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SEPTEMBER 1978

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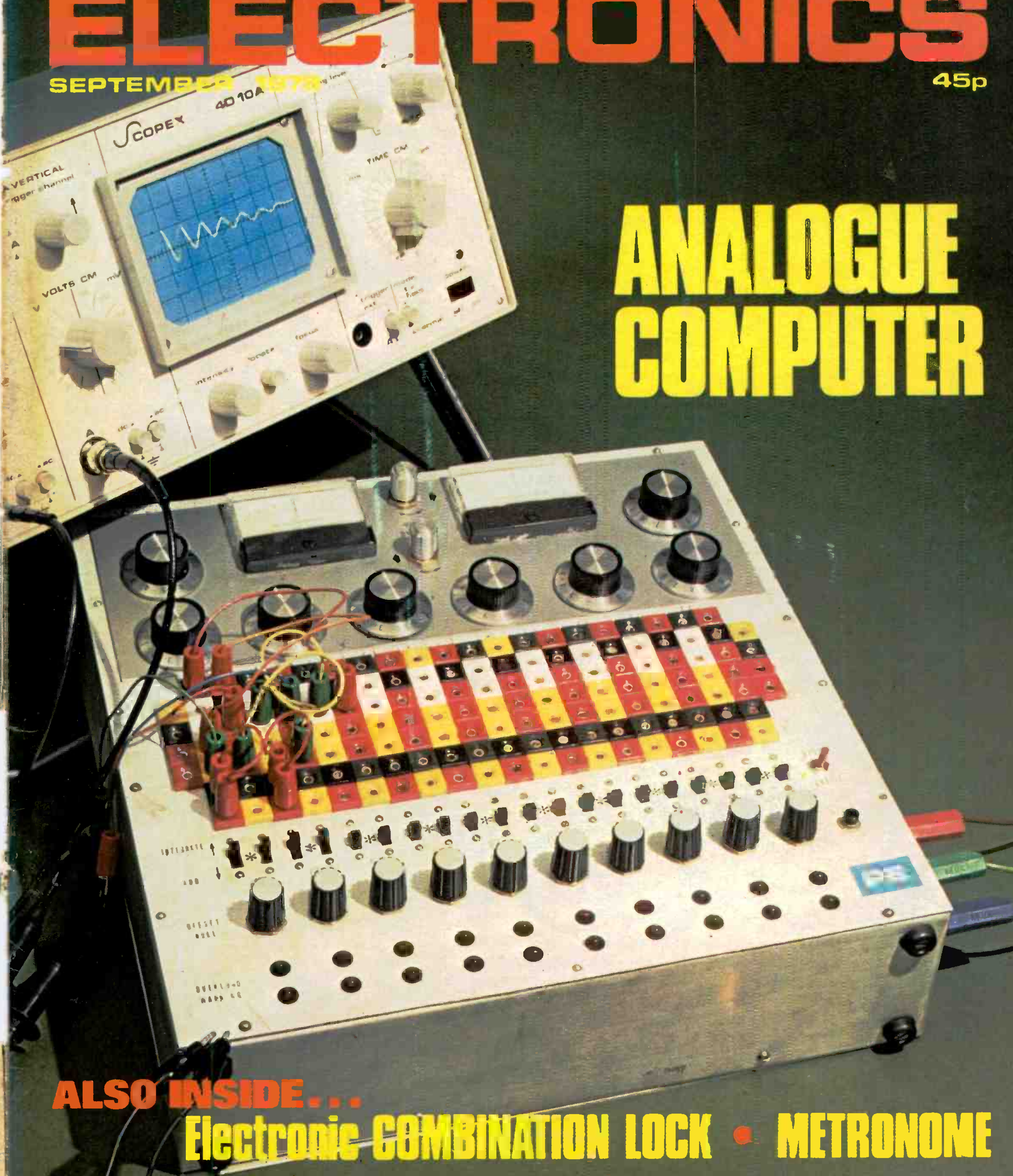

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ALSO INSIDE...

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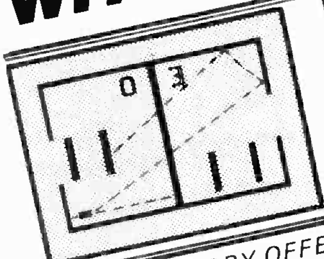
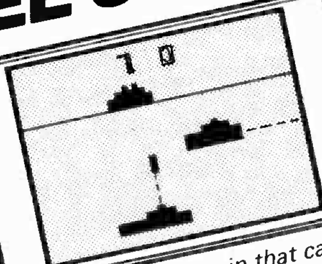
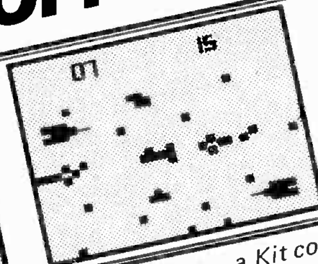
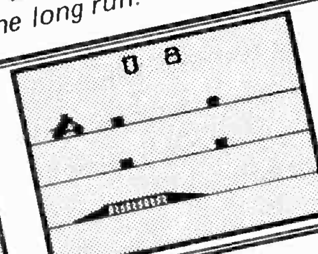
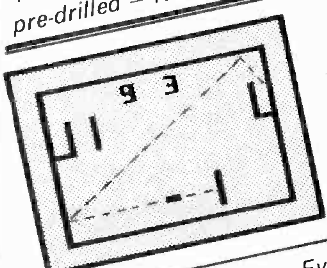
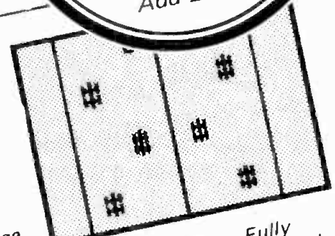
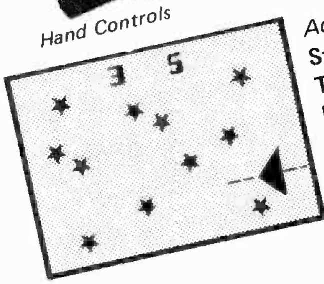
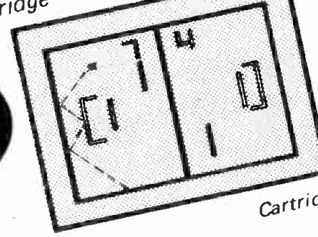
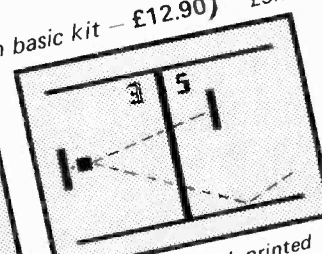








Cartridge




Hand Controls

PRACTICAL
ELECTRONICS

VOLUME 14 No. 13 SEPTEMBER 1978

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

Our October issue will be on sale Friday, 8 September 1978
(for details of contents see page 975)

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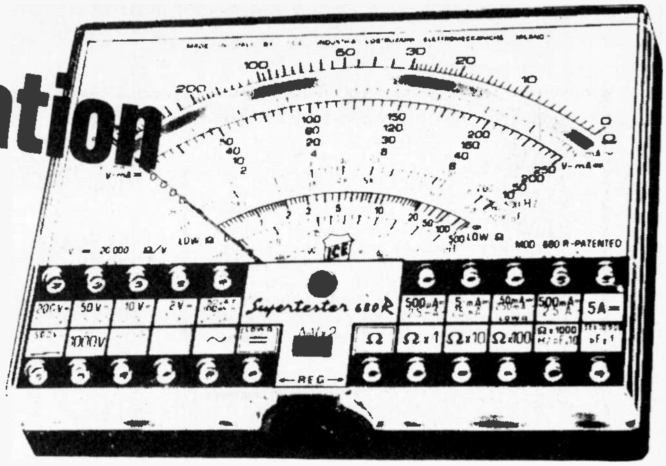
TWICE the information in HALF the size



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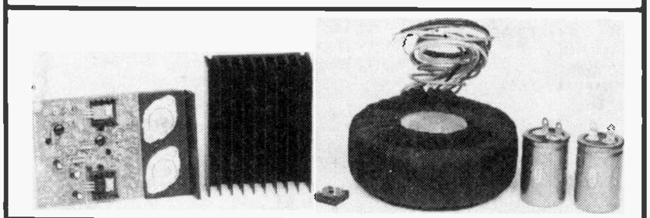

By popular demand we have designed higher powered versions of our well known modules. The CE 1704 which gives 170W into 4 ohms and the CE 1708 which gives 170W into 8 ohms are physically similar to the original types and have the same combination of compatible performance features which makes CRIMSON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

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CE 608 60W/8 ohms 35-0-35V	£16.30	£16.60
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CE 1704 170W/4 ohms 45-0-45V	£29.12	£28.46
CE 1708 170W/8 ohms 60-0-60V	£31.90	£31.04
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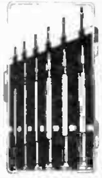

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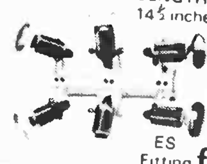

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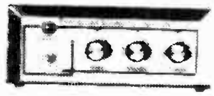

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100μF 350V **8p**

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47, 100 **40p**. **10V**: 22μF, 33, 47 **6V**: 47, 68, 100, **3V**: 68, 100μF **20p each**

MYLAR FILM CAPACITORS

100V: 0.001, 0.002, 0.005, 0.01μF	**5p**
0.015, 0.02, 0.04, 0.05, 0.056μF	**7p**
0.1μF, 0.15, 0.2 **9p** **50V**: 0.47,	**11p**

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

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250, 300, 330, 360, 390, 600, 820 **18p each**
1000, 1800, 2000, 2200 **20p each**

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2–7pF, 4–15pF, 6-25pF, 8-30pF **20p**

MINIATURE TYPE TRIMMERS

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

COMPRESSION TRIMMERS

3–40pF, 10-80pF, 25-190pF	**25p**
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Carbon Track, ¼W Log & ¼W Linear values

500Ω, 1K & 2K (lin only). Single	**27p**
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SLIDER POTENTIOMETERS
0-25W log and linear values 60mm

5KΩ-500KΩ single gang	**70p**
10KΩ-500KΩ dual gang	**80p**
Self Stick Graduated Bezels	**20p**

PRESET POTENTIOMETERS
Vertical & Horizontal

0-1W 50Ω–5MΩ Miniature	**8p**
0-25W 100Ω—3-3MΩ Horiz	**10p**
0-25W 200Ω—4-7MΩ Vert	**10p**

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RANGE	VAL	1–99	100+
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½W 2-2Ω-4.7M	E12	**2p**	**1.5p**
1W 2-2Ω-10M	E12	**5p**	**4p**
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1% Metal Film 5Ω-1M		**10p**	**8p**

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

PE String ENSEMBLE
Components now available.

OPTO ELECTRONICS★
LEDs plus clip

TIL209 Red	**13**
TIL211 Grn	**18**
TIL212 Yellow	**22**
·2" Red	**17**
·2" Yellow Green	**21**
Spare Clips	**2**
LS400	**299**
TIL307	**675**
ORP12	**68**
2N5777	**54**
7 Seg Displays	
TIL312 C An 3"	**105**
TIL313 C Cth 3"	**105**
TIL321 C An 5"	**115**
TIL322 C Cth 5"	**115**
DI704 C Cth ·3"	**99**
DL707 C.A. ·3"	**99**
FND357	**140**
LCD 3½ digit	**975**
LCD 4 digit	**975**

SWITCHES★

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

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

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

SWITCHES ★ Miniature Non-Locking
Push to Make **15p** Push to Break **25p**

ROCKER (white) 10A 250V	
SP changeover centre off	**30p**
ROCKER: (black) on/off 10A 250V	**23p**
ROCKER: Illuminated (white)	
Lights when on: 3A 240V	**52p**
ROTARY: (ADJUSTABLE STOP) 1 pole/2-12 way 2p/2-6W 3p/2-4W 4p/2-3W	**41p**
ROTARY: Mains 250V AC, 4 Amp	**45p**

DIL SOCKETS ★ (Low Profile – Texas)
8 pin **10p**; 14 pin **12p**; 16 pin **13p**; 18 pin **20p**; 20 pin **27p**; 24 pin **30p**; 28 pin **42p**; 40 pin **55p**.

DIGITAL MULTIMETER

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

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

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

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

The prototype accuracy is better than 1%.

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

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

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

SPECIAL INTRODUCTORY OFFER
Price: **£49.95*** only (p&p insured add 75p)
Ready Built units available on order
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(Demonstration on at our shop)

VDU CHIP and MODULE

Convert your TV into a VDU by using the new Thomson-CSF, TV-CRT controller chip SF.F 96364. 16 lines by 64 characters, text refreshment, cursor management on TV screen, line erasing, line end erasing. Compatible with any computing system. (Send 20p plus SAE for full technical data.)

SFF 96364E	**£11.50***
AY-5-1013 UART	**£4.50***
71301 ROM	**£8.20***
SFS80102 RAM 1K	**£2.05***
74LS163 RAM	**£0.95***
Complete module	**£136.50***

ASC11 Keyboards*
Full 56 Key ASC11 coded keyboards now available **£49.50*** (P & P 75p)

TTL 74★		7494	78	74194	105	4056	134				
		7495	65	74195	95	4057	2570				
7400	13	7496	57	74196	99	4059	480				
7401	13	7497	189	74197	85	4060	99				
7402	14	74100	119	74198	150	4061	2380				
7403	14	74105	62	75150	110	4062	999				
7404	14	74107	29	75491	75	4063	110	**LINEAR IC'S**		MC1310	175
7405	18	74109	64	75492	80	4066	58	702	75	MC1312PO	195
7406	38	74110	54			4067	380	709C 14 pin	35	MC1458★	50
7407	38	74111	68	**CMOS★**		4068	22	710★	48	MC1496	92
7408	17	74112	88			4069BE	20	723★	45	MC1488★	99
7409	17	74116	198	4000	15	4070	32	733★	125	MC1489★	99
7410	15	7411B	83	4001	17	4071	21	741C★ B pin	22	MC1495★	395
7411	20	74119	119	4002	17	4072	21	747C★	70	MC1710CG	79
7412	17	74120	115	4006	105	4073	21	748C★	36	MC3401	69
7413	30	74121	25	4007	18	4075	23	753	150	MC3340P★	150
7414	51	74122	46	4008	87	4076	85	810	159	MC3360P	89
7416	30	74123	48	4009	50	4077	40	8038CC★	370	MFC4000B	85
7417	30	74125	38	4010	50	4078	21	AY-1-0212	580	MFC6040★	97
7420	16	74126	57	4011	18	4081	20	AY-1-1313	660	MK50398★	635
7421	29	74128	74	4012	18	4082	21	AY-1-5051	145	MK50362★	650
7422	24	74132	73	4013	42	4085	74	AY-1-6721/6	195	MM2102-2★	190
7423	27	74136	73	4014	86	4086	73	AY-3-8500★	385	MM2112-2N★	310
7425	27	74141	56	4015	89	4089	150	AY-3-8710★	978	NE518A★	210
7426	36	74142	269	4016	45	4093	85	AY-5-1224A★	260	NE555★	29
7427	27	74143	314	4017	89	4094	190	AY-5-1230★	450	NE556DB★	60
7428	35	74144	314	4018	89	4095	105	CA3011★	82	NE560★	325
7430	17	74145	65	4019	48	4096	105	CA3020	170	NE561★	410
7432	25	74147	175	4020	99	4097	372	CA3023	170	NE562★	410
7433	40	74148	109	4021	91	4098	110	CA3028A★	80	NE565A★	185
7437	30	74150	99	4022	88	4099	145	CA3035	223	NE566★	18C
7438	33	74151	64	4023	20	4160	109	CA3043	190	NE567★	157
7440	17	74153	64	4024	66	4161	109	CA3046	71	NE571★	450
7441	74	74154	96	4025	19	4162	109	CA3048	200	RAM2102-2★	210
7442	68	74155	53	4026	180	4163	109	CA3075	175	RC4136D★	120
7443	115	74156	80	4027	45	4174	110	CA3080E★	80	ROM2513★	700
7444	112	74157	67	4028	81	4175	99	CA3081	190	SG3402	295
7445	94	74159	210	4029	99	4194	108	CA3089E	210	SN76003N	211
7446	94	74160	82	4030	50	4408	720	CA3090AQ	390	SN76013N	140
7447	82	74161	92	4031	205	4409	720	CA3123E	200	SN76023N	140
7448	56	74162	92	4032	100	4410	720	CA3130★	85	SN76033N	211
7450	17	74163	92	4033	145	4411	995	CA3140★	92	SN76115N	215
7451	17	74164	105	4034	196	4412F	1650	ICL7106Ev★	975	SN76227	115
7453	17	74165	105	4035	111	4412F	1380	ICM7205★	1150	TAA621AX1	228
7454	17	74166	161	4036	325	4415F	795	LM3001H	170	TAA661A	155
7460	17	74167	20	4037	100	4415V	795	LM301A	30	TAA700	353
7470	28	74170	230	4038	108	4419	280	LM308	110	TAA960	300
7472	25	74172	625	4039	320	4422	545	LM318	195	TBA120S	70
7473	32	74173	170	4040	105	4433	1225	LM324★	79	TBA5400	220
7474	27	74174	87	4041	80	4435	825	LM339★	80	TBA550Q	330
7475	38	74175	87	4042	75	4440	1275	LM348★	120	TBA641BX11	250
7476	36	74176	75	4043	94	4450	295	LM379★	375	TBA651	180
7480	48	74177	78	4044	88	4451	295	LM380	95	TBA800	90
7481	86	74178	102	4045	145	4490F	695	LM381	145	TBA810S	105
7482	69	74180	85	4046	128	4490V	525	LM381AN	241	TBA820	70
7483	72	74181	165	4047	87	4501	17	LM382	125	TBA920Q	260
7484	95	74182	160	4048	58	4502	120	LM1458★	50	TDA1022★	595
7485	106	74184	135	4049	48	4503	69	LM3900★	60	TOA2020	320
7486	31	74185	135	4050	48	4506	51	LM3909N★	70	TL081CP★	52
7489	210	7418B	275	4051	72	4507	55	LM3911★	125	TL082CP★	96
7490	33	74190	115	4052	72	4508	298	M252AA★	750	TL084CP★	130
7491	75	74191	105	4053	72	4510	99	M253AA★	795	UAA170	198
7492	38	74192	105	4054	110	4511	150	MC1303	88	ZN414	105
7493	32	74193	105	4055	128	4512	98	MC1304P	260	ZN424	130

4513	206	4518	102	4526	199
4514	265	4519	59	4527	152
4515	299	4520	108	4528	99
4516	125	4521	268	4529	165
4517	382	4522	199	4530	85

TRANSISTORS

				8F194	10	OC42★	32	ZTX314	24	2N3614★	169
				BF195	10	OC43★	55	ZTX326	40	2N3615★	135
AC117★	35	BC170	17	8F196	10	OC44★	31	ZTX341	20	2N3663	24
AC125★	19	BC171	11	8F197	10	OC45★	20	ZTX500	13	2N3702	10
AC126★	19	BC172	10	BF198	18	OC46★	28	ZTX501	14	2N3703	11
AC127★	18	BC177★	15	BF200★	28	OC70★	19	ZTX502	19	2N3704	10
AC128★	18	BC178★	14	BF224A	1B	OC71★	25	ZTX503	15	2N3705	11
AC141★	24	BC179★	14	BF244	24	OC72★	30	ZTX504	25	2N3706	10
AC141K★	38	BC182	9	BF256★	50	OC76★	36	ZTX531	25	2N3707	10
AC142★	24	8C182L	10	BF257★	26	OC77★	76	ZTX550	25	2N3708	10
AC142K★	38	BC183	9	BF258★	26	OC79★	76	2N526★	58	2N3709	10
AC176★	18	8C183L	10	BF259★	30	OC81★	28	2N696★	35	2N3710	16
AC187★	20	BC184	9	BF394	22	OC82★	45	2N697★	21	2N3711	10
AC188★	20	BC184L	10	BF594	40	OC83★	48	2N698★	39	2N3715★	250
ACY17	35	BC1B6	21	BF595	38	OCB4★	44	2N699★	39	2N3772★	170
ACY18★	40	BC187★	28	BFR39	25	OC122★	48	2N706A★	19	2N3773★	288
ACY19★	40	BC212	9	BFR40	25	OC123★	48	2N707★	50	2N3819	22
ACY20★	40	BC212L	10	BFR79	28	OC139★	85	2N708★	19	2N3820	32
ACY21	35	BC213	9	8FR80	28	OC140★	85	2N914★	32	2N3823★	65
ACY22★	40	BC213L	11	BFX29★	26	OC141★	85	2N916★	27	2N3824★	70
ACY28★	40	BC214	9	BFX81★	130	OC170★	40	2N918★	30	2N3866★	90
ACY39	78	BC214L	10	BFX84★	24	OC171★	40	2N920★	51	2N3903	18
ACY40★	48	BC307B	14	8FX85★	24	OC201★	75	2N930★	18	2N3904	18
ACY44	39	BC308	13	8FX86★	28	OC202★	85	2N961★	61	2N3905	18
AD140★	69	BC328	13	BFX87★	23	OC203★	B5	2N1131★	22	2N3906	17
AD149★	90	BC338	12	BFX88★	24	OC204★	85	2N1132★	22	2N4037★	52
AD161★	42	BC441★	30	8FY18★	50	TIP29	43	2N1302★	35	2N4058	17
AD162★	42	BC461★	30	BFY50★	20	TIP29A	44	2N1303★	50	2N4061	17
AF114★	25	BC547	11	BFY51★	20	TIP29C	60	2N1304★	50	2N4064★	120
AF115★	25	BC548	11	BFY52★	20	TIP30	47	2N1305★	28	2N4236★	145
AF116★	25	BC549	11	8FY71★	20	TIP30A	47	2N1306★	35	2N4289	20
AF117★	25	BC557	13	BSX20★	1B	TIP30B	64	2N1307★	50	2N4859	65
AF118★	55	BC558	12	BSX20★	18	TIP30C	65	2N1308★	46	2N5135	42
AF121★	48	BCY30★	57	BSY65★	30	TIP31★	40	2N1613★	23	2N5136	42
AF124★	55	BCY34★	75	BSY95★	25	TIP31A★	40	2N1671★	190	2N5138	20
AF125★	35	BCY39★	40	BSY95A★	25	TIP31B★	40	2N1671B★	195	2N5179★	60
AF127★	35	BCY40★	78	BU105	130	TIP31C★	66	2N1893★	28	2N5180★	60
AF139★	35	BCY43	75	BU205★	190	TIP32★	45	2N1986★	60	2N5191★	65
AF178★	70	BCY58★	22	BU20B★	225	TIP32A★	49	2N2160★	105	2N5305★	24
AF180★	70	BCY59★	22	E5567	65	TIP32B★	70	2N2217★	48	2N5457	32
AF186★	50	BCY70★	15	MD8001★	15B	TIP32C★	70	2N2218A★	31	2N5458	32
AF239★	42	BCY71★	15	ME4102	10	TIP33★	80	2N2219A★	22	2N5459	32
ASY26★	40	BCY72★	16	ME6002	14	TIP33A★	80	2N2220A★	26	2N5485	32
ASY27★	45	BCY78★	20	MJ400★	90	TIP33B★	100	2N2221★	23	2N5777★	54
BC107★	9	BD115★	62	MJ491★	160	TIP33C★	105	2N2222★	20	2N6027	40
BC107B★	10	BD121★	95	MJ2955★	120	TIP34★	85	2N2297	45	40311★	50
BC108★	9	BD123★	9B	MJE340★	45	TIP34A★	85	2N2303★	45	40313★	125
BC108B★	12	BD124★	115	MJE370★	55	TIP34B★	110	2N2368★	21	40316★	B5
BC108C★	12	BD131★	38	MJE371★	60	TIP34C★	110	2N2369★	15	40317★	52
BC109★	9	BD132★	38	MJE520★	45	TIP35★	219	2N2476★	125	40324★	85
BC109B★	12	BD133★	43	MJE521★	65	TIP35A★	225	2N2483★	28	40326★	52
BC109C★	12	BD135★	36	MJE2955★	11	TIP35C★	270	2N2484★	30	40327★	62
BC113	17	BD136★	37	MJE3055★	80	TIP36A★	265	2N2646★	48	40347★	80
BC114	19	BD137★	36	MPF102	30	TIP36C★	325	2N2784★	55	40348★	101
BC115	19	BD138★	36	MPF103	36	TIP41A★	63	2N2846★	140	40360★	43
BC116	19	BD139★	36	MPF104	36	TIP41B★	73	2N2B94★	30	40361★	45
BC117	15	BD140★	36	MPF105	36	TIP42A★	64	2N2904A★	22	40362★	48
BC118	19	BD142★	59	MPF106	50	TIP42B★	82	2N2905A★	20	40407★	50
BC119★	26	BD145★	198	MPF107	50	TIP2955★	63	2N2906★	18	40411★	289
BC134	19	BD222★	60	MPSA05★	24	TIP3055★	52	2N2907★	20	40412★	63
BC135	20	BD695A★	75	MPSA06★	24	TIS43	36	2N2907A★	22	40467★	95
BC136	18	BD696A★	75	MPSA55	24	TIS44	45	2N2926G	10	40576★	190
BC137	20	BDY17★	195	MPSA56	24	TIS46	45	2N29260	8	40594★	80
BC140★	28	BDY60★	110	MPSA70	34	TIS50	47	2N2926R	8	40595★	90
8C142★	25	BDY61★	165	MPSU02★	58	TIS60	45	2N2926Y	8	40603★	65
BC143★	25	BF115★	22	MPSU05	48	TIS62	45	2N3011★	24	40636★	125
BC147	7	BF154★	25	MPSU06	54	TIS74	47	2N3053★	20	40673★	68
BC148	7	BF156★	29	MPSU52★	65	TIS90	18	2N3054★	49		
BC149	8	BF167	25	MPSU55★	53	TIS91	22	2N3055★	55		
BC153	14	8F173★	25	MPSU56★	56	ZTX107	11	2N310B	39		
BC154	14	BF177★	24	MPU131★	39	ZTX108	11	2N3121	40		
BC157	10	BF178★	25	OC25★	120	ZTX109	11	2N3133	43		
BC158	11	BF179★	30	OC26★	150	ZTX300	13	2N3135	33		
BC159	11	BF180★	20	OC28★	99	ZTX301	16	2N3250	30		
BC160	27	BF181★	30	OC29★	160	ZTX302	18	2N3252	36		
BC167A	11	BF182★	30	OC35★	80	ZTX303	21	2N3302	35		
BC168C	12	BF183★	30	OC36★	99	ZTX304	24	2N3442★	131		
BC169C	10	BF184★	30	OC41★	48	ZTX311	17	2N3563	20		

Matched Pair 10p extra.

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SC60 100mH 60

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BUY A COMPLETE RANGE OF COMPONENTS AND THESE PACKS WILL HELP YOU

★ *SAVE ON TIME—No delays in waiting for parts to come or shops to open!*

★ *SAVE ON MONEY—Bulk buying means lowest prices—just compare with others!*

★ *HAVE THE RIGHT PART—No guesswork or substitution necessary!*

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K001 50V ceramic plate capacitors, 5%. 10 of each value 22pF to 1000pF. Total 210, **£3·35**
K002 Extended range, 22pF to 0·1μF. 330 values **£4·90**
K003 Polyester capacitors, 10 each of these values: 0·01, 0·015, 0·022, 0·033, 0·047, 0·068, 0·1, 0·15, 0·22, 0·33, 0·47μF. 110 altogether for **£4·75**
K004 Mylar capacitors, min 100V type. 10 each all values from 1000pF to 10,000pF. Total 130 for **£3·75**
K005 Polystyrene capacitors, 10 each value from 10pF to 10,000pF, E12 series 5% 160V. Total 370 for **£12·30**
K006 Tantalum bead capacitors. 10 each of the following: 0·1, 0·15, 0·22, 0·33, 0·47, 0·68, 1, 2·2, 3·3, 4·7, 6·8, all 35V; 10/25 15/16 22/16 33/10 47/6 100/3. Total 170 tants for **£14·20**
K007 Electrolytic capacitors 25V working, small physical size. 10 each of these popular values: 1, 2·2, 4·7, 10, 22, 47, 100μF. Total 70 for **£3·50**
K008 Extended range, as above, also including 220, 470 and 1000μF. Total 100 for **£5·90**
K021 Miniature carbon film 5% resistors, CR25 or similar. 10 of each value from 10R to 1M, E12 series. Total 610 resistors, **£6·00**
K022 Extended range, total 850 resistors from 1R to 10M **£8·30**
K041 Zener diodes, 400mW 5% BZY88, etc. 10 of each value from 2·7V to 36V, E24 series. Total 280 for **£15·30.**
K042 As above but 5 of each value **£8·70**

DIODE SCOOP!!!

We have been fortunate to obtain a large quantity of untested, mostly unmarked glass silicon diodes. Testing a sample batch revealed about 70% useable devices – signal diodes, high voltage rects and zeners may all be included. These are being offered at the incredibly low price of **£1·25**/1000 – or a bag of 2500 for **£2·25.** Bag of 10,000 **£8.** Box of 25,000 **£17·50.** Box of 100,000 **£60.**

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Audio IC's			
76003N	£1·40	76013N	£1·00
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LM380	80p	TBA8105	70p
Linear IC's etc.			
741 (8DIL)	18p	BD131	24p
555	25p	BD132	28p
1N4148	2p	2N3819	18p

74 SERIES PACK

Selection of boards containing many different 74 series IC's. 20 for **£1**; 50 for **£2·20**; 100 for **£4.**

TTL PANEL

52 logic IC's including 32 x 74161 (4 bit binary counter) + 16 tant bead caps, R's, C's, etc. Over £30 worth of TTL alone!! ONLY **£3·00**

DISC CERAMIC PACK

Amazing variety of values and voltages from a few pF to 2·2uF 3V to 3kV! 200 **£1.** 500 **£2·25**, 1000 **£4·00**

EXPERIMENTERS CALCULATOR

Based on the C500 chip, this pack of parts enables the more experienced constructor to make an 8 digit 4 function calculator. The comprehensive data supplied includes full size layout of PCB required, types of suitable display and keyboard that can be used etc. Components included in the pack are C500 calculator chip, driver IC, all components for inverter/clock circuits, R's C's etc. All for only **£3·50.**

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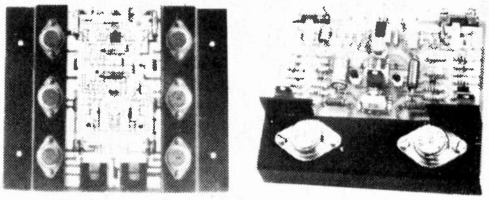

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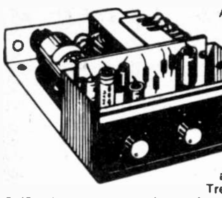

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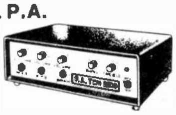

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AF239	30p	BC214L	*10p	OC44	12p	ZTX300	*7p	2N2905	14p
BC107	6p	BC251	*10p	OC45	12p	ZTX301	*7p	2N2905A	15p
BC108	6p	BCY70	12p	OC71	9p	ZTX302	*9p	2N2906	12p
BC109	6p	BCY71	12p	OC72	12p	ZTX500	*8p	2N2906A	14p
BC118	*10p	BCY72	12p	OC75	10p	ZTX501	*10p	2N2907	12p
BC147	*8p	BD115	*40p	OC81	14p	ZTX502	*12p	2N2907A	13p
BC148	*8p	BD131	*35p	TIP29A	35p	2N696	10p	2N2926G	*8p
BC149	*8p	BD132	*37p	TIP29B	36p	2N697	10p	2N2926Y	*7p
BC154	*16p	BF115	17p	TIP29C	38p	2N706	7p	2N3053	12p
BC157	*9p	BF167	19p	TIP30A	38p	2N706A	8p	2N3055	35p
BC158	*9p	BF173	20p	TIP30B	37p	2N708	8p	2N3702	*7p
BC159	*9p	BF180	25p	TIP30C	38p	2N1302	12p	2N3703	*7p
BC169C	*10p	BF181	25p	TIP31A	32p	2N1303	15p	2N3704	*6p
BC170	*6p	BF182	25p	TIP31B	33p	2N1304	15p	2N3903	*11p
BC171	*6p	BF183	25p	TIP31C	34p	2N1307	18p	2N3904	*11p
BC172	*6p	BF184	25p			2N1308	22p	2N3905	*11p
BC173	*7p	BF185	25p			2N1309	22p	2N3906	*11p

DIODES

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
AA119	5p	BAX16/ OA202	5p	BYZ16	30p	OA85	7p	IS44	3p
AAZ13	4p			BYZ17	28p	OA90	6p		
BA100	6p			BYZ18	28p	OA91	7p	IN5400	10p
BA115	5p	BY100	15p	BYZ19	28p	OA95	7p	IN5401	11p
BA144	5p	BY127	*10p					IN5402	12p
BA148	10p	BYZ10	32p	OA47	5p	IN34	5p	IN5404	13p
BA173	10p	BYZ11	32p	OA70	5p	IN60	6p	IN5406	16p
BAX13/ OA200	5p	BYZ12	32p	OA79	7p	IN914	4p	IN5407	17p
		BYZ13	30p	OA81	7p	IN4148	4p	IN5408	19p

LINEAR I.C.'s

TBA800	12 pin QIL	*75p	UA711C	TO99	25p	UA748	TO99	28p
TBA810	12 pin QIL	*£1.00	UA703	TO99 (Plastic)	20p	72558	(Dual 748) TO99	45p
TBA820	14 pin QIL	*80p	741P	8 pin DIL	18p	MC1310P	14 pin DIL	*£1.25
LM380	14 pin DIL	*80p	72741	14 pin DIL	20p	76115	14 pin QIL	*£1.25
LM381	14 pin DIL	*£1.35	UA741C	TO99	20p	NE555	8 pin DIL	25p
72709	14 pin DIL	28p	72747	14 pin DIL	55p	NE556	14 pin DIL	60p
UA709	TO99	28p	748P	8 pin DIL	28p	SL414A	10 pin	*£1.80

NEW CONSIGNMENT ZN 414 RADIO CHIP 75*

OPTOELECTRONICS

Displays

No. 1510	707 LED Display	each 70p
No. 1511	747 LED Display	each £1.50
No. S53	DL33 Triple 7 Segment LED Display Character height 11" Common Cathode 12 pin DIL	each 30p

LED's

No. S51	Red TIL209 (5 x .125")	50p
No. S52	Red FLV117 (5 x .2")	50p
No. 1502	Green .125"	each 18p
No. 1505	Green .2"	each 18p
No. 1503	Yellow .125"	each 18p
No. 1506	Yellow .2"	each 18p
No. S82	Clear .2" (illuminating red)	12p

2nd QUALITY LED PAKS

No. 1507 10 x LED's Assorted **75p**

LED CLIPS

No. 1508/.125	.125	5 for 12p
No. 1508/.2	.2	5 for 15p

SPECIAL REDUCTIONS

No. 1514	NORP 12	each 45p
No. S76	OCP71	5 for £1.00
No. S83	5 NIXIE Tubes ITT 5870 ST (including Data)	£2.00

SILICON SOLAR CELLS

S109 Output 5mA at ½ volt each **50p**

P.O. RELAYS

S85–2 Off Post Office relays **40p**

BATTERY HOLDERS

to take 6 x HP7's
Order No. 202 each **10p**

EX. G.P.O. MICROSWITCHES

Order No. S51 4 for **50p**

CABLE CLIPS

S84–50 2.5mm round single pin fixing **30p**

AUDIO LEADS

Order No.		
117	A.C. Mains connecting lead for cassette recorders and radios Telefunken type	45p*
118	5 pin DIN headphone plug to stereo socket	78p*
119	2 x 2 pin plug to inline stereo socket for headphones	60p*
123	20 ft. of coiled guitar lead	£1.15*
124	3 pin to 3 pin DIN plug	50p*
125	Audio lead 5 pin plug to 5 pin DIN plug	50p*
126	Audio lead 5 pin Din plug to tinned open ends	50p*
127	Audio lead 5 pin DIN plug to 4 phono plugs	90p*
129	Audio lead 5 pin plug to 5 pin DIN plug – Mirror Image	70p*
130	5 metre lead 2 pin DIN plug to 2 pin DIN inline socket	45p*
132	10 metre lead 2 pin DIN plug	65p*

ZENER PAKS

No. S55	20 mixed values 400mW Zener diodes 3-10V	£1.00
No. S56	20 mixed values 400mW Zener diodes 11-33V	£1.00
No. S57	10 mixed values 1W Zener diodes 3-10V	£1.00
No. S58	10 mixed values 1W Zener diodes 11-33V	£1.00

POTENTIOMETERS

Slider 40mm TRAVEL

Order No.			
16191	6 x 470 Ohm	LIN Single	40p*
S24	6 x 1 K	LIN Single	40p*
S25	6 x 5 K	LIN Single	40p*
16192	6 x 10 K	LIN Single	40p*
S26	6 x 10 K	LOG Single	40p*
16193	6 x 22 K	LIN Single	40p*
16195	6 x 47 K	LOG Single	40p*
16194	6 x 47 K	LIN Single	40p*
S27	6 x 100 K	LIN Single	40p*
S28	6 x 100 K	LOG Single	40p*
S29	6 x 500 K	LOG Single	40p*

Slider 60mm TRAVEL

S30	6 x 2.5 K	LOG Single	40p*
S31	6 x 10 K	LIN Single	40p*
S32	6 x 50 K	LIN Single	40p*
S33	6 x 250 K	LOG Single	40p*
S34	4 x 5 K	LOG Dual	40p*
S35	4 x 10 K	LIN Dual	40p*
S36	4 x 100 K	LOG Dual	40p*
S37	4 x 1.3 MEG	LOG Dual	40p*
S94	6 x 220 K	LIN Single	40p*
S95	6 x 100 K	LOG Single	40p*
S96	6 x 500 K	LIN Single	40p*
S38	Mixed slider pots–various values and sizes–our mix		only £1.00*
S39	6 x Chrome slider knobs		40p*

WIREWOUND

S90 Wirewound Pots. Linear 1 Watt rating. Mixed useful values. 5 for **£1.00***

CARBON TYPES

S91 Car Radio type. Dual Switched Pot P.C. mounting 100 K Lin switched 2.5 K Lin each **60p***

DUAL POTS P.C. MOUNTING

6mm Shaft

S92	4 x 100 K Lin	£1.00*
S93	4 x 100 K Log	£1.00*
16173	15 Rotary Pots Assorted	40p*
16186	25 Pre-sets Assorted Values	40p*

MULTI-TURN PRE-SETS

S40 3 x 100 K Lin only **50p***

VOLTAGE REGULATORS

Positive

No. MVR7805	µA7805	TO220	85p
No. MVR7812	µA7812	TO220	85p
No. MVR7815	µA7815	TO220	85p
No. MVR7818	µA7818	TO220	85p
No. MVR7824	µA7824	TO220	85p

Negative

No. MVR7905	µA7905	TO220	£1.10
No. MVR7912	µA7912	TO220	£1.10
No. MVR7915	µA7915	TO220	£1.10
No. MVR7918	µA7918	TO220	£1.10
No. MVR7924	µA7924	TO220	£1.10

µA723C TO99 **38p** 72723 14 pin Dil **38p**
LM309K TO3 **£1.20**

AUDIO PLUG AND SOCKET PAKS

Order No.		
S1	5 x 3.5 mm Plastic Jack Plugs	40p*
S2	5 x 2.5 mm Plastic Jack Plugs	40p*
S3	4 x Std. Plastic Jack Plugs	50p*
S4	2 x Stereo Jack Plugs	30p*
S5	5 x 5 Pin 180° DIN Plugs	50p*
S6	8 x 2 Pin Loudspeaker Plugs	50p*
S7	6 x Phono Plugs Plastic	50p*
S8	5 x 3.5 mm Chassis Sockets (Switched)	25p*
S9	5 x 2.5 mm Chassis Sockets (Switched)	25p*
S10	4 x Metal Std. Chassis Switched Jack	50p*
S11	2 x Stereo Jack Sockets with instruction leaflet for H/Phone connection.	50p*
S12	5 x 5 Pin 180° DIN Chassis Sockets	40p*
S13	8 x 2 Pin DIN Chassis Sockets	50p*
S14	6 x Single Phono Sockets	40p*

FIELD EFFECT TRANSISTORS

2N3819 **15p** 2N5458 **18p**

AUDIO MODULE SALE

Type	Description	Normal Price	Sale Price
AL20A	5W RMS Power Amp	£3.35	£2.65
AL30A	10W RMS Power Amp	£3.65*	£2.95*
AL60	25W RMS Power Amp	£4.35*	£3.55*
AL80	35W RMS Power Amp	£6.95	£5.95
AL250	125W RMS Power Amp	£15.95	£14.45
SPM80	35V Power Supply	£3.75*	£3.10*
PS12	20-30V Power Supply for AL30A/AL20A	£1.30*	£1.15*
PA12	Stereo Pre-Amp for AL30A/AL20A	£6.70*	£5.95*
PA100	Stereo Pre-Amp for AL60/AL80	£13.75*	£12.45*
S450	Stereo F.M. Tuner	£20.45*	£18.65*
MPA30	Magnetic-Ceramic Pre-Amp	£2.85*	£2.55*
Stereo 30	Complete Audio Chassis 7W + 7W RMS	£16.25*	£14.95*

CMOS I.C.'s

Type	Price	Type	Price	Type	Price	Type	Price
CD4000	14p	CD4018	85p	CD4035	£1·40	CD4056	£1·15
CD4001	16p	CD4019	45p	CD4037	78p	CD4069	32p
CD4002	16p	CD4020	95p	CD4040	78p	CD4070	32p
CD4006	80p	CD4021	85p	CD4041	68p	CD4071	20p
CD4007	17p	CD4022	80p	CD4042	68p	CD4072	20p
CD4008	80p	CD4023	18p	CD4043	78p	CD4081	20p
CD4009	50p	CD4024	64p	CD4044	78p	CD4082	20p
CD4010	50p	CD4025	18p	CD4045	£1.15	CD4510	£1·10
CD4011	18p	CD4026	£1·85	CD4046	95p	CD4511	£1·25
CD4012	17p	CD4027	48p	CD4047	75p	CD4516	£1·10
CD4013	42p	CD4028	80p	CD4049	46p	CD4518	£1·10
CD4015	80p	CD4029	95p	CD4050	46p	CD4520	£1·10
CD4016	42p	CD4030	46p	CD4054	95p		
CD4017	80p	CD4031	£2.20	CD4055	£1·60		

P. & P.

Please add 35p towards postage and packing unless otherwise stated.

V.A.T.

Add 12½% to prices marked*
Add 8% to others excepting those marked†
These are zero rated

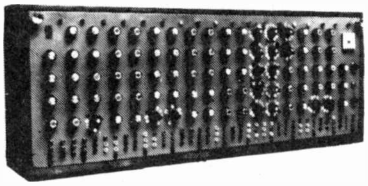
ORDERING

Please word orders exactly as printed including the part number and order number

BI-PAK

Dept. PE9, P.O. Box 6, Ware, Herts

KITS FOR SYNTHESISERS, SOUND EFFECTS



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

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

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

PHONOSONICS

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

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

Set of basic component kits	from £62.23
Set of printed circuit boards	£9.94

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

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

Set of basic component kits	£83.03
Set of printed circuit boards	£13.20

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

Set of basic component kits	£48.18
Set of printed circuit boards	£7.65

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

Component set with special foot operated switches	£7.59
Alternative component set with panel switches	£4.96
Printed circuit board	£1.43

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

Component set for above functions (excl SWs)	£7.84
Printed circuit board	£1.81

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

Component set (incl PCB)	£2.88

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

Component set (incl PCB)	£2.87

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

Component set (incl PCB)	£4.48

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

Component set	£17.69
Printed circuit board	£2.33

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

Component set (incl PCB)	£3.55

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

Component set, PCB, special foot switches	£7.27
Component set and PCB, with panel switches	£4.83

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

Set of components (excl switches) for PSU, Frequency generator, Pitch and Note Divider, Envelope Shapers, Voicings, and Control circuitries. (Order as KIT 71-5)	£109.75
Set of PCBs (Order as PCB SET 71-6)	£29.18

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

Component and PCB (but excl sw.)	£7.45

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

Component set and PCB	£4.22

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

Component set, PCB and foot switches	£4.90
Component set, PCB and panel switches	£3.48

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

Component set (incl PCB)	£3.72

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

Component set using dual slider pot	£6.86
Component set using dual rotary pot	£6.20
Printed circuit board	£1.62

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

Component set (incl. PCB)	£2.05

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

Component set (incl. PCB)	£3.64

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

Component set (incl. PCB)	£2.40

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

Main component set (incl. PCB)	£15.59
Power supply set (incl. PCB)	£7.03

CONSTANT DISPLAY FREQUENCY COUNTER (P.E. AUG. 78) FULL DETAILS IN OUR LIST.

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

Component set (incl. loudspeaker)	£11.62
Printed circuit board	£2.04

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

Standard tolerance set of components	£2.96
Superior tolerance set of components	£3.76
Regulated power supply (will drive 2 sets)	£4.69

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

Component set (incl PCB)	£4.66

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

Component set (incl. PCB)	£6.68

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

Component set	£4.52
Printed circuit board	£1.82

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

Component set (incl. PCB but excl. sw/s)	£8.19

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

Component set (incl. PCB) (Order as Kit 65-1)	£8.22

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

Component set (incl. PCB) (Order as Kit 59-1)	£5.50

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

Component set (incl. PCB) (Order as Kit 60-1)	£3.35

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

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

Component set (incl PCB)	£3.78

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

Component set (incl. PCB)	£3.97

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

Component set (incl. PCB)	£4.58

POST AND HANDLING
U.K. orders—under £15 add 25p plus VAT, over £15 add 50p plus VAT. Keyboards £2.00 plus VAT.
Optional insurance for compensation against loss or damage in post, add extra 50p for cover up to £50, £1.00 for £100 cover, £2.00 for £200 cover.
Eire, C.I., B.F.P.O., and other countries are subject to Export postage rates.

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

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

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PE

VOLUME 14 No. 13 SEPTEMBER 1978

ANALOGUE?

IN THIS fast moving world of digital technology where even the Government discusses 64K RAM (though one wonders just how many in such circles really understand what it is they are considering pouring our money into), it is all too easy to overlook and even dispense with other modes of operation. It is not infrequent that we see highly complex logic designs for equipment that could more easily be realised with simple analogue techniques.

Wonderful as digital technology is, it must never become such an overwhelming part of our lives that we overlook other more suitable circuitry. It is all too easy for any designer—amateur or professional—to become so deeply immersed in one small discipline that others are not even considered.

Most of us have seen and tried such digital games as "moon landing". All that technology, hardware and software to provide a game with a few simple variables. It really is an unnecessary use of a digital system and can be easily achieved with analogue techniques. Surely a case of technology for its own sake.

HISTORY!

It may be something of an eye opener to many readers to see an analogue computer on the front cover of P.E. "Surely these ancient devices have all but disappeared in the face of microprocessors? So what is a leading highly technical magazine doing with this—showing us some history?"

Well, if your feelings are such, then perhaps you are one of those designers who is getting out of touch with the real world and too deeply involved in digital technology! Our analogue computer is a serious instrument for the student and engineer.

It is now more than ten years since PEAC (P.E. Analogue Computer) appeared in our pages. Part of the introduction to that series stated: "A useful tool which is capable of solving complicated problems at high speed. Can be used as a model to simulate mechanical systems." Those statements are equally true of our latest design and such a system has many advantages over digital circuitry when used for certain problems. So don't overlook or dismiss the design, it could be very useful to you.

DIGITAL

What goes before does not mean we will be turning away from the microprocessor—far from it—we have some very exciting projects planned that will interest those at all levels of knowledge and interest in micros. You will find mention of what some might term a "one chip VDU" on our carryover page (p. 975). This, for those that want it, is digital technology that's bang up to date.

Over the coming months we will also be catering for those that want to build a basic microprocessor system and learn how to start programming it.

GENERAL

We know many readers will not be interested in these "computer" areas but a look at the contents page of this issue will assure them that they are not being overlooked. The variety of areas covered within our pages is vast and we hope you will find something of interest in each issue.

We give a glimpse into the future with our wave power feature and wonder just how long it will be before some of our projects are supplied from such systems!

Mike Kenward

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

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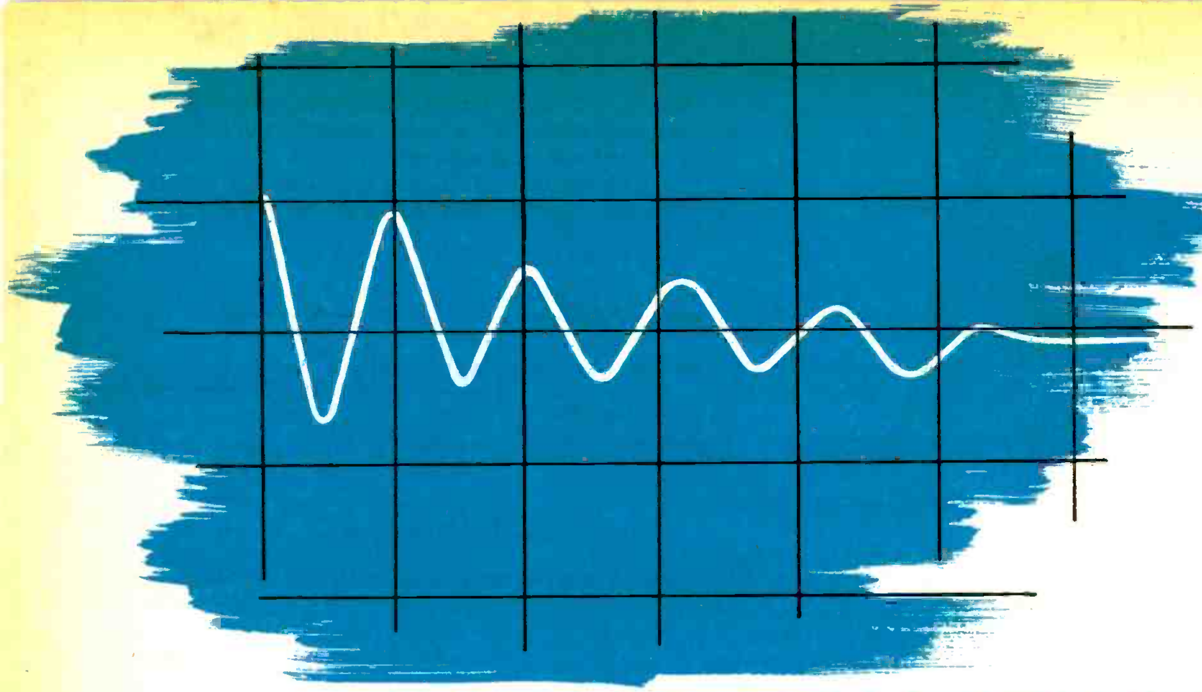
Copies of most of our recent issues are available from: Post Sales Department, IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 0PF, at 65p each including Inland/Overseas p & p.

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

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

Letters

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



★ Ten Amplifiers

★ Eight Coefficient Multipliers

★ Two Four Quadrant Multipliers

★ Over Voltage Indicators on all Amplifiers

★ Provision for "Initial Conditions"

★ Offset Null on all Amplifiers

ANALOGUE COMPUTER

P. J. KRONIS B.Sc.

PART 1

THE analogue computer is a piece of equipment designed to satisfy mathematical equations, usually differential. Mathematics in general and differential equations in particular are the subjects of an exact science which describes the behaviour of physical systems.

Because computers cannot tell us how to solve a physical problem a mathematical model of the problem has first to be formed by the programmer. This is where computers are useful because the formation of the mathematical model is usually easier than the solution of the equations especially as differential equations can be particularly difficult to solve manually and some virtually impossible.

The analogue computer works by handling continuously changing variables using electrical potential or voltage as the analogue, in contrast to the digital computer which manipulates discrete pulses to obtain the solution to a problem.

Fig. 1.1 was produced by the analogue computer to be described here and it will be explained in this article how to program the computer to produce these interesting and artistic designs.

The analogue computer can be used in engineering to simulate the behaviour of complex systems before they are constructed, the behaviour of these complex systems can be thoroughly studied and various parameters changed simply by turning a potentiometer until the system functions in a satisfactory manner. This procedure allows considerable savings both in the cost and time of development.

Analogue circuits similar to those used in analogue computers are employed in a variety of applications, i.e. automatic control in industry, aircraft and spacecraft.

One of the examples to be given in this article will be a simple program to simulate the vertical take-off of an aircraft like the Harrier jump jet, and also a spacecraft moonlanding.

MATHEMATICAL OPERATIONS AND CIRCUITS

The advances in miniaturisation have enabled more computing power to be packed into a smaller space and it is these advances that have helped the digital computer on its way towards becoming a household object. In the analogue

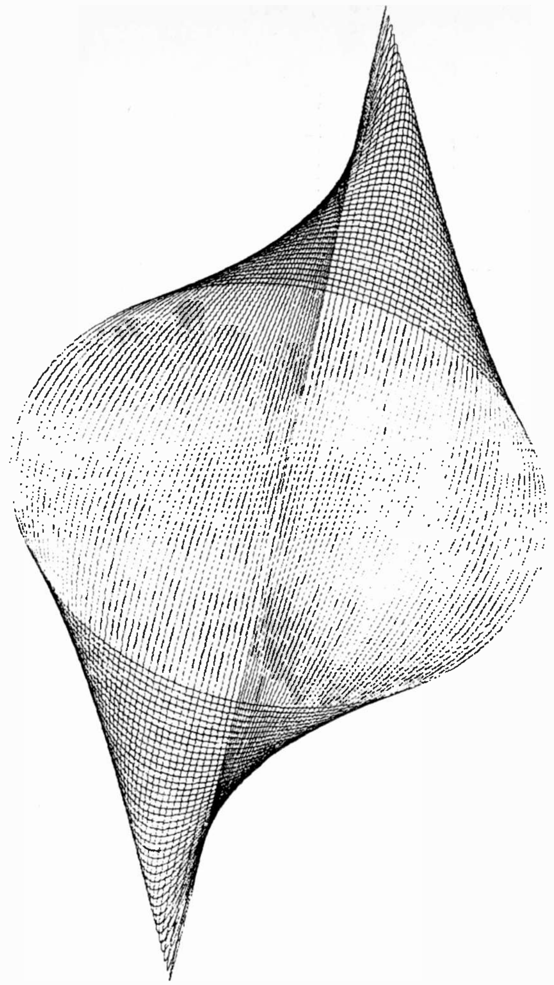


Fig. 1.1. A typical lissajous figure produced using the Analogue Computer and an X–Y plotter

field the high gain d.c. amplifier or operational amplifier which is the main element of the analogue computer, has also come a long way since its inception. It was originally designed for use in computers but has since found many applications in other fields. This large market for other applications has reduced the cost of such devices to very low levels. Of the numerous op-amp i.c.s available on the market the 741 was chosen for the prototype because it is both cheap and easy to handle. More advanced op-amps are available albeit at a higher price and constructors can experiment with these if they wish.

By connecting an op-amp to input and feedback components certain mathematical operations can be performed; addition (and subtraction) integration, and multiplication by a constant. Differentiation can also be performed but is generally avoided due to problems associated with noise generated by components. Multiplication by constant coefficients between zero and one is also performed using potentiometers with some special circuits being employed to enable the multiplication of two variable voltages.

THE ADDITION CIRCUIT

It is possible to add various voltages by means of a resistance network with the output voltage being proportional to the sum of the input voltages. The serious drawback of this method is that this is only true if the load resistance remains constant.

This would be an unacceptable constraint since the output voltage may be applied to other points in the circuit which have different values of load resistance.

To overcome this difficulty a high gain d.c. amplifier is employed in the feedback circuit as shown in Fig. 1.2.

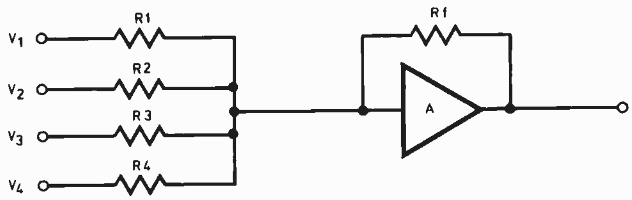


Fig. 1.2. "Addition" circuit

If a voltage V_1 is applied via R_1 to the summing junction the output voltage V_0 is equal to

$$-V_1 \frac{Rf}{R_1}$$

The polarity of the input voltage is also changed by the operational amplifier.

With the output voltage now independent of the load resistance each input voltage is factored by the same ratio of feedback resistance to input resistance.

$$V_o = -\left(V_1 \frac{Rf}{R_1} + V_2 \frac{Rf}{R_2} + V_3 \frac{Rf}{R_3} + V_4 \frac{Rf}{R_4} \right)$$

THE INTEGRATOR CIRCUIT

As with the addition circuit integration can be achieved by using an R.C. network but this method also suffers from a number of serious drawbacks.

The circuit in Fig. 1.3 shows how an operational amplifier can be used to perform integration.

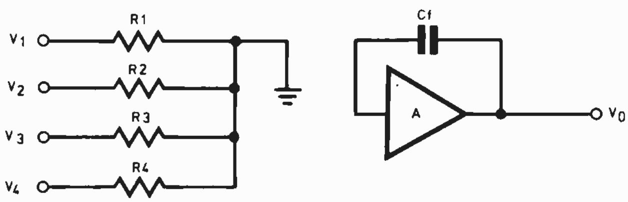


Fig. 1.3. "Integrator" circuit

With a capacitor connected in the feedback loop, and if the open loop gain of the amplifier is very large, the output voltage is given by

$$V_o = -\left(\frac{1}{R_1Cf} \int V_1dt + \frac{1}{R_2Cf} \int V_2dt + \frac{1}{R_3Cf} \int V_3dt + \frac{1}{R_4Cf} \int V_4dt \right)$$

The output voltage is the sum of the integrals, with respect to the time the voltage is applied to the inputs, factored by $-\frac{1}{Rin}Cf$.

By choosing suitable values of Rin and Cf the factors can be given the required values.

THE COEFFICIENT MULTIPLIER

The coefficient multiplier is used to multiply a voltage by a constant between zero and one. This is the only mathematical operation that is usually performed without the use of an op-amp. A potentiometer is connected as shown in Fig. 1.4.

At one extreme of the slider's travel Vo=Vin, i.e. Vin is multipled by 1, whereas at the other extreme Vo=0 i.e. Vin is multiplied by zero.

Any intermediate value can be set up by moving the slider. The dial of the potentiometer can be calibrated to facilitate this. However, it is not normal practice to set up a value on

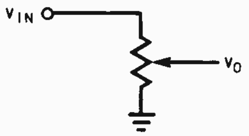


Fig. 1.4. Coefficient Multiplier

the dial of the potentiometer because this circuit also suffers from the effects of load resistance.

An op-amp employed as a voltage follower could be connected as a buffer to isolate the effects of the load resistance, but this is an unnecessary addition because the problem can be overcome by measuring the output of the potentiometer using a voltmeter, after the circuit has been connected, i.e. in the presence of the real load to be applied in the particular problem being examined. The value desired is then set by adjusting the potentiometer and ignoring the graduations on the dial.

The circuits described so far form the fundamental building blocks of the analogue computer. Various special circuits have been developed over the years for other operations. The most important of which is the formation of the product of two variables. One of the early methods developed was the cumbersome servo multiplier. This involved the control of potentiometers using servos. Nowadays this operation can be achieved electronically using four-quadrant multiplier integrated circuits.

INTEGRATION

Addition, subtraction and multiplication are concepts that are easily understood; integration, however, is not so easily grasped by the non-mathematically minded and so a simple explanation may be useful at this point.

If for example a motor car is cruising on a motorway at 50 miles per hour this can be represented by a graph of speed against time (Fig. 1.5). Since the speed is constant the distance travelled will increase by equal amounts in equal

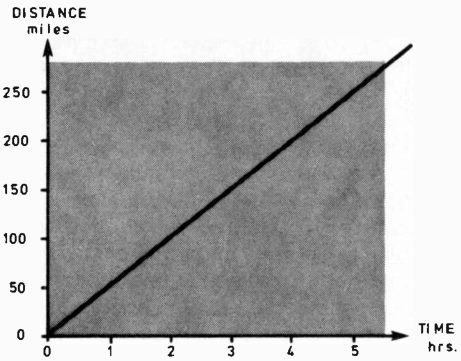


Fig. 1.6. Graph of distance against time

time intervals. These distances are shown plotted on a graph of distance against time for intervals of one hour (Fig. 1.6).

It can be seen from Fig. 1.5 that the distance travelled during a period of time is represented by the area shown shaded on the velocity-time graph. (Velocity × time representing the height × base of the shaded rectangle.) Now if the results of all these intervals were added up, the result would be the total distance travelled in a period of time.

The mathematical way of saying this is that the distance travelled is the integral of velocity with respect to time between two time limits. In the above example since the speed was constant one could have arrived at the required result by multiplying the total period of 5 hours say, by the velocity of 50 m.p.h. to obtain 250 miles travelled, without going into the trivial process of integrating, by considering small time intervals.

In reality the velocity may vary as shown in Fig. 1.7, i.e. in a random manner. To obtain the required result then, the velocity would have to be integrated over the required period of time by considering small time intervals. This is how a digital computer would be programmed to solve the problem. The accuracy in that case would depend on how small the time intervals were made. This is left to the discretion of the programmer. If the intervals were made too big, then the result would be inaccurate. On the other hand too small a time interval would mean that the computer would take longer to solve the problem and involve the programmer in unnecessary expense. The analogue computer programmer need not worry about this since the computer integrates continuously, i.e. it deals with

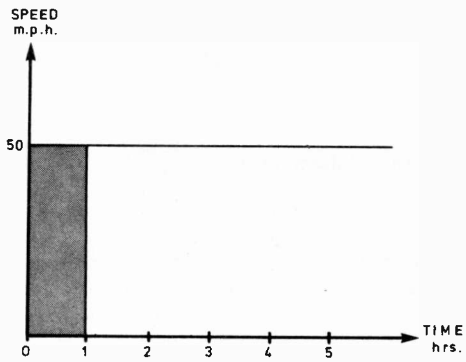


Fig. 1.5. Graph of speed against time

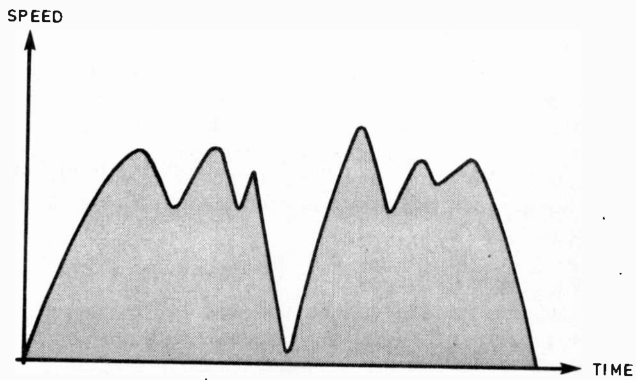


Fig. 1.7. Graph showing variations in velocity

infinitesimally small time intervals and does this at high speed.

Each of the circuits that have been described so far constitutes a computing element. When the computer is programmed to solve a problem, systems of equations can be set up by connecting together combinations of computing elements, and the results can be obtained by measurements taken at various points in the system.

The computer will of course be required to solve many different problems and the computing elements will have to be rewired every time. To facilitate this a patch panel is used, with sockets connected to each computing element in the computer. By using wire leads the computing elements can be connected in any order.

At the beginning of a computation the variables of the problem will have certain values, not all of which need be zero. The requirement here is that is should be possible, if desired, to give the output of integrators a value, before the computation commences. This facility is called "Initial Conditions".

Fig. 1.7 shows how the "Initial Conditions" for the "Compute", "Hold" and "Reset" facilities are achieved for summers and integrators. In the case of the summers no change in the circuit is necessary. For the integrators, the "Hold" mode requires that the input resistors are disconnected from the op-amp and grounded. In this way the charging or discharging of the capacitor stops and the op-amp maintains the charge at a constant level.

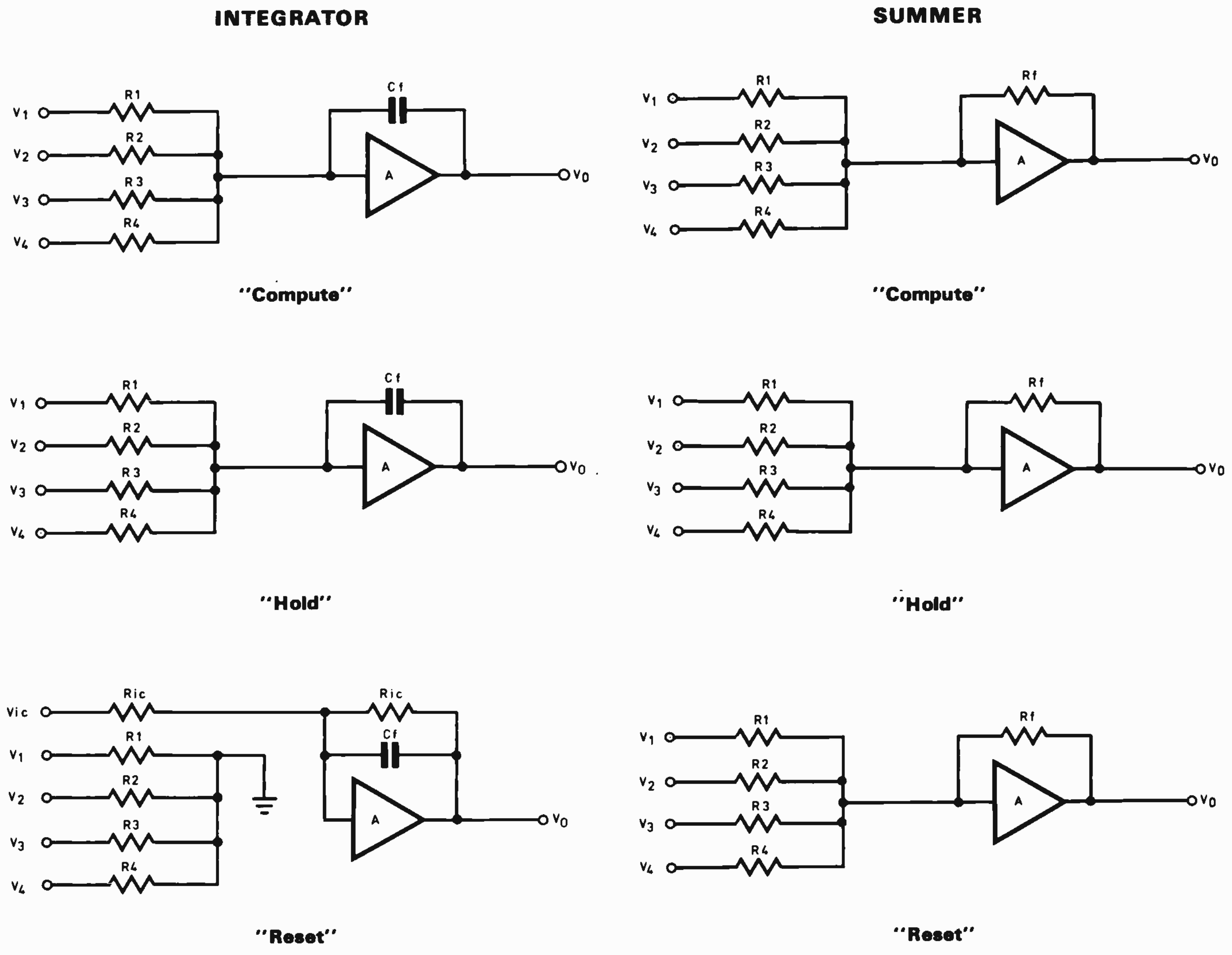


Fig. 1.8. "Initial Condition" circuits for Integrators and Summers

MODE CONTROL AND INITIAL CONDITIONS

The main modes of operation are compute, hold and reset. When in the compute mode the computer proceeds to solve the problem. As it is sometimes desirable to stop the computation after a certain period of time this is achieved by putting the computer into the "Hold" mode. The "Reset" mode is used to make the output of all computing elements take their initial value. Sometimes this mode is called "problem check".

The calculation is therefore frozen and the results can then be observed at leisure. This, however, should not be practised literally, since electronic components, like everything else, are not perfect and some drift will always affect the results. These should therefore be noted as soon as the "Hold" mode has been selected.

The "Reset" mode for the integrators has two resistors R_{ic} in the circuit. These are the "Initial Conditions" resistors and when an initial condition voltage, V_{ic} is applied as shown, the

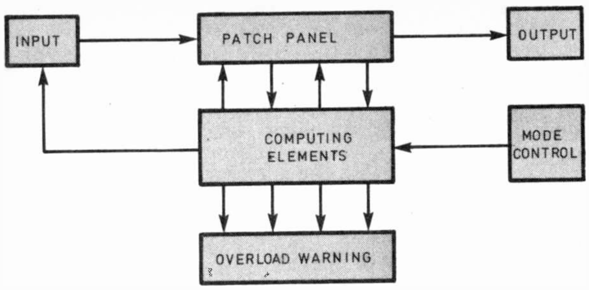


Fig. 1.9. Block diagram of the Analogue Computer

feedback capacitor charges up to this value. When "Compute" is selected these resistors are disconnected and the output of the amplifier, i.e. the voltage across the feedback capacitor, may vary above or below the initial condition value. When "Reset" is reselected the feedback capacitor discharges or charges, through R_{ic} to V_{ic} and the computer is again ready for a repeat of the calculation.

THE OVERLOAD WARNING FACILITY

This facility, usually employed in analogue computers, is necessary because the voltage range over which operational amplifiers operate linearly, is limited to approximately ±13V for readily available i.c.s. In the course of the solution of a problem, all computing elements must operate within this range, otherwise the wrong results will be obtained. The overload warning circuit warns the programmer of any amplifiers that have saturated. Measures can then be taken to scale down the values of the variables.

It is now possible to imagine the general arrangement of an analogue computer and this is depicted by Fig. 1.9 in a block diagram form.

To summarise, input signals are fed to the computing elements via the patch panel and are processed. The results are fed back through the patch panel to the output, which may be an ordinary voltmeter, a CRO or an X-Y recorder. The operation of the computing elements is controlled by the Mode Control and the overload warning circuit monitors the output of the computing amplifiers and warns the programmer of any saturating amplifiers.

NEXT MONTH: CONSTRUCTION DETAILS

readout

... a selection from our postbag

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

Champ Waves

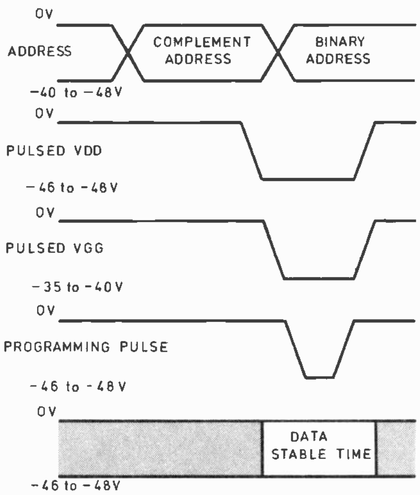
Sir—I hope you can clear up the confusion that has arisen about your EPROM programmer in the CHAMP series.

When purchasing INTEL 1702A EPROMS I was sent a data sheet, which detailed the programming voltages as completely different from those produced by CHAMP-PROG. Since you said that INTEL had supplied the basic circuit for your project, and use it in their "Intellec" development systems, it has resulted in much head scratching on my part.

The waveforms given on the data sheet are as shown.

Any clarification you can give will be greatly appreciated.

T. G. Keslake
Romford
Essex



I can understand your confusion over the difference between the 1702A data sheet and the operation of the CHAMP-PROG board, but really it is quite simple. You will notice in the data sheet that all voltages are related to GND or 0 Volts, and this means that all chip voltages are related to the Vcc pins. In CHAMP-PROG the voltages appear to be positive going, but if you look at the Vcc reference pins you will find that they rise to +47V during programming, and this means that the program pulse is a 3ms −47V pulse as required. As with many things in electronics, the secret lies in viewing the circuit operation with one's feet firmly on the ground (or in this case, the ceiling!). If you check the other supplies with this new perspective, you will find that they are substantially as dictated in the data sheet.

Once again, I quite understand your initial confusion!

R. W. COLES

Too Powerful

Sir,—Working as Product Marketing Engineer for the UK's largest distributor of National Semiconductor products I was highly amused by the letter which appeared in the July issue of P.E. from reader R. G. Silson.

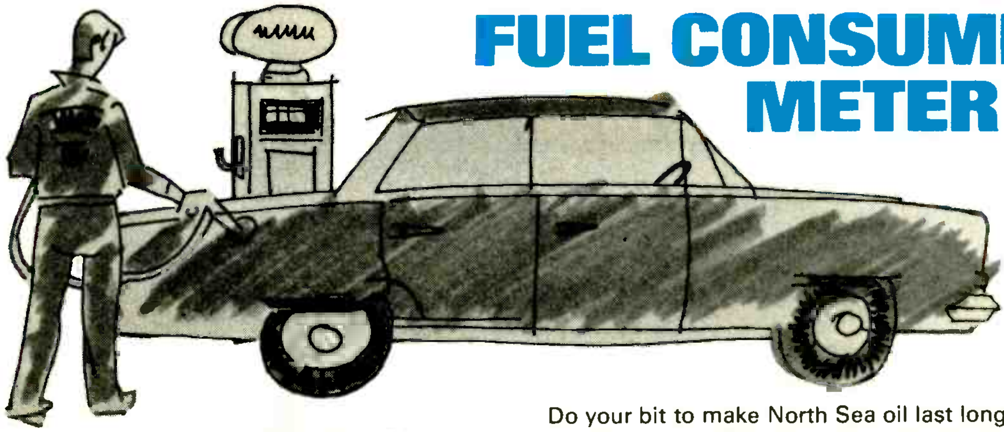
I can only assume from reading his letter that he must be extremely well versed in the world of microprocessors—indeed he must know far more than the vast majority of industry's electronics engineers.

Dealing with engineers every day from all fields of the electronics world I quite naturally get a very good indication of their thoughts and feelings towards various projects.

The number of times I have spoken to customers about the Pace microprocessor, only to be told "Not interested—it's too powerful for what we need", is more than ample evidence for myself that Mr Silson is completely out of touch with the amount of knowledge possessed by the average amateur actively engaged in microprocessors. Further proof of this is the vast amount of 8 bit SC/MP chips sold related to the relatively slow moving Pace.

P. V. Hodson,
Melton Mowbray,
Leicestershire.

...all in our OCTOBER issue!



FUEL CONSUMPTION METER...

Do your bit to make North Sea oil last longer, and save yourself some money. This two digit display shows a consumption factor, derived, via six low priced TTL chips, from an electric fuel pump and the car's speedometer. An alternative analogue display circuit is also given.

FREE! ...IN NEXT MONTH'S ISSUE

Stickies

One sheet of 120 Stickies worth 60p.

These self-adhesive labels identify pin-outs for a range of i.c.s. Useful for building and debugging prototypes, fault finding and designing p.c.b. layouts.

HIGH PERFORMANCE POWER SUPPLY UNIT

Sooner of later you will need to treat yourself to a high performance power supply unit. This design has voltage control down to zero, yes zero volts, and current limitation from a few milliamps to several amps. It uses readily available components and has a regulation system which does not employ foldback and thus can give true constant current operation.

V.D.U. SYSTEM

A complete output peripheral for almost any computer, this memory mapped system is inexpensive, easy to construct, has one chip to control all basic functions.

PRACTICAL ELECTRONICS

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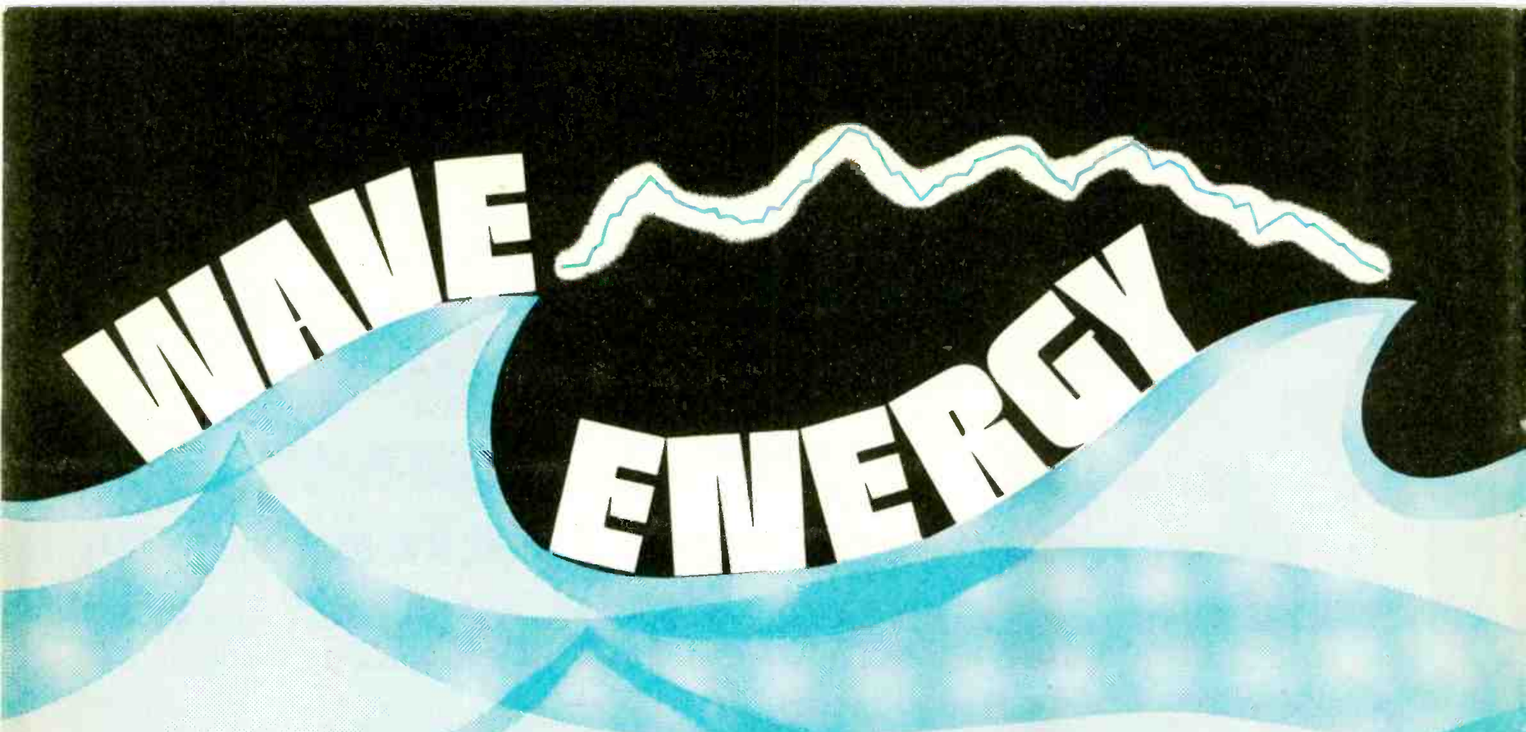
WAVE ENERGY



OUR modern world is a power assisted machine; an energy-hungry life support system for concentrated populations. The threat of *that energy* expiring with nothing to replace it is depressing, yet much publicity is given to such gloom.

Many natural sources of energy are being explored, and too often, propositions are regarded by those who seal our fate, as "pipe dreams", but put two gloomy facts together; Britain's increasing need of energy, and the pounding of winter seas against our shores, and they begin to cancel out! Wave energy is turning that power into electricity. It is possible! *It is even considered practical!*

Oceanographic data indicates that a wave-power installation 500km (310 miles) long, with 50 per cent efficiency, could in principle provide a very substantial proportion of the UK's electrical power requirement, with peak outputs meeting total demand. This calculation is doubtless intended only to allow a grasp of the kind of energy levels existing in the waves off our shores, and is not meant to be a serious suggestion; *for a few generations at least!*

The Government has recently increased its wave-power research budget from £2·5 million to £5·4 million, and to the critics who complain that it's not enough, it has been pointed out that at this early stage technical problems are not going to vanish simply by having large sums of government money thrown at them. Four inventions are being studied, and it is hoped that one of these will emerge to become the blueprint for full-blooded wave-power stations. Money spent on the three "runners-up" will presumably be deemed as having gone towards proving that the fourth *was* best, or perhaps different designs will prove appropriate for different working locations. In any case, the real money will be spent when a design stands ready for full scale construction.

COCKERELL CONTOURING RAFT

When the watts come rolling in, the CCR could well be at the source, and is currently under development by Wavepower Ltd., a company comprising Sir Christopher Cockerell (inventor of the hovercraft), and a partnership of consulting engineers. Early small scale tests conducted in simulating tanks gave such good results that one-tenth scale trials are now taking place in the Solent, where the waves are obligingly also about one-tenth full scale. The photographs show a scaled down raft, and it can be seen to consist of adjacent pontoons whereby the energy may be extracted at their hinges, either via gearing, or by hydraulic rams, to drive alternators.

The probable location of such a wave-power station, it seems, would be five to ten miles off the coast of Scotland, or the western approaches to the Engish Channel. A string of rafts about 24km (15 miles) long would generate perhaps 500 megawatts. Fifteen miles sounds alarming, but remember that a conventional power station can occupy a mile of coastline and 200 acres of land. A wave-power station would not require the continual comings and goings of ugly tankers or coal trains, nor has it any nuclear risk.

The Solent trials are being monitored by a complex computer controlled digital tape recorder system, housed in a 25m sea-going barge anchored nearby, and linked by a sea-bed cable. A considerable list of parameters has to be recorded in connection with the CCR's performance and survival characteristics before construction of a full scale station can be undertaken. Not only power outputs related to wave heights, directions and tidal forces have to be logged, but mooring and hinge loadings, wind, and barometric pressures have to be recorded too, and much more data still. On the equipment barge an EMI p.c.m. recorder is used, which is particularly sophisticated, enabling 21 data channels to be recorded on each track of a 14 track tape.

It may not be until the late 1980s that we see a full scale prototype wave-power station, but an artist's impression illustrates the magnitude of such a system.

SALTER DUCKS

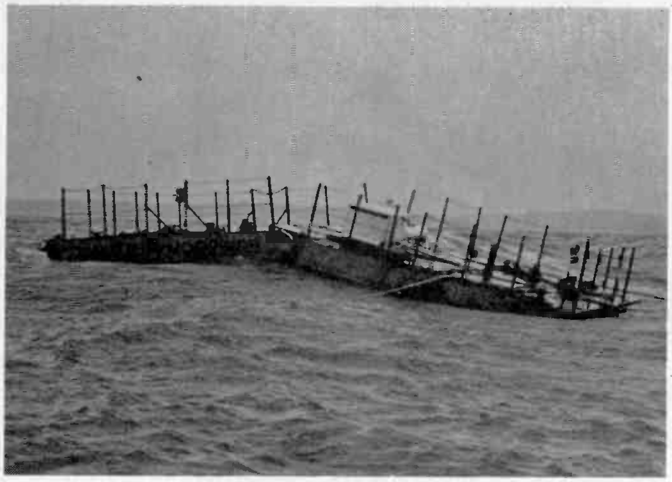
Another device for extracting power from the waves is the Salter Duck, the brainchild of Stephen Salter of the Department of Engineering, Edinburgh University.

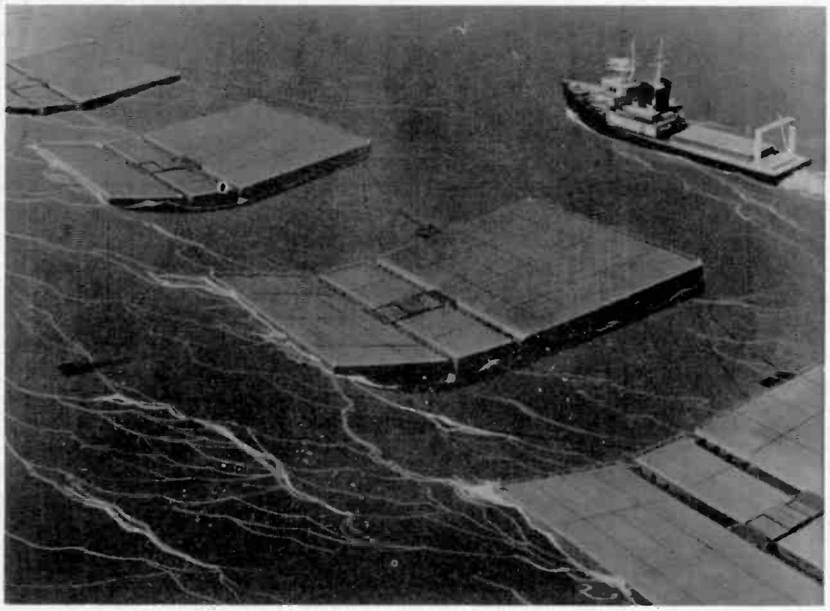
Tank tests showed that the more obvious bobbing up and down action of a "ball-cock" connected to a dynamometer would only extract about 15 per cent of the available energy in a wave; but re-orientating it to obtain a to and fro movement increased energy extraction to about 60 per cent.

So, a vertical flap was tried; however, this was found to displace water behind it, the extra impedance causing about 20 per cent of the wave energy to bounce back at the source. What was called for was a "flap with no back". The end product of this quest is shown (opposite page), and makes the oncoming wave think it's driving another wave—the optimum and natural loading situation!

The strange cam shaped segments are the ducks, and these revolve with respect to the shaft, or backbone as it is called. The combination is referred to as a string. A 500m (approx $\frac{1}{3}$ mile) backbone is clearly going to come in for some enormous

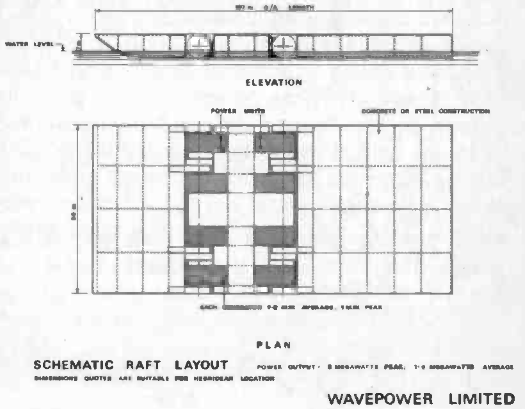
COCKERELL CONTOURING RAFT





Above: One-tenth scale Wavepower Raft under test in the Solent

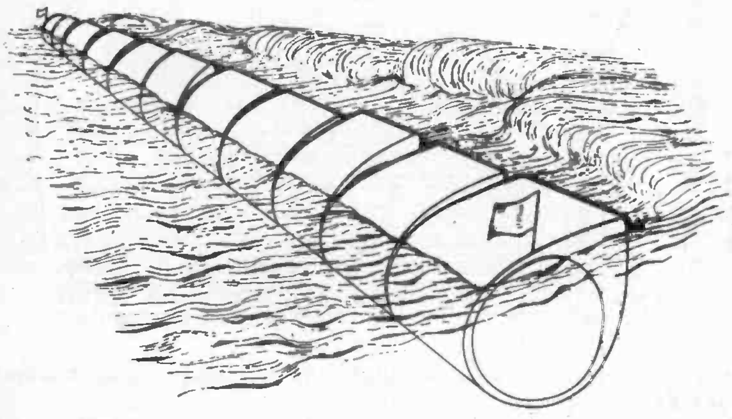
Below: Dimensions of a full-scale raft suitable for Hebridean location

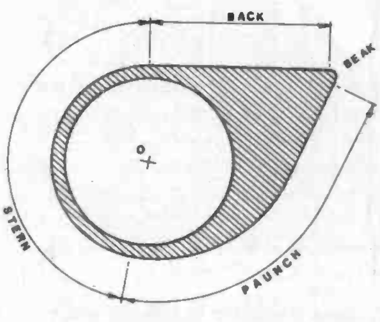


An artist's impression of a full-scale installation. All illustrations courtesy of Wavepower Ltd

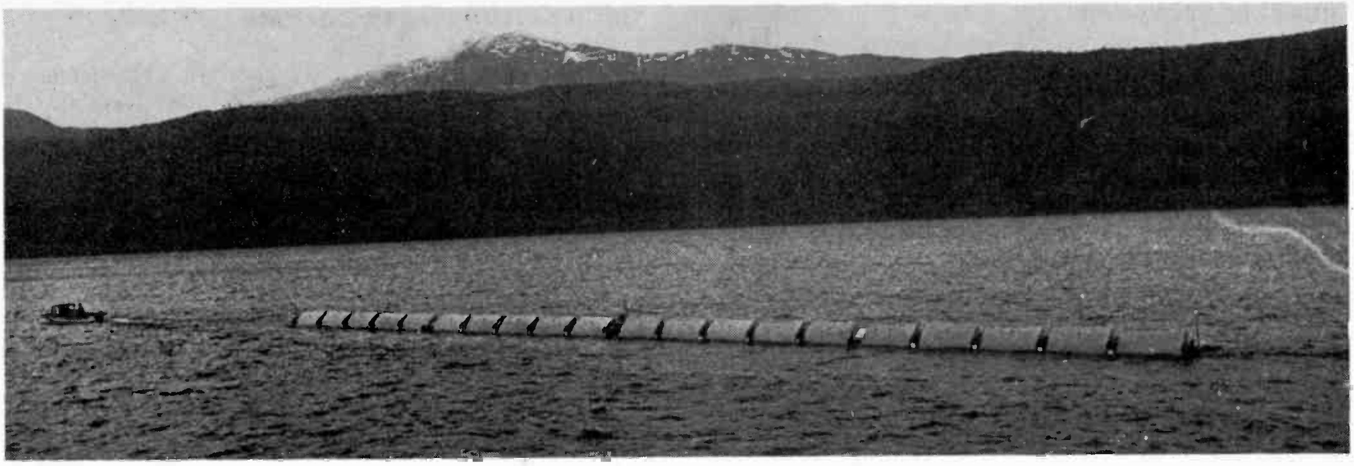
SALTER DUCK

Artist's impression of full-scale equipment





Duck anatomy



At Edinburgh University where the Salter Duck was originally developed, study is now concentrated on the theoretical and behavioural nature of the machine. On a more practical level at Lanchester Polytechnic (Coventry), Sea Energy Associates build scale models for testing. Shown above are one-fifteenth scale machines (50m string with 30 tonnes displacement) undergoing trials on Loch Ness. Illustrations courtesy of Lanchester Polytechnic

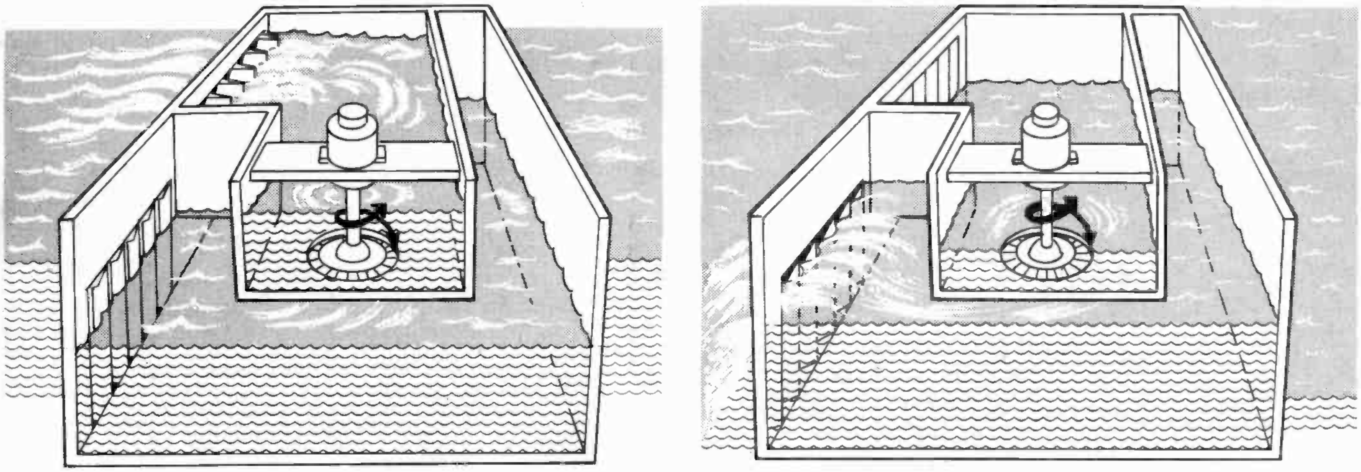
bending moments, and of the "flexible" or "rigid" alternatives for construction, the "long and strong" approach is favoured, since the backbone will experience a variety of phases of wave along its length at any one time, causing a certain amount of averaging. A design has been put forward for a kind of "bistable" backbone which will become flexible when hit by any freakishly powerful waves.

Power take-off is an inherent problem with any wave-power device, and here the ducks will have an angular amplitude of less than half a radian. In addition, duck velocities are far too low for conventional electricity generation, but such things as radial pistons (perhaps around 100 per duck) might produce a flow of hydraulic fluid at pressures of up to 3,000lb/in^2. Electricity can then be generated via hydraulic "swash plate" motors, whereby swash plate angle control will allow constant speed, irrespective of duck "nod" periodicity. Economic considerations leave their fingerprint on everything in life, and so it is fortunate that a wealth of hydrostatic rotary transmission components exist already in the commercial world.

Interesting problems are legion; such as how do you permanently moor a floating structure of some 500m in length, at over 100 tons displacement per metre, in 40 fathoms of fully exposed ocean? And how do you connect this vertically mobile object to high capacity seabed cables? Answers to these and other questions are crystallising, however, and optimism is high. Above photograph shows working model.

Electricity transmission itself poses a dilemma. Cheaper terminal equipment results with a.c. but heavier conductor is necessary to carry the capacitive currents, whereas d.c. requires rectification etc., but evades synchronisation difficulties. For long distances d.c. cables are cheaper, but the crossover distance is roughly that expected with Salter Duck positioning.

RUSSELL RECTIFIER



The Russell Rectifier is shown above in both states of flux. (left) The upper chamber fills as the wave rises. (right) The lower chamber empties during the trough of a wave. Courtesy of HRS

RUSSELL RECTIFIER

Using a rather more straightforward approach to the extraction of wave energy, the RR has a simple one-way system, (hence the name rectifier) which stores a head of water, to release it again when the wave level has dropped. Of course, on finding its way back to the sea, the water has to drive a turbine. This system, which is being developed at the Hydraulics Research Station, Wallingford, is shown on the opposite page in both states of flux.

The upper chamber allows water to enter only, via one-way flaps, and this fills up at the peak of a wave. The lower chamber allows water to leave only, using outlet ports with one-way flaps working in the other direction. These flaps are self-operating due to the pressure differentials generated by the wave motion.

Because the rise and fall of pressure from top to bottom outside the reservoir does not occur simultaneously at all points, the vertical flaps must be capable of twisting, so that they can be open at the top whilst being closed at the bottom. Large numbers of these chambers would be used in this wave-power system, and if used in shallow waters might sit on the sea-bed, but to utilise the more powerful Atlantic swell would probably form some kind of stable floating installation a few miles offshore.

An investigation into suitable low-head turbines is currently taking place, and no efficiency figures were supplied. A model at

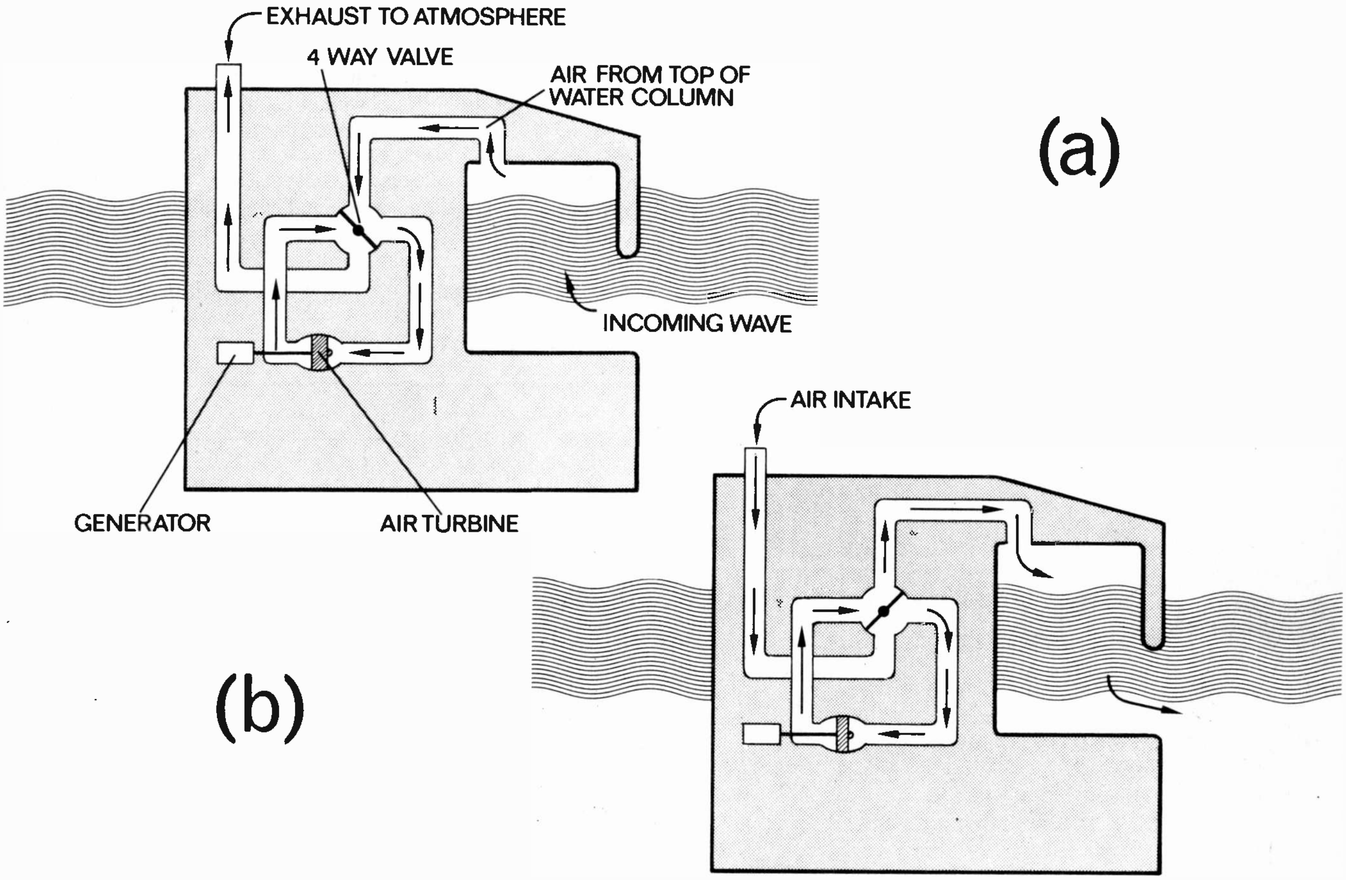
OSCILLATING WATER COLUMN

The National Engineering Laboratory found its inspiration in the Air Pressure Ring Buoy used in Japan (developed by Masuda), and which contains an air turbine-driven generator with storage batteries to provide self-energising navigational lights. The air pressure to drive the buoy's turbine comes from a cylinder in which a column of water moves up and down like a piston, the "push" being provided from underneath by oncoming waves.

This principle has been evolved to a greater level of sophistication by the NEL, who have been examining the cost/efficiency trade-off involved in intensifying the primary conversion force (that produced by the oscillating column of water), from low pressure high volume energy to a more optimum ratio.

Another aspect is that of rectification, since with the simplest form of oscillating water column, *which is nothing more than an inverted "can" with an air-hole at the top,* as air is forced out by rising water within, the air turbine would revolve in one direction. However, as the water level dropped, air would be sucked in, which would then revolve the turbine in the opposite direction. This rapid reversal of the rotor, overcoming its momentum and inertia at every cycle, is clearly not an efficient mode of operation.

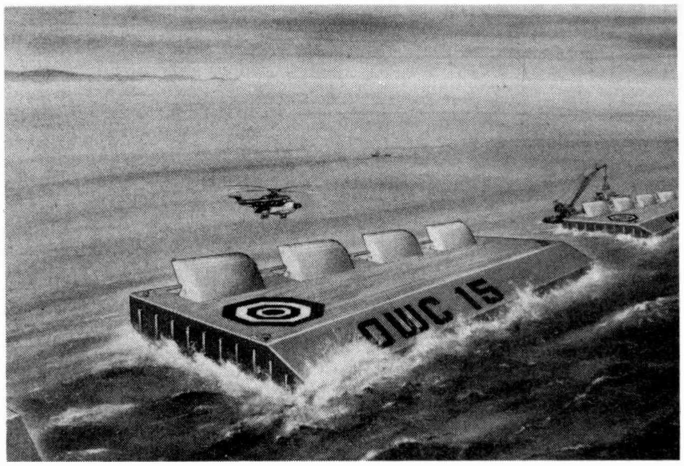
OSCILLATING WATER COLUMN



Rectification is achieved by the system shown above, which illustrates the simple OWC principle in its entirety. It employs a kind of pneumatic version of the familiar bridge rectifier circuit. A four-way valve is used to re-route the flow of air in each half cycle so that it always passes through the turbine blades in the same direction. (a) shows the airflow whilst the wave is rising, and (b) shows the situation as a wave trough develops.

Ideally the OWC should remain motionless when in action, as it wouldn't be very effective if it bobbed up and down on the waves it was supposed to convert. But it is no simple matter to build a structure rising from the seabed, out where the swell is strong, that will not bend during its first storm, particularly at a reasonable cost! It became necessary to confine investigation to the stability of *floating* structures. There are two simple guides to efficiency, one is to consider the amount of surviving wave to appear leeward of the wave-power machine, and the other is the amount of wave bounced back on impact. The OWC's cylinder has a good damping action so that the latter inefficiency is minimal.

Computer models and actual scale models have been used to arrive at the shape of structure shown, which uses the phenomenon of wave cancellation to achieve a stability which gives high efficiency of primary conversion (up to 80 per cent). Of course, the machine *could* be made so large that it hardly moves at all, but the OWC shown experiences relatively low stress, requiring only a soft mooring arrangement, and in a survival situation will limit the maximum stress by being able to ride out the "punch".



Another peep into the crystal ball. Huge volumes of air rushing beneath those cowls would surely sound like a giant in deep slumber. Illustrations courtesy of NEL

ENERGY ENOUGH?

Power from the waves should not be confused with tidal-power, although they both fall into the category known as "renewable" or natural energy sources.

The world's waves, it is estimated, have a potential energy of several times the present global demand for all forms of energy, and it seems Britain has some of the best waves in the world! Couple this with the fact that being a small island, we have a fairly favourable coastline-to-land-area ratio, and it begins to look as though the U.K. should capitalise on its pounding waves for electricity in much the same way that mountainous countries employ hydro-electric power.

Waves cannot approach solar radiation in total amounts of energy, but do exceed wind power. The waves do, however, have a unique advantage over solar energy in that they are most powerful during those winter months when electricity demands are highest, thus corresponding more usefully with our needs.

Measurements made by British Oceanographic Services lead Stephen Salter to conclude that the average power density in the North Atlantic is 80 or 90 kilowatts per metre of wave front. Other observations show that the open oceans are seldom less than 10kW/m.

In British waters, wave-power is worth having for 80 per cent of the time, and this figure moves to 90 per cent during the winter. It is possible for "no power" periods to occur (although rare), and for this reason a secondary source of electricity would be necessary. This could come from a regenerative storage system which had been accumulating energy when power exceeded demand.

CONSEQUENCES

On looking into the wave-power programme, the "contestants" in this technological race, with their ingenious contraptions, are reminiscent of the film *Those Magnificent Men And Their Flying Machines,* and if any natural energy source ever does "take off" it could well be wave-power. But like the aeroplane, which grew from a few struts to the jumbo jet with vast airport complexes and deafening noise, *could* great stretches of coastline, becalmed by strings of wave-power machinery, be ecologically altered? It has been estimated that inshore water temperatures could drop, and even harbours silt up. There would inevitably be shipping accidents too.

The nation has to ask: Is the price worth paying? One view is: The more *wave*-power, the less *nuclear* power.

BOOK REVIEWS

MOBILE DISCOTHEQUE HANDBOOK

By Colin Carson
Published by Bernard Babani Ltd
127 pages, 180 × 108mm. Price £1·35

SETTING up as a mobile D.J. can be done in a bits and pieces way but any serious disco entertainer should know a fair amount about all the elements involved.

This paperback starts with a run down of electricity basics and goes on to explain audio systems.

Quite a lot of money can be saved by studying the great range of record decks available and buying sensibly sturdy gear without being swayed by glossy exteriors. Similarly, cartridges and styli can cost a fortune but for a possibly roughly handled disco outfit the selection of a not too expensively replaced delicacy will be the best bet.

Mixers, decibels, tone controls, input impedance, attenuation, distortion, dynamic range, and wiring up a mixer are explained in some detail.

Designing and building a console is covered and advice is given on ancillary equipment—microphones, stands, headphones, cassette players, jingles.

The many types and sizes of plugs and sockets are rationalised in the section on cables and plugs.

Loudspeakers and their enclosures are very important. The relative advantages of cabinets, columns and bass bins are discussed, as is frequency splitting.

No disco is complete without lighting of some kind. Sound to light units and sequence controlled units are described, but no detailed circuitry is given.

This book may well prevent unnecessarily expensive gear being bought.

A.T.

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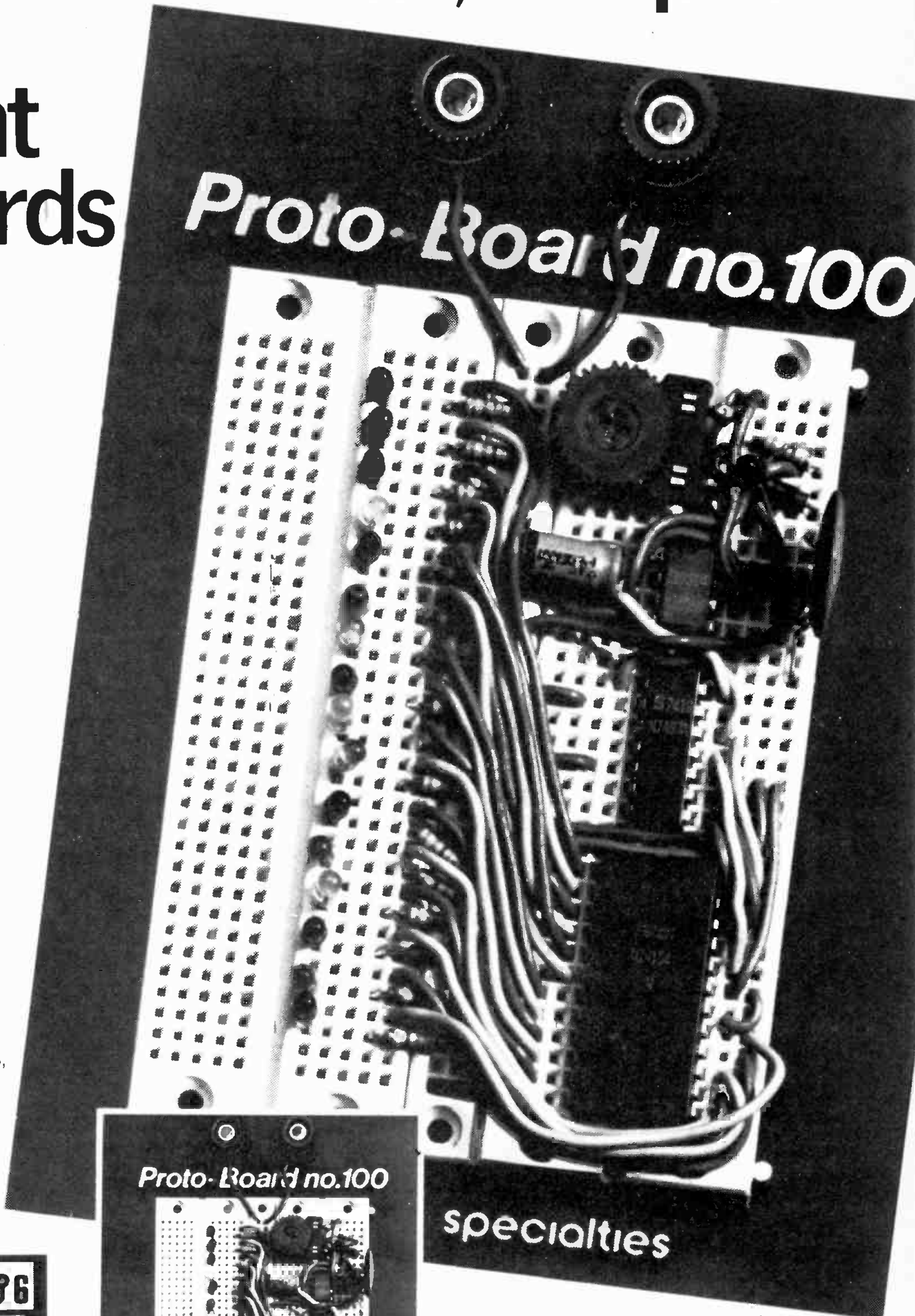

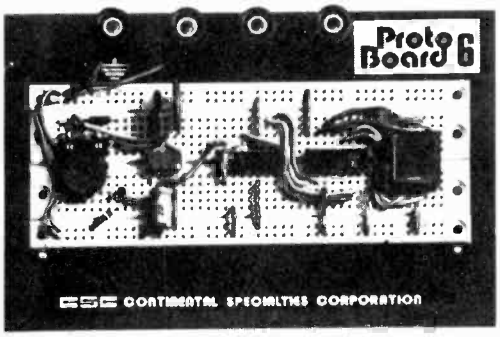

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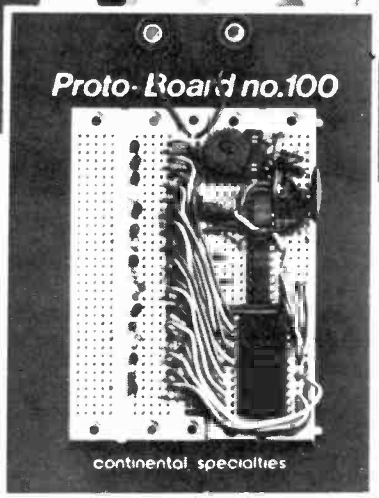

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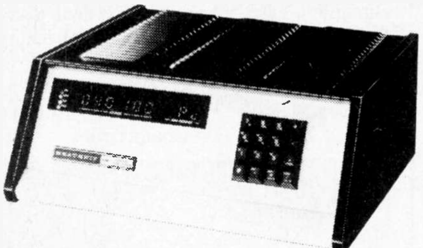

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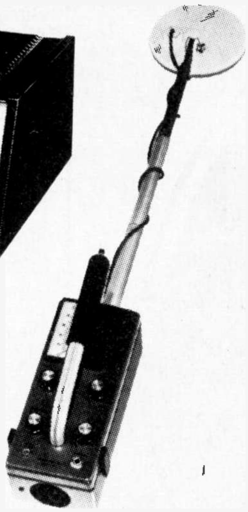

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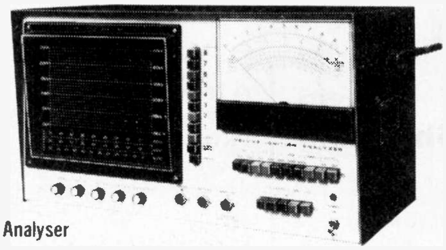

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7404	0.13	7496	0.60	74186	7.20	74LS85	0.90	74LS365	0.50	4060	0.98
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7416	0.27	74119	1.30	74199	1.48	74LS125	0.44	4006	0.92	4077	0.46
7417	0.27	74120	0.82	74221	1.50	74LS126	0.44	4007	0.16	4078	0.22
7420	0.13	74121	0.25	74273	2.15	74LS132	0.69	4008	0.92	4081	0.17
7421	0.28	74122	0.40	74279	1.25	74LS136	0.40	4009	0.45	4082	0.20
7422	0.17	74123	0.53	74283	1.70	74LS138	0.53	4010	0.48	4085	0.72
7423	0.25	74125	0.44	74284	6.85	74LS139	0.53	4011	0.15	4086	0.76
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7427	0.25	74132	0.68	74390	1.92	74LS154	1.20	4014	0.80	4094	1.80
7428	0.34	74135	0.68	74393	2.12	74LS155	0.86	4015	0.77	4095	1.10
7430	0.13	74136	0.75			74LS156	0.86	4016	0.42	4096	1.10
7432	0.24	74137	0.94			74LS157	0.47	4017	0.77	4097	3.50
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7441	0.52	74145	0.64	74LS04	0.20	74LS163	0.69	4022	0.82	4428	0.80
7442	0.55	74147	1.30	74LS05	0.20	74LS164	1.20	4023	0.15	4445	1.50
7443	0.90	74148	1.18	74LS08	0.19	74LS168	2.00	4024	0.66	4449	0.30
7444	0.90	74150	0.99	74LS09	0.19	74LS169	2.00	4025	0.15	4501	0.17
7445	0.70	74151	0.60	74LS10	0.19	74LS170	1.76	4026	1.28	4502	0.88
7446	0.70	74153	0.60	74LS11	0.19	74LS173	1.05	4027	0.50	4507	0.50
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7450	0.13	74156	0.63	74LS14	1.10	74LS189	2.85	4030	0.48	4511	0.98
7451	0.13	74157	0.63	74LS15	0.19	74LS190	0.81	4031	2.34	4512	0.92
7453	0.13	74159	1.70	74LS20	0.19	74LS191	0.81	4033	1.25	4514	2.85
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7476	0.26	74167	2.70	74LS38	0.27	74LS248	0.97	4041	0.77	4527	1.60
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7481	0.90	74172	4.00	74LS42	0.53	74LS251	1.00	4043	0.82	4529	1.10
7482	0.80	74173	1.18	74LS47	0.97	74LS253	1.05	4044	0.82	4536	3.56
7483	0.72	74174	0.89	74LS48	0.97	74LS257	1.05	4045	1.40	4553	4.20
7484	0.90	74175	0.68	74LS49	0.97	74LS258	1.05	4046	1.32	4555	0.85
7485	0.88	74176	0.88	74LS51	0.19	74LS266	0.39	4047	0.96	4556	0.85
7486	0.26	74177	0.88	74LS54	0.19	74LS273	2.50	4048	0.60	4558	1.25
7489	2.00	74178	1.20	74LS55	0.20	74LS279	0.50	4049	0.42	4566	1.40
7490	0.35	74179	1.10	74LS73	0.30	74LS283	1.00	4050	0.42	4583	0.75
7491	0.65	74180	0.90	74LS74	0.34	74LS289	2.85	4051	0.84	4585	1.03

Market Place

Items mentioned are usually available from electronic equipment and component retailers. However, where a full address is given, general enquiries may be made direct to the firm concerned. All quoted prices are correct at time of going to press.

by Alan Turpin and David Shortland

VERO ELECTRONICS AND VEROSPEED

Vero Electronics make a range of housings and passive components for the construction of electronic equipment, much of it allied to computer assembly. The range includes: circuit and breadboards, microprocessor boards, card frames, module racks and cases, wirewrapping tools and wire, connectors—direct/indirect/coaxial, Scotchflex cable/connector system, busbars, pin bars, backplane boards, fan units.

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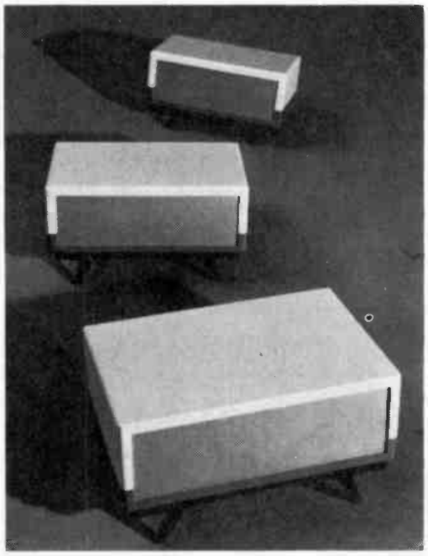
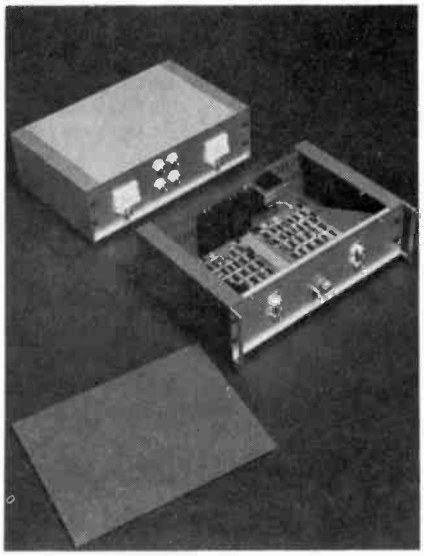


Tilt leg assembly enabling type A and type C Veroboxes to be canted at a comfortable viewing angle for displays, at 62p and 82p per kit. From Verospeed.



Top access version of Vero D series instrument case; two screws gain access; multiple front panel fixing and four optional colour finishes. By Vero Electronics.

DIAL A BOX

If you want to house a project in an aluminium case but are not too neat with the Gilbows (tin shears) then this service may appeal to you.

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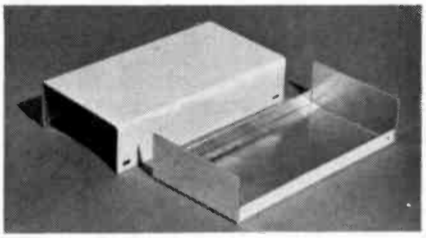


Starting at the minimum size of a one inch cube, any size of box can be made up to a maxima of 13 × 8 × 3 inches. Price guide from small boxes to large is 65p to £3·50, including postage.

The boxes may be painted with vinyl or cellulose paints which bond well to the vinyl pin seal coating.

Cannon Components, 322 Whitehorse Rd, Croydon, Surrey CR0 2LF (01-684 9872).

A NEW PROM

What is believed to be the world's first 16K PROM to go into production was recently announced by Signetics. This new addition to their range of industry standard PROMs is available only in sample quantities at present, to allow designers to evaluate the new PROM and demonstrate its cost effectiveness. Production, capable of meeting full-scale demand, is planned for 1979.

Designated the 82S190/191 the chip itself measures only 4·7 × 5·8mm, which is only 40 per cent larger than the 8K PROM! Manufacturing process is the standard diffused isolation, nichrome fuse system utilising dual-layer aluminium interconnect. Its access time is guaranteed at 80ns (60ns being typical), which is almost as fast as its 8K counterpart.

Using a bit of ingenious technology, Mullard have kept the power dissipation the same as the 4K and 8K PROMs, which is 925mW maximum (650mW being typical). The major problem overcome here was that array power would increase proportionately to the total number of rows and columns in the array. To allow size to be kept down without temperature going up, due to current consumption in the internal decoder circuitry, a technique called "power predecoding" has been used. The 128 rows of the array are predecoded into 16 blocks of 8 rows each, and only one block is powered up at any given time. A similar approach is used in the 128 columns, where a 1:16 decode is required for each of the eight outputs. The circuit is split into two 1:4 predecoding sections resulting in a further substantial reduction in power consumption.

With the addition of one TTL inverter, four 82S191s can be wired together to make up an 8K × 8 PROM, or provide two additional bits of addressing capability. Since the device outputs are tri-state, giving high Z when not selected, all four PROMs can be simply wire ORed together.

Details from **Mullard Ltd., Mullard House, Torrington Place, London WC1E 7HD.**

BYTE FROM THE APPLE

There is no longer doubt that minicomputers will eventually become an accepted part of everyday life at work *and at home.*

For teaching, such subjects as mathematics, physics, and even history (why not?), perhaps these machines will become the *interactive* text book of the future.

For entertainment, games are unlimited and can be as much fun to invent as to play.

However, not every potential user likes to dab around with a soldering iron; hence the trend towards the complete package personal computer. Another one of these has marched onto the scene: Apple II. The size of a portable typewriter, this personal computer built around the 6502 micro has a machine monitor with dis-assembler and mini-assembler, with optional 6K Basic available from plug-in PROMs.

The full ASC11 typewriter style keyboard is "beefy" enough for *real* fingers, and direct colour TV interface means you can plug it into yours, or anyone else's television set, via the aerial socket. It also interfaces to your cassette recorder for dumping programs into permanent storage.

Video games are no fun unless you get plenty of noise (engines roaring and bombs going off etc), and for this purpose a built-in loudspeaker is provided. You can also use Apple II as a music synthesiser. There are eight connectors for most peripherals such as a hard copy printer, or jacking into the Post Office Viewdata service (one computer talking to another!!!).

Where there are input and output ports, *and some imagination,* there is always need of a soldering iron. So, if you are an amateur of practical leaning, there is still plenty of scope for experiment.

The computer is powered by a switching type power supply (screened they hasten to add) for less weight to hump around—*after all it is supposed to be portable.*

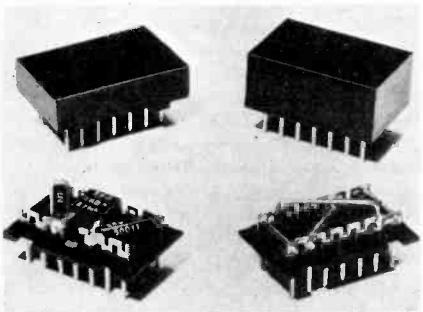
Incidentally, to aid ball type video games, paddles are included. With four analogue inputs, and a memory that can be displayed as either text, colour graphics (15 colours), or high resolution graphics, all modes being software selectable, the machine lends itself to interesting video game possibilities.

The high level language is a fast translated BASIC allowing multiple statements on one line, syntax and range errors being indicated immediately when entered. Integers from −32767 to +32767. String arrays up to 255 characters. Memory boundary adjust (does not destroy current program). Break and continue program execution. Debug commands are line number trace and variable trace. DMA facilities are PEEK, POKE and CALL commands.

The technical details go on too long for Market Place, but for a case measuring 387 × 457 × 113mm, the contents are pretty powerful with BASIC plugged in (and a TV of course!). The display format gives 24 lines of 40 characters.

Some prices. Apple II with 4K bytes of RAM will set you back £995, and is available with memory increments up to 48K bytes of RAM at £1,900. The printer costs £100, and the Applesoft BASIC cassette tape will cost you £20.

Further details from **Topmark Computers, 77 Wilkinson Close, Eaton Socon, Huntingdon, Cambs PE19 3HJ.**



D.I.Y. D.I.L.

Make up your own dedicated devices on these skeletal d.i.l. packages. Ideal for plugging in a series of timing constants; personal code keys; program addressing.

The low profile snap-on covers are a tight fit enabling the pack to be encapsulated. Two covers are available at 5·7mm or 8·9mm height.

On each row, all seven terminals are manufactured linked and individual disconnections are made using only wire cutters.

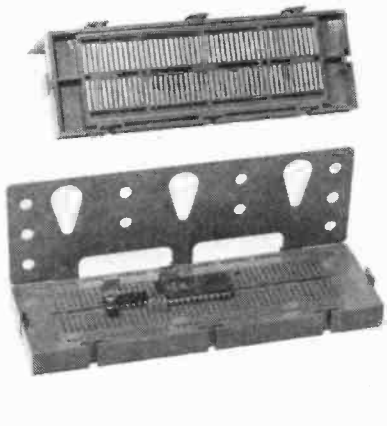
The Dilpack 14 is available in quantities of ten for £3·50 from **Erg Industrial Corp. Ltd., Luton Road, Dunstable, Beds LU5 4LJ.**

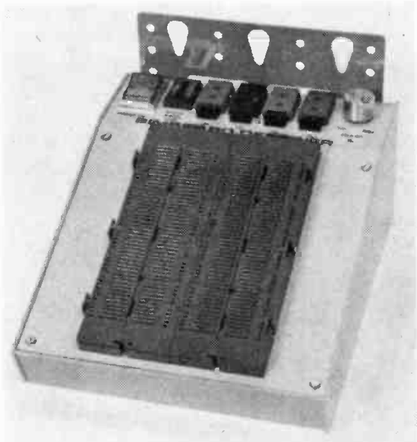
BREADBLOC

A compact breadboard system ideal for design and testing is now available from Lascar Electronics.

The unit has both a +5V 1,000mA power supply and dual tracking outputs adjustable between ±5V and ±15V at 100mA per rail. Both supplies are isolated from earth and each other.

The system enables most digital, linear, bipolar and CMOS circuitry to be accommodated on its 0·1in matrix board which contains 47 rows of 5 interconnected contacts and two continuous contact rows for the power supply rails.





The system is available with one or two boards at £39·96 and £47·95 respectively or one breadboard alone can be obtained for £7·99. To enable designers to construct a unit to suit their own power supply requirements the case itself can also be purchased for £4·48.

For further information contact **Lascar Electronics, P.O. Box 12, Second Avenue, Billericay, Essex.**

DIGITALS

Details of the watches above are, from left to right, as follows:

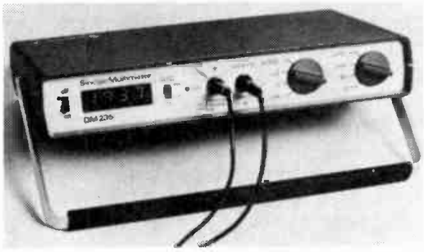
1) LLED/45, ladies l.e.d., date, stainless steel case and strap, £9·50. **2)** LLCD/3S, ladies l.c.d., cocktail bracelet, stainless steel, fully adjustable, date, £26·50. **3)** LCCRO1, l.c.d., chronograph, American electronics, six digit, net/lap/place times, back light, stainless steel, water resistant, £20·56. **4)** and **6)** GLCDB4, l.c.d. quartz, date, back light, American electronics, stainless steel, water resistant, £11·88. **5)** Solar 1, operates without batteries even in subdued or artificial light, batteries fitted provide power at night for watch and back light, batteries charged by solar panel during the day; am.pm., date, polished stainless steel, £28·98. **7)** LLCD8, ladies l.c.d., date, back light, stainless steel, water resistant, approx. size 18mm face × 8mm thick, £15·99. **8)** LLED/43, as 1) but in gold or silver cocktail bracelet, £13·99.

All watches are available by post (add 50p for p&p) from **Readers P.C.B. Services Ltd., P.O. Box 11, Worksop, Notts.**

SINCLAIR MULTIMETER

The latest digital multimeter available from Sinclair Radionics is the DM 235. The design is a direct development of their DM 2 and is a five function 21 range $3\frac{1}{2}$ digit unit which has an additional five test ranges for diodes.

The DM 235 is designed for both bench and field work and has a basic accuracy of 0·5 per cent on its d.c. voltage range of 1mV to 1,000V, 1·5 per cent on its a.c. voltage range of 1mV to 750V, 1·0 per cent on its d.c. current and 1·5 per cent on its a.c. current ranges of 1µA to 1A and a basic accuracy of 1·0 per cent on its resistance range of 1Ω to 20MΩ.

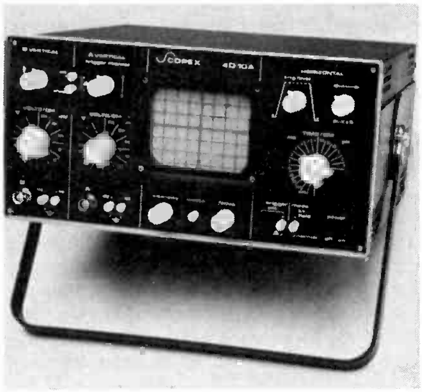


The unit is very light—less than $1\frac{1}{2}$lbs—and measures 255 × 148 × 40mm. It is powered by four dry cell batteries and optional extras include a rechargeable battery pack, carrying case and a 30kV probe.

The price of the DM 235 is £49·80 plus VAT. For further details contact **Instrument Division, Sinclair Radionics Ltd., London Road, St. Ives, Huntingdon.**

SOMBRE SCOPE

Black will be the season's fashion colour for oscilloscopes. This is the pronouncement of Scopex who carried out a European marketing survey earlier this year. They were surprised to find that, while turquoise casings with white front panels were the popular twin-set colours in 1976, continental engineers are all for black gear now.

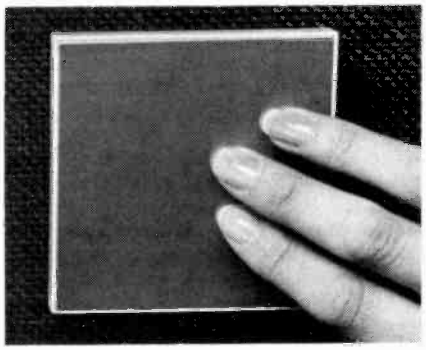


The black 4D10A dual trace scope, at £180, still retains the characteristics of the 4D10; stabilised power supplies in both the low voltage areas and e.h.t. allowing mains variation of as much as ten per cent. Accuracy on both time and voltage measurements is three per cent.

Scopex Sales, Pixmore Avenue, Letchworth, Hertfordshire SG6 1JJ.

LIGHT TOUCH

The new touch dimmer control from Superswitch can be operated by a quick firm touch anywhere on its front panel whilst a long touch will vary the light output at a pre-set rate. To complete a full cycle from bright to dim and back to full brilliance again takes approximately six seconds.



A subsequent long touch will alter the light level in the reverse direction and removing the hand from the control during the cycle will establish the light level.

Further switching on and off will not alter the selected brilliance and thus the control acts as a pre-set dimmer.

Any number of slave units can be used with a master to enable two way and multi switching to be obtained.

The price of a Master unit is £11·60 and a Slave unit is £4·50. For further details contact **Superswitch, 7 Station Trading Estate, Blackwater, Camberley, Surrey.**

FOURTH BATCH

Scrumpy is a crude cider, but John Miller-Kirkpatrick's Scrumpi seems to become more refined with each brew. Scrumpi 4 offers the following features: 1K RAM + 7K expansion sockets (2114), 8K expansion PROM sockets (2708/16), an additional socket for 2K/4K ROM, a socket for 8K ROM, an 8-bit bidirectional I/O port, a cassette interface option, a 2708 programmer option, and on-board voltage regulators. But new is the 4K ROM containing BASIC!

Up to personal computer standard, this SC/MP-2 based MPU is supplied with the ROM ready to speak NIBL (National Industrial BASIC Language) which requires the 1K of RAM capacity to operate. The price of the Scrumpi 4 basic system p.c.b. is £150.

As part of the deal you get the circuit for a PROM programmer, and components for this are available as an add-on pack. An interface is provided to any 20mA loop TTY device (which could be Scrumpi 3!), whereby all main I/O commands are processed by the NIBL ROM.

A fully extended Scrumpi 4 could have 16K RAM plus 16K ROM/PROM, or 8K RAM plus 24K ROM/PROM. Bywood Electronics can support their MPU kits with education facilities and a good range of i.c.s for interfacing with the outside world. A set of books for beginners, called Microsense (complete with cartoons), is available from Bywood, and are given away free with all Scrumpi kits.

More from **Bywood Electronics, 68 Ebberns Road, Hemel Hempstead, Herts HP3 9QR.**

Strictly Instrumental

by K. Lenton-Smith

Organ "nuts" are often mentioned on *The Organist Entertains*, a good example being the case of Stephen Capaldi. According to a recent newspaper report, he said he had been let down by women so often that his third marriage would be to his £8,000 organ. The vicar of St. Paul's, Gloucester, had agreed to perform a service blessing this organ and, at the climax of the service, Mr Capaldi had planned to play his favourite piece "Don't Cry For Me Argentina". However, the vicar, cancelled the service when he heard that it was to be regarded as a wedding ceremony. So another sorry chapter was added to his love life!

At least he tried to be different—but a far better approach would be to consider the latest electronic music i.c. to be announced by Signetics. A frequent complaint in this column is that basic circuit principles have remained unchanged for several decades, counting aside miniaturisation. The TDA 1008 is no exception, but its design is such that it is destined to become an extremely popular device. This extended article will be devoted to looking at some of the many features it offers.

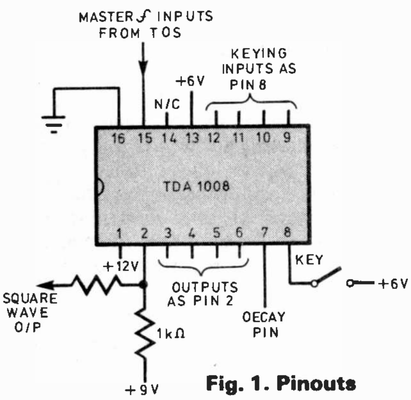


Fig. 1. Pinouts

INPUT PINS

OUTPUT PINS	8	9	10	11	12
2	f*	f/2	f/4	f/8	f/16
3	f/2	f/4	f/8	f/16	f/32
4	f/4	f/8	f/16	f/32	f/64
5	f/8	f/16	f/32	f/64	f/128
6	f/16	f/32	f/64	f/128	f/256

* f = master frequency from TOS

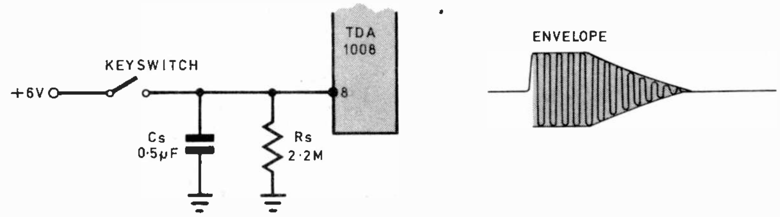


Fig. 2. Sustain mode

TDA 1008 Based on integrated injection logic, this monolithic bipolar device produces square wave output voltages that are symmetrical about a given d.c. voltage, thus overcoming key click problems. It can be driven directly by a Top Octave Synthesiser (TOS) and applies this signal to an internal chain of eight bistable dividers. The nine resulting frequencies are matrixed with nine gates so that each of five keying inputs can select a different combination of five successive octaves.

Bistable divider i.c.s have been in existence for a good many years, and gating i.c.s, but the TDA 1008 combines both functions in a 16 pin package, with the added advantages of TOS drive and ability to control the envelope widely. Assuming a single manual instrument was required, this could now consist of 13 i.c.s (TOS and 12 × TDA 1008), tone forming and amplification; a single keyswitch would control its five pitches.

Three positive supply voltages are required (6, 9 and 12V), the supply current being some 13mA with all keys activated. Keying input impedance is greater than 8MΩ and the input frequency can be up to 100kHz if required. Fig. 1 gives pin connections for the device, which will be seen to have five keying inputs (pins 8 to 12), five outputs (pins 2 to 6), and a Decay pin (pin 7). Fig. 1 shows the truth table.

Master frequencies from the TOS are applied to pin 15, the truth table indicating the effect of keying various inputs. Using a 5 octave keyboard, pin 8 of the twelve TDA 1008s would be used to key the top octave, pin 9 for the next, etc. In its simplest form, keying is achieved by supplying +6V through a keyswitch. Signal output voltage is proportional to keyed input voltage, whilst multiple inputs produce sum signals. Unused outputs should be connected to +6V to avoid intermodulation, though all five will normally be in use.

SUSTAIN The simple keying of Fig. 1 is not pleasing musically, as attack is immediate and decay non-existent. Adding a Sustain capacitor Cs and Sustain resistor Rs will cause the output to die away gradually, as shown in Fig. 2.

Because Cs is charged when the playing key is depressed, a resistor could be inserted between the 6V supply and keyswitch if there is any tendency for the key contacts to spark. This situation would probably be abnormal, but such a resistor could be chosen to imitate the slower attack of a pipe organ. The desired time constant RC could be calculated (where C = Cs).

DECAY Overall control of Decay is by means of pin 7, where all twelve pins are commoned and provided with a small variable voltage. Fig. 3 suggests a method of obtaining the Decay voltage from the 6V line (variable between 0·7V and 2·5V) which will control Sustain period across the manual. See Fig. 3.

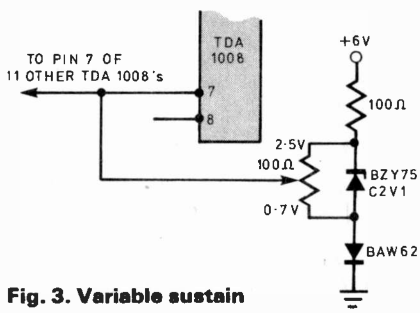


Fig. 3. Variable sustain

PERCUSSION If a changeover keyswitch is employed so that +6V keeps a Percussion capacitor Cp charged in "key up" mode, depressing the playing key will allow Cp to discharge through the input gate. Rs provides sustain as before, the principle being shown in Fig. 4.

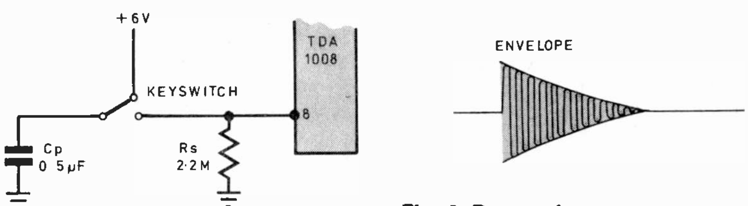


Fig. 4. Percussion

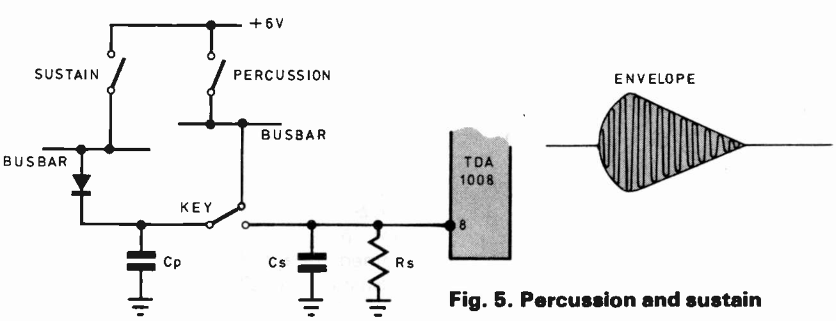


Fig. 5. Percussion and sustain

A combination of Percussion and Sustain is shown in Fig. 5. One capacitor now loads the other, so that staccato playing will produce a larger output than legato. Because the TDA 1008 gives an output voltage that is proportional to the input, we now have *touch-sensitivity*. The effect is similar to an acoustic piano with "loud" pedal in operation.

There are a number of possible variations on this theme. Joining the earthy ends of several Cs together, though not actually earthing them, will cause other gates to open momentarily. This effect may be switched out by earthing the common Cs point. If the seventeenth interval (or 29th note higher) is coupled in this fashion, *chiff* can be produced.

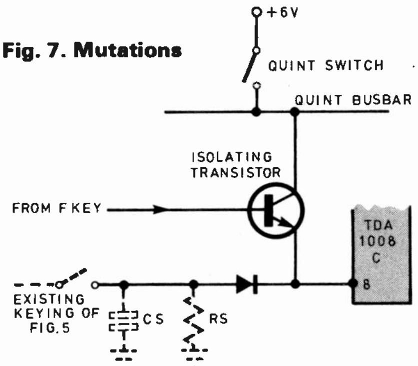
DAMPER ACTION Unless the "loud" pedal of an acoustic piano is pressed, the string is damped as the key is released. To imitate this effect, three more components may be added to the input circuitry, as shown in Fig. 6. Here we require percussion with decay that falls to zero. On releasing the key, the 6V supply is pulsed through Ck, making the transistor conduct briefly and so discharge Cs. The time constant RkCk is sufficient to prevent the transistor conducting if the playing key is struck repeatedly.

QUINT The gate of one TDA 1008 may be controlled by a different chromatic playing key if mutations are required. Fig. 7 shows the method for obtaining a Quint. If F is keyed, C will sound when 6V is supplied to the isolating transistor. The Quint, or other mutation, will still be subject to Sustain and Percussion as before.

Although the proportional nature of input to output voltages has been mentioned, 6V should be regarded as the maximum for the Percussion busbar. Failing this precaution, gates other than those actually keyed could open. Aside from this warning, the possibilities for envelope control are legion. These brief circuit details may serve to give some idea of the flexibility of the TDA 1008.

OUTPUTS The square wave signals could be rounded off individually by low pass filters, and applied to drawbars for an *additive* harmonic synthesis system. With this in view, it is essential to filter individual frequencies rather than trying to filter the mixture from the drawbar busbars.

With *subtractive* tone forming, the best starting point is a sawtooth waveform, containing both even and odd harmonics. A staircase waveform is a close approximation to sawtooth and is obtained by mixing octave related square waves in given proportions. The resistive network of Fig. 8 shows how to apply this principle for feeding subtractive filters. Compared with Fig. 1, alteration has been made in the value of load resistors, and the output pins are now resistively coupled together.



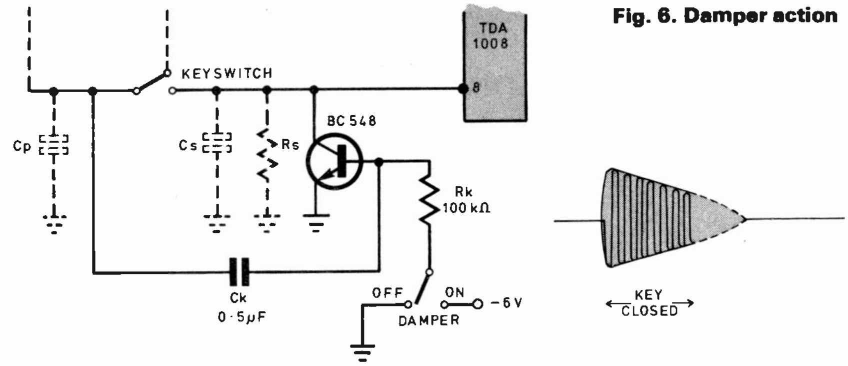


Fig. 6. Damper action

APPLICATIONS The many features of TDA 1008 would appear to make it ideal for the rhythmic player. Organ tones would be available on an electric piano and vice versa.

Before serious musicians dismiss this device as just another gadget for popular music, it should be noted that the only commercial organs made using the TDA 1008 to date are strictly *classical*. Details of this i.c. have been released to the press only within recent weeks but *Electrophonic Organs* of 56 Bedford Place, Southampton, have been building instruments to customers' specification using this device for some time. First in this field, their price list quotes a typical three manual organ, classically voiced and with mutations, at £2,865; eight sets of twelve TDA 1008s are used. This firm will be pleased to quote for a given specification, their telephone number is 0703 21265.

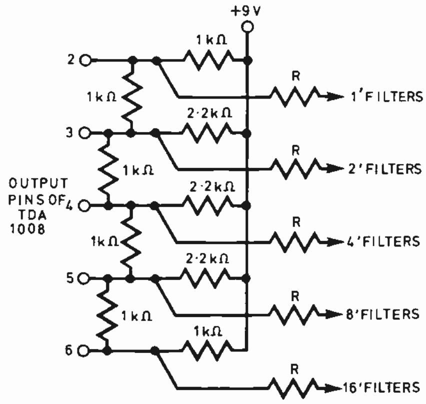


Fig. 8. A method for staircasing the output pitches as an alternative to square waves produced by the simple arrangement in Fig. 1

COST This article will have made it clear that a set of twelve TDA 1008s will have 60 gates in all, to cover one five octave manual (with top C breaking back). The second manual will require a further set and, for the small additional cost of another TOS for these, chorus effect is possible.

A single unit costs £2·90, whereas 25 off is at £2·32 per device. Although this may seem rather expensive compared with other i.c. systems, its versatility makes it an excellent proposition for anyone embarking on construction of a fully comprehensive instrument. Commercial firms will certainly opt for it increasingly because of the reduction in both interwiring and keyswitching it allows.

Ideally, the Pedal section requires a set of TDA 1008s to itself, though a monophonic system might be used here for the sake of economy. But if cost was not important, three sets per manual would allow a full range of pitches, including mutation stops, and form the basis of an excellent instrument. All in all, the TDA 1008 is bound to become an important part of the current generation of commercial and home-constructed electronic instruments.

ELECTRONIC COMBINATION LOCK

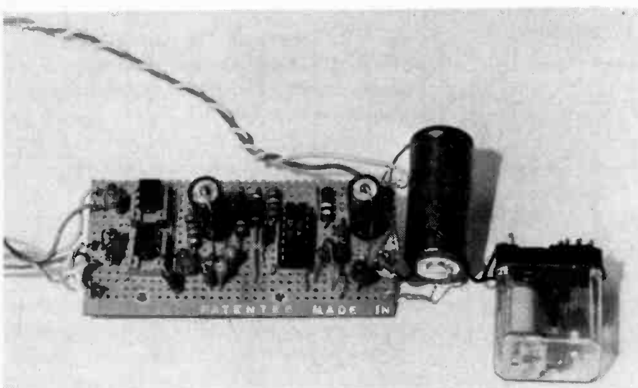
E.A. PARR B.Sc.

THIS article describes an electronic code lock suitable for door or cupboard. To gain entry a person has to dial up a four digit code on the key panel and press a push button. The four decade switches then have to be all returned to zero and the button pressed again. The lock will then open for a preset time.

This double entry on the switches ensures that the important first code *is not left set* on the switches after entry.

CIRCUIT DESCRIPTION

The circuit is shown in Fig. 1 and the key panel is identified by the shaded area at the top of the diagram. The principle of the circuit is to detect current flowing from S4 to S1 on the first code, and from S1 to S4 on the second code. Diodes D1 to D6 on the coding board pass current when the correct code is set up.



As drawn, the first code is 4057, and D2, D4, D6 allow current to flow from the first code cable to S5. Similarly the second code is 0000; D1, D3, D5 allowing current to flow from S5 to the second code cable.

The code is set up on the red and black flying leads from the coding circuit board. Black leads set up the first code and red leads the second code. There are no restrictions on either code (except the least significant digits cannot be the same), and the codes can be easily changed.

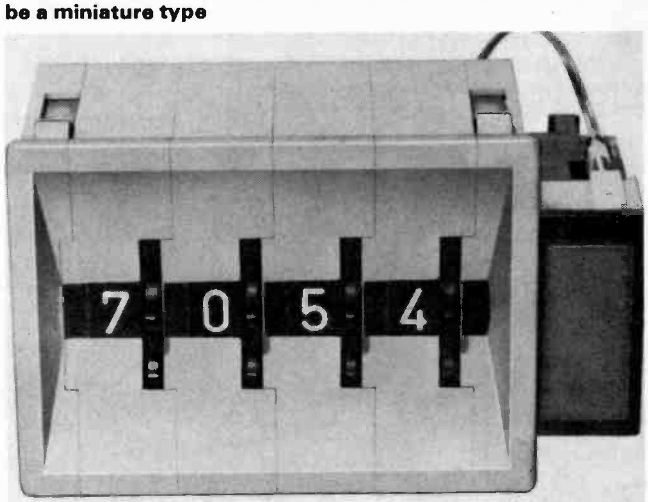
The supply for the currents through the switches is derived from a ±15V supply and S5 applies the centre common. The current flows through opto-isolators IC1 and IC2 which pass the signals to the remainder of the electronic circuit. Opto isolation was considered advisable in view of the likely distance between the key panel and the electronics box. Thus IC1 is energised for a successful first code and IC2 for a successful second code. D9 and D10 are in the current paths for each code, and are useful for checking the operation of the key panel. IC3 is a dual timer, with circuit (a) connected as a monostable with a period of 30 secs and circuit (b) as a monostable with a period 10 secs.

The correct first code fires IC3(a) via the filter R1, C2 and R4. The output of IC3(a) is connected to the reset of IC3(b) (pins 5 and 10 linked). IC3(b) is thus normally inhibited but can now be triggered. The correct second code now fires IC3(b), operating the lock solenoid via RLA contacts. Note D7 in series with RL1 coil as well as the usual diode (D8) across it. This is necessary with 555 timers, because the −0·8V at the coil as D8 clips the back e.m.f. can cause retriggering problems.

After 30 seconds IC3(a) times out and the reset signal is applied again to IC3(b). It is therefore necessary to reset the code and open the door within 30 seconds of setting up the first code *or you have to start again.*

The power supply is straightforward. The 12V supply for the 556 is obtained from an i.c. regulator (IC4), but note that for maximum noise immunity the ±15V supply for the switches is floating, and is not connected electrically to the rest of the circuit. The two secondaries of 15V and 12-0-12V could, of course, be obtained from two independent transformers.

Any 10-way switches will suffice for setting up the unlock code. Although the author has used the type shown below, a cheaper alternative is to use wafer switches with the switch positions marked on the front panel. The push button switch S5 is shown adjacent to the code switches. S5 can be a miniature type



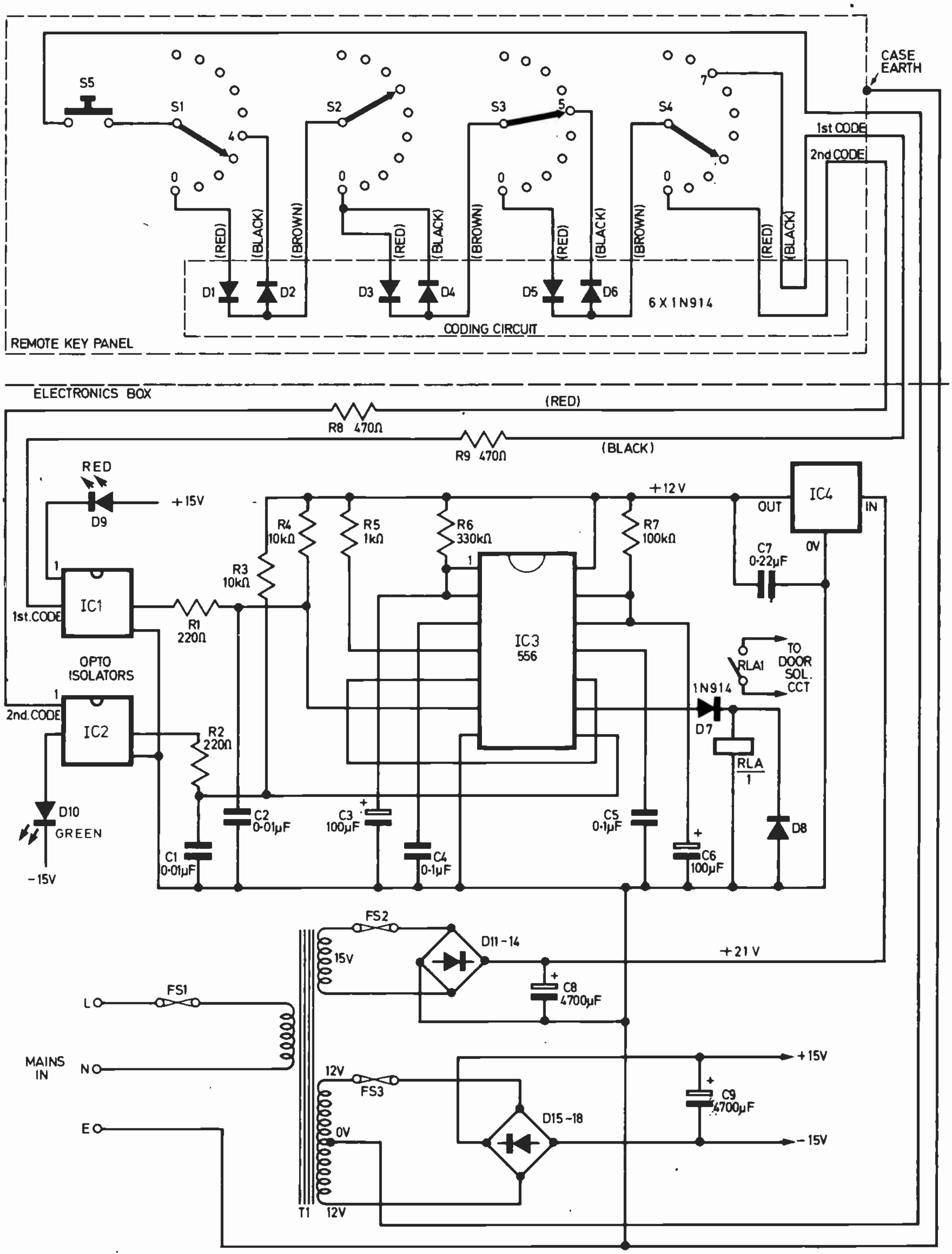


Fig. 1. Full circuit diagram including suggested power supply arrangement

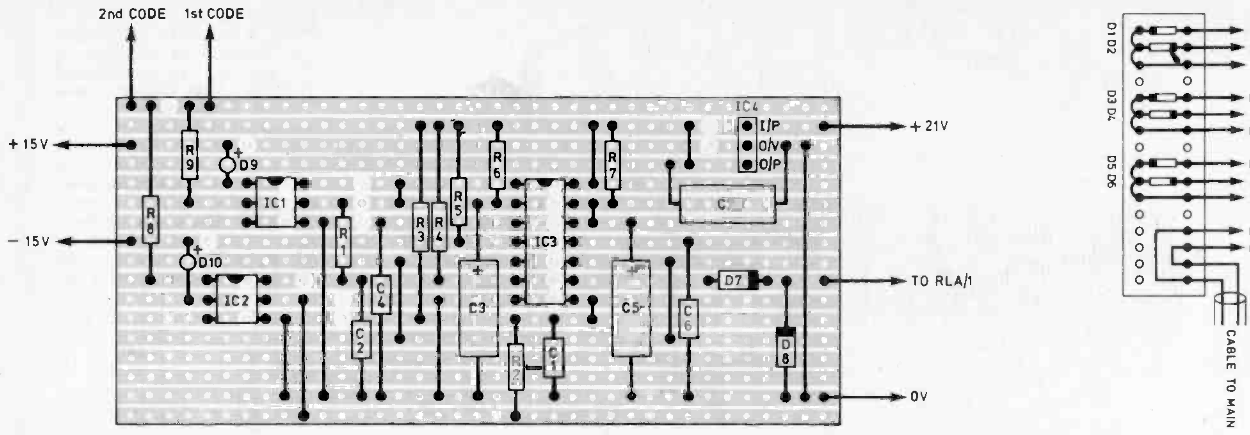


Fig. 2. Stripboard layout of the Combination Lock. The diodes D1 to D6 are mounted separately on a tag board which can be placed next to the code switches. The diode tag board is shown above right

COMPONENTS . . .

Resistors

R1, R2	220Ω (2 off)
R3, R4	10kΩ (2 off)
R5	1kΩ
R6	330kΩ
R7	100kΩ
R8, R9	470Ω ½W (2 off)

All resistors ¼W 5% except where stated.

Capacitors

C1, C2	0·01μF (2 off)
C3, C6	100μF 25V elect (2 off)
C4, C5	0·1μF (2 off)
C7	0·22μF
C8, C9	4,700μF 40V (2 off)

Diodes

D1–D8	IN914 (8 off)
D9	0·1 in l.e.d. (red)
D10	0·1 in l.e.d. (green)
D11–14, D15–18	Rectifier stack 1A (2 off)

Integrated circuits

IC1, IC2	Opto-isolator (Maplin)
IC3	556 Dual timer
IC4	12V 1A Regularor. μA7812UC

Solenoid

240V operation (R.S: 349–478 is suitable)

Miscellaneous

S1–S4	Any type of numbered decade switch (4 off)
S5	Push button switch
RLA/1	12V relay with n.o. mains contacts.
T1	Mains transformer with 0–15V (1A) and 12–0–12V (100mA) outputs. (This can be two transformers)

CONSTRUCTION AND INSTALLATION

The circuit was constructed on Veroboard, the layouts being shown in Fig. 2. The code is set up using the red and black leads along the switch bank.

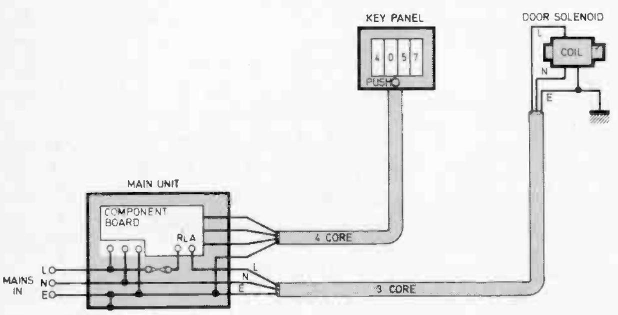


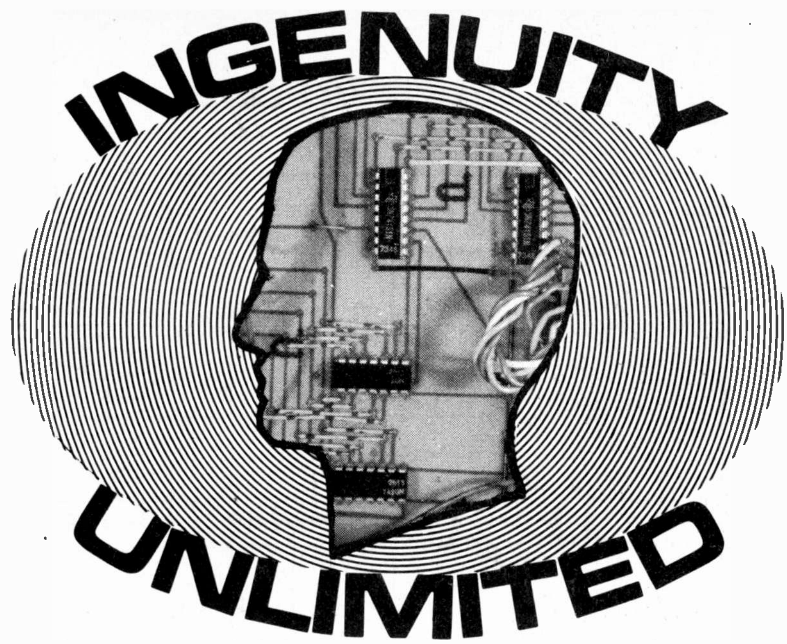
Fig. 3. Wiring diagram of solenoid circuit. Care should be taken when wiring up this mains portion of the system

The unit consists of two boxes, the control box and the key panel. The control box can be any normal electronic case, but the key panel should be constructed with care if tampering is likely. For example, this box should be made so that its innards are accessible only from inside the building, or the lid fitted with Allen keys, then the Allen key holes drilled out to the lid can only be removed with a drill. If necessary the key panel box should be weatherproofed.

The door lock can be any 240V solenoid. Connection of the various units is shown in Fig. 3. Normal care should be taken with the solenoid connections to prevent danger of shock from the 240V mains.

Because of the simplicity of the circuit, testing is straightforward. The two l.e.d.s in series with the opto-isolators allow the correct operation of the key panel to be monitored. D9 should illuminate for a correct first code, and D10 for a correct second code.

One final word of warning: In case of component failure, always have a concealed standby means of opening the door. Even if this standby method is pretty inconvenient, you will have the peace of mind of knowing that should there be a power cut when you wish to gain access, you can get in one way or another. ★



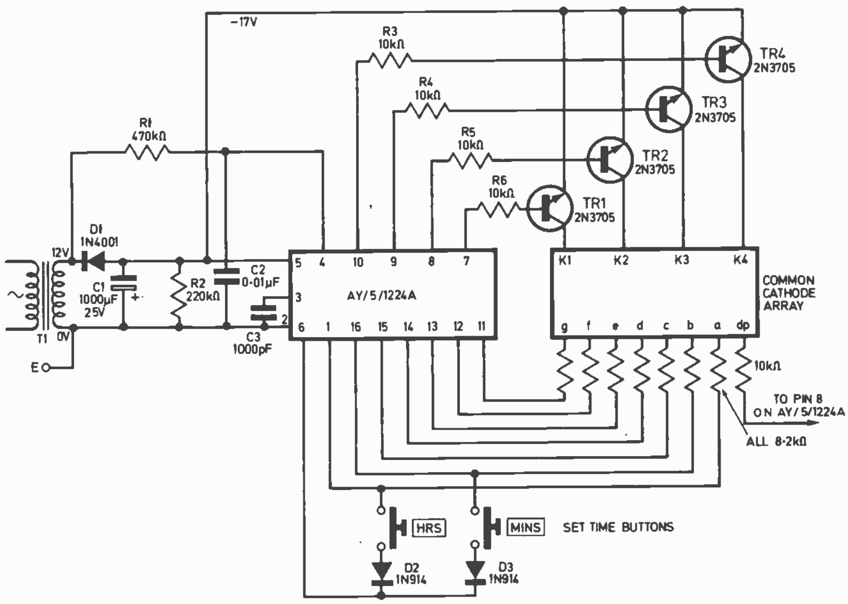
A selection of readers' original circuit ideas. It should be emphasised that these designs have not been proven by us. They will at any rate stimulate further thought.

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

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

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

SIMPLE CLOCK



About 12 to 18 months ago I obtained a small quantity of gas-discharge and l.e.d. displays and purchased a clock chip type AY-5-1224A as it was the cheapest type. I designed a method of driving the gas type displays (normally chips suitable for this cost about £7).

I originally experimented with the midget low current l.e.d. displays as I have a digital watch and thought that if I had a midget desk clock with constant display I wouldn't keep using my watch battery power. The first thing I found was that clock chip circuits are usually for 0·3in displays which require more power than 4mA. However, as I found the little l.e.d.s glow quite brightly at under 4mA, I experimented without the driver transistors. This worked excellently using the resistor values quoted. I tried a different AY-5-1224A and different set of l.e.d.s to ensure it would always work.

The four "multiplex" inverter transistors are necessary as the chip output waveform to the "enables" and the segments are the same levels and directions.

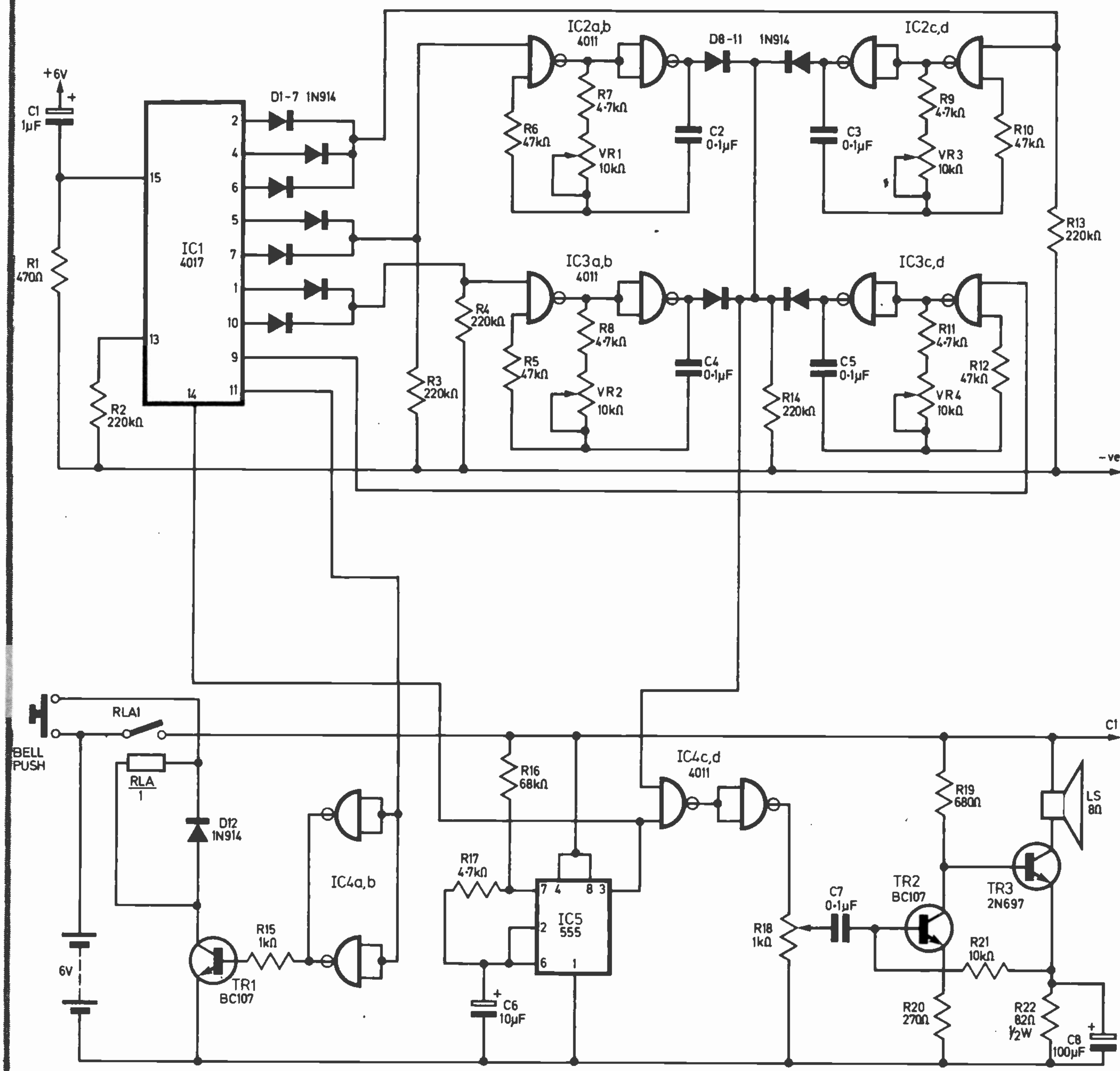
The AY-5-1224A segment output pins can be used as inputs for pre-loading the chip. For example, when setting the minutes and hours the waveform at pin 6 is fed into the chip to advance the time. If clock was to be used for "24 hours" mode or for a 60Hz supply, then diodes would again be connected to pin 6 and the appropriate "input" pin. Setting the time gives no problems whatsoever.

This circuit is not suitable for the "24 hour" mode as due to the lack of segment driver transistors, which give some form of buffering, if the "24 hour" mode diode is added one of the display segments will glow dimly when it shouldn't. If used with the normal "12 hour" mode using circuit as submitted there is no problems. The original clock has been running without problems for several months now.

Note that in the circuit shown I assume that a ready multiplex display array is used. It would probably be better to either use an ex-calculator display array, or that if individual displays are used, join the segments of the four displays in parallel.

G. A. Bobker,
Unsworth,
Bury,
Lancs.

BEETHOVEN'S DOORBELL



THIS circuit was developed from the doorbell published in *Practical Electronics* April 1975, using CMOS which were to hand, and plays the first eight notes of the Beethoven "Ode to Joy" theme. Clock pulses from IC5 are fed to the 4017 decimal counter IC1, which is reset by C1/R1 at switch on. The "0" output is not used as the first clock pulse is longer than those following, and the "9" output (pin 11) is used to switch off at the end of the tune through IC4ab and TR1.

This leaves eight output pulses of equal length, which are used to gate the astables formed by the gates of IC2 and IC3 and associated components, producing the tones in the correct sequence.

VR1–VR4 are adjusted to give the four pitches required. Output from the tone generators is gated with the clock pulses to separate the notes and fed to the audio amplifier via volume control R18.

K. Penton,
Caversham Park,
Reading.

ELECTRONIC COMBINATION LOCK

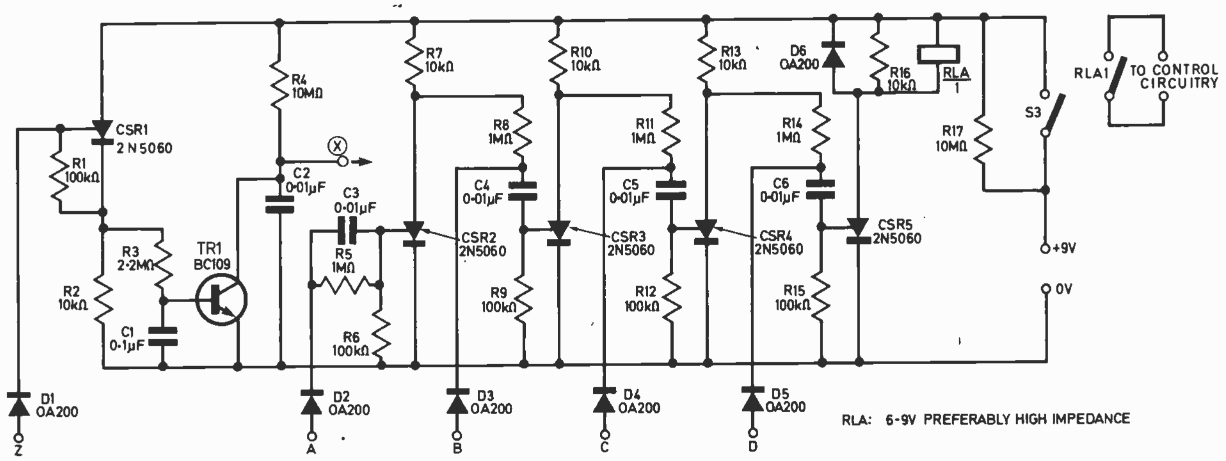
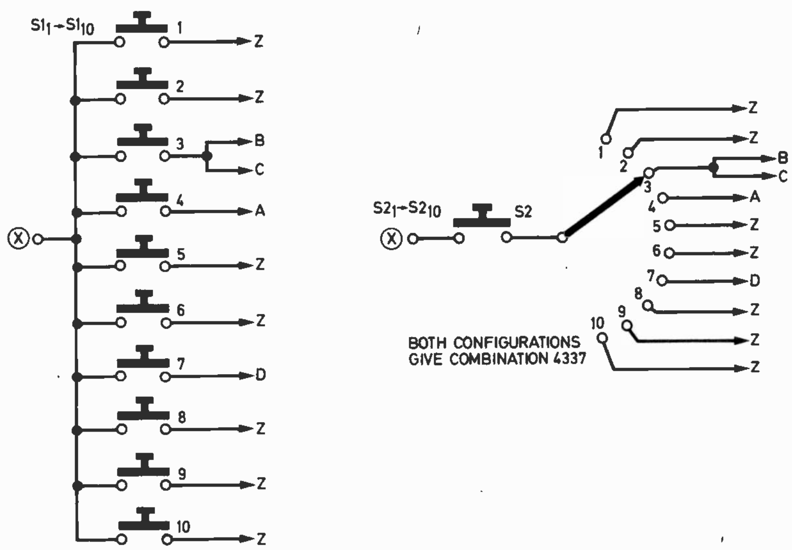


Fig. 1

Fig. 2



THE circuit diagram of a 4 character electronic combination lock is shown in Fig. 1.

The character selector may take the form of a calculator type keyboard (Fig. 2), in which case the combination is entered simply by depressing the buttons in their correct order or, alternatively, the arrangement shown in Fig. 3 may be used, in which case the combination is entered by dialling and registering (by depressing S2) each character in its turn.

Basically the circuit operates by switching on a thyristor each time a character is registered. The triggering pulse is provided by C2 which is normally charged (via R4) to +9V. Initially the gate capacitors C4, C5, C6 are also charged to +9V, so any attempt to trigger CSR3, CSR4, CSR5 (at points B, C, D) will be unsuccessful. By registering (at A) the first character of the combination, TR2 is switched on and its anode potential falls to about 0·7V. C4 rapidly discharges. A triggering pulse may now be applied to B, to turn on CSR3 which discharges C5 etc.

The circuitry to the left of C2, R4 hinders attempts to break the combination. If a wrong character is chosen, TR1 is turned on and this, after a short delay provided by R3, C1, to permit the thyristor to trigger properly, turns on TR1 which saturates; thus preventing further attempts to register characters until S3 is reset. D1 prevents a form of bistable action occurring between CSR1 and TR1.

The 2N5060 thyristor has a tabulated maximum holding current of 5mA. In practice, a realistic typical figure is about 0·1mA; thus the 10kΩ anode resistors should be adequate.

These thyristors have particularly sensitive gates and gate-cathode resistors (100kΩ) are included to dampen the sensitivity. Diodes D2–D5 isolate the gates of those thyristors with a common character. All the diodes are included for convenience.

R17 is a trickle resistor to keep C4, C5, C6 topped up; thus preventing either CSR3, CSR4, CSR5 from being triggered when S3 is closed. R16 ensures that CSR5 switches on even if its load is highly inductive.

P. Hutchinson,
Brockenhurst,
Hants.

DISTORTION ASSESSMENT

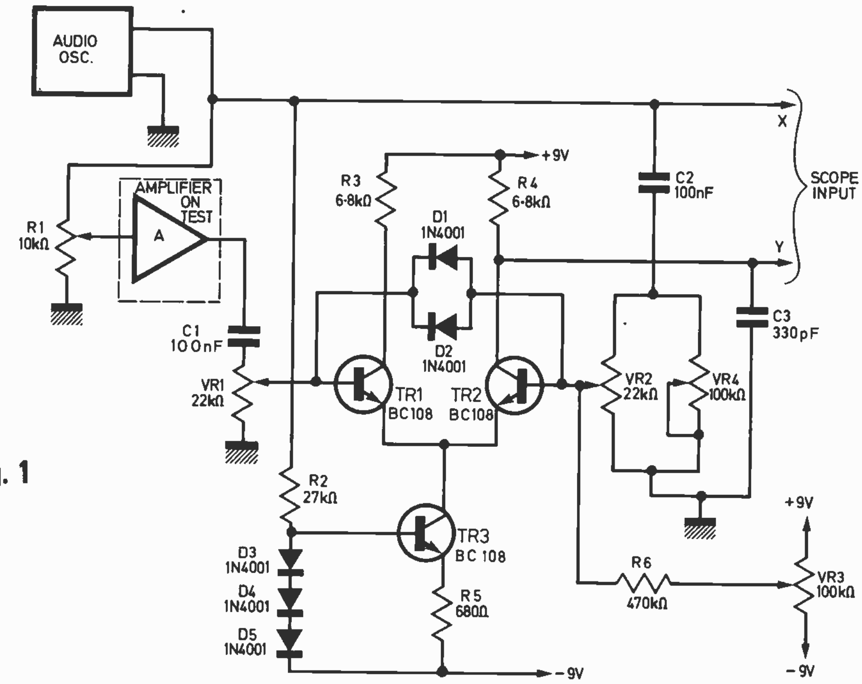


Fig. 1

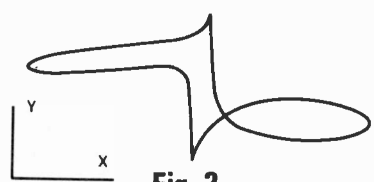


Fig. 2

Fig. 3

Fig. 4

THE circuit (Fig. 1) might be of interest to those readers who wish to test audio amplifiers for distortion without sophisticated test gear such as low distortion oscillators and tuned filters.

The principle is to match the amplitudes of signals derived from the input and output of the amplifier A under test and compare them in a long tailed pair. (An op amp is an obvious alternative.)

With about 1V r.m.s. fed to both inputs and VR1 and VR2 (Fig. 2) at near maximum settings, the residual output can be reduced below the noise level. VR3 is set to balance the TR1 and TR2 collector currents approximately. D1 and D2 protect TR1 and TR2 against surges, reverse voltages, etc.

The circuit is easily set up. Limiting problems are hum in the amplifier under test and phase shift. Passive phase correction components (e.g. VR4) might be needed.

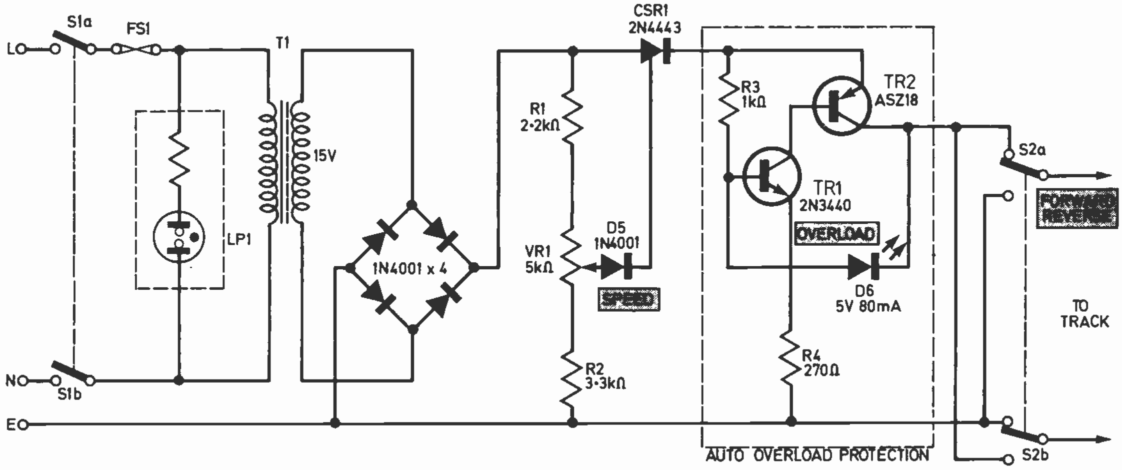
Unless the oscillator is fairly free from harmonics, differential phase shift versus frequency might give misleading results if attempts are made to assess harmonic distortion at high or very low frequencies.

Displaying the output in X-Y form has the advantage of expanding the crossover region in X. The traces show some results from an experimental amplifier, feeding 9V p-p into 3Ω. Scale in all traces is about 4mV/cm in Y.

Fig. 3 shows crossover distortion, only just detectable on a conventional scope display of the output. That in Fig. 3 could not be seen at all. Fig. 4 shows remaining second harmonic, after increasing the amplifier bias current in the output stage. Frequency in all cases was about 700Hz.

C. J. Collins,
Letchworth,
Herts.

PROTECTION FOR A MODEL TRAIN SPEED CONTROLLER



THE circuit shown in the diagram is based on the "Model Train Speed Controller" that appeared in PE December, 1976. The additional circuitry is shown within the dotted lines. This addition, which is suitable for one engine only, can be included to perform three functions:

1. To protect the controller against temporary overload by automatically reducing the available output current when such a condition occurs. This could happen due to a train becoming derailed, or due to incorrect track wiring, etc. This is an important consideration when the system may be operated by young children.
2. To provide a visual indication that an overload has occurred.
3. To eliminate the necessity of providing extra hardware to cope with a manual reset of the controller once the appropriate corrective action has been taken.

Under normal conditions both TR1 and TR2 are switched on, TR1 providing sufficient collector current to drive the base of TR2. The l.e.d. is reverse biased and therefore has no effect.

Should the impedance of the load reduce to a point whereby the potential at the collector of TR2 falls approximately 1·9V below that at the base of TR1, then the l.e.d. becomes forward biased and will illuminate indicating that an overload condition exists.

Once the l.e.d. attains this state it clamps the potential at the base of TR1 to that at the collector of TR2, thereby tending to switch off TR1. This situation results in a reduction in the base current available to TR2, which is reflected as a current limitation into the load. Once the load impedance is restored, the state of the l.e.d. and the two transistors reverts to normal.

In operation the limiter has been found to reduce the current through a short circuited load to approximately 20 per cent of that available to a normal condition with the engine running at full speed. This is particularly useful in the situation whereby a heavy duty transformer can supply power to a number of controllers and trains, since the s.c.r. would burn out very quickly if the limiter were not present.

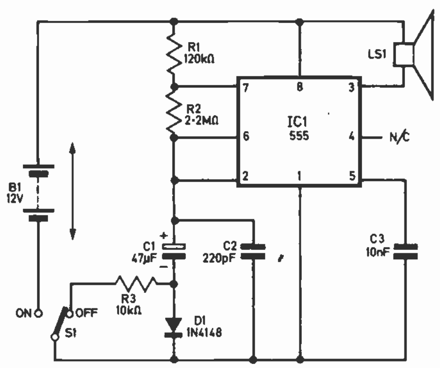
Should an electro-mechanical cut-out system be required, offering a complete shut-down on overload, then this circuit (with the illuminating l.e.d. positioned in close proximity to a photo-transistor or l.d.r., etc.) will interface directly with the *Multichannel Overload Protector* in PE October, 1977.

No component values are critical, the values of R1, R2 and VR1 being given for the 2N4443, as opposed to the CRS1/05 specified in the original article.

TR1 should be a silicon n-p-n transistor capable of maintaining approximately 40mA of base current into TR2, which itself is *pnp* output transistor supplying approximately 1A to the engine.

R. Chapman,
Walton-on-Thames,
Surrey.

SIMPLE ALARM



THE enclosed circuit utilises the timing capability of the 555, together with its capacity to directly drive a small audio transducer. It provides an economical arrangement to provide an audible alarm.

C1, charging via R1, R2 and D1, provides the initial timing delay. When the discharge is initiated, D1 virtually isolates C1 from the circuit and C2 effectively governs the charge/discharge cycle, resulting in audio frequency oscillation.

In practice, C1 isolation is not complete, resulting in a slightly rough tone initially, by no means a drawback as regards audibility. Resistive shunting of D1 increases the roughness, if required (it also alters the frequency).

With the values shown, the circuit gives a three minute delay and an audio frequency of about 1,500Hz, using a 12V supply. Performance as an oscillator can be affected by supply impedance; with some dry battery supplies a shunt capacitor might be desirable across the battery.

C1 is discharged at switch-off via R3, included as a (perhaps unnecessary) precaution to reduce reverse base-emitter potentials in the threshold comparator Darlington long tailed pair. It should certainly not be necessary with supply potentials below 7·5V.

C. J. Collins,
Letchworth,
Herts.

Semiconductor UPDATE...

FEATURING: PBL 3708 TS 04700/10000 SC 100

R.W. Coles

FIT TO BURST

As many readers will no doubt be aware, there are two quite different ways to drive a triac in a.c. power control circuits.

The most familiar of these is probably "phase control", where the triac, off at the start of a half cycle, is turned on part way through by a trigger pulse which can occur at any phase angle selected by external circuitry.

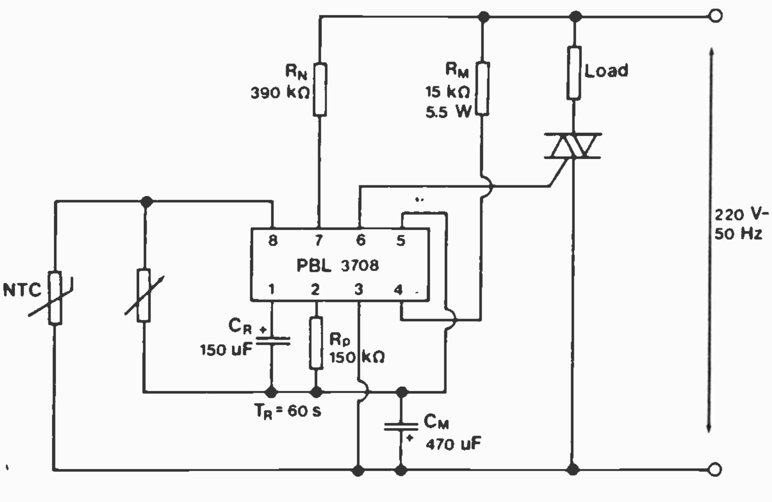
An example of this type of control is the well known lamp-dimmer circuit, quite common these days in the more "switched-on" households! The control for this application comes from a simple variable CR circuit and a diac trigger device, the diac generating a trigger pulse for the triac when the voltage across the CR circuit (which lags the mains input) reaches a sufficiently high value, usually about 40 volts. Adjusting the CR time controls the phase lag and hence the conduction angle of the triac.

Unfortunately, the fact that the triac can be switched on when a considerable voltage exists across it means that the voltage waveform delivered to the load will often contain square edges of large amplitude. Square edges contain harmonics of course, and here we have the makings of an excellent radio and TV jamming system! The only way out is to use an r.f. filter at the device inputs, and to restrict this sort of system to low power applications, say, 200W. If greater power must be controlled, use "plan B," called "burst-firing."

Burst-firing eliminates the RFI (Radio Frequency Interference) problem by delivering only integral numbers of mains half cycles or cycles to the load. The trick here is to always trigger the triac as the mains voltage crosses zero at the start or end of a half cycle, and this does away with all those nasty square edges. Using this technique, loads of several kW can be controlled, at the expense of control circuit complexity, and it is ideal for the proportional control of heating in electric cookers and other domestic appliances.

Despite the availability of this burst-fire technique, and the cheapness of triacs, white-goods manufacturers have been slow to abandon their mechanical gadgets and ingenious bi-metal strips, which are in the stone age by comparison with the smooth, accurate, control now available from the triac.

The problem, as always, is price. The burst fire control circuitry can be expensive, but not for long if the Swedish firm of RIFA have their way. They have introduced a complete trigger control circuit for temperature control applications which fits into a single 8-pin mini-d.i.p. The device is coded **PBL 3708,** is available from Jermyn, and contains almost everything you need apart from a few discretes and a triac. The bits inside include a zero crossing detector, a ramp generator and a comparator, and the whole thing can be powered straight from the mains, thanks to an internal regulator.



A typical design for control of room temperature with a heating element of 1,000W, 220V a.c. and a proportional band of 1°C.

KNEES-UP

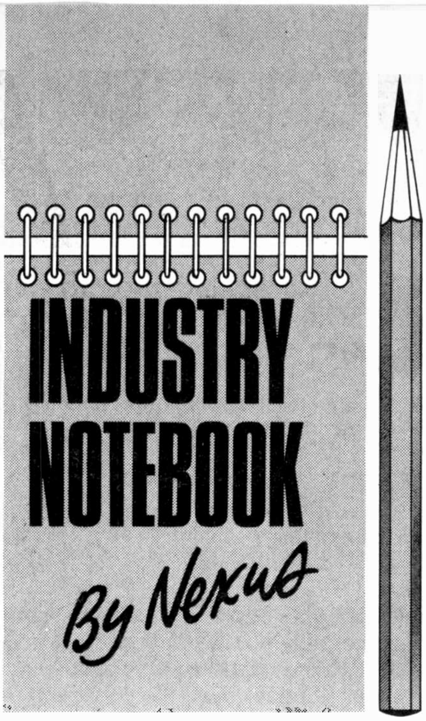
Ordinary Zeners are a bit of a disaster at low currents. Drop much below 5mA operating current, and that breakdown "knee", which looked fine on the 50mA scale, begins to look more like a matronly "bosom"! If your applications are happy passing 5mA or more through the Zener, don't worry about it. But if, like me, you have ever needed a voltage reference in a micropower circuit, you will be interested in a new series of diodes from Teledyne. The **TS 04700 to TS 10000** range, covering 4·7 to 10V in 12 voltage increments, will operate at 1µA or less and yet have knees like set-squares!

To get the best from the range, choose a diode of 6V or greater because the performance here is at its zenith. As an example, a 10V diode (TS 10000) suffers a maximum voltage change of only 0·1V for a current range of 1 milliamp to 10 *nano-amps!* Team one of these up with an emitter follower using a high gain transistor such as the ZTX109 and you can drop your op-amp supply down to 5V for CMOS *without* the regulator taking more current than the logic!

HUNDRED AMP WHOPPER

A new candidate for the electronic "Guinness Book of Records" has just been introduced by the aptly names Germanium Power Devices Corporation. The new arrival is a power transistor with a 100A rating, coded **SC 100,** made with good old *p.n.p.* germanium technology. At 100A the SC 100 still has an h_{fe} of 15, so you only need to supply about 7A of base current.

The SC 100 has a TO 68 package, which looks a bit like two dustbin-lids clamped together, and is of course designed to be securely bolted to a heatsink. I should think that if you used output transistors like these in a domestic system, you could use the waste heat to drive your central heating boiler! Try as I might I cannot dream up much in the way of applications for this monster, "though you could probably make a nifty controller for your electric-car or fork-lift truck. I can't help thinking that the "SC" in SC 100 stands for short-circuit!



The Great Debate

It is all to the good that in the last few months both the promise and the threat of Very Large Scale Integration (VLSI) have received a great deal of public exposure through radio, TV and the printed word.

The promise is in electronic goodies which will make a lot of money for the electronics industry and save a lot of money and give greater convenience, sometimes both, for the VLSI user. The threat is that though the electronics industry may prosper and perhaps employ marginally more people, the end result will cause a great deal of unemployment elsewhere.

Even in the electronics industry itself the advent of comparatively simple (compared with what is yet to come) devices has had a dramatic effect on labour content in assembly of equipment. I recently saw one female assembler and two male technician testers handling the whole assembly and testing procedures of a product, the end value of which totalled some £3 million per year. These three people were not even working at full capacity. Nor were they highly skilled.

To produce an equivalent product with the discrete components and methods of, say, 20 years ago, would have demanded an assembly line of many more people, perhaps ten assemblers and five testers, all working flat out. And the product would have been larger, heavier, used more raw materials, consumed more power, been more expensive and less reliable.

The computing power of a £5 chip today is said to equal that of a first-class computer costing £250,000 in 1950. That's the way it's gone and very nice, too.

Now spare a thought for all those people, skilled mechanics, who have spent years patiently assembling the complicated mechanisms of the common cash register. The mechanical model, even the electro-mechanical, is on its way out. Market researchers Frost & Sullivan are predicting a £2·5 billion market in the next ten years for the all-electronic model in 16 West European countries alone. There are many such examples where traditional skills will no longer be needed in the all-electronic age.

The media, ever-anxious to dramatise and popularise the issues of the day, and limited in time for any particular topic, naturally tend to over-simplify. It is a pity that historical perspective has been largely overlooked for if we face up to it the new "threat" is only another phase of a continuing process which has been with us since the beginning of the industrial revolution.

The old-time craftsmen and labourers were horrified by machines. Later, having become accustomed to machines they were horrified by automation which introduced a limited "intelligence" to machine operation. Today people are petrified at the prospect of microelectronics which promise a further level of "intelligence" to the machine and the transfer, if not the total abolition, of many formerly needed skills.

And yet all the evidence is that the natural inventive progression from manual labour and craftsmanship to automation and to microelectronics in all its aspects has enriched us all, at least in material goods.

The paradox remains that while, for example, a steel worker resists the introduction of a new and more efficient process in his mill, he would be the first to complain if his family car were to cost him £40,000 because it was made entirely by hand or his washing machine £1,000 or so, and the shirt on his back £50.

One sympathises naturally with legitimate fears but nobody can have it both ways. Self-interest is such that we all like to enjoy the fruits of modern invention as long as it is somewhere else, just as most people agree that more airports are needed provided they are located well away from their own area.

In Sweden, which has a small labour force, the trade unions discourage any worker to be employed on dirty or dangerous tasks which could more profitably and easily be undertaken by an industrial robot. Will the recently formed British Robot Association help to change attitudes and dispel fears in Britian?

It seems odd that while the world stock of nuclear weapons is sufficient to vaporise the whole of mankind we are all dead scared of a tiny chip of silicon.

The debate continues . . .

Getting Together

GEC looks like teaming up with the Japanese in colour TV manufacture. There are moves, too, on the computer front with ICL concluding a know-how exchange with Hitachi, and technical co-operation and cross-marketing in an agreement between Siemens in Germany and Fujitsu in Japan. The computer deals are said to be preparatory moves in the forthcoming sales battle expected to start in 1980 when IBM will introduce a new range.

European companies are anxious to get access to new technology being developed in Japan through huge government funding in VLSI, including exotic devices like a megabit memory. For their part, the Japanese are anxious to widen their market beyond Japan. ICL, for example, sells in 80 countries, Hitachi mainly in Japan.

The GEC attitude on colour TV appears to be that if you can't beat 'em then join 'em. Better to have half the cake than no cake at all.

Now it can be TOLD

The Post Office TOLD (Telecommunications On-Line Data) nationwide computer project is now in service. Costing £12 million, the Post Office expects to save £22 million through improved efficiency during the life of the equipment. Pilot trials started in 1975. Now the system is complete it uses 1,300 Cossor CD3005 VDU terminals all linked to ICL 4-72 computers with advantages in speed, control, accuracy and simplicity of use. Direct access to the computer now replaces form-filling and transferring the data from forms to punched cards or magnetic tape.

Qualifications

Starting reading now for an honours degree if you want to join the Institution of Electrical Engineers. As from 1982 second class honours will be the minimum qualification for membership plus relevant industrial experience plus a written professional test demonstrating competence and future potential.

IBC Sell-Out

The biennial International Broadcasting Convention is moving this year from the popular Park Lane venue of Grosvenor House to the new Wembley Conference Centre. Exhibitors are up to 85 as compared with 72 at IBC '76 and the exhibitors have 20 per cent more space. Some 180 technical papers have been submitted for the Conference, another record, but these will be trimmed down into 12 main topics for discussion. The dates this year are September 25–29.

The technical sessions will reflect all the latest techniques including MPU and minicomputers in broadcasting, teletext, quad sound, satellites, video processing, etc.

Car Radar

Anti-collision radar for motor cars was being considered by US General Motors 20 years ago. They will become a reality for the American motorist in the '80s. A simple system would have an audio warning for the driver. A more complex system has radar-activated braking. A combination of Gunn oscillators for the radar section and powerful MPUs for signal processing will help overcome the knotty problem of discriminating real targets (i.e. car "signatures") from roadside objects such as lamp posts, bollards or oil drums.

THERMOSTAT CONTROL

M. EDMUNDS

WHILE developing colour transparencies, particular attention must be paid to the control of the developing solution temperature. Most home developing kits require the temperature of the first and colour developers to be within $\pm 0{\cdot}25$ deg C of a stated temperature, usually in the range 20–40 deg C.

The device described in this article not only acts as a very accurate and stable thermostat, but also provides an analogue readout of the temperature in the bath.

To realise the full potential of the circuit it should be used in conjunction with a stirring device in the tank. This need only take the form of a small paddle driven fairly slowly by a geared down electric motor.

CIRCUIT DESIGN CONSIDERATIONS

The complete circuit is shown in Fig. 1. In order that the overall unit was simple and cheap, operational amplifiers were used throughout.

Although a thermistor has a non-linear resistance relationship with temperature (see Fig. 3a), by making it one of the elements in a potential divider network, the voltage output is almost linear against temperature in the range of 10–15 deg C (see Fig. 3b), assuming the potential divider is fed from a stable voltage.

Components R1, R2, D2, D3, form a sufficiently stable voltage source for this purpose and also serves to supply a switching reference voltage to comparator IC2.

Switch S1 selects either the thermistor TH1 or preset VR1 to be the lower element of the potential divider. VR1 is used to supply a calibration resistance so that the correct operation of the unit can be checked periodically.

The difference between the output voltage from the divider and reference chain R4, VR2 and R5 is amplified approximately 5 times by IC1, the output voltage being read on meter M1. Resistor R9 is a meter shunt and may be adjusted to suit a different meter movement.

As the temperature in the bath falls it is sensed by TH1 and causes an increase in its resistance, the voltage at the inverting input of IC1 increases and the output voltage decreases.

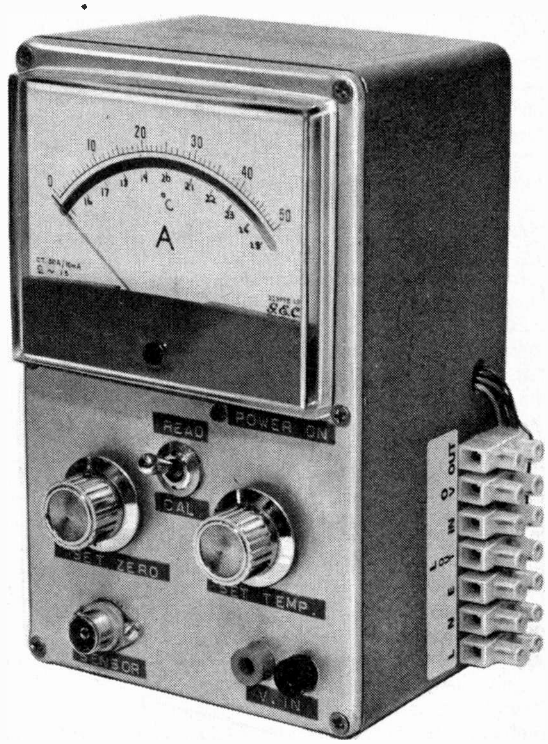
This voltage is fed via R10 to IC2 to be compared with the reference set by VR3 on the non-inverting input. As the temperature falls the output voltage of IC1 falls, and a point is reached when this crosses the reference voltage. The output of IC2 then rapidly swings high, to almost full supply volts. This action brings TR1 into conduction to energise RLA thus switching on a small immersion heater in the bath.

The components R12, R13, R14 form a positive feedback loop to put a hysteresis effect into the switching action. Without this, at the switching temperature the output from IC2 would oscillate fairly rapidly due to the low level noise signals on the output of IC1. The operation of this network is as follows, as the output of IC2 goes high, the voltage at the junction of R13 and R14 increases slightly. This small voltage is effectively added to the reference voltage via R12, it is thus necessary for the voltage at the inverting input to rise slightly further before the output of IC2 drops to the low value, switching off TR1 and the relay.

When this occurs the feedback voltage becomes zero and the reference voltage returns to its pre-set value.

CONSTRUCTION

The prototype device was built on 0·1in. matrix veroboard which after being checked for track shorts etc, was bolted directly onto the input terminals of the meter. Integrated circuit holders are used for the operational amplifiers to avoid soldering damage. Veroboard pins were used where connections were necessary to components not on the board.



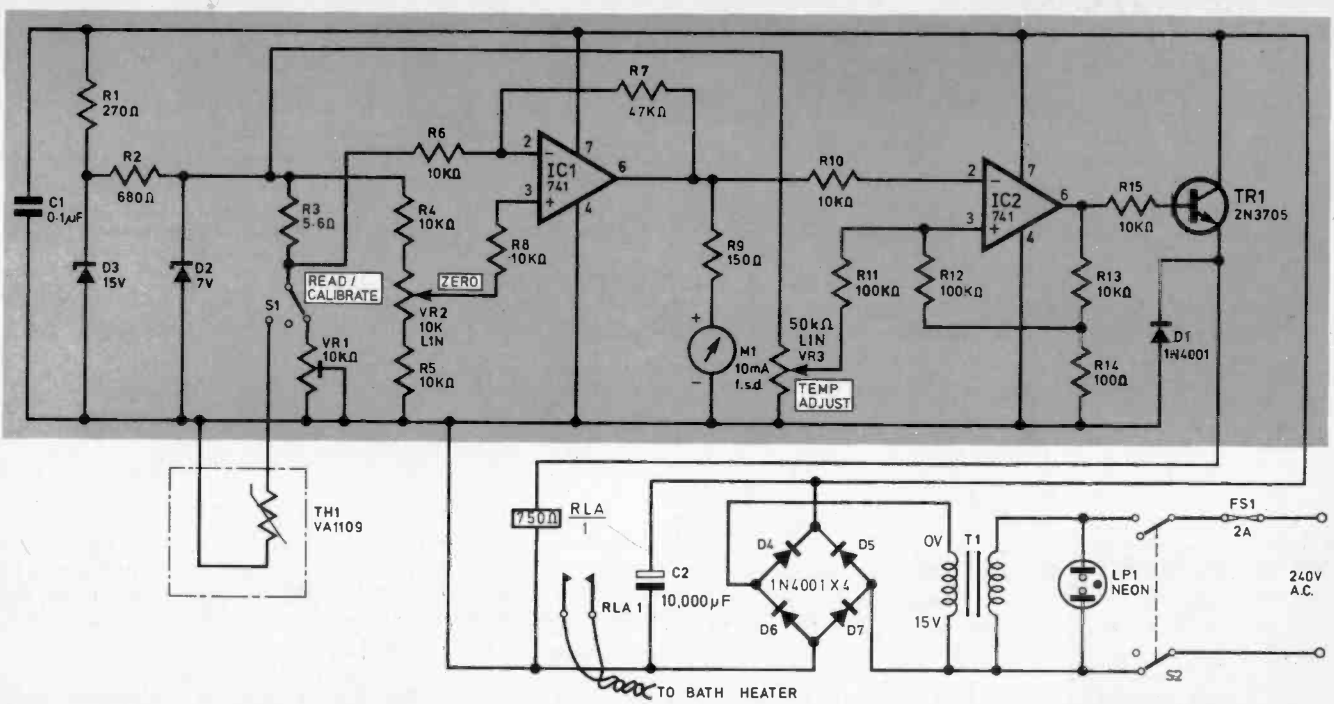
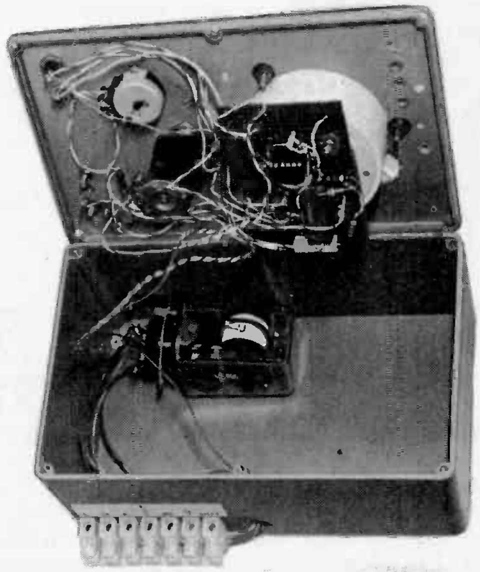


Fig. 1. Full circuit diagram, including suggested power supply circuit (shown outside shaded area)



COMPONENTS . . .

Resistors

R1	270Ω
R2	680Ω
R3	5·6Ω
R4–R6, R8, R10, R13, R15	10KΩ
R7	47KΩ
R9	150Ω
R11, R12	100KΩ
R14	100Ω

All ½W 5% unless otherwise stated

Potentiometers

VR1	10KΩ multiturn preset
VR2	10KΩ linear carbon
VR3	50KΩ linear carbon

Capacitors

C1	0·1μF/25V
C2	10,000μF/25V

Transistors and diodes

D1, D4–D7	1N4001
D2	6·8V 400mW Zener
D3	18V 400mW Zener
TR1	2N3705

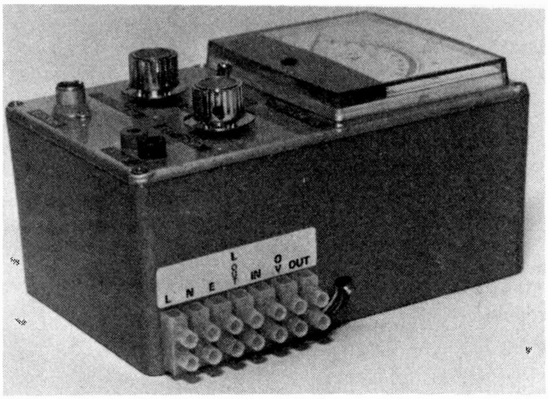
Integrated circuits

IC1, IC2	741 op. amp.

Miscellaneous

M1	10mA f.s.d. meter
RLA	15V operating relay with n.o. 240V 5A contacts
S1	S.p.d.t. toggle switch
S2	D.p.s.t. toggle switch (mains)
T1	Mains transformer. 15V/500mA secondary
FS1	2 amp fuse and holder
Diecast box	203 x 127 x 89mm (used for prototype)
Veroboard	0·1in

8 pin d.i.l. holders (2 off)
Coaxial plug and socket for temperature probe



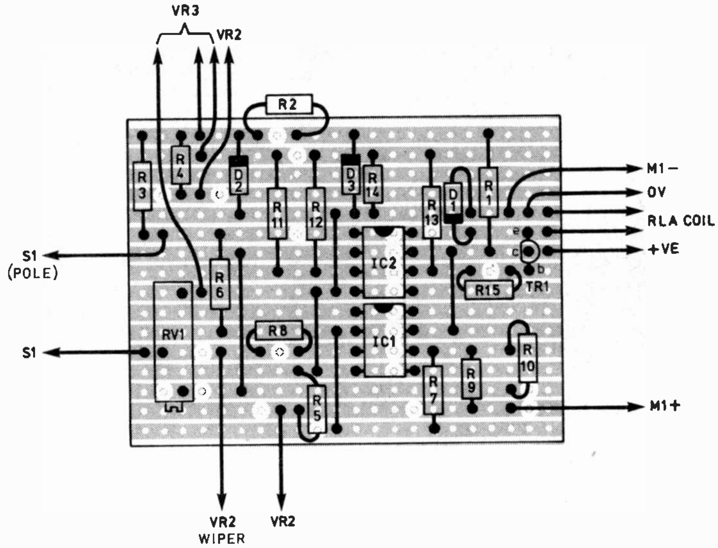
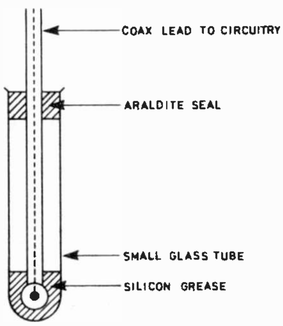


Fig. 2. Stripboard layout shown at full size. Note that C1 is not shown on this diagram



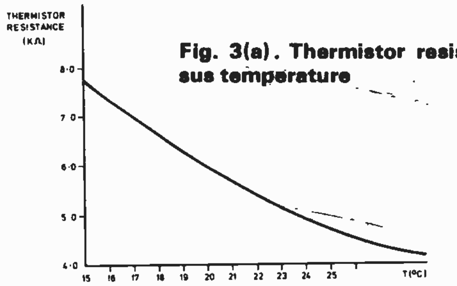


Fig. 3(a). Thermistor resistance versus temperature

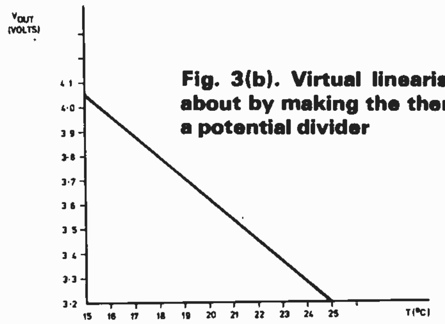


Fig. 3(b). Virtual linearisation brought about by making the thermistor part of a potential divider

A temperature probe can be fabricated from a small test tube

The meter M1, switch S1 and controls VR2 and VR3 are panel mounted together with a coaxial socket for the connection of TH1. If the completed thermostat is to be run from a separate 20V supply then two extra sockets will be needed for this.

Sufficient room is available inside the specified diecast box to house a small mains transformer, rectifier and smoothing capacitor. Using the double Zener arrangement as shown in Fig. 1 the device is immune to ±2V changes in supply voltage, and thus the stability of the supply is not too critical. The Veroboard layout is shown in Fig. 2, and the front panel layout can be seen above.

SETTING UP AND CALIBRATION

All that is needed for this procedure is an accurate thermometer and a vessel of water. After a 5 minute warm up period switch S1 to bring TH1 into circuit. Submerge the thermistor enclosure into water at exactly 20 deg C and adjust VR2 until the meter shows half-scale deflection. Now switch S1 to bring VR1 into circuit and adjust the potentiometer VR1 to return the deflection to half-scale.

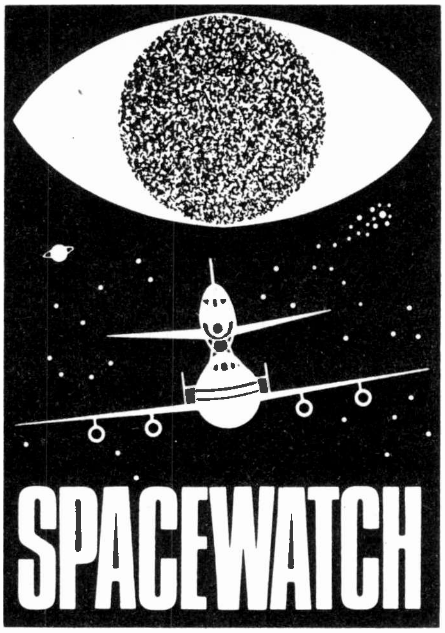
Now return S1 to its original position bringing TH1 into circuit. Suspend the thermistor enclosure in water at several different temperatures marking the meter scale is each case with the temperature indicated by the glass thermometer. Using the value of R9 quoted with the specified thermistor, the device will have a full-scale range of 10 deg C (from 15 to 25 deg C).

To set the switching temperature, bring VR1 back into circuit by operating S1, the meter should read half-scale. Rotate VR2 to bring the meter to read the desired temperature. Now rotate VR3 slowly until the relay is heard to operate. This completes the setting up procedure. Slight adjustments may have to be made when the thermostat is in use, as changes in water-bath geometry may affect the required setting of VR3.

USE OF THE COMPLETED SYSTEM

Switch S1 to connect VR1 in circuit, check that the meter reads half-scale deflection. If not then adjust VR2 to obtain this condition. This checks (and compensates for) the input offset level of IC1, which may tend to drift with ambient temperature changes and age. Switch back to TH1 and the meter will then read the temperature of the water surrounding the thermistor enclosure.

Used in this way, the unit will prove reliable and the complete unit should give trouble free operation for a considerable number of operational hours. ★



FRANK W. HYDE

SOYUS-29 and SALYUT-6

On 17th June, 1978 the Soyus-29 space vehicle docked with Salyut-6 space station. The two cosmonauts, Vladimir Kovalynok and Alexander Ivanchenkov, will continue the programme of experiments on the same lines as those of the record breaking team, Yuri Romanenko and Georgi Grechko.

The programme consists of a wide range of experiments, among them studies of—The Earth's surface and atmosphere to obtain data of both scientific and commercial interest—Astrophysical experiments and investigations—Experiments directed toward new materials—Technical experiments and tests on structural parts of the space station itself and Medico-biological studies.

The biological experiments will be partly concerned with the problem of weightlessness. Both Romanenko and Grechko after their return to earth suffered some days of difficulty in returning to normal. The length of time they spent in the weightless condition was 96 days. During the time spent in this condition no deficiency showed up in their ability to carry out their tasks, indeed, there were signs that their efficiency did in fact improve.

After the flight the cosmonauts were very sensitive to the sensations of weight, not only of their bodies but also of other objects.

During the first few days back on Earth they had to make considerable effort to remain upright and their movements showed some indication of dis-orientation. For several days the cosmonauts wore specially designed suits to assist them to walk.

The studies of the adaptation of the biological machine to gravity was as interesting as that of adaptation to weightlessness, according to Academician Gazenko who controls the Medical and Biological Institute.

On the second day of the new mission of the space station and the supply vehicle, the cosmonauts were engaged in re-activating the Salyut-6 and de-activating Soyus-29. The micro-climate in Salyut-6 is maintained at 20°C with a pressure of 750mm of mercury.

The space parameters of the combined unit Soyus/Salyut are at present apogee 368km, perigee 338km, orbital period 90·4 minutes, and the orbital inclination 51·6°.

The re-activating of the systems is done in stages. The water producing system had been dormant for three months. The system regenerates water from condensate. The cosmonauts enjoyed a cup of tea after the successful re-activation operation. The propulsion system has also been checked and found satisfactory.

Some details of the cosmonauts in the Soyus/Salyut latest mission may be of interest. Colonel Vladimir Kovalynok was the flight commander of Soyus-29, he made his first space flight in October 1977 as commander of Soyus-25 in the first unsuccessful attempt to dock with Salyut-6.

He was born in 1942 on March 3 in the village of Beloye in the Krupsky district of the Minsk region. In 1963 he graduated from the Basahov Higher Military Flying School. He served in military transport aviation, training with several aircraft and clocking up 1,600 hours of flying time, then he became an air-force paratroop instructor.

In 1967 he joined the cosmonauts detachment and went through the complete course of space flight training. He took part in flight testing new spacecraft and in the flight control of piloted space vehicles and orbital stations. In 1976 he graduated from the Yuri Gagarin Military Air Force Academy.

His partner in the Soyus/Salyut mission is Alexander Ivanchenkov who is the flight engineer. Ivanchenkov was born on 29th September, 1940 in the town of Ivanteyevka in the Moscow region. He graduated in 1964 from the Moscow Aviation Institute, then worked in the design office, dealing with the design of new space vehicles in which he proved to be a gifted and ingenious engineer.

His space flight experience began with training for Soyus space ships and Salyut stations. On several missions he was standby flight engineer. He also trained as flight engineer for the joint Soyus/Apollo flight.

USSR LAUNCHINGS

A number of Soviet launchings took place in May and June this year. Cosmos 1011 was launched on 23rd May, with an orbital period of 104·9 minutes at an angle of 82·9°. Apogee is 1,026km and perigee 978km. Cosmos 1012 was launched on 26th May with orbital period 89·2 minutes and an orbital inclination of 62·8°. The apogee is 280km and the perigee 214km.

On 8th June a booster rocket put eight Cosmos satellites in orbit at one launch. The initial orbits ranged from 1,456km to 1,539km. The angle of inclination was 74° and the initial orbital period of revolution was 115·5 minutes.

Cosmos 1021 was launched on 10th June with an apogee of 336km and a perigee of 180km. The period of revolution was 89·4 minutes and the angle of inclination was 65°.

Cosmos 1022 was launched on 12th June with an apogee of 374km and a perigee of 182km. The period of revolution was 89·7 minutes and the inclination 72·9°.

A Molyniya satellite was launched on 2nd June. The parameters were apogee 40,837km, perigee 457km. Apogee is in the northern hemisphere and perigee is in the southern hemisphere. The orbital period is 12 hours 16 minutes and the angle of inclination is 62·5°.

The satellite carries apparatus for the transmission of television programmes and long distance multi-channel radio communication.

INDIA AND THE USSR

Preparations have been completed by the Soviet Union for the launching of India's second artificial satellite. The press were given the details by Nikolai Novikov who is Vice-Chairman of Intercosmos. The interview took place in Delhi.

Novikov heads the delegation of Soviet experts who have been testing a model of the new space laboratory at the Indian Space Centre. Discussions have been taking place between the Indian space experts and their Soviet counterparts.

It was remarked by Novikov that despite the short history of the joint activities, Soviet-Indian space research had brought practical results. The joint preparation of the first satellite, Aryabhata, helped to train India's experts who now handle a very wide range of complex scientific apparatus for space research.

Launching of the new satellite is expected to assist the development of India's economy and enable extensive study of her mineral, water and timber resources.

GOES-3

The geostationary Earth monitoring satellite has been launched. The launch was made from the Kennedy Space Centre in Florida. NASA were responsible for the launching on behalf of the National Oceanic Atmospheric Administration. GOES-3 is destined to play a key part in the Global Weather Experiment.

This is a worldwide project which will last a year. There will be an accumulation of data both oceanographic and meterological in this period. GOES, or to give it its full title Geostationary Operational Environmental Satellite, will gather information from an area centred on the Indian Ocean.

PLACE IN SPACE

Dr. George Ellis of the University of Cape Town has resurrected an old theory of the pre-Copernican days. He is suggesting that the Earth is in fact the centre of the Universe.

He is able to put what will certainly be considered to be an outrageous suggestion, because the present day thinking and observation allows for curved space with a Universe with no edge but two centres in relation to each other. According to Dr. Ellis our galaxy is near to one of these centres. He does not accept an expanding universe but rather believes that the red shift is the result of gravity.

Though there will be many opponents to this idea it must, in fairness to Dr. Ellis, be noted that he does not say that it is so, but that it could be.

SOUND TRACK MONITOR

J. SCHMID

WHEN two-track tapes carry a single recording extending to both tracks, the end-of-recording point on track 1 is usually some minutes away from the physical end of the tape, and for convenience both during recording and during playback the start-of-recording point on track 2 is at the same physical location. Thus, both during recording and during playback the tape has simply to be turned over to make it ready for the second track.

Now if copies of such tapes are to be made unattended, and the first side is allowed to run to the physical end of the tape, and since tape lengths are not normally exactly the same, it is not possible to simply turn over the tapes and start copying the second track. The second track of the copies would be out of synchronism with the first track by the difference in tape length. A rather tedious search for the physical location of the end-of-recording point would ensue, particularly if several copies are being made simultaneously.

The track monitor has been designed to avoid this by alerting the operator when the end of the recording (rather than the end of the reel) has been reached. It contains electronic circuitry which starts an oscillator 15 seconds after the last recorded sound has been received from the track. The 15-second delay ensures that the alarm is not raised because of intended pauses in the recording.

The oscillator is heard via a built-in loudspeaker when the selector switch is in the "Alarm" position. In the "Monitor" position the loudspeaker is connected across the programme line. There is one programme input and three programme outputs. This permits three simultaneous dubbings to be made. The instrument provides a constant 10-ohm load for the line, whether or not the speaker is used. The programme circuit, though routed through the instrument, is not electronically processed in any way and the box can therefore serve as programme distributor, and the speaker as monitor, without being connected to mains power.

The circuit of course can be used in any situation where the cessation of speed or music on a line (whether radio, records, tape etc.) needs to be indicated by some kind of alarm signal.

CIRCUIT DESCRIPTION

The instrument is mains operated and contains a regulated +24V supply. The full-wave a.c. rectifier and filter is followed by a Zener referenced series regulator. Diode D9 temperature compensates D5. The values of C1 and C2 were chosen on grounds of adequacy and availability.

The rest of the circuit divides into sensing section and alarm section, with the relay linking the two. The programme signal is amplified by TR2, operating at 0V gate-to-source bias. Load resistor R4 is chosen to obtain a quiescent drain voltage of about 8V, so that a signal swing of up to 6V can be obtained without clipping the negative excursions. If the input of TR2 is overdriven, R2 will serve both to limit the f.e.t. gate current and to prevent any loading of the programme line. TR2 will in fact frequently be overdriven in normal operating practice.

The amplified signal is coupled through C3. R5 establishes a 0V quiescent level, from which excursions can go to +0·6 and −5·1V before being clipped by D6. The negative excursions are detected by D7 and serve to charge C4 to the negative peak level. This cuts off TR3, and the relay in its drain circuit opens.

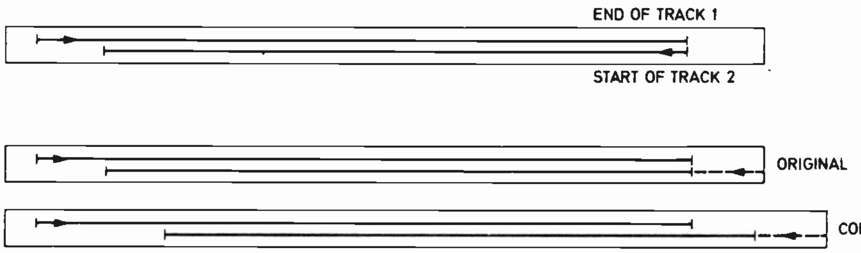


Fig. 1. Showing how copy tracks go out of sync

When no further programme signals arrive, the voltage on the gate of TR3 drifts back towards 0V as C4 discharged through R6. When the current through the f.e.t. reaches the relay switching point RLA1 pulls in and activates the alarm circuit.

The purpose of D6 is to standardise the negative excursions caused by signals of varying amplitudes, so that the return from cutoff to conduction of TR3 will take about 15 seconds regardless of whether the last recorded passage on the tape was loud or soft. TR2 must therefore provide at least a 5V signal swing to reach D6 limiting even on quiet passages, and will habitually be overdriven of loud passages. The minimum signal level on the programme line to reach limiting is 1V peak-to-peak.

The 15 second delay depends not only on the circuit time constant C4–R6, but also on the gate bias level at which TR3 provides enough drain current. When changing TR3, this level is almost bound to be different, and the easiest way to re-establish the 15-second delay is to change the circuit time constant.

ALARM SECTION

Turning now to the alarm section, this consists of oscillator TR4 and speaker driver TR5. The unijunction transistor fires with about 6V at its emitter and then conducts heavily, pulling down the voltage on C5 rapidly to 1V, when the circuit relaxes and C5 charges up again through R7. The frequency of oscillation is about 700Hz.

The current produced when TR4 switches produces a 5V spike at R9, which is used to drive the speaker via TR5. The quiescent interbase current flow in TR4 is so small that the voltage across R9 is less than 0·6V, and TR5 is consequently non-conducting between spikes.

The advantage of using this spike (rather than the sawtooth at C5) can now be seen: because of its very short duration it requires exceptionally small dissipation in TR5, avoiding the use of large transistors (both TR1 and TR5 are 1W types). Another advantage is that this waveform provides a distinctive, harsh sound which should attract attention.

Because of the extremely short and heavy current demand by TR5, with which the regulated supply could not cope, decoupling has been introduced at TR5 collector, and D8 holds the decoupled voltage at 5V to protect both C6 and TR5.

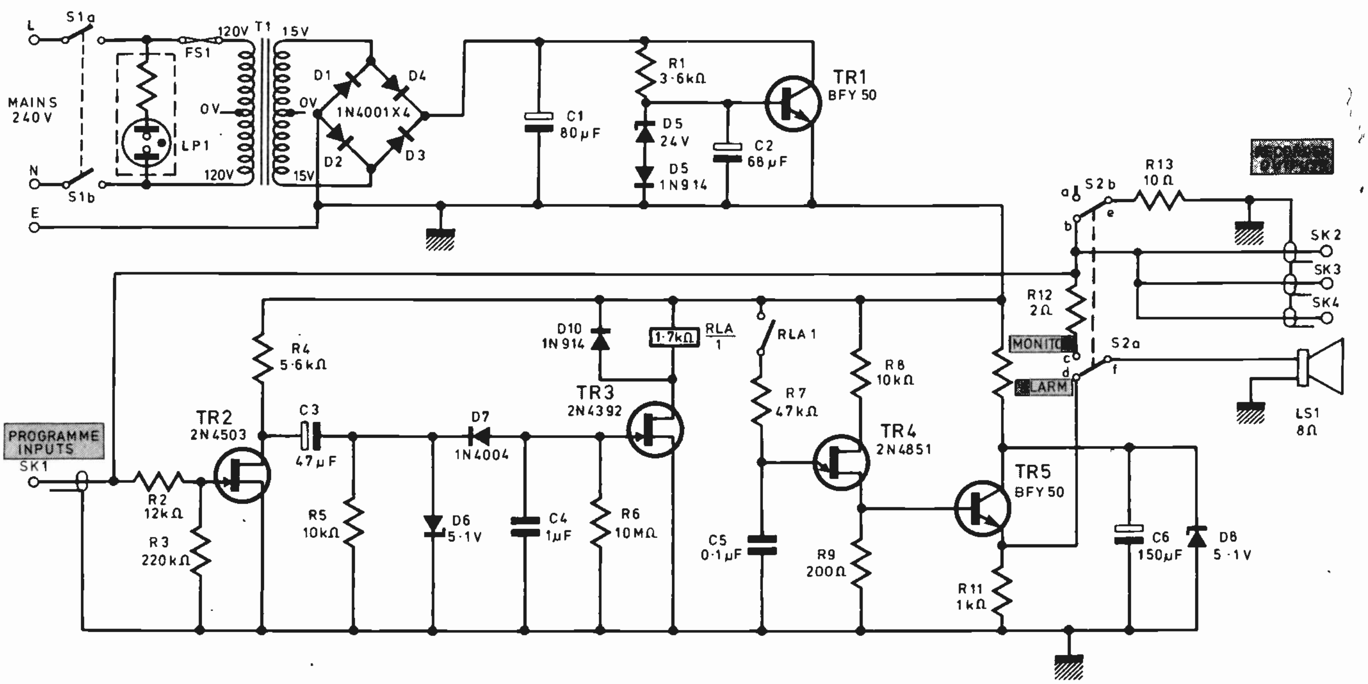


Fig. 2. Circuit of Sound Monitor

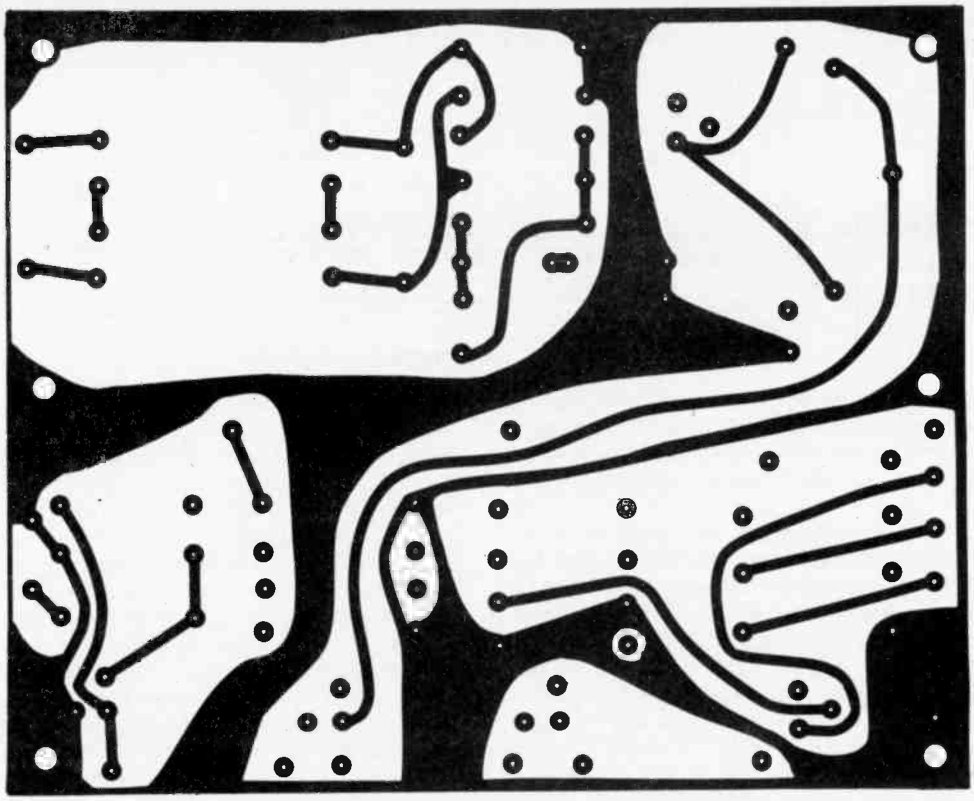


Fig. 3. P.c.b. layout for component side

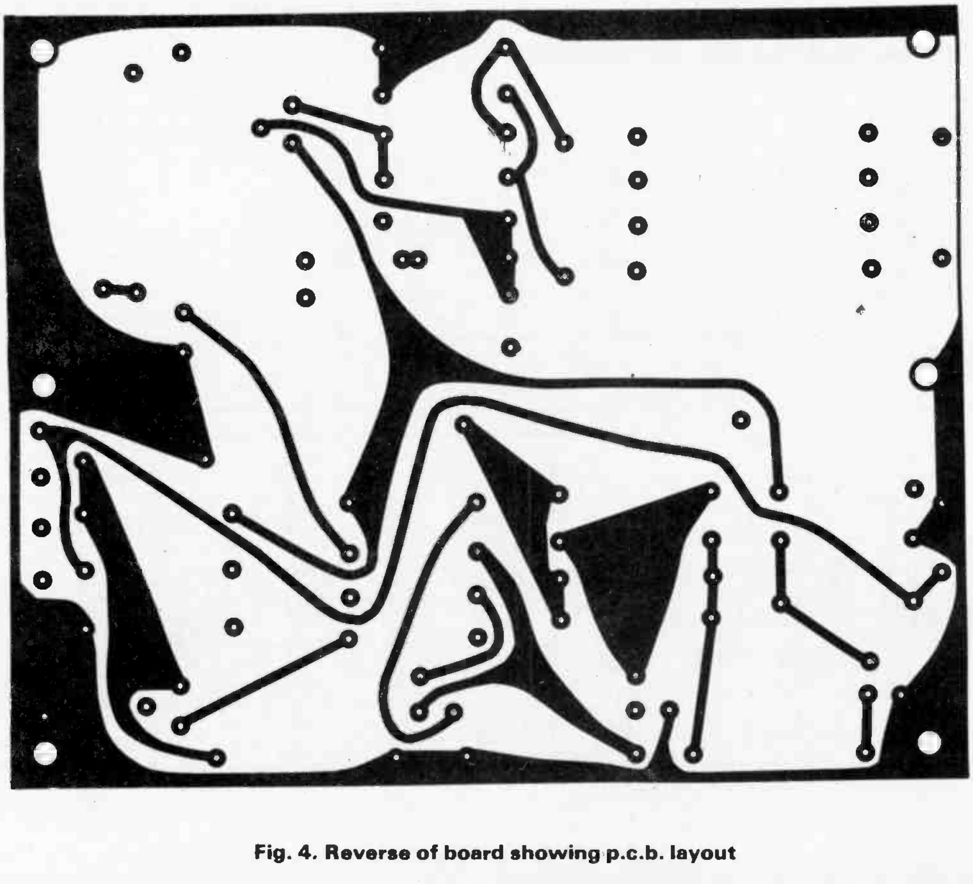


Fig. 4. Reverse of board showing p.c.b. layout

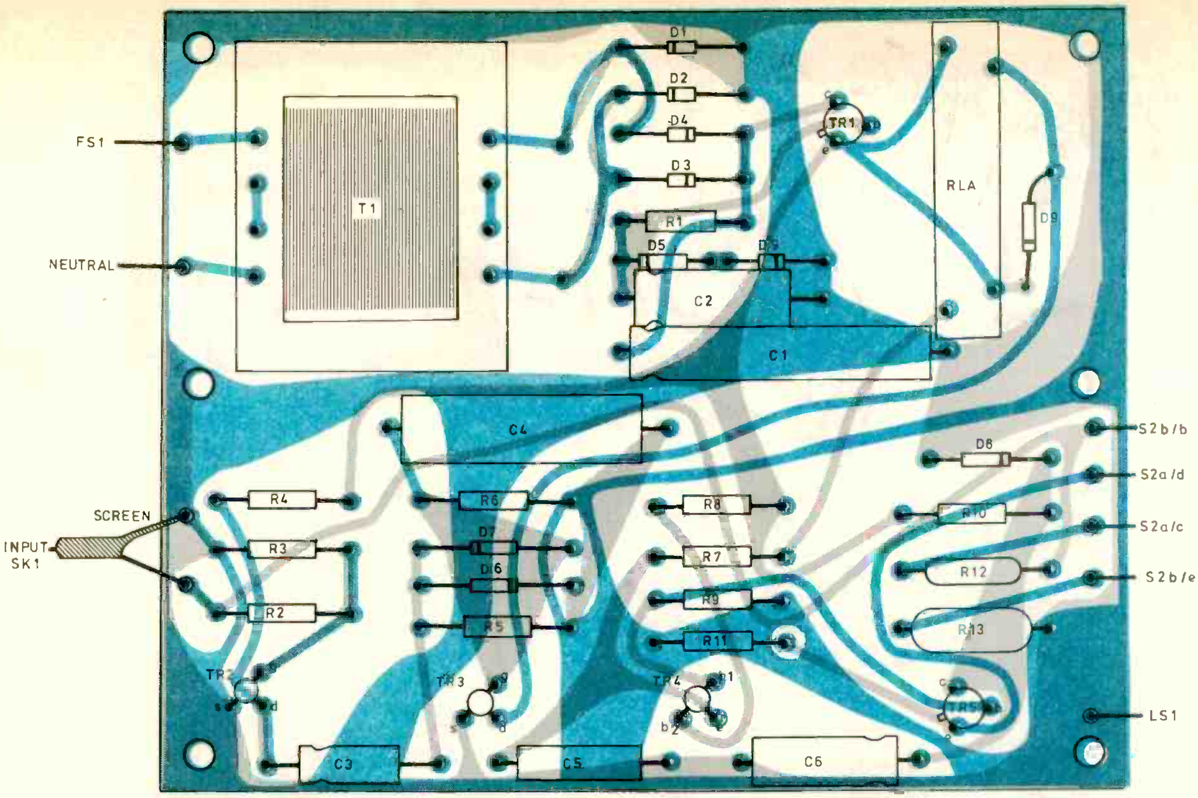


Fig. 5. Component assembly in double sided p.c.b.

At normal programme levels the speaker volume was thought to be adequate with a 2Ω series resistor R12.

No volume control is provided so that the user can gradually build up a mental picture of what constitutes the sound of correct playback volume. R13 provides an equivalent load to the line when the switch is in the "Alarm" position.

CONSTRUCTION

All components except those indicated on the front panel are mounted on a double-sided printed circuit board. Connections to this board are made via square-pin push-on connectors. The board is held in place by six machine screws and can be withdrawn for servicing after removing these.

For the dubbing job the output was fed via a single cable looped to three DIN connectors. A similar cable with appropriate connectors was made for distributing the power from a single supply to the three recording machines, so that by turning on or off that power supply all three machines could be started or stopped simultaneously. ★

COMPONENTS . . .

Resistors

R1 3·6kΩ
R2 12kΩ
R3 220kΩ
R4 5·6kΩ
R5 10kΩ
R6 10MΩ
R7 47kΩ
R8 10kΩ
R9 200Ω
R10 2·2kΩ ½W
R11 1kΩ
R12 2Ω 3W
R13 10Ω 2W
R14 390Ω
All ¼W carbon except where otherwise stated

Capacitors

C1 80μF elect. 50V
C2 68μF elect. 40V
C3 47μF elect. 30V
C4 1μF
C5 0·1μF
C6 150μF 50V

Diodes

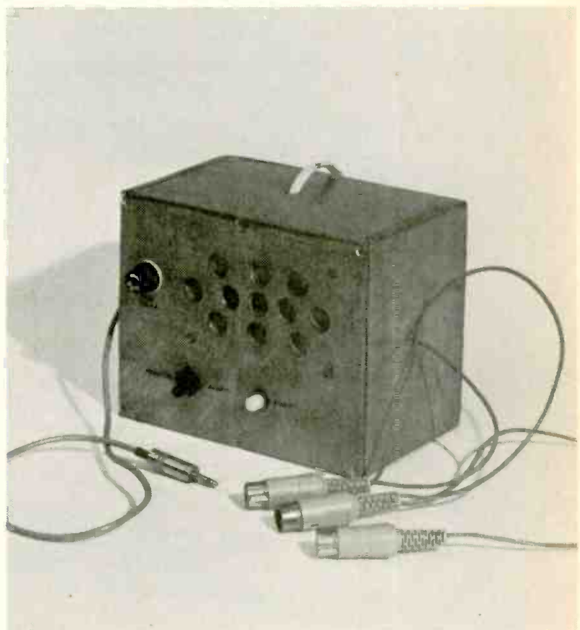
D1–D4 1N4004 (4 off)
D5 BZY88–24 24V Zener
D6 BZY88–5·1 5·1V Zener
D7 1N4004
D8 BZY–5·1 5·1V Zener
D9 1N914

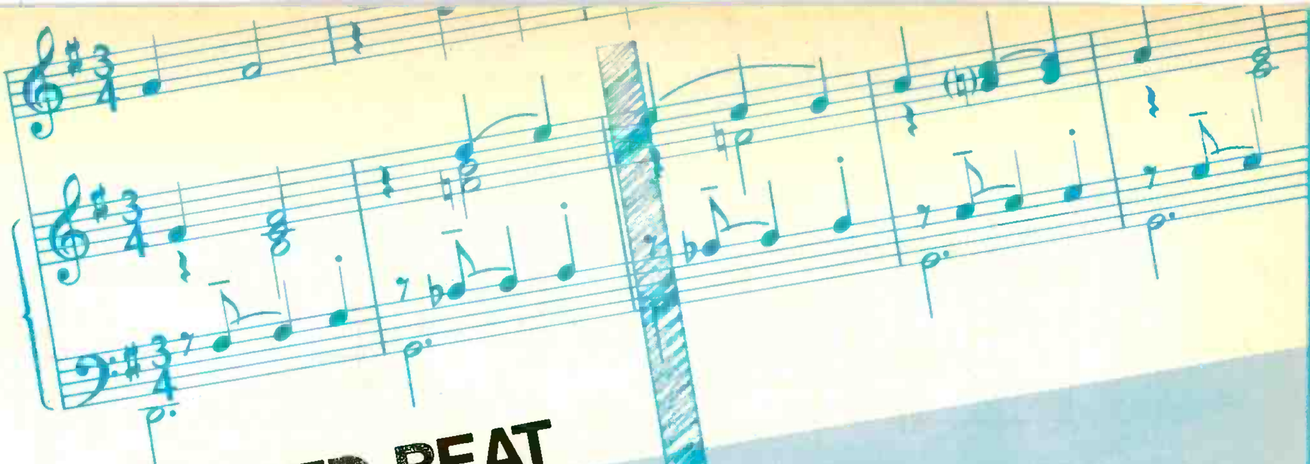
Transistors

TR1 BFY50
TR2 2N4303
TR3 2N4392
TR4 2N4851
TR5 BFY50

Miscellaneous

T1—240V pci—15V, 0·2A, 15V, 0·2A (Stock No. 207—598 R.S. Components)
LSI—1W 8Ω loudspeaker
S1—Mains d.p.c.o
S2—S.p.c.o
RLA—Reed relay 18–30V 3kΩ (Stock No. 349–002 R.S. components)





EMPHASISED BEAT Metronome...

M. BUTT

THE electronic metronome described in this article, in addition to providing the normal variable tempo beat, can also give emphasised beat at the beginning of each bar for the common musical time signatures. The tempo of the metronome can be adjusted from approximately 33 to 220 beats per minute.

CIRCUIT DESCRIPTION

The circuit diagram of the metronome is shown in Fig. 1. The circuit uses CMOS logic i.c.s in order to minimise current consumption.

Referring to the circuit diagram, IC1a and b with the associated circuitry, form the master oscillator which runs at twice the beat frequency. The frequency of this oscillator is varied by potentiometer VR1.

IC2 is a resettable 7 stage binary divider. The master oscillator output is fed to the input of IC2 and the signal corresponding to the beat speed is taken from the divide by two output. This is inverted by IC3d and differentiated by R5 and C5, the short positive pulses so formed, enabling the beat oscillator (comprising IC3a and b with C4 and R7). The negative pulses are clipped by the internal protection circuitry of IC3.

The output of this oscillator when enabled, is a short burst of pulses, the duration of this pulse train and its frequency being chosen to give a realistic sounding beat. This beat is fed via R4 to the output stage, which consists of a double emitter follower (TR1 and TR2), driving the loudspeaker.

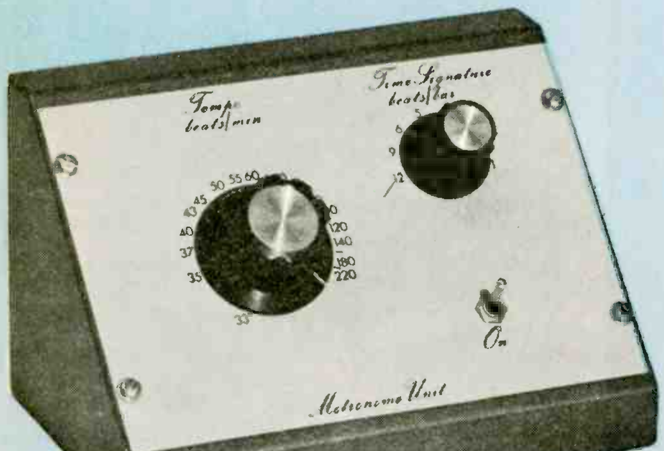
When the beat oscillator is disabled, the output is high which biases TR1 and TR2 off, thus minimising current drain.

EMPHASISED BEAT

For the unemphasised beat the output from IC3c is high. D2 therefore conducts, and so VR2 with D2 forms a potential divider with R4 for the negative going portions of the beat waveforms fed to TR1. The strength of the unemphasised beat can thus be adjusted by VR2.

The divide by four, eight, sixteen and thirty-two outputs of IC2 are selected by switches S1a and b, and then fed to the two inputs of the nand gate IC1c. The output of this is inverted by IC1d and fed to the reset input of the divider. This is reset when the number of beats selected by S1 have occurred. R2 and C2 delay the resetting long enough for C3 to be charged via D1, by the reset pulse. C3 and R3 form a hold circuit which keeps the input of IC3a high for a short time after the divider has been reset. IC3c output is inverted and so is low for this time, therefore D2 does not conduct.

The amplitude of the burst of oscillation fed to TR1 corresponding to the reset beat is greater than the other beats because VR2 has been switched out of circuit. This is the emphasised beat. The divider is reset on this beat, and begins to count again to the next emphasised beat where it is again reset.



The prototype Metronome was housed in a sloping metal case and powered by a PP3 9 volt battery. The Time Signature control ranges from one to twelve beats to the bar.

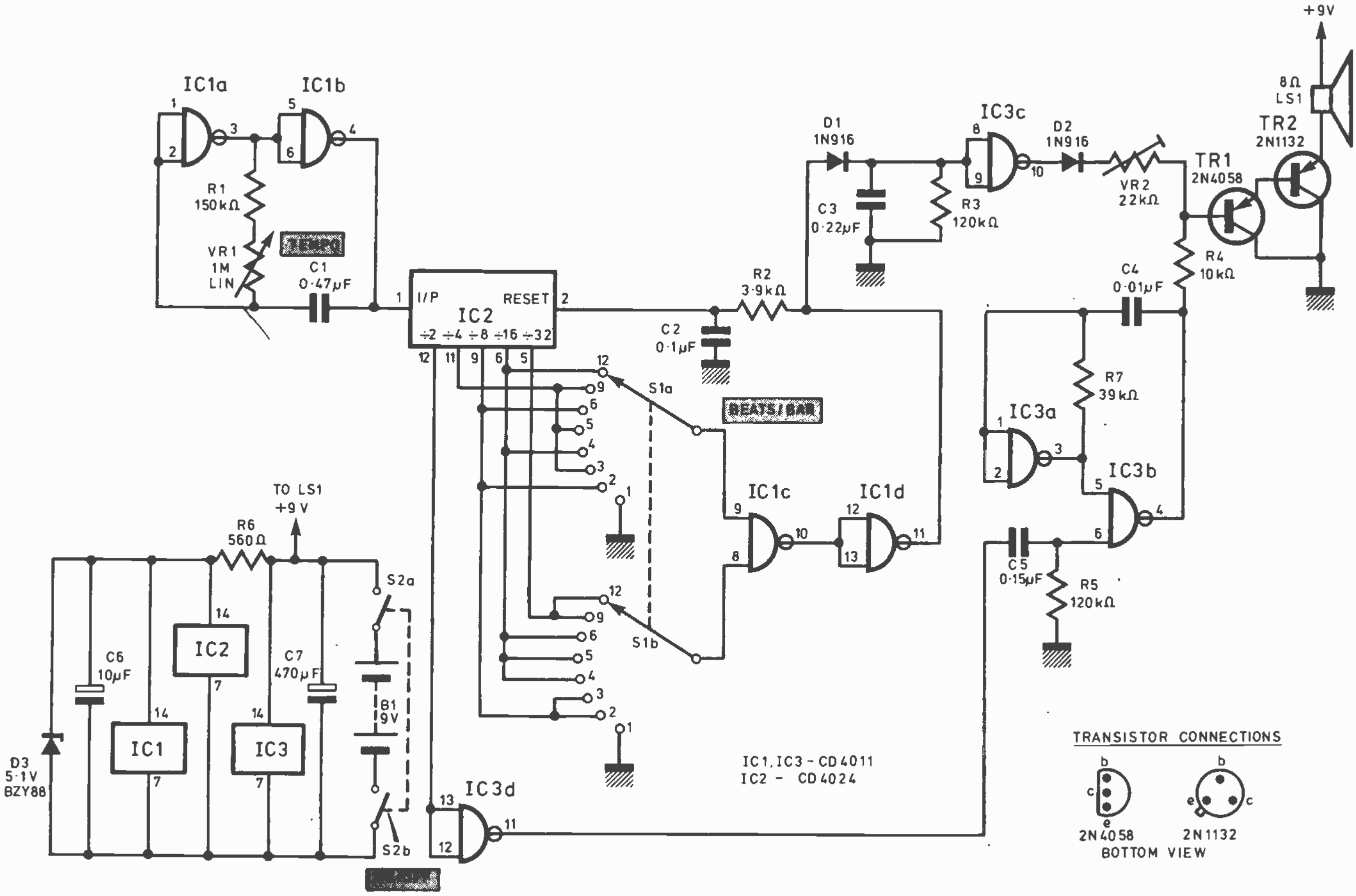


Fig. 1. Full circuit diagram of the Metronome

COMPONENTS . . .

Resistors

R1	150kΩ 2% m.o.
R2	3·9kΩ
R3	120kΩ
R4	10kΩ
R5	120kΩ
R6	560Ω
R7	39kΩ

All resistors ¼W 5% unless otherwise stated

Potentiometers

VR1	1MΩ lin carbon
VR2	22kΩ vert preset

Capacitors

C1	0·47μF 63V 2% polycarbonate
C2	0·1μF polyester
C3	0·22μF polyester
C4	0·01μF ceramic
C5	0·15μF polyester
C6	10μF 25V tant
C7	470μF 16V elect

Semiconductors

IC1, IC3	CD4011 (2 off)
IC2	CD4024
TR1	2N4058
TR2	2N1132
D1, D2	1N916 (2 off)
D3	5·1V Zener BZY88 400mW

Switches

S1	2-pole 8-way rotary wafer switch
S2	d.p.s.t. min toggle

Miscellaneous

LS1	8Ω 57mm (2¼in) dia loudspeaker, PP6 battery and clip, 0·1in matrix Veroboard (95 × 63·5mm), nuts, screws and wire. Case measuring 153 × 100 × 100mm.

Constructor's Note

The 0·47μF 2% polycarbonate capacitor specified for C1 may be obtained from Minicost Trading Ltd. Tel Whixall (094 872) 464/465

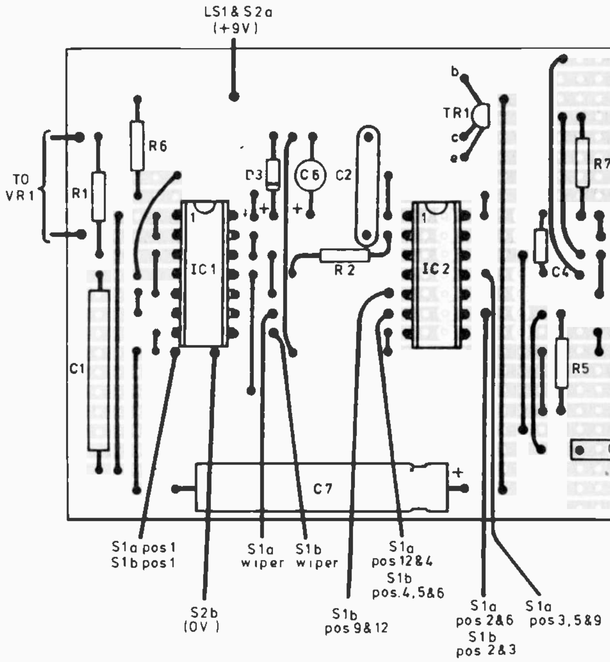
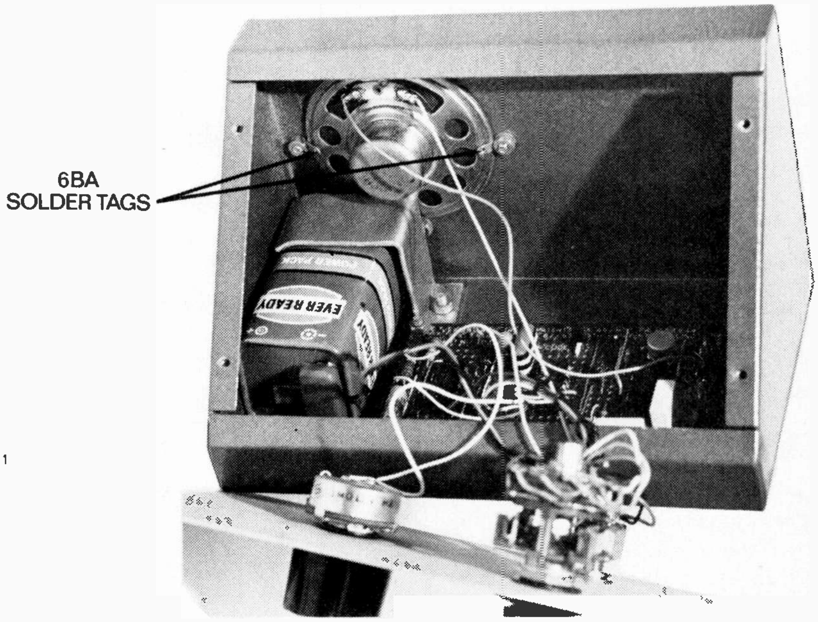


Fig. 2. Stripboard layout shown actual size

A method of mounting miniature loudspeakers which have no fastening lugs, is to fix four 6BA screw and nut assemblies around its perimeter so that they each clamp a 6BA solder tag. The soldering portion of these tags can then be pointed inwards and bent so as to captivate the loudspeaker



A simple battery clip can be made to hold the PP6, using a strip of aluminium about 25mm wide, drilled to give a 4BA fixing hole, and then formed around the battery by hand

Virtually any type of case will suffice to house the Metronome, but a sloping front panel will be found to have more appeal

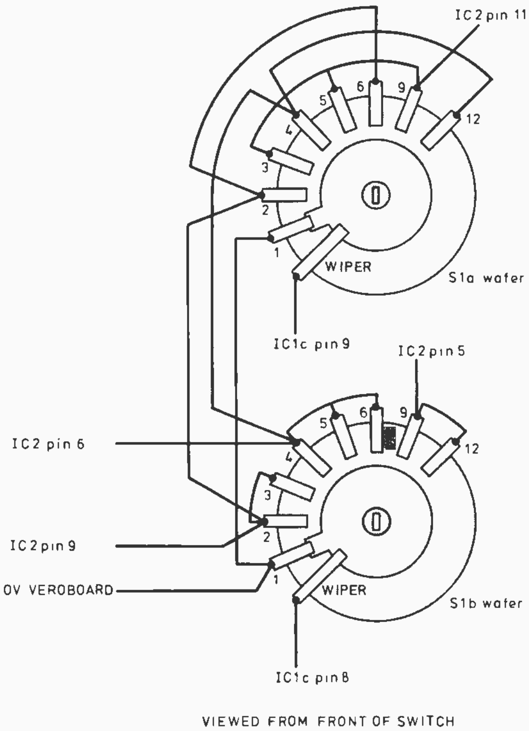
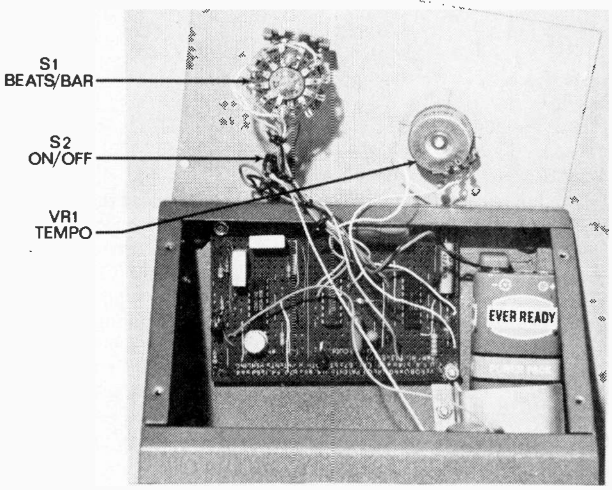
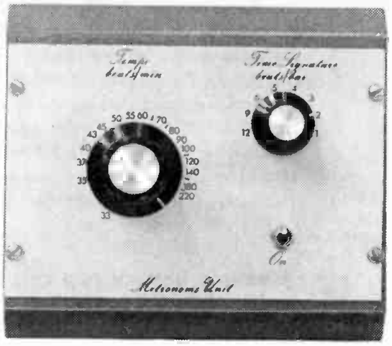


Fig. 3. Switch wiring diagram. The tag numbers refer to the beats per bar positions in order to relate to Figs. 1 and 2





VR1 setting (beats per minute)		Name
50	—	Largo
70	—	Adagio
90	—	Andante
115	—	Moderato
144	—	Allegro
188	—	Presto

SUPPLY ARRANGEMENT

The supply to IC1 and IC2 are stabilised by D3 to keep the master oscillator stable. IC3 is supplied direct from the battery as its outputs have to swing over a larger range than the outputs of the other i.c.s. The circuit is powered from a 9V PP6 battery. The current drawn from it depends on the tempo at which the metronome is running, but is normally below 5mA.

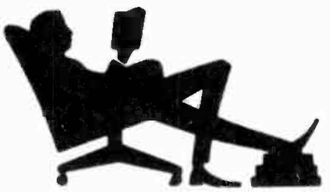
Position 1 of the multiway switch gives a beat of one strength only, the inputs of IC1c being grounded to obtain this.

CONSTRUCTION

The circuit was assembled on 0·1 inch matrix stripboard and the layout is shown in Fig. 2. The inputs of the i.c.s used are protected by diodes, but the normal precautions taken with MOS devices should be observed to be on the safe side.

The metronome was housed in a small sloping fronted instrument case and the front panel labelled with dry transfer labels. A number of small holes were drilled in the case in front of the speaker.

The wiring of the multi way switch wafers is shown in Fig. 3, and if wired as shown, give minimum tempo in the fully anti-clockwise position. The metronome can be calibrated using a stopwatch or the second hand of a watch. ★



BOOK REVIEWS

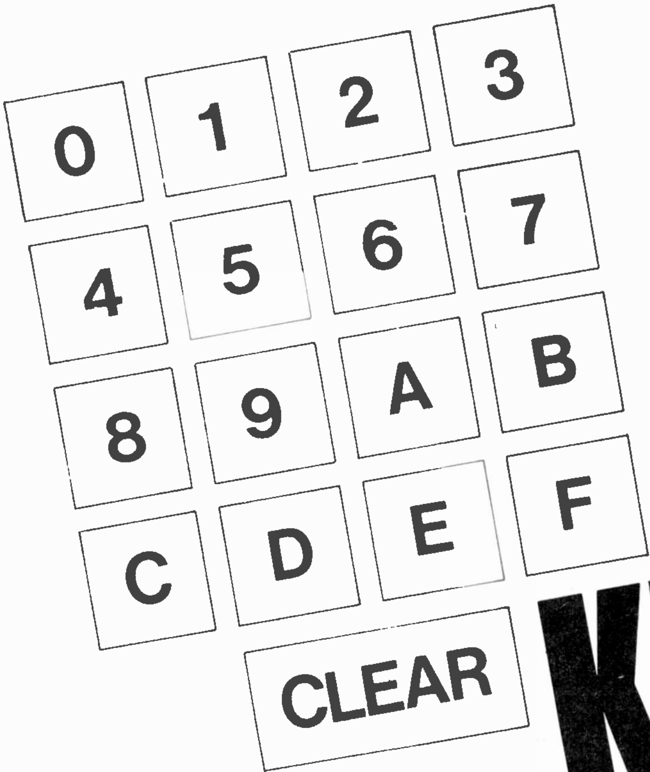
MASTER IN-CAR ENTERTAINMENT
By Vivian Capel
Published by Newnes Technical Books.
122 pages, 135 × 215mm. Price £2·50.

SHOULD anyone consider installing an in-car music system, who is not a hi-fi or electronics "whizz-kid" as such, they would find this book most useful. The explanations throughout are very understandable to the non-technical mind. Coverage of the various options for entertainment source is comprehensive, and would assist a quick decision on which type of radio or tape machine to use if you were in doubt.

With hints and tips on both installation and fault finding, and methods of identifying and curing interference, the d.i.y. car improver could be saved considerable "aggro" by consulting this book. It is all easy to follow, and the use of spot-colour has enhanced the simplicity of electronic and mechanical diagrams.

Chapters are: The Car Equipment Scene, Mono Stereo Or Quad?, Mobile Tape Players, The Cartridge Player, The Cassette Player, Cassette Or Cartridge?, Car Radios, Car Antennas, Interference Suppression, Installing The System, and Trouble Shooting.

In Chapter 9 the author suggests that interference due to static in the bodywork can be identified by coasting down a hill with the engine switched off. I would imagine that this practice, along with the driver's concentration on interference coming from his new hi-fi installation, could well result in some sound effects far more realistic and convincing than any stereo or quad system might produce! M.A.



Easy to build keyboard that provides an eight bit binary word by pressing two keys with l.e.d. readout

By L.G.PARKIN B.A.

KEYBOARD

MOST microprocessors that are suitable for amateur use need data input in the form of an eight bit binary word and hexadecimal characters form a convenient way of handling such data.

The keyboard described here provides an eight bit binary word by pressing two keys in succession. Pressing the first key lights up one of the "byte" l.e.d.s (this is a reminder that another key has yet to be pressed for the full code). At the same time, the binary code corresponding to that character appears in the four left-hand l.e.d.s (H, G, F, E). Each lit l.e.d. represents a "1". Pressing another key puts the binary code for that character into the four right-hand l.e.d.s (D, C, B, A). The second byte l.e.d. now lights, indicating that the full eight bit word is assembled, and a signal is sent to the microprocessor that the data is ready. At any time, the data word can be set to all noughts by pressing the "Clear" key, or by a signal from the microprocessor itself.

This type of keyboard is much simpler to build than a full ASCII keyboard, and it is just as effective if programs are written in machine code.

There are i.c.s available specially developed to do this job, but they are expensive, and they certainly don't crop up in the amateur's stock of i.c.s, or in scrap computer boards.

This project was designed to use common i.c.s and the matrix diodes can be any silicon type. The ones used in the prototype came from an untested lot of 100 for 60p, advertised as "similar to 1N914". About 90 per cent of these were found to be good.

Power supply for the keyboard is standard TTL 5V at about 150mA (all l.e.d.s lit).

SETTING THE CODE

The full circuit is shown in Fig. 1. To help in identification, each pin of an i.c. is labelled with two numbers separated by a hyphen. Thus IC7-10 means pin 10 of IC7.

We can follow the operation of the keyboard by taking an example. Suppose we have a SC/MP microprocessor, and we wish to enter the code for "Load the accumulator". This is 1100 0100 in binary, or C4 in hexadecimal. Before any key is pressed, both data bistables (IC8) are in the reset state, so IC8–8 is at logic "1". This prepares the four gates of IC1 for a key being pressed. Suppose key "C" is now pressed. Lines c, d, and K go to logic "1", so NAND gate outputs IC1–3 and IC1–6 becomes logic "0".

The "0" on IC1–3 sets IC3–3 bistable output to logic "1", and the "0" on IC1–6 sets IC3–6 to logic "1". L.e.d.s G and H light, so setting up the left hand byte (1100).

Line K (now at logic "1" remember) charges C1 through R1, so the Schmitt trigger input IC7–5 arrives at logic "1" level, and IC7–6 goes to logic "0". This has no effect on the clock inputs of IC8 data bistables—they need a positive going edge.

However, when the key is released after setting up the first byte, there is a short delay while C1 discharges (about 10 milliseconds), then IC7–5 returns to logic "0". IC7–6 therefore goes to logic "1", and clocks IC8 bistables. IC8–9 changes to logic "1", but IC8–5 stays at "0" because its data input IC8–2 is at logic "0" when the clock pulse occurs. The "1" on IC8–9 prepares the gates of IC2 for the next key being pressed. The first "byte" l.e.d. is now lit.

Now, key "4" is pressed. This raises lines c and K to logic "1", IC2–3 becomes logic "0", so changing bistable output IC5–3 to logic "1", and l.e.d. C lights. The right hand byte is now set up (0100), and the full eight bit binary code is displayed in the l.e.d.s.

When the key is released, IC7–5 drops to logic "0" level, so IC7–6 rises to logic "1". This clocks the upper data bistable of IC8, so that IC8–5 now rises to logic "1" (its data input is at "1" level). The second "byte" l.e.d. now lights, and the output of IC8–5 also provides a signal to the microprocessor that the keyboard data is "ready".

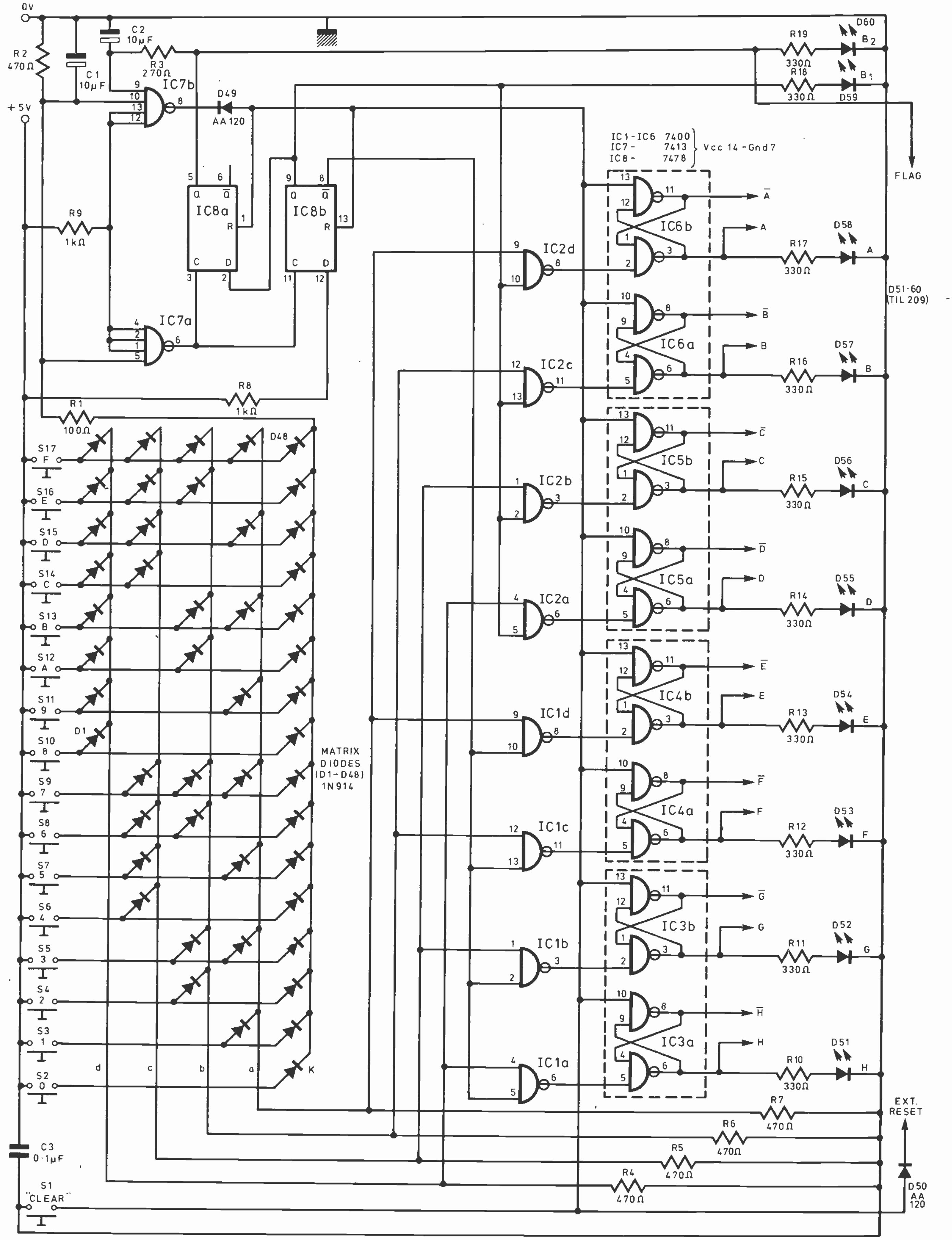


Fig. 1. Keyboard electronics

The eight data bits, and their complements if required, are available to the microprocessor from the outputs of IC3, IC4, IC5, and IC6.

RESET

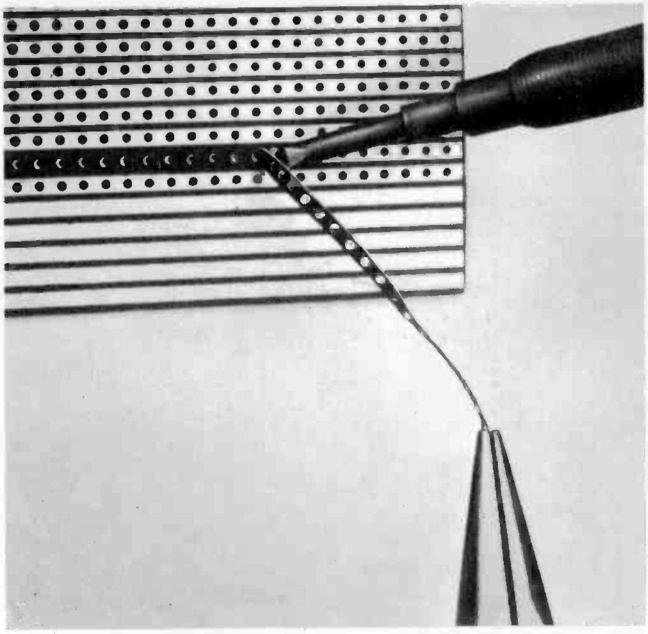
The "Reset" line shown in Fig. 1 is connected to the reset inputs of all bistables. If this line is pulled down to near 0V, all bistables will be reset. This must be done before another word is set up. There are three ways in which this can happen:

(1) **Keyboard reset.**—This is simple—the "Clear" key is pressed, which earths the reset line.

(2) **Microprocessor controlled**—A logic "0" from the microprocessor to the "External reset" line does the same job as pressing "Clear". The diode D2 (a germanium diode for low volts drop) prevents the "External reset" line being pulled down when "Clear" is pressed. Note that the external reset line is resetting 10 i.c.s, so the reset signal from the microprocessor must come from a device capable of doing this. A normal TTL gate has a fan-out of 10, so this is no problem.

(3) **Automatic reset**—If nothing deliberate is done to clear the keyboard before another data word is entered, the previous data will be cleared automatically at the instant another key is pressed. Any key being pressed will raise line K to logic "1". IC7–8 falls to logic "0", and takes the reset line down to logic "0". All bistables reset, and IC8–5 goes to logic "0". IC7–9 also goes to logic "0", so closing that gate. Keeping the key down has no further effect on the reset circuit.

All this takes only a few milliseconds, so, while the key is still pressed, the left hand four bits of the new code are set into IC3 and IC4. Pressing another key sets up the remainder of the new data word. Using this facility, and some cunning program writing, data can be put into memory simply by pressing two consecutive keys.



Lifting a copper strip with iron and pliers

CONSTRUCTION

Veroboard is a convenient way of making the diode matrix, so the same board is used for the remainder of the circuit.

Cut a piece of 0·1 matrix Veroboard, 40 holes by 34, with the copper strips running across the long dimension. Remove four of the strips, as illustrated. This is done by heating the strip with a soldering iron, lifting the strip gently with pliers, and running the iron ahead of the point where the strip is lifting (see photo). Cut the copper tracks, as shown in the illustration, with a $\frac{1}{8}$in drill.

COMPONENTS . . .

Resistors

R1	100Ω
R2	470Ω
R3	270Ω
R4–R7	470Ω (4 off)
R8–R9	1kΩ (2 off)
R10–R19	330Ω (10 off)

Capacitors

C1–C2	10μF elect. 10V (2 off)
C3	0·1μF

Diodes

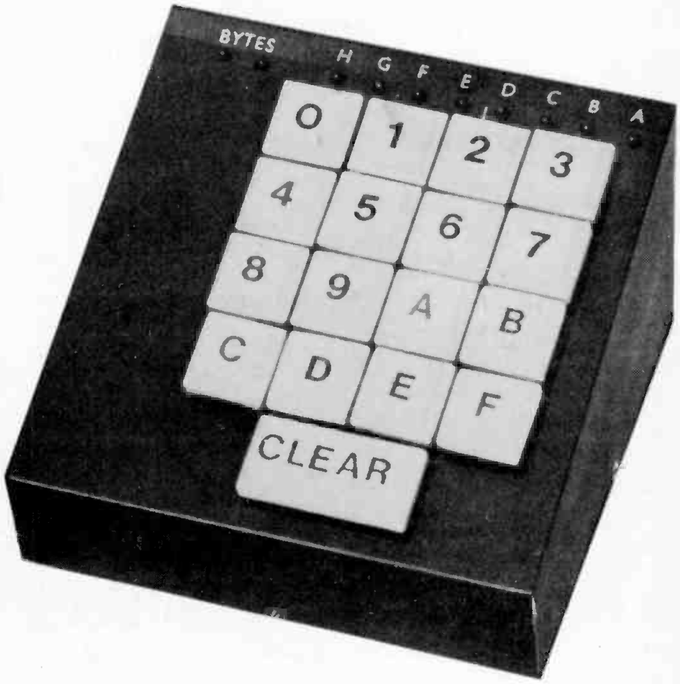
D1–D48	1N914 (any general purpose silicon) (48 off)
D49–D50	AA120 (2 off)

Integrated Circuits

IC1–IC6	7400 (6 off)
IC7	7413
IC8	7478

Keyboard

S1–S17 S.p.s.t. push-to-make keyboard switches (17 off)
A double blank cap can be obtained for the "Clear" key (R.S. Components)



Wiring Schedule—Circuit Board

Component	From	To	Component	From	To
Wire	IC1–1	Row c	Wire	IC7–12	IC7–13
Wire	IC1–2	IC1–5	Wire	IC5–7	Earth
Wire	IC1–3	IC3–2	Wire	IC5–10	Reset row
Wire	IC1–4	Row d	Wire	IC5–13	IC5–10
Wire	IC1–5	IC8–8	Wire	IC5–14	5V row
Wire	IC1–6	IC3–5	Wire	IC6–1	IC6–11
Wire	IC1–7	Earth	Wire	IC6–4	IC6–8
Wire	IC1–8	IC4–2	Wire	IC6–7	Earth
Wire	IC1–9	Row a	Wire	IC6–10	Reset row
Wire	IC1–11	IC4–5	Wire	IC6–13	IC6–10
Wire	IC1–12	Row b	Wire	IC6–14	5V row
Wire	IC1–14	5V row	Wire	IC7–1	IC7–2
Wire	IC2–1	IC1–1	Wire	IC7–2	IC7–4
Wire	IC2–2	IC2–5	Wire	IC7–6	IC8–3
Wire	IC2–3	IC5–2	Wire	IC7–7	Earth
Wire	IC2–4	IC1–4	Wire	IC7–9	J row
Wire	IC2–5	IC8–9	Wire	IC7–14	5V row
Wire	IC2–6	IC5–5	Wire	IC8–1	IC8–13
Wire	IC2–7	Earth	Wire	IC8–2	IC8–9
Wire	IC2–8	IC6–2	Wire	IC8–3	IC8–11
Wire	IC2–9	IC1–9	Wire	IC8–7	Earth
Wire	IC2–11	IC6–5	Wire	IC8–13	Reset row
Wire	IC2–12	IC1–12	Wire	IC8–14	5V row
Wire	IC2–14	5V row	R1 (100Ω)	K row	IC7–5
Wire	IC3–1	IC3–11	R2 (470Ω)	IC7–5	Earth
Wire	IC3–4	IC3–8	R3 (270Ω)	IC8–5	J row
Wire	IC3–7	Earth	R4 (470Ω)	d row	Earth
Wire	IC3–10	IC3–13	R5 (470Ω)	c row	Earth
Wire	IC3–13	Reset row	R6 (470Ω)	b row	Earth
Wire	IC3–14	5V row	R7 (470Ω)	a row	Earth
Wire	IC4–1	IC4–11	R8 (1kΩ)	IC8–12	5V row
Wire	IC4–4	IC4–8	R9 (1kΩ)	IC7–1	5V row
Wire	IC4–7	Earth	C1 (10μF)	IC7–5 (pos)	Earth (neg)
Wire	IC4–10	IC4–13	C2 (10μF)	J rows (pos)	Earth (neg)
Wire	IC4–13	Reset row	C3 (0·1μF)	5V row	Earth
Wire	IC4–14	5V row	D1 (germanium)	IC7–8	Reset row
Wire	IC5–1	IC5–11	D2 (germanium)	Reset row	Ext. reset row
Wire	IC5–4	IC4–8	Wire	Earth (upper)	Earth (lower)
Wire	IC7–4	IC7–12	Wire	Reset (upper)	Reset (lower)

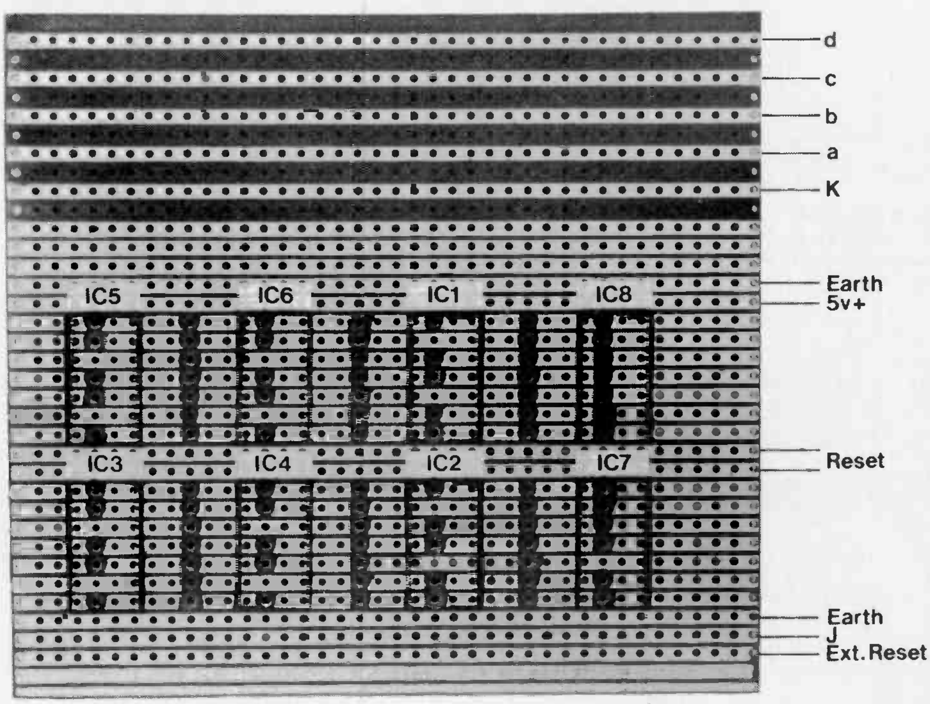


Fig. 2. Identification of rows on the circuit board for the wiring schedule. Copper cuts for the i.c.s are also shown

Wiring Schedule—Keys and l.e.d.s

Component	From	To
Wire	Key 0	"0" column
Wire	Key 1	"1" column
Wire	Key 2	"2" column
Wire	Key 3	"3" column
Wire	Key 4	"4" column
Wire	Key 5	"5" column
Wire	Key 6	"6" column
Wire	Key 7	"7" column
Wire	Key 8	"8" column
Wire	Key 9	"9" column
Wire	Key A	"A" column
Wire	Key B	"B" column
Wire	Key C	"C" column
Wire	Key D	"D" column
Wire	Key E	"E" column
Wire	Key F	"F" column
Wire	Key "Clear"	Reset row
Wire	5V row	Keys "0" to "F" (one side of each)
Wire	Earth	"Clear" key (other side)
Wire	Pad A	IC6–3
Wire	Pad B	IC6–6
Wire	Pad C	IC5–3
Wire	Pad D	IC5–6
Wire	Pad E	IC4–3
Wire	Pad F	IC4–6
Wire	Pad G	IC3–3
Wire	Pad H	IC3–6
Wire	Pad B1	IC2-13
Wire	Pad B2	IC8–5

Component	From	To
R10 (330Ω)	Pad H	l.e.d. H (pos)
R11 (330Ω)	Pad G	l.e.d. G (pos)
R12 (330Ω)	Pad F	l.e.d. F (pos)
R13 (330Ω)	Pad E	l.e.d. E (pos)
R14 (330Ω)	Pad D	l.e.d. D (pos)
R15 (330Ω)	Pad C	l.e.d. C (pos)
R16 (330Ω)	Pad B	l.e.d. B (pos)
R17 (330Ω)	Pad A	l.e.d. A (pos)
R18 (330Ω)	Pad B1	l.e.d. B1 (pos)
R19 (330Ω)	Pad B2	l.e.d. B2 (pos)
Wire	Case earth	Cct. board earth

Connections of a 16 pin plug (mating to microprocessor)

pin 1——bit A (least significant)
pin 2——bit B
pin 3——bit C
pin 4——bit D
pin 5——bit E
pin 6——bit F
pin 7——bit G
pin 8——bit H (most significant)
pin 9——common earth
pin 10——interrupt key
pin 11——go key
pin 12——reset key
pin 13——run/program key
pin 14——reset line from microprocessor
pin 15——keyboard flag to microprocessor
pin 16——5V supply

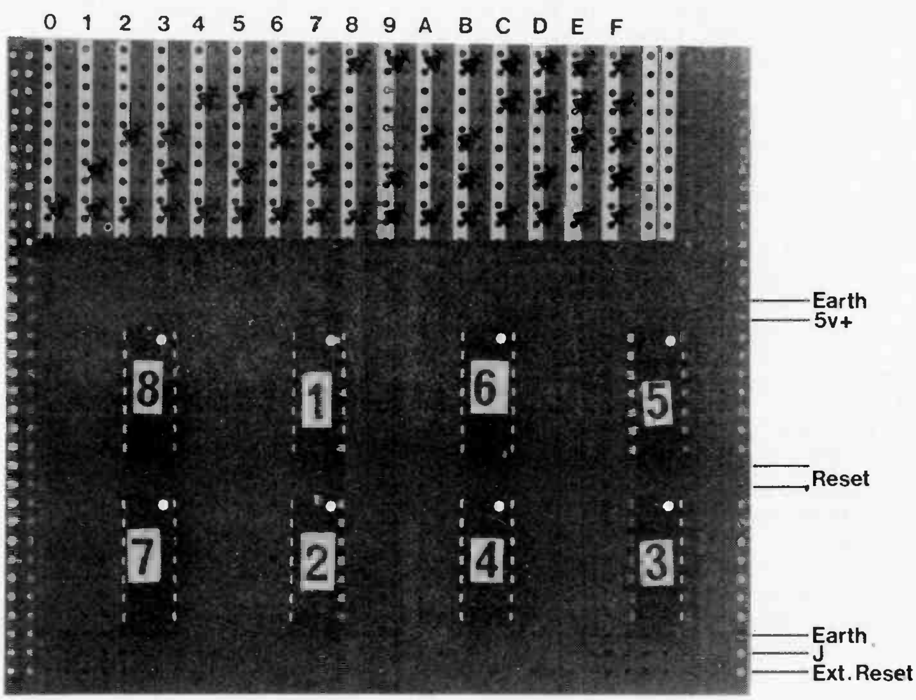
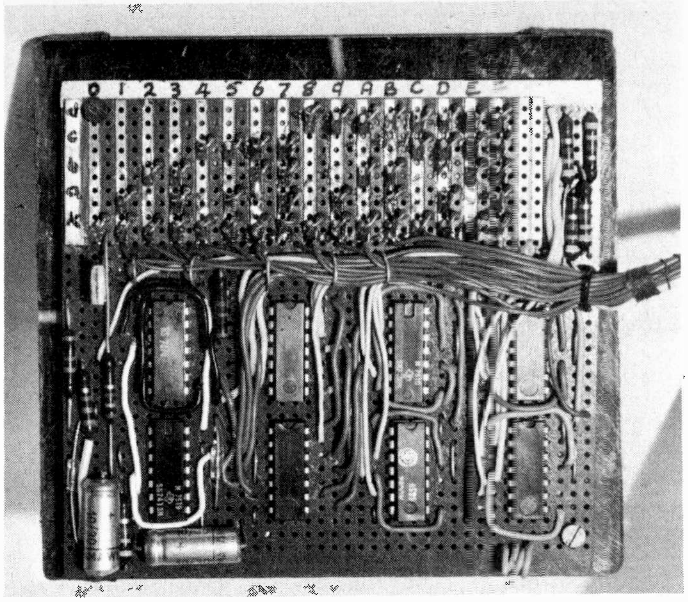


Fig. 3. Showing the connection of the matrix diodes and i.c.s

Main board prototype showing component layout and surface wiring. Note that the copper tracks of the two boards for the diode matrix are at right angles and the diodes are mounted diagonally so that each diode wire passes through the copper strip of only one board



Mount the ten l.e.d.s by gluing them with Araldite into the holes in the top panel, so that they just project above the surface. When the glue has set, connect each l.e.d. negative wire to the earth strip on the inside of the back panel. Connect the positive wires to the appropriate pad on the same panel.

Now follow the wiring schedule again, connecting the ten l.e.d. resistors, and the keyswitches, to the circuit board. Connect power and output wires. Mount the circuit board to the base panel, using 8 BA screws and insulating spacers. Take the power and output wires, plus eight wires from the unallocated keys, through the hole in the back panel.

TESTING

When power is first applied to the keyboard, a random display will probably appear. Press "Clear", and then a single key. One "byte" lamp should light, and the l.e.d.s H to E should display the chosen code. Press a second key, and l.e.d.s D to A should respond to that code. Check that both "byte" l.e.d.s are now lit.

A quick check on all l.e.d.s can be made by keying in "FF", which lights them all. Now test each key methodically, including the "Clear" key, which should always extinguish all l.e.d.s. One can assume that if the correct code appears in the display, it will also be presented to the microprocessor.

The design has been checked for repeatability, by building a second unit, which worked first time power was applied. Compatibility with the requirements of a microprocessor was checked by using the keyboard to input data to a Motorola 6800 evaluation kit.

KEYSWITCHES

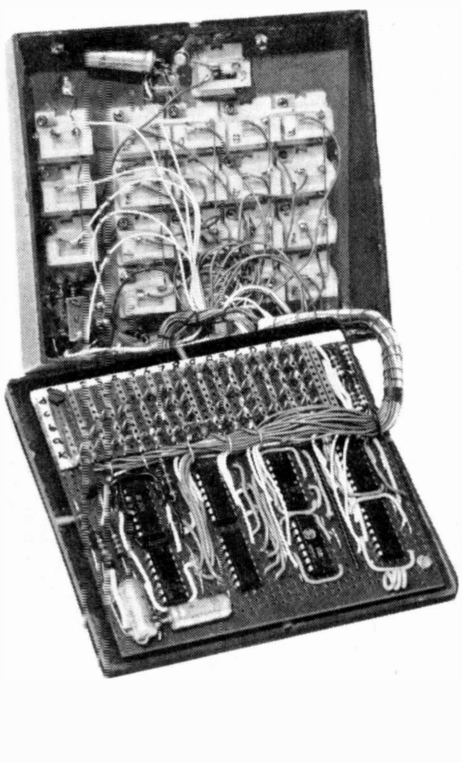
The keyswitches used came from a desk calculator keyboard, sold for 50p, but supplies of these in the surplus shops is very spasmodic, so it is a case of scanning current advertising. The front panel dimensions given suit a keyswitch no larger than $\frac{3}{4}$in square. Radiospares list a keyboard switch which measures less than $\frac{5}{8}$in square, and this would be suitable in this design, though more expensive.

A useful feature of the design of this project is that it needs only a simple "make" contact for each key. Sophisticated low contact bounce double throw switches are not needed, so there is scope for personal ingenuity, even if the resulting keyswitch is electrically rather crude.

Prepare another board, 34 holes by 10, with the copper strips running across the short dimension. Remove alternate strips, giving the pattern shown. Glue this board face to face with the larger board, with the copper strips at right angles. Use pins passing through both boards in two places to keep the holes in alignment until the glue sets. The relative positions of the two boards can be seen in the photo.

Next, mount the matrix diodes on the copper side of the smaller board, in the pattern shown. Each diode has its anode connected to a hole in a copper strip of the smaller board, and its cathode is taken through holes in both boards, to row a, b, c, d, or K of the larger board. When wiring the diodes of row K, leave the anode wires projecting about $\frac{1}{4}$in beyond the board. These will serve as pins to which the wires to the keyboard are attached.

Solder the i.c.s in position, with the locator of each towards the matrix. Now follow the Wiring Schedule to complete the assembly of the board. ★



PATENTS REVIEW...

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

BP 1509 212

The Federal Communications Commission in the USA is currently considering which of five rival systems should be adopted to provide the option for stereo transmissions on the AM (amplitude modulation) medium and long wave bands.

The five systems originate from Belar, Harris, Magnavox, Motorola and Leonard Kahn, a pioneering inventor in this field.

Kahn's system is favoured in some quarters because he claims that it enables anyone owning two existing AM mono sets to receive stereo without the need to purchase any additional equipment.

Doubtless with an eye to the likely adoption by the UK of whatever AM system is chosen by the FCC, Kahn has over recent years been busily patenting his ideas in the UK (BPs 970 051, 1 119 333 and most recently 1509 212).

If Kahn's system is chosen by the FCC, these and the American equivalent patents could quite conceivably make Kahn a millionaire.

The basic concept as protected by BP 970 051 is that of modulating the transmitted carrier wave so that the stereo related intelligence appears as respective upper and lower sidebands.

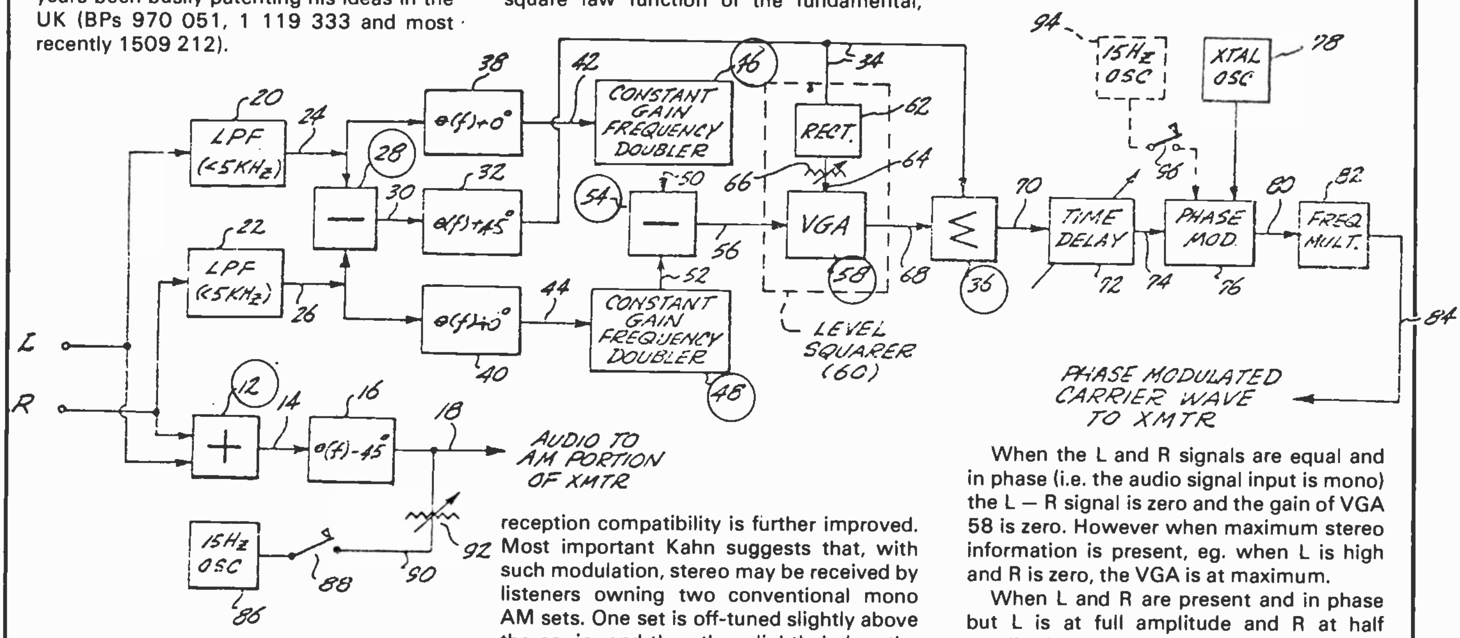
Optionally an infrasonic frequency (eg. 15Hz) is also impressed on the carrier to provide a switching signal for receivers equipped to decode stereo. Kahn suggests that for mono compatibility with existing radio receivers the transmitted signals should have the carrier wave envelope modulated by the stereo sum signal (L + R) and phase modulated by the difference signal (L − R). Existing sets receive only L + R and reproduce a mono sum signal; sets equipped with a stereo decoder matrix L + R and L − R to reproduce L and R as a stereo pair.

In Kahn's most recent patent he proposes a modified means of phase modulating the carrier with the difference signal. The claim is that, by phase modulating the carrier with a stereo difference signal formed from L−R fundamental, together with added second harmonic content varying in amplitude as a square law function of the fundamental, reception compatibility is further improved. Most important Kahn suggests that, with such modulation, stereo may be received by listeners owning two conventional mono AM sets. One set is off-tuned slightly above the carrier and the other slightly below the carrier to provide combined reception in the stereophonic mode.

The figure shows the transmitter encoder. Left and right signals (L and R) are summed at 12 and, with the addition of a −45° phase shift, the sum signal used without further treatment to amplitude modulate the transmitted carrier. The 15Hz stereo switching tone may also be added at this stage. To develop the phase modulation components for the carrier the L and R signals are also fed to a difference circuit 28 and a +45° phase shift imparted to one fraction of the output. This signal now serves as the fundamental phase modulation component and is fed to sum circuit 36.

Further output fractions of the difference circuit 28 are fed to frequency doublers 46 and 48 and the harmonic outputs of these doublers routed to difference circuit 54. The frequency doubled difference output passes through a level squarer formed by a variable gain amplifier 58, controlled by a fraction of the fundamental component tapped off ahead of sum circuit 36.

The VGA feeds sum circuit 36 of which the output is supplied via a time delay to the transmitter for phase modulation of the carrier.



When the L and R signals are equal and in phase (i.e. the audio signal input is mono) the L − R signal is zero and the gain of VGA 58 is zero. However when maximum stereo information is present, eg. when L is high and R is zero, the VGA is at maximum.

When L and R are present and in phase but L is at full amplitude and R at half amplitude the gain of VGA is reduced to limit the second harmonic component.

It follows that when stereo information is present the phase modulating component is composed not only of the fundamental of the stereo difference signal but also a controlled amount of frequency doubled difference signal, the level of the latter being a square law function of the fundamental.

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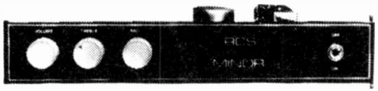
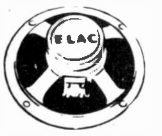
R.C.S. 10 WATT AMPLIFIER KIT



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

Mono kit **£12·50** Stereo kit **£20** post 45p

Easy to build Full instructions supplied



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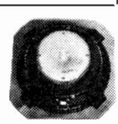
3A, 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£11·00
5A, 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£14·50
5, 8, 10, 16V ½A £2. 12V 100mA £1. 12V 300mA £1.	

12V 750mA **£1·30**. 40V 2A tapped 10V or 30V **£2·95**. 20V 2A **£2**. 40V 2A **£2·95**. 30V 5A 34V 2A ct. **£3·75**. 2 x 18V 6A **£9**. 12-0-12V 2 amp **£2·95**. 20-0-20V 1A **£2.95**. 30V 1½A **£2·75**. 20V 1A **£2·20**. 9V 3 amp **£2·75**. 60V, 40V, 20V or 20-0-20V, 1A **£3·50**. 30-0-30 2A **£7**. 9V 250mA **£1·30**.

AUTO TRANSFORMERS. 115V to 230V or 230V to 115V 150W £5; 250W £6; 400W £7; 500W £8.
CHARGER TRANSFORMERS Input 200/250V for 6 or 12V 1½A £2·75; 4A £5·20.
FULL WAVE BRIDGE CHARGER RECTIFIERS 6 or 12V outputs 1½A 40p; 2A 55p; 4A 95p. HALF WAVE 12V 1½A 25p.

GOODMAN'S COMPACT 12in BASS WOOFER



Standard 12in diameter fixing with cut sides 10¾in square 14,000 gauss magnet. 30 watt r.m.s. 4 ohm impedance. Bass resonance 30 c.p.s. Frequency response 30-8,000 c.p.s. £10.95 each. Post £1.00. 20 Watt model £9.95.

10 WATT PER CHANNEL STEREO AMPLIFIER

In chassis form. A.C. mains operated. Volume, balance, treble and bass slider controls. Pick up and tape inputs. Recording output. Socket. Front panel size: 16½ x 1½in. Chassis size: 13 x 15in. Bargain **£18·50** Post 50p

HEATING ELEMENTS WAFER THIN

Size 10¼ × 8½ × 1/16in Operating voltage 200/250V a c 250W approx Suitable for Heating Pads, Food Warmers, Convector Heaters etc Must be clamped between two sheets of metal or asbestos ONLY **40p** EACH (FOUR FOR £1·50)

ALL POST PAID—Discounts for quantity

E.M.I. 13½ × 8in SPEAKER SALE!

With tweeter. And crossover.

10W Model	**£7·95**	Post 45p
State 4 or 8 ohm.		
15W model	**£10·50**	Post 65p
8 ohms		
20W model	**£11·50**	Post 75p
State 8 or 15 ohms.		

TEAK VENEER HI-FI SPEAKER CABINETS

MODEL "A" 20 × 13 × 12in. For 12in. dia. or 10in. speaker. Illustrated **£14.50** Post £1.60
MODEL "B" BOOKSHELF For 13 x 8in. EMI Loudspeakers. **£8.50** Post £1
R.C.S. BOOKSHELF complete with speakers. Size 14 x 9 x 6in. approx. Response 50 to 14,000 cps 12 watt rms 8 ohms **£19 pair** Post £1.50
ACOUSTIC WADDING 18in. wide, **20p** ft.

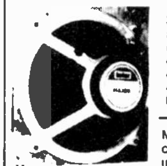
MONO PRE-AMPLIFIER

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

£4·50 ea. – 2 for £8. Post 50p.

BAKER MAJOR 12 INCH £16.88

Post £1 00



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

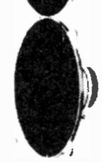
Module kit, 30–17,000 c/s with tweeter, crossover, baffle, 19 × 12½in, instructions. As illustrated. **£20.52**
Please state 4 or 8 or 16 ohms. Post £1 60

"BIG SOUND" BAKER SPEAKERS

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

GROUP "25"

12in 30W
4, 8 or 16 ohms. **£12.96** Post £1



GROUP "35"

12in 40W
4, 8 or 16 ohms. **£15.12** Post £1

GROUP 50/12in

12in 60W
4 or 8 or 16 ohms with aluminium presence dome. **£22.68** Post £1 60

GROUP 50/15in

15in 75W
8 or 16 ohms. **£28.08** Post £1 60

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

BAKER 150 WATT ALL PURPOSE TRANSISTOR AMPLIFIER

Ideal for Groups, Disco, P A and Musical Instruments 4 inputs speech and music 4 way mixing Output 4/8/16 ohm. a.c. Mains 240V. Separate treble and bass controls. **£85** Carr £1 50

NEW "DISCO 100 WATT" £59

ALL TRANSISTOR AMPLIFIER Carr £1
2 inputs. 4 outputs separate volume treble and bass controls. Ideal disco or slave amplifier chassis Made by Jennings

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

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

GOODMANS CONE TWEETER

18,000 c/s. 25W 8 ohm. Price **£3·25**

3 WAY CROSSOVER WITH TREBLE & MID RANGE CONTROLS. 50 WATT. £5 POST £1.

R.C.S. 100 WATT VALVE AMPLIFIER CHASSIS

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

LOW VOLTAGE ELECTROLYTICS

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

HIGH VOLTAGE ELECTROLYTICS

8/350V	22p	8+8/450V	50p	50+50/300V	50p
16/350V	30p	8+16/450V	50p	32+32/450V	75p
32/500V	75p	16+16/450V	50p	100+100/275V	65p
50/350V	50p	32+32/350V	50p	150+200/275V	70p

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Size 6¼ x 3½ x 2in with brushed aluminium facia. Ideal for constructional projects. **£1·50** Post 30p

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

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

ELECTRO MAGNETIC PENDULUM MECHANISM

95p Post 30p

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

BSR AUTOCHANGER

Plays 12in, 10in or 7in records Auto or Manual. A high quality unit backed by BSR reliability with 12 months guarantee. a.c. 200/250V. Size 13½ × 11½in. Above motor board 3½in. Below motor board 2½in.

With STEREO/MONO CARTRIDGE	**£12·95** All Post 75p
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GARRARD AUTOCHANGER plays all records	£14·95
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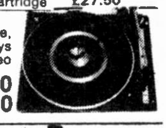
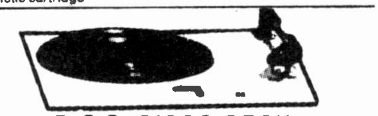
GARRARD AP76 Single Player less cartridge	£27.50

BSR DE LUXE AUTOCHANGER



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



R.C.S. DISCO DECK SINGLE RECORD PLAYER

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

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Extra Large Plinth and Cover. For transcript on decks. Size 20 × 17½ × 9in. uncut board. Shop callers only **£18·50.**

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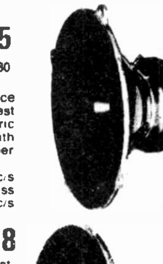
HIGH QUALITY—BRITISH MADE



SUPERB £24.75

12in 25 watt

Post £1 60

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

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

8 or 16 ohms models

AUDITORIUM £22.68

12in 35 watt

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

Bass Resonance	35 c/s
Flux Density	15,000 gauss
Useful response	25–16,000 c/s

8 or 16 ohms models

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15in 45 watt

Post £1 60

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Model BW 630

Battery Wire-Wrapping Tool Complete with Bit and SI Line

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For .025" (0,63mm) sq. post "MODIFIED" wrap, positive indexing, anti-overwrapping device.

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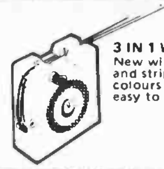
B	For AWG 26-28	BW-2628
C	Bit for AWG 30	BT-30
D	Bit for AWG 26-28	BT-2628



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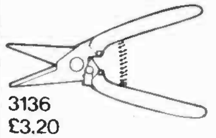
£3.77



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Extractor Tool EX-1.

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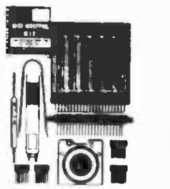
INS-1416



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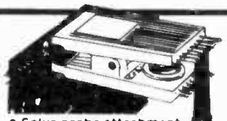
Contains: Hobby Wrap Tool WSU-30 M, Wire Dispenser WD-30-B, (2) 14 DIP's, (2) 16 DIP's, Hobby Board H-PCB-1, DIP/IC Insertion Tool INS-1416 and DIP/IC Extractor Tool EX-1.

Wire-Wrapping Kit	WK-4B (Blue)

£17.82



IC TEST CLIPS £2.77
FOR DUAL-IN-LINE PACKAGES
- Provide full access to integrated circuit DIP leads.
- Remove DIP's damage free.
- Available in sizes to accommodate all DIP's; TC-14 fits 14-pin DIP's etc.
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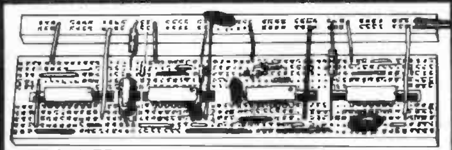

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Bread boarding building blocks with universal matrices of solderless plug-in tiepoints.
- Facilitate quick, solderless circuit build-up and check-out on universal .1" x .1" matrix.
- Are offered in ten configurations.
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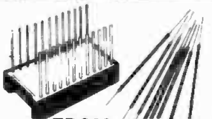
A£4.39 B£4.69

Regular Wrap	A	WSU-30
Modified Wrap	B	WSU-30M



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Dual-In-line package, 3 level wire-wrapping, phosphor bronze contact, gold plated pins .025 (0,63mm) sq., .100 (2,54mm) centre spacing.

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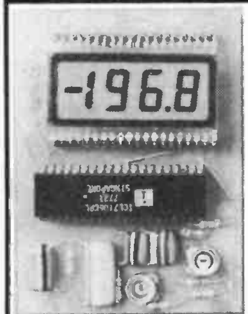

Based on the 7106 single IC 3½ digit D.V.M. the Kit contains a PCB, resistors, capacitors, presets, I.C. and 0.5" liquid crystal display. Components are also included to enable the basic D.V.M. kit to be modified to a Digital Thermometer using a single transistor as the sensor.
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16A	113p
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25A	205p
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Diac	23p

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4 x 555	£1.08
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0.2" L.E.D.s		
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Green	23p	
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Standard 240V mains primary 100mA secondary

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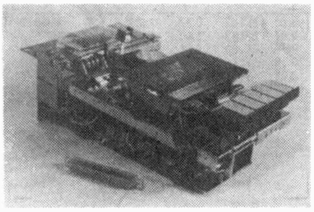
STEREO

CASSETTE RECORDER DECK



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1 SCR 10 Diodes

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4mm thick walls
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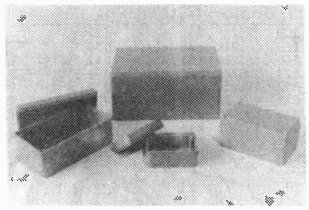

Box No.	Breadth mm	Length mm	Height mm	Weight gm
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1002	75	130	61	175
1003	90	160	71	285
1004	93	193	95	340
1005	125	220	110	575

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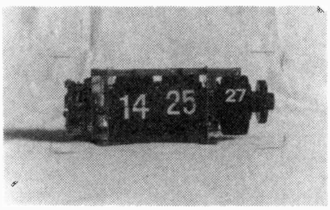

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2N696	0.39	2N2219	0.38	2N3397	0.19	2N4062	0.20	2N5247	0.44	40410	0.82					BC214B	0.17	BC549B	0.14	BD244A	0.70	BF182	0.37	BFX89	1.37	MJE520	0.50
2N697	0.31	2N2219A	0.39	2N3438	0.85	2N4064	1.35	2N5248	0.44	40411	3.10					BC214C	0.17	BC549C	0.15	BD244C	0.87	BF183	0.44	BFY50	0.27	MJE521	0.70
2N698	0.49	2N2220	0.39	2N3440	0.75	2N4074	2.65	2N5294	0.44	40594	0.87	BC147	0.13	BC182B	0.13	BC214L	0.18	BC557	0.14	BD245A	0.69	BF184	0.41	BFY51	0.27	MJE2955	1.65
2N699	0.58	2N2221	0.25	2N3441	0.92	2N4121	0.27	2N5295	0.44	40595	0.98	BC147B	0.13	BC182L	0.15	BC214LB	0.18	BC558	0.13	BD245C	0.85	BF185	0.37	BFY52	0.27	MPF3055	1.05
2N706	0.30	2N2221A	0.25	2N3442	1.45	2N4122	0.27	2N5296	0.44	40673	0.80	BC148	0.13	BC182LA	0.15	BC214LC	0.18	BC559	0.15	BD246A	0.72	BF194	0.16	BFY90	1.35	MPF102	0.33
2N706A	0.30	2N2222	0.25	2N3638	0.17	2N4123	0.19	2N5298	0.44	40669	1.30	BC148B	0.13	BC182LB	0.15	BC237B	0.16	BCY70	0.21	BD246C	0.93	BF195	0.16	BR101	0.55	MPF103	0.44
2N708	0.30	2N2222A	0.25	2N3638A	0.17	2N4124	0.19	2N5447	0.16	AC126	0.48	BC148C	0.13	BC183	0.12	BC238A	0.13	BCY71	0.26	BD433	0.44	BF196	0.16	BRY39	0.55	MPF104	0.44
2N718	0.30	2N2369	0.27	2N3702	0.14	2N4125	0.19	2N5448	0.16	AC127	0.48	BC149	0.15	BC183A	0.12	BC238B	0.13	BCY72	0.18	BD434	0.46	BF197	0.18	BSX19	0.35	MPS105	0.44
2N718A	0.54	2N2369A	0.27	2N3703	0.14	2N4126	0.19	2N5449	0.20	AC128	0.48	BC149C	0.15	BC183B	0.13	BC238C	0.13	BD115	0.88	BD435	0.46	BF198	0.19	BSX20	0.35	MPSA05	0.27
2N720A	0.85	2N2646	0.80	2N3704	0.14	2N4284	0.38	2N5457	0.38	AC151	0.43	BC157A	0.15	BC183C	0.13	BC239B	0.16	BD131	0.55	BD436	0.46	BF199	0.19	BSX21	0.35	MPSA06	0.27
2N722	0.45	2N2647	1.55	2N3705	0.14	2N4286	0.22	2N5458	0.35	AC152	0.54	BC158A	0.15	BC183L	0.15	BC239C	0.17	BD132	0.75	BD437	0.55	BF224J	0.22	BU104	1.80	MPSA12	0.44
2N727	0.50	2N2903	1.60	2N3706	0.14	2N4287	0.22	2N5459	0.32	AC153	0.59	BC158B	0.15	BC183LA	0.15	BC257A	0.16	BD135	0.40	BD438	0.55	BF225J	0.27	BU105	1.55	MPSA14	0.33
2N914	0.38	2N2904	0.31	2N3707	0.14	2N4288	0.22	2N5460	0.65	AC153K	0.59	BC159A	0.17	BC183LB	0.15	BC258B	0.19	BD136	0.40	BD529	0.49	BF244A	0.38	BU126	1.08	MPSA55	0.27
2N916	0.33	2N2904A	0.31	2N3708	0.12	2N4289	0.22	2N5484	0.37	AC176K	0.70	BC159B	0.17	BC183LC	0.15	BC259B	0.19	BD137	0.41	BD530	0.55	BF244B	0.33	BU204	2.20	MPSA56	0.27
2N917	0.38	2N2905	0.31	2N3709	0.12	2N4347	2.20	2N5485	0.40	AC176	0.54	BC160	0.38	BC184	0.12	BC300	0.43	BD138	0.41	BD535	0.70	BF245A	0.44	BU205	2.40	R2008B	2.45
2N918	0.45	2N2905A	0.31	2N3771	2.16	2N4348	2.65	2N5486	0.40	AC187	0.59	BC161	0.38	BC184B	0.13	BC301	0.43	BD139	0.43	BD536	0.70	BF245B	0.44	BU206	2.70	R2010B	2.15
2N929	0.37	2N2906	0.25	2N3772	2.20	2N4918	0.65	2N5490	0.64	AC187K	0.65	BC167	0.13	BC184C	0.13	BC302	0.37	BD140	0.43	BD537	0.74	BF257	0.35	BU208	2.70	TIP29A	0.49
2N929A	0.37	2N2906A	0.25	2N3773	3.15	2N4919	0.70	2N5492	0.64	AC188	0.54	BC167B	0.13	BC184L	0.15	BC303	0.54	BD181	1.90	BD538	0.77	BF258	0.35	ME0401	0.22	TIP29C	0.65
2N930	0.37	2N2907	0.25	2N3819	0.36	2N4920	0.83	2N5494	0.65	AC188K	0.65	BC168A	0.13	BC184LB	0.15	BC307	0.16	BD182	2.20	BD539	0.60	BF259	0.35	ME0402	0.22	TIP30A	0.54
2N930A	0.95	2N2907A	0.25	2N3820	0.39	2N4921	0.54	2N5496	0.67	AD161	1.00	BC168B	0.13	BC184LC	0.15	BC307A	0.16	BD183	2.35	BD540	0.60	BF336	0.42	ME0404	0.17	TIP30C	0.70
2N1711	0.30	2N2923	0.17	2N3821	0.96	2N4922	0.60	2N6027	0.64	AD162	1.00	BC168C	0.13	BC212	0.15	BC307B	0.16	BD187	0.95	BDX14	1.32	BF337	0.49	ME0412	0.22	TIP31A	0.54
2N1889	0.30	2N2924	0.17	2N3900	0.28	2N4923	0.75	2N6107	0.45	AF106	0.60	BC169B	0.13	BC212A	0.15	BC308	0.16	BD235	0.46	BDX18	1.90	BF338	0.52	ME0414	0.22	TIP31C	0.72
2N1890	0.30	2N2925	0.19	2N3901	0.30	2N4924	1.15	2N6108	0.55	AF109	0.52	BC169C	0.13	BC212B	0.15	BC308B	0.16	BD236	0.44	BDY20	1.10	BFR39	0.30	ME4001	0.16	TIP32A	0.59
2N1893	0.30	2N2926	0.17	2N3903	0.20	2N5086	0.30	2N6109	0.55	BC107	0.16	BC177	0.22	BC212L	0.18	BC309A	0.16	BD237	0.44	BDY55	1.90	BFR40	0.29	ME4002	0.16	TIP32C	0.82
2N2102	0.50	2N3053	0.25	2N3904	0.18	2N5087	0.30	2N6111	0.49	BC107A	0.16	BC177A	0.22	BC212LA	0.18	BC309B	0.16	BD238	0.44	BDY56	2.10	BFR41	0.30	ME4003	0.16	TIP41A	0.76
2N2192	0.58	2N3054	0.72	2N3905	0.18	2N5088	0.30	2N6121	0.41	BC107B	0.16	BC177B	0.25	BC212LB	0.18	BC309C	0.16	BD239A	0.44	BF115	0.39	BFR79	0.30	ME4101	0.11	TIP41C	0.97
2N2193	0.50	2N3055	0.75	2N3906	0.18	2N5089	0.30	2N6122	0.44	BC108	0.16	BC178	0.22	BC213	0.15	BC327	0.22	BD239C	0.59	BF160	0.33	BFR80	0.30	ME4102	0.11	TIP42A	0.86
2N2193A	0.52	2N3390	0.50	2N4031	0.55	2N5190	0.65	2N6123	0.48	BC108A	0.16	BC178A	0.25	BC213A	0.15	BC328	0.20	BD240A	0.49	BF161	0.65	BFR81	0.30	ME4103	0.11	TIP42C	1.08
2N2194	0.42	2N3391	0.40	2N4032	0.65	2N5191	0.75	2N6124	0.45	BC108B	0.16	BC178B	0.35	BC213B	0.15	BC337	0.20	BD240C	0.59	BF167	0.37	BFX29	0.34	ME4104	0.11	TIP2955	0.70
2N2194A	0.45	2N3391A	0.45	2N4036	0.72	2N5192	0.80	2N6125	0.47	BC108C	0.17	BC179	0.25	BC213C	0.15	BC338	0.23	BD241A	0.49	BF173	0.37	BFX30	0.34	ME6101	0.22	TIP3055	0.59
2N2195	0.40	2N3392	0.17	2N4037	0.60	2N5193	0.75	40361	0.55	BC109	0.16	BC179A	0.25	BC213L	0.17	BC547	0.13	BD241C	0.65	BF177	0.27	BFX84	0.30	ME6102	0.22	TIS34	1.05
2N2195A	0.40	2N3393	0.17	2N4058	0.22	2N5194	0.80	40362	0.55	BC109B	0.17	BC179B	0.25	BC213LA	0.17	BC547A	0.13	BD242A	0.55	BF178	0.27	BFX85	0.38	MJ2955	1.35	TIS42	0.50
2N2217	0.55	2N3394	0.17	2N4059	0.17	2N5195	0.97	40363	1.45	BC109C	0.18	BC179C	0.26	BC213LB	0.17	BC547B	0.13	BD242C	0.62	BF179	0.33	BFX86	0.30	MJE340	0.62	TIS43	0.47
2N2218	0.35	2N3395	0.19	2N4060	0.22	2N5245	0.37	40408	0.82	BC140	0.30	BC182	0.12	BC213LC	0.17	BC548	0.13	BD243A	0.65	BF180	0.37	BFX87	0.35	MJE370	0.62	TIS90	0.22
2N2218A	0.38	2N3396	0.19	2N4061	0.19	2N5248	0.38	40409	0.82	BC141	0.32	BC182A	0.12	BC214	0.17	BC549	0.14	BD243C	0.87	BF181	0.37	BFX88	0.30	MJE371	0.86	TIS91	0.27

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CA3020	2.20	LM380N14		LM7824K	1.75	TBA120	0.80
CA3020A	2.50		1.08	LM78L05CZ		TBA500	2.24
CA3028A	0.90	LM381AN	2.70		0.30	TBA5000	2.34
CA3028B	1.25	LM381N	1.69	LM78L12CZ		TBA510	2.35
CA3030	1.50	LM382N	1.32		0.30	TBA5100	2.48
CA3030A	2.20	LM384N	1.55	LM78L15CZ		TBA520	2.60
CA3038	2.90	LM386N	0.88		0.30	TBA5200	2.70
CA3038A	4.10	LM387N	1.10	MM5314	4.60	TBA530	2.35
CA3045	1.55	LM388N	1.00	MM5316	4.60	TBA5300	2.45
CA3046	0.77	LM389N	1.00	NE555	0.33	TBA540	2.60
CA3048	2.45	LM702C	0.81	NE556	0.85	TBA5400	2.70
CA3052	1.78	LM709	0.70	NE558N	1.98	TBA550	3.60
CA3080	0.85	LM7098	0.50	NE560	4.50	TBA5500	3.80
CA3080A	2.10	LM70914	0.49	NE561	4.50	TBA56000	3.00
CA3086	0.50	LM710	0.67	NE562	4.50	TBA570	2.10
CA3088B	1.87	LM71014	0.64	NE565	1.39	TBA5700	2.20
CA3089B	2.90	LM711CN	0.72	NE566	1.75	TBA7000	2.20
CA3090Q	4.40	LM723C	0.75	NE567	1.90	TBA720AQ	2.06
CA3130	1.06	LM723C14	0.45	NE571N	4.95	TBA750	2.36
CA3140	1.04	LM726	5.80	SAS560	2.70	TBA7500	2.45
LM301	0.30	LM741C	0.70	SAS570	2.70	TBA800	1.30
LM307N	0.50	LM741C8	0.30	SAJ110	2.10	TBA810S	1.30
LM308N	0.95	LM741C14	0.30	S041P	1.35	TBA820	0.80
LM309KC	1.95	LM747CN	0.99	S042P	1.35	TBA920	2.99
LM317K	3.35	LM7488	0.50	SN76001N		TCA160C	2.36
LM318N	2.45	LM74814	0.90		1.30	TCA160B	2.55
LM320TS	2.15	LM1303N	1.15	SN76003N		TCA270	2.99
LM320T12	2.15	LM1304N	1.52		2.38	TCA730	4.50
LM320T15	2.15	LM1305N	1.52	SN76013N		TCA740	4.50
LM320T24	2.15	LM1307N	1.22		1.50	TCA750	3.00
LM320P5	1.15	LM1310N	2.10	SN76023N		TCA760	2.00
LM320P12	1.15	LM1351N	1.30		1.50	TCA105	1.49
LM320P15	1.15	LM1458N	0.45	SN76033N		TCA440	1.65
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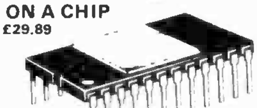

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74LS30N	0.26	74C00N	0.24	7413N	0.36	74122N	0.55
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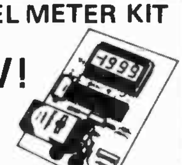

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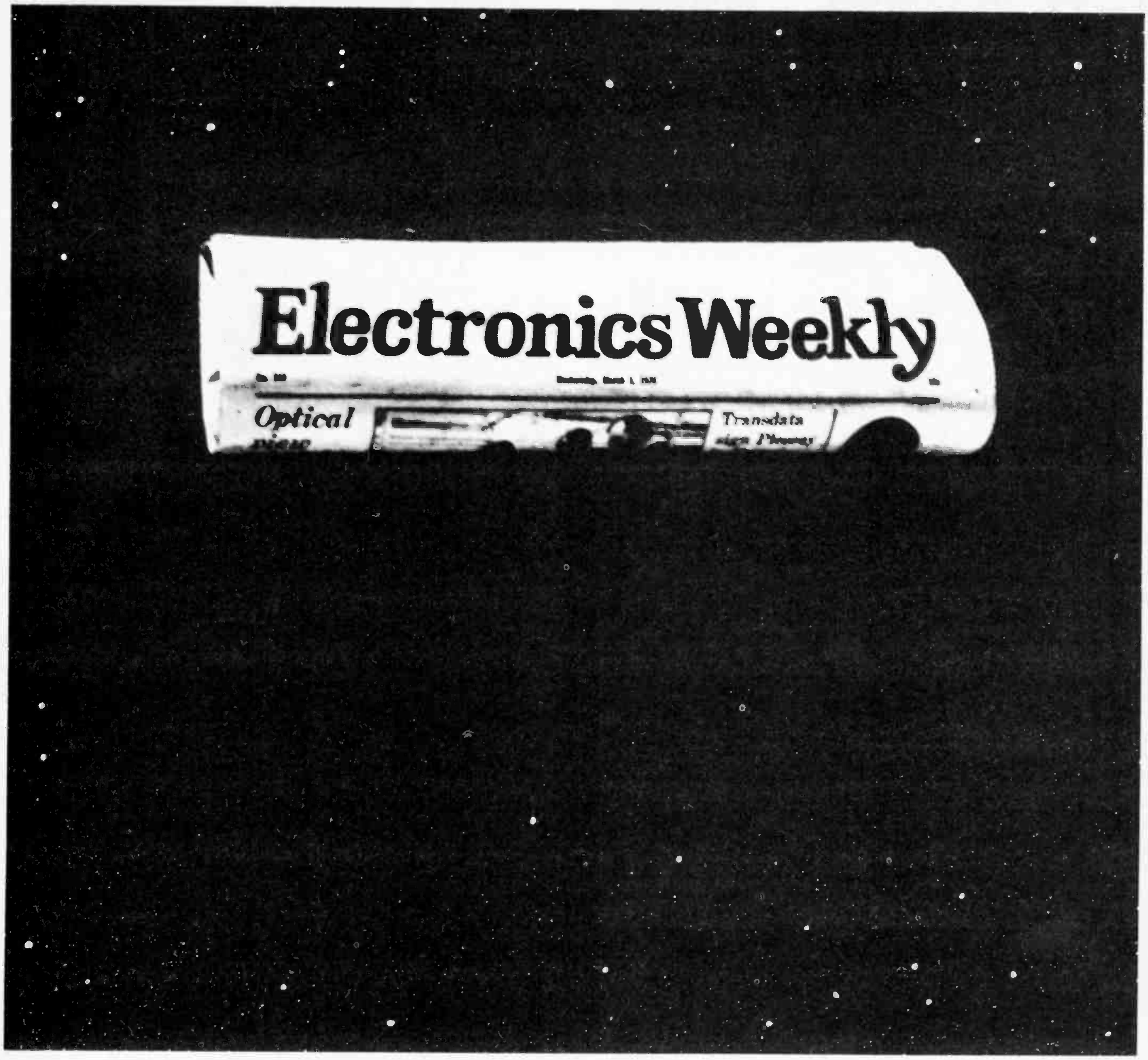
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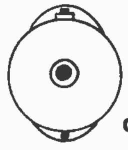

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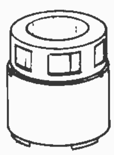

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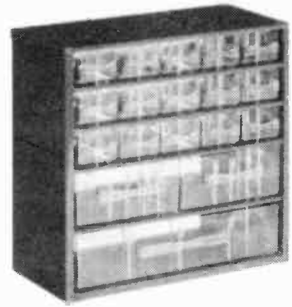

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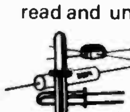

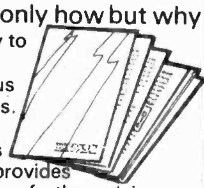

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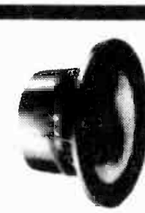

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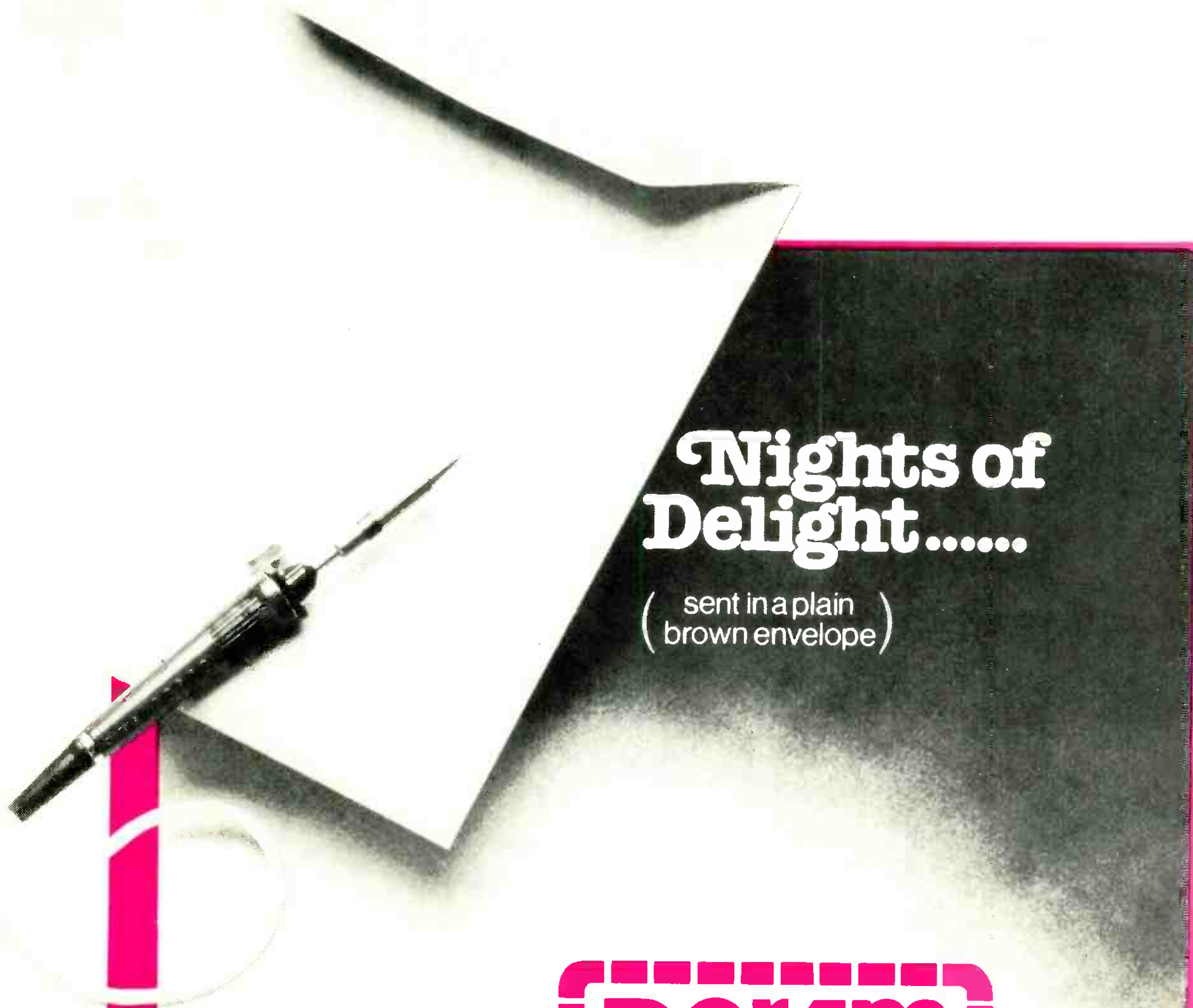

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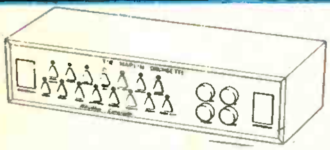

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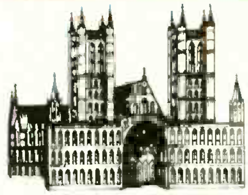

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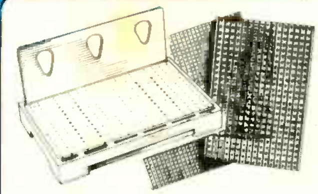

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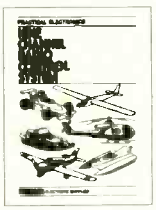

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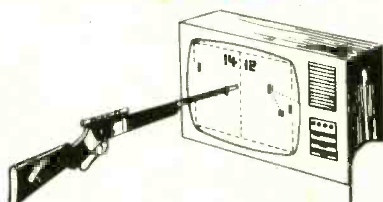

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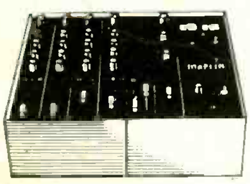

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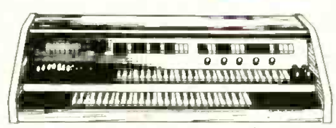

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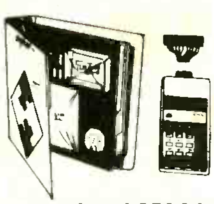

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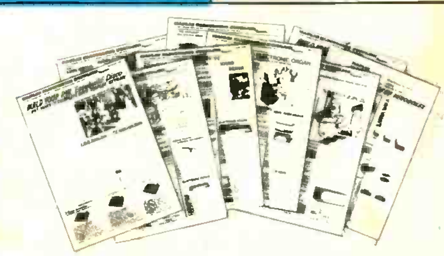

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