ELECTRONICS TODAY

electronics today international

DECEMBER 1976

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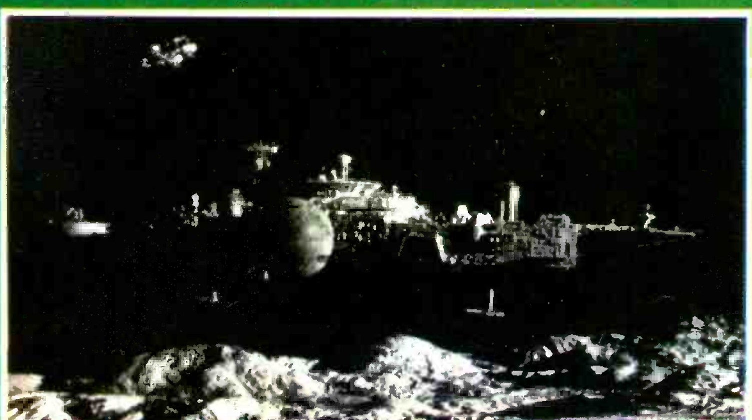

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NEWS . . . CONSTRUCTION . . . DEVELOPMENTS . . . AUDIO

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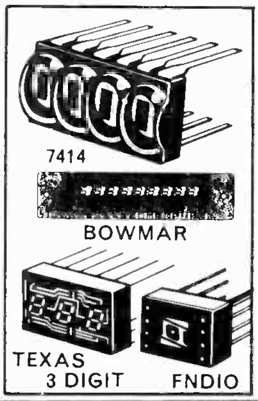

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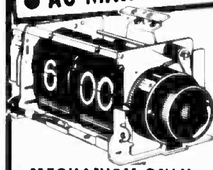

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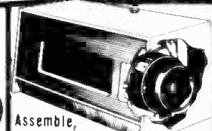

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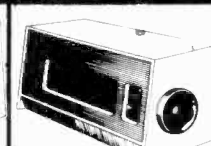

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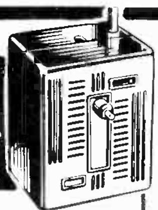

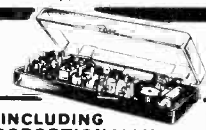

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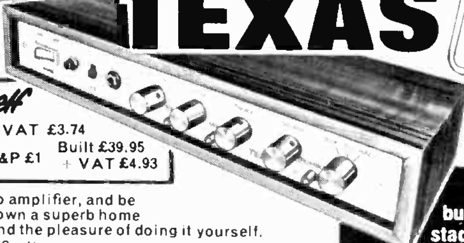

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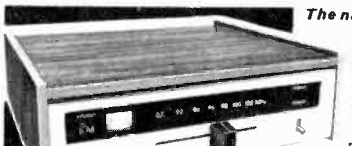

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AC132	•0.15	BC177	•0.16	BFX84	•0.19	2N1305	•0.18
AC134	•0.15	BC178	•0.16	BFX85	•0.25	2N1306	•0.21
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AC141	•0.19	BC180	•0.25	BFX87	•0.22	2N1308	•0.24
AC141K	•0.80	BC181	0.25	BFX88	•0.22	2N1309	•0.24
AC142	•0.19	BC182	0.09	BFY50	•0.13	2N1613	•0.16
AC142K	•0.26	BC182L	0.09	BFY51	•0.13	2N1711	•0.16
AC151	•0.16	BC183	0.09	BFY52	•0.13	2N1889	•0.32
AC153K	•0.24	BC183L	0.09	BFY53	•0.13	2N1890	•0.46
AC154	•0.20	BC184	0.09	BSX19	•0.16	2N1893	•0.38
AC155	•0.20	BC184L	0.09	BSX20	•0.16	2N2147	•0.73
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AC167	•0.20	BC209	0.12	BSY29	•0.16	2N2217	•0.22
AC168	•0.25	BC212	0.10	BSY38	•0.19	2N2218	•0.18
AC169	•0.15	BC212L	0.10	BSY39	•0.19	2N2218A	•0.18
AC176	•0.11	BC213	0.10	BSY40	•0.29	2N2219	•0.18
AC176K	•0.26	BC213L	0.10	BSY41	•0.29	2N2220	•0.22
AC177	•0.25	BC214	0.10	BSY95	•0.13	2N2221	•0.18
AC178	•0.29	BC214L	0.10	BSY95A	•0.13	2N2222	•0.18
AC179	•0.29	BC225	0.26	BU105	•1.90	2N2368	•0.18
AC180	•0.20	BC226	0.36	MAT100	•0.19	2N2369	•0.12
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AC187	•0.22	BC303	•0.31	MJE521	•0.56	2N2646	•0.34
AC187K	•0.23	BC304	•0.37	MJ2955	•0.88	2N2711	•0.21
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ACY17	•0.26	BC337	0.12	MPF102	•0.28	2N2904	•0.14
ACY18	•0.20	BC338	0.12	MPF104	•0.28	2N2904A	•0.18
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ACY20	•0.20	BC460	•0.37	OC19	•0.36	2N2905A	•0.18
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ACY35	•0.21	BCZ10	•0.20	OC35	•0.45	2N2926Y	0.09
ACY36	•0.29	BCZ11	•0.26	OC36	•0.51	2N2926O	0.08
ACY40	•0.18	BCZ12	•0.26	OC41	•0.20	2N2926R	0.07
ACY41	•0.19	BD115	•0.63	OC42	•0.25	2N2926B	0.07
ACY44	•0.36	BD116	•0.81	OC44	•0.16	2N3010	•0.71
AD130	•0.39	BD121	•0.61	OC45	•0.13	2N3011	•0.15
AD140	•0.49	BD123	•0.67	OC70	•0.10	2N3053	•0.15
AD142	•0.53	BD124	•0.70	OC71	•0.10	2N3054	•0.40
AD143	•0.49	BD131	•0.36	OC72	•0.15	2N3055	•0.40
AD149	•0.45	BD132	•0.40	OC74	•0.15	2N3391	0.15
AD161	•0.36	BD133	•0.67	OC75	•0.16	2N3391A	0.17
AD162	•0.36	BD135	0.41	OC76	•0.16	2N3392	0.15
AD161 &		BD136	0.41	OC77	•0.26	2N3393	0.15
AD162(MP)		BD137	0.46	OC81	•0.16	2N3394	0.15
	•0.69	BD138	0.51	OC81D	•0.16	2N3395	0.18
ADT140	•0.51	BD139	0.56	OC82	•0.16	2N3402	•0.21
AF114	•0.22	BD140	0.61	OC82D	•0.16	2N3403	•0.21
AF115	•0.22	BD155	•0.81	OC83	•0.20	2N3404	•0.29
AF116	•0.22	BD175	•0.61	OC139	•0.20	2N3405	•0.45
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AF180	•0.51	BD189	•0.77	OC205	•0.38	2N3702	0.09
AF181	•0.51	BD190	•0.77	OC309	•0.41	2N3703	0.09
AF186	•0.51	BD195	•0.87	OCP71	•0.44	2N3704	0.08
AF239	•0.38	BD196	•0.87	ORP12		2N3705	0.08
AL102	•0.75	BD197	•0.92	NSL4931	0.48	2N3706	0.08
AL103	•0.75	BD198	•0.92	ORP60	0.41	2N3707	0.08
ASY26	•0.26	BD199	•0.98	ORP61	0.41	2N3708	0.08
ASY27	•0.31	BD200	•0.98	P20	•0.51	2N3709	0.08
ASY28	•0.26	BD205	•0.81	P346A	•0.20	2N3710	0.09
ASY29	•0.26	BD206	•0.81	P397	•0.43	2N3711	0.09
ASY50	•0.26	BD207	•0.98	ST140	•0.13	2N3819	•0.29
ASY51	•0.26	BD208	•0.98	ST141	•0.18	2N3820	•0.51
ASY52	•0.26	BDY20	•1.02	TIP29	•0.40	2N3821	•0.36
ASY54	•0.26	BF115	•0.15	TIP30	•0.45	2N3823	•0.29
ASY55	•0.26	BF117	•0.16	TIP31A	•0.52	2N3903	0.29
ASY56	•0.26	BF118	•0.71	TIP32A	•0.60	2N3904	0.31
ASY57	•0.26	BF119	•0.71	TIP41A	•0.65	2N3905	0.29
ASY58	•0.26	BF121	0.46	TIP42A	•0.72	2N3906	0.28
ASY73	•0.26	BF123	0.51	TIS43	•0.25	2N4058	0.12
ASZ21	•0.41	BF125	0.46	UT46	•0.20	2N4059	0.10
BC107	•0.08	BF127	0.51	ZTX107	0.07	2N4060	0.12
BC108	•0.08	BF152	0.56	ZTX108	0.07	2N4061	0.12
BC109	•0.08	BF153	0.46	ZTX109	0.07	2N4062	0.12
BC113	0.10	BF154	0.46	ZTX300	0.07	2N4284	0.18
BC114	0.16	BF155	•0.71	ZTX500	0.09	2N4285	0.18
BC115	0.16	BF156	•0.19	ZN414	1.11	2N4286	0.18
BC116	0.16	BF157	•0.56	2G301	•0.19	2N4287	0.18
BC117	0.19	BF158	0.56	2G302	•0.19	2N4288	0.18
BC118	0.09	BF159	0.61	2G303	•0.19	2N4289	0.18
BC119	•0.31	BF160	0.41	2G304	•0.25	2N4290	0.18
BC120	•0.81	BF162	0.41	2G306	•0.41	2N4291	0.18
BC125	0.12	BF163	0.41	2G308	•0.36	2N4292	0.18
BC126	0.19	BF164	0.41	2G309	•0.47	2N4293	0.18
BC132	0.12	BF165	0.41	2G339	•0.20	2N5172	0.12
BC134	0.19	BF167	•0.22	2G339A	•0.17	2N5194	•0.56
BC135	0.12	BF173	•0.15	2G344	•0.19	2N5294	•0.56
BC136	•0.16	BF176	0.36	2N404	•0.20	2N5296	•0.56
BC137	•0.16	BF177	•0.36	2N404A	•0.29	2N5457	•0.32
BC139	•0.41	BF178	•0.31	2N521	•0.43	2N5458	•0.32
BC140	•0.31	BF179	•0.31	2N527	•0.50	2N5459	•0.41
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BC145	0.46	BF183	•0.41	2N697	•0.11	2S302	•0.43
BC147	0.09	BF184	•0.26	2N698	•0.20	2S303	•0.56
BC148	0.09	BF185	•0.31	2N699	•0.36	2S304	•0.71
BC149	0.09	BF187	•0.28	2N706	•0.08	2S305	•0.80
BC150	0.19	BF188	0.41	2N706A	•0.09	2S306	•0.80
BC151	0.20	BF194	0.10	2N708	•0.11	2S307	•0.80
BC152	0.18	BF195	0.10	2N711	•0.43	2S321	•0.57
BC153	0.29	BF196	0.12	2N717	•0.36	2S322	•0.43
BC154	0.20	BF197	0.12	2N718	•0.25	2S322A	•0.43
BC157	0.11	BF198	0.12	2N718A	•0.51	2S323	•0.57
BC158	0.11	BF199	0.12	2N726	•0.29	2S324	•0.71
BC159	0.11	BF200	•0.46	2N727	•0.29	2S325	•0.71
BC160	•0.46	BF222	•0.46	2N743	•0.20	2S326	•0.71
BC161	•0.51	BF257	•0.28	2N744	•0.20	2S327	•0.71
BC167	0.10	BF258	•0.36	2N914	•0.15	2S701	•0.43
BC168	0.10	BF259	•0.46	2N918	•0.31	40361	•0.41
BC169	0.10	BF270	•0.36	2N929	•0.21	40362	•0.51

*74 SERIES T.T.L. I.C's

BI PAK STILL LOW PRICE FULL SPECIFICATION GUARANTEED

Type	Quantities 1	25	100+	Type	Quantities 1	25	100+
7400	0.09	0.09	0.08	7486	0.32	0.30	0.29
7401	0.10	0.09	0.08	7489	2.90	2.80	2.70
7402	0.11	0.10	0.09	7490	0.37	0.35	0.33
7403	0.11	0.10	0.09	7491	0.60	0.58	0.56
7404	0.13	0.12	0.11	7492	0.43	0.12	0.11
7405	0.13	0.12	0.11	7493	0.43	0.12	0.41
7406	0.25	0.24	0.23	7494	0.43	0.42	0.41
7407	0.25	0.24	0.23	7495	0.70	0.68	0.66
7408	0.15	0.14	0.13	7496	0.68	0.66	0.61
7409	0.15	0.14	0.13	74100	1.00	0.98	0.96
7410	0.09	0.09	0.08	74104	0.40	0.38	0.36
7411	0.23	0.22	0.21	74105	0.40	0.38	0.36
7412	0.26	0.25	0.24	74107	0.36	0.34	0.32
7413	0.26	0.26	0.25	74110	0.56	0.54	0.52
7416	0.28	0.27	0.26	74111	0.83	0.81	0.79
7417	0.28	0.27	0.26	74118	0.90	0.88	0.86
7420	0.12	0.11	0.10	74119	1.25	1.20	1.15
7422	0.28	0.27	0.26	74121	0.26	0.26	0.25
7423	0.30	0.28	0.26	74122	0.50	0.48	0.46
7425	0.30	0.28	0.26	74123	0.58	0.56	0.54
7426	0.30	0.28	0.26	74141	0.60	0.58	0.56
7427	0.30	0.28	0.26	74145	0.96	0.94	0.92
7428	0.42	0.38	0.36	74150	1.30	1.25	1.20
7430	0.12	0.11	0.10	74151	0.76	0.71	0.72
7432	0.30	0.28	0.26	74153	0.95	0.93	0.91
7433	0.39	0.37	0.35	74154	1.50	1.45	1.40
7437	0.30	0.28	0.26	74155	0.80	0.78	0.76
7438	0.30	0.28	0.26	74156	0.80	0.78	0.76
7440	0.12	0.11	0.10	74157	0.95	0.93	0.91
7441	0.64	0.62	0.60	74160	1.00	0.98	0.96
7442	0.65	0.63	0.61	74161	1.00	0.98	0.96
7443	1.10	1.05	1.00	74162	1.00	0.98	0.96
7444	1.10	1.05	1.00	74163	1.00	0.98	0.96
7445	0.95	0.80	0.85	74164	1.25	1.20	1.15
7446	1.10	1.05	1.00	74165	1.25	1.20	1.15
7447	0.67	0.65	0.63	74166	1.48	1.41	1.39
7448	0.80	0.78	0.76	74174	1.00	0.95	0.90
7450	0.12	0.11	0.10	74175	0.95	0.93	0.91
7451	0.12	0.11	0.10	74176	1.16	1.11	1.06
7453	0.12	0.11	0.10	74177	1.16	1.11	1.06
7454	0.12	0.11	0.10	74180	1.16	1.11	1.06
7460	0.12	0.11	0.10	74181	2.00	1.90	1.80
7470	0.25	0.24	0.23	74182	0.90	0.88	0.86
7472	0.22	0.21	0.20	74184	1.67	1.62	1.58
7473	0.26	0.24	0.22	74190	1.50	1.45	1.40
7474	0.27	0.25	0.23	74191	1.50	1.45	1.40
7475	0.48	0.46	0.44	74192	1.15	1.10	1.05
7476	0.25	0.24	0.23	74193	1.15	1.10	1.05
7480	0.50	0.48	0.46	74194	1.15	1.10	1.05
7481	1.02	1.00	0.98	74195	0.80	0.78	0.76
7482	0.83	0.81	0.79	74196	1.00	0.98	0.96
7483	0.98	0.96	0.94	74197	1.00	0.98	0.96
7484	0.90	0.88	0.86	74198	2.10	2.00	1.90
7485	1.25	1.20	1.15	74199	1.95	1.90	1.85

Devices may be mixed to qualify for quantity price (T.T.L. 74 Series only). Data is available for the above series of IC's in booklet form PRICE 35p.

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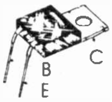
R.C.A. 2N5295. NPN to 3 PLASTIC POWER

VCE 50V VCB 60V
P 38W Ic 4A

hFE 30-120



ONLY £1.50* for 10

*THYRISTORS

PIV	0.6A TO18	0.8A TO92	1A TO5	3A TO66	5A TO66	5A TO64	7A TO48	10A TO48	16A TO48	30A TO48
10	0.13	0.15	—	—	—	—	—	—	—	—
20	0.15	0.18	—	—	—	—	—	—	—	—
30	0.19	0.22	—	—	—	—	—	—	—	—
50	0.22	0.28	0.20	0.25	0.36	0.36	0.48	0.51	0.54	1.18
100	0.25	0.30	0.25	0.25	0.48	0.48	0.51	0.57	0.58	1.43
150	0.31	0.38	—	—	—	—	—	—	—	—
200	0.38	0.41	0.25	0.30	0.50	0.50	0.57	0.62	0.62	1.63
400	—	—	0.30	0.39	0.55	0.57	0.62	0.71	0.77	1.79
600	—	—	0.39	0.48	0.69	0.69	0.78	0.99	0.90	—
800	—	—	0.58	0.65	0.81	0.81	0.92	1.22	1.39	4.07

LINEAR I.C's

Type	Quantities 1	25	100+	Type	Quantities 1	25	100+
72702	0.46	0.44	0.42	TAA350A	1.71	1.67	1.57
72709	0.23	0.21	0.19	μA703C	0.26	0.24	0.22
72709P	0.19	0.18	0.17	μA709C	0.19	0.18	0.17
72710	0.32	0.31	0.28	μA711C	0.32	0.31	0.28
72741	0.28	0.27	0.26	μA712C	0.32	0.31	0.28
72741C	0.26	0.25	0.24	μA723C	0.45	0.43	0.40
72741P	0.28	0.27	0.26	76003	1.39	1.34	1.30
72747	0.79	0.74	0.61	76023	1.39	1.34	1.30
72748P	0.35	0.33	0.31	76660	0.88	0.86	0.83
SL201C	0.46	0.42	0.37	LM380	0.93	0.90	0.88
SL701C	0.46	0.42	0.37	•NE555	0.45	0.43	0.40
SL702C	0.46	0.42	0.37	•NE556	0.88	0.86	0.83
TAA263	0.74	0.65	0.56	TBA800	1.39	1.34	1.30
TAA293	0.93	0.88	0.83	ZN414	1.11	—	—

SILICON RECTIFIERS

PIV	300mA (DO7)	750mA (SO16)	1A Plastic		1.5A (SO16)	3A (SO10)	10A (SO10)	30A (TO48)
50	0.05	0.06	1N4001	0.05	0.07	0.14	•0.19	•0.56
100	0.05	0.07	1N4002	0.06	0.09	0.16	•0.21	•0.69
200	0.06	0.09	1N4003	0.07	0.12	0.20	•0.24	•0.93
400	0.07	0.14	1N4004	0.08	0.14	0.28	•0.35	•1.25
600	0.08	0.16	1N4005	0.09	0.16	0.33	•0.42	•1.78
800	0.11	0.18	1N4006	0.10	0.18	0.35	•0.51	•1.94
1000	0.13	0.28	1N4007	0.11	0.23	0.44	•0.60	•2.31
1200	—	0.32	1N4007		0.28	0.54	•0.69	•2.88

*TRIACS

Case		100V	200V	400V
2 Amp	TO5	0.41	0.51	0.71
6 Amp	TO66	0.51	0.61	0.77
10 Amp	TO48	0.77	0.92	1.12

DIACS

BR100	•0.23
D32	•0.23

(These two diacs are recommended for use with triacs)

SUPER UNTESTED PAKS

THE FINEST VALUE IN UNTESTED SEMICONDUCTORS

Pak No.		
U50	100 Germ. Gold bonded OA47 diode	★0.60
U51	150 Germ. OA70 81 diode	★0.60
U52	100 Silicon Diodes 200mA OA200	★0.60
U53	150 diodes 75mA 1N4148	★0.60
U54	50 Sil Rect Top Hat 750 mA	★0.60
U55	20 Sil Rect Stud Type 3 Amp	★0.60
U56	50 400mW Zeners DO7 Case	★0.60
U57	30 NPN Trans BC107 8 Plastic	0.60
U58	30 PNP Trans BC177 178 Plastic	0.60
U59	25 NPN TO39 2N697/2N1711 sil	★0.60
U60	25 PNP TO59 2N2905 silicon	★0.60
U61	30 NPN TO18 2N706 silicon	★0.60
U62	25 NPN BFY50/51	★0.60
U63	30 NPN Plastic 2N3904 silicon	0.60
U64	30 PNP Plastic 2N3905 silicon	0.60
U65	30 Germ. OC71 PNP	★0.60
U66	15 Plastic Power 2N3055 NPN	★1.20
U67	10 TO3 Metal 2N3055 NPN	★1.20
U68	20 Unijunction trans TIS43	★0.60
U69	10 1amp SCR TO39	★1.20
U70	8 3amp SCR TO66 case	★1.20

Code Nos. mentioned above are given as a guide to the type of device in the pak. The devices themselves are normally unmarked.

*INDICATOR

L.E.D. Displays

DL707 Common anode, 0.3" — 85p
DL747 Jumbo common anode, 0.6" — £1.70
DL727 Double digit display, common anode, 0.5" — £2.00

L.E.D.s

Available in 0.125" and 0.2" dia. lenses.
Red 10p. Green 17p. Yellow 17p.
Mounting clips 2p each.
3015F Minitron 7 segment filament £1.11

NIXI TUBE — ITT 5870S

Character height 13.46mm
SPECIAL OFFER 5 for £2.00

V.A.T.

All prices EXCLUDE V.A.T.
Please add 8% to all prices marked ★ Remainder add 12½%

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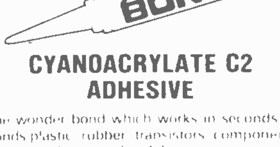

CYANOACRYLATE C2 ADHESIVE

The wonder bond which works in seconds bonds plastic, rubber, transistors, components permanently, immediately!

OUR PRICE ONLY 70p★

for 2gm phial

VOLTAGE REGULATORS

TO3 Plastic Encapsulation

μA7805 L129 5V (equiv. to MVR5V)	1.25
μA7812 L130 12V (Equiv. to MVR12V)	1.25
μA7815 L131 15V (Equiv. to MVR15V)	1.25
μA7818 18V (Equiv. to MVR18V)	1.25

D.I.L. SOCKETS

	1	25	100+
BPS8 8 pin type (low cost)	0.14	0.12	0.10
BPS14 14 pin type (low cost)	0.15	0.13	0.11
BPS16 16 pin type (low cost)	0.16	0.14	0.12
BPS24 24 pin type (low cost)	0.35	0.33	0.30

* DIODES

AA119	0.08	BYZ16	0.41
AA120	0.08	BYZ17	0.36
AA129	0.08	BYZ18	0.36
AAY30	0.09	BYZ19	0.28
AAZ13	0.10	CG62	
BA100	0.10	(OA91 Eq)	0.06
BA116	0.21	CG651	
BA126	0.22	(OA70-OA79)	0.07
BA148	0.15	OA5 Short	
BA154	~~0.12~~	~~Leads~~	0.21
~~BA155~~	0.15	OA10	0.14
BA165	0.14	OA47	0.07
BA173	0.15	OA70	0.07
BB104	0.15	OA79	0.07
BY100	0.16	OA81	0.07
BY101	0.12	OA85	0.09
BY105	0.18	OA90	0.07
BY114	0.12	OA91	0.07
BY124	0.12	OA95	0.07
BY126	0.15	OA200	0.07
BY127	0.16	OA202	0.07
BY128	0.16	SD10	0.06
BY130	0.17	SD19	0.06
BY133	0.21	IN34	0.07
BY164	0.51	IN34A	0.07
BYX38-30	0.43	IN914	0.06
BYZ10	0.36	IN916	0.06
BYZ11	0.31	IN4148	0.06
BYZ12	0.31	IS021	0.10
BYZ13	0.26	IS951	0.07

UNTESTED AUDIO PACKS

Comprising 5 I.C.s 76003/76023 series

ONLY £1 per PAK
Complete with data

FM STEREO DECODER

Comprising 5 I.C.s like MC1307 and SN76110

ONLY £1.50 per PAK
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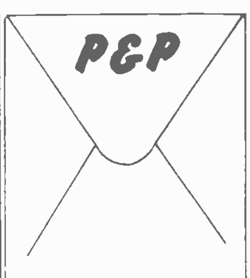
BRIDGE RECTIFIERS

2A 50vRMS	0.35
2A 100vRMS	0.40
2A 200vRMS	0.45
2A 400vRMS	0.50
2A 1000vRMS	0.60



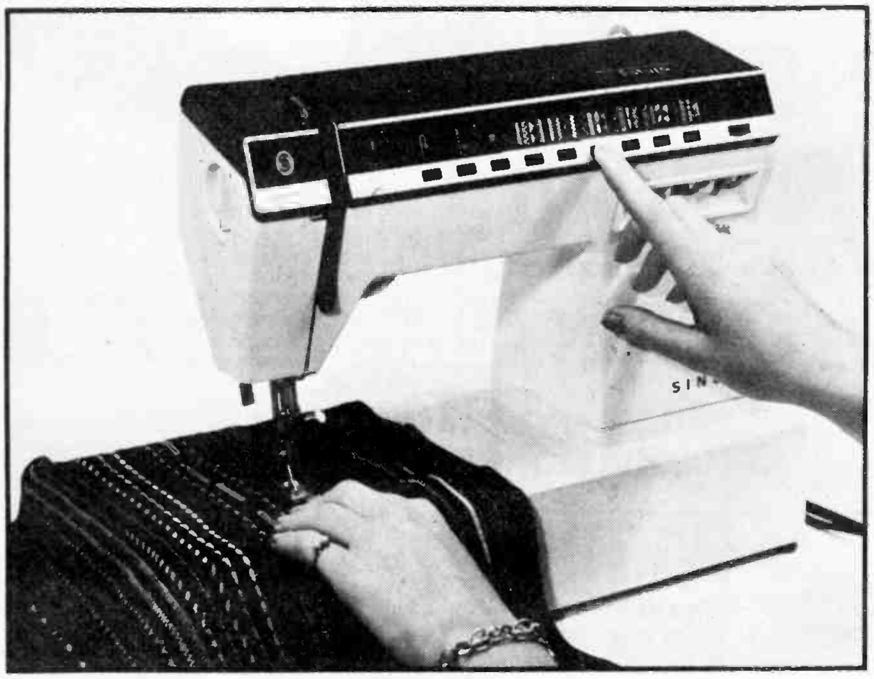
Postage and packing add 25p. Overseas add extra for airmail. Minimum order £1

BI-PAK

PO BOX 6, WARE, HERTS

news digest

MPU's SEW IT UP



Singer have just introduced a sewing machine which is MPU controlled. No, this is not a joke. Yes I did say sewing machine. The MPU replaces 300 mechanical parts, and means that 25 stitch patterns can be obtained at no more energy expense than a button push.

TV RENTAL PROFITS 'TOO HIGH'

The average return on capital of 16.5% a year by the TV rental companies has been condemned by Prices Secretary, Roy Hattersley, as being too high.

Wicked companies!

These are the people who have a) brought Colour TV to over half British homes b) kept TV rentals to the lowest cost anywhere in the world that we know about c) prevented TV rentals costs going up far less than inflation d) kept the British TV industry going despite the best attempts of the government to kill it by juggling with VAT e) forced down the cost of outright purchased sets to remain competitive f) raised the standard of servicing enormously.

Wicked companies!

Still, there is a foolproof way of ensuring that these companies make far less than 16.5%, in fact for them to make a loss (rather fashionable today): nationalise them. The costs of renting would go up instantly of course – but it would put an end to these wicked profits.

POWER TO THE PEOPLE

A new power cable is to be installed in Russia to link two power stations 1500 miles apart. Nothing special there. You might think we're just pylon it on in fact. What is unusual is that this reel of metal cotton is to carry 1.5MV, and a later 2000 mile link will be under 2.5MV tension. The 'super-lines' will be constructed of steel strands braided with aluminium. Thyristor crystals are employed as rectifiers.

Just the thing to hang your cassette player on.

COLOUR PREJUDICE?

Official figures for the number of homes with colour TV's, i.e. those with a license, have just exceeded 50% of the total. Some lesser mortals might well be tempted to conjecture how high the total would be if the un-licensed felons in our midst could be stood up and counted. Naturally we refrain from any such thoughts.

READER WRITER (SR 52) DATA!

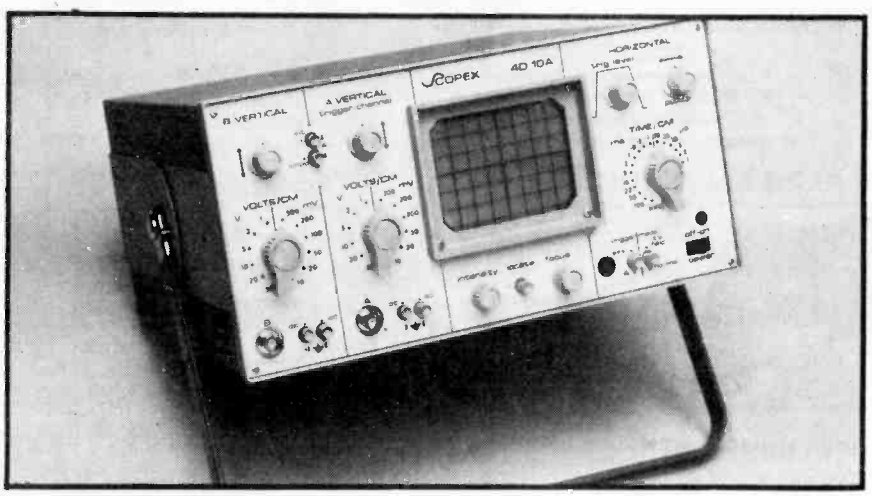
One of our intrepid readers – Mr. P.A. Brown of Ergonomic developments has informed us of a follow up to last months little snippet on the SR 52. It seems this machine is capable of more than anyone is letting on.

Locations 70–97 can be used to store data without affecting the programme store. If the machine is now put into the learn mode, this data will be read out into the magnetic card. Data storage with avengence! Locations 98–99 affect the programme store.

PLAY–ALONG–WITH–RCA

Single chip I/O for video games is the laudible aim of messers. RCA. To be introduced in January the device is primarily a vertical and horizontal synching circuit designed for use with RCA's 1802 MPU. Price could well be around £12 when and if introduced into this country.

NOT A TRACE OF INSTABILITY



This new oscilloscope from Scopex offers a very high performance for its £150. With completely stabilised PSU's (trace stability over ±10% mains variation) measurement accuracy ±3%, input up to 50V/cm, T.V. field mode triggering to allow for Ceefax etc, and triggering up to 10MHz in ordinary mode, the dual beam 4D10A is an attractive proposition to the affluent amateur or small business.

Scopex Ltd., Pixmore Estate, Pixmore Avenue, Letchworth, Herts.

WHATS HAPPENED? ....

We've moved thats whats happened! Increasing numbers of staff and our ever increasing circulation has meant that we're working stacked up like sardines in a can.

Just to keep up with ourselves — being the fastest growing, most modern (and most modest) electronics magazine in the country — we're taking up residence in Oxford Street, Our new address is shown below, and all letters, boquets of flowers, messages of congratulations and cheques for vast sums of money should be sent there in future. **ETI EDITORIAL AND ADVERTISEMENT OFFICES, 25—27 OXFORD STREET, LONDON W1R 2NT. Telephone 01-434 1781/2.**

BAND OF HOPE AND GLORY?

FROM: RADIO SOCIETY OF G.B.

The matter of citizens' band is under continual consideration by the Society's Telecoms Liaison Committee and the Council approves its present views which are:

(a) The RSGB exists to safeguard the interests of its members and of the Amateur Service in the UK. The Amateur Service is a defined service in the Radio Regulations (Geneva 1976) and is accorded world wide status in the same way as the professional services.

(b) While the RSGB may have no direct interest in a citizens' band facility by its present articles of association it must, in the interests of its members, take heed of developments likely to affect the Amateur Service.

(c) The major consideration affecting the introduction of any new facility is the ability of the admisiatration to exercise complete and effective control. Anything less is not acceptable.

(d) The RSGB is not opposed to the introduction of a short range personal communications facility provided that its location in the spectrum and the equipment used are suitable. The 27MHz band as used in the USA and some European countries is probably one of the most unsuitable frequency bands that could be envisaged. There are three main reasons:

(i) its proximity to the amateur 28MHz band and the consequent availability of high power equipment together with the ease of illegal operation in this band.

(ii) the existence of long distance propagation during part of the sunspot cycle, and

(iii) the interference to television receivers, particularly those operating in Band 1. Having regard to equipment now available it would appear that a VHF or UHF FM service with power limitation, crystal control and type approved apparatus could be suitable.

(e) Location of a citizens' band within an existing amateur service allocation is not acceptable to the RSGB. Further, if this facility is eventually allowed it ought to be located in a part of the spectrum remote from any amateur allocation to prevent illegal operation in an amateur band such as is now experienced in the USA.

(NEW) HOME ON THE (TEXAS) RANGE?

Texas introduces its new SR-51-II. With a suggested retail price of £59.95 inc. VAT the SR-51-II supersedes the SR-51-A.

Key features include the capability to enter complex equations in left to right order as they are staed, full memory arithmetic, key entry conversions and engineering notation.

Separate keys for the seven most-used conversions are included on the SR-51-II keyboard.

The seven conversion keys include inches to centimetres; U.S. gallons to litres; pounds to kilograms; degrees to radians; grads to radians; Farenheit to Celsius (Centigrade); and degrees/minutes/seconds to decimal degrees.

Engineering notation, which displays results having scientific notation

exponents in multiples of three, is also included.

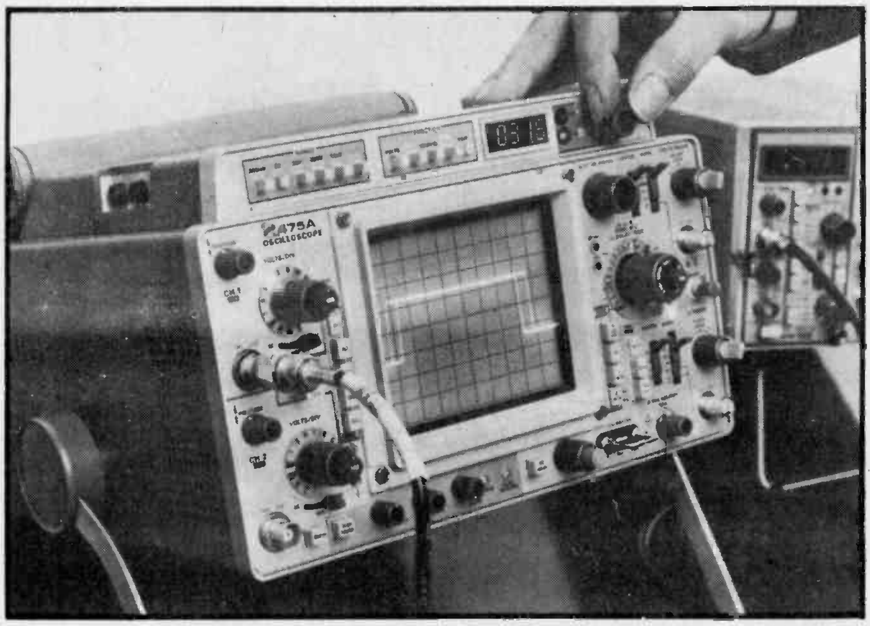
The SR-51-II suggested retail price includes a rechargeable battery pack, AC adapter/charger and carrying case. It has a 10-digit light-emitting diode display but calculates up to 12 digits internally, rounding to 10.

The new model is warranted for one year from the original purchase date against defective materials and workmanship to the original purchaser.

European Calculator Division, Texas Instruments Ltd., Block C, Manton Centre, Manton Lane, Bedford, MK41 7PU.

news digest

DMM ADD ON ADDS SCOPE!



The DM44 Digital Multimeter is an optional item on several Tektronix portable oscilloscopes. It permits time interval measurements between any two points on waveforms displayed by the oscilloscopes, indicated by a 3½ digit LED readout with 1% accuracy. A Delta Delayed Sweep feature is used with the oscilloscopes' main delayed to mark the start and stop points of the time interval measurement.

It also includes a DC Voltmeter ranging up to 1.2kV with 0.1% accuracy, an Ohmmeter covering 0 to 20MΩ (0.3% accuracy) and Temperature Probe from -55°C to +150°C, and is available on Tektronix 464, 465, 466, 475A and 485 portable oscilloscopes.

Tektronix UK Limited, Beaverton House, P. O. Box 69, Harpenden, Herts.

TRIPLETS FROM HP

Hewlett Packard have just released details of their latest offsprings, two of which are described here and the third in Microfile.

The 3455A is a healthy (bouncing?) 21lb DMM with a choice of 5½ or 6½ digit display. This siamese-twin-microprocessor based machine (2 MPU's inside) features self-check of calibration, mathematical abilities (at less than 1 month?), HP-IB compatibility, and 0.002% accuracy over 24 hours with resolution down to 1μV.

Sister to the 3455A is the 3437A systems voltmeter with 3½ digit digit display. Up to 5000 readings per second with .03% accuracy, variable trigger delay from .01μS to .999999 seconds. Number of readings from one trigger up to 9,999.

Both these machines light up like Xmas trees, with LED's in all control buttons to indicate status.

Further details from Hewlett Packard Ltd., King Street Lane, Winnersh, Wokingham, Berks RG11 5AR.

SHIFT WORK IN CCD

Somewhere amid the redwoods in Mountain View, California although admittedly hardly under a bush Fairchild are slaving over a hot soldering iron to perfect their latest toy – a 65,536 bit shift register. Naturally CCD. This plaything of the boffins is organised in 16 blocks of 4096x1 bits. One bit from any block can be addressed, and all blocks recirculate automatically in read mode. Typical power drawn is around 400mW, and it will arrive in a 16 pin pack – when it arrives at all.

ON THE DOT DISPLAYS

ITT Optical Equipment Division has introduced a 7 x 5 dot alphanumeric LED display which features 17mm-high characters and integral MOS shift registers for serial feed electronic drive systems.

The brightness of the display can be controlled by a single DC voltage and any number of displays can be controlled by one clock and one data line.

The devices do not require separate limiting resistors.

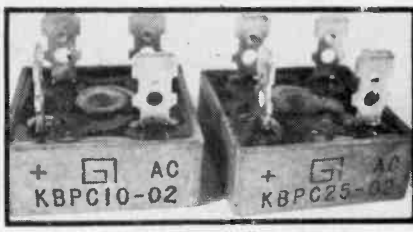
ITT Components Group Europe, Optical Equipment Division, Westfield Mill, Broad Lane, Leeds.

BRIDGING THE GAP

Two new types of high-current bright rectifiers – the first capable of handling up to 10A, the second capable of handling up to 15A – have been announced by General Instrument (UK) Limited.

Designated the KBPC-10 and -25 series, the two types occupy identical cases, measuring 18.5 x 28.5 x 25.4mm (1 1/8 x 1 1/8 x 1in) overall. they are available in operating PIV's of 50, 200, 400 and 600V.

General Instrument (UK) Limited, Cock Lane, High Wycombe, Bucks.



CORRECTION OF THE MONTH

Project Book 4 – Sweet Sixteen. The components are missing from the overlay diagram. For those sinners amongst you who don't have the back issue – July 1976 – we will forward the diagram on receipt of an SAE.

Specials from eti

Electronics – It's Easy – the first thirteen parts of our popular introductory series and a good way to begin finding out more about your hobby. £1.20 + 20p P and P.

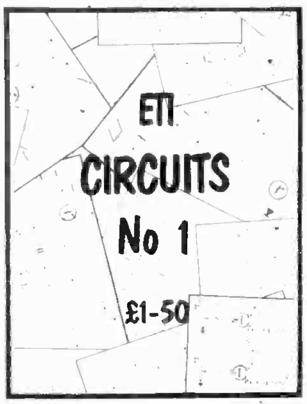
Electronics – It's Easy Volume 2 – the next twelve parts in our series for beginners. £1.20 + 20p P and P.

4600 Synthesiser – complete reprint of our surperb synthesiser design produced by Maplin, who can also supply the parts. £1.50 + 20p P and P.

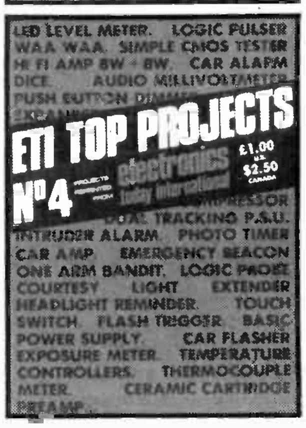
Project Book Two – contains 26 popular projects from the pages of ETI, first published July 1975. 75p + 20p P and P.

Project Book Three – 27 more popular ETI projects first published March 1976. £1.00 + 20p P and P.

New



£1.50 + 20p P and P.



£1.00 + 20p P and P.

HURRY! PRE PUBLICATION OFFER . . . Normal mail order price for Circuits 1 is £1.50 + 20p mail. Orders placed before publication will be dispatch, hot from the printers, mail free. Orders must be postmarked before 14th November. Available after this date at £1.70.

A brand new concept from the house of ETI, more than 100 pages packed with a wide range of experimenters circuits. Based on the tremendously popular 'Tech-Tips' section of ETI, Circuit 1 is the first of a series of specials – produced for the enthusiast who knows what they want, but not where to get it! Circuits 1 will also act as a catalyst for further development of ideas, ideal for the experimenter. The collection of more than 200 circuits is complemented by a comprehensive index, making searches for a particular circuit quick and simple. Also similar circuits can be compared easily, due to the logical layout and grouping used throughout. Last and by no means least Circuits 1 has no distracting advertisements in the main section!

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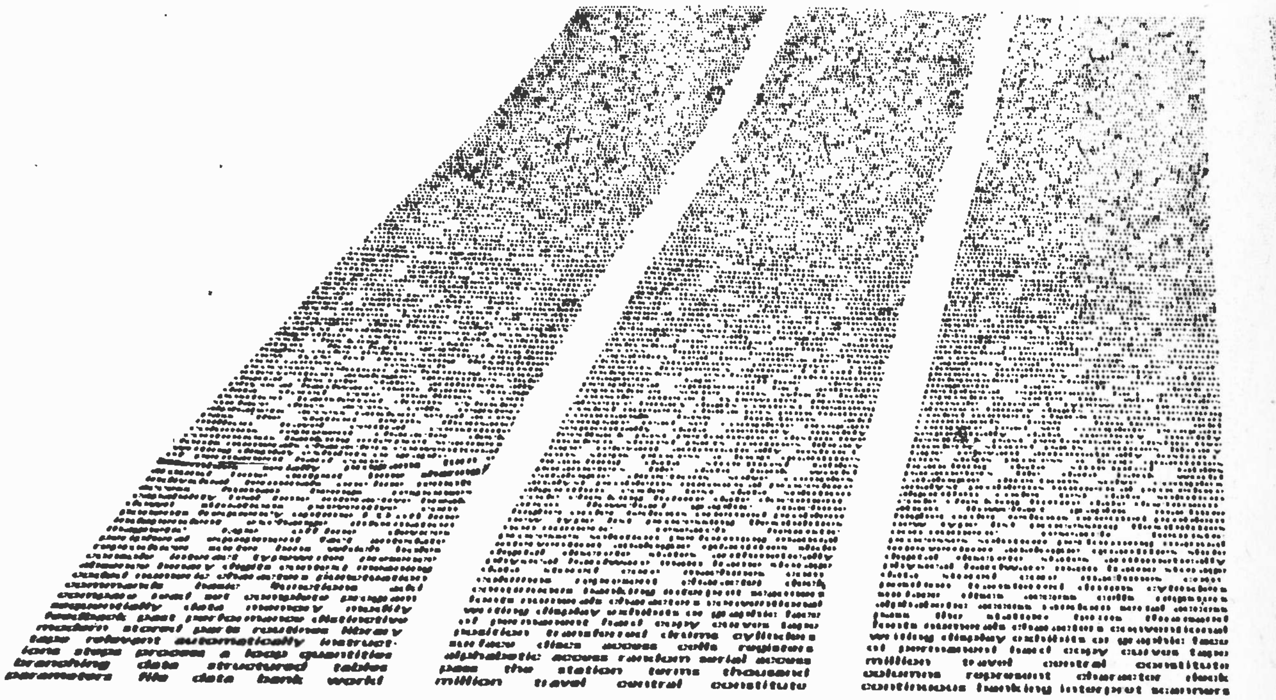
EVOLUTION OR

By Peter S



YEAR 2000 A.D. – A LOOK INTO THE FUTURE OF ELECTRONICS

Part 1. Forecasting – Fame and Fortune or Failure and Futility?

IT IS AN interesting and fascinating exercise to try and predict the future. Clairvoyance aside, this short series of articles investigates what we might expect to find ahead. It is a logical step to extrapolate into the future by studying the ideas of the past, but this does not necessarily produce correct answers. New inventions and discoveries markedly alter the pattern of progress.

REASONS FOR FORECASTING

So why attempt a forecast? Many good reasons exist. One is to see if we like what we expect to see.

First we could go to the clairvoyant. Their history of correctness has often been amazingly good, nevertheless at our present state of understanding we can still put little faith in that method. A far more reliable way open to us at present is to systematically study the already proven *possible, extending it to its naturally set limits.*

This approach is logical and appears to have its roots in the late 17th and early 18th century writings of that great mathematician, philosopher and politician, Gottfried Wilhelm von Leibniz. His hypothesis about prediction was that events of the future are determined by the many events of today. We call this approach determinism.

Philosophers are still unable to resolve whether life is entirely deterministic or whether indeed there are factors that man will never understand. Experience continues to demonstrate, however, that the more we look into processes the better we can determine the properties. It is safe to say a great deal can be predicted by using time extensions of current systems. The problem is the enormously large number of variables and interconnections: these make many a system virtually unmanageable as an accurate enough model. To illustrate this point, Fig. 2 is a copy of one of many simplified models proposed to simulate the economy of a country. The difficulties still to be overcome are to get correct and relevant input data and to ascertain if the model is detailed enough.

ON BREAKTHROUGHS

Looking forward 25 years is not too great a step. Where a given currently existing state-of-the-art will evolve to

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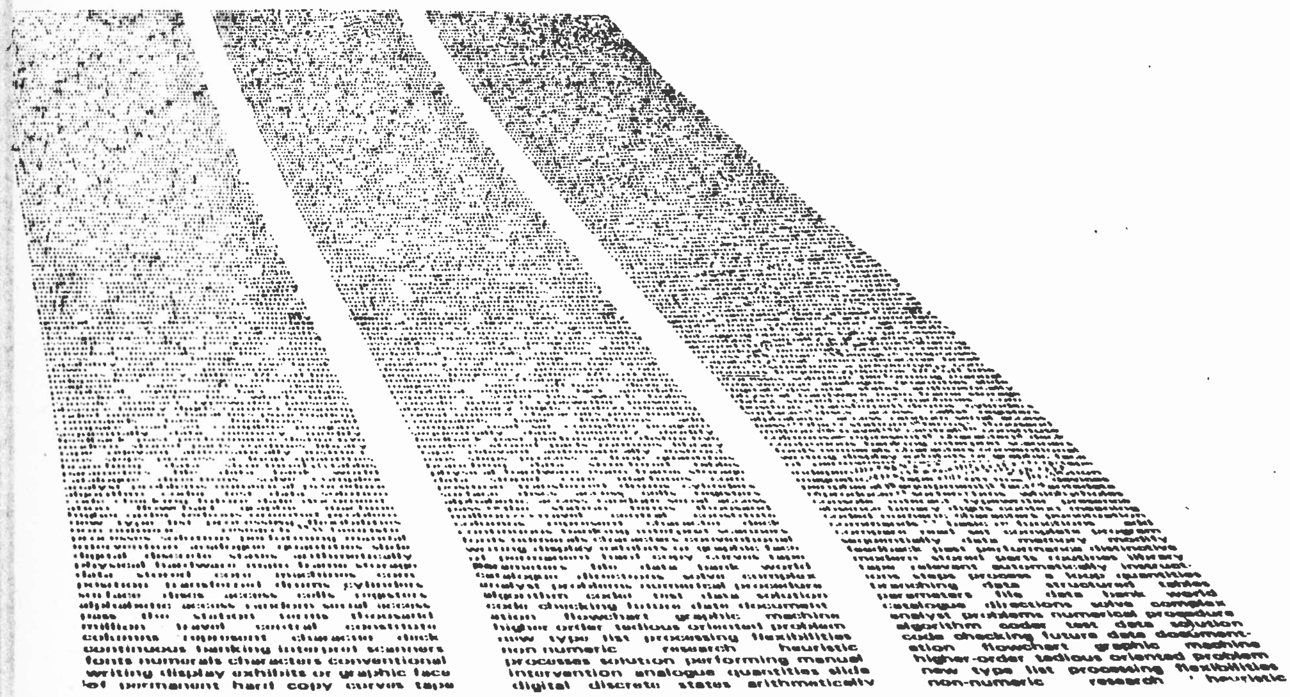

is often reasonably obvious to the adequately trained and involved person. The real unknown is the so-called "break through" that changes the path of progress abruptly. Break-throughs are not usually brand-new concepts but ideas that materialise gradually from the maturing thoughts of many, finally coming to a head as an apparently "new idea". Radio waves were predicted by mathematical means (that is they were seen to exist by studying a mathematical model of the physical situation) before they were demonstrated in practice. Even when we have the final stage of a new development within our grasp we may still be unable to harness it. Edison did not realise he had built the first vacuum-tube diode during his lamp experiments. Nearly twenty years had to pass before the idea was applied.

Faraday's experience illustrates that breakthroughs are as much a release of man's mind, into new areas of the possible as they are a really new discovery. The notice given in Fig.3 exemplifies changes in attitude. The late eminent scientist and Nobel Laureate, Sir George Thomson, skilled in physics, aviation and fuel research did not seem to conceive (in a 1955 prediction of his) inter-country communications without a massive network of waveguides or co-axial cables to convey the necessary bandwidth. And what about this futuristic statement on television from an earlier source:

"It has been assumed by many and stated by some, that within a reasonable number of years, long-distance transmission, even across the Atlantic, will be broadcast regularly . . . so the sensational theories predict. The truth is that long-distance television of the type we know today is never likely to be practical or even possible."

Alan Chappell, Discovery, February 1937.

Just as wild was this statement by Lee de Forest (who invented the triode around 1906). He stated in a New York Times article of 1926:

"While theoretically and technically television may be feasible commercially and financially I consider it an impossibility, a development of which we need waste little time dreaming."

The art of the possible depends not only on human ingenuity but on the economic cost involved. Given a huge production run — great demand in other words — the cost per article falls remarkably. This, in turn, allows the basic idea to flow on into other areas of utility. The cheapness of domestic telephone components enabled many other sensors to be realised.

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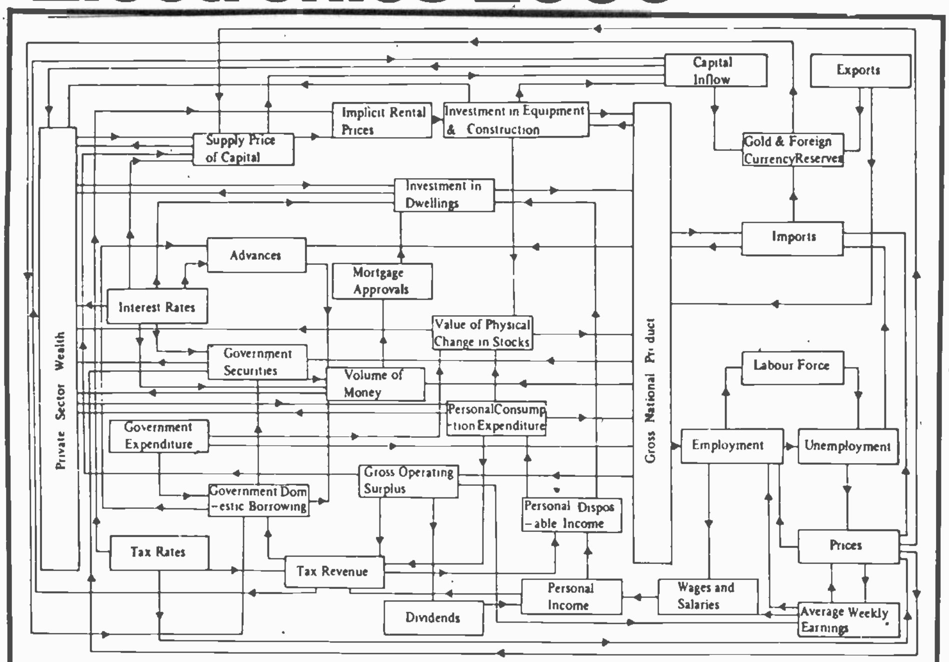


Fig. 1. A mathematical model — such as this one of a country's economy — provides predictions if the right input data can be fed into it.

This Room Is Equipped With

Edison Electric Light

Do not attempt to light with match, Simply turn key on wall by the door.

The use of Electricity for lighting is in no way harmful to health, nor does it affect the soundness of sleep.

Fig.2. This notice demonstrates how our minds need releasing to understand new ideas.

ESTABLISHING THE STATE OF IGNORANCE

Another reason for attempting a forecast is because:

"The first step to knowledge is to know that we are ignorant" — Cecil.

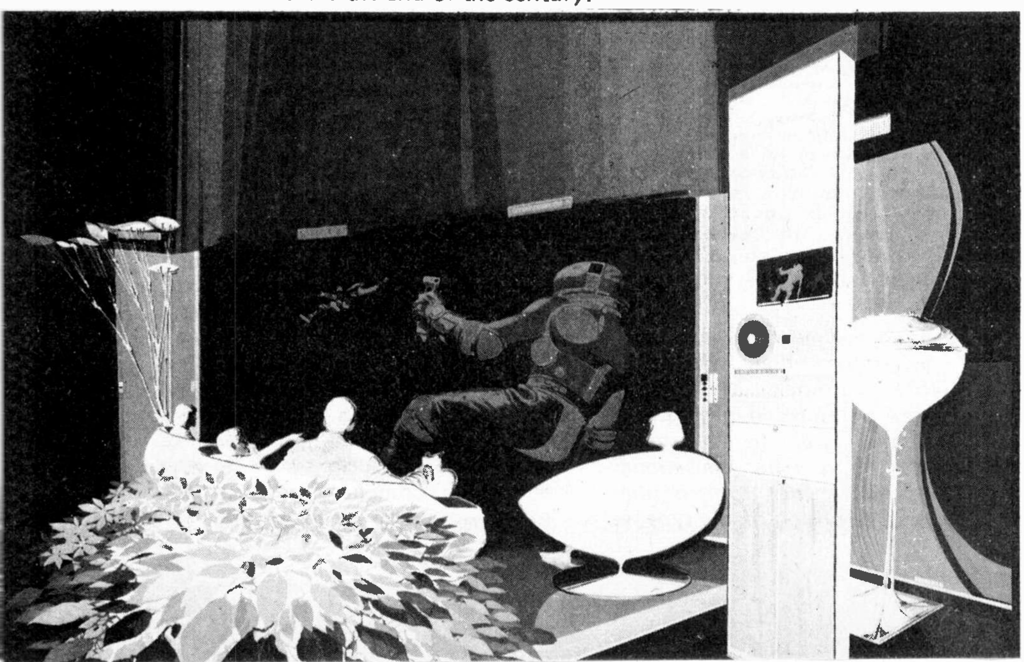
By studying the likely new situations we usually reveal areas of ignorance. The subsequent process of research aiming to reduce this lack of knowledge often leads to improved development. We have a term for such studies — impact studies. A good historical example of this principle was the discovery of the more recently found chemical elements.

Antimony was discovered in 1450 A.D. by Valentine, a German alchemist. (Iron and several other common elements were known at that time, of course). A steady growth in the discovery of more elements continued. By 1900 about 90 were known to exist, many being added as the result of prediction based on the work of Mendelyeev. In 1869 this Russian chemist carefully studied the relation between all known elements of his time. He proposed the so-called periodic table which placed elements in the table according to certain properties. There resulted gaps in the table — such as the position of the noble gases (argon, krypton, etc.) where an element should be. Knowing the expected properties of these gases it was just a matter of time before they were isolated to further confirm the truth of the predictive framework proposed.

Germanium and gallium were predicted in the same way; before they were known to exist.

Knowing something about the fundamental properties of material before it is isolated in workable quantities does not always assure instant technological use. Silicon was discovered in 1823, germanium in 1886. Both were available to technology at the same time that the thermionic valve grew in importance (1910 onward) as the basis of a new discipline — electronics. It is not surprising that few people could realise in the 1950's that the germanium transistor, then just invented, would so enormously alter our visions by allowing the eventual use of mass produced dirt-cheap electronic systems.

Colour TV's like this are possible now but they should be common in most households before the end of the century.



SCIENCE-FICTION

Good sci-fi writers often come remarkably close to the truth about future developments. We cannot objectively assess how the writer arrives at the script but it is fairly safe to assert he or she does so largely by extrapolating current situations into time, throwing in innovations of their own.

Jules Verne and H.G. Wells wrote fiction that seemed fantasy in their time. Verne did it for amusement; Wells as a message. In 1865 Verne wrote "De la terre a la lune"; in 1901 Wells write "The First Men on the Moon". But even before then Cyrano de Bergerac had written two novels of journeys into space using jet propulsion — and that was around 1640.

These writers are able to throw-off the bonds of the establishment, to imagine other societies, other uses of technology. Robots, in mechanical master form, go back at least to Mary Shelley's Frankenstein (1818). To the society of the day such figments of the imagination — they could be little else at that time — must have been a most

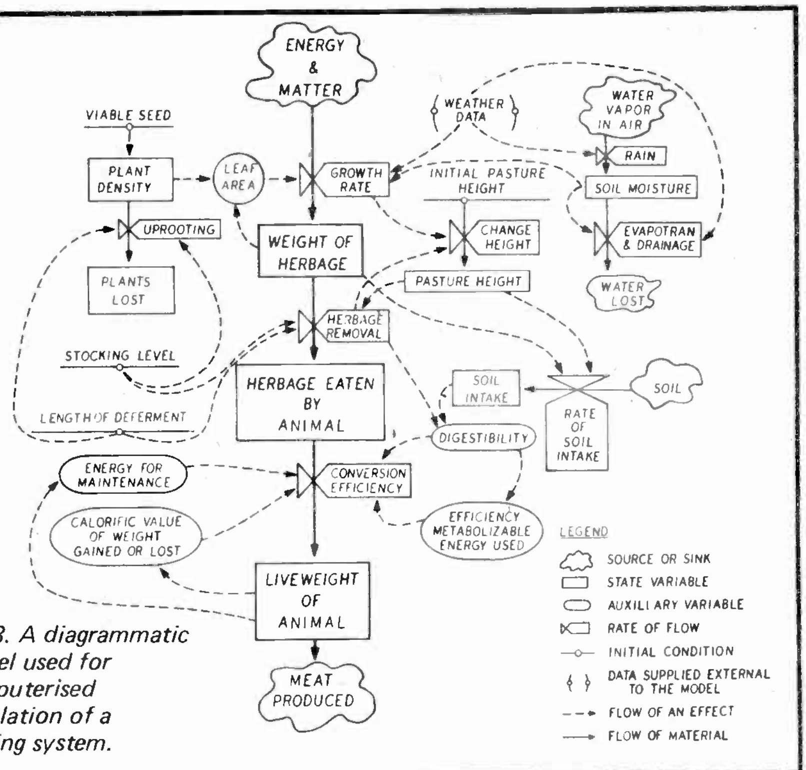


Fig.3. A diagrammatic model used for computerised simulation of a grazing system.

and business with interest arising in government and corporate planning. The methods employed relate to reasonably measurable quantities such as a business operation or advance in a certain kind of technology. It has the merit of being confirmable with time as its standards and norms remain much the same with time.

Systems theory and analysis, dynamic modelling: The system under study is progressively isolated from the rest of its environment. Black boxes are drawn and interconnected such that they represent the input to output changes of the variables flowing around in the total system. The system has inputs, outputs, transfer functions and measured variables as depicted by the example given in Fig.3 The next step is to transform this form of model to a mathematical, rather than notional one, and begin computation to get the dynamic state of each part of the system.

Even the simplest systems handled this may soon tax human powers to handle the data conversions.

frightening concept. Today we regard such horror tales more as humorous recreation than likely fact.

One major difficulty with science-fiction predictions is that we cannot begin to devise tests of confidence of their validity beforehand because this mode lacks an objective scientific basis of arriving at the result. Intuition can be so wrong and 'gut-feelings' are hard, extremely hard, to justify to others.

THE ACADEMIC APPROACH TO FUTURE'S STUDIES

A significant number of Universities and other tertiary teaching institutions offer courses in the various aspects of what is collectively known as future's studies. Many topics qualify for inclusion – technology forecasting and assessment, cross impact analysis, policy studies, demographic projection, statistical prediction, economic forecasting, systems studies, peace studies, morphology, utopian litrature, science fiction and even gaming are each relevant to prediction making.

Academic studies – many hundreds of courses exist – attempt to put forecasting on a firm objective basis. There is, however, as yet, little evidence that the various methods are indeed reliable enough to be entirely worth the effort. Key methods in vogue today include the following:

Technology forecasting and assessment (TF or TA): This is used in military

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Mammoth computing ability enables complicated systems to be set going into the future (the time scale being stepped up beyond real time). One example of the use of this form of simulation is when it is employed constantly to check the future stability of nuclear power stations — as based "on past to current" data. But such a system must have correct measurement inputs to give correct answers.

Cross-Impact analysis: This is, in essence, a type of systems analysis because it is based on the premise that "everything is connected to everything else" and has impact on each other.

The users of cross-impact analysis devise a "mathematical matrix that expresses the probability of occurrence of a number of possible developments and represents the direction and strength of the impact one occurrence would have upon the probability of another."

An example of an impact was when silicon became so significant to us as the transistor circuit element. The matrix contains all of the many impacts involved, expressed as probability values ranging from 0 to 1.

Delphi technique: Most people are familiar with the "think-tank" idea of generating ideas. A group of people, each expert in a specific area and each overlapping a little, meet to talk-out a scheme that will fulfil a stated need. Although this concept works reasonably well it only does so if the people involved blend satisfactorily from the human relations and sociological points of view. There is great risk that the individual views become influenced by those of the others.

In a Delphi study the experts do not meet, nor know who else in involved. Each answers questionnaires sent to them by the co-ordinator who has control over the feed-back between experts. The study passes through several 'rounds', as decided by the co-ordinator, until hopefully a consensus viewpoint emerges.

It was first developed in the 1950's by Olaf Helmer, who subsequently became Foundation President of the "Institute for the Future" in Connecticut, U.S.A. Delphi style studies have been used in education, sociology, science, weapons systems, customer choice plus many more. It is also the basis of assessing the worth of research-grant applications which by their nature, are predictions made by the applicant of what is felt should and can be achieved. It is essential that the experts are truly expert in the field of interest and that they have the flair for forecasting.

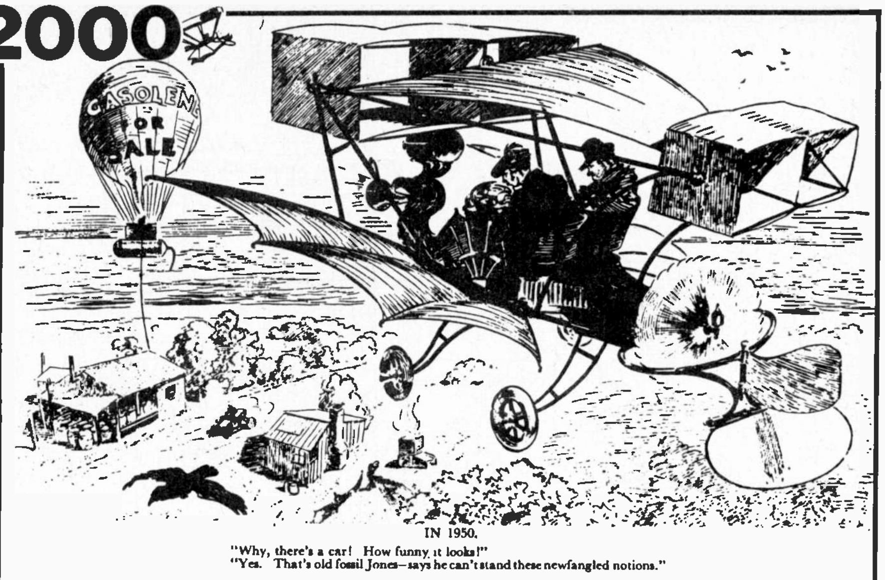

Fig. 4. A 1907 cartoon predicts aircraft will replace the car by 1950.

The Delphi method does, however, lack that competitive and inventive situation wherein an idea expands to a maturity by constant innovation working on the basic premise.

Experimental Learning, Creativity, Scenarios, Simulations: These are rather loose academic exercises (soft as opposed to hard thought processes are involved) wherein, as the names suggest, participants exercise artistic, intuitive skills to create new situations. Mock-up models of future cities may be built to investigate their design. Museums of the future exist in Denmark and the U.S. These methods use speculation based on reason and judgement; a game of "if".

For all of the academic effort that has been put into the design of techniques and the now many courses, the situation has been summed up as *"some past futurists were amazingly accurate, others amusingly inaccurate", Langley, 1975, U.S.A.*

FORECASTING SUCCESSFUL OR NOT?

Some forms of forecasting have been notably successful. Weather forecasts are more right than wrong today. Tides in the seas between Britain and the Continent can be predicted to a point where dangerously high tides can be forecast several days ahead. It was not so long ago that weather forecasting to such precision would have been regarded as fantasy. We must not lose sight of the fact that fantasy is only such because of ignorance of some aspect of physical manifestation. We are more likely, at this instant in time, to be able to correctly forecast well-known physical phenomenon than the ill-defined sociological issues because we have more knowledge about the deterministic variables.

In this first part, we have explained the various methods of forecasting. Very few of even the most objective methods will, however, tell us much about less tangible things such as the way of life ahead. The various methods are applicable to business and military ventures, to applications where enough parameters of the system are in close enough control of the forecaster.

We now look at some more successes and failures of past forecasting.

Electric Lamp: After a discourse on the difficulties of manufacturing incandescent electric lamps, James Swinburne had this to say in 1904:

"A new invention that wants a great deal of working out has against it all the experience and knowledge gained in old manufacture: so unless it is very much better on the face of it, it is not worthwhile troubling about it."

His article suggested that electric light was not worth the development effort!

Telephone: We all have witnessed how the telephone has changed the style of commerce, how it led to radio and then to the television. But did you know Bell was regarded as an "imposter", a "ventriloquist", "a crank who says he can talk through a wire". The Times, of London, said it was humbug. Lord Kelvin greatly helped Bell by issuing a statement that is regarded as the Charter of Telephony. In it Kelvin wrote:

"With somewhat more advanced plans and more powerful apparatus, we may confidently expect that Mr Bell will give us means of making spoken words audible through electric

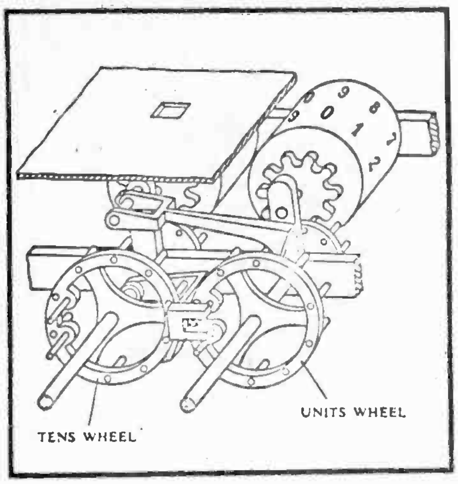

Fig.5a. Sketch of a Pascal calculating mechanism (17th Century).

wire to an ear hundreds of miles distant."

Rockets: In 1955 Lord Thompson wrote:

"It is doubtful if such a large rocket (8000 tons to give one ton freedom of space was predicted) would be practical, though von Braun, the designer of the V_2, has seriously proposed one."

Apollo missions use Saturn rockets weighing over 3000 tons to launch a comparable payload.

Aircraft : A reversible plane was devised in 1922 with two tails, two fuselages and which could reverse direction in flight. Later, in 1932 Captain Dibovsky, a Russian, designed a plane that could rise vertically into the air and could land on a roof-top, or a river. These ideas were not sound as presented then, but today we have the Hawker-Harrier jump-jet that achieves at least part of the aim of these earlier inventors. In 1907 the cartoon, shown in Fig.4, appeared predicting the decline of the car in favour of the airplane. It was drawn, however, just one year before the "Tin-Lizzie" put motor transport within the working-man's reach.

Writing: And who would have thought that the 1950's new-fangled writing pen of the Biro brothers would have found such overwhelming acceptance in our civilisations.

THE VARYING PACE OF DEVELOPMENT

To illustrate the varying rate of change experienced in a development let us look at some pictorial views showing successive development of the pocket-sized calculator.

The pocket calculator begins its history with the Ancient Greeks who made a calendrical computer in the tradition of planetarium construction (known as the Antikythera mechanism and dated ca. 80 B.C.). The abacus is also extremely old in origin. Other mechanical machines, such as Pascal's many variations shown sketched in Fig.5a, followed – employing small degrees of innovation and change. The real change in attitude came with the Babbage engine developments starting in 1830's. His ideas were sound but machines such as that shown in Fig.5b could not be built at the time. By the turn of the century workable mechanical calculators were in common use. Figure 5c shows the "Millionaire" which was first marketed

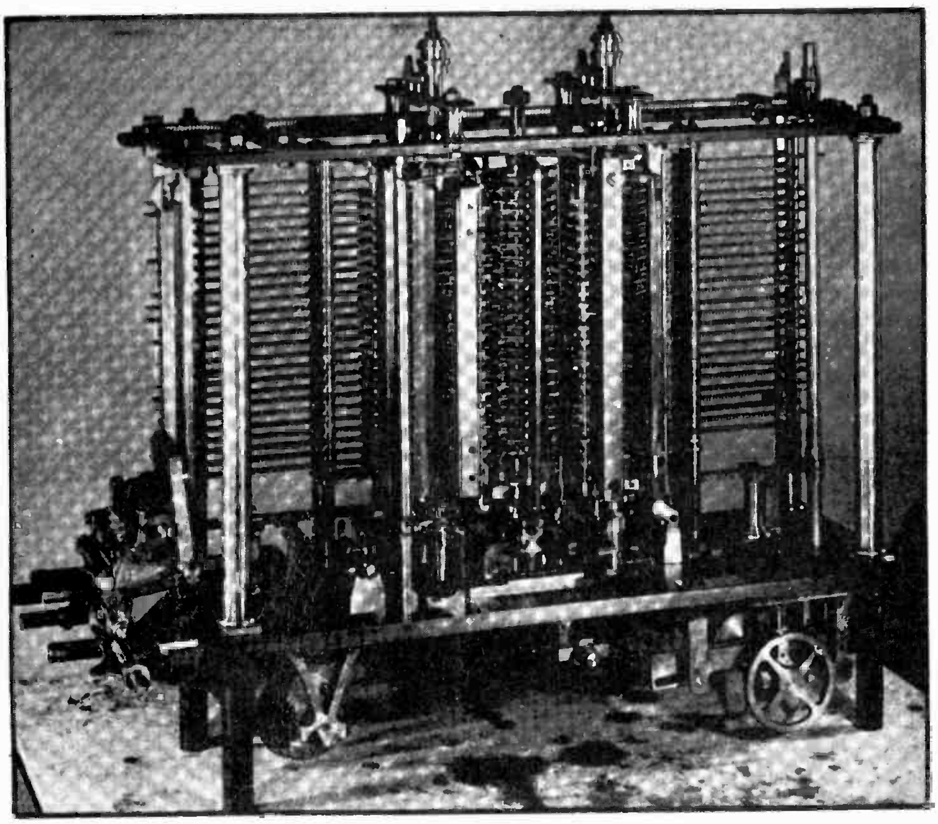

Fig.5b. A Babbage engine: by incorporating storage the design significantly advanced computer technology.

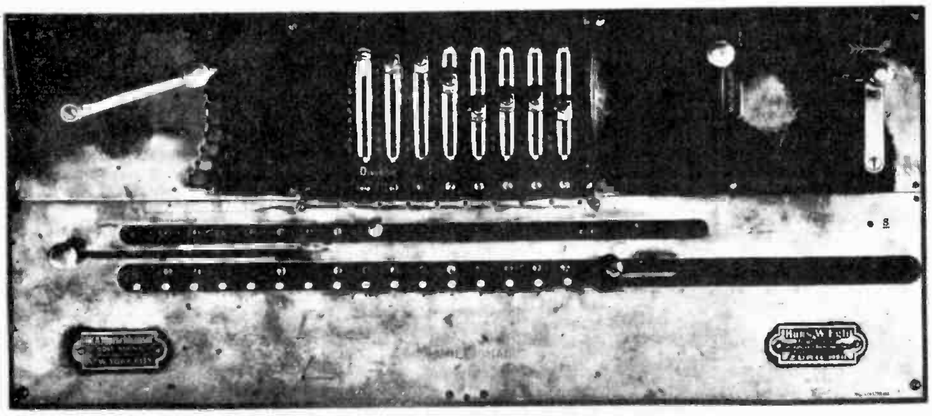

Fig.5c. Working face of 'Millionaire' calculating machine (1890's).

Fig.5d. Handcranked mechanical calculators were common-place in the early part of this century.

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Fig.5e. The first electronic computer — ENIAC, at Moore School in the US (1948).

Fig.5f. Programmable pocket calculators have power undreamed of even a few years ago.

in 1893. Until the 1950's mechanically cranked mechanical calculators, such as shown in Fig.5d were widely in use for all manner of calculation. Then came the electronic versions based on valve technology, Eniac being the first general-purpose electronic calculator. It was begun in 1944, and, as Fig.5e shows, was hardly portable but had much greater capacity to compute than any mechanical machine. Pocket electronic calculators became closer when integrated circuits enabled the release of the desk-top style, densely-packed (by the then standard) minicomputers of the late 60's. Then came, the truly pocket calculators of today. Today we need not regard complex calculation as a limitation of an objective. Half a week's wage now buys extraordinary capability, at least as much as cost many hundreds of year's wages just thirty years ago. Computers cannot become much more compact — or can they? We have yet to build replicas (see Fig.5g) of Nature's calculators using electro-chemical signal processing!

What were the breakthroughs? They seem to be when Babbage laid the ideas for improved and advanced computing machine structure, when electronics was able to do the mechanicals job, and later, when solid-state methods allowed extremely cheap, vastly complicated, circuits to be made. ●

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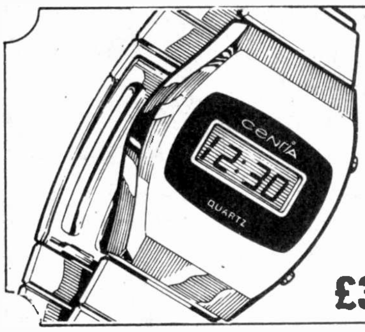

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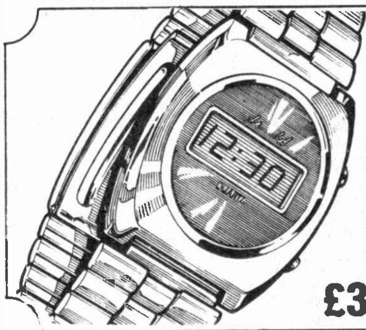

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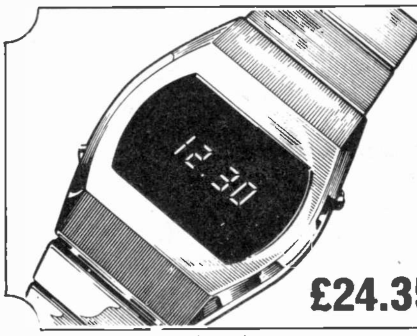

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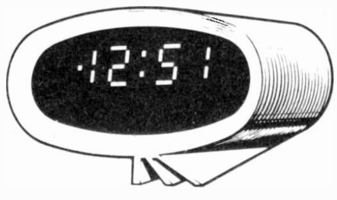

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ETI project 544

HEART-RATE MONITOR

An invaluable tool for the bio-feedback experimenter or for the assessment of athletes.

THERE ARE MANY METHODS of measuring heart rate ranging from feeling the pulse, to chart recordings via an electrocardiograph. Other methods include monitoring the electrical potential which triggers each heart best; resistance changes due to changes in blood flow; and change in the volume of blood in blood vessels with each beat.

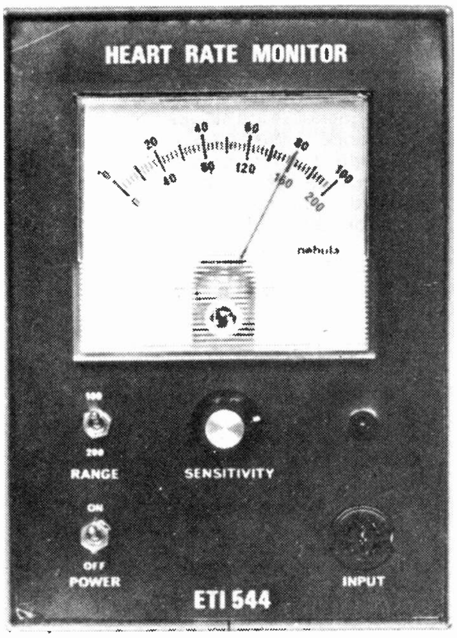
The detection of electrical signals associated with heart action is the best and most reliable method especially if the subject is exercising. However good connection must be made to the body by special electrodes and conductive paste to ensure very low contact resistance. The method is messy and requires skill in attaching the electrodes.

Similar electrodes are required to measure changes in body impedance and in addition the measurement is usually made by passing an electrical current through the body. This poses a considerable safety hazard as any fault in the insulation of mains-operated equipment can cause lethal currents to pass through the body. For this reason we did not use the method and we strongly recommend that experimenters do not either! With very well attached electrodes even small voltages can produce lethal currents.

LIGHTING UP TIME

This leaves us with the light-beam method, two variations of which are in common use. One is to pass light through flesh to a bone where it is reflected to a photo sensitive device adjacent to the lamp. This has the advantage that the sensor may be taped to any convenient part of the body, eg, the forehead, but the signal generated is very low. A second method still uses a light source and photo-sensor but the light is passed to the sensor through some thin section of flesh — the fleshy part of a finger or the ear lobe work very well. As there are no electrical contacts with the body this type of sensor is very safe to use and was therefore chosen for use in the ETI meter.

Specific Circuitry: While the detection and amplification of the signal due to heart action can be done with normal linear amplifiers the frequencies involved are very low. Measures must be taken to reject frequencies other than those of interest and to overcome dc offset problems due to differences in the path lengths depending on where the probe is attached.



Thought must also be given to the type of readout to be used. Were a digital readout to be used, counting of the rate would have to be performed for a full minute in order to obtain a one beat resolution and a new reading could only be taken at one minute intervals if normal frequency measurements are used. However, this problem may be overcome by measuring the period between the pulses and converting this to a frequency which can then be measured using digital logic to obtain a reading on every beat. This is quite valuable in a machine used for diagnostic work where information on the variations in regularity of the interval between adjacent beats can be quite meaningful. However, the method is complex, and expensive and requires some other type of sensor than the light beam type to obtain the accuracy required. As our meter is not intended for diagnosis the digital technique was rejected in favour of a simple analogue meter display.

CHOICE INTEGRATION

Even with an analogue readout we still have a choice of operating methods. We can measure the period between beats as previously discussed or we can use it as an integrating frequency meter. The latter method requires about 25 seconds for the reading to stabilise initially but thereafter it will follow variations in heart rate quite faithfully. The measurement of period between each beat is more rapid in its response but requires more

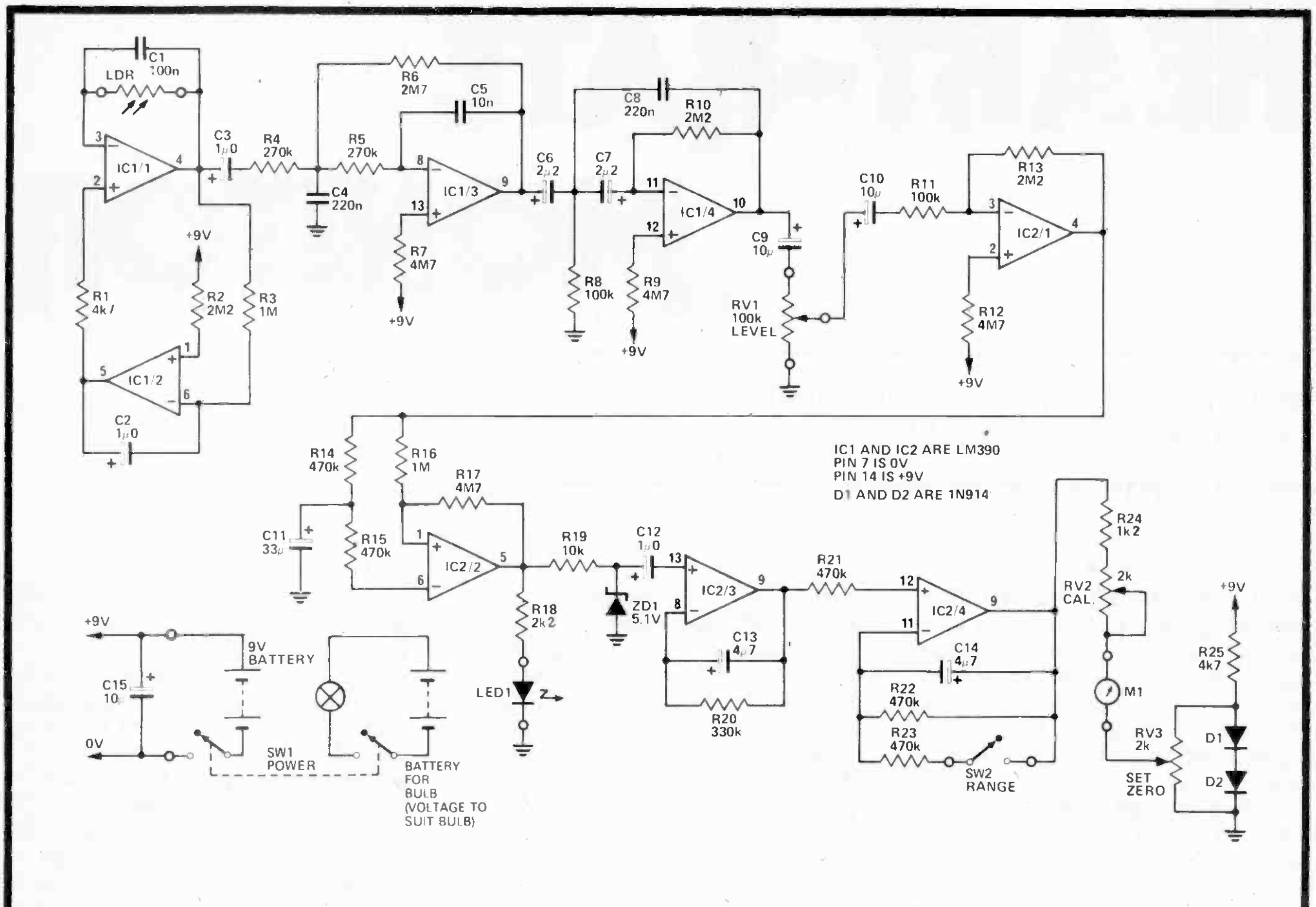


Fig. 1 Circuit diagram for heart-rate monitor.

How it works

The sensor consists of a light bulb and a light-dependant resistor mounted in a clothes peg in such a way that they may be positioned on opposite sides of a small section of flesh such as the ear lobe or a finger. As the heart beats it pumps blood through all the blood vessels of the body which swell. The density of the body therefore changes giving rise to a change in light transmission through the section of flesh to which the sensor is clipped. The LDR which is subject to this change of illumination therefore changes its resistance, and it is this change in resistance which eventually drives the meter. As the actual amount of light transmitted varies greatly from person to person and according to the thickness of flesh between the sensors, some method of stabilising the working base line is required.

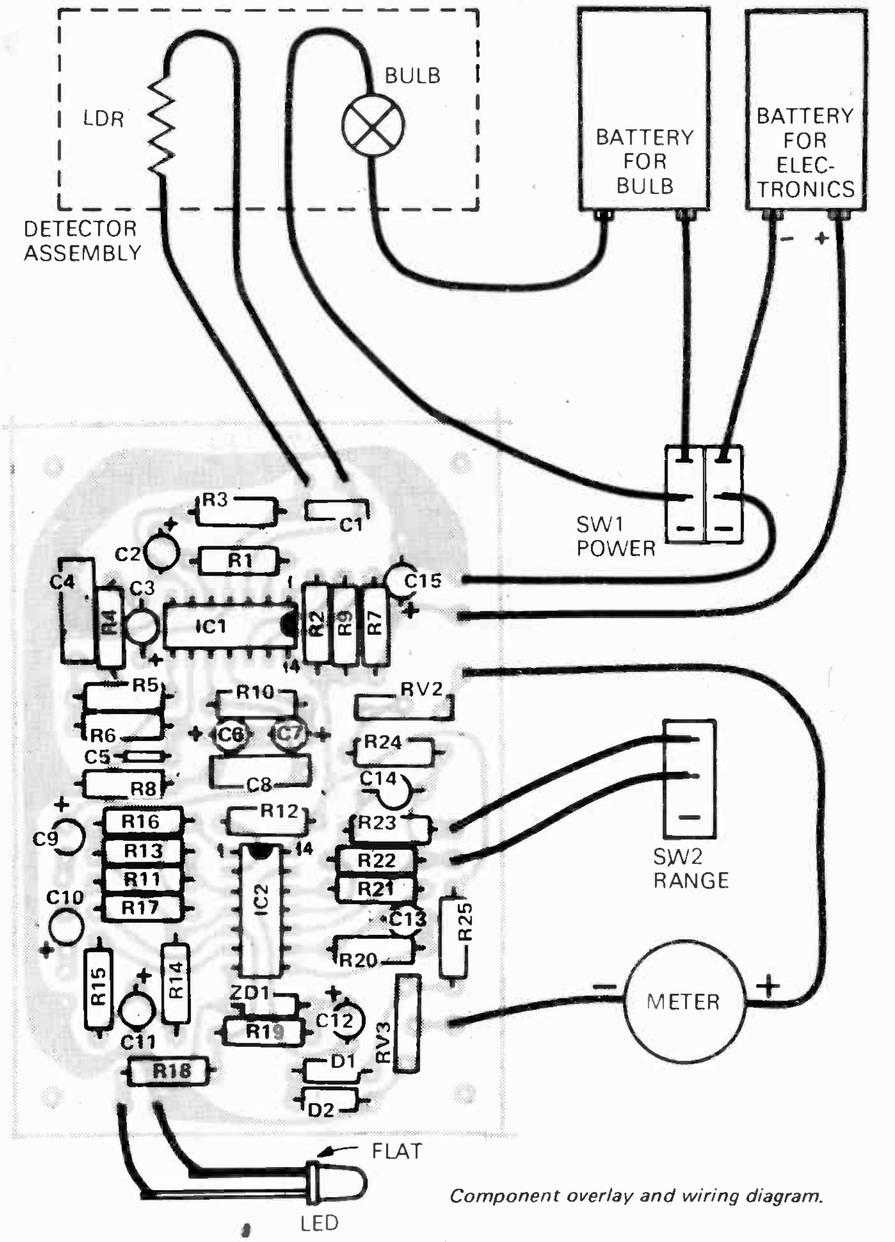
The stabilising function is performed by IC1/1 and IC1/2. Due to the operating mode of IC1/1 the current through the LDR is always equal to the current through R1. The current in R1 is automatically adjusted by IC1/2 such that the output of IC1/1 sits at about four volts (as the current in R2 must equal the current in R3). Capacitor C2 prevents the current in R1 from changing quickly and hence, relatively fast changes due to heart-beat (which cause changes in LDR resistance) are detected.

As the output of IC1/1 is at a very low level this signal must be amplified by IC1/3 and IC1/4 by about 40 dB. A low-pass filter which limits the rate, which can be detected to about 250 beats per minute, is also formed by IC3/3; and a low-pass filter which cuts off all frequencies below 30 beats per minute is formed by IC1/4. These filters eliminate 50 Hz pickup and any other signals generated by slow movement of the body which could also interfere with the measurement. As the actual signal can vary over a range of 20 dB with different people a level control is incorporated, after IC1/4, and the output from this control is amplified by 26 dB in IC2/1.

The output of IC2/1 has now to be squared up before it can be used. This is performed by a Schmitt trigger formed by IC2/2 where the necessary positive feedback is supplied by R17. Both inputs are biased from the output of IC2/1 but the ac signal is prevented from reaching the negative input by capacitor C11. An LED driven by the output of IC2/1 is incorporated to give a visual indication that heart beat is actually being detected.

It is now necessary to convert the square wave from the output of IC2/2 into a voltage proportional to heart rate and this is the purpose of IC2/3. Each time the output of IC2/2 goes high, capacitor C12 is charged up via R19 and the positive input from IC2/3. By the nature of the IC this current has to be balanced by a corresponding current in the negative input. This current can only be supplied by the output going high and supplying current via C13. This charges C13 up a little. On the negative edge of the output from IC2/2 the capacitor is discharged via the protection diodes on the input of IC2/3. If R20 was not present C13 would continue to charge up on each input pulse, however R20 bleeds a little current from C13 and the charging stops when it reaches a voltage where the amounts of charge and discharge become equal. The voltage reached will of course now be proportional to the heart rate. The amount of ripple on this voltage is determined by the time constant of R20 and C13 and this is selected as a compromise between response time and ripple. The zener diode is used to stabilise the output of IC2/2 against any changes in supply voltage.

The last section of IC2 is used as a buffer amplifier which provides the two ranges required along with an extra stage of filtering. The output of IC2/4 is metered to give a direct readout of heart rate. A resistor and trimpot in series with the meter allow the instrument to be calibrated and the potentiometer RV3 provides a zero correction (as the output of IC2/4 is not at zero volts but at about 0.8 volts). Diodes D1 and D2 stabilise this against supply variations.



Component overlay and wiring diagram.

Parts List

Resistors all ½w 5%

R1	4 k7
R2	2 M2
R3	1 M
R4,5	270 k
R6	2 M7
R7	4 M7
R8	100 k
R9	4 M7
R10	2 M2
R11	100 k
R12	4 M7
R13	2 M2
R14,15	470 k
R16	1 M
R17	4 M7
R18	2 k2
R19	10 k
R20	330 k
R21-R23	470 k
R24	1 k2
R25	4 k7

Potentiometers

RV1 100 k log rotary
RV2 2 k Trim.
RV3 2 k Trim.

Capacitors

C1	1 μF 35V electrolytic
C2	100 n polyester
C3	1 μF 35V electrolytic
C4	220 n polyester
C5	10 n "
C6,7	2 μ 2 25V electrolytic
C8	220 n polyester
C9,10	10 μ 35V electrolytic
C13,14	4 μ7 25V electrolytic
C15	10 μ 16V electrolytic

Semiconductors

IC1,2	LM3900
D1,2	1N914
ZD1	5.1 V Zener 400mW
LED1	

Miscellaneous

Meter	1mA FSD
PC board ETI 544	
Box to suit	
9V battery	
2 x 9V batteries	
One single pole switch	
One double pole switch	
LDR ORP12 or similar	
12V 30mA bulb	

complex circuitry and is very responsive to noise 'glitches' or to phenomena other than heart beat. Furthermore the scale for such an instrument is non-linear and wrong reading. That is high readings are at the left of the scale and vice versa. For these reasons the integrating frequency meter was chosen as the cheapest and most effective method for our particular application.

PROTOTYPE PROBLEMS

Our original prototype was built with 741 type operational amplifiers but in the final version we used the LM3900 which contains four Norton type operational amplifiers in the one package. This is a very economical solution as although the circuit is quite complex in concept, the whole device only uses two inexpensive ICs.

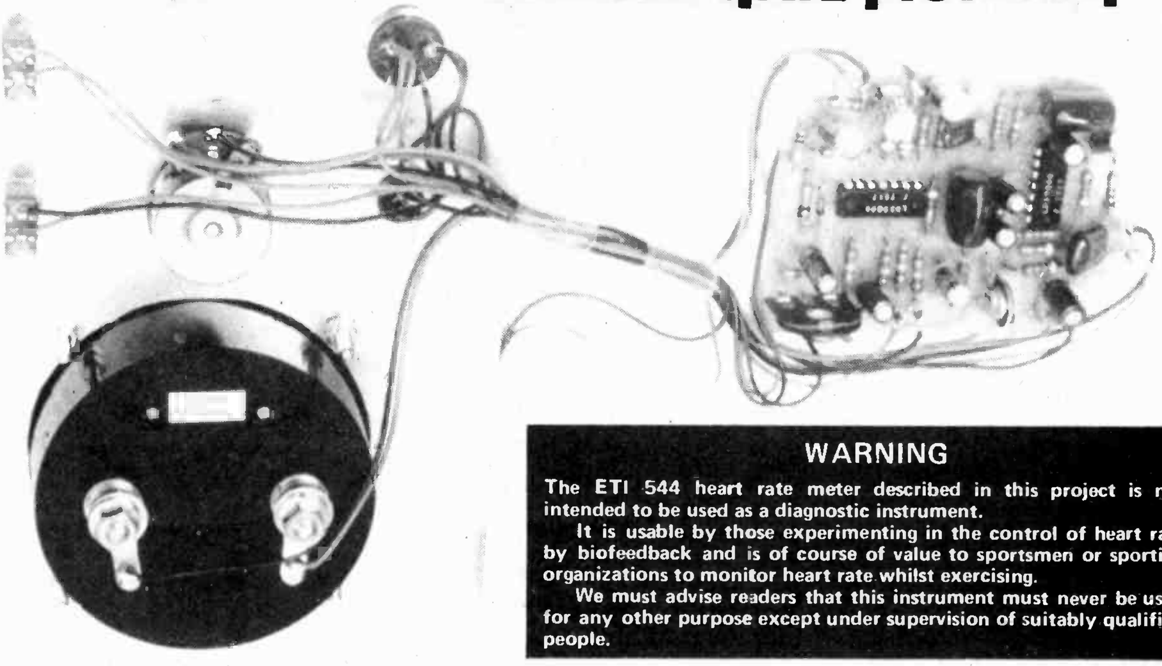
In the development of the circuit for this instrument a laboratory power supply was used. However, when the completed board was mounted into its case and run from batteries it worked alright until the batteries had been used for a while and then problems were encountered. The unit would just not count correctly. After much experimentation it was discovered that when the Schmitt trigger operated the power rail changed by about 10 millivolts or so and this modulated the bulb thus generating a spurious pulse.

Having located the problem it was a simple matter to cure it — just run the bulb from a separate battery.

CONSTRUCTION

There is no need to use the box that we used either — any suitable one will do. Just use the wiring diagram supplied to connect up the unit.

The sensor was made from a spring clip type of clothes peg, by mounting the bulb on one leg of the peg and the LDR on the other. Holes must be provided in the peg so that the light can pass through to the LDR. Fix the bulb and LDR into position with a little epoxy cement. The area around the rear of the LDR should be painted black or covered with tape to prevent all light other than that from the bulb reaching it.



WARNING

The ETI 544 heart rate meter described in this project is not intended to be used as a diagnostic instrument.

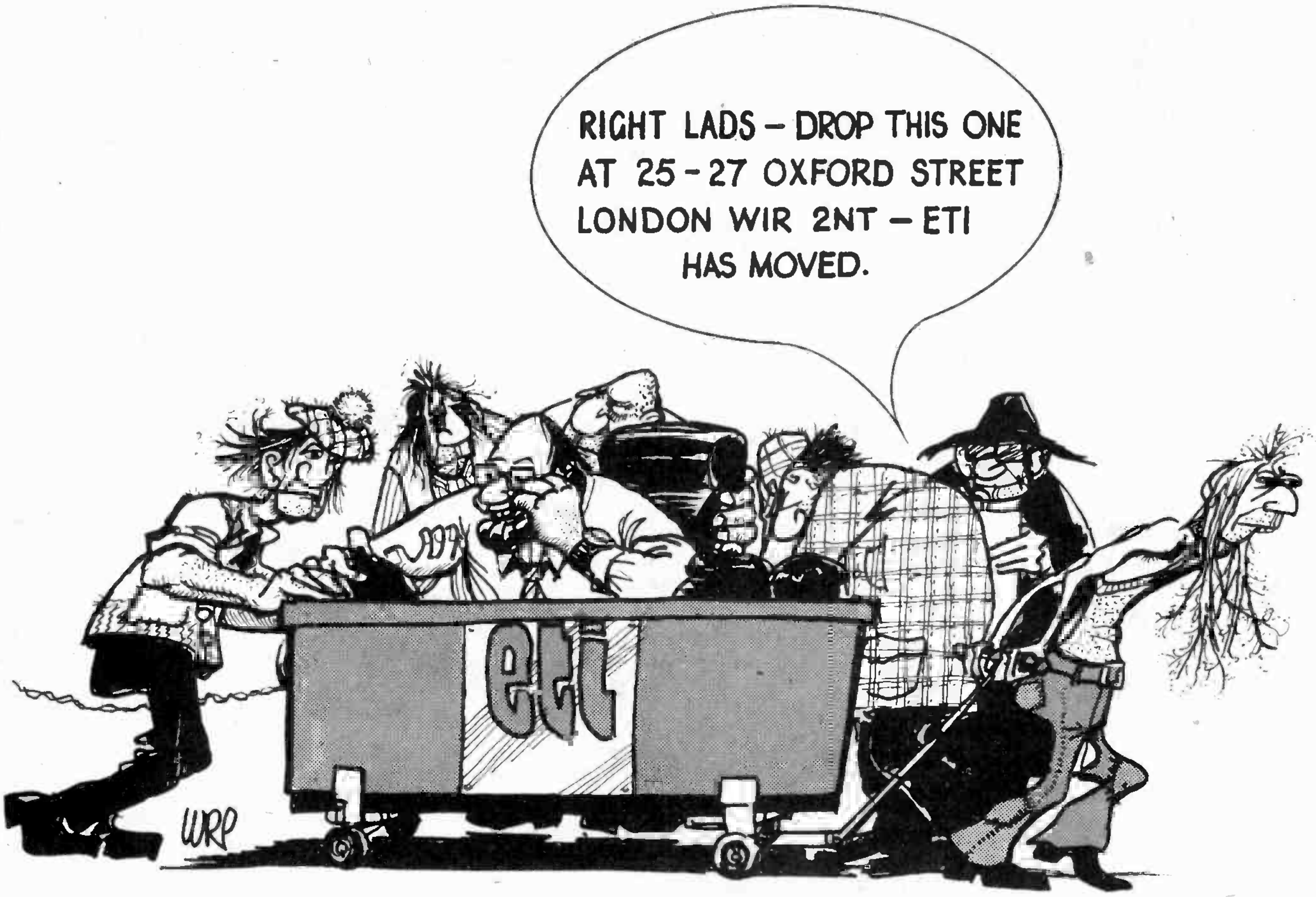
It is usable by those experimenting in the control of heart rate by biofeedback and is of course of value to sportsmen or sporting organizations to monitor heart rate whilst exercising.

We must advise readers that this instrument must never be used for any other purpose except under supervision of suitably qualified people.

USING THE MONITOR

To use the monitor simply clip the sensor to the ear lobe or to the fleshy part of the finger or thumb. Now adjust the sensitivity upward until the LED justs starts to flash regularly — indicating that heart beat is being detected reliably. The reading on the meter will start to rise and will become stable after about 25 seconds. Hereafter the reading will faithfully follow variations in heart rate.

Note that the finger or thumb should not be moved whilst taking a reading as this will cause a change in the flesh — which can be interpreted as a spurious heart beat thus giving an erroneous change in the indicated rate. ●



Mankind's exploration of space continues — but what are the effects of space on man? Bruce Sibley considers.

MAN IN SPACE

BIOMEDICAL aspects of space flight are less publicized than many other phenomena associated with the exploration of space. It is the purpose of this article to attempt to 'fill-in' this gap and acquaint the reader with some possibly fascinating facts.

There are three main biomedical objectives. First, to determine how long the human organism can be exposed to the hazards of space without suffering physical or psychological harm. Secondly to determine which agents are responsible for any physical or psychological deterioration, and thirdly to discover and develop protective and preventive techniques to combat and nullify such agents.

HEARTS OF AMERICA

The combined Mercury, Gemini, and Apollo space programmes, undertaken by the Americans between 1961 and 1975, have provided many thousands of man-hours of space environment experience. Generally, the effects of human beings were less serious than expected, although it is still too early for us to suppose that all of the effects experienced are completely understood and are therefore of little concern in future missions.

For example, post-flight medical examinations revealed that astronauts suffer irregular heart beat rates for several days following their mission, when standing up suddenly, or when given a special 'tilting table' test. The blood also undergoes some changes, the skeleton loses calcium, the muscles deteriorate and the body loses weight.

LONG EXPOSURES

The latest findings of Apollo and Skylab suggest that long term voyages may well involve an exposure which will seriously damage the tissues of the astronauts. The variations in the blood and skeleton are believed to be the result of several influences working together — confinement, weightlessness, and possibly breathing a low pressure atmosphere of pure oxygen. Heart and breathing rates are affected by zero gravity, work loads, and possibly psychological stress.

EVA AND THE ASTRONAUTS

During the first American Space Walks (EVA — Extra-vehicular activity), the spacesuits were unable to maintain a cool environment for heavy work loads indeed, even for relatively simple tasks! This resulted in rapid fatigue, and subsequent curtailment of the EVA.

Measurements taken from the biomedical sensors indicated that the work being done by the EVA astronaut was exceeding 3000 Btu/hour. The life-support system of the early suit was rated at peak loads of 2000 Btu/hour, small wonder their visors got fogged up! Heart and breathing rates returned to normal following rest.

Alterations to the spacesuit, including the addition of water-cooled underwear, has largely removed this problem and from the manner in which the lunar astronauts performed their heavy and varied work load it would certainly appear that the original problems experienced with EVA have been overcome.

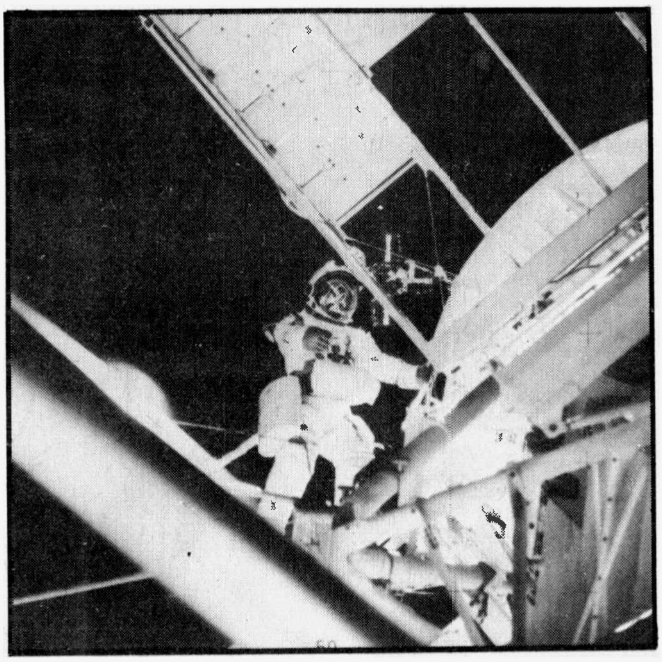
KEEPING FIT AND HEAVY

The problem involving bone calcium loss and body weight loss has been largely solved by the introduction of calcium rich diets both before and during the mission. Exercises performed regularly reduce the deterioration of muscle tissue and hence stabilize body weight.

RADIATING DANGER

There are two huge belts of radiation, called the Van Allen belts, which surround the Earth rather like the outermost layers of an onion. Missions are now planned to avoid plunging astronauts through all but the least intense regions of these belts, as the metalic walls of the spacecraft will only shield the astronauts from the less energetic radiation, and the most powerful rays will penetrate the craft and hence the tissues of the crew.

MAN IN SPACE



EVA activities, such as this walk around Skylab, are said to produce very high heart rates and rapid fatique. The reasons for this are perhaps to some extent psychological as well as physical. Inside the spacecraft the astronauts do not suffer from fatique to anything like the same extent, although naturally much less exertion is called for.

DOSED UP

Now, it is held that a short term exposure of 50 Rads (whole-body dose) is unlikely to harm the victim — unless repeated several times in one year. Between 50 and 200 rads the victim will suffer from nausea and sickness, fatigue, and his blood undergoes minor changes. At a dose of 400 Rads the victim becomes very ill and it has been statistically calculated that 50 percent of people receiving such a dose will die within a few days or a couple of weeks. The percentage of deaths rises proportionally with further increases in radiation dosage until a value of 1000 rads is reached — where there is a 99.9% *certainty* of death!

OFFICIAL VIEW

So far the 'officially released dosage figures' indicate that astronauts have only been exposed to doses of a few millirads. These doses have been present during the entire flight and are accordingly accumulative — hence a dose rate of say, 10 millirads per hour will add up to an accumulative dose of 100 millirads for a 10 hour mission and 1000 millirads (= 1Rad) for a 100 hour mission.

Naturally, longer mission times involve the astronaut in higher accumulative doses of radiation. The crews aboard the Apollo Moon craft and those participating in experiments aboard Skylab, were subjected to much lower hourly doses of radiation. Hence their 'accumulative' whole-body dosage was relatively 'safe' upon their return to the surface of earth.

It has been suggested that an astronaut returning from a Mars mission would have 'lost' about 10 percent of his brain tissue as a result of cosmic ray bombardment. Certainly if this theory proves correct we shall have to solve the daunting problem of cosmic radiation before we permit our astronauts to risk their 'lives' in such a way, even for such a prize as the Red Planet. ●

PREDICTED EFFECTS	MEASURED EFFECTS
Poor Circulation	None
Skin Infections	Same Dandruff
Sleep Deprivation	Minimal
Vision Affected	Improved — but occasionally sore eyes
Sore Nose and Throat	Some stuffiness (due to pure oxygen atmosphere?)
Disorientation, Nausea, Sickness, Hallucinations	None
Fainting	None
Dehydration	Some, at first
Body weight loss	Averages 3.4kg (7½lb)
Fatique	Low in spacecraft, high in EVA
Blood changes	Red cell and plasma reduced
Muscular weakness	Slightly on return to earth
Skeletal losses	Calcium reduced in bones
High/Low Blood pressure	Slight variations on occasions
High Heart Rates	Launch:110—180 per minute EVA: 130—190 per minute Re-entry: 90—185 per minute
Heart Failure	None
Low Heart Rate	In long term earth orbit dropped to 47 beats per minute
Gravity tolerance	Weak on return to earth weight
Radiation (known to cause blood and cell changes)	Low orbital, higher on lunar flights As yet no harm experienced
Cosmic Ray effects	Flashing Lights 'seen' within brain by cosmic rays hitting optic nerves, etc. Long term exposure suspected dangerous.

The table compares predicted spaceflights effects against those actually experienced. It was thought that weightlessness would seriously hinder the circulation of the blood, no such effect was found. Predictions were made of fainting, variable blood pressure, nausea, hallucination, disorientation, sickness and heart failure. All of these effects did not occur

In the case of nausea, however, slight signs were discovered in a few cases. Other forecasts involving high and low heart beat rates, chemical changes in the blood, calcium losses in the skeleton, reduced body weight and dehydration; were correct! Radiation hazard was another predicted effect, but the doses received were relatively small.

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FND500

TIL321, TIL322

XAN652, XAN654 GREEN

D500-6

Part No.	Manufacturer	Colour	Type	Size	Price
FND500	Fairchild	Red	Common Cathode LED	0.5"	**£1.02**
TIL321	Texas Instr.	Red	Common Anode LED	0.5"	**£1.30**
TIL322	Texas Instr.	Red	Common Cathode LED	0.5"	**£1.20**
XAN652	Xciton	Green	Common Anode LED	0.6"	**£1.75**
XAN654	Xciton	Green	Common Cathode LED	0.6"	**£1.75**
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—ETI project 447

AUDIO PHASER

THERE AREN'T MANY ELECTRONIC music accessories that we haven't published as projects in ETI and this project will make the list even shorter.

Most musicians will know what a phaser sounds like and it is going to be very difficult for us to describe the effect to readers who don't know the sound. It really has to be heard to be appreciated.

The most dramatic effect, and the easiest to describe, is that caused by feeding white noise through a phaser. The sound is similar to the sound of surf, an 'atmospheric' whooshing sound. On recordings phaser effects can be heard on electric guitars, drums, electric piano, and other instruments.

Technically the phaser acts as a filter — it phases out certain frequencies in the audio spectrum and over a period of a second or two these minima in the response curve sweep up and down the audio band. The response of the ETI phaser can be seen in figure 1. Frequencies between 10 Hz and 4 kHz are present in varying proportions between 0 and 100% of the input signal level. As the values of the components in the phase-shift network change, the proportions of these frequencies will change as the response curve moves up and down the audio spectrum.

The unit we have designed is a six-stage phaser (there are six phase-shift networks in the phase-change path) which gives three minima in its response curve. It is built into a die-cast box so it can be used on stage by a guitarist. The only external control adjusts the speed, except for the foot-operated switch which puts the phaser in or out of circuit. The power is switched on by plugging the jack plugs into their sockets.

Specification

Phase-shift stages:
Six stages providing a maximum 1080 degrees phase-shift, and consequently three minima (see graph).

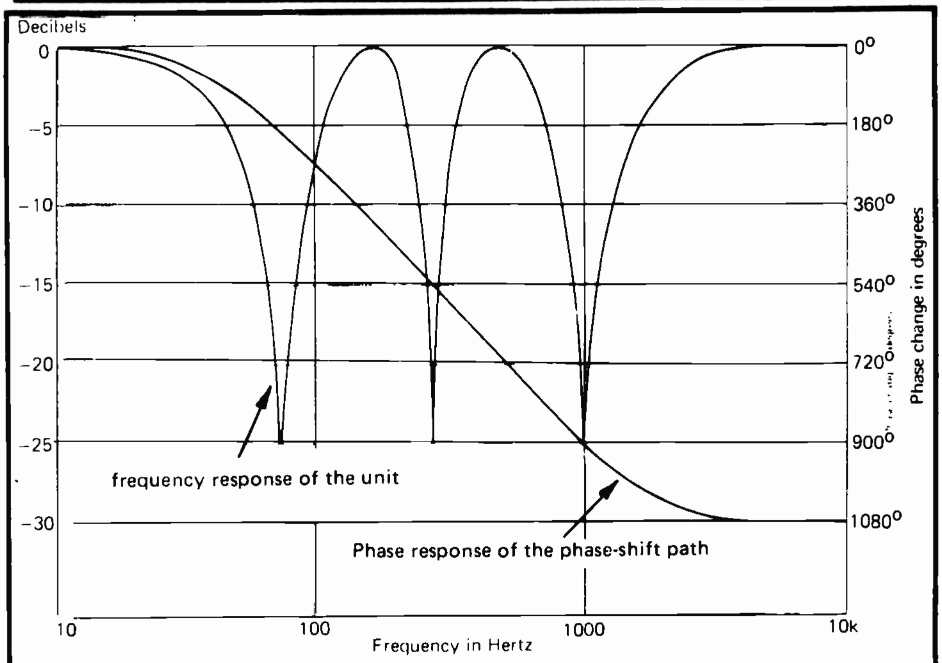
Frequency range:
With 10n and 100k networks, minima at 40 Hz, 160 Hz, and 600 Hz.
With 10n and 56k networks, minima at 70 Hz, 270 Hz and 1 kHz (as shown in Figure 3).
With 10n and 10k networks, minima at 400 Hz, 1600 Hz and 60 kHz.

In operation the resistive element of the phase-shift networks varies continuously and these minima sweep across the spectrum.

Input impedance:
500k.

Input sensitivity:
3 mV to 1 V.

Overall gain:
Unity.



Frequency response of the unit.

CONSTRUCTION

Apart from the PCB the box contains one pot, two jack sockets and a foot-operated switch, so construction is unlikely to be any problem. Use our design for the PCB pattern and insert the components according to the overlay drawing. IC sockets do not have to be used but a socket would spare the CMOS IC from the dangers of direct soldering.

First solder the low-profile components to the board, then the other components. When the case-mounted parts have been installed, wire up the board to these using sufficiently long leads to enable easy fault-finding, should this be necessary.

For stage use, the phaser needs properly protecting against physical shocks so we strongly recommend you use a die-cast box and wrap the PCB in foam sheeting rather than screwing it to the case. If the phaser is to be built into a mixer or an effects unit then housing is obviously less important.

SETTING UP

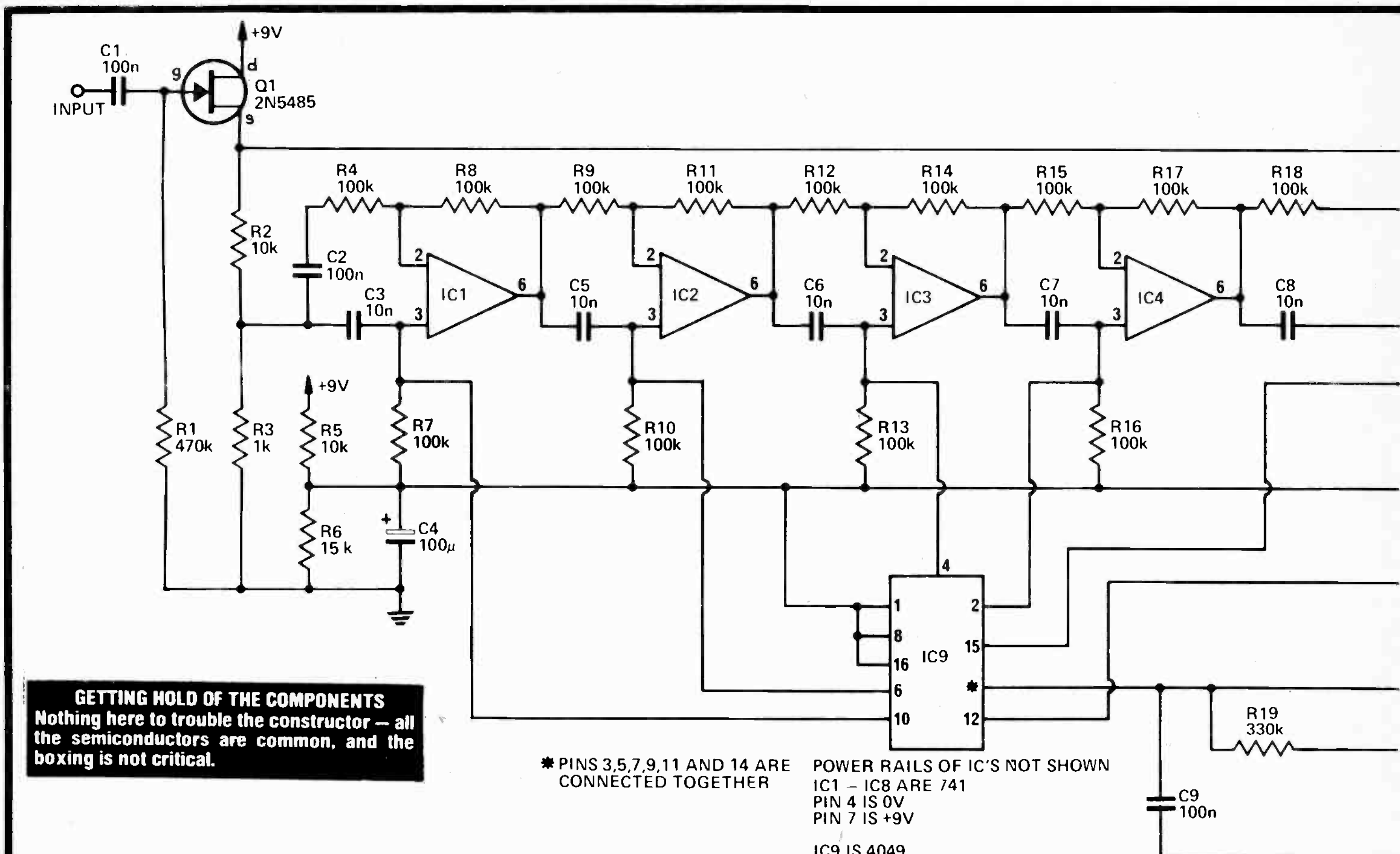
The best way to set up the phaser is to use a white noise source and then adjust the bias preset to give a continuous whooshing sound. If the bias is incorrectly set the sound will be interrupted, it will not whoosh continuously.

If you do not have a white noise source use a signal high in harmonic content: electric guitar, crowd noise, FM hiss, etc.

We cannot teach you how to use the phaser, it is a special effect offered as an aid to creative musicians. It can produce weird effects with almost any audio source (it can, for example, simulate long-distance phonecalls or radio stations) and it is necessary to play certain styles of electric guitar and electric piano.

The phaser can be plugged into the echo send and echo return sockets of the ETI Master Mixer for use on any channel as desired.

AUDIO PHASER



GETTING HOLD OF THE COMPONENTS
Nothing here to trouble the constructor — all the semiconductors are common, and the boxing is not critical.

Fig 2 Circuit diagram for the Audio Phaser

How it works

The input impedance of the phaser has to be high to prevent damping of the strings when used with an electric guitar. Loading caused by a low input impedance would stop the notes from sustaining properly. In the ETI phaser this is achieved by the high impedance buffer, Q1.

After the input buffer the signal is split along two paths, and the two parts do not meet again until they are mixed back together again at the junction of R26 and R27. One part of the signal undergoes phase-shift, via ICs 1 to 6, and the other part follows a direct path. Q2 amplifies the output to give an overall gain of unity.

The phase-shift is achieved in six idential RC networks; the overall shift being the sum of the shifts at each stage. IC9 varies the value of resistance in each stage, but we will first look at the operation with a fixed value, say 56 k.

In this case each stage puts a 10n capacitor and 56k resistor across the signal. The waveform at the junction of these two components has to be of such phasing as to reconcile the perpendicular phasing of the waveforms across each component.

The signal fed into the op-amp undergoes a phase-shift, but the phase-shift is not the same for all frequencies. In the one stage the signal undergoes a change of 180 degrees at high frequencies and a negligible change at low frequencies. The curve of Figure 1 shows that there is little shift at 10 Hz and 1080° at 4 kHz (that is 180° at each stage: a total of 1080° from all six stages).

When all six stages are taken into account, frequencies from 10 Hz to 4 kHz have a continuous range of phase-shifts from 0 to 1080°.

Figure 1 also shows what happens when equal amplitudes of the two signals (from the direct and phase-shift paths) are mixed.

Because frequencies outside the range 10 Hz to 4 kHz are in phase the response is flat. In-Phase mixing also occurs within this range at two places. These are at phase differences of 360° and 720°, in this case at 160 Hz and at 460 Hz.

The holes in the response are caused by out-of-phase mixing, as occurs when the phase differences are 180°, 540°, and 900°. With 10n and 56k in the phase-shift networks these minima occur at 70 Hz, 270 Hz, and 1 kHz.

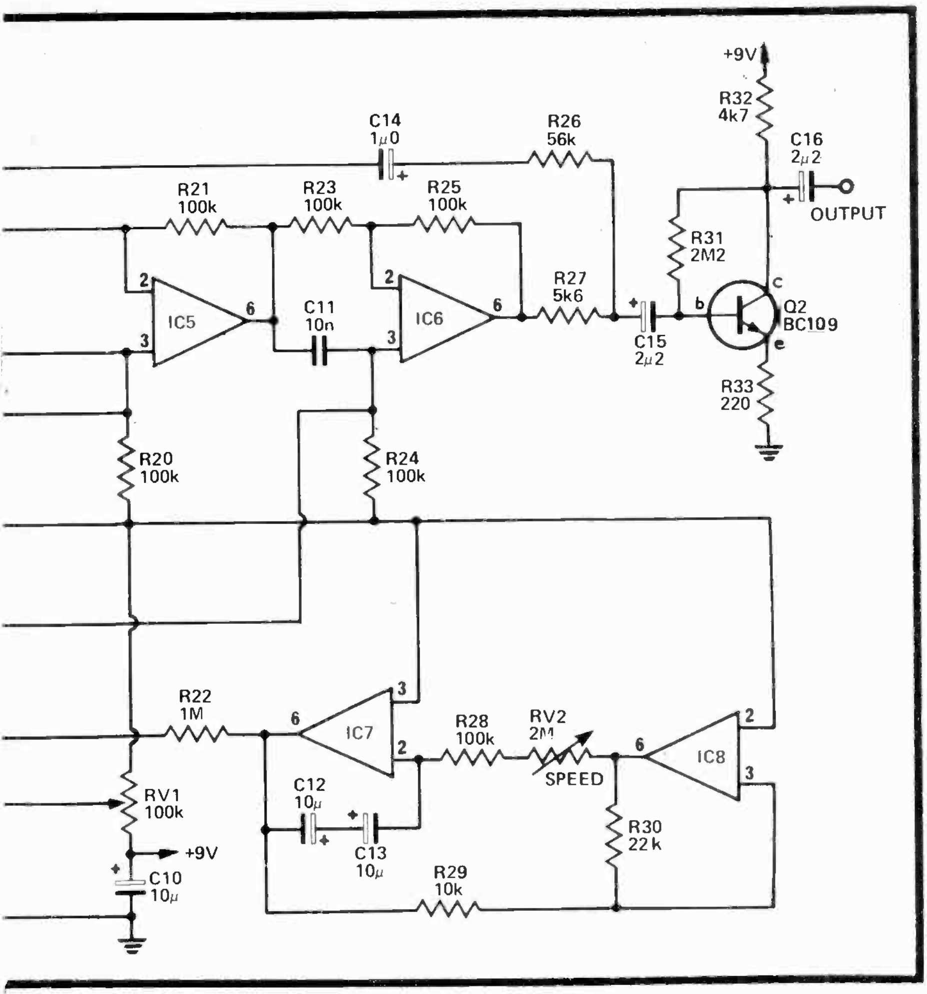
The number of minima in the response is directly related to the number of phase-shift stages. Four stages would give a maximum phase shift of 720° and minima would then only occur at 180° and 540°. If you use eight stages another minimum will occur at 1260°, giving four in all.

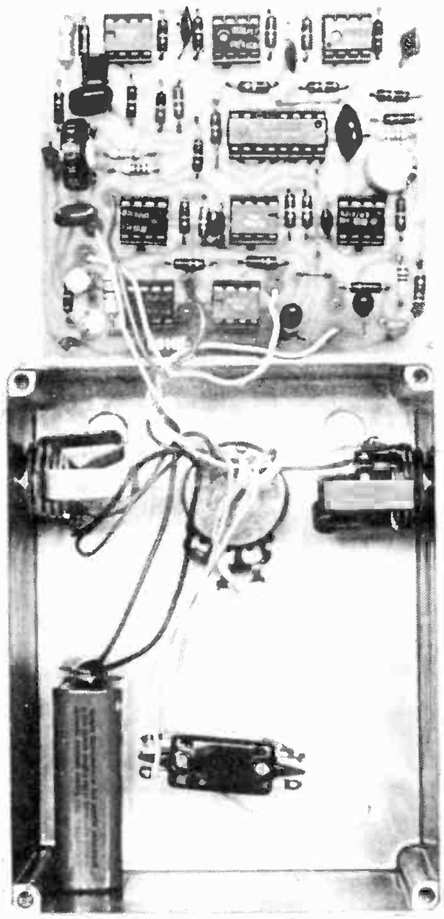
The rest of the circuitry in the phaser is used to vary the resistance in the phase-shift networks to move the response curve of the phaser up and down the frequency axis. IC9 is effectively six sets of complementary FETs and the resistance of each can be controlled by applying a voltage onto its gate. Varying the gate voltage of IC9 causes the effective resistance of R7 to be shunted from 100k down to a few kilohms.

IC7 is an integrator and IC8 is a Schmitt trigger, together they make a triangle-wave oscillator. This triangle waveform gives a rising and falling voltage to the gates in IC9. The waveform has to be correctly biased to give the desired resistance change in each phase-shift stage. The bias voltage is set by RV1.

RV2 controls the speed of the triangle-wave oscillator to give periods ranging from a few seconds down to a tenth of a second or so.

The zero reference voltage for the op-amps is taken from the junction of R5 and R6, which is at half the supply voltage. This does away with the need for a split supply — a single 9V battery is sufficient. The power is switched on and off by the jack socket. The foot-switch switches the phaser in and out of circuit.





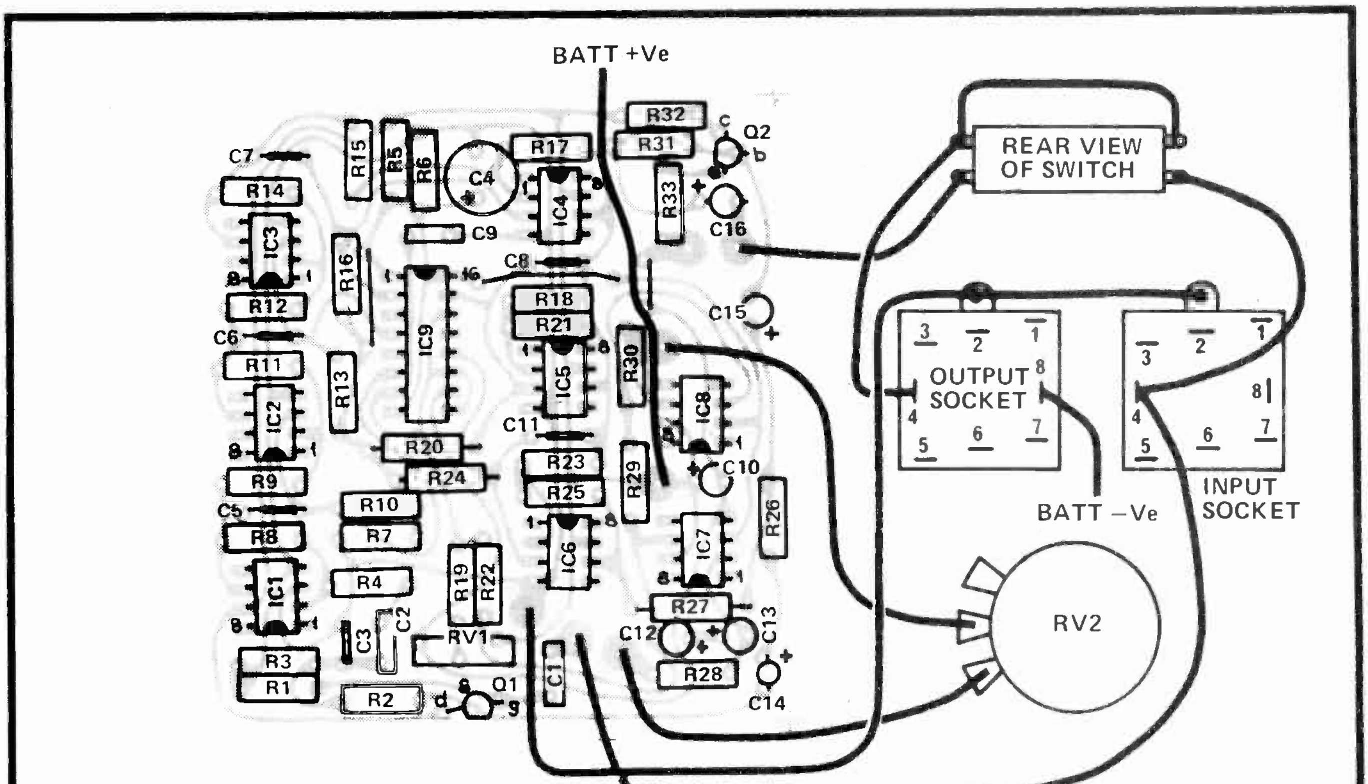


Fig 3 Component overlay and wiring diagram

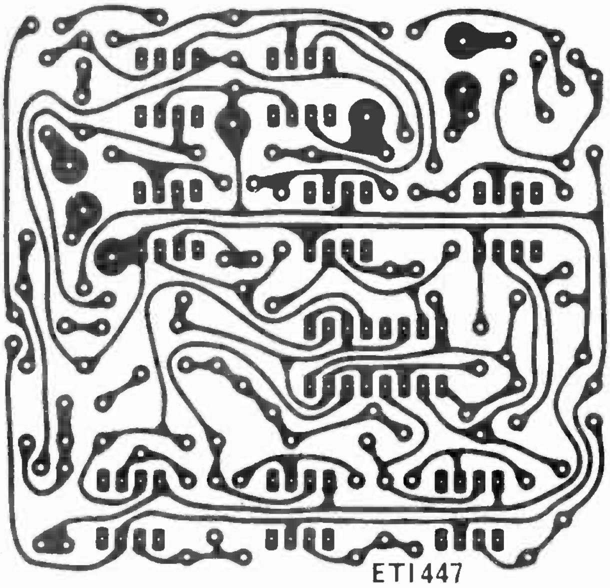


Fig 4 Printed-Circuit Layout. Full Size 81 x 76 mm.

Parts List

Resistors	all ½ W 5%
R1	470 k
R2	10 k
R3	1 k
R4	100 k
R5	10 k
R6	15 k
R7-R18	100 k
R19	330 k
R20,21	100 k
R22	1 M
R23-R25	100 k
R26	56 k
R27	5 k6
R28	100 k
R29	10 k
R30	22 k
R31	2 M2
R32	4 k7
R33	220

Potentiometers	
RV1	100 k trim type
RV2	2 M log rotary

Capacitors	
C1,2	100 n polyester
C3	10 n "
C4	100 µF 6 V
C5-C8	10 n polyester
C9	100 n "
C10	10 µF 25 V
C11	10 n polyester
C12,13	10 µF 25 V
C14	1 µF 25 V
C15,16	2 µF 25 V

Semiconductors	
Q1	2N5485 or similar
Q2	BC109 or similar
IC1-IC8	µA741 op-amp
IC9	4049 CMOS

Miscellaneous

PC Board ETI 447
Two stereo phone sockets
Switch — push on push off push button
Case to suit
9 V battery
Knob

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(THIS IS ETI–HOLLAND)

Australia, Britain, France . . . now Holland (and as you'll see below, soon Canada) . . . the number of ETI editions is growing!

ETI-Holland – known there as Electronica Top Internationaal – was launched on October 4th with the 100W Disco article (featured in September ETI-UK) as the cover feature.

The Dutch edition is being published for the group by Radio Rotor of Emmen – a town in north-east Holland near the German border.

Although sales figures won't be known for some time, over 1,000 subscriptions were received even before the first issue was available. In a country which already has three established hobby-electronics, this can only be regarded as a good omen!

Apart from the 100W Disco, other features include Microfile, the start of the components series, and five constructional projects. Locally produced articles are of course included, one of which covers a review of a new microprocessor kit (not available in Britain).

The staff of ETI in Britain wish ETI-Holland the same success as we have enjoyed here.

Above is shown the headquarters of Radio Rotor who are publishing our Dutch edition. The ETI offices are in the same building. Below left is Anton Kriegsmann, Editor-in-Chief of Electronica Top Internationaal. Below right is a small section of the labs where all projects are rebuilt before going into the Dutch edition.

THE COVER OF THE FIRST ISSUE OF ETI–HOLLAND

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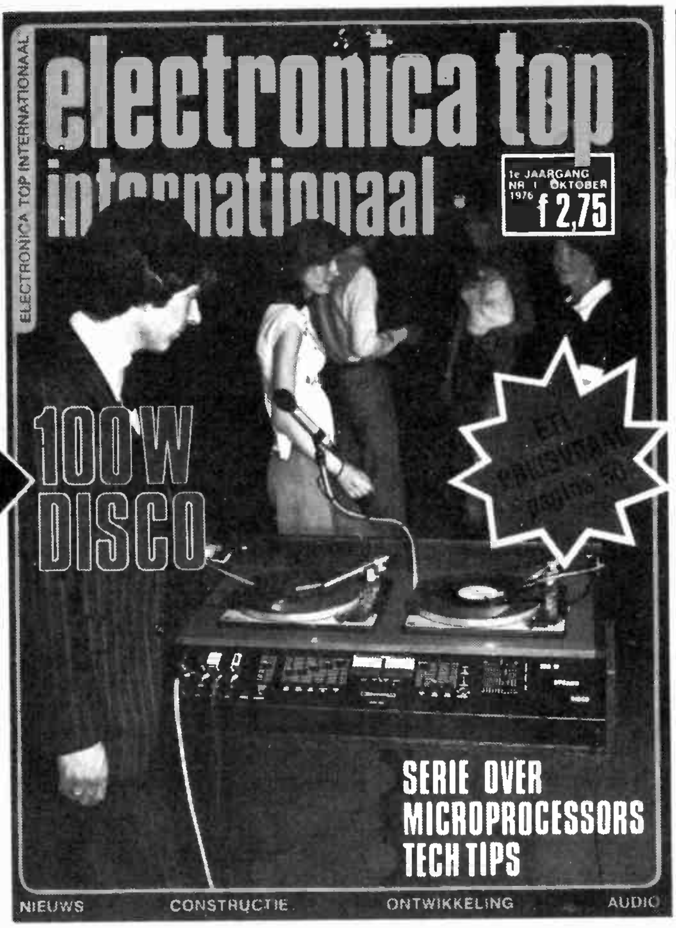

CANADA

The British edition of ETI was first introduced to Canada in February 1976. Sales and response have been so good that this will be replaced by ETI-Canada, to be published in Canada, by Canadians, for Canadians.

ETI-Canada will cover very much the same ground as ETI-Britain but will carry many locally produced articles specifically for the Canadian reader. Articles from other editions will be carried but only where these are also of interest to Canadian readers. News and news-type articles will relate to Canada and will be as up-to-date as possible.

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Photograph courtesy of Ontario House, London

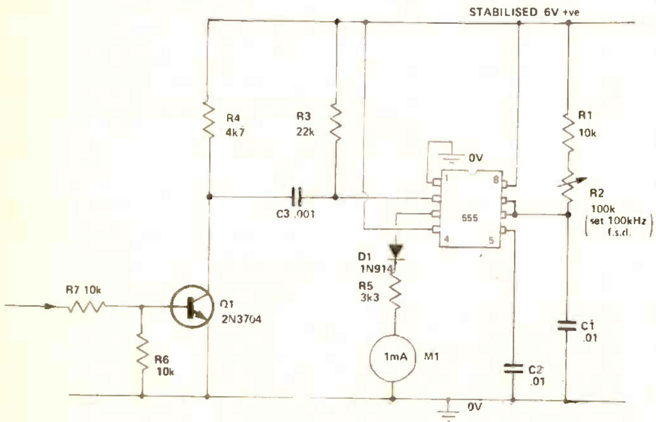
electronics today international

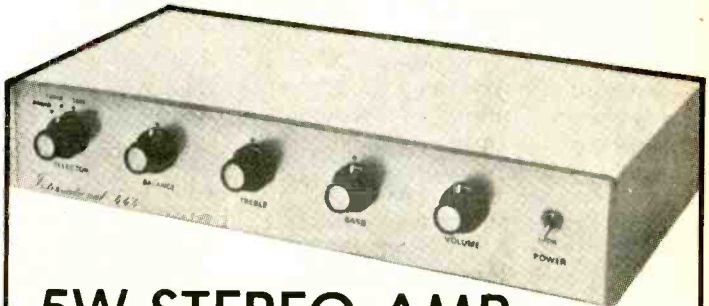
What to look for in the January issue: On sale Dec 3rd

R.M. MARSTON DESCRIBES:

38 555 TIMER CIRCUITS

The definitive words on the famous 555 IC from R. M. Marston — one of Britain's best known and respected electronics authors. This article provides no less than 38 different applications for the 555 many of them brand new!





5W STEREO AMP

A 'nice and easy' project. A simple but high quality 5W stereo amplifier. Based on two I.C.s, the construction is simple, but the sound is superb!

ELECTRONICS IN THE NORTH SEA:

We got wet on this one! Providing a well detailed look at how Britain pulls in the black gold from the North Sea — from the electronics point of view. The companies have been very co-operative and we think you'll agree this was worth the trouble.

READER OFFER

READER OFFER. We're faced with a problem with this type of offer: as the product hasn't been announced yet we're sworn to secrecy (sorry about the cloak-n-dagger bit). What we can say is that it's a very low priced offer on a new aid for the electronics lab and amateur enthusiast.

NEW SERIES:

SHORT CIRCUITS

In the next issue we start a new series: Short-circuits. These will describe straightforward projects in a short and sweet form — there'll be no unnecessary 'blurb' with them. Many will be simple but it's not specifically a beginners' series — some projects will be highly sophisticated in concept.

The January issue contains three such projects. PATCH DETECTOR is a one-transistor circuit costing under £2.00. For use when buying a second-hand car to find if body filler has been used. HEADS OR TAILS is an ingenious application of a very standard circuit. Our SCR TESTER can be built easily in an evening and can also be used to test power diodes.

VCT?

For the last few weeks when you've met anyone well informed about electronics they'll have brought up VCT. What is it? Well it may not replace the Op. Amp but it'll stunt its growth: it's a completely new type of IC. Information is very, very scant at present — and much of sheer rumour but we hope to bring you the essence next month — at least a month before it's officially announced!

The cover price of ETI will go up from 30p to 35p with the January issue. We've held our price since May 1975 — that's probably a record for magazines — but we'll still be the cheapest electronics magazine and the one with the most editorial.

We hope readers will still consider ETI overwhelmingly the best value for money.

eti microfile

PART 10 - PROGRAMMING

IT SEEMS TO BE a fairly common problem amongst electronics engineers and enthusiasts approaching microprocessors for the first time, that although they can usually wade through the electrical characteristics, timing diagrams, interface circuitry and conventional problems of that type, they almost always have a mental block on the subject of programming. Although programming is taught in many schools and probably all universities now, it is still somewhat of a mystery to the majority of people. Perhaps this is due to the popular image of the programmer as a white-coated demi-god who commands vast roomfuls of spinning tape reels and flashing lights, and who spends his time computing the origins of the universe or checking tax returns (equally complex problems as far as I'm concerned!).

The fact of the matter is that there is no mystique to computer programming, and if the truth be known,as many computer programmers are baffled by electronics as vice-versa. Let's tackle the problem of programming and see what's involved.

A program is simply a sequence of instructions which make a computer (including a microcomputer) perform a specified function. That's the definition that's perpetually given in the textbooks, but it's not much use if you're faced with writing a program for the first time. What the budding programmer wants to know is: what is the process that takes you from the problem to be solved to the program that will give the solution?

The first step is usually a definition of the problem; in other words, ask yourself what *exactly* you want to do. Research the problem thoroughly so that you understand it – it's no good writing a beautifully elegant solution for the wrong problem. This is a good time to think about the people who will be using the system and design in some useful features – for instance, a program which calculates the voltages in a circuit as the input varies could give the results in the form of tables or a graph. Which would be more useful – or can you offer both?

This section of the process will usually give some possible methods of tackling the problem. The trick here is to break the problem down into a number of separate tasks which can be performed *sequentially* – a computer (or MPU) cannot do more than one thing at a time, though of course it operates so fast that it may seem to. Let's take as an example the simple problem of controlling a single traffic light. The processor has to first turn on the red light. It will then wait for a preset time interval by performing a a loop program such as counting down from a preset number to zero. At the end of the loop it will turn on the amber light, and start counting again. At the end of this time interval it will turn off both the red and the amber, and turn on the green. Again it counts down and then turns off the green and turns on the amber. Finally, another counter loop and then back to red.

That's a rough idea of how an MPU would tackle the job – now let's get more specific and examine how the abilities of the processor and the hardware around it can modify your approach. If we use M6800 as an example, it seems obvious to use the M6820 Peripheral Interface Adapter to drive the lamps. In fact one PIA could drive 5 sets of traffic lights and still have inputs available for detecting cars passing over sensors in the road. The individual lamps would be connected to bits in the PIA Data Registers, so that a '1' in that position would turn the light on and a '0' would turn it off. Thus, a single memory write instruction could instantaneously set up 8 lamps and there is now no need for an instruction to turn off lamps.

SUBROUTINES

Notice also that we had 4 sections of the program concerned only with counting down to zero – it seems rather silly to write the same thing 4 times over. The M6800, in common with most micros, has the capability of jumping to, and returning from, subroutines. Hence we would write a subroutine to subtract 1 perpetually

O.K. MASTERMIND ---- DON'T TELL ME YOUR DIAGNOSIS OF BARKHAUSEN OSCILLATION WAS WRONG AFTER ALL!?

from an accumulator and then check to see if it is zero. If it is, control will then be passed back to the main program, otherwise it will keep on subtracting. This can be written in various forms: as the flowchart in Fig.1, or as the assembly language routine or object code given in Fig.2.

In general, flowcharts are a very good way of concreting one's thoughts on a particular problem. However, as the program gets more complex, so does the flowchart, only more so! The trend today seems to be towards programmers writing in a high level language and then either using a compiler or converting to assembly language or object code by hand. The idea is to firm up one's approach to the solution and gradually, through several intermediate stages, to become more specific until one reaches the level of machine code. This tends to ensure that all the segments of the program are compatible.

PROGRAM EXAMPLE

This is an example of a very useful program which has been sent to us by Mr. J. Kennedy of Wantage. A frequent requirement in microprocessor systems is that they respond to the passage of time. To do this they need to have some form of internal clock apart from the one which actually drives the system. Such a device is called a Real Time Clock. The one described here relies upon both hardware and software to gain the advantages of both. To write a Real Time Clock entirely in software would mean (a) a long program and (b) the processor could not execute any other program - which is a bit useless! On the other hand, to implement a clock completely in hardware can be quite expensive, even using a CMOS clock chip with BCD outputs.

This system uses 1Hz pulses (derived from the mains) to pulse the Non-Maskable Interrupt of the processor chip, thus causing it to jump to the interrupt service routine given here and update its internal time which is held in 3 consecutive memory locations.

A suggested circuit to derive these pulses is given in Fig.3, but this has not yet been tried and tested. An alternative would be to use a crystal controlled oscillator and dividers.

The software consists of 2 sections which is a lump of data comprising time and data required by the main program and the Real Time Clock program itself (memory locations 10 to 28). We shall leave the reader to puzzle the operation of this program out for himself but you should note the extensive use of indexed addressing which is one of the most useful features found in current microprocessors.

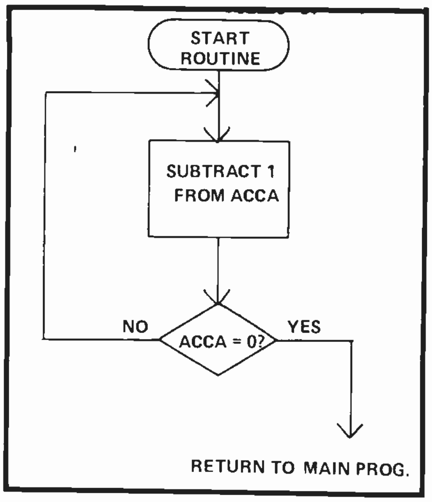
MICROPROCESSORS AT WORK

was the title of a symposium held for 3 days in September at Sussex University by the Society of Electronic and Radio Technicians.

The dictionary defines 'symposium' as an ancient Greek drinking party, or a set of articles on one subject, or philosophical or other free discussion. This symposium managed to be all of these, allowing for the fact that there weren't any Greeks there.

20 papers were presented by representatives from the semiconductor manufacturers, by industrial users and academics.

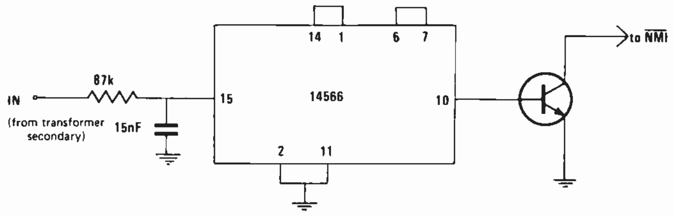
These were varied in content from the almost abstract to the completely down to earth. Two papers in particular are of interest to the amateur: 'Some Experience for Multipurpose Microprocessor System Development' by R.A. Smith of Essex University, and 'Hardware for Teaching Microprocessor Interfacing and Programming' by Dr. D.J. Quarmby of Loughborough University. Both these papers dealt with the development of low cost hardware, in particular avoiding the use of a Teletype.



One interesting fact that emerged from the symposium was the ability of large organisations undertaking development to generate their own development systems in both hardware and software. For instance, several large organisations anticipated that program development would be considerably speeded up by the use of a high level language and so they wrote a compiler for the language of their choice. At least one organisation specially adapted a minicomputer to check out their special purpose hardware.

British Rail engineers presented an amusing (almost Pythonesque) paper on 'Microprocessors in Safety Systems'. This dealt with a self-

```
LOOP DEC A        4A
     BEQ RETN     27  02
     BRA LOOP     20  FB
RETN RTS          39
```



Memory Location	Op-code	Logic Instruction		
001	11			
002	03	Time = 11-03-58		Data
003	58			
004	24	limit of Hrs. loop		
005	60	limit of Mins. loop		Data
006	60	limit of Secs. loop		
010	CE	LDX	03	
011	00			
012	03			
013	A6	LDA A	0,X	
014	00			
015	4C	INC A		
016	19	DAA		
017	A1	CMP A	3,X	
018	03			
019	2D	BLT	0B	
01A	0B			
01B	6F	CLR	0,X	
01C	00			
01D	09	DEX		
01E	8C	CPX	0000	
01F	00			
020	00			
021	27	BEQ	03	
022	03			
023	7E	JMP	0013	
024	00			
025	13			
026	A7	STA A	0,X	
027	00			
028	3B	RTI		

checking system based on 3 micros which checked each other and on finding a disagreement tried to blow each other up. Although this may sound rather odd, it is in fact an extremely sensible principle to follow in the design of fail-safe systems where a faulty processor has to be removed from the system before it can adversely influence performance.

Volumes of papers presented at the Symposium are available from SERT at *8–10 Charing Cross Road, London WC2H OHP.* for £7.50 inc. postage.

8080 RESIDENT COMPILER

Intel have just announced a major new software system that enables PL/M programs to be compiled on the 8080 itself. The new resident compiler and its supporting software automatically link program modules together to form the user's overall program. PL/M is a high level language which was developed by Intel from the well-known IBM language PL/1 about 3 years ago. Until now,programs written in PL/M had to be compiled into 8080 machine code using a main frame computer which usually meant that the user employed the services of a time-sharing bureau for this purpose. Running this compiler on the Intellec MDS800 development system will enable the high cost of time-sharing to be avoided.

The linkage facility is provided by a new disk operating system called ISIS2 which generates linkable and relocatable object code modules from a new macro assembler contained in the package, thus enabling several independent software designers towork on the same overall program without conflict.

The resident PL/M compiler provides other features which have not been available hitherto. It allows the programmer to define data structures and also gives him access to absolute addresses. The user can request the compiler to generate re-entrant code for any procedure, and it will also produce a cross reference list on request or optionally print an 'inner list' of generated assembly language after each PL/M statement.

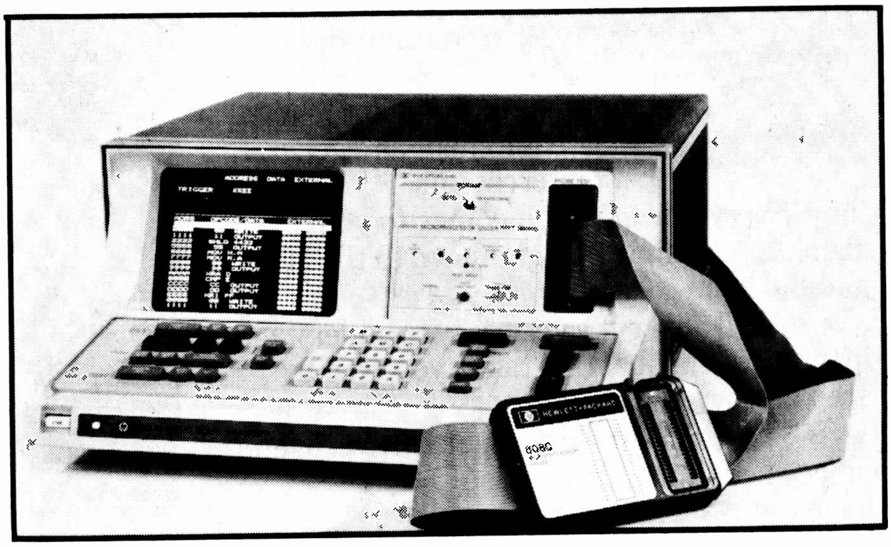
Also new from Intel is a system controller chip for the 8080A micro which is particularly suited for use in systems containing dynamic RAMs. The 8238 is identical in pin-out and function to the 8228 system controller except that the that the timing of the 'Memory Write' (MEMW) and 'Input/ Output Write' (IOW) outputs has been advanced so that they become available two clock pulses earlier than with the 8228. This means that memory and I/O circuitry have longer to respond and system timing margins are improved.

IM6100 ON OFFER

Rapid Recall are offering the IM6100 microprocessor and support chips in a set for only £42.70 + VAT. The set comprises one IM6100 CMOS processor, one 6312 1k x 12 ROM containing a system monitor, three 6561 256 x 4 CMOS RAMs, one 6101 CMOS parallel interface element and one 6402 CMOS UART for serial interface. The IM6100 (as we never tire of saying!) is software compatible with DEC's PDP-8/E minicomputer. In addition, being CMOS theMPU consumes very little power and can be halted without loss of register contents.

If you don't feel like doing it the hard way, Rapid Recall would no doubt be happy to sell you an Intercept Junior evaluation system. This comprises a complete IM6100 microcomputer with 256 12-bit words of RAM and a socket for ROM evaluation, a data/instruction entry keyboard, an eight-digit octal output display, a microinterpreter, 3 expansion card connectors and a mounting arrangement for the four torch batteries which power the unit. At the present moment three expansion modules are available: a 1k x 12 bit non-volatile RAM card, a ROM/PROM card, and a serial communications card for VDU or TTY.

Rapid Recall Ltd., 9 Betterton Street, Drury Lane, London WC2H 9BS.



HP LOGIC ANALYZER

New keyboard-controlled logic state analyzers from Hewlett-Packard are dedicated to the design and trouble-shooting of systems using 8080 or 6800 microprocessors. An HP-1611A is specialised to one type of system or the other by choice of an 8080 or 6800 'personality module.' Others will be added.

When a 1611A Logic State Analyzer is connected to the circuitry (at the microprocessor's socket, and simultaneously to as many as eight other points if desired), system activity can be displayed on the instrument's CRT directly in the alphanumeric mnemonics of the particular microprocessor's own instruction set. With powerful qualifiers, the 1611A can frame a real-time window around virtually any event, or set of related events - any desired sequence of system operations. The 1611A also accurately measures true execution timing, or counts selected events, as specified by the keyboard. At a point defined by the user, the instrument can halt microprocessor operations; then, if desired, the 1611A can control the transactions that follow, in single or multiple keyed steps.

On the 1611A CRT screen appears alphanumeric information about the keyboard settings, as well as the data captured. As directed by the keyboard, the instrument traces and identifies memory transaction after memory transaction in the system's sequence of operations.

It stores 64 of these, displaying the top 16 until the scroll keys are used. (The number of instructions identified is usually less than the number of memory transactions, since an instruction often calls for more than one memory fetch.) A switch selects octal or hexadecimal data listing. Op Code readout may be numeric, or alphanumeric mnemonics may be spelled out, as in the microprocessor manufacturer's programming manual.

The 1611A is, itself, a microprocessor-controlled instrument operated from a keyboard (The micro used is the 8080). U.K. price of the HP-1611A, Option 080 (for 8080 systems) or Option 068 (for 6800 systems) is £3,650. Extra personality modules are £730.*Hewlett-Packard Ltd., King Street Lane, Winnersh, Wokingham RG11 5AR.*

—ETI project 602

TOUCH ORGAN

With all the electronics on one pc board this organ is easy to build yet has features like touch keyboard, variable tremolo, two voices and a full two-octave range.

AN ELECTRONIC ORGAN IS A fascinating instrument which these days seems to be rapidly assuming the position in the home once occupied by the piano. Modern organs are, however, very expensive which puts them beyond the reach of most people. Lower down the scale in cost and performance are chord organs which although still polyphonic are fairly limited reed type instruments operated by a small blower. The name chord organ comes from the fact that the bass accompaniment is by means of buttons which generate the appropriate chord.

The cheapest possible organ is the so called monophonic organ (only one note can be played at a time) which is usually little more than pocket sized and is played with a stylus.

The first obvious improvement required is to devise a better keyboard arrangement as the stylus operation can only be described as somewhat of a nuisance. However the £40 cost of a full keyboard cannot be justified. As can be seen from the photographs the new keyboard is still of the touch type but has now been designed so that the organ is played simply by touching the appropriate key, as in a full scale instrument. Tremolo is also provided and this too is switched on and off by means of touch switches and a control is provided to adjust tremolo depth.

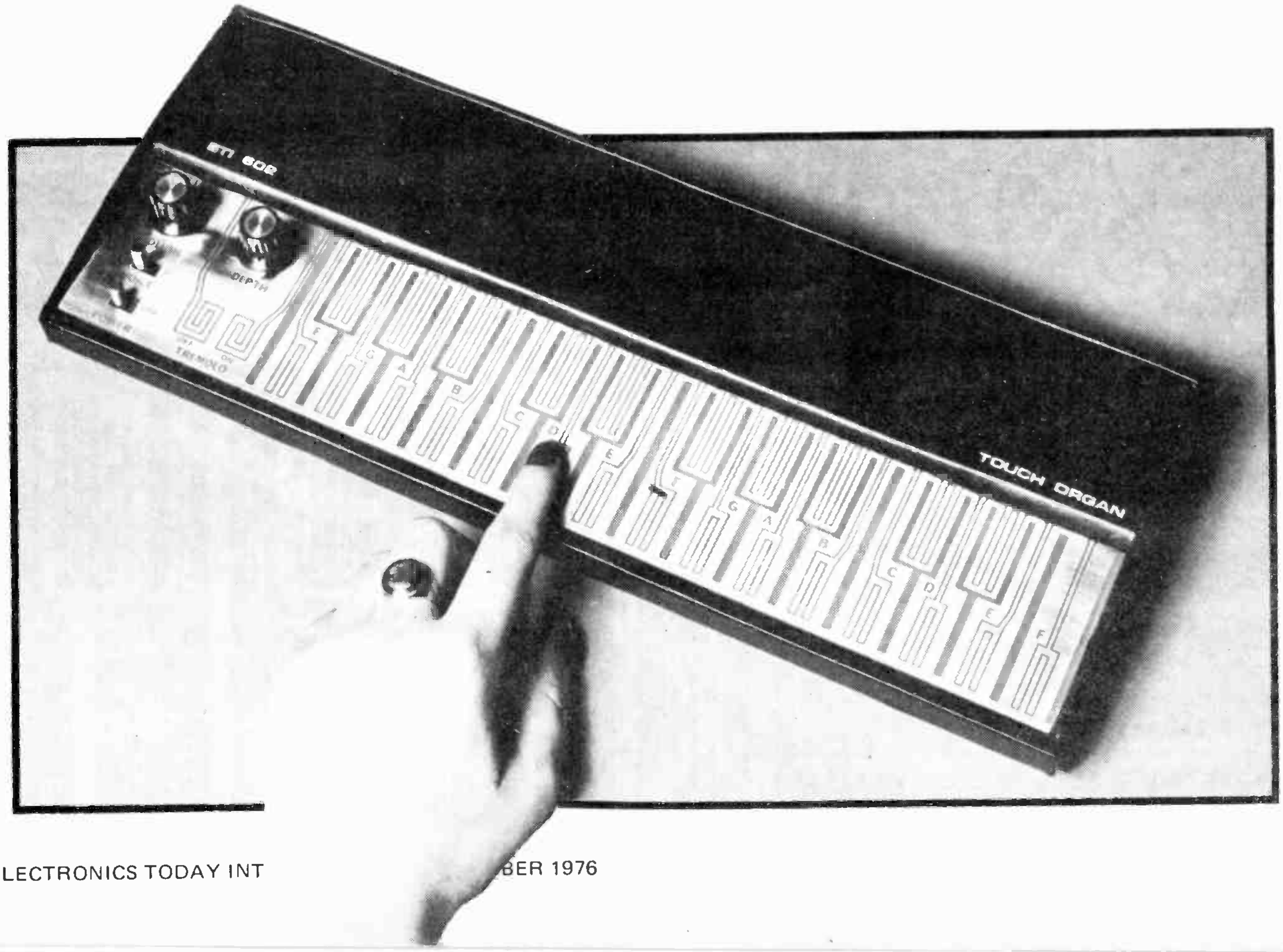
The next improvement is in the accuracy of the tuning, which in the previous instrument varied over the keyboard due to the one-only resistor used to increment between each note. In our new version tuning over the keyboard is much improved by using two resistors, where necessary in series or parallel, to obtain the nearest possible to the correct value of resistance. Finally the instrument is provided with two voices or stops which add greatly to the variety of the music which can be produced.

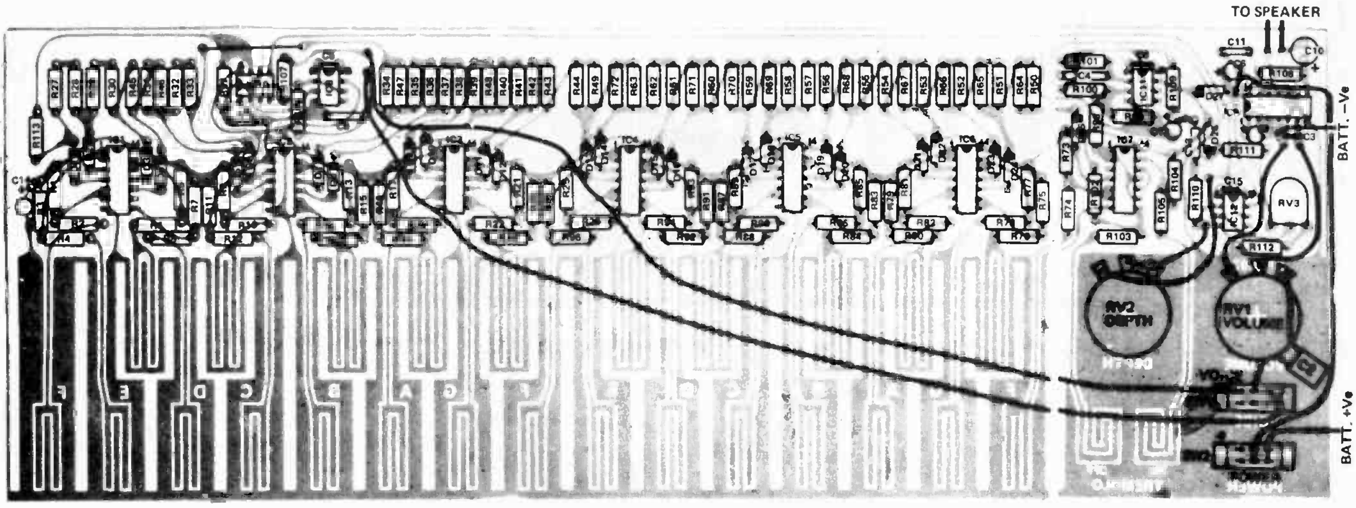
This little organ is relatively inexpensive to build, should provide a great deal of enjoyment and is musically and electronically educational.

DESIGN FEATURES

As mentioned earlier the major feature is the implementation of the keyboard by means of a finger touch system rather than the "probe" type.

This means that some electronics must be associated with each key to detect that it has been touched. Touch control is usually effected by the capacitive, resistive or 50 Hz injection methods. Whilst the capa-





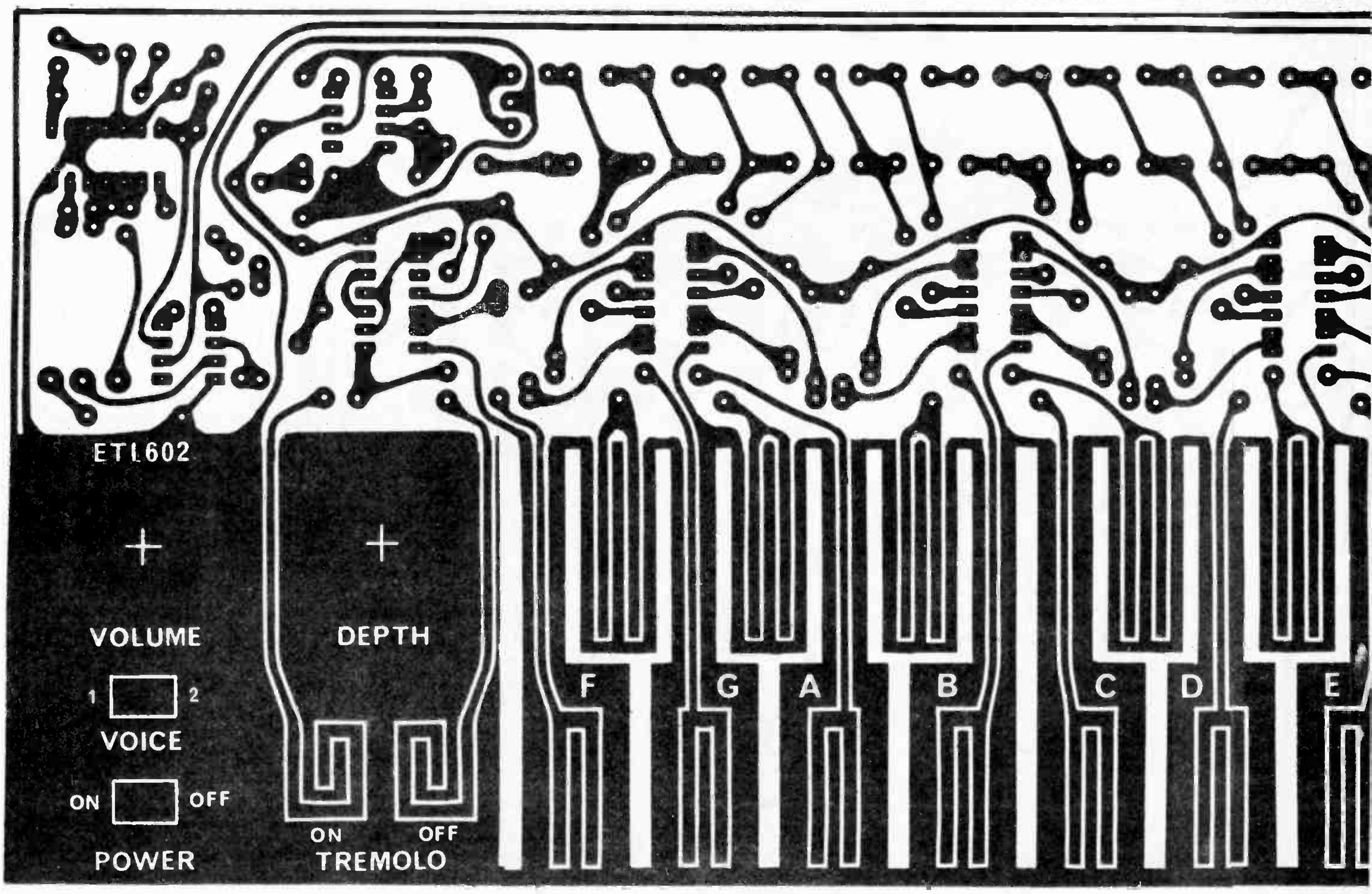
Parts List

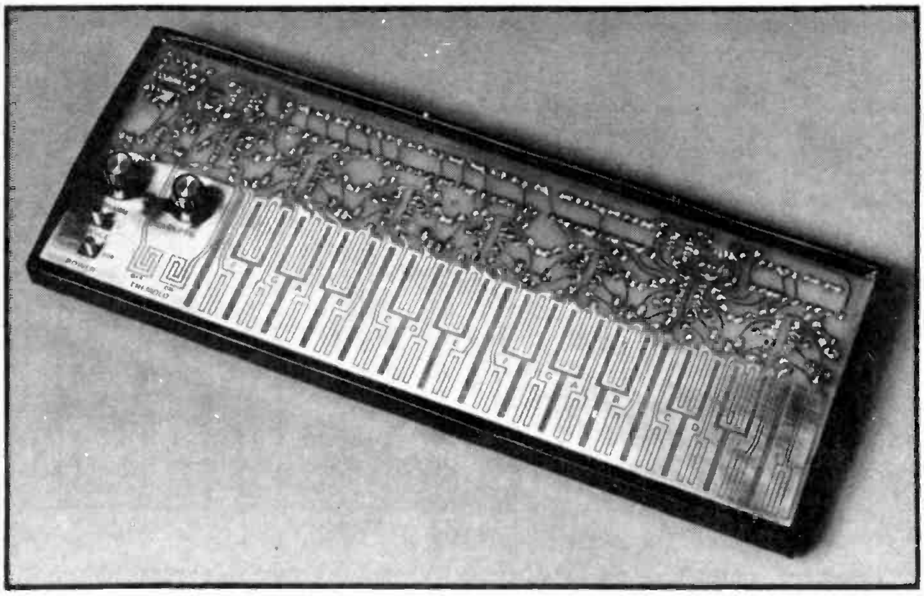
Resistors all ½W 5%

R1,3,5,7	4M7
R9,11,13	4M7
R15,17,19	4M7
R21,23,25	4M7
R2,4,6,8	100k
R10,12,14	100k
R16,18,20	100k
R22,24,26	100k
R27	6k8
R28	330
R29	6k8
R30	390
R31	10k
R32	8k2
R33	1k2
R34,35	10k
R36	270
R37	10k
R38	1k
R39	12k
R40	10k
R41	2k2
R42	8k2
R43	4k7
R44	15k
R45	8k2
R46	68k
R47	220k
R48	330k
R49	120k
R50	180k
R51	560k
R52	270k
R53	180k
R54	22k
R55	390k
R56	4k7
R57	15k
R58	120k
R59	470k
R60	150k
R61	3k3
R62	12k
R63	220k
R64	33k
R65,66,67	27k
R68,69	22k
R70,71	18k
R72	15k
R73,75,77	4M7
R79,81,83	4M7
R85,87,89	4M7
R91,93,95	4M7
R74,76,78	100k
R80,82,84	100k
R86,88,90	100k
R92,94,96	100k
R97	6k8
R98,99,100	100k
R101	820k
R102	4M7
R103	100k
R104	4M7
R105	100k
R106	5k6
R107	820k
R108	2.7Ω
R109	22k
R110	330k
R111	10k
R112	15k

Potentiometers

RV1	47k log
RV2	47k log
RV3	2k trim



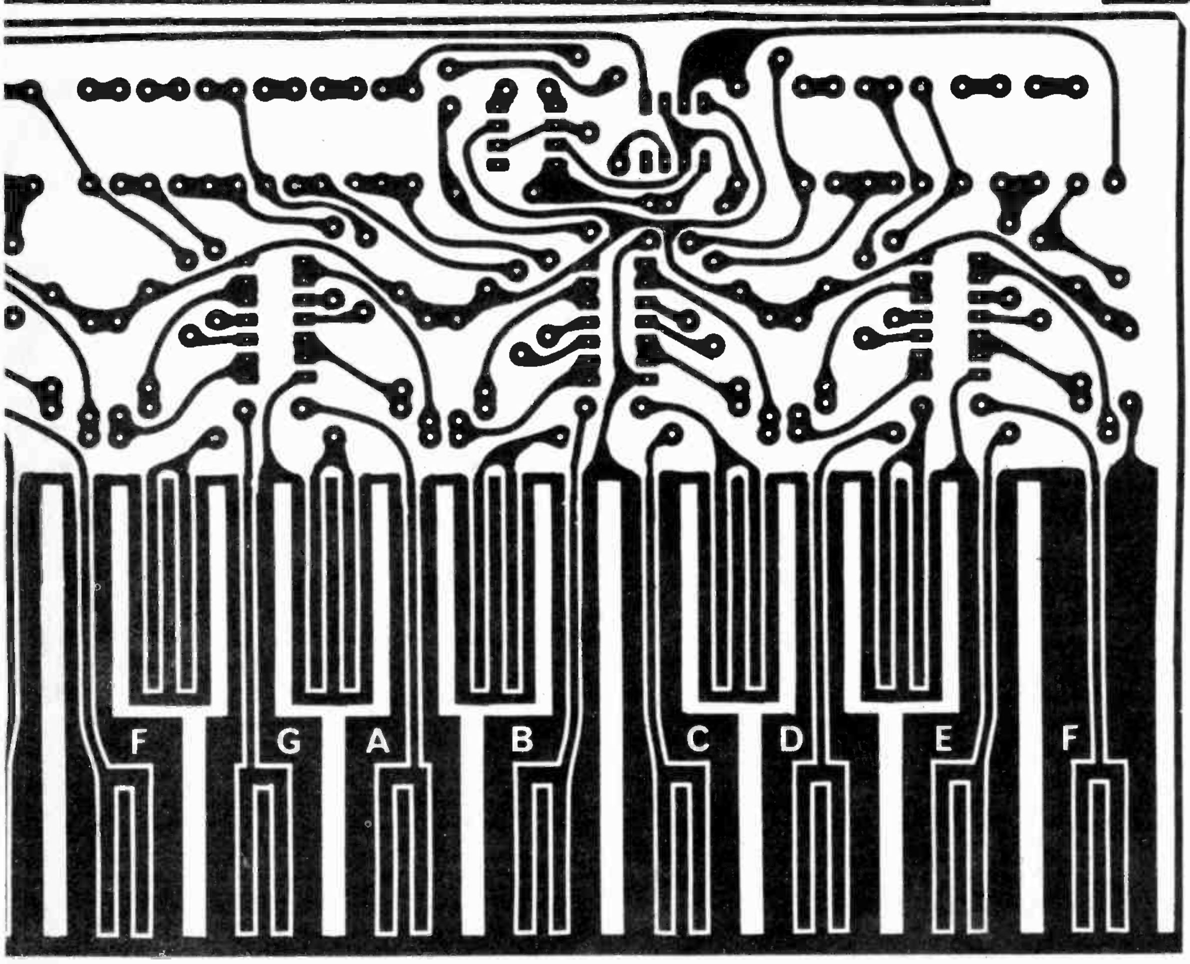


	Capacitors	
	C1	22n polyester
	C2	100n polyester
	C3	330p ceramic
	C4	100n polyester
	C5	33p ceramic
	C6,7	4μ7 25V electrolytic
	C8	33p ceramic
	C9	100n polyester
	C10	100μ 16V electrolytic
	C11	100n polyester
	C12	4μ7 25V electrolytic
rotary	C13	100n polyester
rotary	C14	100μ 16V electrolytic
mer	C15	33p ceramic

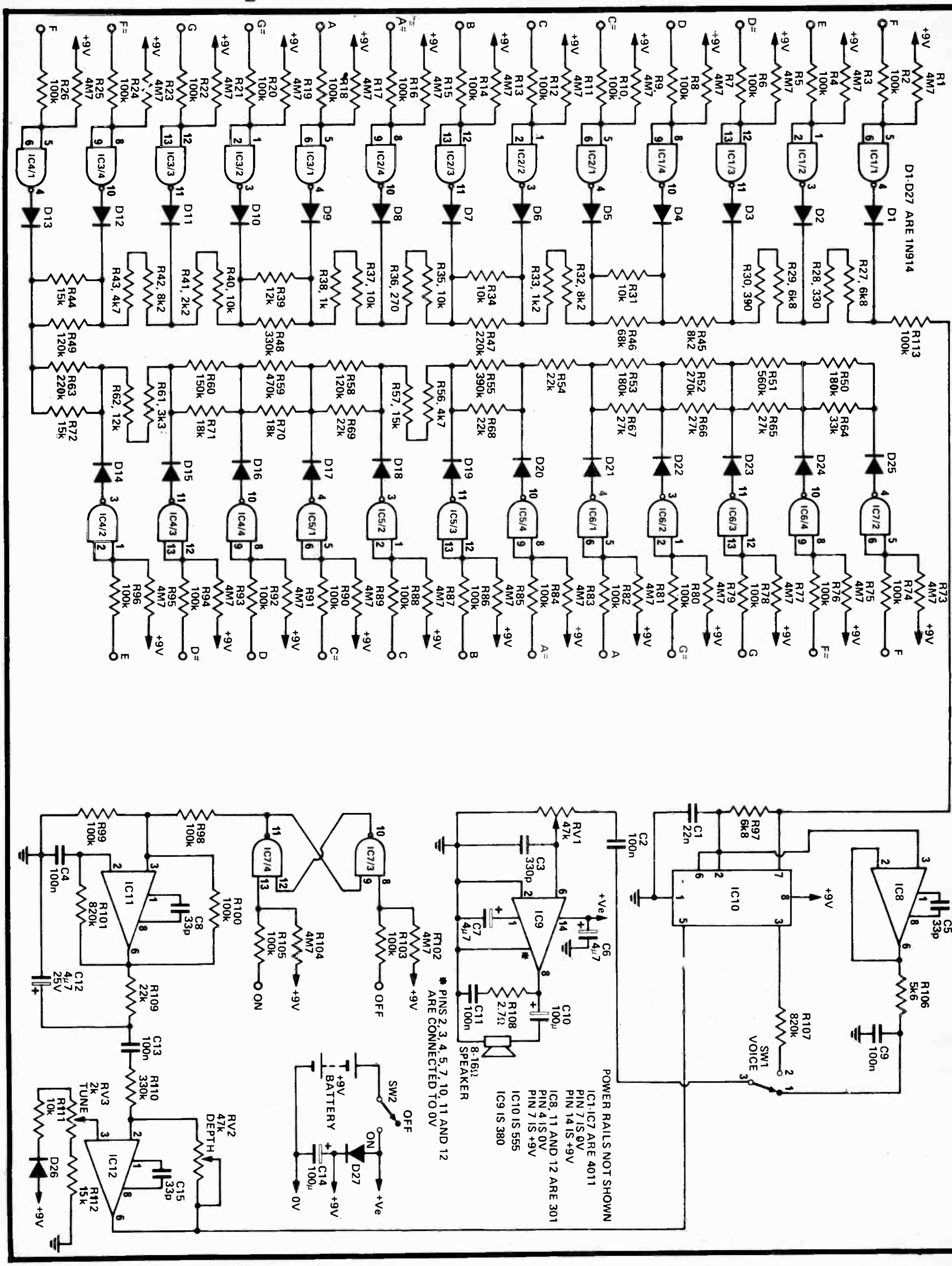
Semiconductors	
D1-D27	1N914 or similar
IC1 — IC7	4011 (CMOS)
IC 8,11,12*	LM301 or 741
IC9	LM380,SL60745
IC10	NE555
*if 741s are used delete C5,8,15	
Miscellaneous	
SW1,2	single pole, 2 position slide switches
PC board ETI 602	
Two knobs	
6 way battery holder	
Small 8 or 16 ohm speaker	
battery clip	
case to suit	

Frequency of Notes used

F	698.5
E	659.3
D#	622.3
D	587.3
C#	554.4
C	523.3
B	493.9
A#	466.2
A	440.0
G#	415.3
G	392.0
F#	370.0
F	349.2
E	329.6
D#	311.1
D	293.7
C#	277.2
C	261.6
B	246.9
A#	233.1
A	220.0
G#	207.7
G	196.0
F#	185.0
F	174.6



Printed-circuit board layout for the monophonic organ. Full size 345x120 mm.



Circuit diagram of the monophonic organ

How it works

Operation of the organ will be described by considering separately the five sections of which it is composed. These are:

(a) Keyboard
(b) Oscillator
(c) Filter
(d) Output amplifier
(e) Tremolo circuit

(a) Keyboard. Unlike the previous organ the keyboard is operated by the contact resistance of the finger and not by a probe. Each key has a CMOS gate associated with it where both inputs to the gate are connected together and to the positive supply via a 4.7 megohm resistor. When the key is touched the inputs of the gate are pulled low (0V) via the 100 k resistor causing the output of the gate to go high. This pulls the corresponding point in the resistor chain high via the diode. Thus by selecting and touching different keys we connect various amounts of resistance between pins 2 and 6 of the 555 oscillator and the positive supply, thus enabling it and varying the frequency determining time constant circuit.

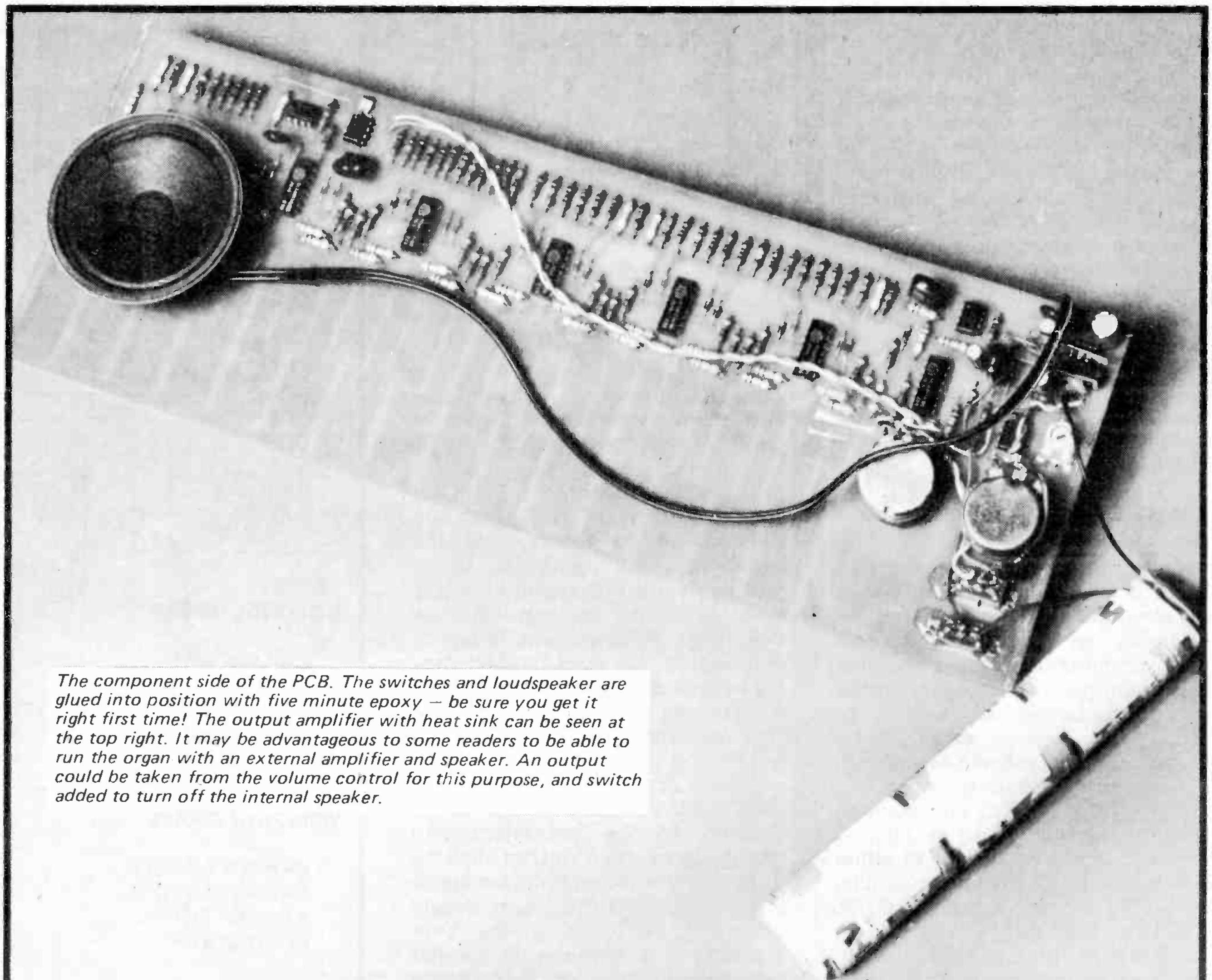
(b) The Oscillator. The oscillator is based on a 555 timer IC. The capacitor C1 is charged up via a section of the resistor chain (as by the keyboard) together with the resistor R113. When the voltage at pins 2 and 6 reaches that set at pin 5, the capacitor is discharged rapidly via R97 and an internal transistor connected to pin 7 of the 555. When the voltage across C1 has dropped to half that set at pin 5, the internal transistor turns off and the capacitor is allowed to charge up again — thus repeating the cycle and generating a sawtooth waveform across the capacitor. This waveform has a high harmonic content but is generated at a high-impedance point. A unity gain buffer is therefore used (IC8) to prevent this output from being loaded by the following circuitry. A second output of a narrow pulse waveform is available at pin 3 of the 555 and this is used to generate a second voice for the instrument.

(c) Filter. A number of different filters were tried but from a cost point of view it was difficult to justify anything more than a simple RC filter on the sawtooth which gives quite a pleasant flute-like effect. As the narrow pulse train sounds somewhat similar to strings it is merely attenuated to match the level of the filtered sawtooth.

(d) The Output Amplifier. The loudspeaker is driven by an LM380. Volume control is provided by means of potentiometers RV1 and the required voice is selected by means of switch SW1. The LM380 should be fitted with heatsink fins as detailed in the construction.

(e) The Tremolo Circuit. Tremolo is produced by means of a low frequency oscillator running at approximately 8 Hz (IC11). The oscillator can be turned on and off by means of the flip flop formed by gates IC7/3 and IC7/4. This flip flop is set to the 'on' or 'off' mode by means of touch switches which operate in exactly the same manner as the main keyboard. To increase tremolo frequency decrease R101 and vice versa.

The output from the tremolo oscillator is filtered by C12 and R109 to give a smoother waveform and the resultant waveform buffered by IC12. The gain of IC12 is adjustable by means of RV2 and this control therefore adjusts the depth of the tremolo modulation. The potentiometer RV3 is a trim potentiometer which effectively sets the output from IC12 to pin 5 of the 555 and thus the frequency of the organ. If it is required to shift the keyboard up or down an octave or so this may be done by changing the value of C1 by a factor of two. If the keyboard tuning is found to be skewed (when tuned correctly at the centre one end of the keyboard is low whilst the other is high) this may be cured by changing the value of R97. If it is sharp at the low end decrease R97 while if flat at the low end increase R97.



The component side of the PCB. The switches and loudspeaker are glued into position with five minute epoxy — be sure you get it right first time! The output amplifier with heat sink can be seen at the top right. It may be advantageous to some readers to be able to run the organ with an external amplifier and speaker. An output could be taken from the volume control for this purpose, and switch added to turn off the internal speaker.

citive method is the best of these it is also the most expensive and for this reason is not used. The 50 Hz injection method is also complex and thus the resistive method was considered to be the only practical way from a cost point of view.

As the keyboard is now played by the finger it also needs to be larger than usual although still not quite as large as a full-size keyboard.

In the original concept an OM 802 was used as the tone oscillator. This was replaced by a 555 timer IC as this is cheaper and easier to use. The 555 has two outputs which can be used, a sawtooth wave and a narrow pulse. Both of these outputs are used in our design to provide different voices for the instrument. The sawtooth is filtered by means of a simple RC filter to remove some of the harshness due to the harmonic structure and the resultant voice has a rich flute-like sound. The pulse output is matched in level to the sawtooth by means of a resistive attenuator but is otherwise unfiltered. This voice has a string-like sound.

Filtering has been kept very simple, again from a cost point of view. If the constructor desires he may experiment with different filters in order to achieve different sounds. With conventional organs the stop-filtering is done for every octave of the organ to prevent undue tone and level changes at different frequencies. With the two octave span of this organ some change in tone and level must be accepted over the range of the keyboard when using simple filters.

As attenuating filters are used in the organ plenty of gain is required in the audio stage and for this reason an LM380 is used in the audio output stage to drive the loudspeaker.

CONSTRUCTION

The keyboard pattern is etched directly onto the printed-circuit board which also carries the rest of the electronics. As the copper of the keyboard would rapidly tarnish when continuously being touched with the finger it is necessary for the board to be either tinned or protected with some other plating process that will prevent tarnishing.

Commence construction by mounting the LM380 into position and then fit small heatsink fins, as shown in the photograph, to either side of the IC. Solder them to pins 3, 4, 5 on one side and pins 10, 11 and 12 on the other. This should be done first as there is little room in this area of the board once other components are in position. Fit the two wire links and assemble the low-height components to the board as shown on the overlay.

Mount the remaining ICs last of all and take particular care not to handle the CMOS ICs excessively before insertion. Check the polarities of polarised components such as ICs, capacitors and diodes before soldering them into position.

To avoid having screws showing on the keyboard we glued the two switches into position with five-minute epoxy. Use a piece of printed-circuit board or metal behind each mounting hole to obtain extra glueing surface and extra strength. Mount the potentiometers and wire the complete board as detailed in the overlay diagram.

The complete unit should now be tested to ensure that all notes and functions are operating correctly before mounting into a suitable cabinet.

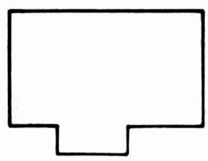


Fig 3
Details of heat sink shown full size, two required material tinplate or thin copper.

PLAYING THE ORGAN

Although the new organ is played with the fingers as with a full instrument there are a few small playing differences which should be kept in mind.

Firstly the instrument is monophonic. That is, if two notes are touched simultaneously only the higher note will sound. Secondly, the fingers must be kept dry, as any moisture across the key will hold that note on when the finger is removed. If this does happen they the keyboard should be wiped with a clean rag. In stubborn cases a little methylated spirits on the rag will help.

Finally, it should be remembered that unlike a piano there is no "touch" to the instrument and hitting the key hard will not alter the sound. In this respect it is similar to a real organ and the player should get used to touching the keys smoothly and firmly with the flat part of the finger — not the extreme tip. ●

TOUCH TUNES

WALTZING MATILDA

VERSE:
EEEDDCDECABC
GCEGGGGGGG
CDEEEDDCDECABC
GCEGFEDDDC
CHORUS:
GGGGE
CCCBA
GGGAGGGFED
CDEEEDDCDECABC
GCEGFEDDDC

HYMM TO JOY (BEETHOVEN'S NINTH)

EFGGFEDCCDEEDD
EFGGFEDCCDEDCC
DECDEFECDEFEDCDG
EFGGFEDCCDEDCC

'FRERE JACQUES'

CDEC
CDEC
EFG
EFG
GAGFEC
GAGFEC
CGC
CGC

GOD SAVE THE QUEEN

CCDBCD
EEFEDC
DCBC
CDEF
GGGGFE
FFFFED
EFEDCEFG
AFEDC

COLONEL BOGEY

CAAA#CAAF
CAAA#ACCA#
A#GGAA#CA
ABAGCABGDC

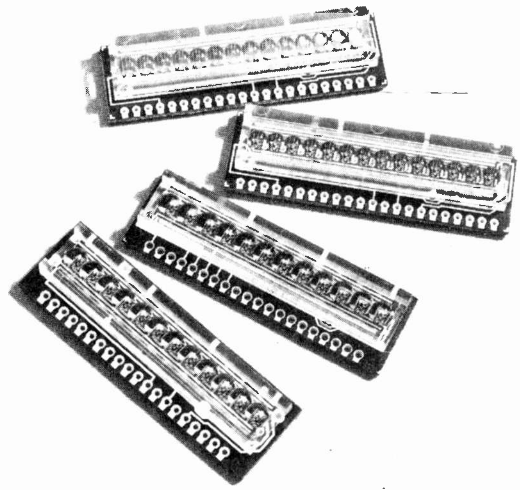
AMAZING GRACE

CFFAGFAGFDC
CFFAGFAGCC
ACCAGFAGFDC
CFFAGFAGF

ETI DATA SHEET

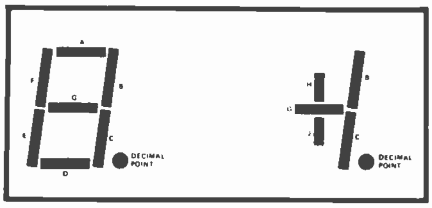
ABOUT THE ONLY feature common to the ranges of displays described in this Data Sheet is the way in which the various manufacturers identify the segments.

The standard method for doing this is shown below. We have deliberately excluded the 'overflow' type of L.E.D. display, in order to provide a better selection of normal types in the space available to us.



Calculated omission

There is another type of L.E.D. display now becoming more popular in general usage. This is the calculator display, of a type personified by the H/P device shown here. We hope to deal with these more fully at a later date. Generally these types use very low power, being readable at about 100µA and with a varying number of digits, usually eight or ten.



Inclusion

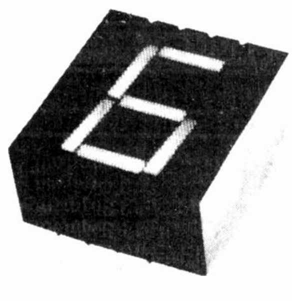
Now that we've told you what isn't in here, perhaps we should explain what we have covered. Each display is described in a standard manner, using the same form of presentation for the relevant technical data. This is to facilitate easy comparison and subsequent selection.

Prices vary enormously from supplier to supplier, so we have not tried to give a definite price, just an indication. Don't be mis-LED, some market segments might well display lower prices!

FND 500/507 — FAIRCHILD

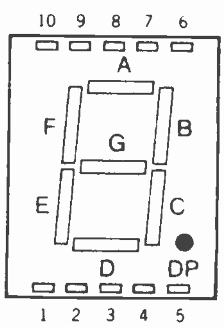
The FND 500 is a common cathode display with an integral red filter. The decimal point is on the right-hand side of the device, which measures 15.3mm by 16.5mm high. This device is a pin for pin replacement to the Texas Instrument TIL322 display.

The FND 507 is a common anode version of the FND 500, and as such can be used to replace a TIL 321.



ELECTRICAL CHARACTERISTICS	
DIGIT SIZE	0.5ins
COLOUR	red
AVERAGE FWD CURRENT/SEGMENT	25mA
FORWARD VOLTAGE	1.7V
MIN. REV. BREAKDOWN VOLTAGE	3.0V
MAX. REV. CURRENT	100uA
LIGHT INTENSITY PER SEGMENT	600ucd
MAX. POWER DISSAPATION	400mW

TYPICAL PRICE £1.10



PIN OUT - FND 500/507

1 Segment E	6 Segment B
2 Segment D	7 Segment A
3 Common	8 Common
4 Segment C	9 Segment F
5 Dec. point	10 Segment G

FND 500-----common cathode
FND 507-----common anode

LED DISPLAYS

DL 704/707 — MONSANTO

TYPICAL PRICE £1.00

ELECTRICAL CHARACTERISTICS	
DIGIT SIZE	0.3ins
COLOUR	YELLOW/RED/ORANGE
AVERAGE FWD CURRENT/SEGMENT	25mA
FORWARD VOLTAGE	2.5/1.6/1.6V
MIN. REV. BREAKDOWN VOLTAGE	3.0V
MAX. REV. CURRENT	100uA
LIGHT INTENSITY PER SEGMENT	320ucd
MAX. POWER DISSAPATION	500mW

A very common and widely available display, the 707 is the common anode version, with the 707R having a right-hand decimal point, as opposed to the standard left decimal on the 704 and 707. The 704 is thus a common cathode device.

PIN OUT- DL707/707R

1 Segment A	8 Segment D
2 Segment F	9 Anode
3 Anode	10 Segment C
4 NC	11 Segment G
5 NC	12 NC
6 Dec. point	13 Segment B
7 Segment E	14 Anode

PIN OUT-DL 704

1 Segment F	8 Segment C
2 Segment G	9 Dec. point
3 NC	10 NC
4 Cathode	11 NC
5 NC	12 Cathode
6 Segment E	13 Segment B
7 Segment D	14 Segment A

DL 747/750 — MONSANTO

ELECTRICAL CHARACTERISTICS	
DIGIT SIZE	0.6ins
COLOUR	RED
AVERAGE FWD CURRENT/SEGMENT	25mA
FORWARD VOLTAGE	2.4V
MIN. REV. BREAKDOWN VOLTAGE	6.0V
MAX. REV. CURRENT	100uA
LIGHT INTENSITY PER SEGMENT	600ucd
MAX. POWER DISSAPATION	960mW

A 'Jumbo version' of the 707 and 704 devices. Widely available. Identify the common anode 747 by the missing pins — 1, 9, 10 and 18.

The 750 is in full possession of its pins, and is common cathode. Decimal point is right-handed.

TYPICAL PRICE £1.40

PIN OUTS- DL747/750

1 NC	10 NC
2 Segment A	11 Segment D
3 Segment F	12 Common
4 Common	13 Segment C
5 Segment E	14 Segment G
6 Common	15 Segment B
7 Dec. point	16 NC
8 NC	17 Common
9 NC	18 NC

DL747-----common anode
DL750-----common cathode
Pins 1,9,10,18, ommitted from747

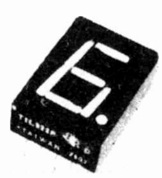
TIL RANGE — TEXAS

PIN OUTS -

TIL321/323/325

As FND 507. Direct replacement.

PIN OUTS- TIL322/324/326
As FND 500. Direct replacement.



A uniform range of large displays, with red, green or amber encapsulation. No filters are needed, and a wide viewing angle is possible. Within defined categorys, the devices are matched for luminous intensity. These can also act as direct replacements for the Fairchild FND500/507 duet.

TYPICAL PRICE £1.30

ELECTRICAL CHARACTERISTICS	321/322
DIGIT SIZE	0.5ins
COLOUR	RED
AVERAGE FWD CURRENT/SEGMENT	20mA
FORWARD VOLTAGE	1.7V
MIN. REV. BREAKDOWN VOLTAGE	3V
MAX. REV. CURRENT	100uA
LIGHT INTENSITY PER SEGMENT	600ucd
MAX. POWER DISSAPATION	300mW

ELECTRICAL CHARACTERISTICS	323/324
DIGIT SIZE	0.5ins
COLOUR	GREEN
AVERAGE FWD CURRENT/SEGMENT	20mA
FORWARD VOLTAGE	2.5V
MIN. REV. BREAKDOWN VOLTAGE	3V
MAX. REV. CURRENT	100uA
LIGHT INTENSITY PER SEGMENT	320ucd
MAX. POWER DISSAPATION	600mW

ELECTRICAL CHARACTERISTICS	325/26
DIGIT SIZE	0.5ins
COLOUR	AMBER
AVERAGE FWD CURRENT/SEGMENT	20mA
FORWARD VOLTAGE	2.5V
MIN. REV. BREAKDOWN VOLTAGE	3V
MAX. REV. CURRENT	100uA
LIGHT INTENSITY PER SEGMENT	340ucd
MAX. POWER DISSAPATION	400mW

XAN 352/4 — XCITON

ELECTRICAL CHARACTERISTICS	
DIGIT SIZE	0.3ins
COLOUR	GREEN
AVERAGE FWD CURRENT/SEGMENT	25mA
FORWARD VOLTAGE	2.0V
MIN. REV. BREAKDOWN VOLTAGE	5V
MAX. REV. CURRENT	100uA
LIGHT INTENSITY PER SEGMENT	450ucd
MAX. POWER DISSAPATION	400mW

PIN OUT—XAN 352

1 Segment A	8 Segment D
2 Segment F	9 NC
3 Anode	10 Segment C
4 Omitted	11 Segment G
5 Omitted	12 Omitted
6 Dec. point	13 Segment B
7 Segment E	14 Anode

PIN OUT— XAN 354

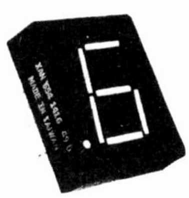
1 Segment F	8 Segment C
2 Segment G	9 Dec point
3 Omitted	10 Omitted
4 Cathode	11 Omitted
5 Omitted	12 Cathode
6 Segment E	13 Segment B
7 Segment D	14 Segment A

These two come from what is the largest range of displays available. Xciton make big play of having all devices brighter than the competition, and a list of equivalents from their range for most of the others. These two are common cathode (XAN 354) and common anode (352) 0.3" numerics, using high efficiency GaAsP.

TYPICAL PRICE £1.20

XAN 650 SERIES — XCITON

ELECTRICAL CHARACTERISTICS	82/84
DIGIT SIZE	0.6ins
COLOUR	YELLOW
AVERAGE FWD CURRENT/SEGMENT	25mA
FORWARD VOLTAGE	2.2V
MIN. REV. BREAKDOWN VOLTAGE	3.0V
MAX. REV. CURRENT	100uA
LIGHT INTENSITY PER SEGMENT	700ucd
MAX. POWER DISSAPATION	400mW



TYPICAL PRICE £1.75

PIN OUT XAN 652/654/682/684

1 Segment A	8 Segment D
2 Segment F	9 Common
3 Common	10 Segment C
4 Segment E	11 Segment G
5 Omitted	12 Segment B
6 Dec. point	13 Omitted
7 Omitted	14 Common

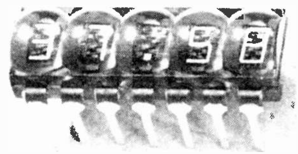
XAN 684/654---common cathode
XAN 682/652---common anode

ELECTRICAL CHARACTERISTICS	52/54
DIGIT SIZE	0.6ins
COLOUR	GREEN
AVERAGE FWD CURRENT/SEGMENT	25mA
FORWARD VOLTAGE	2.0V
MIN. REV. BREAKDOWN VOLTAGE	3V
MAX. REV. CURRENT	100uA
LIGHT INTENSITY PER SEGMENT	2000ucd
MAX. POWER DISSAPATION	350mW

7400 SERIES — HEWLETT-PACKARD

ELECTRICAL CHARACTERISTICS	
DIGIT SIZE	(magnifier) 0.11ins
COLOUR	RED
AVERAGE FWD CURRENT/SEGMENT	5mA
FORWARD VOLTAGE	1.6V
MIN. REV. BREAKDOWN VOLTAGE	5V
MAX. REV. CURRENT	100uA
LIGHT INTENSITY PER SEGMENT	20ucd
MAX. POWER DISSAPATION digit	80mW

Digits per Cluster	Center Decimal Point	Right Decimal Point
3 (right)	5082-7402	5082-7412
3 (left)	5082-7403	5082-7413
4	5082-7404	5082-7414
5	5082-7405	5082-7415



PIN OUT HP7402/7412	
1 NC	8 Segment D
2 Segment E	9 Segment F
3 Segment C	10 Cathode
4 Cathode	11 Segment B
5 Dec. point	12 Segment A
6 Cathode	13 Omitted
7 Segment G	14 Omitted

PIN OUT HP7404/7414	
1 Cathode	8 Segment D
2 Segment E	9 Segment F
3 Segment C	10 Cathode
4 Cathode	11 Segment B
5 Dec. point	12 Segment A
6 Cathode	13 Omitted
7 Segment G	14 Omitted

PIN OUT HP 7403/7413	
1 Cathode	8 Segment D
2 Segment E	9 Segment F
3 Segment C	10 Cathode
4 Cathode	11 Segment B
5 Dec. point	12 Segment A
6 NC	13 Omitted
7 Segment G	14 Omitted

PIN OUT HP7405/7415	
1 Cathode	8 Segment 9
2 Segment E	9 Cathode
3 Segment C	10 Segment F
4 Cathode	11 NC
5 Dec. point	12 Segment B
6 Segment D	13 Cathode
7 Cathode	14 Segment A

The 7400 series are 2.79mm GaSP numeric indicators, packaged in end stackable DIL casings. They are readable at 500μA per segment, and constructed for strobed operation in such a way that less lead connections are needed.

A lens magnifier is fitted, with a good viewing angle.

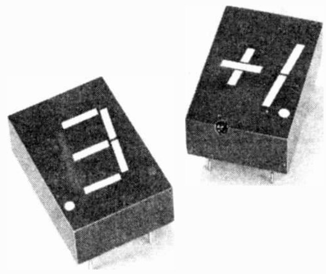
7750 SERIES — HEWLETT-PACKARD

ELECTRICAL CHARACTERISTICS	
DIGIT SIZE	0.43ins
COLOUR	RED
AVERAGE FWD CURRENT/SEGMENT	20mA
FORWARD VOLTAGE	1.6V
MIN. REV. BREAKDOWN VOLTAGE	6V
MAX. REV. CURRENT	10uA
LIGHT INTENSITY PER SEGMENT	400ucd
MAX. POWER DISSAPATION	300mW

PIN OUT HP7750	
1 Segment A	8 Segment D
2 Segment F	9 NC
3 Anode	10 Segment C
4 Omitted	11 Segment G
5 Omitted	12 Omitted
6 Dec. point	13 Segment B
7 Segment E	14 Anode

PIN OUT HP7751	
1 Segment A	8 Segment D
2 Segment F	9 Dec. point
3 Anode	10 Segment C
4 Omitted	11 Segment G
5 Omitted	12 Omitted
6 NC	13 Segment B
7 Segment E	14 Anode

PIN OUT HP7760	
1 Segment A	8 Segment D
2 Segment F	9 Dec. point
3 Cathode	10 Segment C
4 Omitted	11 Segment G
5 Omitted	12 Omitted
6 NC	13 Segment B
7 Segment E	14 Cathode



A fairly standard range of slightly larger than standard displays. The material is GaSP, and the devices use a standard 14 pin DIL package so that they can be plugged into standard sockets.

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2N456	1.40	2N3390	0.37	2N5295	0.40	AF186	0.50
2N456A	1.54	2N3391	0.29	2N5296	0.36	AF200	0.70
2N457A	1.70	2N3391A	0.34	2N5298	0.40	AF239	0.74
2N490	4.60	2N3392	0.14	2N5457	0.29	AF240	0.90
2N491	5.00	2N3393	0.15	2N5458	0.26	AF279	0.80
2N492	5.75	2N3394	0.15	2N5459	0.29	AF280	0.85
2N493	5.98	2N340 30		2N5492	0.42	AL102	1.50
2N696	0.25	2N3414	0.15	2N5494	0.45	AL103	1.50
2N697	0.16	2N3415	0.17	2N5496	0.50	BC107	0.14
2N698	0.82	2N3416	0.23	2N5777	0.45	BC108	0.12
2N699	0.55	2N3418	0.27	2N6027	0.45	BC109	0.15
2N706	0.12	2N3440	0.57	3N128	0.80	BC113	0.17
2N706A	0.12	2N3441	0.78	3N139	1.45	BC115	0.19
2N708	0.21	2N3442	1.20	3N140	1.00	BC116	0.19
2N709	0.50	2N3638	0.16	3N141	0.85	BC116A	0.20
2N711	0.55	2N3638A	0.16	3N200	2.60	BC117	0.22
2N718	0.22	2N3639	0.30	40361	0.45	BC118	0.16
2N718A	0.40	2N3641	0.20	40362	0.48	BC119	0.30
2N720	0.69	2N3702	0.17	40363	1.00	BC121	0.45
2N914	0.22	2N3703	0.15	40389	0.50	BC125	0.18
2N916	0.43	2N3704	0.15	40394	0.60	BC126	0.25
2N918	0.34	2N3705	0.15	40395	1.20	BC132	0.30
2N929	0.25	2N3706	0.14	40406	0.48	BC134	0.15
2N930	0.26	2N3707	0.18	40407	0.38	BC135	0.15
2N1302	0.37	2N3708	0.14	40408	0.50	BC136	0.19
2N1303	0.37	2N3709	0.15	40409	0.55	BC137	0.14
2N1304	0.40	2N3710	0.14	40410	0.55	BC140	0.80
2N1305	0.40	2N3711	0.15	40411	2.30	BC141	0.65
2N1306	0.45	2N3712	1.20	40594	0.75	BC142	0.30
2N1307	0.45	2N3713	2.30	40595	0.85	BC143	0.30
2N1308	0.60	2N3714	2.45	40601	0.70	BC147	0.10
2N1309	0.60	2N3715	2.45	40602	0.60	BC148	0.10
2N1671	1.80	2N3716	2.60	40603	0.60	BC149	0.13
2N1671A	1.92	2N3771	1.60	40604	0.60	BC153	0.27
2N1671B	2.12	2N3772	1.70	40636	1.15	BC154	0.27
2N1711	0.27	2N3773	2.65	40673	0.73	BC157	0.12
2N1907	5.50	2N3779	6.00	AC126	0.37	BC158	0.11
2N2102	0.60	2N3790	2.75	AC127	0.44	BC160	0.78
2N2147	1.40	2N3791	2.75	AC128	0.37	BC167	0.12
2N2148	1.65	2N3792	2.90	AC151V	0.35	BC168	0.12
2N2160	1.10	2N3794	0.20	AC152V	0.50	BC169	0.12
2N2218A	0.47	2N3819	0.36	AC153	0.40	BC170	0.15
2N2219	0.42	2N3820	0.29	AC153K	0.42	BC171	0.14
2N2219A	0.52	2N3823	0.61	AC154	0.45	BC172	0.12
2N2220	0.35	2N3904	0.21	AC176	0.40	BC177	0.19
2N2221	0.22	2N3906	0.22	AC176K	0.45	BC178	0.18
2N2221A	0.26	2N4036	0.67	AC187K	0.46	BC179	0.21
2N2222	0.25	2N4037	0.65	AC188K	0.45	BC182	0.11
2N2222A	0.25	2N4058	0.20	AD142	0.65	BC182L	0.14
2N2368	0.17	2N4059	0.15	AD143	0.75	BC183	0.11
2N2369	0.25	2N4060	0.20	AD149	0.74	BC183L	0.14
2N2369A	0.21	2N4061	0.17	AD150	1.20	BC184	0.12
2N2646	0.55	2N4062	0.18	AD161	0.75	BC184L	0.14
2N2647	1.10	2N4126	0.17	AD162	0.75	BC207	0.11
2N2904	0.36	2N4289	0.30	AF106	0.45	BC208	0.10
2N2904A	0.37	2N4919	0.85	AF114	0.65	BC212	0.14
2N2905	0.37	2N4920	0.90	AF115	0.65	BC212L	0.17
2N2906A	0.38	2N4921	0.80	AF116	0.65	BC214L	0.17
2N2906	0.28	2N4922	0.85	AF117	0.65	BC237	0.14
2N2906A	0.25	2N4923	0.70	AF118	0.65	BC238	0.12
2N2907	0.21	2N5190	0.70	AF124	0.65	BC239	0.15
2N2907A	0.22	2N5191	0.80	AF125	0.65	BC251	0.15
2N2924	0.15	2N5192	1.00	AF126	0.65	BC253	0.22
2N2926	0.13	2N5195	1.10	AF127	0.65	BC257A	0.17
2N3053	0.25	2N5245	0.29	AF139	0.69	BC258A	0.17
2N3054	0.50	2N5294	0.35				
2N3055	0.65						

ENQUIRIES WELCOME FOR DEVICES NOT LISTED

BC259B	0.18	BF194	0.12	8DIL	0.44	SN76003N	2.36
BC261A	0.21	BF195	0.11	14DIL	0.41	SN76013N	1.50
BC262B	0.19	BF196	0.13	LM7805P	1.39	SN76023N	1.95
BC263C	0.24	BF197	0.14	LM7812P	1.39	SN76033N	2.50
BC300	0.45	BF198	0.15	LM7815P	1.39	ST2DIAC	0.20
BC301	0.45	BF200	0.31	LM7824P	1.39	TAA300	2.67
BC303	0.60	BF225J	0.25	MC1303	1.47	TAA263	1.25
BC307	0.20	BF244	0.35	MC1310	1.96	TAA350	2.48
BC308	0.18	BF245	0.34	MC1330P	0.75	TAA550	0.60
BC309C	0.25	BF246	0.75	MC1351P	0.87	TAA611C	2.25
BC317	0.14	BF254	0.20	MC1352P	0.87	TAA621	2.15
BC318	0.13	BF255	0.20	MC1466L	3.95	TAA661B	1.32
BC337	0.19	BF257	0.37	MC1469R	2.50	TBA641B	2.50
BC338	0.21	BF258	0.49	ME0402	0.20	TBA651	1.80
BC547	0.12	BF259	0.49	ME0404	0.15	TBA810	1.16
BC548	0.10	BF459	0.39	ME0412	0.20	TBA820	1.03
BC549	0.13	BFR39	0.24	ME4102	0.10	TBA920	1.79
BCY30	1.03	BFS21A	2.60	ME4104	0.10	TIL209	0.30
BCY31	1.06	BFS28	1.04	MJ480	1.05	TIP29A	0.50
BCY32	1.18	BFS61	0.30	MJ481	1.30	TIP30A	0.60
BCY33	0.90	BFS98	0.27	MJ490	1.05	TIP31A	0.62
BCY34	0.98	BFX29	0.36	MJ491	1.55	TIP32A	0.75
BCY38	2.00	BFX30	0.38	MJ2955	1.21	TIP33A	1.00
BCY42	0.60	BFX84	0.38	MJE340	0.58	TIP34A	1.20
BCY58	0.55	BFX85	0.41	MJE370	0.68	TIP35A	2.50
BCY59	0.32	BFX87	0.35	MJE371	0.81	TIP36A	3.35
BCY70	0.25	BFX88	0.32	MJE520	0.65	TIP41A	0.70
BCY71	0.26	BFX89	0.95	MJE521	0.75	TIP42A	0.90
BCY72	0.24	BFY50	0.30	MJE2955	1.25	TIP29c	0.75
BD115	1.20	BFY51	0.38	MJE3055	0.75	TIP30c	0.85
BD116	1.20	BFY52	0.36	MP8111	0.35	TIP31c	0.85
BD121	2.00	BFY53	0.34	MP8112	0.40	TIP32c	1.00
BD123	2.00	BFY90	1.27	MP8113	0.45	TIP33c	1.45
BD124	2.00	BRY39	0.50	MPF102	0.30	TIP34c	1.70
BD131	0.51	BSX20	0.31	MPSA05	0.20	TIP41c	1.00
BD132	0.54	BSX21	0.32	MPSA06	0.20	TIP42c	1.20
BD135	0.42	BU105	3.05	MPSA12	0.35	TIP2955	1.00
BD136	0.42	BU205	2.40	MPSA55	0.20	TIP3055	0.50
BD137	0.45	CA3028A	0.85	MPSA56	0.20	TIS43	0.30
BD138	0.48	CA3030A	1.50	MPSU05	0.40	ZTX300	0.15
BD139	0.50	CA3035	1.35	MPSU06	0.40	ZTX301	0.15
BD140	0.50	CA3046	0.73	MPSU55	0.45	ZTX302	0.20
BD529	0.35	CA3048	2.15	MPSU56	0.45	ZTX500	0.15
BD530	0.38	CA3052	1.62	NE555V	0.48	ZTX501	0.15
BDY20	1.13	CA3080A	1.10	NE556	1.30	ZTX502	0.18
BF115	0.36	CA3089E	2.00	NE560D	4.48	ZTX530	0.23
BF117	0.70	CA3090Q	4.25	NE561	4.48	ZTX531	0.22
BF121	0.55	CA3130	0.88	NE565	1.30		
BF123	0.58	LM301A	0.47	OC28	2.00		
BF152	0.25	LM308N	1.32	OC35	1.50		
BF153	0.25	LM309K	1.80	OC42	0.50		
BF154	0.25	LM380	0.98	OC45	0.75		
BF159	0.35	LM381AN	2.07	OC71	0.45		
BF160	0.30	LM702C	0.75	OC72	0.45		
BF161	0.60	LM709CAN	0.40	OC81	0.75		
BF166	0.40	LM741CAN	0.38	OC83	0.50		
BF167	0.33	8DIL	0.35	ORP12	0.60		
BF173	0.33	14DIL	0.40	R53(NTC)	1.80		
BF177	0.38	LM710	0.45	SL414A	2.35		
BF178	0.45	LM3900N	0.55	SL610C	2.35		
BF179	0.48	LM723C	0.60	SL611C	2.35		
BF180	0.45	LM733	0.88	SL612C	2.35		
BF181	0.45	LM709CAN	0.40	SL620C	3.50		
BF182	0.45	8DIL	0.40	SL621C	3.50		
BF183	0.45	14DIL	0.40	SL623	5.75		
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CD4012	0.20	CD4028	0.91	CD4511	1.54
CD4013	0.57	CD4029	1.17	CD4516	1.40
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3.5mm socket	10p
3.5mm line socket	10p
2.5mm plug	10p
2.5mm socket	10p

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1p 2w Min Toggle	55p
2p 2w Min Toggle	60p
1 pole push test	15p
2p 2w Slide	15p
2p 2w C.off Slide	20p
1p 2w C off Rocker	30p
Mains Neon Rocker	65p
10A C.off Toggle	50p
1p on off Std Toggle	28p
2p 2w Std Toggle	35p
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CARBON RESISTORS

PART 5

Don't take them for granted . . . there's a lot more to them than you ever realised . . .

CARBON COMPOSITION RESISTORS have been used extensively in the manufacture of radio and television sets since the valve era but are being rapidly replaced in production by film resistors. These have superior characteristics and are becoming increasingly cost competitive.

Carbon resistors are manufactured in wattage ratings ranging from 0.1 watt to 2 watts and resistance values ranging from 10 ohms to 100 M. They are made to tolerances of ± 5% (E24 series, ± 10% (E12 series) and ± 20% (E6 series), although the latter is the more usual and least expensive.

There are three basic types of carbon composition resistor:

(a) uninsulated
(b) insulated
(c) filament or filament-coated

Uninsulated type: In this type, the resistive element consists of fine carbon particles mixed with a refractory filling, which is non-conducting, bonded together by a resin binder. The proportion of carbon particles to filler determines the resistance value. The mixture is compressed into shape, usually cylindrical, and fired in a kiln. The end connections are made by any one of a variety of methods. These are illustrated in Fig. 1. In the first method, Fig. 1(a), the ends of the composition rod are sprayed with metal, and wire leads soldered on to provide radial connections. The resistor is then painted and colour coded. This method was extensively used with 1 W and 2 W resistors. A second method, much more widely used now, involves enlarging the ends of the connecting leads and moulding them directly into the carbon composition rod — Fig. 1(b). This method is used extensively as it is adaptable to all wattage ratings and sizes of the resistor body. A third method is also employed. Pressed metal caps, usually having integral leads, are forced onto the ends of the carbon rod — Fig. 1(c). These caps have radial leads and are particularly suited to printed circuit board mounting as they may be plugged straight into mounting holes on the board without the necessity of preforming the leads as is required with axial lead components. These are also known as 'pluggable' types. Film resistors are also made in this style.

Uninsulated carbon composition resistors are generally smaller than the insulated types for a given wattage as their open construction permits good heat dissipation. There is the danger however, that short circuits may occur to adjacent components, and for this reason, the insulated type is preferred.

Insulated Type: This type has the composition element made in the same manner as just described, but it is then

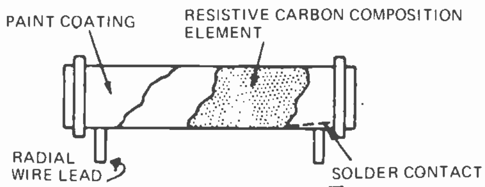

Fig. 1(a). Carbon composition resistor with the end connections made by spraying the ends with metal and the leads soldered.

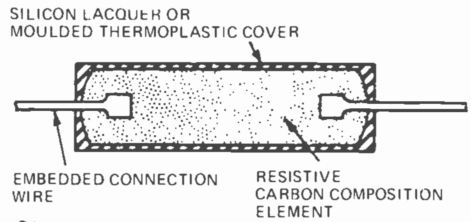

Fig. 2(a). Insulated carbon composition resistor construction.

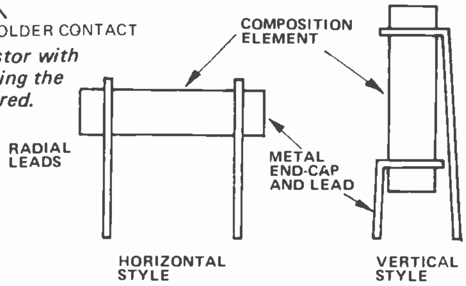

Fig. 1(c). Carbon composition resistor with pressed metal end-cap and lead connections for plugging into p.c. boards — the 'pluggable' style. The end-caps are forced over the ends of the composition rod element.

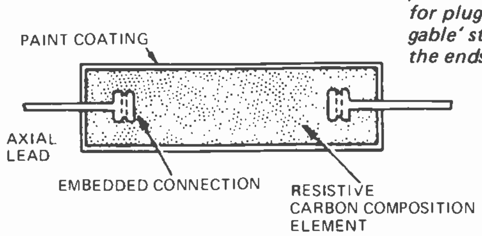

Fig. 1(b). Carbon composition resistor with the connections made by embedding leads in the element.

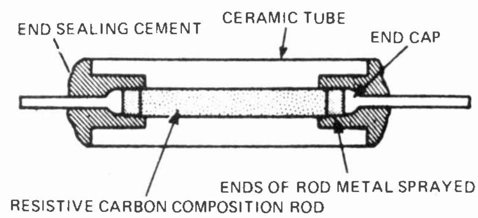

Fig. 2(b). Assembly of a ceramic tube type insulated carbon composition resistance.

encapsulated in either a silicon lacquer, a thermoplastic moulding or epoxied into a ceramic tube. The first two generally employ a resistance element having embedded connections, as illustrated in Fig. 2(a). The type having the element sealed in a ceramic tube generally have an element constructed as shown in Fig. 2(b). The ends of the element are sprayed with metal and an end-cap having an integral lead is force-fitted over them. This assembly is then put inside the ceramic tube and the ends sealed with an epoxy or other compound.

Filament or Filament-coated Type: With this type, carbon granules are dispersed, along with a filler, in a varnish which is then applied to the surface of a continuous glass or ceramic filament which is then baked. The resistance value depends on the length and mixture, the filament is cut into appropriate lengths and leads applied by one of the methods detailed above. It is usually encapsulated in an insulating compound as per the insulated style of resistor.

Carbon composition resistors have a large voltage coefficient. The value of this coefficient varies with the resistance of the component (being highest for high value resistors) and the size of the resistance element. Small resistors of a given value have less insulating filler in their composition and will have a lower voltage coefficient. Commonly available composition resistors have quoted voltage coefficient between 0.02 and 0.035 for values up to 1M. Values above this have a coefficient of typically 0.05. These values may cause a maximum change in resistance of 2% when used within their ratings. The voltage coefficient of the other types of resistors is considerably smaller than for composition types – typically 0.002% or less.

A large negative temperature coefficient is one of the disadvantages of composition resistors. It is typically between 0.1% and 0.15% per ^{o}C (i.e. 1000 ppm per ^{o}C or greater), across the whole resistance range. This means that a 1 M resistor will change its value by 1 k or more for each ^{o}C change in temperature. The curve of percentage resistance change versus temperature is not linear and may be positive over one portion of the temperature range and negative over another. Figures 3 and 4 show typical temperature coefficient curves for two types of carbon composition resistor for different values between 1 k and 10 W.

Critical Resistance Value: A resistor of specified power and voltage ratings has a critical resistance value above which the allowable voltage limits the permissable power dissipation. Below this value, the maximum permitted voltage across the resistor is never reached at the rated power.

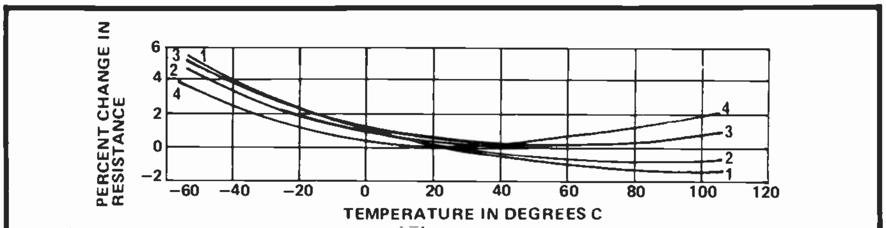

Fig. 3. Resistance-temperature characteristicsl ½ watt, 3mm by 9.5mm, composition resistor, Curve 1, 10 megohms; curve 2, 0.27 megohm; curve 3, 10,000 ohms; curve 4, 1,000 ohms.

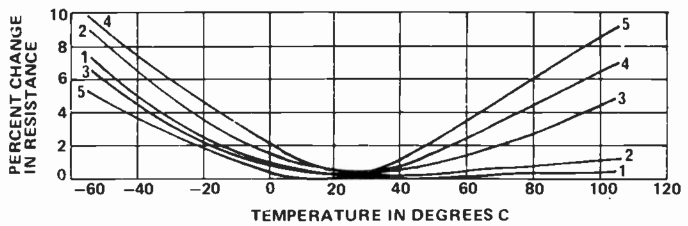

Fig. 4. Resistance-temperature characteristic, ½ watt, 3mm by 9.5mm, solid composition resistors. Curve 1, 1,000 ohms; curve 2, 10,000 ohms; curve 3, 0.100 megohm; curve 4, 1.00 megohm; curve 5, 10.0 megohms.

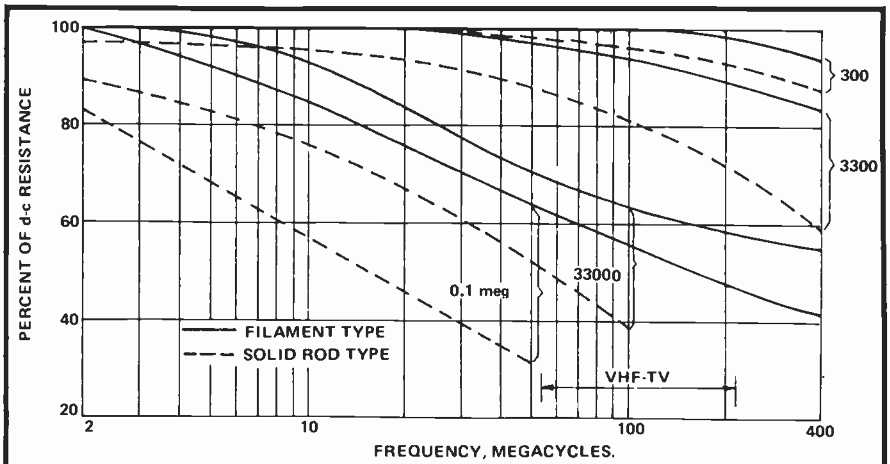

Fig. 5. Frequency characteristic of filament and solid rod types of ½-watt composition resistors.

Carbon composition resistors show a pronounced fall-off in apparent AC resistance, compared to their DC value, with increasing frequency. The effect which is particularly bad with the higher values is known as the 'Boella' effect after its Italian discoveror. The filament-coated type is less affected than the solid rod type. Figure 5 illustrates the frequency characteristics of the two basic construction styles of composition resistor for a variety of values. The values below 200 ohms are obviously quite useful right up to UHF. Values below 100 ohms may show an increase in value with increasing frequency.

Obviously at frequencies in the VHF range and above, mounting and lead length affect characteristics considerably. Absolute minimum lead length is necessary to minimise unwanted inductance. Lead lengths of 6 mm have considerable inductance at 200 MHz. Printed circuit layout can assist in minimising the problem, and mounting the resistor flat on the board – bending the leads as close as possible to the component body – is good Naturally, this applies to all resistors. Radial lead components are best in this situation.

The amount of noise generated by carbon composition resistors is a function of the materials used in the composition mix. Generally, the noise generated increases with increasing voltage, increasing resistance, and decreasing size, for a given mix of materials. The noise due to current flowing through the resistor is generated by random changes in the material of the element, caused by the current flow. This noise decreases with increasing frequency and Johnson noise, which is frequency independent, becomes dominant above about 1 kHz. The current noise generated by composition resistors is a major limitation against using them at dc and low frequencies. They are not recommended for use in amplifier input stages or DC amplifiers for this reason. Microphony is also

CARBON RESISTORS

noticeable, caused by modulation of the noise voltage generated by the component. Composition resistors having values above about 1 M Johnson noise makes them unsuitable for use in high impedance amplifier inputs or other critical applications.

When subjected to overload, carbon composition resistors usually decrease in value owing to their large negative temperature coefficient. This causes the temperature to rise until the hotspot temperature is exceeded and failure occurs, usually by fracturing.

There are two basic power derating curves for carbon composition resistors. The common commercial grade types have a spot temperature of about 107°C while the more expensive types that meet more stringent specifications (usually produced to meet military specifications — MIL-spec.) have a hot spot temperature of 130°C and can be used to full ratings up to 70°C whereas the former types must be derated above 40°C. The commercial grade derating curve is given in Fig. 6 and the military grade derating in Fig. 7.

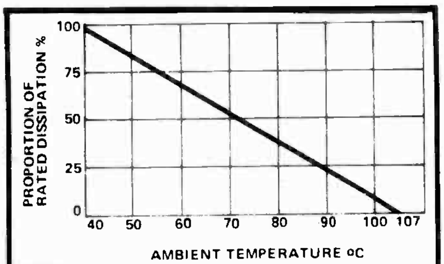

Fig. 6. Power derating curve for ordinary commercial grade carbon composition resistors.

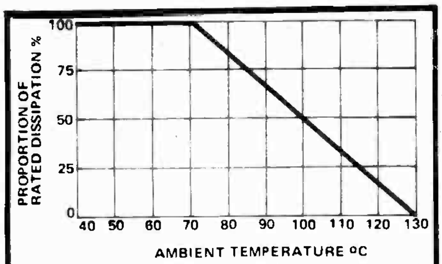

Fig. 7. Power derating curve for mil-spec or high quality commercial grade carbon composition resistors.

The requirements of solid state circuitry created a demand for high stability, high quality resistors. Increasing use of electronics, and the demands of evermore complex consumer and domestic electronic equipment and appliances contributed to the development and production of low cost film resistors. Carbon composition resistors are gradually being superceded, despite the excellent specifications of types available, by film resistors which are inherently superior in many respects. ●

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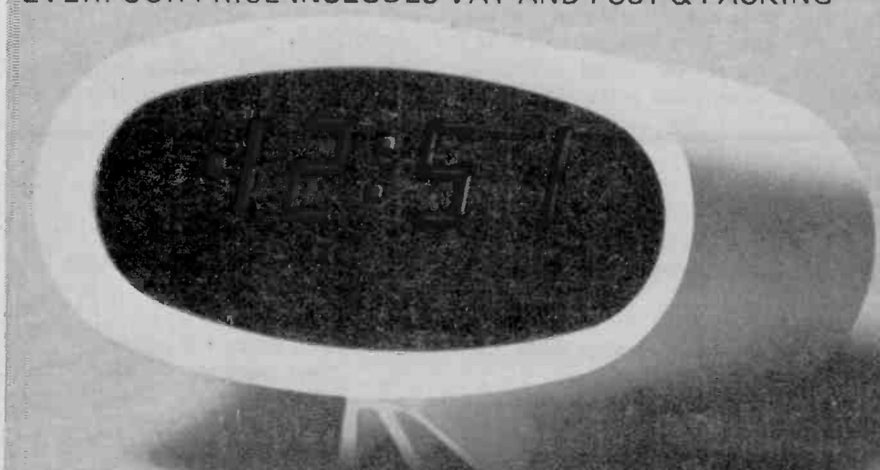

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This simple but effective unit can be used as a limiter, automatic volume control or voltage controlled amplifier.

THE AUDIO COMPRESSOR EXPANDER project described in the May 1976 issue of ETI has proved to be very popular with readers and we have since had many requests for a simpler limiter circuit. Whilst limiters and compressors are similar in operation they are used in completely different ways.

A compressor is normally used in a linear compression mode. That is, for say every 10 dB of input signal level change the output is arranged to change by, for example, 6 dB. The output will change this fixed amount of 6 dB for every 10 dB increment of input. The reverse of this procedure is called expansion. That is, for a 6 dB change in input signal level the output is caused to change by 10 dB.

A compressor/expander is typically used for improving the dynamic range (and hence signal-to-noise ratio) of tape recorders. The signal is first compressed so that its dynamic range can be handled by the tape. On subsequent replay the signal is expanded by a corresponding amount to restore the original dynamic range. As the amount of noise on the tape is constant and the level of signal has been effectively increased, the signal-to-noise ratio has also been increased.

A limiter is a form of compressor which operates only when the signal exceeds a certain predetermined level. For example signals which do not exceed say 80% of the predetermined maximum are not compressed at all and are amplified with their full dynamic range. For signals above the 80% level the limiter begins to operate and very large input signals are required to obtain the extra 20% of output.

Another use of a limiter is in the continuous-limit mode such that it acts as an automatic volume control (AVC). In this mode a 60 dB change in input level can be limited to say, a 6 dB change in output level.

Finally the limiter may also be used as a voltage controlled amplifier having a range of about 55 dB. A typical application of such a device would be a remote volume control. It should be noted, however, that although the transfer function of such a voltage,controlled amplifier is fairly sharp, two of them may not necessarily track perfectly due to differences in the FETs in the ICs. Thus on our prototype the difference between channels when used as a stereo volume control was up to 5 dB at some points with any given input.

DESIGN FEATURES

The first decision to be made when designing a limiter is what type of controlled resistive element to use. Common alternatives are FETs, LDRs, base-emitter junctions of transistors, thermistor or balanced modulator ICs. All of these have their respective advantages and disadvantages and all have been tried in our laboratory at one time or another. We selected FETs because we considered them the most cost effective.

When FETs are used in voltage controlled amplifiers it is essential that the voltage across them is kept as low as possible if the distortion is also to be kept low. This means that the FET must be used as an attenuator where the voltage across the FET can be kept low irrespective of input voltage. The most suitable type of FET for this purpose is the enhancement-mode device but these are not readily available. The commonly available types require a negative voltage to turn them off. However, there is a suitable alternative, the 4049 CMOS IC which contains six inverting buffers. By suitable interconnection the IC may be made to provide six enhancement-mode FETs and this is the approach we decided to use.

To restore the signal level an amplifier is required and originally we intended to use the LM382 but, because of cost and availability considerations, we finally decided to use an LM301 or 741 operational amplifier together with a transistor pair at the front end. The noise performance of this arrangement was found to be as good as the LM382's and supply voltage to be less critical (although a dual supply is required). If only a single-ended supply is available then a 382 may be used, although a different board layout would be required.

CONSTRUCTION

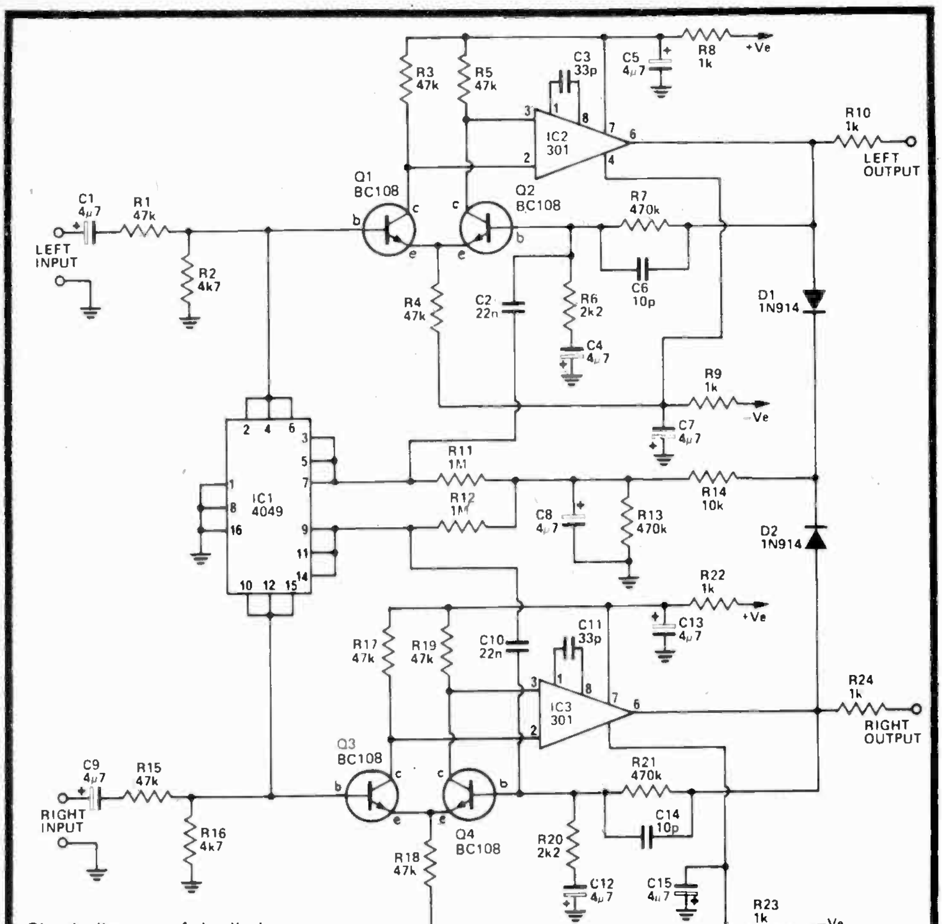
Although a printed-circuit board is not essential it certainly makes construction very much easier. Before assembly decide whether a limiter or an AVC is required as the

Specification ETI 446

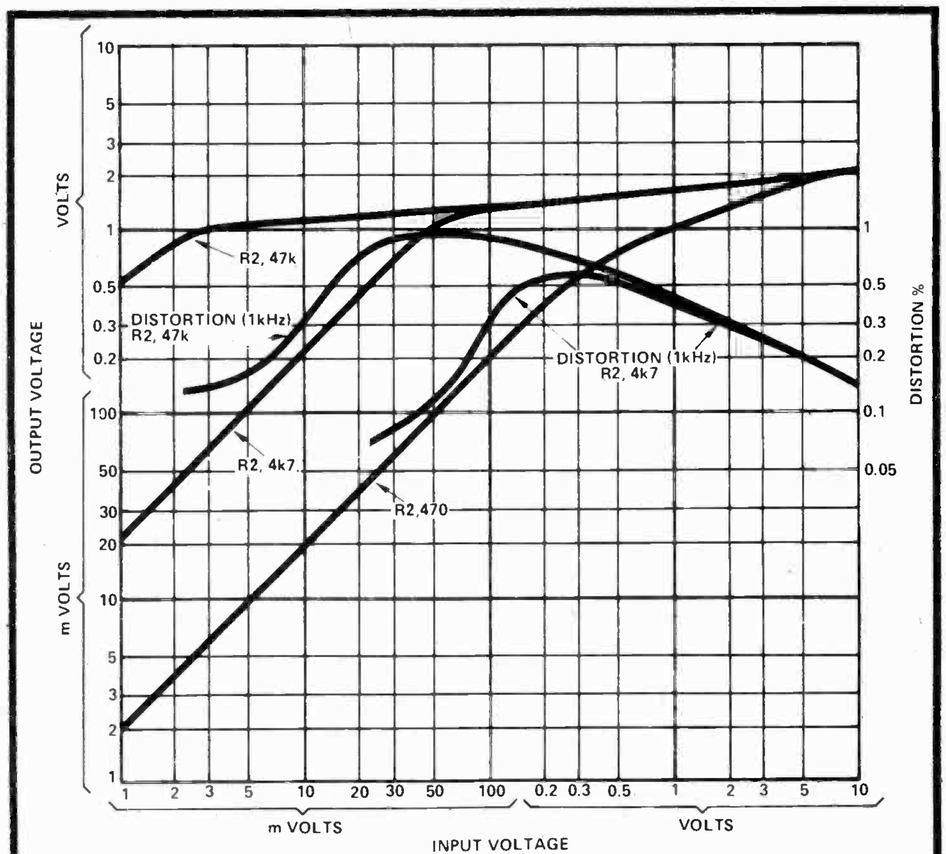
Input voltage range	**1 mV – 10 V**
Frequency response	**± 3 dB 10 Hz – 20 kHz**
Limiting point	
set by R2/16	**3mV**
Equivalent signal-to-noise ratio	**70 dB re 1 V out**
Distortion	**see graph**
Input impedance	**47 k**
Maximum gain	
R2/16 = 4k7	**26 dB**
R2/16 = 47k	**40 dB**
Maximum attenuation	
as voltage controlled amplifier	**55 dB**
Supply voltage	**± 8 V to ± 16 V dc at 5 mA**

values of R2 and R16 will vary accordingly. Use 47k for R2 and R16 in the AVC mode and in limit mode, depending on limit point, between 470 and 4k7. The transistor type specified is available from a number of different manufacturers but pin connections are different. If a different brand is used the transistor should be reversed (emitter and collector interchanged). The overlay also shows the arrangement for using the LM301 ICs — these may be directly replaced by 741s simply by omitting the 33 pF capacitors.

Although the CMOS ICs 4449 and 4009 are electrically similar to the 4049 and are interchangeable with it when the devices are used as hex-inverters, they cannot be used as replacements in this circuit. The 4049 must be used. The 4449 and 4009 have different circuitry and will not work in this mode.



Circuit diagram of the limiter



Input versus output voltage for various values of R2 (and R16) Distortion at 1kHz for R2=4K7 and R2=47K are also shown.

How it works

The circuit basically consists of a voltage-controlled attenuator followed by a low-noise amplifier with a gain of 46 dB. The output of this amplifier is rectified to generate a dc voltage which is used to control the attenuator.

The variable element in the attenuator is an enhancement mode FET. This is made from a CMOS hex-inverter IC, the 4049, by special interconnection. The difference between enhancement mode FETs and the normally available depletion-mode junction FETs is as follows: The enhancement mode FET has a high resistance between source and drain when the gate is at zero volts, but this decreases as the gate is taken more positive. A JFET (N type) is hard-on with the gate at zero volts and turns off as the voltage is taken negative.

The amplifier is required to have high open-loop gain and have fairly low noise. The gain requirement is provided by an LM301 operational amplifier and the low-noise requirement by a pair of transistors (connected as a differential pair) placed before the operational amplifier. The gain is set, by the combination of resistors R6 and R7, to 215 (or 46 dB). The lower 3 dB point is set at 15 Hz by C4 and R6 whilst the upper 3 dB point is set at 33 kHz by C6 and R7.

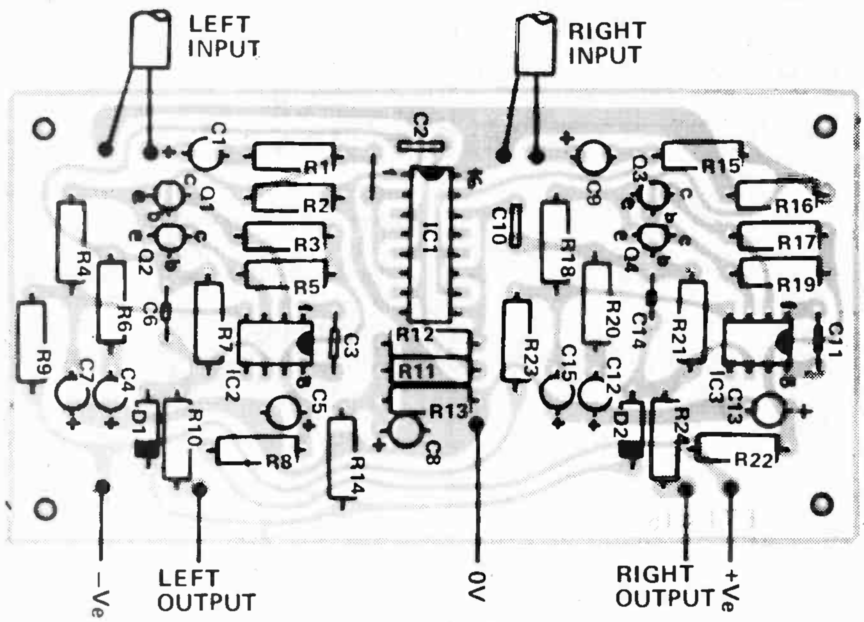
The outputs of both channels are summed and rectified by diodes D1 and D2 to charge C8 via R14. The voltage on C8 is coupled to the gate of the FETs (three in parallel on each channel) via R11 and R12.

As the input voltage increases the output also tends to increase and voltage on capacitor C8 also increases and this increase is applied back to the gates of the FETs. This reduces the resistance of the FETs and thus increases the attenuation, tending to prevent the output from changing as much as the input does.

With all FETs the resistance changes with applied voltage and this gives rise to distortion. However by modulating the gate voltage with a signal equivalent to the voltage across the FETs the distortion is greatly reduced (3.5% down to 0.8%).

The attack and release times can be adjusted by varying R14 for attack and R13 for release.

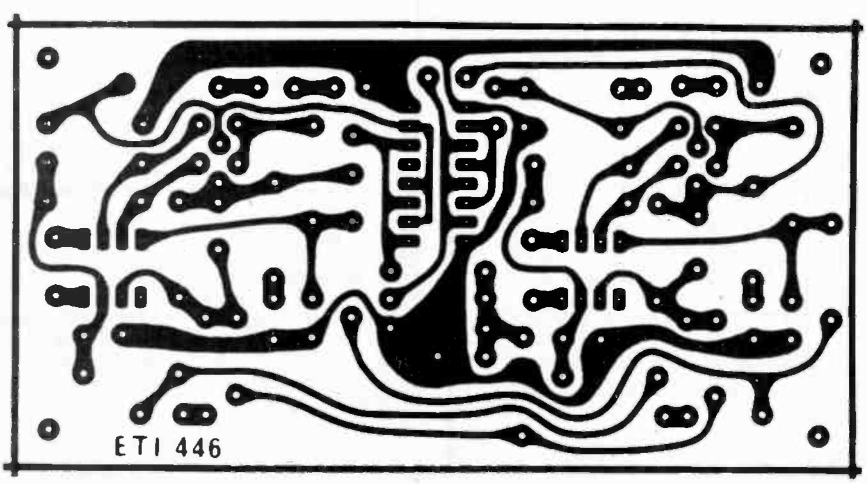
AUDIO LIMITER



Component overlay.

Parts List

Resistors					
R1	47k	½ W	5%	C4,5	4µ7 25 V electrolytic
R2	4k7	"	"	C6	10p ceramic
R3-R5	47k	"	"		
R6	2k2	"	"	C7-C9	4µ7 25 V electrolytic
R7	470k	"	"	C10	22n polyester
				C11	33p ceramic
R8-R10	1k	"	"	C12,13	4µ7 25 V electrolytic
R11,12	1M	"	"	C14	10p ceramic
R13	470k	"	"	C15	4µ7 25 V electrolytic
R14	10k	"	"		
R15	47k	"	"	**Semiconductors**	
				Q1-Q4 Transistors BC108	
R16	4k7	"	"	D1,2 Diode 1N914	
R17-R19	47k	"	"	IC1 Integrated circuit 4049 *	
R20	2k2	"	"	IC2,3 " " LM301	
R21	470k	"	"		
R22-R24	1k	"	"	**Miscellaneous**	
				PC board ETI 446	
Capacitors				9 PC board pins	
C1	4µ7 25 V electrolytic				
C2	22n polyester			**Do NOT substitute a 4009 or 4449*	
C3	33p ceramic			*as the input protection is different.*	



Printed-Circuit layout for the limiter. Full size 58 mm x 110 mm.

As this unit will normally be used in association with another piece of equipment, and most likely built in to it, a case has not been described. When installing the unit make sure that the input cables are coaxial or shielded cable — outputs are not important and can be normal hookup wire.

USES OF A LIMITER

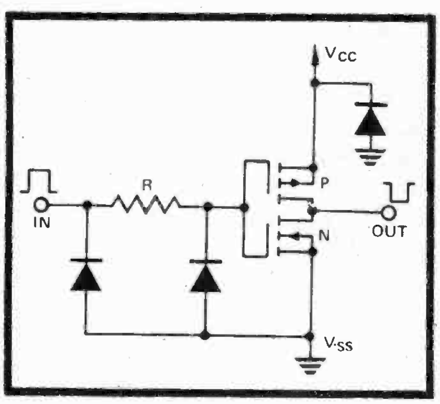
Peak Limiting. In this mode only signals above 85% of maximum level are attenuated. This is useful for preventing amplifier clipping (for pop groups or other live shows) which gives rise to objectionable distortion. It may also be used when tape recording the same type of programme material as above, to prevent the tape being saturated, which again would give rise to distortion.

AVC. In this mode, the limiter is used typically to drastically reduce the dynamic range of a programme being recorded. For example, when recording a lecture the 60dB dynamic range of lecture room speech may be compressed to 6dB.

Voltage Controlled Amplifier. As a voltage-controlled amplifier the unit lends itself to a variety of remote or automatic control applications. For example, it may be used as a remote control for stereo amplifier volume. Alternatively, it may be adjusted to increase car radio volume as ambient noise level rises.

Special Effects. The limiter may also be used to modify the sound of musical instruments. For example, such a limiter is often used to eliminate the attack transient on a bass guitar to give a smoother mellower sound.

The uses of such a circuit are wide indeed, and we are sure our readers will think of many more applications for this interesting circuit. ●



Internal circuit diagram of one of the six inverter stages in the CMOS 4049 IC

ELECTRONICS PART 34
—it's easy!

More about digital instrumentation.

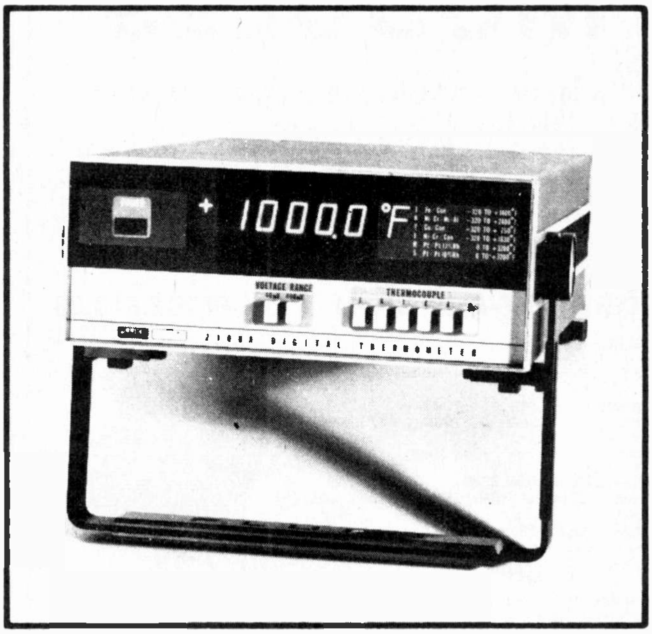


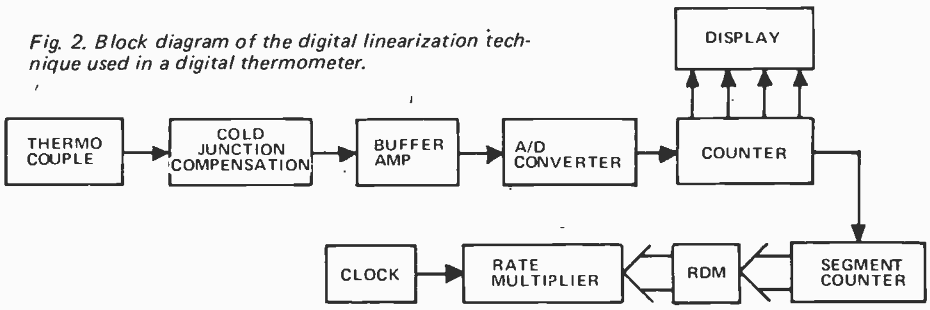
Fig. 1. This Fluke 2100 series digital thermometer incorporates digital linearization. It is suitable for use with any one of six common thermocouples.

VERY FEW VARIABLES to be measured by electronic means provide a digital signal directly: this is because the real-world is predominantly analogue by nature. Consequently, most so-called digital measurement systems involve a number of stages to make the signal compatible with the digital circuits of a system.

The most straight-forward 'digital' measurement method (at least at present), is to employ a suitable analogue sensor that provides a voltage (or current) output, related to the variable being measured. This signal then feeds an A/D converter to obtain a digital equivalent.

The low cost of digital calculation circuitry now enables linearization of sensor processes at moderate cost. Figure 1 gives an example of the digital linearization used in a thermocouple thermometer unit.

Fig. 2. Block diagram of the digital linearization technique used in a digital thermometer.



By referring to Fig. 2.we see that the linearization process, in the dual-slope digital voltmeter section of the system, is achieved by changing the ramp slope at a number of points. To do this a rate multiplier is used to multiply the clock frequency by a variable number, N/256, where N may be any number between 1 and 256. By this means 256 different ramp slopes may be generated. The slope in use is tracked by a segment counter which, in turn, causes a read-only-memory (ROM) to set up the correct digital-readout code.

Some sensing principles lend themselves to a more direct digital signal approach. For example, in the Moire-fringe displacement sensor, a grid of fine lines (called a grating) formed on glass is attached to the moving (or fixed) member of the machine whose movement is to be monitored. This is shown in Fig. 3. The other member carries a small index grating set to produce Moire-fringes which move as the two grids pass relative to each other. Movement of these fringes is monitored by photocells which provide a number of electronic pulses proportional to the magnitude of the displacement. These pulses can be counted directly with a reversible direction counter, thus allowing both directions of movement to be followed. Such a unit is known in the metal working industry as digital readout (DRO). A somewhat similar length measuring system is the laser interferometer — this also provides fringes that can be counted to provide a measure of absolute displacement. Clearly in such cases the digital instrument must not lose or gain stray counts or else the wrong value is indicated. Such systems are called incrementals.

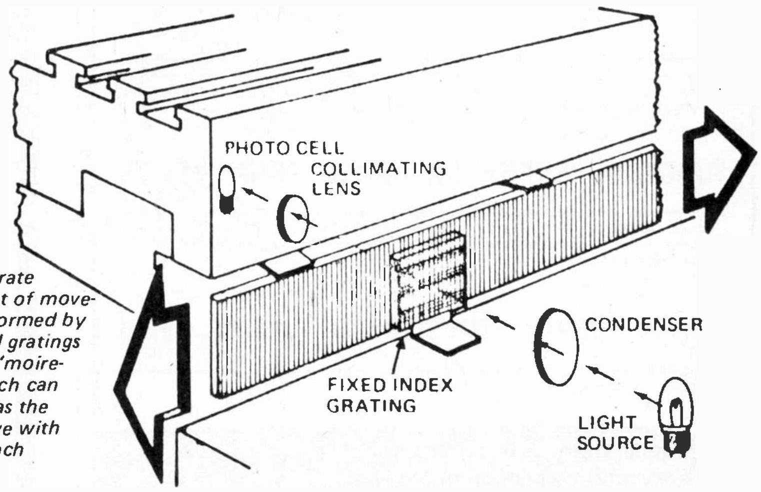


Fig. 3. Accurate measurement of movement is performed by using optical gratings to produce "moire-fringes" which can be counted as the gratings move with respect to each other.

There is an alternative method which uses digitally encoded discs similar to those shown in Fig. 4. This is an absolute method which is not subject

Fig. 4. A 10 bit optical Gray code disc. The value read from this gives the angular displacement.

to pulse loss or gain, or to power failure errors which occur in the previous system if not fitted with a special non-volatile memory. The discs of such a system are read optically as though they were registers or other forms of digital store, each position having a different digital code as read across a radial line.

In some forms of digital pulse transducer it is the rate of pulse production that represents the variable, not the absolute number of pulses. An example of this sensor is the turbine flow meter used to measure liquid or gas flow. Figure 5 shows such a flowmeter where a small turbine rotates inside a pipe at a speed related to the flow rate. Rotation may be converted into pulses using optical, magnetic, capacitive or, in earlier designs, mechanical sensing. This form of sensor provides a variable frequency output which can be converted by a counter/timer system into a direct readout of flow rate.

Digital transducers are somewhat similar. They provide a signal which varies in frequency as the variable being measured changes. The sensor of such a transducer is made such that it alters a parameter of a frequency generating circuit. For example the quartz-crystal thermometer shown in Fig. 6 operates in this manner. In this unit temperature causes the resonant frequency of a crystal, mounted in the end of the probe, to change in a predictable fashion.

It is interesting to note that many natural physiological sensors operate on the pulse-rate system — neurons (the digital nerve sensors on the end of the nervous system) trigger with pulse repetition rates that rise in accordance with the intensity of the actuating signal (heat, cold etc).

Considerable effort has been expended — especially in the Eastern European countries in the late 60's — to produce reliable low-cost industrial sensors that provide a digital form of output. These have not, however, been accepted to the extent hoped. The current low-cost of extremely powerful digital circuits, however, is likely soon to produce a trend toward sensing devices having digital output.

ANALYSERS

Analysis is the general process used to break down an unknown by methods which separate and distinguish basic elements of seemingly complex arrangements, the elements so derived being satisfactorily understood basic quantities.

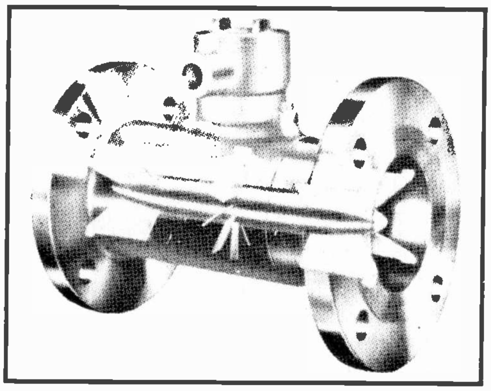


Fig. 5. Turbine flow meters like this one provide an output in the form of a pulse train with a pulse repetition rate proportional to flow rate.

Synthesis is the alternative approach wherein a system is built up from known elements to produce the complex case.

Analysis may be regarded as being required when the behaviour of an existing system needs to be *studied.* Synthesis is used when a system is to be *devised.* There are of course many instances when both approaches are used to yield a solution.

Various types of electronic analysers are used in electronics. We will look here at spectrum analysers, logic state analysers and pulse-height analysers as these types are commonly met in modern circuit work. Each of these operates on an existing electrical signal breaking it down into frequency content, logic-state content and height of pulses, respectively.

SPECTRUM ANALYSERS

Signals in the time-domain, that is those displayed as amplitude versus time graphs, can also be displayed in terms of their amplitude-versus-frequency and phase-versus-frequency characteristics. (This was discussed in Part 4 where an example wave-form — a square wave — was broken up into its harmonics). The relationship between time, amplitude and frequency are seen by studying the three forms (shown in Fig. 7) of a fundamental sinewave having a large degree of second harmonic added in. Signals displayed as amplitude (or phase) versus frequency are said to be in the frequency domain. This kind of plot shows the frequency spectra of the signal, hence the name spectrum analysers.

The role of spectrum analysers is to display the signal content in its frequency domain form. There exists many instances where this form of display is better than a time-domain representation. Typical examples are where a fundamental has distortion (Fig. 8a) or where low levels of modulation or noise exist (Fig. 8b). Neither of these conditions could be satisfactorily detected, let alone measured, by a time-domain test.

Basic spectrum analysers use analogue circuitry and therefore do not qualify properly for inclusion in a discussion on digital instruments. However, as we will see later, the current trend is to incluc digital techniques in such inst ments. Advanced analysis equipments, for example, often use a built-in digital computer.

There are two alternative forms of spectrum display. First, the repetitive signal can be studied over an extended time period by scanning across the expected frequency-range with narrow band-pass filters. A speedier, but more expensive method, works in a real-time mode thus preserving the time-dependency between signals.

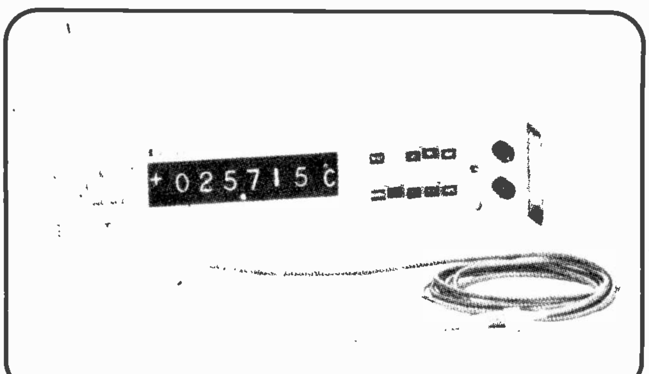


Fig. 6. Quartz-crystal thermometer from Hewlett-Packard.

ELECTRONICS–it's easy!

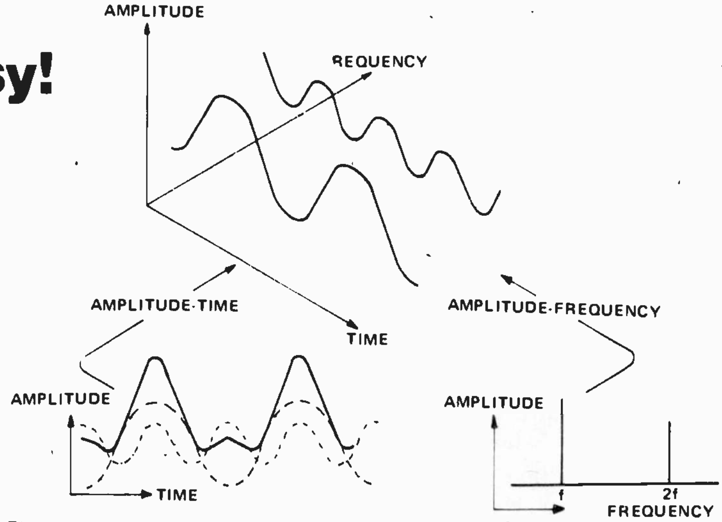


Fig. 7. Second harmonic distortion is not always easily seen on an amplitude versus time display. In the amplitude versus frequency display the second harmonic distortion and its amplitude are clearly seen.

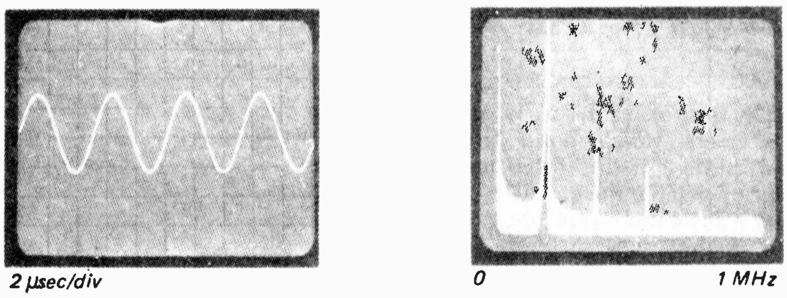


Fig. 8a. Frequency domain displays are often better than the time-domain method as these HP displays illustrate: (a) In the time domain (left) the signal looks pure but the spectrum analyser shows that it has significant distortion.

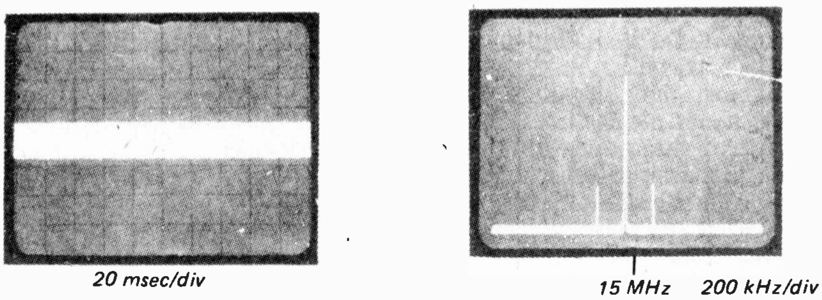


Fig. 8b. A 2% amplitude modulation is barely discernible on time domain plot (left). The frequency domain plot clearly shows the frequencies present and their amplitude.

These are known as swept-tuned and real-time spectrum analysers respectively.

Swept-tuned systems – Basically the task is to establish the amplitude (and sometimes phase) of the signal at each frequency in turn. Many practical difficulties exist because the absolutely narrow band filter does not exist and even if it did, it would take an enormous time to sweep it across the full bandwidth of the signal. Practical filters also have finite bandwidth and roll-offs. The bandwidth of the filter may also need to change if the requirement is for a filter bandwidth that is always a given proportion of the signal frequency as it sweeps the range.

Most difficulties are overcome by mixing the signal with a swept local oscillator and then detecting the output and using it to drive the Y plates of an oscilloscope. The sweep signal drives the X plates. Figure 9 depicts this arrangement.

Real-time systems – These use a stack of band-pass filters and detectors each connected to the signal simultaneously and with each having staggered centre frequencies. This is shown schematically in Fig. 10. The scan generator multiplexes the individual channels in order to produce a continuous spectrum on the oscilloscope screen.

It is clear that this method is much more expensive because many filters are needed. It does, however, enable a detailed analysis of once-only transient signals which could not be analysed with the swept-tuned arrangement of a spectrum analyser.

A range of spectrum analysers is available for the study of signals from 5 Hz to 50 GHz. Different instruments (or the use of different plug-ins with the same display unit) are needed because units typically cover only 4 to 5 decades, that is, say 5 Hz-50 kHz, 10 kHz-300 MHz and so on. The range is, however, ever widening. Wide range, however, is not always the virtue needed for spectral resolution is related to width of display screen.

Fourier Analysers – A third method of providing a frequency analysis is based on direct mathematical calculation using the Fourier transform technique to convert a time-domain signal into its frequency-domain equivalent. Such systems are extremely expensive compared with the above analysers, but provide a vastly greater capability.

They can also handle signals at the very-low-frequency end – dc to 100 kHz is typical. Their operation is quite different from the above in that the signal is fed as data values into the analyser unit via keyboard or paper tape from another computer or mass-storage system. It can also be fed in as an analogue signal from, for example, magnetic tape. The heart of the Fourier analyser is a micro-programmable computer system which can be set to compute using various programmes such as the so-called Fast-Fourier method of analysis. The same unit may also be able to carry out correlations between signals, plus many other processing techniques.

Digital circuitry in spectrum analysers – Digital circuits are being added by manufacturers to enhance the performance of analysers. Advantages claimed include operating ease and better placement of controls. Digital storage of the display signals can be used to enhance the display brightness and to allow a spectrum to be 'held' for comparison against a second spectrum obtained later. Digital

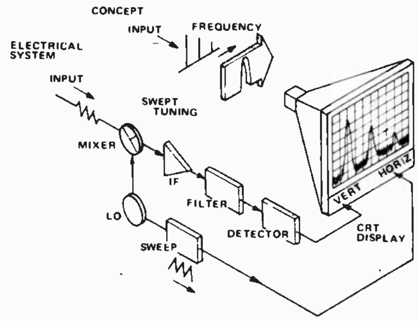


Fig. 9 : Schematic of swept-tuned form of spectrum analyser.

included; this reduces the noise thereby enhancing the signal/noise ratio on the display — as is illustrated in Fig. 11. Character generation (using digital methods) has been incorporated to display the relevant graph-axes factors — as shown in Fig. 11. The same unit also uses a photo-optical absolute-digital code disk to replace the mechanical switch usually used in a range control-knob.

Spectrum analysers are invaluable and are finding increasing use. Successful use is, however, a matter of experience and frequency-domain techniques are not dealt with as extensively as time-domain ones in training programmes. More details are available in the reading list — we can only provide the most elementary introduction here.

Logic-State Analysers — We check the operation of analogue circuits by measuring signal levels and frequency spectra at various points in the circuit. Digital circuits are different in that they contain the signal information in the form of multi-digit 'words' made up of two-state bits. To check operation, therefore, we must ascertain simultaneous logic-states at various points in the circuitry. The simplest analyser for this work is a probe which indicates logic hi or lo state at a selected point; coloured lights are used as indicators. A store function can be built-in to the probe to catch a short transition that would not otherwise be seen in the lamp display. It must also have connections suitable for PC board digital circuitry — see Fig. 12.

The single probe can be used to analyse the state of a circuit by moving from point to point in turn. To speed-up the analysing process a more extensive facility to use would be one that simultaneously shows the logic states of multiple points in the so-called Data-domain. The Hewlett-Packard system, for example (shown in Fig. 13), displays over 500 points as a matrix of 0's or 1's on a CRO screen. These instruments are used to debug, test or trouble-shoot complex digital circuits. Only large laboratories, however, would be able to justify the cost of such advanced logic analysers.

Pulse-height analysers (Discriminators) — Measurement processes involving ionising radiation and sometimes light-intensity levels rely on pulse counting, the pulses appear as rapid electrical currents produced from a photo-multiplier or ionisation detector. The relative amplitude of a pulse often distinguishes it from pulses from other sources. For example, different radio-active isotopes produce pulses of different energy, enabling an assay of radio-active mineral to be made by a study of occurence of pulses of different height. Photons arising from the various noise sources in photo-multipliers have different energy from those generated at the photo-cathode. This is a true detection process: noise can be reduced by discrimination of pulse heights.

Pulse height analysers use carefully selected trigger levels to accept only those pulses (for counting) that arise from the particular source of interest. Pulses above the trigger window, or below are rejected (not counted) as demonstrated in Fig. 15.

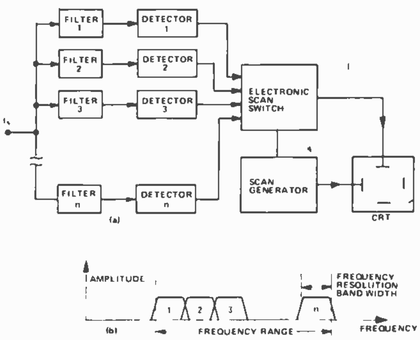
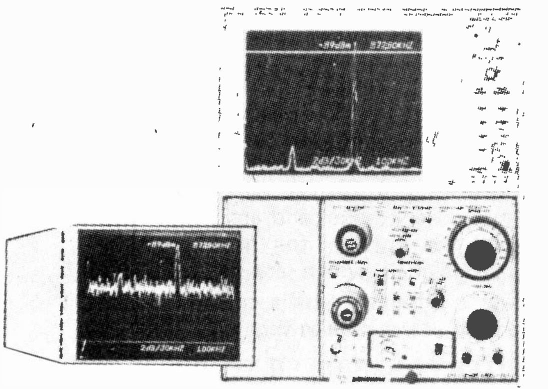


Fig. 10. Block diagram of real-time spectrum analyser based on stacked filters:
(a) schematic
(b) frequency response showing individual filter windows.

Fig. 11. The Tektronix spectrum analyser incorporates various digital techniques that provide character generation on the display and reduce the noise level of a signal. The adjacent photo shows the original unfiltered signal containing the two small signals and noise (recovered in the CRO display).



SYNTHESIZERS

These are a special kind of signal generator in that the signal output is formed by addition of a number of sources or by manipulation of a single, stable-reference frequency. A music synthesizer provides a whole range of musical sounds by combining many different tones into a single output. Although synthesizers work upon basic analogue signals the trend is to combine or modify the signals using digital control.

The advantages offered are (in the variable frequency generator kind of synthesizer) that a very stable reference oscillator has its frequency translated to (literally) billions of other values (the HP 8660 gives 10 kHz-2600 MHz) whilst retaining high stability. By pressing digital-key inputs, any chosen frequency value is generated. It is also possible to control the output via a programmable BCD digital input. Programming enables an enormous range of signals to be synthesized, a typical requirement being as part of an automatic test procedure. Figure 14 shows the philosophy of the HP 3330 series of automatic synthesizers with a typical programme card marked up for a frequency sweep routine.

Digitally-controlled power sources

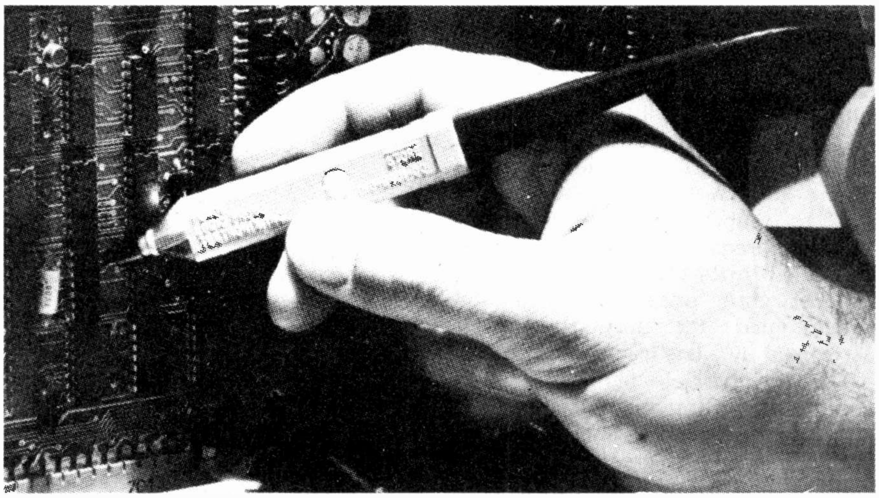


Fig. 12. Simple logic probe in action.

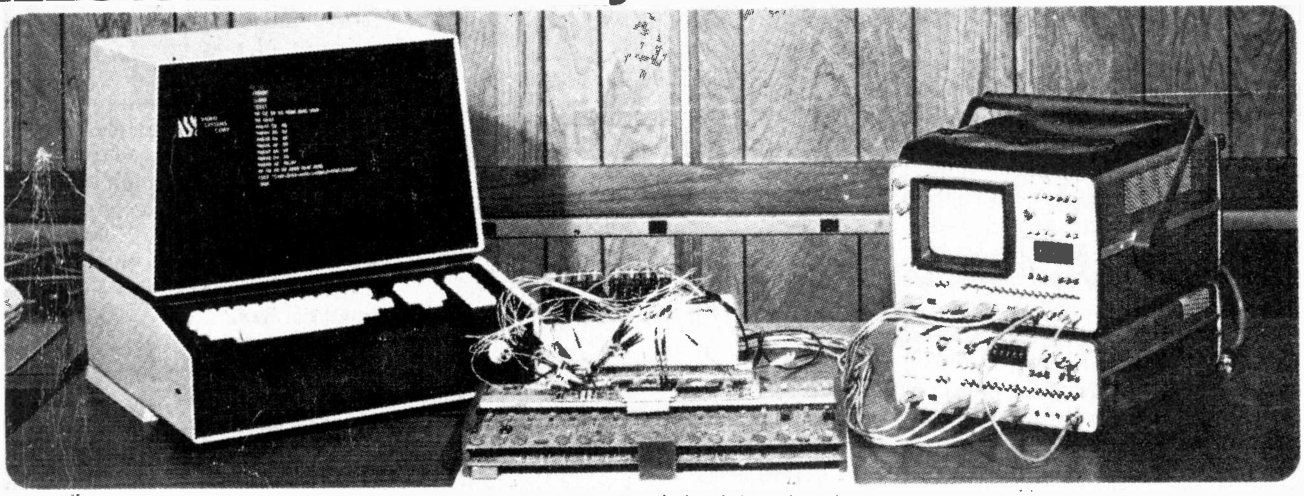


Fig. 13. Hewlett Packard logic-state analyser as set up to test a printed-circuit board card.

may be used to synthesize varying voltage (or current) levels over a test period at the commands of a mini computer in the same way as the above unit synthesizes frequencies.

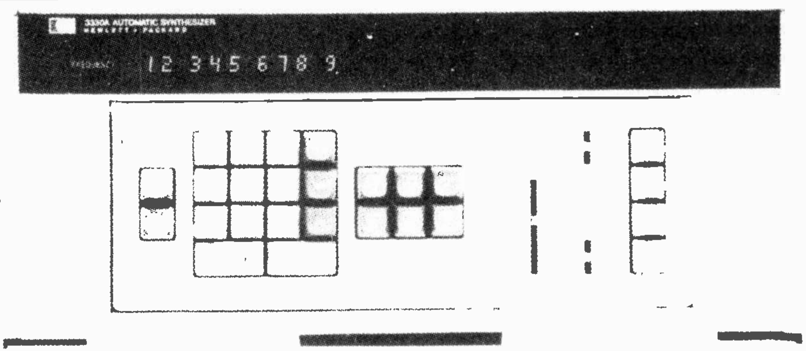
Frequency and voltage synthesizers are often combined in the hybrid-computer (digital and analogue combined) in order to generate synthesized signals which are needed to derive a simulation of a complex system, such as a missile in flight.

COMPUTER CONTROLLED TEST SYSTEMS

With the enormous increase in complexity of routine complex processes (such as aircraft instrumentation and controls, refineries, automatic and large-volume manufacture of electronic systems) came the need to improve and speed-up the testing procedures needed to check out the thousands of different parameters involved. Computer controlled testing is far more reliable than human operator testing and is extremely fast. It can be economic even for the testing of small volume electronic equipment, especially where a large range of tests is involved.

The instrument or process to be tested is interfaced to the main test console which usually incorporates a wide range of facilities that are chosen with flexibility of operation in mind. Figure 15 shows an automatic system used to calibrate a test instrument. The test programme must be devised by a highly-trained professional designer, but once developed and programmed the testing can be performed by a less trained person.

It is not possible here to deal in depth with automatic testing as the range of requirements and equipment available are both great. The overall concept and scope of an automatic test system is shown in Fig. 16. Suffice to say very complicated automatic testing systems are in routine use in a wide variety of manufacturing and maintenance situation.



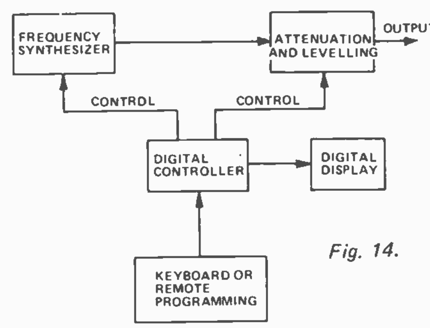


Fig. 14.

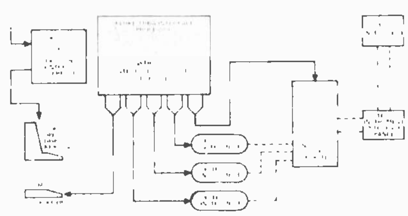
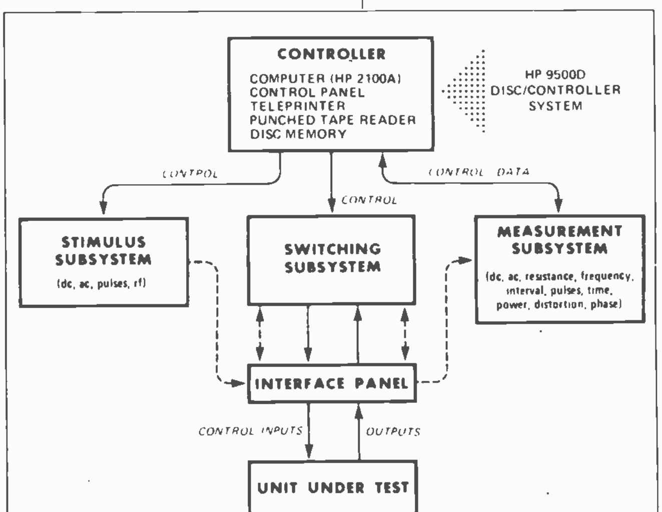


Fig. 15. Block diagram of Fluke calibration standard.



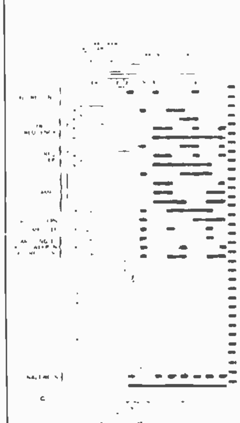


Fig. 16. Overall concept of HP9500 series of automatic test systems.

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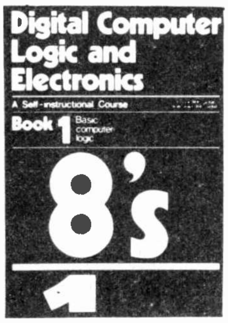

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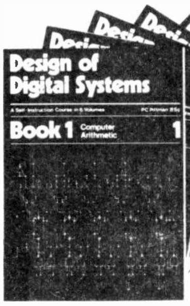

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ELECTRONICS TOMORROW

by John Miller-Kirkpatrick

DIRECT ACCESS

SINCE I MENTIONED converting a record player into a mass storage device for a microprocessor a few people seem to have been considering the problem. If you remember I had suggested converting a 12in LP into a magnetically coated disk and then using a Read/Write head to travel across to one of several 'tracks' and then to read or write data on that track. The problems appeared to be in coating the disk and also in the low data capacity of the system. Eric Huggins of Stoke Poges suggested using a 16in disk at 78RPM divided into tracks ⅛in apart, recording in CUTS format which would give 128K bits of data with an access time of one second, if the more common 12in disk was used then the capacity would be reduced to 64K bits.

The main disadvantage of the disk appears to be in getting the thing coated and this problem led to the idea of a Mr Edison of America recording on a drum rather than a disk. Glyn Phillips of Highgate pointed this obvious omission in my line of thinking, if early phonographs used drums then why not early MPUs. To combine his ideas and those of Mr Francis of Sheffield you end up with a cylinder covered with rolls of magnetic tape. If you consider a cylinder about 6in in diameter (20in circumference) rotating at 1 revolution every ten seconds then the data would be passing the R/W head at 2 ips which is nearly the 1⅞ ips used for cassette recording. With the CUTs system the recording speed is 300 bits per second or 150 bits per inch, thus each of our 20in tracks would hold 3,000 bits of data. With a standard monaural cassette recording head each track would be ⅛in wide and thus a drum 10 inches long would have a capacity of 80 tracks of 24,000 bits of data. Using a stereo head would double the capacity of each drum as would doubling the diameter. If an ex-computer 9 track head and 1in wide tape can be found then the same system could be used at much higher densities. The data in this case could be recorded in parallel with the 9th track being used as a data clock, as densities of 800 and 1,600 bits per inch can be used then the capacity of our 10in by 6in drum would be 160 Kilobytes. Even if the unit cost £80 to build then the storage cost is only 50p per kbyte compared to nearly £50 per kbyte for RAM. If anybody gets anywhere near building one please let me know if it works!

RAM IT IN YOUR ROM SLOT

Or vice-versa if you prefer. One of the standard RAM chips made by several manufacturers is a 256 x 4 bit device in a 16 pin package, a typical number for this is the MM2112. The problem with RAM is that it is not very good for keeping long term storage such as programs or look-up tables. ROM is a much better storage medium for these applications as the data is not lost when the chip is unpowered, however, ROM is expensive for prototypes as each has to be manufactured complete with its data.

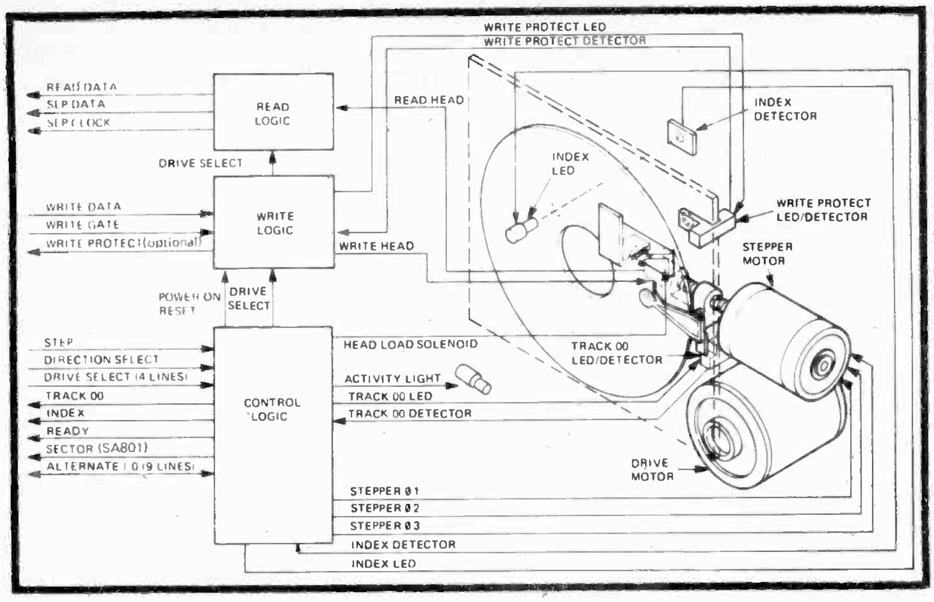
National Semiconductors have now announced the 74S287 TRI-STATE PROM which is pin compatible with the 2112 RAM and can be programmed easily in low volumes. This means that a microprocessor could be programmed and tested using RAM and than a PROM copy made and plugged in in place of the RAM. The PROM programming sequence is fairly simple and a programmer could be built at little cost (again, let me know if you do build one). Programming will occur at a selected address when Vcc is held at 10.5v, the appropriate output is held between 9.5v and 11v and the chip is subsequently enabled.

1. Select the word address by applying high or low logic levels to the appropriate address pins. Ensure that the chip is disabled by a high level to one or both of the chip enable inputs.
2. Increase Vcc to 10.5v at a rate between 1 and 10 volts per microsecond, (Vcc must be capable of supplying 400mA).
3. Select one of the outputs where a logical '1' is required by raising that pin to 10.5v. Outputs not being programmed must be left open circuit and only one output can be programmed at each time.
4. Enable the chip by taking both enable inputs low for 10μS.
5. Remove the voltage from the output pin and then reduce Vcc to 4v. Enable the chip and check that the bit has been programmed to a logical '1'. For high programming yield steps 2-5 may be repeated up to 10 times.
6. Repeat 2-5 for each bit to be programmed in the selected word.
7. Repeat 1-6 until all 256 words are programmed, re-check each word.

Full details of the programming procedure of these PROMs and similar devices can be obtained from the manufacturers.

REAL FLOPPIES

Previously we discussed the idea of a direct-access device for use by an amateur constructor but we missed out on one important point. If you only require to store and retrieve information on your own MPU then a unit which is unique to your system is OK. If you wanted to exchange data with another MPU or with a large mainframe computer then you would have to use cassette or floppies. I have not heard of a mainframe unit which will accept CUTS format cassette tapes and therefore the best intercommunications device would be a floppy disk. Several types are now available on the market covering a range from full IBM compatibility to a new mini-floppy which was mentioned a couple of months ago.



The SA800 Diskette Storage Drive from Shugart Associates has an IBM compatible capacity of 2 Megabits and an absolute maximum of 6.4 Megabits. The diagram shows its mechanical operation as follows — the required disk is slid into place and the unit started, this causes the drive motor to spin the disk at high speed. The Write Protect system works in a similar manner to that of a cassette tape by not allowing a write to the disk if the disk is for read-only operation. An electrical stepping motor and lead screw positions the read/write head. The stepping motor rotates the lead screw clockwise or counter-clockwise in 15° increments, each increment moves the R/W head one track position. The R/W head is mounted on a carriage which is located on the Head Postion Actuator lead screw.

The high rotational speed of the floppy (360 RPM) gives data transfer rates of 250 kilobits per second and an access time for any data on the disk of 260mS (average). Compare this to our earlier figures and some of you may decide to save up to buy a floppy rather than building your own. If the £625 price tag for the SA800 is too high then how about the £495 tag on a minifloppy? The SA400 is only 3½ x 6 x 8 inches in size but has about one-third of the capacity of the SA800 and uses a 5in disk rather than the 8in disk used on the standard floppy. With each disk costing only about £5 and holding nearly 100 kilobytes of data the price per kbyte is only 5p compared to 50p for our system and £50 for RAM.

REFERENCES:

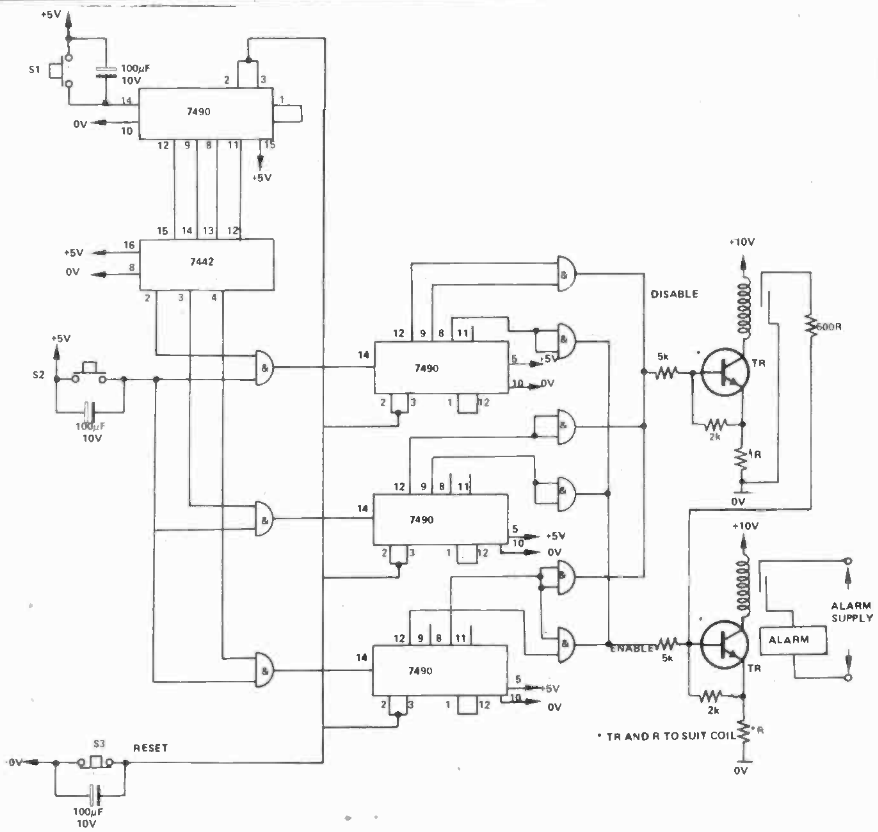
RAM/PROMs — National semiconductors (UK) Ltd, 19 Goldington Road, Bedford. Signetics, Texas, Intel, etc. also do similar chips. Floppies: Shugart Associates, 435 Indio Way, Sunnyvale, Calif 94086; or contact Bywood Electronics.

tech-tips

Tech-Tips is an ideas forum and is not aimed at the beginner. We regret we cannot answer queries on these items.

ETI is prepared to consider circuits or ideas submitted by readers for this page. All items used will be paid for. Drawings should be as clear as possible and the text should preferably be typed. Circuits must not be subject to copyright. Items for consideration should be sent to ETI TECH-TIPS Electronics Today International, 36 Ebury Street, London SW1W 0LW.

COMBINATION LOCK



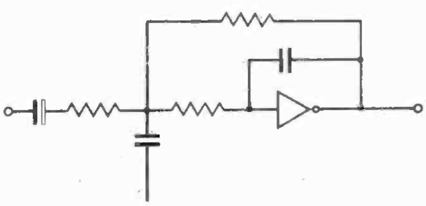
The circuit and switching system is simplified by the use of a multiplex system. S1 inputs pulses to the decade counter 7490. The resulting BCD is decoded by the 7442. It is the decimal output of this which carries out the multiplexing via the AND-gates.

S2 inputs pulses which are transferred to the other 7490 decade counters by the AND-gate multiplex system. The BCD output from the 7490's is taken to the AND-gates whose outputs control the Alarm 'Disable' and 'Enable' switch system.

The 'Disable' function effectively prevents TR2 from being biased on and hence prevents the 'Enable' Reed relay from working.

This circuit has several advantages over conventional electronuc combination locks as only two switches need be installed on the object to be guarded, regardless of the number of figures in the combination. The value of the example combination is 314. The alarm is triggered if any of these digits is exceeded in value. While the circuit is capable of directly driving an actuator it is recommended that it is only used to disable an alarm system — conventional locks doing the actual locking. (To operate the example the switch sequence would be: S1, S2, S2, S2, S1, S2, S1, S2, S2, S2, S2.)

FILTERS USING CMOS

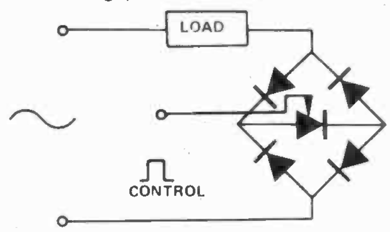


High pass and low pass filters may be readily constructed using CMOS inverters (CD4007 CD4069 74C04) since these have only a single complementary pair, and hence lower power dissipation and less likelihood of instability. A form of Sallen and Key:

Standard equations are used to determine component values. It is recommended that passband gain be restricted to unity.

THYRISTOR TIP

For full-wave control from a thyristor, add a bridge, how about:



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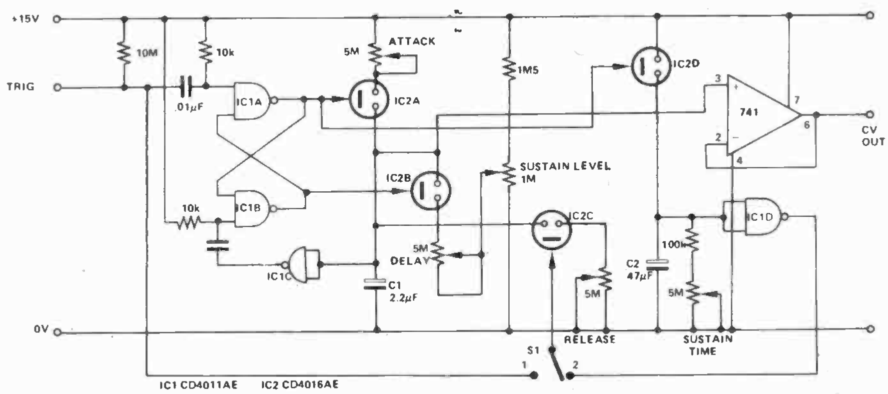

When a negative going trigger pulse is applied to the input, IC2(c) disconnects the 'release' pot, the bistable is set and the 'attack' pot connected to C1. C1 charges up to the threshold voltage of IC1(c) where the bistable is reset. IC2(b) causes C1 to discharge to the level set on the 'sustain level' pot. If S1 is in position '1', when the trigger pulse goes high again IC2(c) causes C1 to discharge via the 'release' pot.

During the time IC1(a) is high C2 is charged up forcing the output of IC1(d) low. Once IC1(a) has gone low C2 begines to discharge and after a while IC1(d)'s output will go high again. When S1 is in position '2' the sustain is controlled by the monostable thus formed. It is retriggable so that should a second trigger arrive before the cycle has completed the cycle will restart. The 741 buffers the output.

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APPLICATIONS: Hi-Fi — Mixers — Disco — Guitar and Organ — Public address

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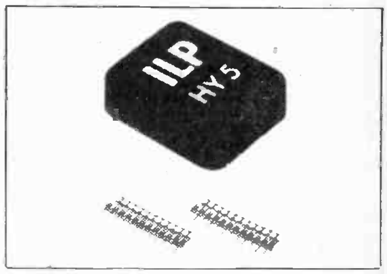
OUTPUTS Tape 100mV Main output 500mV R.M.S.
ACTIVE TONE CONTROLS Treble ± 12dB at 10kHz Bass ± at 100Hz
DISTORTION 0.1 at 1kHz Signal/Noise Ratio 68dB
OVERLOAD 38dB on Magnetic Pick-up SUPPLY VOLTAGE ± 16-50V

Price £4.75 + 59p VAT P&P free.



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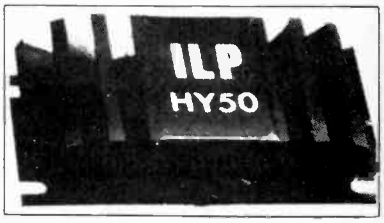
SUPPLY VOLTAGE ± 25V SIZE 105.50.25mm

Price £6.20 + 77p VAT P&P free.



HY120
60 Watts into 8Ω

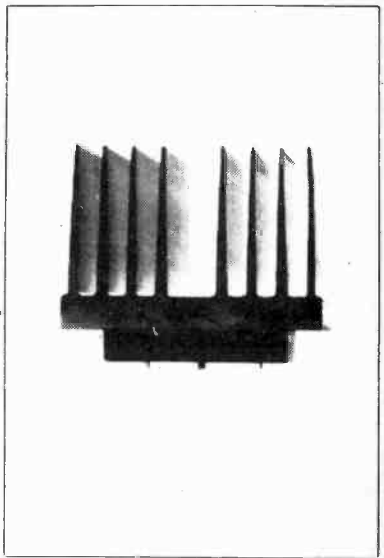
The HY120 is the baby of I.L.P.'s new high power range, designed to meet the most exacting requirements including load line and thermal protection this amplifier sets a new standard in modular design.

FEATURES: Very low distortion — Integral heatsink — Load line protection — Thermal protection — Five connections — No external components

APPLICATIONS: Hi-Fi — High quality disco — Public address — Monitor amplifier — Guitar and organ

SPECIFICATIONS
INPUT SENSITIVITY 500mV
OUTPUT POWER 60W RMS into 8Ω LOAD IMPEDANCE 4-16Ω DISTORTION 0.04 at 60W at 1kHz
SIGNAL/NOISE RATIO 90dB FREQUENCY RESPONSE 10Hz-45kHz 3dB SUPPLY VOLTAGE ± 35V
SIZE 114.50.85mm

Price £14.40 + £1.16 VAT P&P free.



HY200
120 Watts into 8Ω

The HY200 now improved to give an output of 120 Watts has been designed to stand the most rugged conditions such as disco or group while still retaining true Hi-Fi performance.

FEATURES: Thermal shutdown — Very low distortion — Load line protection — Integral heatsink — No external components

APPLICATIONS: Hi-Fi — Disco — Monitor — Power slave — Industrial — Public Address

SPECIFICATIONS
INPUT SENSITIVITY 500mV
OUTPUT POWER 120W RMS into 8Ω LOAD IMPEDANCE 4-16Ω DISTORTION 0.05 at 100W at 1kHz
SIGNAL/NOISE RATIO 96dB FREQUENCY RESPONSE 10Hz-45kHz 3dB SUPPLY VOLTAGE ± 45V
SIZE 114.100.85mm

Price £21.20 + £1.70 VAT P&P free.

HY400
240 Watts into 4Ω

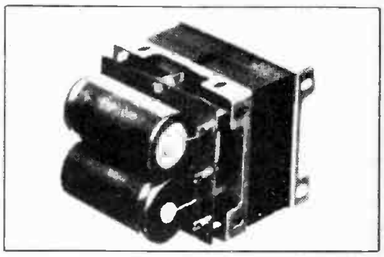
The HY400 is I.L.P.'s "Big Daddy" of the range producing 240W into 4Ω! It has been designed for high power disco or public address applications. If the amplifier is to be used at continuous high power levels a cooling fan is recommended. The amplifier includes all the qualities of the rest of the family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

FEATURES: Thermal shutdown — Very low distortion — Load line protection — No external components

APPLICATIONS: Public address — Disco — Power slave — Industrial

SPECIFICATIONS
OUTPUT POWER 240W RMS into 4Ω LOAD IMPEDANCE 4-16Ω DISTORTION 0.1 at 240W at 1kHz
SIGNAL/NOISE RATIO 94dB FREQUENCY RESPONSE 10Hz-45kHz 3dB SUPPLY VOLTAGE ± 45V
INPUT SENSITIVITY 500mV SIZE 114×100×85mm

Price £29.25 + £2.34 VAT P&P free.



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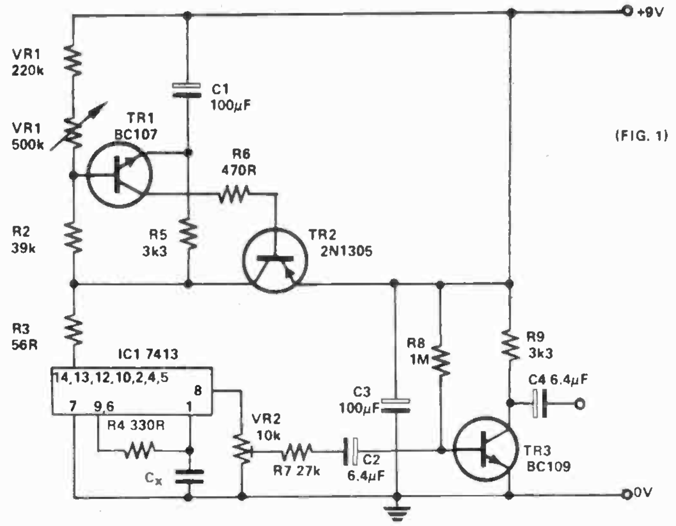
TONE BURST GENERATOR

The circuit in Fig. 1 generates the waveform shown in Fig. 2. The output is basically oscillations at a certain frequency outputed in small pulses. This type of waveform has varied uses ranging from a beat for an organ or synthesizer to audio or radio frequency testing.

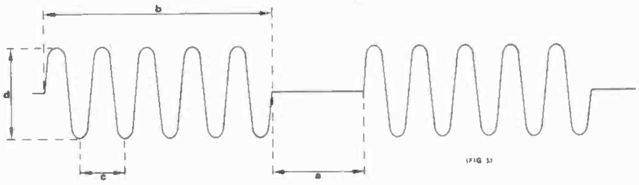
The variable parameters of the waveform are shown in Fig. 3:-

VR1 alters the time between pulses.
C1 alters the length of the pulse.
VR2 alters the amplitude of the waveform.
Cx alters the frequency of the waveform within a pulse. This ranges from .0005 giving RF, to 5 giving AF. (microfarads)



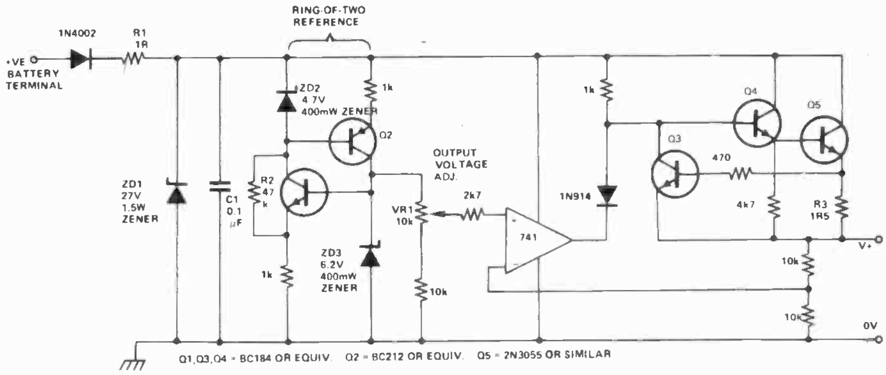
(FIG. 1)

(FIG. 2)



(FIG. 3)

MOBILE POWER SUPPLY



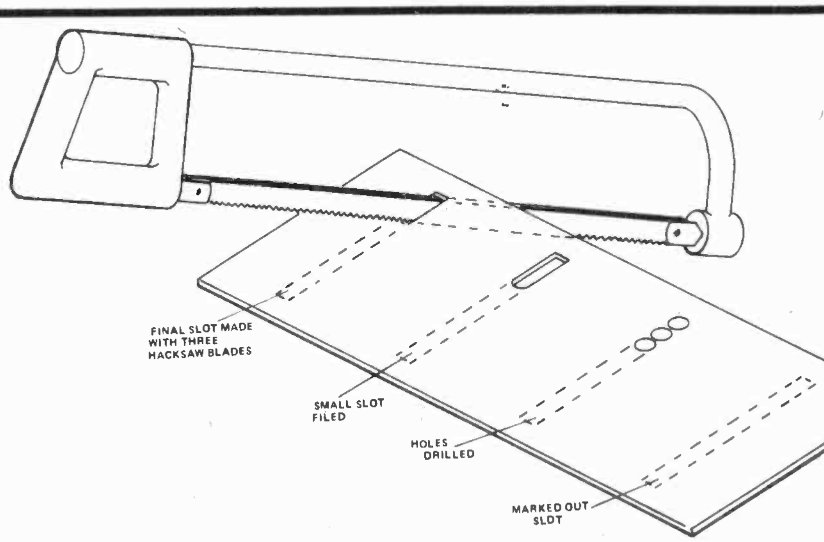
R1, C1 and ZD1 provide clipping and smoothing of supply spikes, while D1 protects against reverse polarity connection. The reference voltage is provided by the ring-of-two, since in this configuration the zeners bias constant-current sources for each other, the output across ZD3 is almost totally independent of supply variations. R2 ensures the ring starts reliably.

A set fraction of the reference voltage is applied, via VR1, to the 741, which in conjunction with current amplifiers Q4, Q5 forms a negative feedback loop to maintain the output voltage constant. It may be set between 10 and 6 volts, so, for instance, most battery cassette equipment may be driven. Short-circuit protection is provided by Q3; when the output current exceeds 400mA sufficient voltage is dropped across R3 to turn on Q3, which shunts drive away from the base of Q4 and hence prevents the output current from rising further.

EASY SLIDER FITTING

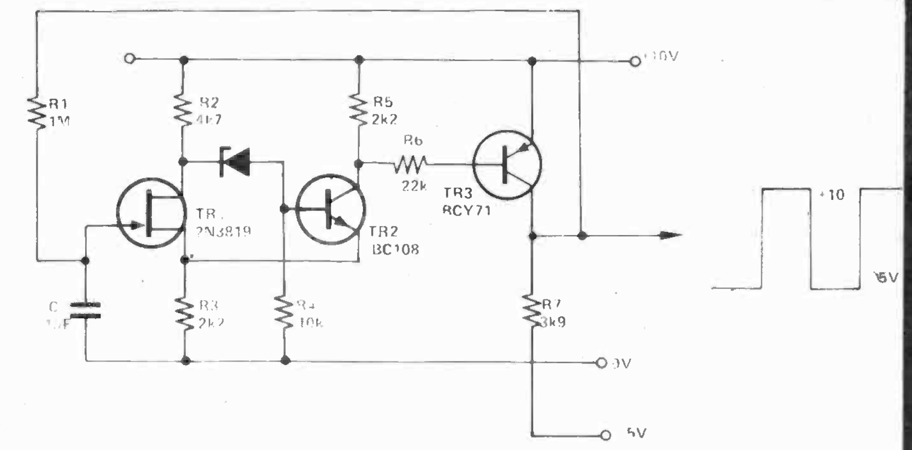
After making out the slots in their respective positions, three or four holes are drilled close to each other at one end of the slot. These holes are then joined up by initially using a needle file followed by a flat ward file. The resultant slot should be large enough to accommodate three hacksaw blades side by side as shown on the sketch.

These blades are fixed in a standard hacksaw frame or can be hand held. Using this arrangement, the required width of the slider control slot can be easily cut for any given length, and finishing off with a file.



tech-tips

LOW FREQUENCY SQUARE WAVE OSCILLATOR



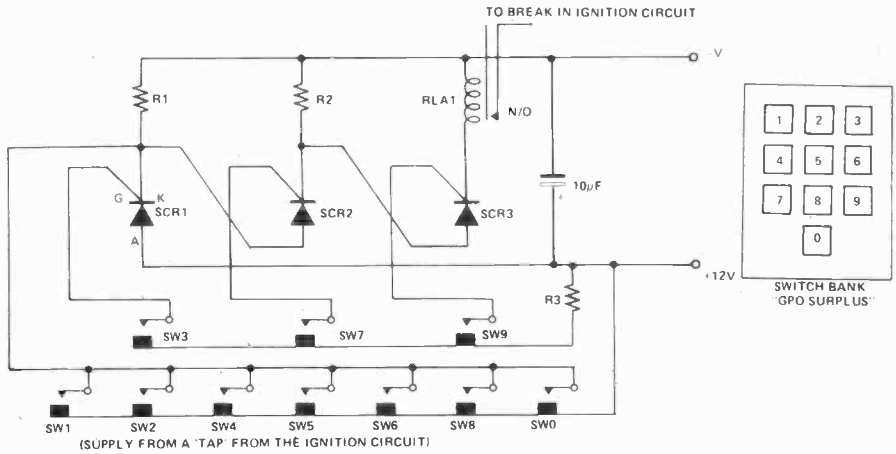
A drawback of low frequency oscillators using bipolar transistors or TTL logic is that the timing capacitor usually has to be a high value electrolytic. Using a field effect transistor at the input of a schmitt trigger, means a low value capacitor can be employed. The trigger by TR1 and TR2 has a hysterisis of approximately 3V. This is controoled by the 3V zener.

With C1 uncharged TR1 is off and TR2 is forward biased. The voltage at the source of TR1 is approximately +4V. TR2 conducts, thus turning on TR3. The output is therefore at +10V. C1 then charges via R1 and the gate voltage of TR1 goes positive. When the gate voltage is sufficiently positive TR1 conducts, turning off TR2. The positive feedback from the emitter of TR2 to the source of TR1 ensures a rapid switch off. TR3 also switches off and the output goes to −5V. Capacitor C1 now discharges towards −5V, but when the voltage across C1 falls by approximately 3V, TR1 ceases to conduct, turning on TR2.

The collector load of TR3 is connected to a negative supply giving a 50% duty cycle. (The circuit still oscillates if R7 is connected to 0V but the duty cycle will change, the output remaining at 0V for a longer period than at +10V).

With the components as shown the frequency of the output is approximately 0.025Hz.

CODE SWITCH



When button 3 is pressed R3 'Gates' SCR 1, which remains on with a load of R1. It also supplies voltage to the anode of SCR 2.

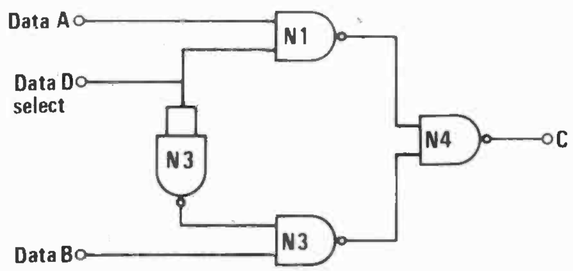
When button 7 is pressed SCR 2 is 'Gated' by R3 also, and held on by R2, thus supplying the anode of SCR 3, which when 'Gated' by button 9 closes the relay and makes an external circuit.

It can also be used to switch a circuit off depending on how the relay is wired. This would be an advantage in a home intruder alarm.

Components: The Thyristors can be any type and values for R1 and 2 selected to hold the SCR's in conduction. R3 is selected to suit the thyristors. The remaining buttons, 1,2,4,5,6, 8,0 when pressed short out SCR1, thus switching off any following SCR.

THE 7400 A TWO-WAY DATA SELECTOR!

When the "DATA SELECT" terminal is at logical '0', the output of N1 is held high, whilst information presented on the "DATA B" terminal is transferred to the output of the circuit. Similarly, when the "DATA SELECT" terminal is at logical "1", the output of N3 is held high, whilst "DATA A" is transferred to the output. In a parallel data system one 7400 would be used for each bit.



input			output
D	A	B	C
0	X	0	0
0	X	1	1
1	0	X	0
1	1	X	1

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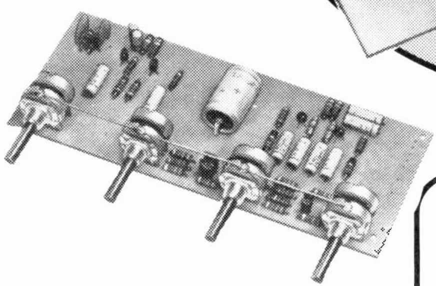

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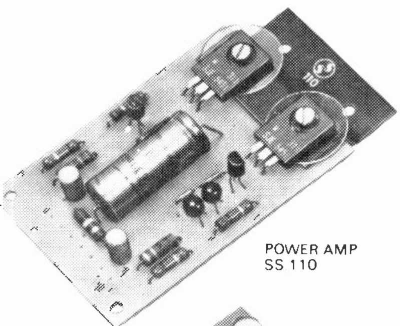

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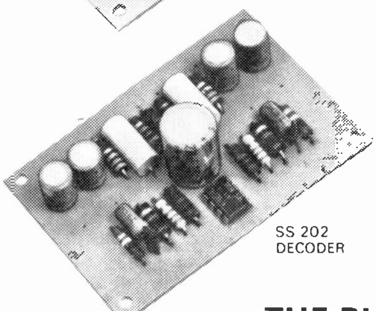

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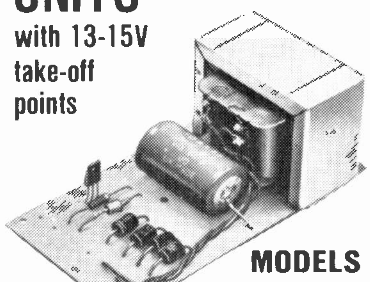

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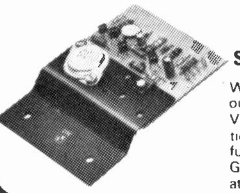

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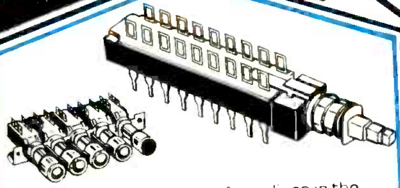

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