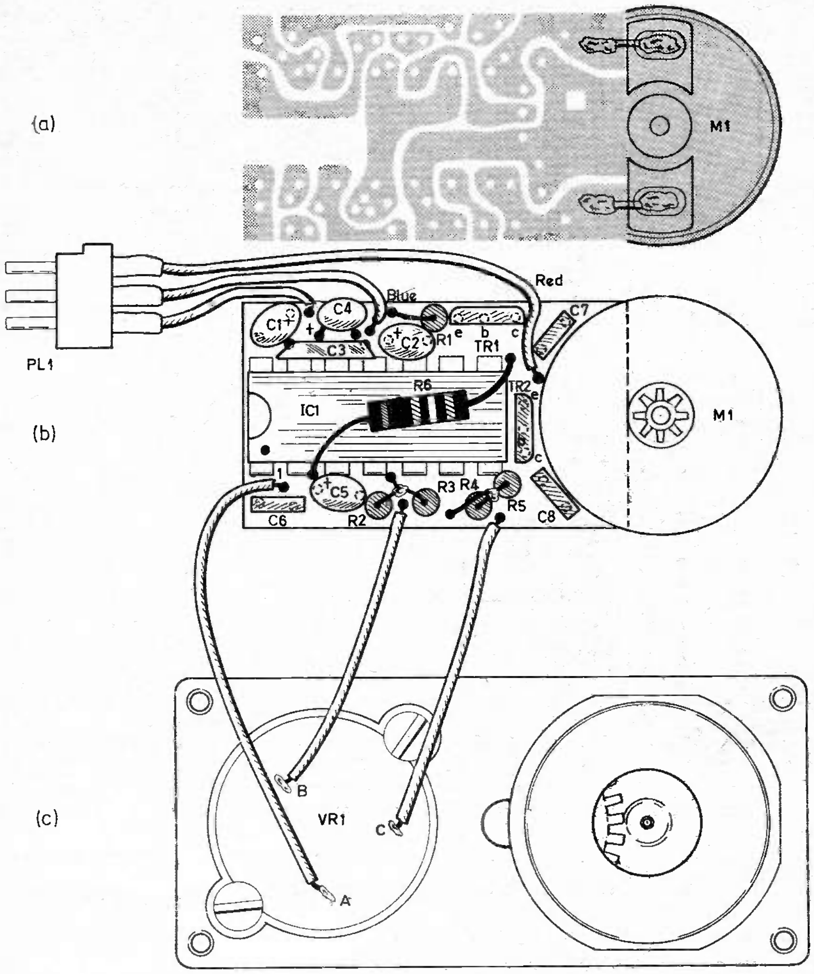


Fig. 4.5. The completed Servo unit (a) Underside view of p.c.b. showing how this is secured to the motor M1 by means of two soldered link wires. (b) Top view of p.c.b. (twice actual size) with all components in situ, and showing external wiring. (c) Underside of servo mechanics showing connections to the feedback pot VR1.

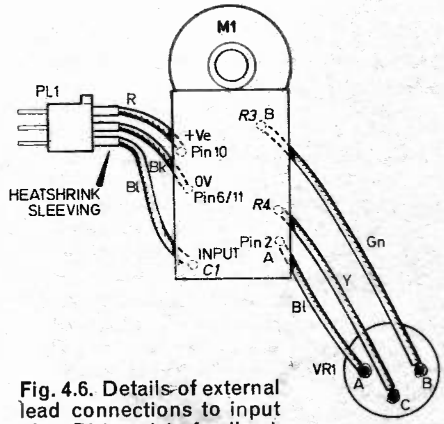
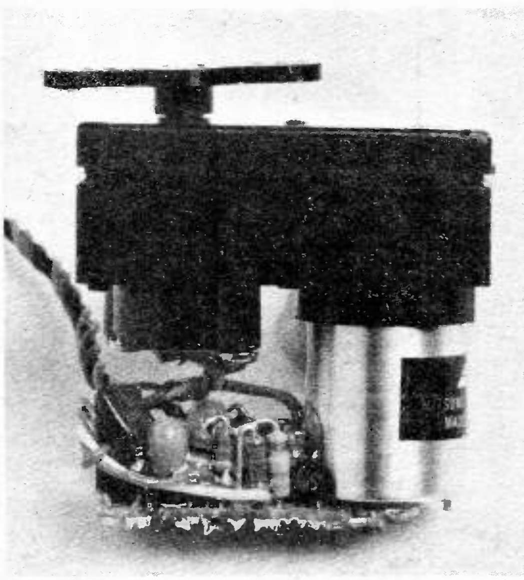
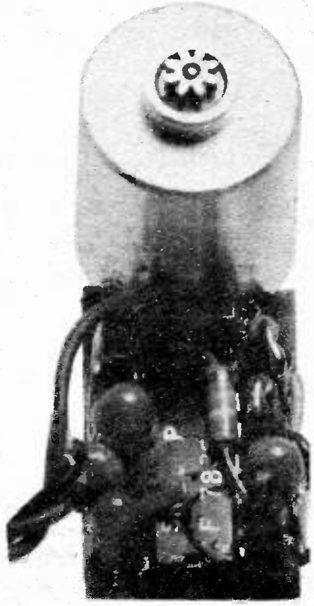


Fig. 4.6. Details of external lead connections to input plug PL1 and to feedback pot VR1.





Side and plan views of the servo unit.

COMPONENTS

SERVO

Resistors

- R1 150kΩ
- R2 100kΩ
- R3 10kΩ
- R4 1·2kΩ
- R5 300kΩ
- R6 300kΩ
- All $\frac{1}{8}$W carbon ± 5%
- VR1 1·5kΩ plastic film potentiometer*

Capacitors

- C1 1μF tantalum bead 10V
- C2 22μF tantalum bead 6·3V
- C3 2,200pF ceramic
- C4 0·47μF tantalum bead 10V
- C5 0·22μF tantalum bead 35V
- C6 0·047μF ceramic disc
- C7 0·01μF ceramic
- C8 0·01μF ceramic

Semiconductors

- TR1,2 ZTX550 or ZTX750 (Ferranti) (2 off)
- IC1 ZN419CE or SRC419P

Miscellaneous

- M1 Motor, 11Ω*
- PL1 3-pin plug (SLM)
- Printed circuit board. Wire for leads. Heat shrinkable, plastic sleeving.

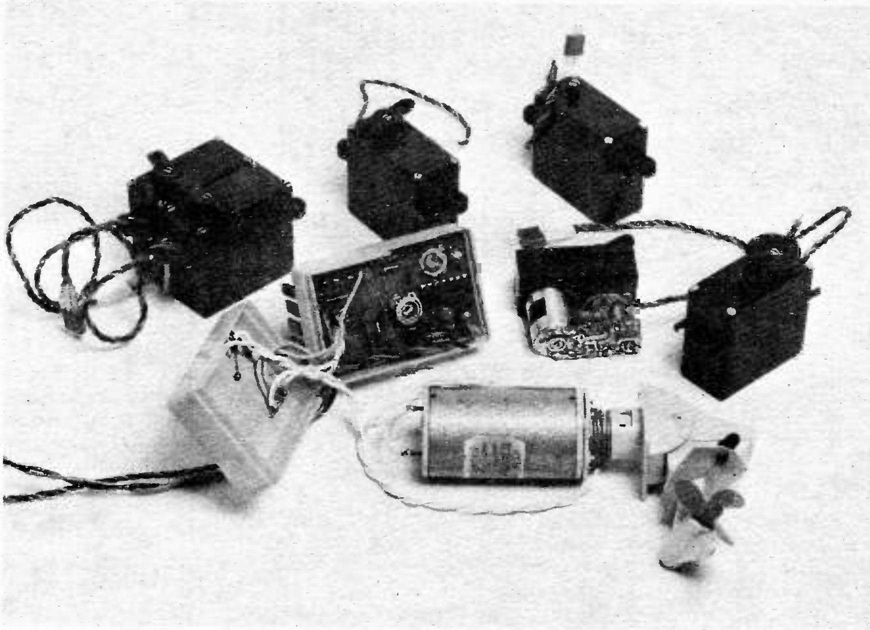
*Part of Servo mechanism, type FB1 or FB2, available SLM Model Engineers.

FEEDBACK RESISTORS

The resistors R5 and R6 are the feedback resistors which stop any tendency of the servo to overshoot its final position. The values of 300kilohm are chosen for servo mechanics which are fairly fast in the movement where overshoot tendencies are highest, whereas if the user intends to use a slow servo (such as a SLM FB3) then this value can be raised to 360kilohm or even 390kilohm.

The variable feedback pot VR1 is of 1·5kilohm in value and is usually supplied as a plastic film pot with the servo mechanics. The 11ohm motor M1 also comes with the mechanics.

It is strongly recommended that the transistors TR1 and TR2 are of the ZTX550 type as these have an exceptionally low saturation voltage thus enabling more power to be transmitted to the motor.



A group of five typical servo units, and (centre) the proportional speed controller and drive motor with propeller/rudder attachment.

CONSTRUCTION starts here

The servo electronics are assembled on a small p.c.b. and this is finally attached to the servo motor.

The motor and the feedback pot are integral parts of the servo mechanism unit.

If you thought the soldering for the transmitter and receiver was tricky then you may have difficulty with the servo amp. However, the building of these units should have given you enough practice and confidence to attempt the servo amp and produce a working and reliable servo.

The p.c.b. pattern is given in Fig. 4.4 and the component layout in Fig. 4.5. The smallness of this board and the close packing of the components on its upper (plain) side demand a high order of skill and dexterity on the part of the constructor. **This is obviously NOT a task to be undertaken by the inexperienced.**

ASSEMBLY OF COMPONENTS

Assembly on the p.c.b. should start with the mounting of IC1, followed by the two components C3 and R6 which sit on top of it.

The resistors R2 and R4 are fitted next, before the resistors R3 and R5 which require to be fitted in by soldering to the top lead of the former, respectively, as in Fig 4.5(b).

In all cases where a wire is to be soldered into the same "land" on the p.c.b. as a component lead it is best to leave the soldering of the component until you are ready to fit the wire in then solder in both at once.

The remaining components can be fitted in in any order.

WARNING: When you purchase a ZN419CE you may get an old type in the full length package. On these packages it is possible for a small bit of metal to protrude from the pin 7, 8 end of the package and short to the base of TR2, so you may have to insulate accordingly. On the shortened package this is not possible as the metal is ground down flush with the plastic, also there is plenty of clearance with the pack and TR2.

EXTERNAL LEADS

To connect to the feedback pot VR1 you will require three lengths of thin insulated wire (the R.S. "miniature" wire is suitable). Lengths of 2 inches should be sufficient. For the input leads, 6 inch lengths of the same wire will be required. The input leads will require to be twisted together for neatness and connected to the plug as was done with the transmitter pot leads and the receiver output leads. See Fig. 4·5 and Fig. 4·6.

FITTING TO MOTOR

The amplifier is finally secured to the motor by the two tinned copper wire leads and the motor case tag. Again, cut-off resistor leads are suitable as the links. Fig. 4.5 shows the connections to be made to the amplifier.

The input leads will require to have a suitable plug attached, which in the case of a new constructor is the 3-pin SLM plug as mentioned in the receiver section (Part 3). Fig. 4.5 shows the connections to it. Three $\frac{1}{4}$ inch lengths of heat shrink sleeving will be required over the connector soldered joints, and for the pot joints.

TESTING

The completed servo should be thoroughly checked for any shorts between tracks—which on this p.c.b. are particularly close. If in doubt check with the p.c.b. artwork.

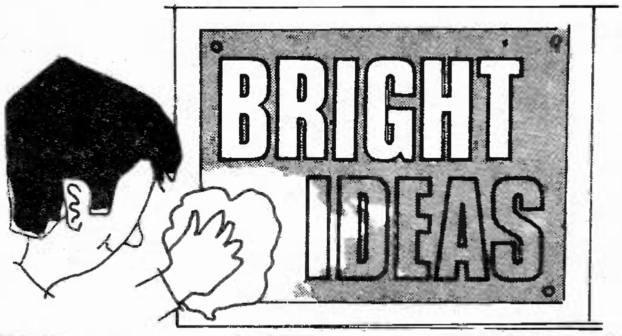
Providing that everything is connected the correct way round there is little else that can be wrong so connect to the receiver and switch on both the transmitter (first) and then the receiver. The servo should rotate to some position, and then follow the relevant stick on the transmitter.

If the servo continuously rotates or hunts around a certain position then the likely fault is that pot connections require to be reversed. This is done by removing from the pot the two end connections *A* and *B* on Fig. 4.5 and swopping them around. Reconnect the servo and switch on again and the servo should now follow the stick correctly.

Should problems still be present, recheck everything especially the transmitter and receiver if this is first time they have been tried with a servo.

A comprehensive fault finding chart will be given at the end of this series.

Next Month: Proportional speed controller.



BRIGHT IDEAS

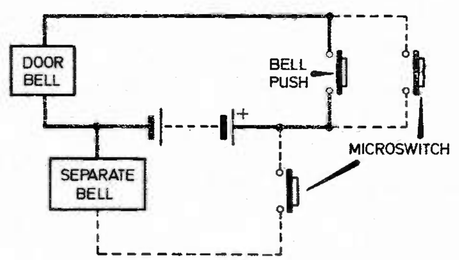
Readers' Bright Ideas; any idea that is published will be awarded payment according to its merit. The ideas have not been proved by us.

LETTER BELL

Nearly all houses have doorbells for visitors to attract our attention. The same idea could be used on a letter box. It would tell us when the post arrived.

A microswitch fixed on the letter box could be in parallel with the doorbell switch as shown. If a separate alarm is wanted the circuit could still run off the same batteries as shown below.

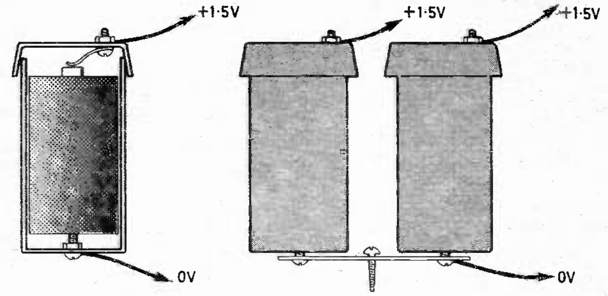
Robin Hudson,
Bracknell, Berks.



BATTERY HOLDER

If a circuit requires a 1·5V supply, an effective holder can be made from a vitamin tablets container normally available to expectant and nursing mothers from clinics.

The container is made of plastic with a snap-fit lid, which produces a leak-proof holder. The centres of the lid and base are drilled and a bent-over solder tag bolted to the inside of the lid (orange/red conveniently to indicate positive terminal) and a pointed screw through the base. When the lid is clicked into position, a good connection is made. The holders can then be fixed with confidence inside a small project box, alongside the circuit board.



K Croft,
Broadstairs, Kent.

SIGNAL TRACER

I have evolved a simple method of tracing audio signals in a circuit. A crystal earpiece is used, but the plastic jack plug is replaced with a 3·5mm metal barrelled jack plug.

Whilst holding the metal barrel, the tip of the jack plug is touched against the various audio points in the circuit and a signal should be heard in the earpiece.

One point to notice is that apparently a complete circuit is not made; but this is not usually necessary due to stray capacitance.

Kevin Hadfield (aged 15),
Clifton, Nottingham.

NOVEL CASES

I have found that by looking around the most unlikely objects can make novel and interesting cases.

A tape cassette box is ideal for "mini" projects if some sort of clip is used to hold the sides together. A plastic lunch box of the type which has two sections the same size makes a very professional looking case.

Holes for potentiometers, switches etc, can be made with twist drills. The cases can, of course, be painted if desired.

J. Murphy (aged 15),
Waterfall, Ireland.

PLEASE TAKE NOTE

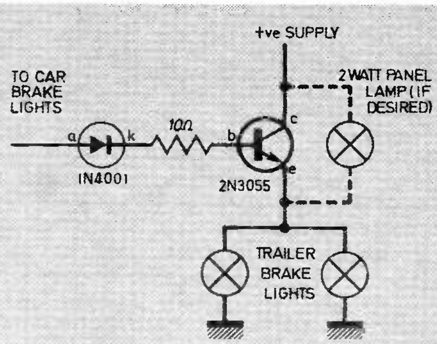
Twinkling Star—December 1979

A discrepancy exists between the value of C1 in the circuit diagram and the components list. Either value can be used. A 2200μF was used in the prototype.

Trailer Flasher Unit—August 1979

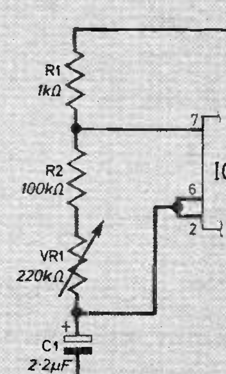
An important factor regarding the extension of the brake lights has recently been brought to our attention.

The Lucas hydraulics—pressure brake—light switch fitted to some cars cannot be used to additionally power the trailer lights as simply as was suggested, since the switch was designed to handle only 50 watts. Exceeding this rating could cause rupture of the diaphragm in the switch, resulting in a loss of brake fluid. For cars fitted with such a switch a "third channel" is required as shown above.



Xmas Bright Ideas—December 1979

In the Santa's Eyes circuit, Fig. 1 page 782, resistor **R2** has been misplaced. The circuit diagram should be amended as shown below.



Everyday News

POST OFFICE VIEWDATA GETS TOP AWARD

Britain's premier engineering award, The MacRobert Award, has been won, this year, by a consultant engineer, Mr. Sam Fedida, and Post Office Telecommunications for the invention and development of the Prestel viewdata software system.

HRH The Duke of Edinburgh, Founder President of the Council of Engineering Institutions, made the presentation of the MacRobert Medal and £25,000 to Mr. Fedida for the invention of the viewdata concept and the MacRobert Gold Medal to Mr. Peter Benton, Managing Director of Post Office Telecommunications, at Buckingham Palace.

The MacRobert Award, made annually by the Council of Engineering Institutions on behalf of the MacRobert Trustees, is presented in recognition of an outstanding contribution to innovation in engineering and physical technologies, or in the application of physical sciences, which has enhanced the prestige and prosperity of the United Kingdom. The rules allow the prize to be made to a team of no more than five people or to an individual.

The concept of viewdata was invented by Mr Fedida whilst working at the Post Office Research Establishment, Dollis Hill, in the 1960s. Prestel is the Post Office's electronic information service which combines a modified TV, telephone line and computer and is claimed to put Britain years ahead in the mass marketing of electronic information.

The Post Office launched Prestel last year as the first public viewdata service in the world. A push-button, remote-control panel calls up a "page" of the information required by a subscriber on to a television screen using a telephone line link routed into a computer data bank.

There are currently 1,750 Prestel sets linked to the system and some quarter of a million "pages" of information in the storage bank provided by 800 British and international organisations. The growth potential of Prestel is such that it will eventually be within the grasp of every telephone user in the country.

The service, now centred in London, will be extended to other centres during the year. Prestel is a joint project in which the Post Office has co-operated with the country's electronics industries and information providers.

The Post Office has already sold Prestel technology to telecommunications authorities in West Germany, Holland, Switzerland, Hong Kong and the USA.

Swiss Time Olympics

This year's Olympic Games in Moscow will be officially timed throughout by Swiss electronic equipment.

This prestige appointment reinstates Switzerland as world leaders in time-keeping and in their traditional role in the Olympics. The Japanese took over only when the Games were staged in Japan.

TRIP OF A LIFETIME

A week in Japan with all expenses paid is the first prize to be announced for the "Young Engineer for Britain 1980" competition.

The award, a new one sponsored by "The Engineer", will be made for the best individual electronics project. The trip will enable the winner to see some of the many electronics applications in Japan. An alternative to the trip is £500 in cash.

Honour for CPU Work

One of the United States' most coveted awards for scientific and technical achievements, The Franklin Institute "Stuart Balantine Medal", has been won by Dr Marcian E. (Ted) Hoff, of the Intel Corporation, for his development of the Microprocessor.

In addition to his work on digital microprocessors he contributed to the development of the first high-density memory devices for both mainframe computers and microcomputers and more recently the first analogue microprocessor.

In 1969 he proposed the microprocessor architecture, the first microprocessor, leading to the production of Intel 4004, in 1971.

CB Hit By Cuts

On Monday night 26 November, Mr. Timothy Raison Minister of State Home Office told the all Party Committee on CB that a good deal of work had been done in examining the possibility of introducing a CB Service in the United Kingdom, but it was too early for any firm decision to be reached.

Mr. Raison told the Committee that there was no question of having a CB Service on 27MHz; the main problem was that of providing staff to undertake regulatory duties on alternative frequencies at a time when the Government was committed to reducing the size of the Civil Service.

An electronic device which emits a loud tone if a "this-way-up" packing crate departs substantially from its correct upright position has been designed by Auto-systems Development, Huddersfield.

Called Topsy-Turvy, it should help protect fragile products or delicate scientific equipment from careless handling while in transit.

ANALYSIS

SURVIVING WITH LSI

Large scale integration (l.s.i.), has been overshadowed in the headlines by more pressing problems of the Ayattolah, the energy crisis and the continuing debate on the economy. L.S.I. and its consequences have not, however, gone away, nor has the debate.

Let's take the simple everyday example of the wristwatch, once universally regarded as the highest level of precision engineering and a miracle of mechanical ingenuity and craftsmanship. Today's digital watch of chronometer accuracy has only five components or assemblies; the display, the l.s.i. chip, the quartz crystal, the case and the battery. It can be assembled by anyone with nimble fingers without years of apprenticeship and experience in the watchmaker's art.

The threat is that all old-style watchmakers are to lose their jobs, as many clearly have. The promise is that everyone is now able to afford a wristwatch of chronometer accuracy. In its cheaper forms it is already a throw-away item, not worth the cost of repairing, and so it can be argued that even the watch repairer will suffer damage to, if not the complete destruction, of his traditional business.

This, and other examples feature in a report issued by the European Trade Union Institute which was discussed in Oslo last December. For instance in a well-known make of sewing machine 350 mechanical parts are replaced by one MPU. A new German telex terminal goes even better with the MPU throwing out 936 mechanical parts. The electronic office is also prominent with Bradford Council quoted as an example where the typing staff has been reduced from 39 people to 19 for the same volume of work.

Wherever we look we find electronics making work easier and cutting costs. L.S.I., by slashing assembly costs compared with that of discrete solid state, let alone the older valved sets, has more than stabilised the cost of colour TV sets. They are much cheaper relative to income as well as of better quality and more reliable than they were in 1970. In fact electronics is the only commodity which gets cheaper every year.

Naturally trade union leaders are concerned that their members' employment is under threat in a great number of occupations. But they only too easily forget that while many traditional skills are being phased out new skills are needed for the new technology. Put a stop to electronic data processing and whole armies of equipment and component assemblers as well as programmers would finish up in social security queues.

My own view is that, on balance, electronics has proved beneficial rather than harmful. And that we shall all adapt to changing circumstances as mankind has always done in the past. Imagine the screams of protest from stage-coach drivers when the railways came. Not all that different, one imagines, from postal workers today confronted with the prospect of electronic mail.

Brian G. Peck.

Heath Carries On

The supplier of the popular Heathkit home construction electronic kits Heath (Gloucester) Ltd, has changed its name to Heath Electronics (UK) Ltd. This follows the sale by former parent company Schlumberger to Zenith Radio Corp.

All electronic kits will still be sold under the Heathkit brand name. MPUs and peripherals are to be marketed as Zenith Data Systems and education courses as Heath Education Products.

When the activities of the British Post Office are separated by Act of Parliament into two separate businesses the new name for the telephone business will be British Telecommunications.

Teletext

A low-cost system for adding Ceefax, Oracle and Prestel services to TV sets has been developed by General Instrument Microelectronics.

It uses only three MOS-LSI chips and a few peripheral components and can be built on a PCB only 15×10cm. The chips will be made available to TV set manufacturers.

NEW TECHNOLOGY IN INDUSTRY

A report entitled "Impact of Microprocessors on British Industry" published recently by the NCC states that Britain has no choice but to go forward with micro-electronics technology or "go out of business". The significance of this particular publication lies in the fact that it represents a concensus of opinion between several disparate groups—management, trade unions, academics, etc, and its importance was summed up at a recent press conference by the author Francis Kinsman when he said, "We must manage a change and not let it manage us".

On a more sinister note when asked whether a "Clockwork Orange" situation of disaffected youth running amok amongst society could develop, it was said that there was always such a danger if the new technology was mishandled and educational possibilities were not taken up although the microprocessor should not be made a scapegoat for societies ills.

In effect most aspects of the applications of micro-technology to industry are covered in the report which can be obtained from the National Computing Centre, Oxford Road, Manchester, at a cost of £5·50.

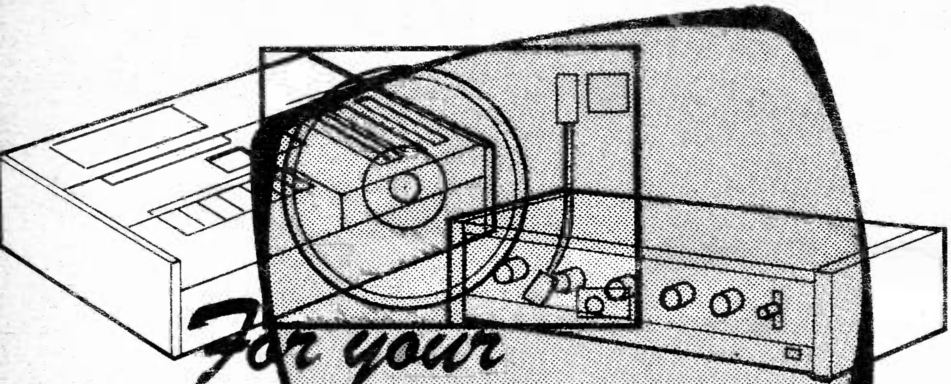
BREADBOARD '79
SECOND SUCCESSFUL YEAR

Over 11,000 electronics enthusiasts and dealers from all over the UK flocked to Breadboard '79 during its successful five-day run at the Royal Horticultural Halls, London, last December.

A capacity crowd on the last day necessitated the closing of the show for part of the morning in order that numbers could be controlled.

"*Breadboard '79 has now firmly established itself as the major public exhibition for the home electronics enthusiast*" say the organisers Trident International Exhibitions Ltd. A statement firmly endorsed by the delighted exhibitors.

The Everyday Electronics stand at Breadboard '79



For your ENTERTAINMENT

By ADRIAN HOPE

Call for Freedom

Everybody loves to hate the British Post Office. On the whole they do a pretty good job, but like all government backed monopolies, can be infuriatingly insular.

Currently, until the new laws regarding telephones take effect, the Post Office monopoly on telephones is still total. But in the USA the phone company's monopoly now stops at the telephone users front door. Here's how it's happened.

Up to five years ago any USA sub-subscriber who wanted to use his own telephone or telephone gadget had to pay the phone company for the installation of a "protective device" to isolate it from the telephone system. He then had to cough up a monthly rental of between 2 and 4 dollars.

Nationwide cries of extortion, finally prompted the Federal Communications Commission (the FCC is equivalent to the British Post Office and Home Office rolled into one) to rule in 1975 that subscribers needn't use a phone company protector as long as the equipment used was registered. Then in the Winter of 1977, after two years of court battles, the US Supreme Court completely broke the phone company's monopoly. The Court ruled that private equipment could be hooked up to the telephone system provided it was compatible with the network and of a make approved by the FCC.

With this ruling a market for 125 million home telephones was created overnight and sales have quadrupled every year since then. In the USA phones are now big business. They are sold already fitted with a tiny plug that fits into a wall jack socket. In theory the phone company should install this socket, but in practice it is often installed by the user or an independent contractor.

Choice of Equipment

You can now buy an extraordinary range of plug-in telephone gadgetry in the USA. Push button telephones are all the rage and many of these have memory circuits which enable the sub-subscriber to call the same number over and over again without re-keying it.

On some telephones this "last number recall" is commanded by the push of a button. But on more exotic phones a number can be automatically recalled over and over again, until connection is made.

This can be very useful if you are trying to dial overseas or long distance over lines that are continually "engaged, please try again later." It could also be useful if you are dialling a telephone that is in heavy use and thus often engaged.

There is gadgetry to divert calls automatically from one telephone number to another, there is gadgetry to patch in several phones at one and the same time and there are memory and calculator phones on which you can do sums, and in which you can store dozens of numbers for auto-dialling at the push of a button.

Voice analysers are available and these are supposed to detect stress in the speech of a caller. There are countless answering and message machines based on simple tape recorders.

One Californian hospital had a cardiograph permanently hooked to a telephone line so that patients can call in to the hospital, feed the sound of their heart beat down the line and receive instant diagnosis of any problems.

Because CB radio is legal in the USA there are now any number of cordless telephones which rely on a radio link. A mains powered CB transceiver base station is hooked up instead of the phone and this links with a hand set with a built in battery powered transceiver which the user can carry around the house or into the garden. Calls can be made or received from anywhere within a hundred yards of the base station.

Exotic Memory

Until recently the British Post Office showed little or no interest in telephone gadgetry, other than to remind subscribers that they were forbidden to use anything other than authorized and rented PO equipment on PO lines. But you can now buy exotic phone gadgetry in England, mainly thanks to enterprising importers who bring it in from abroad. Also many people holidaying overseas now bring a telephone or two home with them. The Post Office has countered by offering British subscribers more variety.

In theory at least, British subscribers in some parts of the country can now rent a push button memory telephone from the Post Office. But it's not cheap, connection charge is £5·00 and rental is an *extra* £7·00 a quarter plus VAT, which makes it almost twice as expensive as an ordinary telephone.

As memory recall phones of this type are on open outright sale in the USA for £50 upwards, and on open sale in some British shops for around twice that figure, it's hardly surprising that more and more British subscribers are crossing their fingers and buying their own phones for unauthorised installation. What's more although authorised memory, phones are advertised as available from the Post Office, in practice they seem to be in pretty short supply.

Installation Problems

Anyone tempted by the idea of unauthorised installation of an exotic phone should bear a few technical and legal facts in mind.

In the USA there are two quite different types of telephone. One, the so-called MF type, switches a matrix of passive components across the line as you dial or key in the number.

This produces a series of different musical tones which the exchange equipment recognizes as a dialling instruction. The advantage of this type of phone is that it can be made and sold very cheaply, because very little circuitry need be incorporated in the user's equipment.

In the distant future the UK system will be capable of handling MF telephones, but so far it isn't. So anyone travelling abroad and bringing back an MF telephone to the UK will find it utterly useless.

The other type of phone generates a stream of pulses either from a dial or keyboard. All UK exchanges use the pulse system but a pulse phone bought abroad may or may not work in the UK. It all depends on the rate of the pulses. If they are too rapid the British telephone exchange will simply ignore them.

Contrary to public opinion, it is not *illegal* to connect an unauthorised phone in the UK. You won't be arrested and charged if you are caught. But, perhaps more important, the Post Office can cut off your line.

When you apply to the Post Office for a telephone line you sign an agreement not to connect "anything not provided by the Post Office". The Post Office Telecommunications Scheme, which legally reinforces the Post Office monopoly, makes it quite clear that anyone with an unauthorised attachment can be asked to disconnect it. If they refuse the Post Office is entitled simply to disconnect their phone line at the exchange.

The Best

The British phone system is one of the best in the world and growing by more than a million more customers each year. It risks being degraded if subscribers hang unauthorised gadgetry on the line, often introducing faults through their ignorance of subtleties such as ringer resistance and the need to wire multi-phone installations in a series-parallel combination.

Moreover the amateur connection of mains powered gadgetry risks feeding potentially lethal voltages onto the lines. If a wide range of approved gadgetry were readily available for outright purchase at reasonable price, there would be a positive disincentive for subscribers to act irresponsibly.

RADIO WORLD

By Pat Hawker, G3VA

WARC—Uneasy Outcome

Those who have been closely involved with the recent World Administrative Radio Conference in Geneva seem agreed that by no stretch of the imagination can it be said that the ten or so weeks spent solidly talking about the division of the radio spectrum among its many users have produced a significantly mored orderly or more workable International Table of Frequency Allocations. The highest praise seems to be that conceivably (and at one time likely) the outcome could have been worse.

It has been suggested to me that only two groups of spectrum users have any cause to be moderately pleased with the results: the radio astronomers (who need protected bands primarily for reception only); and the radio amateurs who at least succeeded in their quest for three completely new (although very narrow) h.f. bands: 10·100 to 10·150MHz (29·6 metres); 18·068 to 18·168MHz (16·5 metres); and 24·890 to 24·990MHz (12 metres).

However, even the amateurs are not jumping for joy. The main worry is that it is very difficult at this stage to assess just what effect the many new "footnotes" and "resolutions" will have on existing and future services: very few frequencies are likely to be available on a world-wide "exclusive" basis and much depends on the extent to which the various reservations and footnotes are actually used.

Amateur enthusiasts should have every reason to be grateful for the work of their national and international organisations, particularly the Radio Society of Great Britain and the International Amateur Radio Union. British amateurs seem unlikely to lose any of their existing frequencies although many of these have to be shared with other services.

Broadcasting

Broadcasters and short-wave listeners concerned with international services have gained a good deal less than they originally hoped. It became clear that many of the developing countries still regard point-to-point h.f. communications as more important than broadcasting and are not yet ready to agree to transfer services to space satellites; yet at the same time these countries wish to ensure that when they are ready to use satellite systems there will still be geostationary orbital positions available for them.

For U.K. domestic listeners the most important result would seem to be that the Band II v.h.f./f.m. broadcasting band will eventually extend up to 108MHz rather than 100MHz. It should be noted that it is by no means certain that all of the 100 to 108MHz sector will necessarily be available to broadcasters in the United Kingdom, even after 1995. Nevertheless, it seems likely that some extra Band II frequencies will be available here within a few years.

A new footnote makes provision for traffic information services such as Carfax at the low-frequency end of the medium wave band. And again, a footnote will facilitate the use of mobile (transportable) earth stations to allow space satellites to be used for relaying news and sports events on television, as pioneered during the past year or so by the IBA.

Much more doubtful is the future of direct-satellite sound broadcasting in a band somewhere about 1GHz and 2·5GHz; although a number of countries urged that such a facility should be reflected in the frequency table, there was an argument about which band would be technically most suitable. In the end the decision was deferred, coupled with a resolution that experimental work should be undertaken. Indeed, many questions relating to broadcasting have been deferred to a whole series of planning conferences due to be held over the next few years.

Meanwhile it looks as though we shall be burdened with a rather tattered International Table with something approaching three times the number of "footnotes" (virtually agreements to disagree) than before, plus a large number of "resolutions" that may or may not be taken up by national administrations. For most spectrum users the decisive power governing what they can and cannot do will rest firmly with their own national administrations. Just as a British "Citizen's Band" appears once again to have been shelved for an indefinite period, so must all radio spectrum users depend on what the Home Office Radio Regulatory Department ordains.

Radio and the Fastnet tragedy

Recently the "Observer Magazine" commenting on the tragedy that overtook the 1979 Fastnet yacht race questioned whether it should be mandatory for all yachts in such events to carry two-way radio equipment. At present the rules of the Royal Ocean Racing Club require only the yachts must carry a radio receiver capable of picking up weather forecasts. If all boats had carried radio communications equipment "panicking crews on small boats could have been advised and reassured".

Certainly the need for effective communications in such circumstances may seem an obvious and necessary precaution. But there is a counter argument put forward by the Observer's writers that if all the yachts in trouble had been equipped for VHF Channel 16 (the marine emergency channel for v.h.d. radiotelephones) "nobody would have been able to pick up anything... old hands were complaining about very irregular radio procedure and such a density of traffic that it was difficult to make out just what was going on. If boats in the Fastnet are going to be required to carry a two-way radio then it will also be necessary to demand proof that somebody on board is trained to operate it."

The fact that equipment is only part of any successful communications link and that the human operator still occupies a key role is something, I feel, that too often gets overlooked in these days of "intelligent" hardware. Perhaps part of the trouble is the way that in films and television plays, the users of two-way radios never seem to have any troubles.

All the actors seem to know exactly how to use their equipment and to pass messages clearly and without ambiguity. None of those confusing "send three-and-four-pence we're going to a dance" messages that turn out to be "send reinforcements we are going to advance" —or the tangles that can take place when there are a number of unskilled operators all trying to use the same channel.

Although the classic Tony Hancock disc "The Radio Ham" tends to be resented by some amateurs as totally unfair to the hobby, his hapless attempts to deal with the "Mayday" message from the sinking yacht "Billet Doux" 300 miles off the African coast is not only extremely funny but contains more than a hint of all the things that can in real life go wrong with emergency radio communications: broken pencils, radio interference, complaining neighbours, the electric meter running out, the mix up between latitude and longitude and the valves that go *phut* at the critical moment.

Although it would be an unfortunate sailor whose distress messages were subject to all these mishaps at the same time, not even the most skilled operators could claim that things never go awry.

The Cocktail Party Effect

One scientist who fully recognised the importance of the human being as an element of a communications system was Professor Colin Cherry of Imperial College, London whose death was reported recently.

It was Professor Cherry who first raised public interest in the curious "Cocktail Party effect". He showed that in a crowded room, with a number of people split into small groups and with each group talking simultaneously, it is usually still possible for a listener to concentrate on, and follow, the words being spoken in his particular group, even under conditions of such poor signal-to-noise ratio that one would expect the messages to become unintelligible.

This effect depends upon the very complex and still imperfectly understood directional characteristics of the auditory system and the ear/brain interface. It is these mechanisms that have been so successfully exploited in stereophonic sound systems and other sound processing techniques.

For instance, a few years ago it was my privilege to describe for the first time in print, how F. J. Charman, G6CJ had proved by deliberately simulating the "Cocktail Party" effect on incoming speech and Morse radio signals, by introducing an electronic delay line on part of the signal, it is possible to make intelligible signals that would otherwise be lost in the background noise.

micro MUSIC BOX

By R. D. Palmer B.Sc.

IN THIS article we show you how to make a replacement for the traditional musical box mechanism using the Chromatronics TMS 1000N MP 0027A musical microcomputer chip. This musical box is able to automatically sequence the tune each time it is played. Out of a total repertoire of 24 tunes it plays eight tunes in rotation. Alternative banks of eight tunes are selected by means of a three-way selector switch or link.

TUNE GENERATION

In a traditional type of mechanical musical box the tune is "stored" by means of the position of little brass pegs set into a barrel. The read only memory fabricated as an integral part of the microcomputer chip is virtually an analogue of the mechanical system. This 1,024 word×8 bit device has all its data put in as part of the manufacturing process, and is therefore as permanent as the metal pins.

In the method of tone generation there is no comparison between the old type mechanical music box and this contemporary counterpart. Instead of plucking a set of metal reeds the TMS 1000N MP 0027A produces its notes by a complicated mathematical process which basically counts machine cycles (derived from the master oscillator) to produce the correct timing intervals for the precise frequencies needed for musical output.

An output from the chip oscillates at audio frequencies and drives a loudspeaker via an audio amplifier and processing network.

SYSTEM ARRANGEMENT

The functional areas of the music box are shown in the block diagram, Fig. 1.

The whole system is triggered by means of a touch plate which can either be fixed to the sides or the top of the music box. This is much easier to make than a switch which would be closed once the lid of the box was opened. The touch plate is much more adaptable and of course much more novel!

Once the plate is touched a minute amount of current is fed to the trigger input of the monostable which fires producing a pulse of approximately 60mS. This turns on the micro computer chip which within a few milliseconds activates the electronic power switch to maintain its own power supply.

It then starts to scan eight of its outputs *R0 to R7* by turning each one on sequentially. It would continue to do this indefinitely if the three selector inputs *K1*, *K2* and *K4* stayed at a low logic level. However, one of the selector gates is arranged to be turned on by the divide-by-8 counter. Thus one of the *R* outputs activates one of the *K* inputs and the micro computer senses this and jumps to a new subroutine to play the tune associated with the particular *R* and *K* connections linked.

A raw audio frequency square wave is derived from the *07, 06, 01* outputs from the chip and fed to an envelope generator. At the beginning of each note the envelope generator is triggered so that the square wave is shaped with an exponential decay. This makes a sound very similar to that of a chime or dulcimer.

The resulting waveform is fed to a simple audio amplifier in order to drive the output loudspeaker.

The tempo at which the microcomputer plays the tune being played is controlled by means of an external timer; for each note which is generated the processor produces a number of trigger pulses at its *R9* output. These initiate a simple *RC* timer which is sensed by its *K8* input. The number of timing cycles used for each note depends on the length required i.e. crotchet, quaver, semi-quaver etc.

When the system reaches the end of the tune the output controlling the power switch *R10* goes low, causing the supply to be cut off to

COMPONENTS approximate cost £10 excluding case

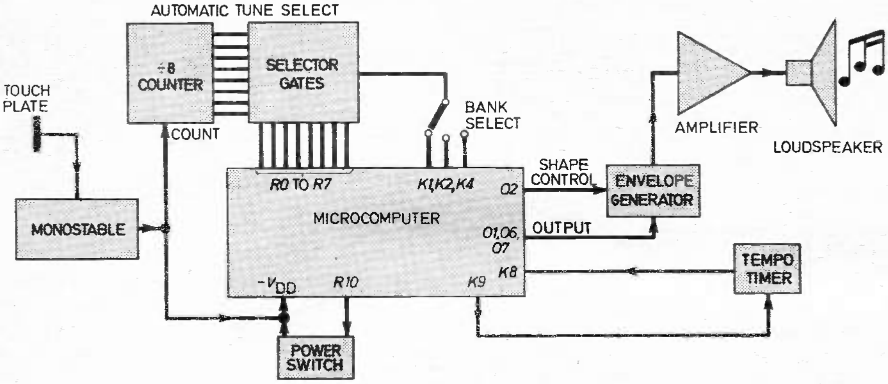


Fig. 1. Block diagram of the Micro Music Box.

the chip. Obviously this causes a complete halt of further activity. However, at this instant the divide-by-8 counter is clocked, thus enabling a new tune to be played the next time the touch plate is activated.

CIRCUIT DESCRIPTION

The complete circuit diagram shown in Fig. 2 should be regarded such that the positive $+V_{SS}$ rail is the common. This is because the TMS 1000N is a *p*-channel device and therefore powered from a negative supply. However, this should not provide any undue difficulty. It is not recommended to stand on one's head whilst comprehending the circuit diagram, nor indeed, inverting the magazine!

Power for the system is provided by two PP3 9-volt batteries in series, B1 and B2, making a total supply voltage of 18 volts. The three CMOS chips IC2, IC3 and IC4 used in conjunction with IC1 are permanently connected to the battery. This is possible due to the very low current drain of CMOS devices when not actually switching i.e. their quiescent current. The actual supply current for the musical box when it is not playing is less than 1 microamp.

TOUCH INPUT

A simple monostable is formed around an AND gate ($^1_4$IC3) by means of R2 and C1. The second input to the AND gate at pin 12 provides the trigger function. This is normally held logically high by R1 via R3.

When the touch plates are touched, current is diverted through the skin connecting the plates from the input therefore the level at pin 12 goes low, triggering the monostable for a time set by C1 and R2 which is approximately 60 milliseconds. However, if the touch input persists longer than this period then the output from the monostable will remain low until the input stimulus is removed. This would mean the musical box will play continuously provided the touch plate is kept touched.

Resistor R19 is designed to protect the delicate CMOS input device against possible static electricity damage discharged onto the touch plate. The value is kept as high as possible to minimise the peak current in this event.

The sensitivity of the touch input is controlled by R1. The lower the value of this resistor the more current which has to be diverted through the touch plates to activate the monostable. With R1 equal to 10 megohms the input is extremely sensitive and might be troublesome should condensation or sticky fingers contaminate the touch plate. If this is likely to be a problem then R1 could be 2·2 megohms or even 1 megohm.

POWER CONTROL

The output from the monostable going low applies the negative supply $-V_{DD}$ to IC1 via D1. Within a short period of activation the processor turns on its output at *R10* (pin 3) which is arranged to turn on switch transistor TR2 via R3. This transistor then holds on the negative power supply from the battery. Resistor R5 simply makes sure that leakage does not effect TR2 and also ensures a fast turn-off. At the end of a tune sequence, the *R10* output turns off causing TR2 to turn off thereby removing $-V_{DD}$ from IC1.

TEMPO CONTROL

The tempo is timed by means of the *RC* network comprising C2 and R6 and VR1 in series. At the start of each note the processor turns on its output line at *R9* (pin 2) momentarily. This turns on TR1 in order to discharge C2 completely. The timing capacitor C2 is then charged via the tempo control potentiometer VR1 and R6 until its voltage reaches about -3 volts with respect to $+V_{SS}$. At this point the *K8* input (pin 8) senses a logical low and *R9* is turned on once again to discharge C2.

This timer operation may repeat a number of variable cycles depending on the length of the note being played. The setting of VR1 can be arbitrarily set at any position according to taste.

The master clock timing components R8 and C3 set its frequency at approximately 400kHz. This only affects the overall pitch of the music, not the tempo.

TUNE SELECTION

Each time IC1 "shuts down" ($-V_{DD}$ line removed) the selection counter IC4 is clocked via its input, pin 14. This device is a Johnson decade counter which turns on each of its outputs sequentially on receipt of a clock pulse. All outputs of IC4, except one, are low (at logic 0). The position of the "high" output depends on the number of clock pulses received. Hence on the rising clock edge the "high" moves on to the next output.

The outputs are arranged to turn on sequentially each of seven AND

CHOICE OF REPERTOIRE

LINK TO *K1*	LINK TO *K2*	LINK TO *K4*
Oh Come All Ye Faithful	Soldiers Chorus (Faust)	Mozart
Oranges and Lemons	Twinkle Twinkle Little Star	Colonel Bogie
Westminster Chimes	Great Gate of Kiev	Wedding March (Mendelssohn)
Sailor's Hornpipe	Red Flag/Maryland/Tannenbaum	The Lorelei
Land of Hope and Glory	William Tell Overture	Tocatta in D Minor (Bach)
Rule Britannia	Beethoven's Ode to Joy (9th)	Deutschland Uber Alles
God Save the Queen	The Star Spangled Banner	The Marseillaise
Greensleeves	Cook House Door	Beethoven's "Fate Knocking"

The selection of the tune repertoire is made by the positioning of the *K* link (or switch if fitted)

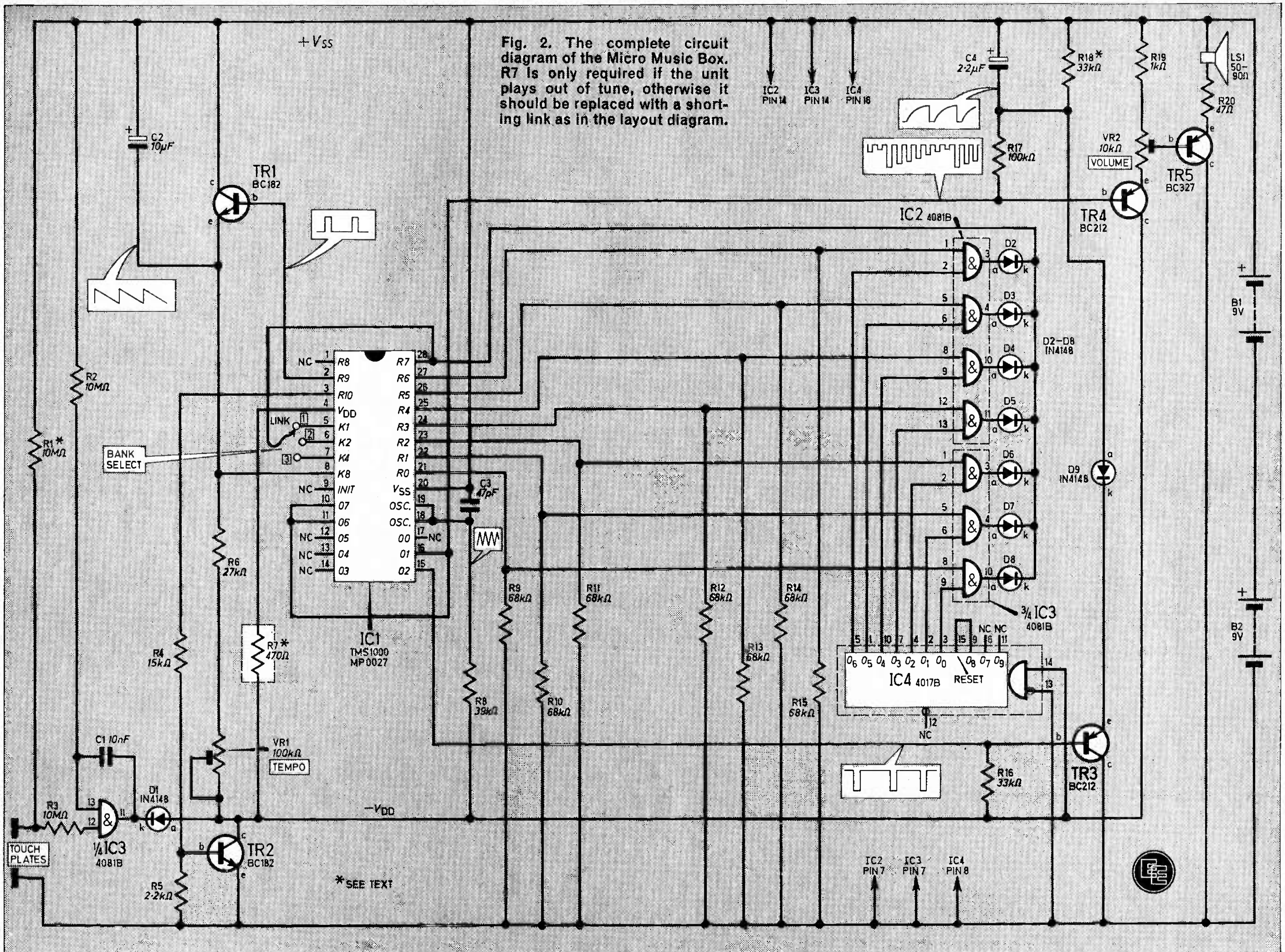


Fig. 2. The complete circuit diagram of the Micro Music Box. R7 is only required if the unit plays out of tune, otherwise it should be replaced with a shorting link as in the layout diagram.

gates (IC2 and IC3), forming a 7-to-1 multiplexer. The connection of output pin O_8 (pin 9 IC4) to *MR* (pin 15) forces a reset on each eighth clock input.

When the processor first receives power it steps through its *R0* to *R7* outputs sequentially turning each one on for approximately 100µS.

Thus when an *R* output matches to the counter output in one of the selector AND gates its output goes high, ORed by one of the diodes D2 to D8. This signal is linked to one of the *K* inputs *K1*, *K2* or *K4*.

Output *R7* does not need to be multiplexed by an AND gate in the same way as the others since it is the last one to be strobed. Resistors R9 to R15 merely provide a pull-down function for the *R* outputs to establish a proper logical low for the inputs of the AND gates.

If only one set of eight tunes is required then "Link 1" bank-select may be wired permanently. Otherwise a single-pole three-way switch can be simply installed so that all 24 tunes in the repertoire of the microcomputer can be played.

OUTPUT CIRCUITRY

All the microcomputer's outputs are open-drain types. This means they all need pull-down resistors of one sort or another to establish their output amplitudes. This facility makes it very easy to control the envelope of the audio output coming from *06/07/01* in combination.

Basically resistor R17 is the pull-down for these outputs, the voltage on C4 controlling the actual audio amplitude. As C4 effectively discharges through R17 and R18 (if fitted) then an exponential decay is applied to each note.

At the beginning of each note the output at *02* (pin 15, IC1) turns on TR3 momentarily charging C4 via D9. Thus peak amplitude occurs at the beginning of the note and gradually decays away.

The decay rate can be shortened by introducing R18, a typical value for this would be about 33 kilohm and would tend to make the sound more like a plucked pizzicato string rather than a chime sound.

Audio amplification is provided by TR4 and TR5 operating as a modified Darlington pair. This amplifier only needs to be fairly crude as the audio signal has a pulse format and is unaffected by additional clipping. Resistor R20 is used to limit the maximum current into the loudspeaker in order to prevent overheating of TR5. This value may be larger than 47 ohms if very loud volume is not required.

If an 8 ohm speaker is used then the volume will be quite low and R20 must be 68 ohms $^1{}_2$ watt or larger in value.

CONSTRUCTION starts here

The prototype Micro Music Box was built on a piece of 0·1 inch matrix stripboard. All integrated circuits were mounted in sockets, IC1 using soldercon pins so that the unit could be safely assembled without the risk of static electricity damage etc. The i.c.s can then be plugged into their respective sockets only when the unit is complete and ready for testing.

An i.c. socket may be used instead of soldercon pins for mounting IC1, but will be more expensive. When soldercon pin sockets are used never remove the connecting strip until the board is absolutely ready and complete with the i.c.s pushed into position.

ASSEMBLY

Most of the components are mounted on a piece of 0·1 inch matrix stripboard size 26 strips×46 holes. The layout of the components on the board is shown in two stages, for clarity, in Figs. 3a and 3b, the latter showing the wire links to be made after component assembly.

Begin by making the breaks along the copper strips on the underside according to Fig. 3c.

In the prototype the board was secured to the case by means of self-adhesive foam pads. If the board is to be held by bolts, the necessary mounting holes and isolating breaks around them should be made at this stage.

Assemble and solder in place the i.c. sockets and Veropins (or soldercon pins). These will then aid component positioning.

At this stage, it should be decided whether or not any of the controls, TEMPO, VOLUME, are to be adjustable by control knobs on the outside of the case. If so, flying leads should be attached to the board in place of the preset potentiometers.

Also, the bank select link may be made externally switchable by using a single-pole three way switch wired to the four Veropins near IC1.

Continue assembly by positioning and soldering in the resistors, capacitors, presets (if applicable), transistors, diodes and bare link wires,

COMPONENTS

Resistors

R1 10MΩ, see text
R2 10MΩ
R3 10MΩ
R4 15kΩ
R5 2·2kΩ
R6 27kΩ
R7 470Ω, see text
R8 39kΩ
R9 68kΩ
R10 68kΩ
R11 68kΩ
R12 68kΩ
R13 68kΩ
R14 68kΩ
R15 68kΩ
R16 33kΩ
R17 100kΩ
R18 33kΩ, see text
R19 1kΩ
R20 47Ω ½W
All ¼W carbon ±5% except where stated otherwise

See **Shop Talk** page 114

Potentiometers

VR1 100kΩ horizontal skeleton preset or shafted type as required, see text
VR2 10kΩ horizontal skeleton preset or shafted type as required, see text

Capacitors

C1 10nF ± 20% ceramic or polyester
C2 10µF 25V elect.
C3 47pF ±5% ceramic or polystyrene
C4 2·2µF 25V elect.

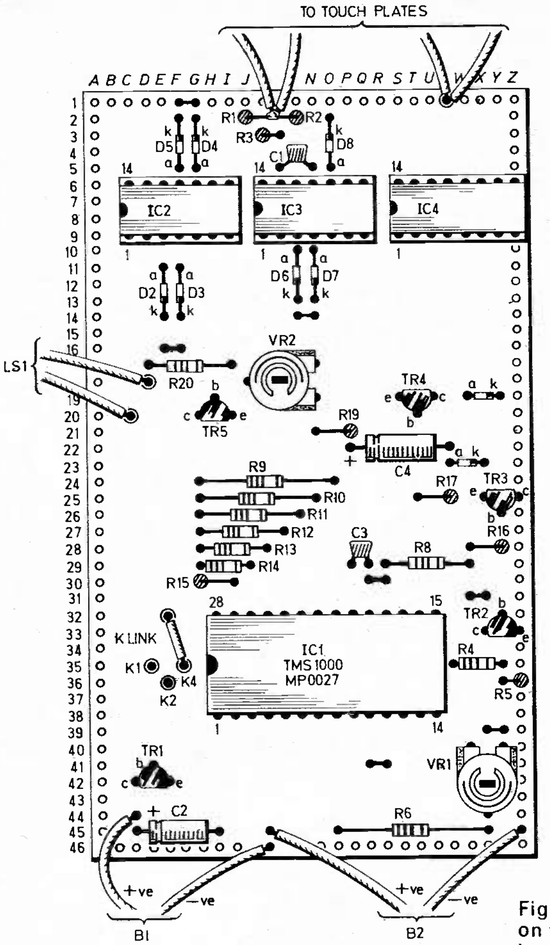
Semiconductors

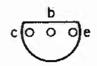
D1 to D9 1N4148 or other general purpose silicon diode (9 off)
TR1,2 BC182 or other general purpose 30V *npn* silicon (2 off)
TR3,4 BC212 or other general purpose 30V *pnp* silicon (2 off)
TR5 BC327 or other general purpose medium power 500mW 30V *pnp* silicon
IC1 TMS 1000N MP0027A (CS107-01) microcomputer (Chromatronics)
IC2,3 CD4081B CMOS Quad dual-input AND gates (2 off)
IC4 CD4017B CMOS decade counter/divider

Miscellaneous

LS1 miniature moving coil loudspeaker 50 to 90 ohms, see text
B1, B2 9V type PP3 (2 off)

Stripboard: 0·1 inch matrix size 26 strips × 46 holes; battery connectors for B1, B2 (2 pair); d.i.l. sockets for i.c.s: 28 pin (1 off), 16 pin (1 off), 14 pin (2 off), or soldercon pins; case, minimum internal dimensions 75 × 200 × 38mm or Perspex sheet to build case; self-adhesive foam pads; self-adhesive rubber feet (4 off).





◉ = VEROPINS

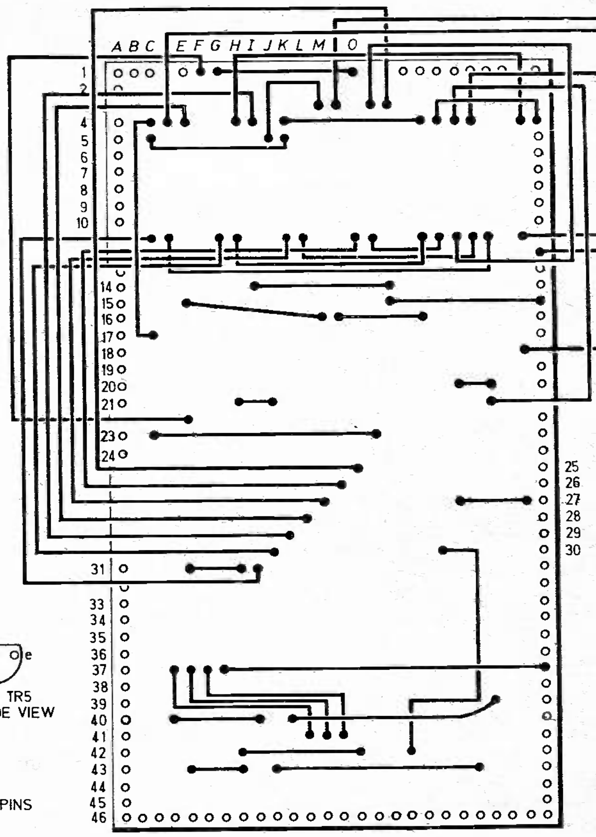


Fig. 3(a) (top left). The layout of the components and bare link wires on the topside of the circuit board; (b) (above right) Shows the remaining board interlinks to be made using lightweight p.v.c. covered wire.

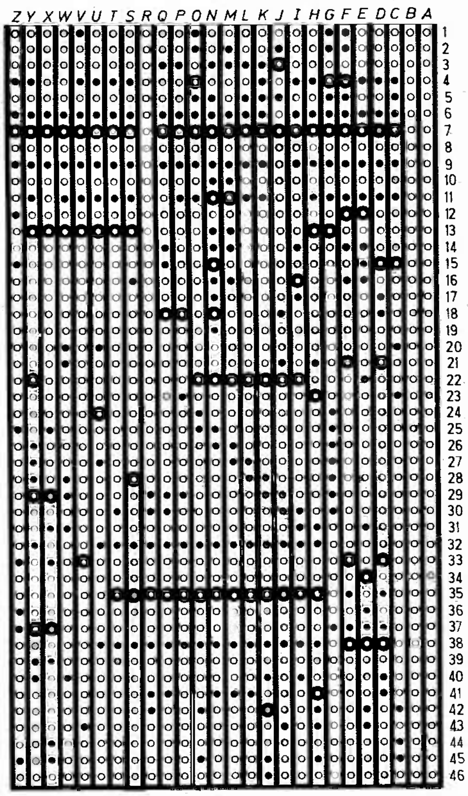
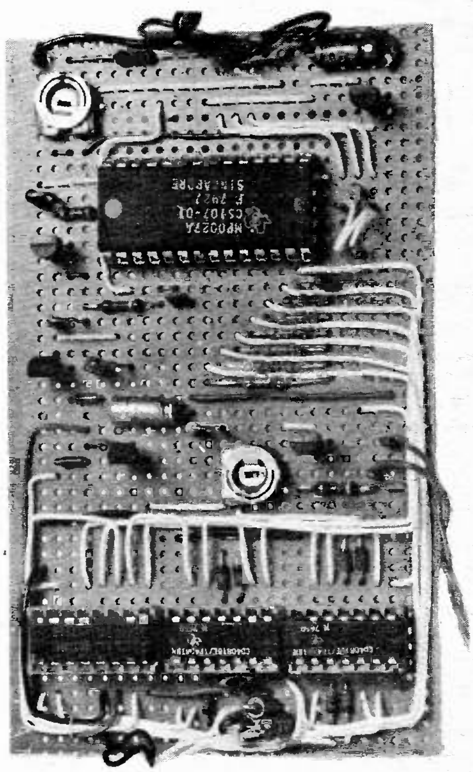


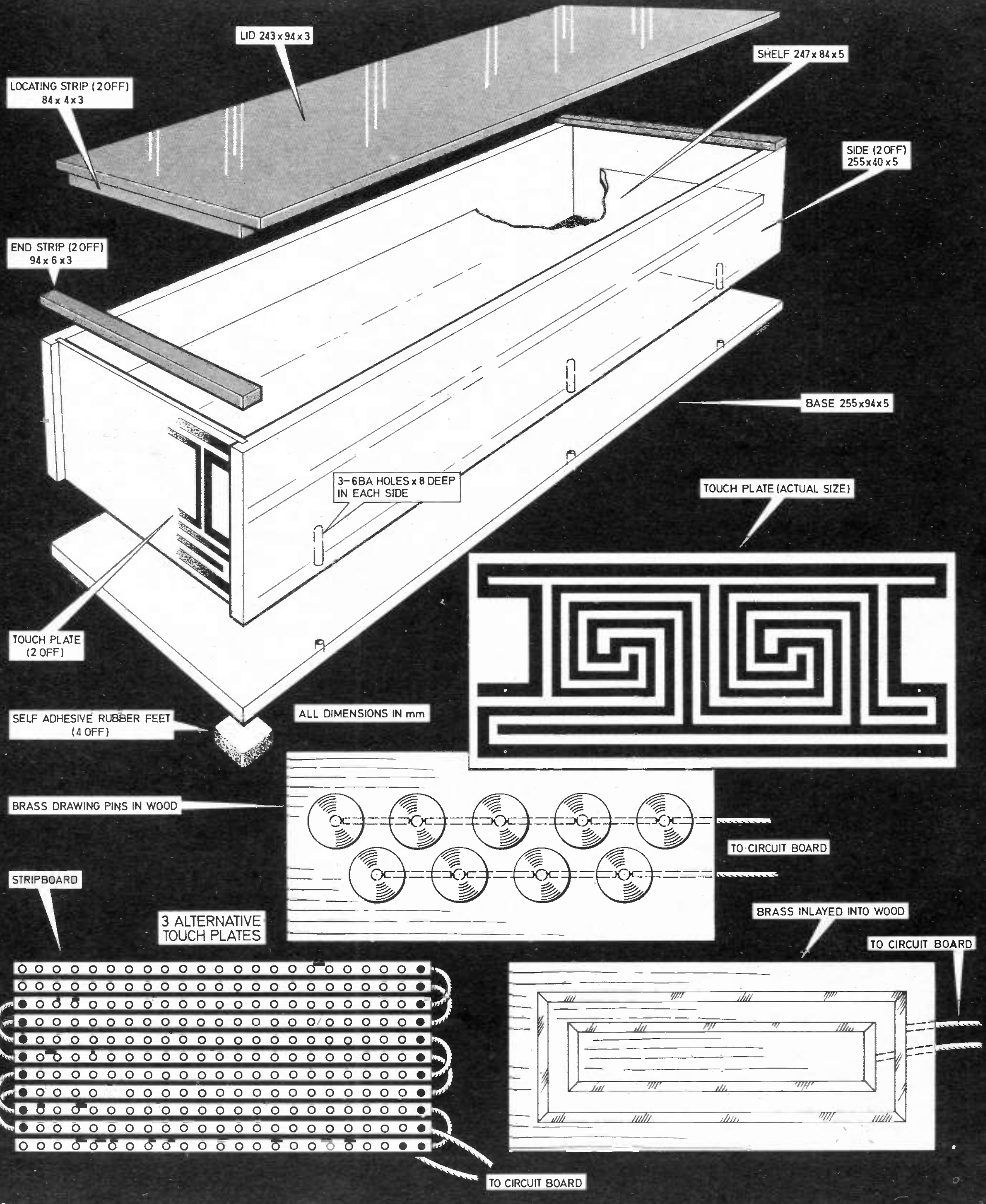
Fig. 3c. The underside of the circuit board showing the breaks to be made along the copper strips and all the soldered connections.

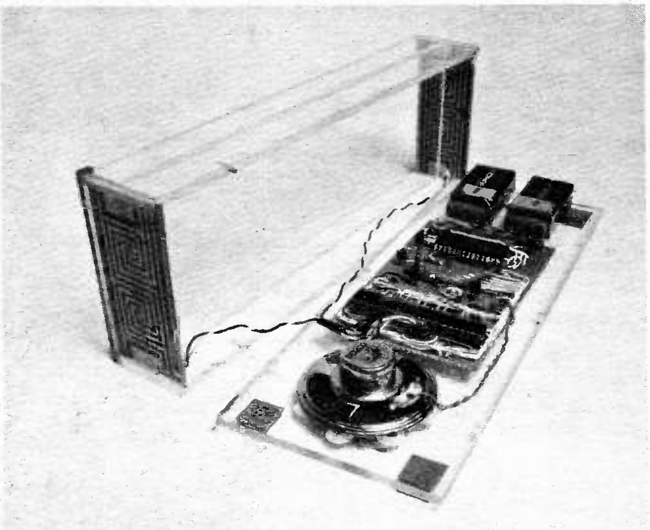


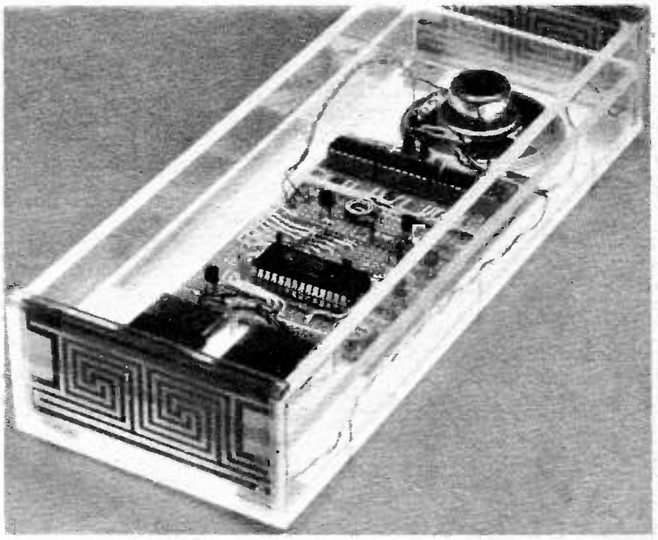
Prototype circuit board.

micro MUSIC BOX

Fig. 4. Shows the construction of the Perspex case used in the prototype together with the full-size printed circuit board pattern for the touch plates. The case panels shown shaded were colour tinted in the prototype. Three alternative touch plate ideas are shown at the foot of the page.







Now referring to Fig. 3b, begin connecting all the p.v.c. covered link wires.

Connect the speaker, battery and touch plate leads and then thoroughly check over your construction and read the following before inserting the integrated circuits.

HANDLING THE I.C.s.

Do not handle the integrated circuits unnecessarily prior to insertion in the sockets. All these devices are susceptible to static electricity damage and should only ever be handled by their plastic bodies. Check that the pins are true and straight. If not they may be carefully bent with long-nose pliers.

The rows of pins are usually splayed out very slightly wider than the mounting holes in the i.c. sockets. If this is so gently push the i.c. down edgeways on the flat of the pins onto a hard surface such as wood or Formica worktop. Make sure all the devices are inserted the correct way round and into their sockets as shown.

It may be slightly confusing at first to identify which end of the TMS 1000N MP 0027A is which! However, if you look carefully you will see that the top end i.e. that with pin 1 on the left hand side, has an indentation with flat sides to it whereas the opposite end sometimes has a small circular depression left by the moulding process.

If soldercon pins have been used, then once the i.c.s have been inserted the bridging strip can now be snapped off.

TESTING

On connecting the batteries, if all is well a tune will be heard in the loudspeaker—without touching the touchplate. Briefly placing a finger on the touch plate will cause another different tune to be played. If this is repeated at the end of each tune, the full eight tunes will be heard in sequence which will repeat in order for further operations.

The tempo can be varied by means of VR1, and the volume set by VR2.

If the unit does not operate as outlined, the following fault finding section should be consulted.

FAULT FINDING

If you have a multimeter then check the quiescent current when the batteries are connected is less than $10\mu A$. Playing out of tune usually means a low voltage spec TMS1000N. This is cured by the insertion of R7 (470 ohms) to drop the voltage to the V_{DD} pin. Normal supply current when playing is approximately 30 to 70mA.

If the unit should fail to operate properly then a multimeter on a voltage range between 20 to 30 volts d.c. may be used as a logic level detector. The positive lead of the multimeter is connected to the $+V_{SS}$ line and the negative lead used to probe various parts of the circuitry as follows:

1. When the touch plates are touched the voltage at pin 11 of IC3 should go from 0 to full battery volts.
2. When the touch plates are touched the voltage on the $-V_{DD}$ line should go from 0 to full battery volts and stay there after the touch is removed.
3. Check the voltage at the junction C2 with TR1 collector for 1·5 volts (approx.).
4. Check that one of the outputs on either pin 2, 3, 4, 5, 6, 7 or 10 of IC4 is low, all the others should be high. The low one should step round each time the unit is activated (plate touched).
5. The measured voltage on C4 at the junction of R15 should be 3 volts minimum.
6. The operation of the master clock that appears at pins 18 and 19 of IC1 can only be checked using an oscilloscope using a ×10 probe. This will be normally 300 to 400kHz at a few volts peak to peak.

CASE CONSTRUCTION

The electronics for the Micro Music Box are small enough to be fitted into a variety of commercially made boxes of various sorts. One could even use an old cedar wood cigar box!

When selecting a box one must bear in mind that access is needed for the replacement of batteries and that the touch plate contacts be conveniently mounted somewhere on the exterior of the box. In addition it is important that the loudspeaker can be mounted in such a position to "baffle" it and let the sound out.

For the prototype it was decided to make a box from sheet Perspex with printed circuit board touch panels. This makes the box even more interesting being of transparent material which enables admirers to see the marvellous technological electronic miracle that you have built!

A fully dimensioned drawing showing the construction of the case, and a master p.c.b. pattern for the touch panels are shown in Fig. 4. Also shown are three alternative touch plate ideas that could be used instead. These are not drawn to the same scale as the p.c.b. pattern.

By fitting the loudspeaker into the base of the box and fitting feet to raise it a little above the table to let the sound out, the top of the box will be totally unemcumbered with wires etc.

For symmetry two touch plates, one at either end of the unit are connected together in parallel. However this is not entirely necessary and one small touch plate would do quite nicely or even two large drawing pins side by side could be used where one doesn't want to spoil the exterior of a wooden box. ⌑

BOOK REVIEWS

TELETEXT AND VIEWDATA
Author Steve A. Money
Price £5·50
Size 223 × 140mm 151 pages
Publisher Newnes Technical Books
ISBN 0 408 00378 2

With the growth in the number of TV sets equipped with teletext decoding and display equipment and the imminent general introduction of the GPO's Prestel system, the publication of a book explaining the principles of operation of this system is welcome.

This particular publication covers the ground from the basic system concept to circuit principles and ends with a look at the future. Although the book is well written and presented it seems to suffer from a general fault that whereas some sections are explained using full circuit diagrams others are left at the block diagram stage.

Some knowledge of electronics is assumed and students, engineers and particularly electronics enthusiasts should find the book stimulating and interesting. Separate chapters are devoted to an explanation of basic logic devices, data acquisition, memory, graphics and Teletext production. The various types of decoder are considered and the fitting of these into a standard colour TV receiver is discussed.

The book is not particularly cheap at £5·50 but it does present a worthwhile introduction to this expanding field of data communication.

S.E.D.

ADVENTURES WITH MICROELECTRONICS
Author Tom Duncan
Price £3·25
Size 254 × 193mm 64 pages
Publisher John Murray
ISBN 0 7195 3672 3

An interesting and appealing title which is not let down by the contents inside. Clear diagrams, bold type and two-colour printing make this book an obvious choice for the inexperienced constructor wanting to familiarise himself with some of the more common i.c. chips.

One feature that is not made clear in the title is the fact that all the projects are built up on a proprietary breadboard. In fact this is a great help to constructors as it eliminates the need for messy interwiring and soldering although you would have to translate the layouts onto some other form of board if you didn't wish to pay out the £4 or £5 for a special breadboard.

The book opens with a brief explanation of the more common components including the breadboard and also mentions the resistor colour code before launching into the circuits proper. These are preceded by an in-depth examination of most (although one wonders why not all) of the i.c.s used and one or two preliminary experiments are given to show their operating features.

The projects featured cover a wide range of gadgets and each one is complete with a "how it works" section and suggestions for circuit modifications. The last idea is especially useful if the reader is looking for a deeper understanding of the circuit.

S.E.D.

ADVENTURES WITH PHYSICS
Author Tom Duncan
Price £2·95
Size 254 × 193mm 58 pages
Publisher John Murray
ISBN 0 7195 3643 X

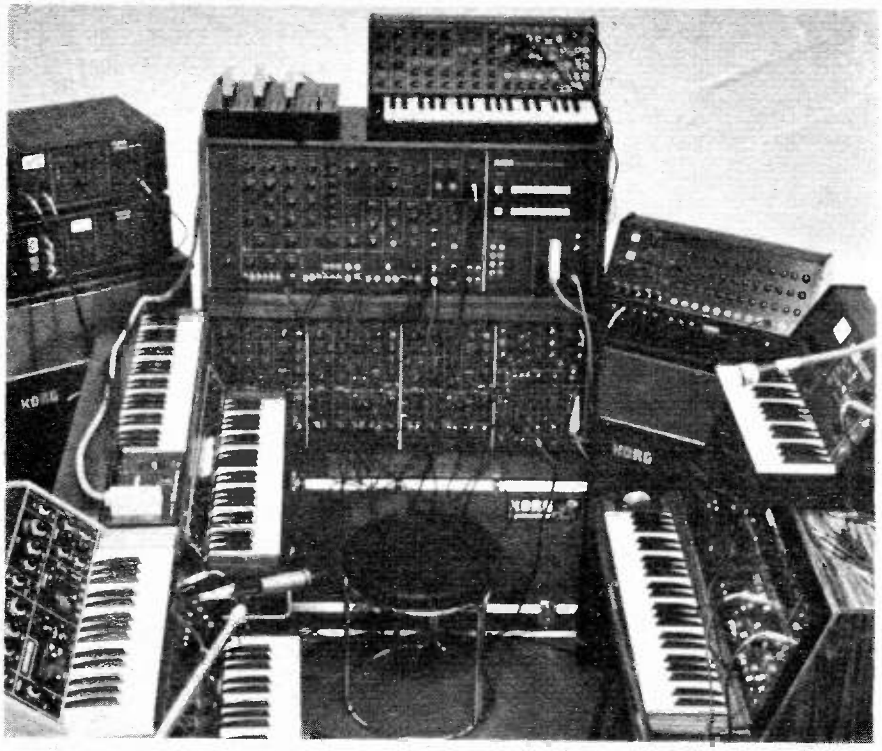
With a front cover strongly reminiscent of the latest kid's comic this book cannot fail to catch the eye of the younger reader. However, despite an abundance of two-colour illustrations, it is debatable whether our younger reader would persevere past the first half dozen or so pages.

The layout and style of the book is very similar to the Exploring Physics series of "O" level text books by the same author. Unfortunately this approach does not work quite so well for a general interest book and it is a pity that the cartoon style of the front cover could not have been carried on through the book.

This apart there are a great number of interesting experiments to try, none of which need special apparatus, followed by some fourteen models although a gas burner is required for some of these. All the major areas of physics are covered including mechanics, optics and electricity.

S.E.D.

JACK PLUG & FAMILY...
BY DOUG BAKER



By B. H. Baily

Synthesisers EXPLAINED PART 3

THE circuits and functions described in the preceding articles form the basic heart of a synthesiser, and they are the blocks concerned mainly with the production of tone in conjunction with the keyboard switching. We shall now take a look at some other circuit blocks and discuss their uses and the way in which they function.

VOLTAGE CONTROLLED AMPLIFIER

The *Voltage Controlled Amplifier* (v.c.a.) is just what one would expect it to be. It is an amplifier, the degree of amplification of which is controlled by the value of a voltage applied on its voltage control line. The function of the voltage control is akin to the volume control in a conventional amplifier.

If the synthesiser output signal is applied to the v.c.a. input, the level of this signal at its output will depend on the voltage applied at the voltage control line input. Thus, if a varying voltage is applied to the voltage control input, the signal level at the output will vary up and down in sympathy with the varying voltage control input.

An interesting use of v.c.a.s is to incorporate one in each channel of a stereo system, and connect them such that when the gain of one is increased by a varying voltage on its control input, the gain of the other is decreased simultaneously. The effect on the stereo signal is a *panning* or gradual changeover of sound positioning from one speaker to the other.

Another use of the v.c.a. is to produce an identical envelope for a second signal, from the envelope shaper handling the first signal. This can be done by controlling the voltage control line of the v.c.a. from the trapizoid output of the envelope shaper.

ENVELOPE FOLLOWER

Another circuit concerned with envelopes is the *Envelope Follower*. This has its primary use in conjunction with signals produced outside the synthesiser, the envelopes of which is required to be used inside the synthesiser to control other signals. It operates by accepting an audio signal and producing a d.c. level, the voltage of which is proportional to the amplitude of the incoming signal.

Hence, when for example a guitar signal is fed into the envelope follower, the plucking of the string results in a high-amplitude signal at the envelope follower circuit input, and produces a high-level output, say, for example, 6 volts. As the signal from the guitar string decays, the output voltage of 6 volts drops in unison, so that the output traces the shape of the envelope of the guitar signal, see Fig. 3.1. This d.c. output can be applied to a v.c.a. to create an envelope for a signal in the synthesiser, or it can be used to control a voltage controlled filter, or of course, another voltage controlled circuit.

PHASING

The popular phasing circuit appears as a built-in facility on some synthesisers. The effect itself is familiar to all who listen to modern music of the pop variety, and is easily recognised

by its "sky-riding" quality. This is accomplished by altering the phase of a signal, basically by slightly altering its timing, and mixing this altered signal with the original signal. Depending on how much the timing is affected, so certain frequencies will be affected such that the altered and unaltered signals cancel one another out, and a particular frequency will be conspicuous by its absence! But the change is made gradually, so that a whole spectrum of frequencies is affected serially, i.e. the sweep of cancelling covers the spectrum.

Various degrees of cancelling are passed through, and at certain points some frequencies are boosted by the effect. When this is done by a voltage controlled circuit, it becomes very versatile, and, as with the voltage controlled filter, can be controlled in a variety of ways, depending on what voltage control source is used to control it.

RING MODULATOR

One of the most novel in its effects, and most interesting in its function, is the circuit called the *Ring Modulator*. It is used for a variety of effects, one of which is well known as the Dalek voice of the well-known serial "Dr Who," and television advertisements depicting the voices of outer-space beings. It has also varied uses in the production of electronic music and sound effects.

The circuit normally functions with two different frequency inputs by intermodulating the two signals such that neither is present at the output. Instead, the output comprises the sum of the input frequencies, and the difference of the two inputs see Fig. 3.2. In simple mathematical terms this may be expressed: Output $=(f_1+f_2)$ and (f_1-f_2) where f_1 and f_2 are the two input frequencies.

The Dalek voice is produced by applying a low-frequency signal to one of the inputs, and applying a normal voice signal from a microphone to the other input. Thus, when normal speech is applied via the microphone, a modulated complex signal is produced at the output, with the characteristic Dalek-like quality.

OCTAVE LIFTING

An unusual and intresting use of the ring modulator is that of frequency-doubling, or octave-lifting. If a single signal (it is better to use a sinewave for this) is applied simultaneously to the two inputs, a signal of one octave higher is generated at the output.

Looking back to the simple equation above, it can be seen why this is so. Because the two inputs are in fact the same signal, then f_1 must equal f_2. So (f_1-f_2) must cancel out, so will not be present at the output, and (f_1+f_2) must equal $2\times f_1$, which in words is twice f_1. Twice a frequency is in music one octave higher!

Unfortunately, the ring modulator is fussy about the shape of waveforms it will frequency-double, and really only works properly in this particular function with pure sinewave input. However, its other functions are not limited to sinewaves, and some very interesting effects are created by using a wide range of waveshapes as inputs.

The two signals f_1 and f_2 are applied at the respective inputs, see Fig. 3.2. Notice the form which the output takes. It comprises a higher frequency, (f_1+f_2), which is "modulated" by the lower frequency (f_1-f_2). Apart from these two component frequencies the output contains no other components.

In practice, a very small amount of the two input frequencies sometimes breaks through into the output, but where this occurs the breakthrough is very small indeed and does not impair the main function of the circuit.

Although the ring modulator can be used in various ways in a synthesiser, a favourite way is to use it to modulate together the outputs of two voltage controlled oscillators, both of which take their scaling, or pitch control from the keyboard. In order to bring the modulating function to the fore, the two oscillators are offset from one another to produce a harmonious chord, e.g. root and fifth, or, in easier terms, one is set to "doh" of the tonic solfa, and the other to "soh". The result, without going into the mathematics of the analysis, is a pleasant sound which, if given suitable attack and decay has a curiously pleasant bell-like quality to it.

PATCHING

We have thus far covered a fair number of modules in isolation. In practical synthesisers there must be a way of arranging for the various circuits required at any one time to be brought into use. Some synthesisers use rotary switches to select their various functions, but this system can only be used to a limited degree. Where greater versatility is required a system of "patching" is used, and this can take more than one form.

One system may be likened to a manually operated telephone switchboard, where a large number of cords with plugs on their ends can be connected to a similarly large number of sockets. This system is very unwieldy and a system often used is one in which a matrix of sockets are laid out in rows and columns in a rectangular area.

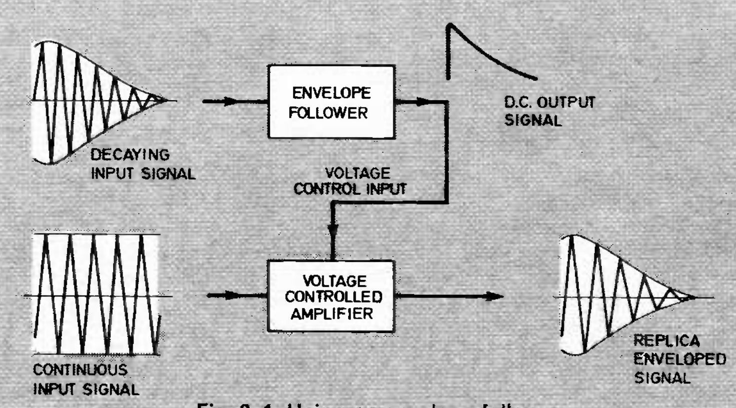


Fig. 3. 1. Using an envelope follower.

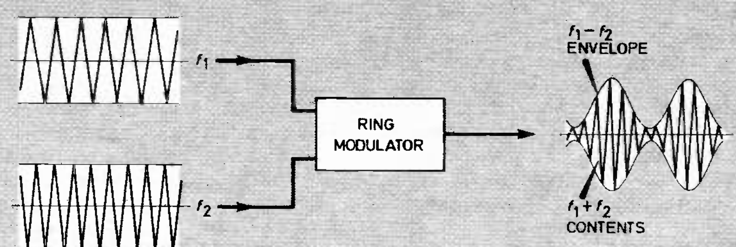


Fig. 3. 2. The effect of a Ring Modulator.

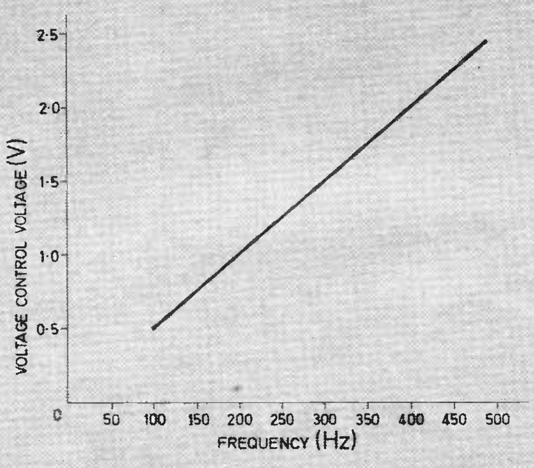


Fig. 3. 3. Linear law v.c.o.

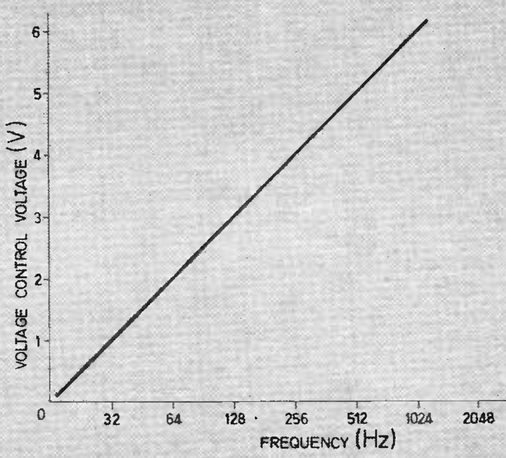


Fig. 3. 4. Log law v.c.o.

The horizontal rows are each labelled as outputs from the various circuits, and the vertical columns are labelled inputs to the same circuits. When it is required to connect the output of a particular circuit to the input of another, a plug is placed in the socket which is located at the intersection of the two circuits concerned, and electrical continuity is made via the inserted plug.

By placing a number of plugs in the correct sockets it is possible to route the v.c.o. output signals through, say, filter, phaser, envelope shaper and any other circuitry required for a given set of effects. In a similar way, the voltage control routing can be patched to give the required results.

LOG-LAW AND ITS PURPOSE

Of all the circuits discussed in this series of articles, it will have become evident that the heart of any synthesiser is surely the circuit which produces the basic tone, that is the voltage controlled oscillator. As such, it is felt that it deserves perhaps a deeper treatment than the other circuits, and indeed its actual circuitry and design is certainly very special.

A simple v.c.o. can be produced fairly easily, and there are various integrated circuits ("chips") which can be obtained which form a complete oscillator in a single package these days. However, a simple v.c.o. is not suited to synthesiser use as its electrical characteristics have to be rather special to make it really versatile in this application.

In a simple v.c.o. the frequency produced at the output is directly proportional to the voltage applied at its voltage control input, as was stated earlier. This means that if we want to double the output frequency (i.e. raise it by one octave) we must double the voltage control voltage. When this is applied practically, it is found that to raise the frequency by steps of one note at a time, the voltage change per step varies over the range of the keyboard.

CHANGING THE LAW

In some synthesisers this is not found to be too important, but in most designs steps are taken to remedy the situation, and change the "law" of the oscillator voltage control so that each successive note requires the same change in voltage to attain a one note interval. This, in turn, means that the resistance ladder for the keyboard voltage selection can be built up of a series of equal-value resistors.

One small advantage of this is that vibrato can be applied to the voltage control lines of the v.c.o.s and the same variation in musical pitch will result, no matter what note is being produced.

The change in law of each oscillator used is produced by a special circuit, nowadays forming part of the v.c.o. circuitry. The circuit changes the linear voltage-to-frequency law to what is termed a *log-law*.

Instead of having to double the input voltage to raise frequency one octave, log-law makes the circuit require a constant change in voltage to raise frequency one octave. For instance, a linear law circuit would require say one volt change to raise its frequency by one hundred cycles, whereas in a log-law circuit the change of one volt would give a frequency change of one octave. Some circuits may be 0·5V.

The two laws are shown in graphical form in Fig. 3.3 and 3.4. Note that both lines in the graphs are straight, but that the frequency axis of the second graph has been altered from a linear representation to a log representation, i.e. it is shown in terms of octave points.

Had the linear form of frequency been repeated in Fig. 3.4 the graph would have become very cumbersome, as can be seen by comparison with that in Fig. 3.3. Had linear representation been possible, then the graph trace would have appeared curved.

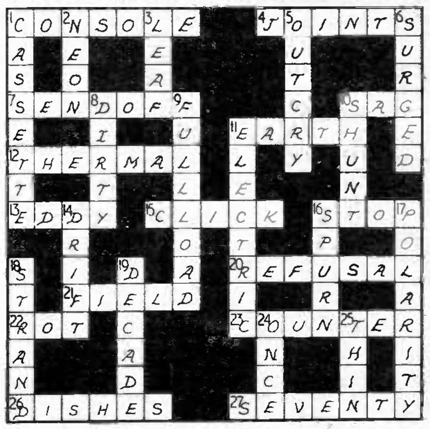
CONCLUSION

In this short series of articles the basic principles of electronic organs and monophonic synthesisers have been described. As previously stated, there are now obtainable polyphonic synthesisers, and these use principles used in both the simple synthesisers described, and also organ techniques.

The way developments are going today, we have many surprises to come in the field of electronic sound synthesis. If the last decade's progress is to be maintained, let alone overtaken, some of those surprises are likely to be almost unimaginable at present, like the phaser effect was some years ago.

Already, light and music are being combined in discos. Could smell be the next sensation to be exploited? The mind fairly boggles!

Crossword No. 24—Solution



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With WEEKLY Alarm.
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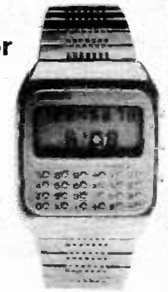

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(Mode) Net time/lap-time/ 1st-2nd place times.
Dual time function.
Accuracy 15 secs per month.
Battery life approx 4 years.

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Elegant slim line.
Stainless steel bracelet, fully adjustable.
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Accuracy per month 15 secs.
Battery life approx 15 months.

£29.95 **M23**

CASIO F-200 Sports Chrono

Attractive Mans watch in black resin with mineral glass.
Hours, mins, secs, am/pm.
Month, date, alpha-numeric day.
Auto-calendar set 28th Feb.
Stopwatch working range 1 hour, units 1/100 sec. Mode, Net Time/lap/time/ 1st-2nd place times.
Accuracy approx 15 secs per month.
Battery 12 months.

£14.95 **M24**

CASIO ALARM CHRONO 81CS-36B

Hours, mins, secs, day, and also day, month and year perpetual automatic calendar.
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Net time/lap/time/1st and 2nd place times. User optional 12/24 hr display. 24 Alarm. User optional, hourly chime.
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£14.95 **M34**

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Dual time function.
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Backlight.
Chrono – 1, full scale chrono with lap, counting hours upto 24 hrs. Mins, secs, 1/100th secs.
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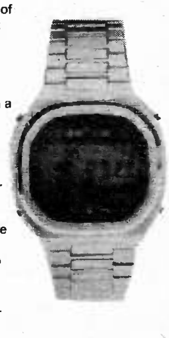
Two time zones.



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SEIKO CHRONOGRAPH

Hours, mins, secs and day of the week.
Month date and day of the week.
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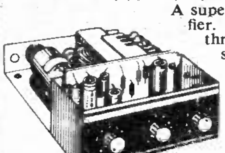
SUPERSOUND 13 HI-FI MONO AMPLIFIER



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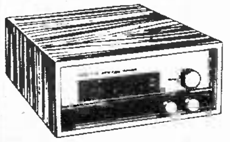

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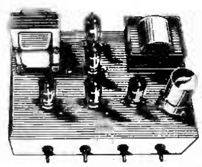

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Published approximately the third Friday of each month by IPC Magazines Ltd., Kings Reach Tower, Stamford St., London SE1 9LS. Printed in England by Index Printers Ltd., Dunstable, Beds. Sole Agents for Australia and New Zealand—Gordon and Gotch (A/Sia) Ltd. South Africa—Central News Agency Ltd. Subscriptions: Inland £9.00, Overseas £10.00 per annum payable to IPC Services, Oakfield House, Perrymount Road, Haywards Heath, Sussex. Everyday Electronics is sold subject to the following conditions namely that it shall not, without the written consent of the Publishers first given, be lent, resold, hired out or otherwise disposed of by way of Trade at more than the recommended selling price shown on cover, excluding Eire where the selling price is subject to V.A.T., and that it shall not be lent, resold, or hired out or otherwise disposed of in a mutilated condition or in any unauthorised cover by way of Trade, or affixed to or as part of any publication or advertising, literary or pictorial matter whatsoever.

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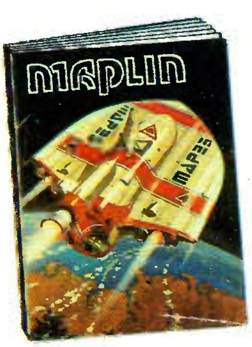

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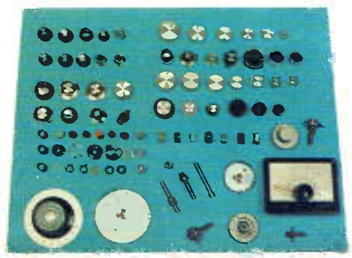

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