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JUNE 1976

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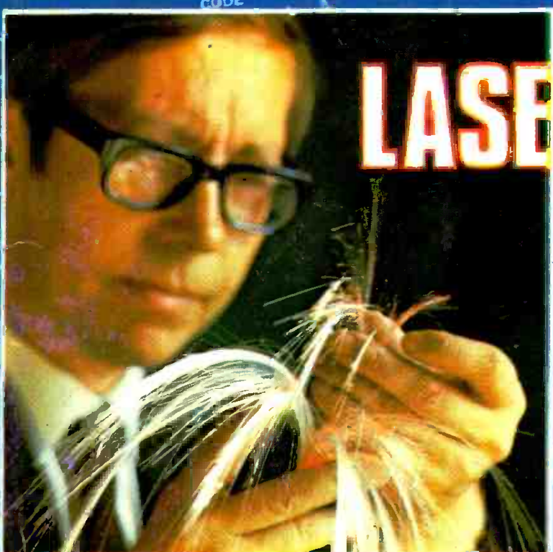

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JUNE 1976 VOL 5. No. 6

Features

Projects

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BI-PAK SEMICONDUCTORS

TRANSISTORS

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TYPE	PRICE						
		BC170	0.10	BFX88	*0.22	2N718A	*0.51
AC107	*0.20	BC171	0.10	BFY50	*0.20	2N726	*0.29
AC113	*0.19	BC172	0.10	BFY51	*0.20	2N727	*0.29
AC115	*0.20	BC173	0.15	BFY52	*0.20	2N743	*0.20
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AC122	*0.12	BC175	*0.35	BSX19	*0.16	2N914	*0.15
AC125	*0.18	BC177	*0.19	BSX20	*0.16	2N918	*0.31
AC126	*0.18	BC178	*0.19	BSY25	*0.16	2N929	*0.21
AC127	*0.19	BC179	*0.19	BSY26	*0.16	2N930	*0.31
AC128	*0.19	BC180	*0.25	BSY27	*0.16	2N1131	*0.20
AC132	*0.15	BC181	0.25	BSY28	*0.16	2N1132	*0.22
AC134	*0.15	BC182	0.15	BSY29	*0.16	2N1302	*0.15
AC137	*0.15	BC182L	0.15	BSY38	*0.19	2N1303	*0.15
AC141	*0.19	BC183	0.15	BSY39	*0.19	2N1304	*0.18
AC141K	*0.30	BC183L	0.15	BSY40	*0.29	2N1305	*0.18
AC142	*0.19	BC184	0.20	BSY41	*0.29	2N1306	*0.21
AC142K	*0.26	BC184L	0.20	BSY95	*0.13	2N1307	*0.21
AC151	*0.16	BC186	*0.29	BSY95A	*0.13	2N1308	*0.24
AC154	*0.20	BC187	*0.29	BU105	*2.04	2N1309	*0.24
AC155	*0.20	BC207	0.11	C111E	*0.51	2N1613	*0.20
AC156	*0.20	BC208	0.11	C400	*0.31	2N1711	*0.20
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AC165	*0.20	BC212L	0.13	C424	*0.26	2N1890	*0.46
AC166	*0.20	BC213L	0.13	C425	*0.51	2N1893	*0.38
AC167	*0.20	BC214L	0.17	C426	*0.36	2N2147	*0.73
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AC176	*0.20	BC301	*0.28	C442	*0.31	2N2192	*0.36
AC177	*0.25	BC302	*0.25	C444	*0.36	2N2193	*0.36
AC178	*0.29	BC303	*0.31	C450	*0.22	2N2194	*0.36
AC179	*0.29	BC304	*0.37	MAT100	*0.19	2N2217	*0.22
AC180	*0.20	BC440	*0.31	MAT101	*0.20	2N2218	*0.20
AC180K	*0.30	BC460	*0.37	MAT120	*0.19	2N2219	*0.20
AC181	*0.20	BCY30	*0.65	MAT121	*0.20	2N2220	*0.22
AC181K	*0.30	BCY31	*0.65	MJE521	*0.56	2N2221	*0.20
AC187	*0.22	BCY32	*0.70	MJE2955	*0.88	2N2222	*0.20
AC187K	*0.26	BCY33	*0.60	MJE3055	*0.57	2N2368	*0.18
AC188	*0.22	BCY34	*0.65	MJE3440	0.51	2N2369	*0.15
AC188K	*0.23	BCY70	*0.15	MPF102	*0.43	2N2369A	*0.15
ACY17	*0.26	BCY71	*0.20	MPF104	*0.38	2N2411	*0.25
ACY18	*0.24	BCY72	*0.15	MPF105	*0.38	2N2412	*0.25
ACY19	*0.24	BCZ10	*0.50	OC19	*0.36	2N2646	*0.48
ACY20	*0.24	BCZ11	*0.50	OC20	*0.65	2N2711	0.21
ACY21	*0.24	BCZ12	*0.50	OC22	*0.47	2N2712	0.21
ACY22	*0.24	BD115	*0.63	OC23	*0.49	2N2714	0.21
ACY27	*0.19	BD116	*0.81	OC24	*0.57	2N2904	*0.18
ACY28	*0.19	BD121	*0.61	OC25	*0.39	2N2904A	*0.21
ACY29	*0.36	BD123	*0.67	OC26	*0.30	2N2905	*0.21
ACY30	*0.29	BD124	*0.70	OC28	*0.51	2N2905A	*0.21
ACY31	*0.29	BD131	*0.51	OC29	*0.51	2N2906	*0.16
ACY34	*0.21	BD132	*0.61	OC35	*0.43	2N2906A	*0.19
ACY35	*0.21	BD133	*0.67	OC36	*0.51	2N2907	*0.20
ACY36	*0.29	BD136	0.41	OC41	*0.20	2N2907A	*0.22
ACY40	*0.18	BD137	0.46	OC42	*0.25	2N2923	0.15
ACY41	*0.19	BD138	0.51	OC44	*0.16	2N2924	0.15
ACY44	*0.36	BD139	0.56	OC45	*0.13	2N2925	0.15
AD130	*0.39	BD140	0.61	OC70	*0.15	2N2926G	0.13
AD140	*0.49	BD155	*0.81	OC71	*0.15	2N2926Y	0.11
AD142	*0.49	BD175	*0.61	OC72	*0.15	2N29260	0.10
AD143	*0.30	BD176	*0.61	OC74	*0.15	2N2926R	0.10
AD149	*0.51	BD177	*0.67	OC75	*0.16	2N2926B	0.10
AD161	*0.36	BD178	*0.67	OC76	*0.16	2N3010	*0.71
AD162	*0.36	BD179	*0.71	OC77	*0.26	2N3011	*0.15
AD161 &		BD180	*0.71	OC81	*0.16	2N3053	*0.18
AD162(MP)		BD185	*0.67	OC81D	*0.16	2N3054	*0.47
	*0.69	BD186	*0.67	OC82	*0.16	2N3055	*0.42
ADT140	*0.51	BD187	*0.71	OC82D	*0.16	2N3319	0.15
AF114	*0.25	BD188	*0.71	OC83	*0.20	2N3391A	0.17
AF115	*0.25	BD189	*0.77	OC139	*0.20	2N3392	0.15
AF116	*0.25	BD190	*0.77	OC140	*0.20	2N3393	0.15
AF117	*0.25	BD195	*0.87	OC169	*0.26	2N3394	0.15
AF118	*0.36	BD196	*0.87	OC170	*0.26	2N2295	0.18
AF124	*0.31	BD197	*0.92	OC171	*0.26	2N3402	*0.29
AF125	*0.31	BD198	*0.92	OC200	*0.26	2N3403	*0.29
AF126	*0.29	BD199	*0.98	OC201	*0.29	2N3404	*0.29
AF127	*0.29	BD200	*0.98	OC202	*0.29	2N3405	*0.34
AF139	*0.31	BD205	*0.81	OC203	*0.29	2N3414	0.16
AF178	*0.51	BD206	*0.81	OC204	*0.26	2N3415	0.16
AF179	*0.51	BD207	*0.98	OC205	*0.36	2N3416	0.29
AF180	*0.51	BD208	*0.98	OC309	*0.41	2N3417	0.29
AF181	*0.51	BDY20	*1.02	OCP71	*0.44	2N3525	*0.77
AF186	*0.51	BF115	*0.25	ORP12	*0.60	2N3614	*0.69
AF239	*0.38	BF117	*0.46	ORP60	*0.60	2N3615	*0.76
AL102	*0.68	BF118	*0.71	ORP61	*0.60	2N3616	*0.76
AL103	*0.68	BF119	*0.71	P20	*0.51	2N3646	0.09
ASY26	*0.26	BF121	0.46	P346A	*0.20	2N3702	0.12
ASY27	*0.31	BF123	0.51	P397	*0.43	2N3703	0.12
ASY28	*0.26	BF125	0.46	ST140	*0.13	2N3704	0.13
ASY29	*0.26	BF127	0.51	ST141	*0.18	2N3705	0.12
ASY50	*0.26	BF152	0.56	TIP29	0.44	2N3706	0.12
ASY51	*0.26	BF153	0.46	TIP30	0.52	2N3707	0.13
ASY52	*0.26	BF154	0.46	TIP31A	*0.56	2N3708	0.08
ASY54	*0.26	BF155	*0.71	TIP32A	*0.68	2N3709	0.09
ASY55	*0.26	BF156	*0.49	TIP41A	*0.68	2N3710	0.09
ASY56	*0.26	BF157	*0.56	TIP42A	*0.68	2N3711	0.09
ASY57	*0.26	BF158	0.56	TIS43	*0.31	2N3819	*0.29
ASY58	*0.26	BF159	0.61	UT46	*0.28	2N3820	*0.51
ASY73	*0.26	BF160	0.41	ZN414	*1.11	2N3821	*0.60
ASZ21	*0.41	BF162	0.41	2G301	*0.19	2N3823	*0.29
BC107	*0.08	BF163	0.41	2G302	*0.19	2N3903	0.29
BC108	*0.08	BF164	0.41	2G303	*0.19	2N3904	0.31
BC109	*0.08	BF165	0.41	2G304	*0.25	2N3905	0.29
BC113	0.10	BF167	*0.22	2G306	0.41	2N3906	0.28
BC114	0.16	BF173	*0.22	2G308	0.36	2N4058	0.12
BC115	0.16	BF176	0.36	2G309	0.37	2N4059	0.10
BC116	0.16	BF177	*0.36	2G339	0.20	2N4060	0.12
BC117	0.19	BF178	*0.31	2G339A	0.17	2N4061	0.12
BC118	0.10	BF179	*0.31	2G344	0.19	2N4062	0.12
BC119	*0.31	BF180	*0.31	2G345	0.17	2N4284	0.18
BC120	*0.81	BF181	*0.31	2G371	0.17	2N4285	0.18
BC125	0.12	BF182	*0.41	2G371B	0.12	2N4286	0.18
BC126	0.25	BF183	*0.41	2G373	0.17	2N4287	0.18
BC132	0.11	BF184	*0.26	2G374	0.18	2N4288	0.18
BC134	0.19	BF185	*0.31	2G377	0.31	2N4289	0.18
BC135	0.12	BF187	*0.28	2G378	0.17	2N4290	0.18
BC136	0.16	BF188	0.41	2G381	0.17	2N4291	0.18
BC137	0.16	BF194	0.12	2G382	0.17	2N4292	0.18
BC139	*0.41	BF195	0.12	2G401	0.31	2N4293	0.18
BC140	*0.31	BF196	0.15	2G414	0.31	2N5172	0.12
BC141	*0.31	BF197	0.15	2G417	0.26	2N5194	0.56
BC143	*0.31	BF200	*0.46	2N388	0.36	2N5294	*0.56
BC145	0.46	BF222	*0.98	2N388A	0.56	2N5296	*0.56
BC147	0.10	BF257	*0.46	2N404	0.26	2N5457	*0.32
BC148	0.10	BF258	*0.61	2N404A	0.29	2N5458	*0.32
BC149	0.12	BF259	*0.87	2N524	0.45	2N5459	*0.41
BC150	0.19	BF262	0.56	2N527	0.50	2N6122	*0.69
BC151	0.20	BF263	0.56	2N598	0.43	2S301	*0.51
BC152	0.18	BF270	*0.36	2N599	0.46	2S302A	*0.43
BC153	0.29	BF271	*0.31	2N696	0.13	2S302	*0.43
BC154	0.21	BF272	*0.81	2N697	0.14	2S303	*0.56
BC157	0.19	BF273	0.36	2N698	0.25	2S304	*0.71
BC158	0.12	BF274	0.36	2N699	0.36	2S305	*0.80
BC159	0.12	BFW10	*0.61	2N706	0.11	2S306	*0.80
BC160	*0.46	BFX29	*0.28	2N706A	0.12	2S307	*0.80
BC161	*0.51	BFX84	*0.22	2N708	0.14	2S321	*0.75
BC167	0.12	BFX85	*0.31	2N711	0.31	2S322	*0.43
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Type	Quantities 1	25	100+	Type	Quantities 1	25	100+
7400	0.14	0.13	0.12	7486	0.32	0.31	0.30
7401	0.14	0.13	0.12	7489	3.70	3.47	3.24
7402	0.14	0.13	0.12	7490	0.60	0.58	0.56
7403	0.14	0.13	0.12	7491	1.02	0.97	0.93
7404	0.14	0.13	0.12	7492	0.69	0.66	0.59
7405	0.14	0.13	0.12	7493	0.69	0.66	0.59
7406	0.36	0.31	0.29	7494	0.79	0.76	0.69
7407	0.36	0.31	0.29	7495	0.79	0.76	0.69
7408	0.23	0.22	0.21	7596	0.89	0.86	0.80
7409	0.23	0.22	0.21	74100	1.39	1.34	1.30
7410	0.14	0.13	0.12	74104	0.56	0.54	0.51
7411	0.23	0.22	0.21	74105	0.56	0.54	0.51
7412	0.26	0.25	0.24	74107	0.41	0.39	0.37
7413	0.30	0.29	0.28	74110	0.56	0.51	0.46
7416	0.28	0.27	0.26	74111	0.83	0.81	0.78
7417	0.28	0.27	0.26	74118	0.93	0.88	0.83
7420	0.14	0.13	0.12	74119	1.39	1.30	1.20
7422	0.28	0.27	0.26	74121	0.46	0.44	0.41
7423	0.37	0.36	0.35	74122	0.65	0.63	0.60
7425	0.37	0.36	0.35	74123	0.69	0.68	0.65
7426	0.37	0.35	0.33	74141	0.79	0.76	0.73
7427	0.37	0.35	0.33	74145	1.20	1.16	1.11
7428	0.42	0.39	0.37	74150	1.39	1.30	1.20
7430	0.14	0.13	0.12	74151	1.02	0.97	0.93
7432	0.37	0.35	0.33	74153	0.93	0.88	0.83
7433	0.39	0.37	0.35	74154	1.57	1.43	1.48
7437	0.32	0.30	0.28	74155	1.11	1.06	1.02
7438	0.32	0.30	0.28	74156	1.11	1.06	1.02
7440	0.14	0.13	0.12	74157	0.93	0.88	0.83
7441	0.69	0.66	0.59	74160	1.30	1.25	1.20
7442	0.69	0.66	0.59	74161	1.30	1.25	1.20
7443	1.11	1.06	1.02	74162	1.30	1.25	1.20
7444	1.11	1.06	1.02	74163	1.30	1.25	1.20
7445	1.48	1.44	1.39	74164	1.67	1.62	1.55
7446	1.11	1.06	1.02	74165	1.67	1.62	1.55
7447	1.02	0.99	0.97	74166	1.48	1.44	1.39
7448	1.02	0.99	0.97	74174	1.48	1.44	1.39
7450	0.14	0.13	0.12	74175	1.02	0.97	0.93
7451	0.14	0.13	0.12	74176	1.16	1.11	1.06
7453	0.14	0.13	0.12	74177	1.16	1.11	1.06
7454	0.14	0.13	0.12	74180	1.16	1.11	1.06
7460	0.14	0.13	0.12	74181	3.66	3.56	3.47
7470	0.30	0.27	0.25	74182	1.16	1.11	1.06
7472	0.30	0.27	0.25	74184	1.67	1.62	1.55
7473	0.38	0.36	0.32	74190	1.81	1.76	1.71
7474	0.38	0.36	0.32	74191	1.81	1.76	1.71
7475	0.56	0.54	0.52	74192	1.81	1.76	1.71
7476	0.41	0.40	0.39	74193	1.81	1.76	1.71
7480	0.56	0.54	0.51	74194	1.20	1.16	1.11
7481	1.02	0.97	0.93	74195	1.02	0.97	0.93
7482	0.83	0.79	0.74	74196	1.11	1.06	1.02
74197	1.11	1.06	1.02	7483	1.11	1.06	0.97
74198	2.55	2.50	2.45	7484	0.93	0.90	0.88
74199	2.31	2.21	2.11	7485	1.48	1.44	1.39

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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	0.44	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	uA703C	0.26	0.24	0.22
72709P	0.19	0.18	0.17	uA709C	0.19	0.18	0.17
72710	0.32	0.31	0.28	uA711C	0.32	0.31	0.28
72741	0.28	0.27	0.26	uA712C	0.32	0.31	0.28
72741C	0.26	0.25	0.24	uA723C	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	IN4001	0.05	0.07	0.14	*0.19	*0.56
100	0.05	0.07	IN4002	0.06	0.09	0.16	*0.21	*0.69
200	0.06	0.09	IN4003	0.07	0.12	0.20	*0.23	*0.93
400	0.07	0.14	IN4004	0.08	0.14	0.28	*0.35	*0.25
600	0.08	0.16	IN4005	0.09	0.16	0.33	*0.42	*1.76
800	0.11	0.18	IN4006	0.10	0.18	0.35	*0.51	*1.94
1000	0.13	0.28	IN4007	0.11	0.23	0.44	*0.60	*2.31
1200	—	0.32	IN4007		0.28	0.54	*0.69	*2.88

*TRIACS

Case		100V	200V	400V
2 Amp	TO5	0.31	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

Pak No.		Description	Price
U1	120	Glass Sub-min G.P Germ. diodes	0.60
U2	50	Mixed Germanium transistors AF/RF	*0.60
U3	75	Germ. gold bonded sub-min like OA47	0.60
U4	30	Germ transistors like OC81, AC128	*0.60
U5	60	200mA sub-min silicon diodes	0.60
U6	30	Sil. trans. NPN like BSY95A, 2N706	*0.60
U7	16	Sil. rect. 750mA up to 1000	0.60
U8	50	Sil. diodes DO-7 250mA like OA200/202	0.60
U9	20	Mixed voltages, 1 Watt Zener Diodes	*0.60
U10	20	BAY50 charge storage diodes DO-7	0.60
U11	20	PNP Sil trans, TO-5 like 2N1132, 2N2904	*0.60
U13	30	PNP-NPN Sil. trans OC200 & 2S104	*0.60
U14	150	Mixed silicon and Germ. diodes	0.60
U15	20	NPN Sil. trans TO-5 like 2N696	*0.60
U16	10	3Amp Sil. rect. stud up to 1000 PIV	*0.60
U17	30	Germ PNP AF trans. TO 5 like ACY17-22	*0.60
U18	8	6Amp sil. rect. BYZ13 up to 600 PIV	*0.60
U19	20	Silicon NPN trans. like BC108	*0.60
U20	12	1.5 Amp sil. rect. top hat up to 1000 PIV	0.60
U21	30	AF Germ trans. 2G300 series & OC71	*0.60
U23	25	MADT's like MHz series PNP series	*0.60
U24	20	Germ. 1 Amp rect. GJM up to 300 PIV	0.60
U25	25	300MHZ NPN sil trans. 2N708, BSY27	*0.60
U26	30	Fast switching sil. diodes like IN914	0.60
U29	10	1 Amp SCRs TO-5 up to 600 PIV	*1.20
U32	25	Zener diodes 400mW DO-7 3-33 volts mixed	0.60
U33	15	Plastic 1 Amp. sil. rect. IN4000 series	0.60
U34	30	Sil. PNP trans. TO-5 BCY26, 2S302/4	*0.60
U35	25	Sil. trans. PNP TO-18 2N2906	*0.60
U36	20	Sil. NPN trans. TO-5 BFY50/51/52	*0.60
U37	30	Sil. trans. SO-2 PNP OC200, WS322	*0.60
U38	30	Fast switch sil. trans NPN 400MHz	*0.60
U39	30	RF. Germ. PNP trans. 2N1301/5 TO-5	*0.60
U40	10	Dual trans. 6 lead TO-5 2N2060	*0.60
U43	25	Sil. trans. plastic TO-18 BC113/114	0.60
U44	20	Sil. trans. plastic TO-5 BC115	0.60
U45	7	3A SCR TO66 up to 600 PIV	*1.20
U46	20	Unijunction trans. similar to TIS43	*0.60
U47	10	TO220AB plastic triacs 50V 6A	*1.20
U48	9	NPN sil power trans. like 2N3055	*1.20
U49	12	NPN sil. plastic power 60W like 2N5294	*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%

AVDEL BOND

SOLVE THOSE STICKY PROBLEMS!

with

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

uA.7805/L129 5V (equiv. to MVR5V)	1.25
uA.7812/L130 12V (Equiv. to MVR12V)	1.25
uA.7815/L131 15V (Equiv. to MVR15V)	1.25
uA.7818 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	BTZ17	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	ISO21	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

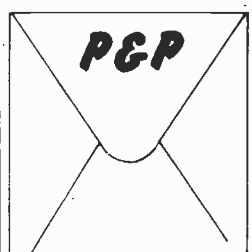
Complete with data

GP 300

115 WATT SILICON TO3 METAL CASE

Vcbo 100V, Vceo 60V, IC 15A, Hfe 20-100 suitable replacement for 2N3055, BDY11 or BDY20.

1-24	25-99	100+
50p	48p	46p



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

BI-PAK

PO BOX 6, WARE, HERTS

BI-PAK

High quality modules for stereo, mono and other audio equipment.

NEW

PUSH-BUTTON STEREO FM TUNER

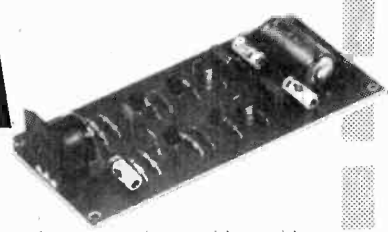
OUR PRICE ONLY **£19.95** **Fitted with Phase Lock-loop Decoder**

The 450 Tuner provides instant program selection at the touch of a button ensuring accurate tuning of 4 pre-selected stations, any of which may be altered as often as you choose, by simply changing the settings of the pre-set controls.
Used with your existing audio equipment or with the BI-KITS **STEREO 30** or the **MK60** Kit etc. Alternatively the **PS12** can be used if no suitable supply is available, together with the Transformer **T461**.
The S450 is supplied fully built, tested and aligned. The unit is easily installed using the simple instructions supplied.

- ★ FET Input Stage
- ★ VARI-CAP diode tuning
- ★ Switched AFC
- ★ Multi turn pre-sets
- ★ LED Stereo Indicator

Typical Specification:
Sensitivity 3μ volts
Stereo separation 30db
Supply required 20-30v at 90 Ma max.

MPA 30



Enjoy the quality of a magnetic cartridge with your existing ceramic equipment using the new M.P.A. 30, a high quality pre-amplifier enabling magnetic cartridges to be used where facilities exist for the use of ceramic cartridges only.
It is provided with a standard DIN input socket for ease of connection. Full instructions supplied. **£2.65**

VAT ADD 12½%

POSTAGE & PACKING

Postage & Packing add 25p unless otherwise shown. Add extra for airmail. Min. £1.00

STEREO PRE-AMPLIFIER PA100

OUR PRICE **£13.50**

A top quality stereo pre-amplifier and tone control unit. The six push-button selector switch provides a choice of inputs together with two really effective filters for high and low frequencies, plus tape output.

Frequency Response + 1dB 20Hz 20KHz. Sensitivity of inputs:
1. Tape Input 100mV into 100K ohms
2. Radio Tuner 100mV into 100K ohms
3. Magnetic P.U. 3mV into 50K ohms

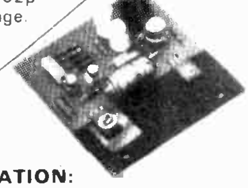
P.U. Input equalises to R1AA curve with 1dB from 20Hz to 20KHz.
Supply — 20-35V at 20mA.

Dimensions 299mm x 89mm x 35mm

MK. 60 AUDIO KIT: Comprising 2 x AL60's, 1 x SPM80, 1 x BTM80, 1 x PA100, 1 front panel and knobs, 1 Kit of parts to include on/off switch, neon indicator, stereo headphone sockets plus instruction booklet. **COMPLETE PRICE £27.55.** plus 62p postage.

TEAK 60 AUDIO KIT: Comprising Teak veneered cabinet size 16¾"x11½"x3¾", other parts include aluminium chassis, heatsink and front panel bracket plus back panel and appropriate sockets etc. **KIT PRICE £9.20** plus 62p postage.

AL10-20-30 AUDIO AMPLIFIER MODULES



The AL10, AL20 and AL30 units are similar in their appearance and in their general specification. However, careful selection of the plastic power devices has resulted in a range of output powers from 3 to 10 watts R.M.S.
The versatility of their design makes them ideal for use in record players, tape recorders, stereo amplifiers and cassette and cartridge tape players in the home.

SPECIFICATION:
- **Harmonic Distortion Po=3 watts f=1KHz 02.5%**
- **Load Impedance 8-16ohm**
- **Size: 75mm x 63mm x 25mm**
- **Frequency response ±3dB Po=2 watts 50Hz-25Hz**
- **Sensitivity for Rated O/P — Vs=25v. RL=8ohm f=1KHz 75mV.RMS**

AL10 3w R.M.S. **£2.30** | **AL20** 5w R.M.S. **£2.65** | **AL30** 10w R.M.S. **£2.95**

STEREO 30

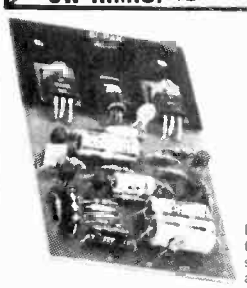
COMPLETE AUDIO CHASSIS
7+7 WATTS R.M.S.

P & P 45p **£15.75**

The Stereo 30 comprises a complete stereo pre-amplifier, power amplifiers and power supply. This, with only the addition of a transformer or overwind will produce a high quality audio unit suitable for use with a wide range of inputs i.e. high quality ceramic pick-up, stereo tuner, stereo tape deck etc. Simple to install, capable of producing really first class results, this unit is supplied with full instructions, black front panel knobs, main switch, fuse and fuse holder and universal mounting brackets enabling it to be installed in a record plinth, cabinets of your own construction or the cabinet available. Ideal for the beginner or the advanced constructor who requires Hi-Fi performance with a minimum of installation difficulty (can be installed in 30 mins).

TRANSFORMER £2.45 plus 62p p &p
TEAK CASE £3.65 plus 62p p & p.

AL 60 25 Watts (RMS)



★ Max Heat Sink temp 90C. ★ Frequency response 20Hz to 100KHz ★ Distortion better than 0.1 at 1KHz ★ Supply voltage 15-50v ★ Thermal Feedback ★ Latest Design Improvements ★ Load — 3,4,8, or 16 ohms ★ Signal to noise ratio 80db ★ Overall size 63mm. 105mm. 13mm.

Especially designed to a strict specification. Only the finest components have been used and the latest solid-state circuitry incorporated in this powerful little amplifier which should satisfy the most critical A.F. enthusiast. **£3.95**

NEW PA12

NEW PA12 Stereo Pre-Amplifier completely redesigned for use with AL10/20/30 Amplifier Modules. Features include on/off volume, Balance, Bass and Treble controls. Complete with tape output.

Frequency Response 20Hz-20KHz (—3dB). Bass and Treble range 12dB. Input Impedence 1 meg ohm. Input Sensitivity 300mV. Supply requirements 24V .5mA. Size 152mm x 84mm x 33mm. **£6.50**

PS12

Power supply for **AL10/20/30, PA12, SA450** etc.

Input voltage 15-20v A.C. Output voltage 22-30v D.C. Output current 800 mA Max. Size 60mm x 43mm x 26mm

Transformer T538 £2.30

OUR PRICE £1.20

Stabilised Power Supply Type SPM80

SPM80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watts (R.M.S.) per channel simultaneously. With the addition of the Mains Transformer **BMT80,** the unit will provide outputs of up to 1.5A at 35V. Size 63mm. 105mm. 30mm. Incorporating short circuit protection.
Transformer BMT80
£2.60 + 62p postage

£3.00

BI-PAK

P.O. BOX 6, WARE, HERTS.

news digest

UPS AND DOWNS

From the heights of success in mountaineering, (ND Feb '76) Ampex have now sunk to the depths .... literally. Ampex cameras were in action deep under the St. Gotthard massif in Switzerland on March 26th, to provide television coverage of the north-south link-up in the new St. Gotthard road tunnel. The Ampex BCC-2 colour cameras had to work in temperatures of over 26°C with 80% humidity with knee-deep water in places and finally had to survive the percussive effect of the explosive used to break through the last section of rock. Nevertheless the cameras operated perfectly for the whole 3 days, providing coverage of the event for Swiss TV.

THE SHOP FOR PEOPLE WITH 4 EARS

This month sees the opening of THE QUADROPHONIC RECORD CENTRE which is unique among record shops in that it sells exclusively quadrophonic discs of the SQ, QS and CD4 formats. This new store has been opened by the West London chain of Beggars Banquet shop in response to continual complaints from record buyers that they had extreme difficulty in finding quadrophonic records; to allow customers to browse through the largest possible selection of records, the QUADROPHONIC RECORD CENTRE stocks all the quad discs currently available both in this country and in America, as well as many from Europe and the Far East — a total of around 1000 titles. The store is conveniently situated at 8 HOGARTH ROAD, EARLS SW5 (01-373 2987) a short distance from the exhibition halls of Earls Court and Olympia; it will be open till 9.30 pm for personal customers and will operate a mail order service, for which an exhaustive catalogue has been compiled and may be obtained for 50p. An additional feature is that they will allow customers to trade-in old records for new, thus those who have just switched to quad may part exchange. their old stereo discs.

LCD TV DISPLAY EXPERIMENTS

It has recently been revealed that prototype consumer TV sets in the US have been built using LC displays. It is unlikely that this work will lead to a radical switch-over for quite some time as resolution so far is very poor.

ALL-ELECTRONICS SHOW REPORT

APRIL 13th-15th saw the Ballroom and Great Room of Grosvenor House in Park Lane invaded by the massed ranks of the electronics industry for the All Electronics Show. Designed to provide a showplace for the industry in the South as opposed to the new IEA/ Electrex venue of the National Exhibition Centre, near Birmingham, the show seemed well-attended and was certainly crowded and hot. Several interesting new products were on show, ranging from Aerials to Zeners.

Plessey Semiconductors exhibited their range of telecommunications, avionics, radar process control and consumer ICs. Of particular interest in the context of current interest in Citizen's Band radio was a kit of 3 ICs to make a 23 channel synthesizer for CB, the SP820 synthesizer chip, SP8921 phase comparator and reference generator, and SP1648ECL III as VCO. The only other components required are the programming BCD switches. Also on display was the SL600 series which will be well known to radio enthusiasts.

B & K Laboratories had an instrument loudly proclaimed to be 'The only instrument of its kind known to be currently available anywhere in the world' — their 2131 Digital Frequency Analyser which uses sophisticated digital filtering and processing techniques to analyse and display frequency spectra in the range 2Hz to 1.6kHz.

Microprocessors were rife, offering ideal displays in the form of games. One could play Mastermind, Blackjack and there was even a lunar landing simulation game on Texas Instruments SR-52 calculator (Did anyone manage to land successfully?).

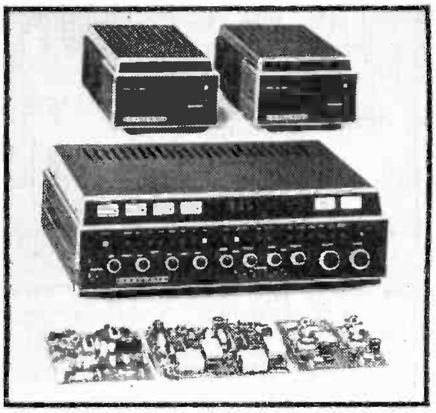
All in all there was plenty to interest the visitor, although of course it was aimed at professionals in the industry.

32-INCH COLOUR TUBE

The Sony Corporation has developed a 32 inch colour TV tube which will be marketed in two products, initially in Japan only. A deluxe console which includes a two way speaker system, electronic tuner and and a video terminal permitting direct connection to a U-matic or Betamax VCR, will be released in the Autumn, for around £2,500 in Japan. A monitor will also be available, retailing in Japan for £1,700. Seems these big tubes are quite pricey!

NEW HEATHKITS

Heath (Gloucester) have just brought out some interesting new models, which are described in their latest Catalogue Supplement, which is available, along with the catalogue, on postal enquiries enclosing a 10p stamp for return postage. Pages 2 and 3 describe the Heatkit Modules (illustrated), a modular tuner-amp of contemporary styling which gives "total control" of your musical environment. The AN-2016 tuner/preamp £550.00 inc. VAT) is the heart of the system, incorporating an AM/FM tuner with digital readout, stereo/quadraphonic preamp with headphone amplifiers and comprehensive switchery. The power amps, AA-1505 and AA-1506, offer 35 and 60 watts RMS per channel, respectively, into 8 ohms with less than 0.1% THD. These amps sit beside the preamp and are of similar styling.



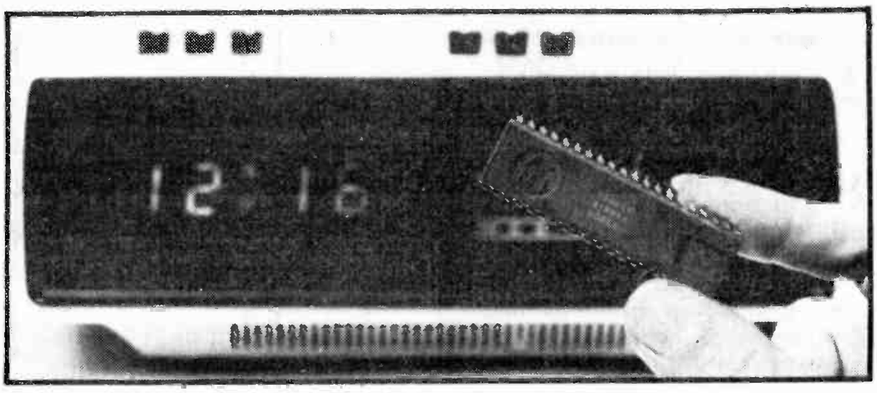
The AA-1640 power amp gives over 200W per channel RMS with under 0.1% THD for £340 including VAT. The optional peak-responding output meters can be installed when the amp is built, or later.

Also introduced in the supplement are a new stereo preamp, and an Audio Equaliser as well as a 10MHz dual-trace oscilloscope and a digital IC tester. Complementary to the new instructional courses we mentioned last month is a lab breadboard for circuit development.

US TV DUMPING

It seems that, following the recent accusations levelled against Japanese manufacturers of 'dumping' in the UK of TV sets, the same story is being repeated in the US. The International Trade Commission is to look into the methods Japanese manufacturers are alleged to be using in order to unfairly force their competitors out of business. These include artificial price fixing in Japan, duboius accounting techniques to get round the US 'dumping duties', conspiring to monopolize trade by acquiring or controlling US companies and selling below cost of production in the US. The decision to set up an inquiry follows a complaint from GTE–Sylvania.

HIGH CURRENT DIGITAL CLOCK CIRCUIT



AMI Microsystems have introduced a new digital clock module which offers a high current output for direct drive of large LED displays as used in clocks, clock radios, and timers/elapsed-time counters.

Designated S1998A, it provides more than 8mA per segment, and directly interfaces with both solid-state LED displays, and fluorescent/gas discharge displays. The time-keeping function operates on 50Hz or 60Hz inputs, and the display output is available with either AM/PM indicators or 24-hour format options.

Other outputs include timed radio turn-off, and radio/alarm enable. A power failure indication is provided to inform the user of an incorrect time display. The S1998A also incorporates a presettable 59-minute count-down timers, an alarm with snooze feature, and unlimited snooze repeat.

AMI Microsystems Ltd., 108A Commercial Road, Swindon, Wiltshire.

DIDN'T HE DO WELL!

Mr. M. S. Blunt, of Tooting, is shown accepting the prize of a 22" colour TV from Mr. Roger Powell of Bi-Pak Semiconductors. Mr. Blunt won 1st prize in the Christmas Competition Bi-Pak ran in their adverts, 2nd prize of a Legionnaire Stereo Amp, with deck and speakers went to Mr. W. Atrill of Barking, the 3rd prize of a monochrome portable TV was won by Mr. I. A. Barton, of Maidstone, while Mr. R. Attwood, of Imperial College won the 4th prize of an electronic calculator. 49 consolation prizes of Electronic Slide Rules have also been sent out. A full list of winners is available on request from Bi-Pak.

STEVE BRAIDWOOD 'DOWN UNDER'

Regular readers who notice such things (but we believe very few do) may have seen the name Steve Braidwood, G3WKE, missing from the list of Editorial staff of ETI. He is currently in Australia.

No, he hasn't been transported, but has taken up residence for a while in Sydney as Assistant Editor of the Australian edition ETI.

There are editions of ETI in France and Australia as well as Britain – that is what justifies us tacking the word International to the end of our name.

VAT CHANGES

As most readers will know, Mr. Healey has seen the error of his ways (not our comment – his) and has reduced the higher rate of VAT from 25% to 12½%. A few advertisements and prices in this issue may be incorrect: if in doubt check with the advertiser.

news digest

MARINE FACSIMILE ENDS MORSE CODE ERA

Muirhead have announced details of a new Compact Marine Facsimile Transmitting and Recording systems for radio use. The K449 recorder now extends the facsimile applications from purely weather chart reception to ship-to-shore communication associated with the normal commercial needs of running a ship at sea. Documents transmitted and received include: ships' logs, manifests, bills of lading, route instructions, maps, maintenance and general engineering drawings. A further application is the reception of ships' newspapers or news bulletins at sea.

Weather charts are of course of prime importance, allowing Masters to choose the best routes in the light of prevailing weather and sea conditions, thus saving fuel and ships time and avoiding possible damage to ships and cargo. Further applications in ship-to-shore communications, for the transmission and reception of commercial documentation and engineering drawings, emergencies and routine maintenance at sea, as well as sustaining seafarers' morale by helping to produce ship newspapers, are now being more widely appreciated. With this latter point in mind the Norwegian PTT are now operating a marine radio news facsimile broadcast on a daily basis. The Japanese supply a similar service in Far Eastern waters.

The versatility of the new machines is enhanced by two other main characteristics: compactness and ease of use. This allows the equipment to be installed on sea-going vessels down to 40 feet in length, as well as considerably lightening radio officer's loads — transmission times being substantially shorter, and reception involving no operator time. The combination of small size, very high definition and the option of a built-in radio receiver makes them suitable for use in any location on land or at sea. Although primarily intended for use in ships, the equipment is also highly suitable for small airfields, ports, harbours, etc; Muirhead Ltd, Data Communications Division, Kent, BR3 4BE.

SHOCKING SUNSHINE

MELBOURNE UNIVERSITY'S department of electrical engineering is working with farmers in a bid to perfect an electric fence powered by silicon solar cells. "Keeping kangaroos out of farmland is a much more humane way of dealing with the problems than shooting them" said Mr. John McCutchan, leader of the research team. "Since the cost of electric fencing is about one quarter of that of conventional fencing, there is a potential saving of millions of dollars a year. The use of solar-powered electric fences in areas where there is no easy access to mains electricity could make it worth while farming marginal country, at present considered uneconomic."

TIMEX BUY RCA's LCD DIVISION

Timex — the watch giants — appear to be determined not to be left behind in the digital watch field. The market leaders up to now in digital watches have been the 'vertically integrated' semiconductor companies such as Fairchild and National. Although these have a good lead, Timex at least are going to give good competition as they have recently purchased RCA's Liquid Crystal Display Division in the US.

YET ANOTHER CBM!

At only £9.95 including VAT, CBM's latest introduction, the 899D, brings to the UK market more features than any other freely available calculator under £10.00.

As well as a full four key memory, percentage and constant available on several models in this price range, the Commodore 899D in addition offers brackets for easy key-in-as-you-think calculations, square root, square, reciprocal, II plus x-y exchange and memory display exchange.

"The Commodore 899D is aimed at bringing a greater sophistication into a market that is already showing mass demand for better featured machines at realistic prices", commented Kit Spencer, Marketing Manager of CBM.

Continued on page 78.

QUARTZ NEWS

METAC Technical Services Dept.

The Electronic Watch war continues with the contestants being reduced to multi-function models with all metal bracelets.

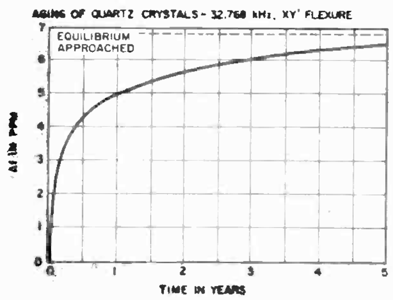
The LCD watch is at the present the most expensive of the two models and it is strongly favoured because of its CONTINUOUS DISPLAY, whereas with an LED watch a button has to be pressed to read the time. The reason for these differences is that LED display has a higher current consumption than the LCD.

The reliability of the displays and their projected life times is a topic under considerable discussion in the electronics industry. LED displays have been with us longer than the LCD, therefore, more has been published about them. The important criterion however, is, as always, the quality of the products you purchase. Not all LED and LCD displays are the same. At present there are something like 45 different companies manufacturing LCD displays world wide. It is therefore important that you have a good guarantee and also purchase from a company that is experienced in the handling of these products.

TIMING DEVICE	DRIFT IN SECONDS PER DAY
ATOMIC CLOCK	0.00000864
QUARTZ CRYSTAL	0.01034
TUNING FORK	0.864
BALANCE WHEEL	8.64

The heart of an electronic watch is the quartz crystal which vibrates at a frequency of 32,768 cycles per second. To achieve this exact vibration rate the quartz crystal must be cut to an exact dimension, then electrodes are attached to convert the crystal to an electro-mechanical resonant assembly.

Crystal engineering can now mass produce crystal oscillators with accuracies of + or − 5 seconds per month. This is twelve times better than the metal tuning fork timing devices, they are unaffected by altitude or position. Time keeping accuracy actually improves as the crystal ages.



Once again it must be pointed out that not all quartz crystals are manufactured the same. There are certain parameters which affect the stability of the crystal oscillation and it is these parameters which can be varied by the manufacturers, thus making it important that your supplier is equipped with the high accuracy electronic calibration equipment necessary for quartz watches.

The effects of temperature change or vibration are minimal. Tests of watches worn on the wrist result in much lower time variations, as would be expected. The wrist acts as a thermal regulator.

Vibration is of no major concern, as even after severe mechanical shock, the crystal units tend to recover within 40 to 60 minutes.

LASERS LIGHT AND TELEPHONES

by Professor W.A. Gambling
University of Southampton.

Spectacular advance in the way that telecommunications can serve us are promised by the transmission of light along optical fibres instead of electricity along wires.

IN 1588, when the Armada was sighted sailing up the English Channel for the invasion of England, a warning signal was sent to the Queen by the lighting of bonfires on a chain of hilltops from Devon to London. This was a common method of sending important messages for many centuries, and the hills on which the fires or beacons were made came to be known as 'Beacon Hill' — a name which many of them still retain.

Although nowadays it seems a crude and clumsy technique, it represents one of the earliest forms of optical communication system. Only the simplest possible message could be sent, either a 'yes' or a 'no': absence of the fire meant 'No, the Armada has not been sighted' changing when the bonfire was lit to 'Yes, the Armada is coming'.

Only one 'binary digit' or 'bit' of information could be sent at a time and could not be repeated until the beacon had burnt out and was rebuilt. When one reflects that it takes nearly four million bits of information to make one frame of a colour television picture and the frames are flashed onto the screen fifty times every second, it is possible to appreciate just how sophisticated present-day communications systems have become.

An improvement on beacons is the heliograph, which consists of a mirror so adjusted as to reflect sunlight to an observer. By tilting the mirror a series of flashes can be sent in the form of Morse code, and the rate of transmission is increased from something like one bit of information per *day* in the case of the beacon to perhaps several bits or flashes per *second.*

The heliograph can only be used if the sun is visible but in the modern version an artificial light source is provided and, by means of a shutter or a dipping reflector, coded flashes of light can be sent, as with a naval signalling lamp. However, the rate at which messages can be sent is limited by two factors: firstly by the mechanical shutter and secondly by the fact that the human eye has a response time of about a tenth of a second. If the eye did not retain images for this length of time, then we would see on our television screen pictures flickering on and off at the rate of fifty times per second, instead of the steady image that there appears to be.

Thus the signalling lamp can send relatively slow and simple messages, such as those required between ships at sea when radios cannot be used, but it would take a long time, no less than 11½ days at 24 hours/day to send as much information with a lamp as there is in even a single static colour television picture.

SIMPLE OPTICAL SIGNALLING

One way of speeding up the transmission of information is to replace the mechanical shutter by an electrical one which can be switched on and off much more rapidly. These came about with the development of transistors. Now certain semiconductor diodes emit light when an electric current is passed through them, and the intensity of the light varies with the strength of the current. These devices are called light-emitting diodes and some versions can be switched on and off by electrical pulses more than a hundred million times per second. The most common use of such devices is in electronic pocket calculators. The readout is produced by arrays of light-emitting diodes, seven to each figure.

Thus light-emitting diodes can replace the flashing light. The eye, in turn, can be replaced by a semiconductor diode detector which also can have a very fast response.

A light detector acts more or less in the opposite way to a light-emitting diode in that it can be so operated that, when light of varying intensity falls on it, an electric current of varying strength is produced. The combination of light-emitting diode and diode detector can be used to transmit more than a hundred million bits of information per second, which is enough to send many television pictures simultaneously.

Although a lot of information can be sent along such a light link it cannot be sent very far because the light from ordinary lamps and diodes, however carefully they are collimated, always spreads out. As a result, when the detector is far away the light is spread over a large area and not enough gets into the detector to give a usable signal.

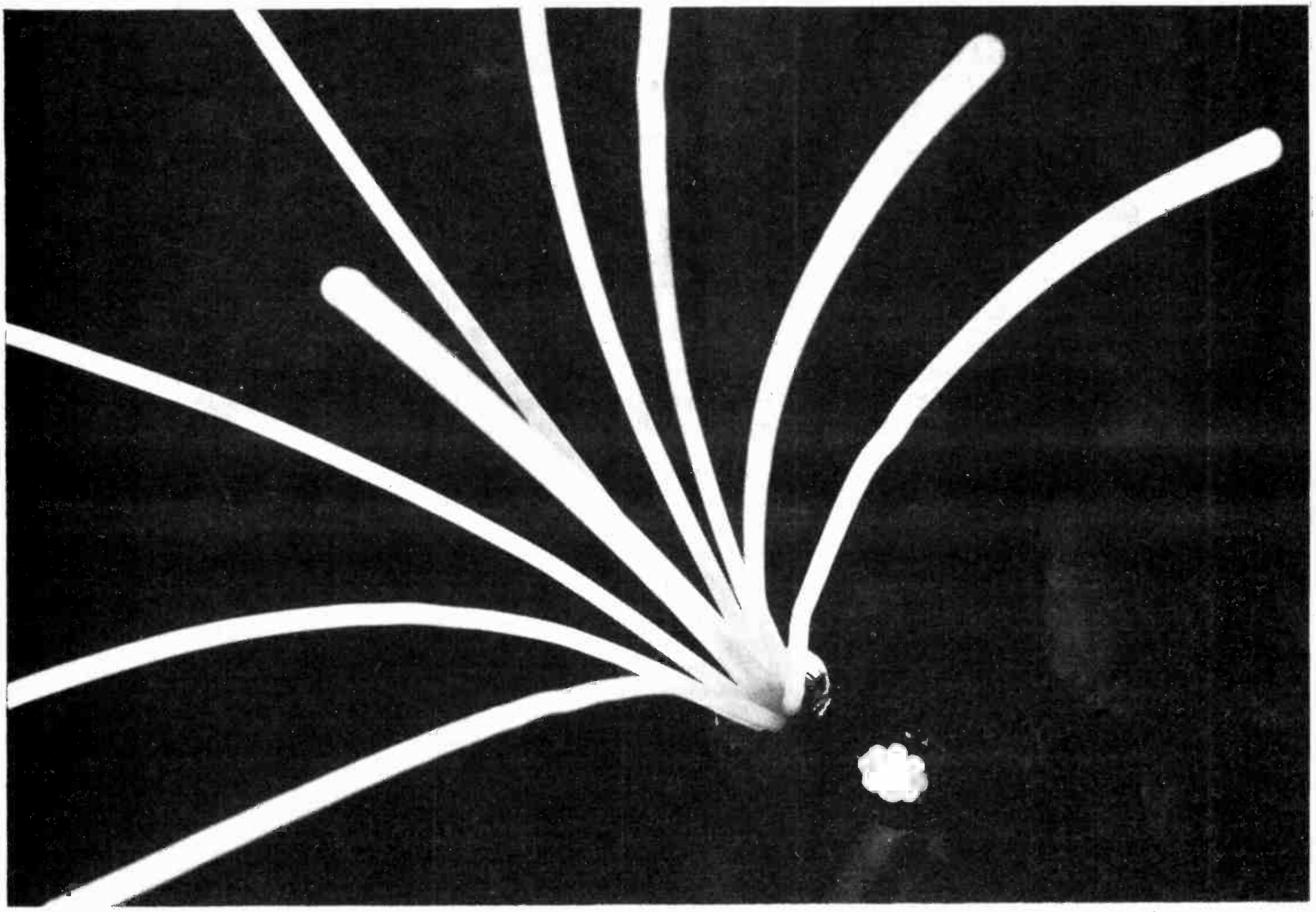
THE LASER

What is needed therefore for long-distance transmission is a new type of light source producing very pure light that can be accurately controlled, so that it can be made into a narrow beam that does not spread much. Such a light source is the laser.

The laser is completely different from any other light source. The light it produces is very pure and bright (since brightness is defined in terms of power per unit area per unit solid angle). The laser behaves almost like an electronic oscillator which operates at a very high frequency, about 5 x 10^{14}Hz in fact. This has several consequences which are of great importance.

Firstly it is possible to collimate the output radiation very accurately. Even the smallest and cheapest laser produces a narrow pencil-like beam that can be sent over long distances without spreading too much. This directional property has been used in an experiment where a laser beam was directed at the Moon from a 60-inch (1.52m) telescope, with the result that in travelling 400,000 km it only spread to a spot 0.8 km across. In other words the beam spreads by only 25 mm in every 16 km of travel. Incidentally the distance to the Moon was measured to an accuracy of plus or minus 25 mm!

Laser light can also be modulated, or switched on and off, very much faster



Optical fibre cable with eight cores. When made of the purest materials available, such a line is theoretically capable of carrying more than one million telephone channels simultaneously. The prototype seen here was developed by Standard Telecommunication Laboratories at Harlow (UK).

than other light sources and can, in principle at least, be used to send more information per second, than any other method including radio, microwaves, etc. Thus if we can learn to use laser light, and to transmit it efficiently from one place to another, then we will have a greatly improved method of sending messages in the form of telephony, television and so on.

COMMUNICATIONS DEMAND

However, before looking into optical communication more closely let us ask the question 'Is such a new system needed and will it be of any practical value?' The answer is strongly in the affirmative and telecommunications authorities the world over are spending a lot of money on developing new systems. Many more connections are being made to computers over the telephone system, and computers are becoming bigger and more numerous, so that more and better telephone lines are required. Television programmes are increasingly sent over landlines, and there are other new and interesting possibilities. So let us consider how we might be able to use laser beams and light signals instead of electric currents in a wire.

LASER SIGNALLING

A simple way of sending a signal along a laser beam is to pass it through an electro-optic crystal which can act as an amplitude modulator to control the intensity of the beam passing through. Thus an ordinary electrical signal, such as that from a telephone or a television signal, when applied to the modulator causes the strength of the beam to vary in synchronism with the signal. If a light detector is placed at the other end of the beam it will pick out the variations in beam intensity and turn them back into electrical signals. These are amplified and used in the normal way.

With a technique such as that just described, signals can be sent on a laser beam over quite long distances and when the beam is protected there are no great problems. Out of doors, on the other hand, there are two big disadvantages. Firstly the beam can be blocked by rain, clouds and snow, but even in clear weather it will be bent and broken up by temperature gradients or turbulence in the atmosphere and therefore transmission is unreliable. Secondly, light beams travel in straight lines, making it difficult to turn corners and get in and out of buildings since it would be necessary to have a highly-reflecting and accurately-positioned mirror at every slightest bend.

GUIDING THE LIGHT

In 1966 two British engineers suggested a novel method of sending light over long distances. They said that if pure glass could be produced, glass fibres would be capable of guiding light over several kilometres at a time. Glass fibres have been known for many years but at the time they could send light over only a few metres because of the high transmission loss of nearly 1000 decibels/km; that is to say, half of the energy was lost in travelling only three metres.

To understand how glass fibres 'conduct' light it is necessary to recall some simple physics. If a ray of light is travelling in a dense medium and strikes the surface of a less dense medium at an angle near the

LASERS LIGHT AND TELEPHONES

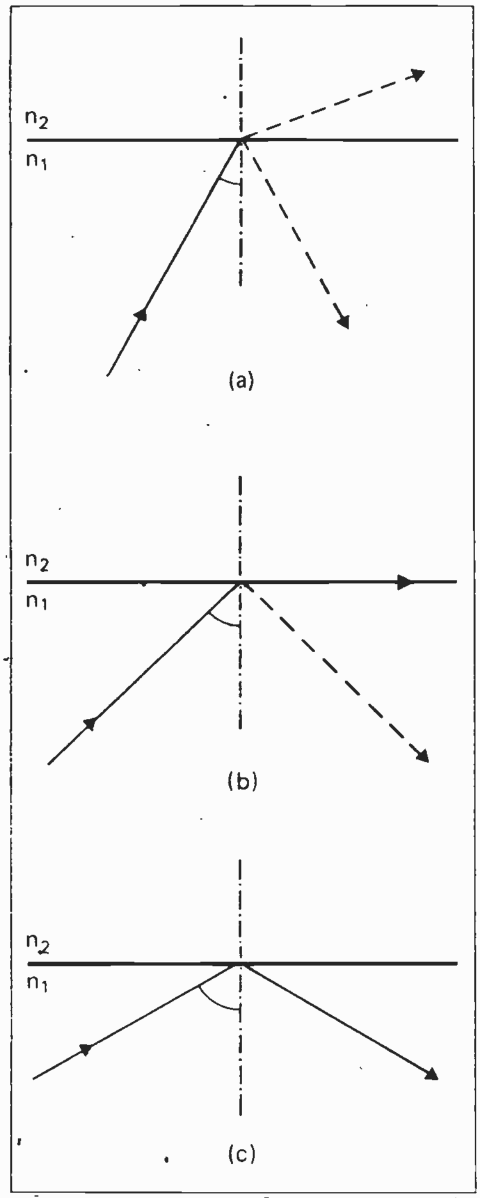


Fig. 1. Total internal reflection of a ray of light at an interface between two media of refractive indices $n_1 > n_2$.
a). A ray at a small angle to the normal to the interface is partially reflected and partially transmitted.
b). At the critical angle to the normal most of the light travels along the interface but the remainder is reflected back into the denser medium.
c). At a larger angle to the normal (a small angle to the interface) all the incident light is totally reflected within the denser medium.

perpendicular, as in Fig 1, then some of the light is reflected and some is transmitted through the surface. On the other hand, if the ray strikes the surface at a shallow angle, then it is all reflected; that is, there is no energy lost due to reflection. A perfect reflection of this kind is known as 'total internal reflection'. The angle to the perpendicular at which total internal reflection just occurs is known as the critical angle.

A light-guiding optical fibre consists of dense core material of pure glass surrounded by cladding material, also of glass but having a smaller refractive index. Thus if rays enter the fibre and strike the surface of the core at a large angle to the axis (a small angle to the perpendicular), they are partially reflected and go on to make another reflection at the same angle at the other side of the core, and then another and so on. However, some energy goes into the cladding each time, and after many reflections there is no light left in the core and the ray does not reach the far end of the fibre. On the other hand an input ray at a shallow angle to the axis is totally reflected with no loss of energy and, if it is not absorbed in the body of the core, it can keep on reflecting right to the end of the fibre. The beauty of this technique is that the fibre does not need to be straight.

As Fig 2 shows, the rays continue to reflect around curves and, within broad limits, the fibre can be bent as much and as often as required. In addition it can be very thin, as fine as a human hair, 50 micrometres (μm) in fact, thus becoming quite flexible; it behaves much as a piece of copper wire and can be wound around the finger without harm.

An unprotected fibre is rather weak, since surface flaws form very rapidly on exposure to air, but if suitably protected immediately after drawing, a glass fibre even as small as 100 μm in diameter becomes surprisingly difficult to break by hand.

A single fibre is so small that it is difficult to see easily and to handle, but bundles consisting of a large number of fibres contained in plastic tubing have been used for light transmission over distances of a metre or two for some years. Typical examples are fibre endoscopes for viewing internal cavities of the human body by surgeons. Several fibre bundles can be used to display patches of light in a particular configuration to produce display signs, the advantage being that only one simple light bulb is used, instead of many bulbs or expensive fluorescent tubing. In addition they are less easily damaged by vandals. Traffic signs on motorways are of this type.

COMMUNICATING BY FIBRES

While bundles of fibres can guide light, to send a signal we need only one fibre and a small amount of light which can be modulated in some suitable way. One fibre could guide laser light over distances of several kilometres. By using one of the techniques described earlier, the laser beam itself could be made to carry as beam itself could be made to carry as many as 100,000 telephone

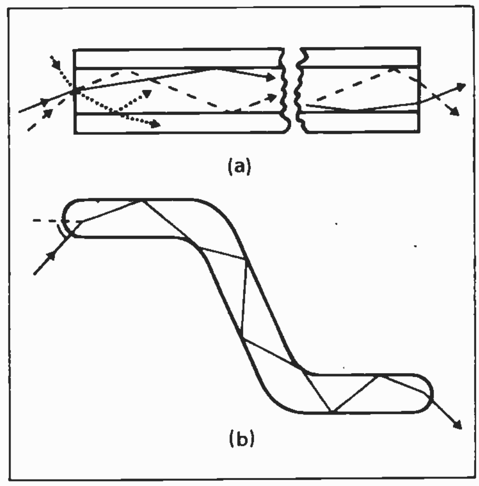


Fig.2. Ray propagation along a cladded multimode fibre.
a). Rays incident on the core/cladding interface at an angle greater than the critical angle are completely reflected (if core and cladding are lossless) and are guided by the core. The ray represented by the dotted line falls outside the numerical aperture of the fibre and loses energy at each reflection.
b). Providing a ray strikes the interface at an angle to the normal greater than the critical angle it will continue to be reflected along the fibre, even around bends.

calls. Thus a thin fibre could transmit more information than a telephone cable made of the rather expensive metal copper, and presently about 50-100 mm in diameter.

Since glass fibres have been used for conducting light for some years one might well ask why they have not been used for communications purposes before. The answer is that glass of sufficient purity has not been available. Ordinary window glass looks quite transparent, but if you look at a pane of glass edge on, it appears dark because very little light can come through a thickness of even half a metre or so. Even the best available optical commercial glass is not nearly good enough because, after going along a kilometre of it, the light would be ten thousand million times weaker!

This is because some of the light propagating along a fibre is lost by absorption due to impurities and some is scattered by even very small inhomogeneities. Some of the impurities are difficult to remove and they can have a serious effect even if present only as one part in every hundred million parts of glass. To ensure that the signal is not lost completely it has to be amplified when the power has fallen to a low value; each amplification being carried out in repeaters spaced at suitable intervals along the fibre. To keep the number of repeaters, and therefore the total cost, down to an economic level the transmission loss has to be as low as possible and certainly less than 20 dB/km (corresponding to a fall in signal power to 1 per cent of its original value after travelling 1 km).

FIBRE FABRICATION

At first it seemed that this low-loss transmission requirement would be very difficult to achieve but in the past four years tremendous advances have been made in several laboratories, including my own at Southampton University. Two years ago we held the world record for the best fibre, with a loss of only 5.8 dB/km, in a configuration consisting of a fine glass capillary tube as the cladding filled with a special liquid (hexachlorobutadiene) as the core. Other laboratories in the USA improved on this result using solid fibres consisting of silica doped with titania, germania or boric oxide as one component and pure silica as the other. Then a year ago we produced another new type of fibre using a rather unexpected material (because it is extremely difficult to make in bulk form), namely a phosphosilicate glass.

The fibre is made by passing vapours of phosphorous oxychloride ($POCl_3$) and silicon tetrachloride ($SiCl_4$), together with oxygen (O_2), down a silica tube (which need not be very pure), and heating to a temperature of about 1500°C in a furnace. Layers of phosphosilicate glass can then be deposited on the inside of the tube. The initial layers, which become the cladding, can be made to have a low refractive index by using a small concentration of phosphorous oxychloride (or by using boron trichloride instead) while the later layers of higher refractive index form the core. After deposition of the layers the tube is collapsed to a solid preform which is then drawn into fibre by the precision fibre-drawing machine shown in the photograph; the overall process is depicted in Fig 3.

The great advantages of the foregoing process are that the raw materials are cheap and, because they come in liquid form, they are easily purified. The resulting fibre is dimensionally very accurate and has the low attenuation of only 2 dB/km over the interesting wavelength range of 0.8 to 0.9 μm where gallium arsenide lasers and light-emitting diodes operate. Figure 4 shows that the transmission loss is low over a wide range; only one other fibre has been produced having a lower attenuation and that not, apparently, repeatedly.

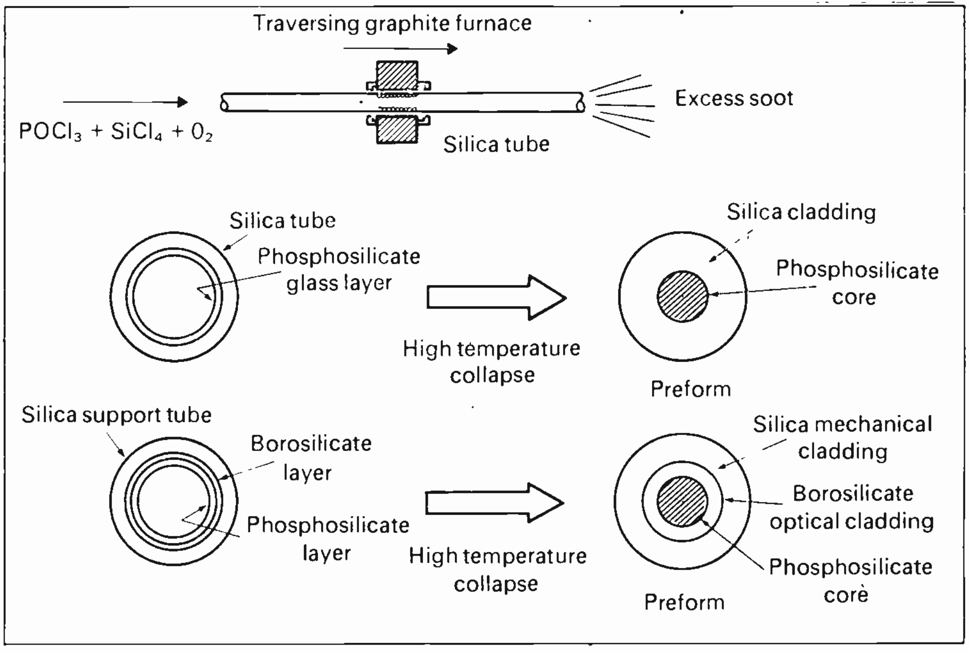


Fig.3. The manufacture of phosphosilicate fibres. In the two-layer process the silica tube acts only as a supporting structure.

BANDWIDTH

Another major factor of prime importance in the design of optical fibres for signal transmission, and indeed of any communications medium, is the bandwidth or maximum rate at which information can be transmitted.

The components of a modulated carrier wave cover a spread of frequencies and normally all travel at different velocities (an effect called dispersion) so that over a long length of fibre the components become separated in time, and distortion occurs. In a single-mode fibre, that is, one with a very fine core, the limiting dispersion is that caused by the bulk glass and the particular surface wave mode and corresponds to pulse rates, or bandwidths, of several gigahertz over several kilometres. However, if a semiconductor laser source is used, the spread in its output would limit the overall bandwidth to about 1GHz over 1 km or perhaps even less. There are problems with single-mode fibres because of the very small core diameter (about 1 μm), namely those of launching efficiently from semi-conductor lasers and jointing (especially at night in a trench in the rain!) between adjacent sections of fibre. To get fibre ends flat and accurately aligned to an accuracy of better than 0.1 μm is no mean problem.

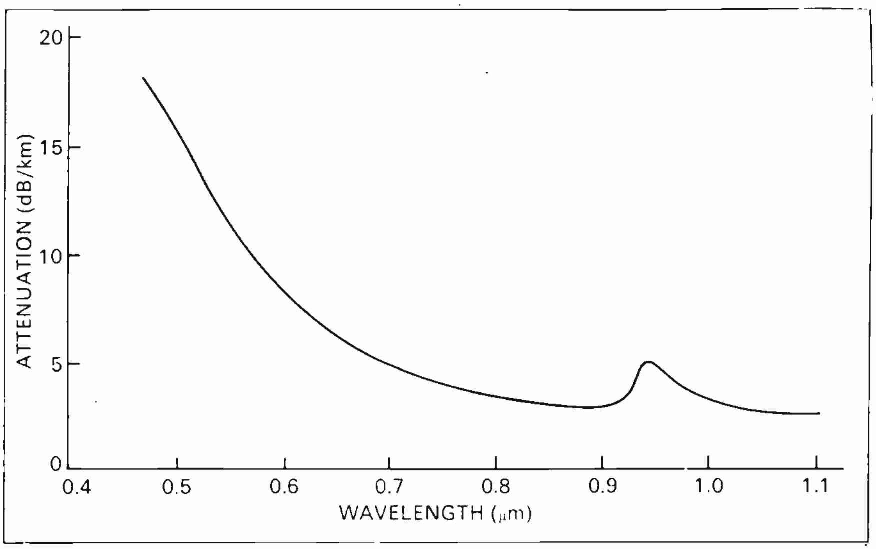
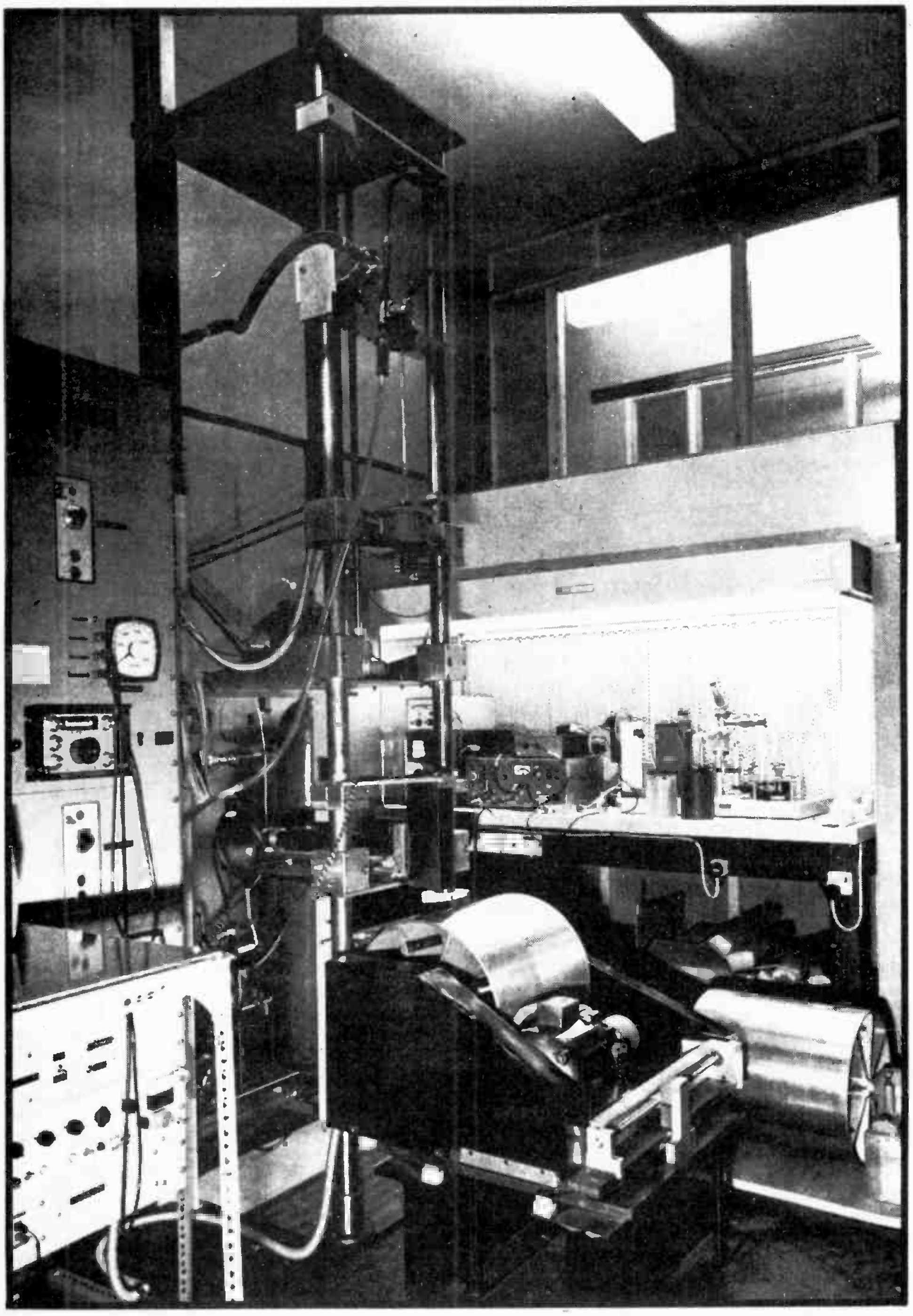


Fig.4. Spectral attenuation curve of a 1.2 km length of silica-cladded fibre with phosphosilicate core.

LASERS LIGHT AND TELEPHONES



Fibre-drawing machine built at Southampton University. A glass preform can be seen entering a small vertical furnace; the resulting fibre is drawn onto the winding drum at the bottom. The precision is such that a fibre of diameter 100 μm varies by less than 1 μm over a length of several hundred metres. Several kilometres of fibre can be drawn in one continuous operation.

MULTIMODE FIBRES

An alternative approach, begun in 1967 as a joint project between Britain's Signals Research and Development Establishment and the Department of Electronics at the University of Southampton, is to consider multimode fibres.

These have core diameters in the region 20 to 100 μm and are easier to manufacture than single-mode fibres. However, because of the large core diameter they are capable of supporting many modes and it was expected that the bandwidth would be quite small. For a thick-core fibre, instead of thinking of modes, it is more convenient to visualise energy propagation in terms of rays, as discussed earlier, which travel along the fibre by total internal reflection from the core/cladding interface. As long as the angle to the interface is not greater than that corresponding to the critical angle, given by $\cos^{-1}(n_2/n_1)$ where n_1, n_2 are the refractive indices of core and cladding respectively, no energy is coupled into the cladding, at least when the latter is lossless.

If an input beam is launched so as to fill the aperture of the fibre, or if scattering occurs, then the spreading of a transmitted pulse can become comparable with the difference in transmission times of the axial and extreme rays which, for a length of 1 km and a typical fibre, is 0.5 μs. This is equivalent roughly to a bandwidth of 1 megahertz. However, careful measurements showed that if a narrow beam is properly launched into a well-made fibre, a pulse spread of as little as 0.3 nano-seconds (ns) occurs over 50 m with core diameters in the range 50–100 μm. It followed that if such a low dispersion could be maintained for greater lengths, a bandwidth exceeding 100MHz over 1 km might be attained. This is greater than that currently available from coaxial cables, and the spatial multiplexing which is possible increases the advantage still further.

Later work has confirmed this result, and, by the introduction of a refractive index which falls gradually from the axis of the core, instead of having a step changed at the core/cladding interface, the phosphosilicate and other fibres can be made to have a bandwidth of 1GHz over a 1 km length.

TELEVISION TRANSMISSION

As a result of these and other developments there is now a great interest in the use of optical fibres for communications. The major difficulties of attenuation and bandwidth have been solved but before fibres find widespread applications there are many other problems to be faced, such as jointing and cabling, but these are not likely to be difficult. The first use of fibres is likely to be for special links such as data or television transmission, with trial installations in the telephone network following by the end of this decade.

Equipment developed and built at Southampton University for the BBC was used in the first commercial application of optical fibre communications by any national network in January 1973, when an entire colour television programme from the Royal Institution was sent through 1.25 km of fibre before being broadcast. The electrical signals from the colour camera were taken to drive circuits feeding into a light-emitting diode, which turned the fluctuations of electric current into fluctuations in light intensity passing along the fibre. Light emerging from the fibre was directed onto a fast-acting light detector so as to reproduce faithfully the original electrical signal, and the output from the detector was amplified and fed to the television transmitter. Thus the pictures on all the domestic receivers had been transmitted through a long length of fibre. Needless to say there was no deterioration in the normal picture quality.

POTENTIAL

The simple but realistic demonstration described above showed that glass fibres can be used for long-distance communication. Various forms exist and while the ideal fibre has perhaps not yet been made, suitable ones are already available. Light detectors are no problem. Although present-day diode lasers are not yet reliable enough, they are getting better all the time and light-emitting diodes can also be used.

If optical-fibre transmission lines are put into use what effect will they have on our everyday lives? Initially the result would not be spectacular but it would mean that telephone system costs would not rise as fast as they would do otherwise, and telephoning might become easier. Videophones which require 300 times the frequency space of conventional telephones, might become feasible. Branches of banks are connected to a central computer to enable a rapid and up-to-date check to be kept of all accounts, a service so valuable that perhaps in the future offices and factories of most firms may be inter-connected in the same way, thus increasing the amount of data transmission throughout the country. Already attempts are being made to provide computerised references for research workers, and the logical extension of this would be to commit all journals and books to some form of computer store. It would then be possible to do away with most school, college, industrial and public libraries in favour of video links to a relatively few regional centres. The advantages would be many.

There are many other fascinating possibilities. If a glass fibre cable can be made as cheaply as the telephone wires that come into the home from the local exchange, then the meagre bandwidth we presently have could be greatly increased.

The private citizen could have a communication capability, or bandwidth, exceeding that of any commercial or private enterprise today. He could have direct access to a national or regional computing centre and could dial the computerised library of the future from his armchair, to have pages from books displayed on his own TV screen.

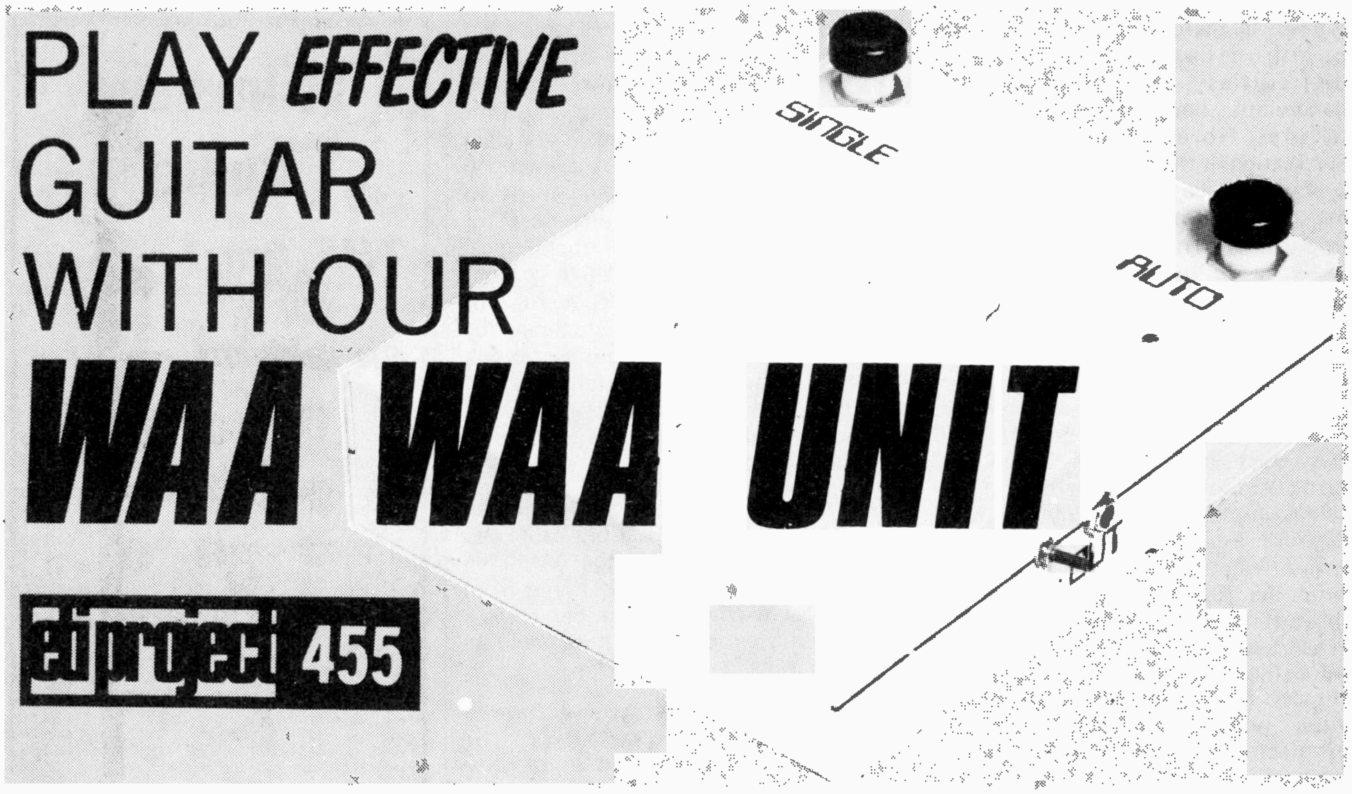
If we miss our favourite TV programme perhaps we could dial it from a video store at a time convenient to us rather than to the television authorities.

Viewed objectively the present method of disseminating news by means of newspapers is crazy. We cut down acres of forest, ship thousands of tons of wood pulp all over the world. When the papers are printed, trains and trucks and vans in every country carry hundreds of tons of newspapers in all directions and thousands of paper boys and girls deliver them to homes. After that there is the problem of disposing of them. Great damage is done to the environment and there is a great waste of natural resources. Sending news by electrical or optical means is easier and much more efficient. It would be more sensible to dial our newspapers from home and read them on the television screen.

There are lots of other exciting ideas — it has even been suggested that instead of *commuting* to work we will *communicate* to work. These developments will depend on our ability to understand, design and produce new and better materials, and to make communicating with light a practical reality. ●

PLAY *EFFECTIVE* GUITAR WITH OUR WAA WAA UNIT

eti project 455



PERHAPS THE MOST used of all the various guitar effects is that of the 'Waa-Waa' unit. The sound of this circuit has been screaming from speaker stacks for many a decibel-ridden year now, and no doubt will continue to do so for a while yet.

Our unit described here will, we hope, contribute to this longevity!

Basically the chracteristic sound of a Waa-Waa unit is produced by sweeping a band-pass filter across the audio spectrum of a guitar. A frequency range of approx 70Hz–6kHz. This can be done in various ways, but is usually tailored to be operated by a foot pedal. However, these pieces of hardware are both expensive and hard to obtain other than full of electronics.

BACK PEDALLING

Since our design was to be for the home constructor, we decided against the use of a pedal, and instead we have substituted two foot switches. These are much cheaper and should be easy to get hold of. Ours came from the surplus bins at HL Smiths.

By avoiding the pedal, we created a problems for ourselves, in that we could no longer operate the filter with a variable resistor. Instead it is made to sweep across the range by the switching into circuit of three capacitors, which alters the resonant frequency of the filter.

GETTING WOUND UP

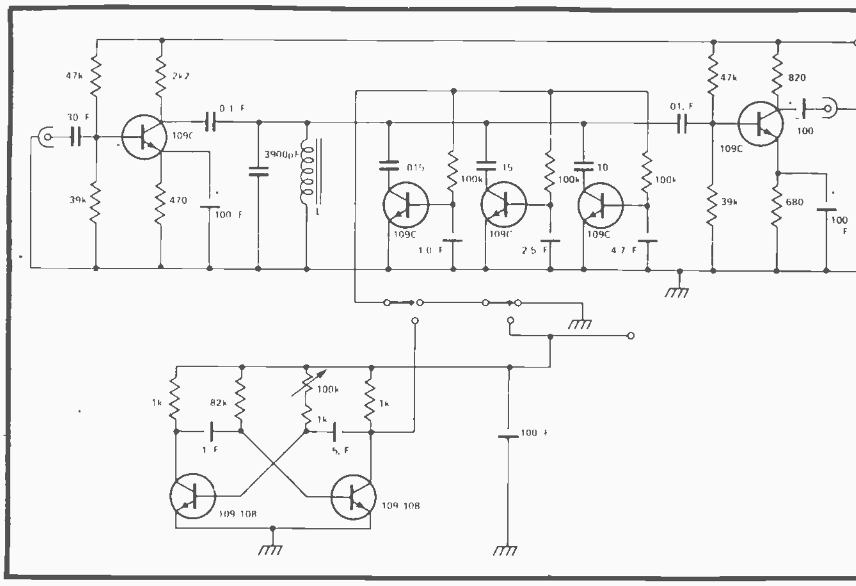
Coils are generally to be avoided, if for no other reason than that they are so much trouble to wind, but in this case there really wasn't any other way! At least we used a ready wound coil from one of our earlier projects (Graphic Equaliser) so that problems were sidestepped as much as possible. Should you be one of these strange people who derive pleasure from enmeshing yourself in yards and yards of wire, we have repeated details in the parts list. Good luck.

ON THE LEVELS

The input impedance of the unit is about 2k and the first stage gain such that the device operates best with an input of around 10–20mV. Signals much higher will cause the stage to distort the incoming signal. If you wish to cause distortion of course, then go ahead (did someone mutter 'Fuzz to you too'?) If not then a volume control of at least 2k is a good idea if the input exceeds 50mV. Output impedance is low and will match any amplifier.

USE AND ABUSE

Using the unit should pose no real problems, and there is no setting up to be done. Operating the single switch will result in a 'waa' on the next note played through the circuit. It is best not to hold the siwitch closed, but to release it quickly. After a short while it becomes easy (relatively!) to add the effect to any required note or chord. Depressing the auto switch couples the filter to the oscillator, and thus produces a 'waa-Waa' sound



independent of the input, at a rate set by VR1, for as long as the switch is held down.

With no controls operated, the section of the filter which remains in circuit means that a 'teble boost' occurs on the signal. If you don't want this effect, then a third switch wired to take the signal away from the waa-waa is needed, and should not be difficult to add.

BUILDING UP

Construction of the unit is made easier by using the PCBs, but layout is not that important, and something like veroboard would serve the purpose. We split up the circuit onto two boards to facilitate the fitting of the small multivibrator auto control into the guitar itself. This system has the advantage that the rate control for the auto-waa is then easy to alter while playing. The lead between the two parts of the circuit need not be screened, as it carries no audio signal just the supply to the oscillator, and the square wave switching signal to the filter.

The sound of the effect in use is set by the capacitors in the filter section, and these can be experimented with to change the nature of the resulting sound.

HOW IT WORKS

L and C4 form a band-pass filter with resonant frequency equal to

$$f = \frac{1}{2\Pi\sqrt{L.C4}}$$

With the values shown here this value is about 6kHz. The R-C networks R5–C6 R6–C8 R7–C10 act as time delays to switch on Q2,3,4 respectively in sequence following the depression of SW2.

This switches C5, C7, C9 across the filter in turn, pulling the resonance point across the audio band. The time constants are such that the order of switch on is Q2, Q3 and Q4.

This resonance changes from 6kHz–2k7Hz–950Hz–to 400Hz when Q4 switches on. Upon releasing the switch the electrolytics discharge through the 100k resistors to earth, switching off the transistors.

Automatic switching is provided by the multivibrator, the frequency of which is set by VR1. When the 'auto' switch, S1, is depressed a slow square wave of about 8V is applied to the charging resistors. Thus the transistors are pulsed on and off. C13 is to decouple the supply to the oscillator to prevent problems with variations as the oscillator switches state.

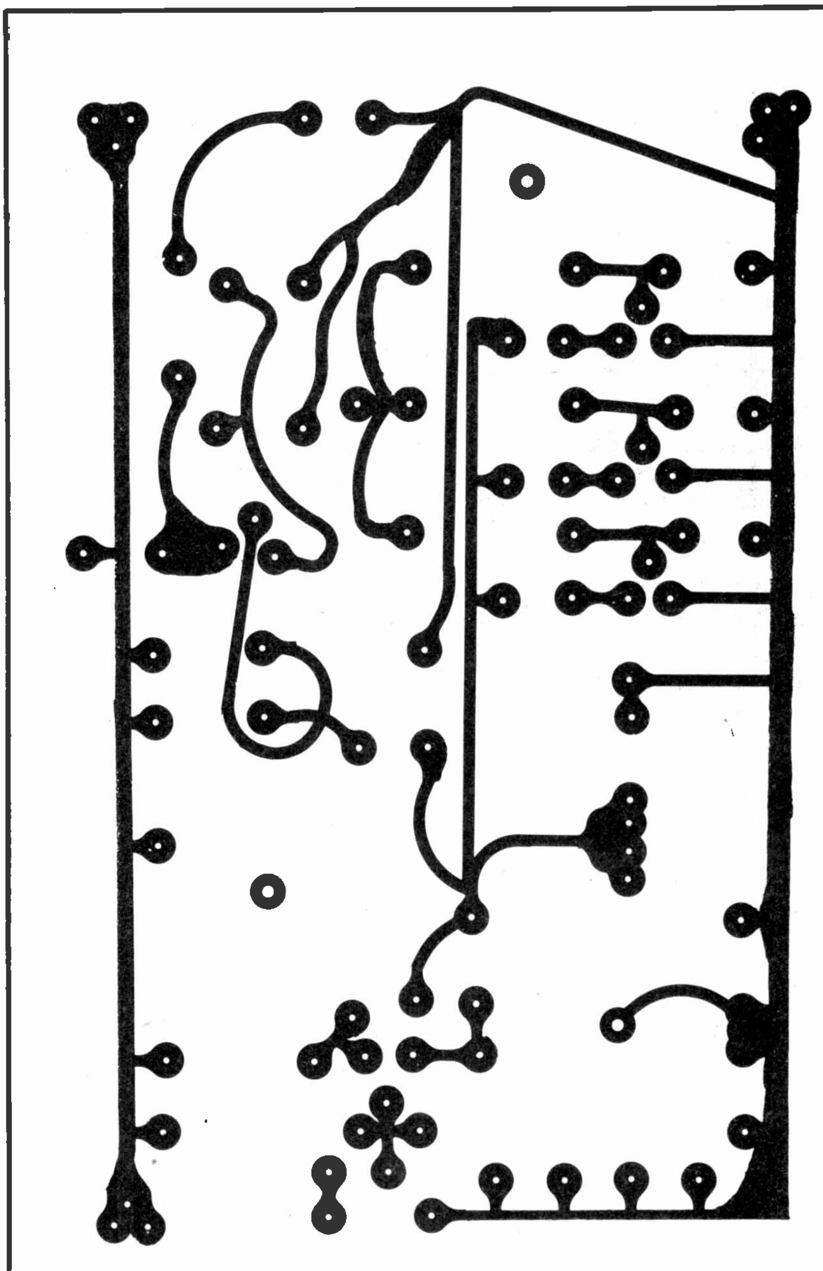


Fig. 2. P.C.B. Layout for main board (Full size)

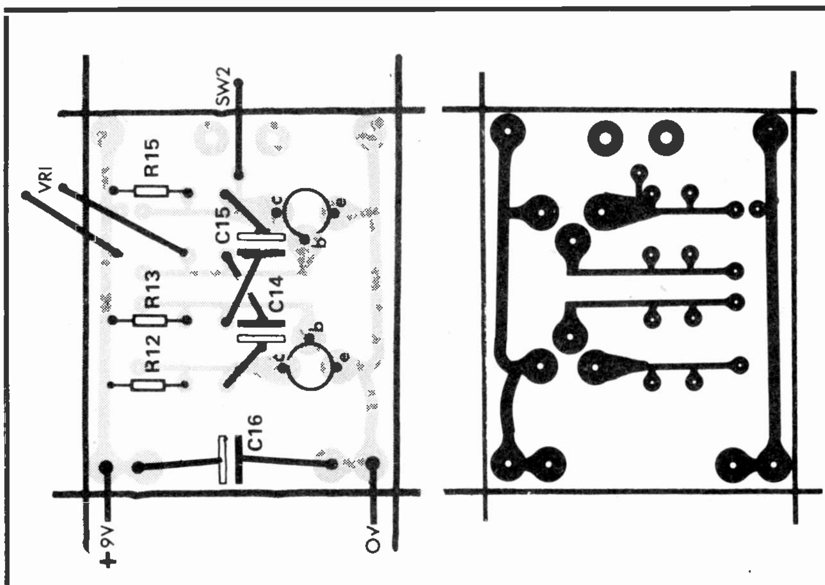


Fig 3. Oscillator Board and overlay (Full size).

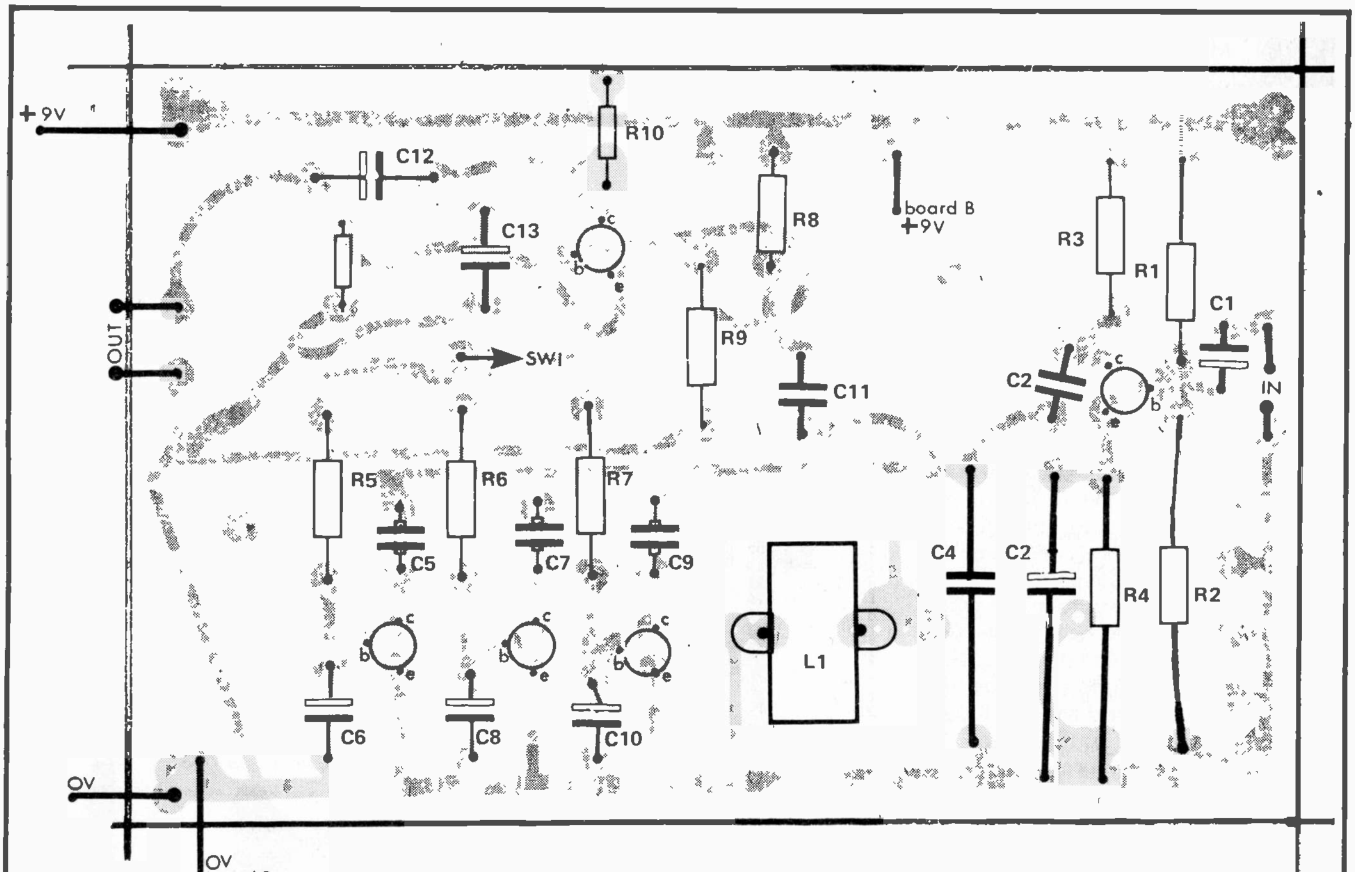


Fig. 3. Component overlay

PARTS LIST

R1,8	–	47k
R2,9	–	39k
R3	–	2k2
R4	–	470R
R,5,6,7	–	100k
R10	–	820R
R11	–	680R
R12,14,15	–	1k
R13	–	82k
	–	
C1	–	30µF
C2	–	0.1µF
C3,12,13,14	–	100µF
C4	–	3900pF
C5	–	.015µF
C6,15	–	1.0µF
C7	–	.15µF
C8	–	2.5µF
C9	–	1.0uF
C10	–	4.7µF
C11	–	.01µF
C16	–	5µF
Q1,5	–	BC109C
Q2,3,4,6,7	–	BC109 or similar

L – 180mH – available from Maplin Electronics as 'L5' for the ETI Graphic Equaliser at £1.26 ready wound. Add 20p 20p p and p. Can be wound as 424t of 38swg on Mullard LA 4543 core and DT2534 bobbin.

SW1, SW2 – Single pole changeover foot switches

Aluminium case to suit. On/off switch, 9V battery. ¼" jack sockets (2 off).

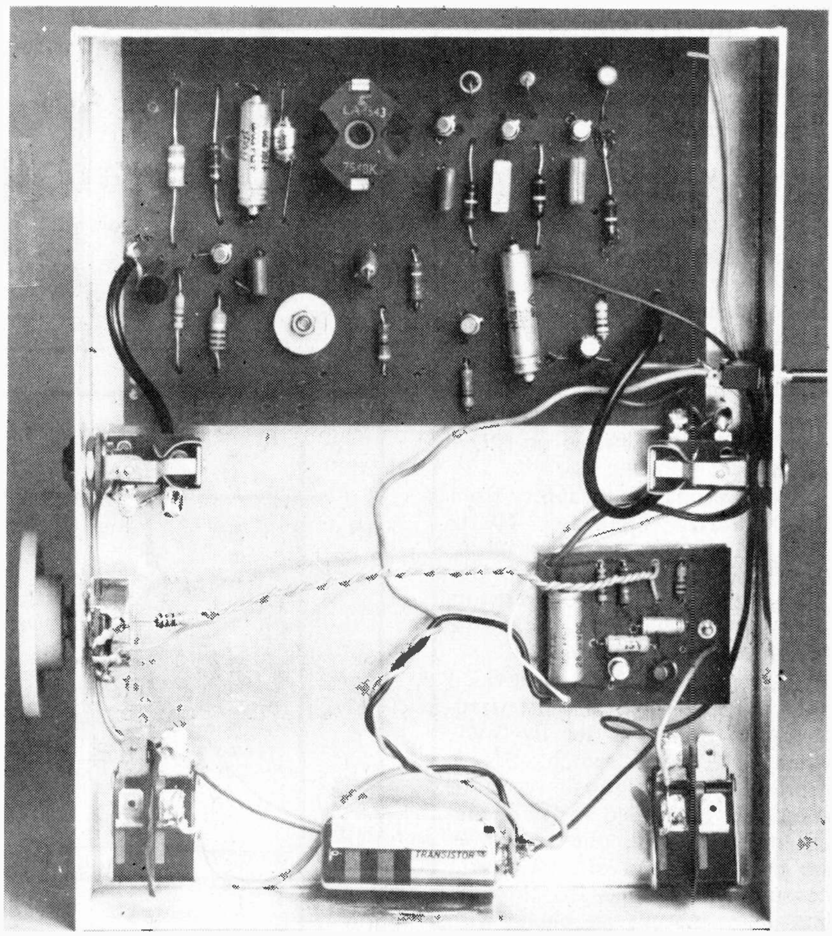


Fig. 4. Internal view of the unit.

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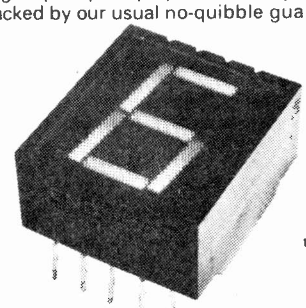

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TIL 322	Texas Instr.	Red	Common Cathode LED	13mm	**£1.20**
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5LTO1	Futaba	Green	Phosphor Diode	0.5"	**£5.80**

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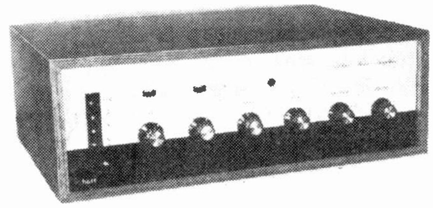

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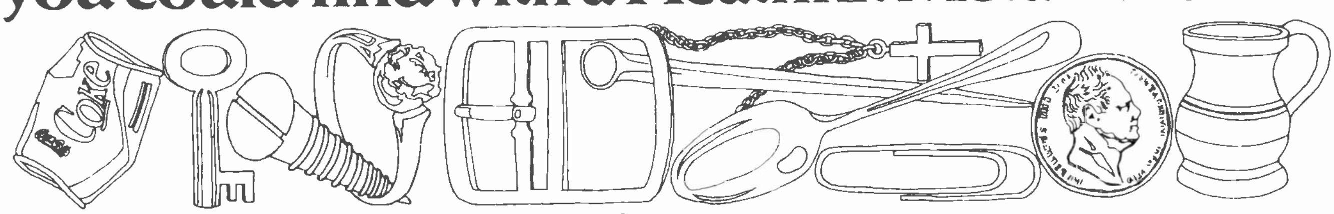

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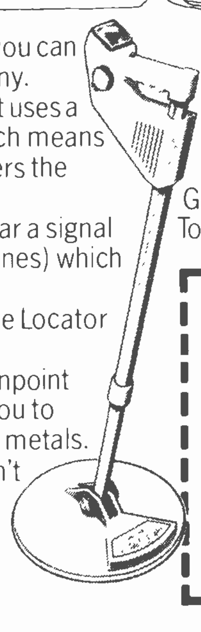

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OVERCOMING

THE PURPOSE of public address and sound reinforcement systems is to enable an audience to hear participants in a function-programme, intelligibly and clearly.

Contrary to the practice in some quarters it is not just to make a loud sound. If the information, whether speech or music, is not heard and understood without strain, the system has failed its purpose.

The ideal is for the audience not to be aware that a p.a. system is in actual use, only that they can hear comfortably with adequate volume, but otherwise as though the speaker was just using his natural voice.

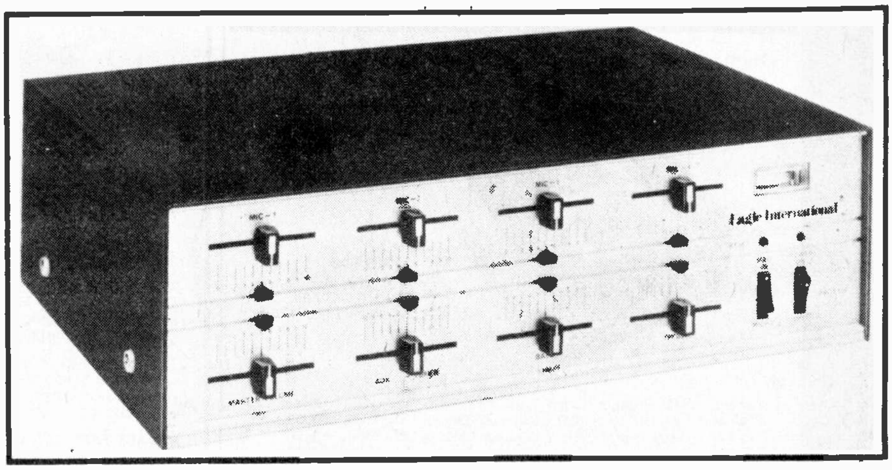
Practical installations pose many problems, both of a temporary and permanent kind.

One of the biggest problems is acoustical feedback, often called "threshold howl". Sound from the loudspeaker is picked up by the microphones, amplified, reproduced by the speakers and picked up again. This cycle is repeated until it builds up into a massive howl limited only by the power output capabilities of the amplifier. The frequency of the signal is governed by the main resonance in the feedback loop, usually that of the microphone, and the whole process takes little more than a second.

Feedback will occur when the gain of the system exceeds a certain critical level. The microphone must of course be live, but does not have to be receiving for speech or music. Ambient noise or electrical noise in the amplifier is sufficient to trigger it off. If the system gain is just below the critical level, we can have *incipient* feedback, where every word uttered by the speaker is followed by a decaying ringing sound.

The critical level depends on many factors, but where it is low due to poor acoustics, inferior equipment or inexpert installation, the amount of volume which can be used may well be restricted to a level below that required for reasonable audience audibility. They will have to strain to hear, and non-technical members may protest that the volume should be turned up more, or a bigger amplifier used.

In order to get as high a volume level as possible, the p.a. operator may turn the gain up to as near the critical level as he dare go. The resulting ringing considerably reduces intelligibility and so makes matters worse; and of course there is the real danger that the system may "go over the top" at any moment. It is always better to operate with a safety margin well below critical feedback level to achieve maximum intelligibility, even though the volume may be rather less than desired.



Eagle PROA 120 Professional PA amplifier.

HOW TO REDUCE ACOUSTIC FEEDBACK

Single-unit loudspeakers radiate sound forward in all directions in the shape of a cone (Fig. 1). The first basic principle then, is to avoid positioning any loudspeaker so that it directly faces into a microphone. Loudspeakers should never be placed at the back of the speaker's platform with the microphone(s) in front of them. They should be placed at the sides and slightly forward. Any loudspeakers placed in the auditorium should likewise not face back toward the platform. Unless the rear of the loudspeaker cabinet is completely sealed, there will be some radiation from the back, so unsealed backs should also not face toward the microphone. The ideal position is to angle them so that they are sideways-on to the microphone (Fig. 2).

Directly radiated sound is by no means the whole problem. Sound will be reflected from various objects in the auditorium, especially the rear wall. If this surface is hard and reflective such as unpapered plaster, with no absorbent areas such as curtains, wooden panels or doors, feedback may well cause difficulties. The platform wall is also important as a reflector, because sound from the auditorium will bounce from the wall behind the platform right into the front of the microphones. Very often though, this wall is covered with drapes or otherwise decorated with absorbent material over all or part of its surface, so its effect is reduced. Where both walls are bare and hard, the p.a. engineer may be in real trouble!

Of recent years, the single-unit loudspeaker has given way to the column or line-source speaker. This has many decided advantages. The sound radiation pattern from a column is shown in Fig. 3 (in simplified form), omitting minor secondary lobes. The outputs from the line of drive-units all reinforce each other in the forward direction in the same plane. Above and below, the sound field is minimal.

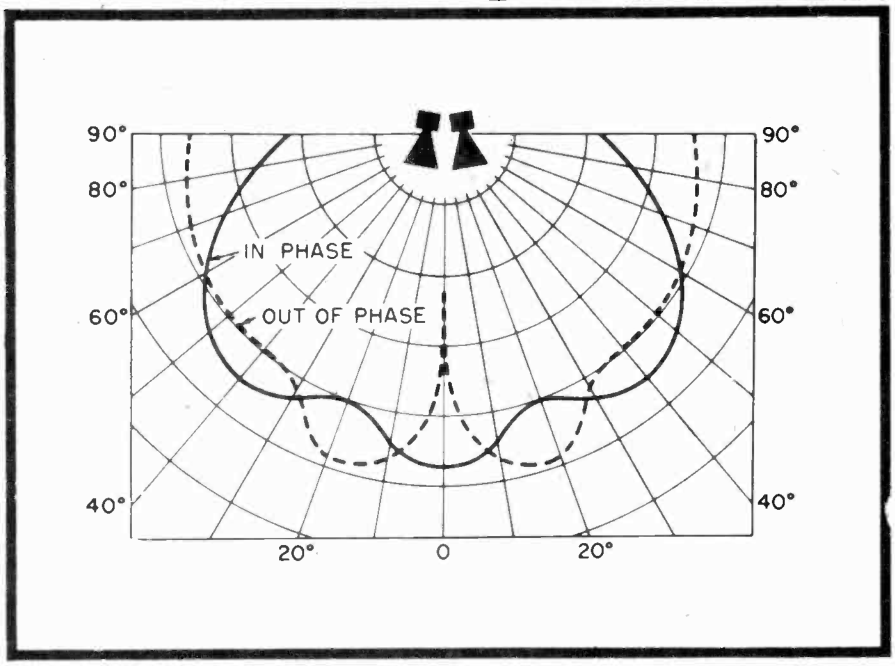
If positioned and angled correctly, this cheese-shaped radiation pattern can be used greatly to reduce unwanted reflections. To start with, very little sound is directed to the ceiling, that which does arrive there is as a result of reflections from the floor and seating. Arched and domed ceilings are nowhere near the bogeys they can be when using single-unit speakers.

The elevation and angle of a column loudspeaker should be such that the sound beam is directed along the heads of the audience in a gradually descending path, (Fig. 4). It can be seen that when finally reaching the rear wall, only a small area at the bottom will be affected. Thus there will be minimal reflection.

All too often installations are seen where the column is vertical, and mounted too high. In this position the sound beam is directed over the heads of the audience, straight at the rear wall, about the worst possible condition. A further aid is to turn the columns inward to some degree, by this means any sound reaching the rear wall does so at an angle and thereby is not bounced directly back, but must be reflected by other surfaces (being attenuated each time), before finally arriving at the platform. Such an inward turn is obtained by the

P.A. PROBLEMS

Photos courtesy of Eagle International.



If two or more loudspeakers are used close together it is essential that they are in phase, otherwise 'blind spot's will occur – especially in the area between the main axes of the speakers.

sideways-on positioning relative to the microphones (Fig. 2). And so a dual benefit is obtained. Also, the audience in the front-centre of the auditorium who may otherwise be missed with a straight-to-the-back speaker position, are well served. Where the floor rises toward the back as it does in many theatres, vertical-mounted columns will achieve the desired angle with the audience, so in this case tilting forward is not necessary.

Some columns are designed to stand on the floor, using tripods or other means of support. These are convenient to erect and position for temporary jobs, but one possibility must not be overlooked. Feedback can take place through the floor from speaker to microphone. If the critical feedback level is much lower than would be expected from experience, lift the microphone stand off the floor. If there is an improvement, then the feedback is indeed structural rather than airborne, and absorbent pads should be placed under the microphone and loudspeaker stands. In most cases, the loudspeaker will be suspended from some convenient wall support.

A major factor in the control of feedback is the choice of microphone. Some microphones are omni-directional, they pick up from all directions, others have a figure-8 polar diagram, these pickup from front and back but not at the sides. Still others have a polar diagram that has a large lobe at the front which decreases

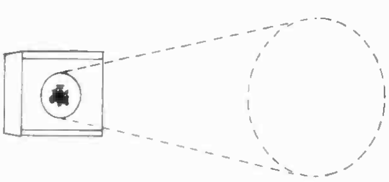


Fig.1. Conical sound distribution pattern of single-unit loudspeaker.

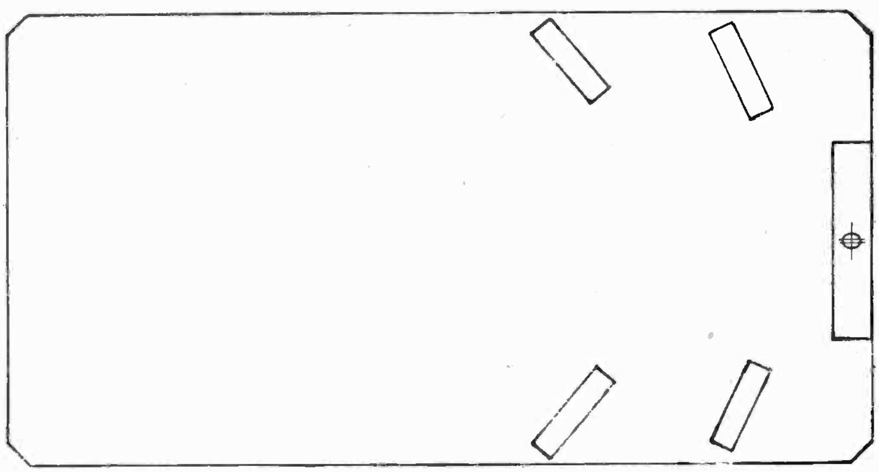


Fig.2. Loudspeakers mounted with their sides facing the microphone give the minimum direct feedback.

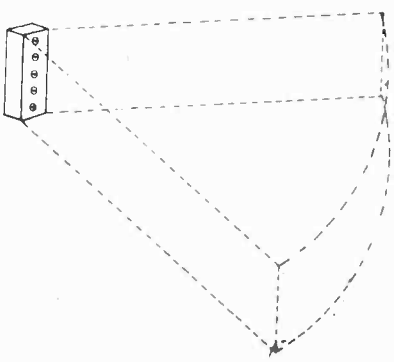


Fig.3. Distribution pattern (simplified) of column loudspeaker. Note flat top and bottom.

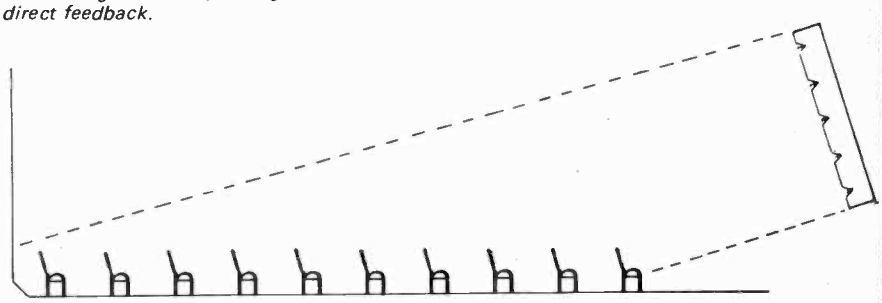


Fig.4. Column loudspeaker angled to cover whole audience yet give minimum rear-wall reflection.

OVERCOMING P.A. PROBLEMS

around the sides to form two small lobes to back left and right, with minimal pickup at back centre. The diagram resembles a heart-shape, hence its name, cardioid. Some that have still greater front-to-back ratio, are termed super or hypercardioid.

Super, or hypercardioid microphones can assist in controlling feedback because of the rejection of sounds coming from the rear. However, their advantage is lost if the microphone position is moved such as when hand-held to give the speaker mobility. There are also the reflections from the platform wall which enter the front of the microphone. These can be more significant than those entering the rear. Although cardioid microphones are strongly recommended in some quarters for feedback prevention, the advantage is slight and overstated.

All cheaper microphones, and many dearer ones of the moving-coil type, exhibit a resonance to a greater or lesser degree somewhere in their response curve. This is due to a basic cone resonance and although the better units have this resonance damped to a certain extent, it cannot be eliminated.

If this peak on the response curve causes the gain of the system to reach the critical feedback level at that frequency, feedback will result, even though the rest of the curve lies well below (see Fig. 6). Thus the maximum volume at most frequencies will be much lower than the critical level. A microphone with a flat response, such as a ribbon or condenser type, is also shown; this has a higher usable gain level, and yet will not run into feedback because no part of the curve is over the critical line. Furthermore a 'peaky' microphone is very unstable, it needs only the small amount of energy encompassed within the frequency band of the peak to take it 'over the top', and it will feed back at the slightest provocation even when the gain is well down. On the other hand, a flat-response microphone is much more docile. Even when operating near the critical level, it is slow to feed back because a large amount of energy over a much broader band is required to make it do so. A microphone such as the ribbon Beyer M260, has a response completely free from peaks and has proved its worth in difficult feed back conditions.

REVERBERATION

From acoustical feedback we will turn to another p.a. problem — that of reverberation.

Reverberation is caused by reflections of the sound from one surface to another over multiple paths. Each introduces a time delay, so that from one single original sound, the listener hears a whole series separated by minute fractions of a second. Concert halls have designed reverberation. This is measured at various frequencies and defined as the time taken for a sound to die away to a millionth of its original level.

While reverberation in moderation is essential for music,for it imparts depth and richness, it tends to obscure speech and reduce intelligibility.

The observations made regarding loudspeaker siting and angling to reduce feedback will also help to reduce reverberation. The clothed human body is very sound absorbent, and directing the sound beam from column speakers into the audience, will lessen the amount that will be free to bounce about the walls and furnishings. The relative freedom from roof and ceiling reflections which result from the use of column speakers is a big help.

Unfortunately the measures adopted for reducing feedback, while helpful, are not always *completely* effective in controlling reverberation. In dealing with feedback we try to prevent reflected sounds from the auditorium from reaching the platform. In inhibiting reverberation, we try to stop the sounds bouncing around in the auditorium itself, a rather more difficult undertaking.

Some situations, such as underneath balconies, can be particularly prone to high reverberation. Higher frequencies are more readily absorbed than lower ones, so it is usually those at the lower end of the spectrum that tend to continue being reflected, and so contribute most toward the reverberation. Considerable improvement can often be made therefore, by cutting the bass response of the amplifier, thereby reducing the level of the bass frequencies.

BLIND-SPOTS

Blind-spots can sometimes be found in an auditorium; everywhere else in the auditorium sound coverage is good, but in one spot, often just

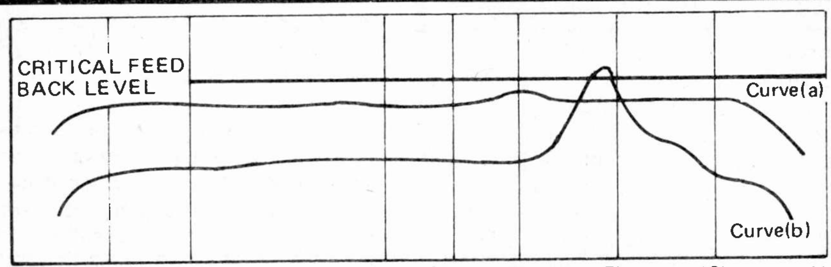


Fig.6. A microphone with a bad resonant peak (curve b) will initiate feedback because peak tip is over the critical feedback level. A flat-response microphone (a), can operate at a much higher gain level without crossing the critical point. (most good-quality moving coil microphones would have a much less pronounced peak, a bad case is here shown to illustrate the principle. However all peaks reduce the usable gain level by the peak amplitude plus a safety margin).

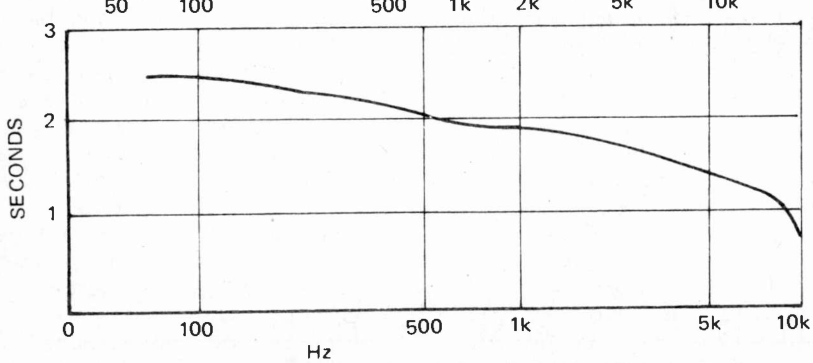


Fig.7. A typical public hall reverberation characteristic. Note how the reverberation time increases at low frequencies which are therefore responsible for most of the reverberation. Judicious bass-cut can greatly improve matters.

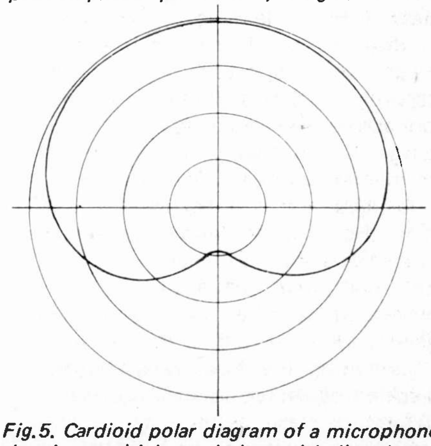


Fig.5. Cardioid polar diagram of a microphone showing sensitivity variations with direction.

affecting three or four seats, it is very poor.

The most likely cause is overlap between two speakers that are out of phase. This is why it often occurs near the centre of an auditorium which is served from speakers on either side. If speakers are connected out of phase, so that the cones in one column are moving forward while those of another are moving backward, the sound waves produced by both will cancel when they meet. Prevention is better than cure, so the polarity of every speaker should be marked on its terminals, and two-colour wire used to connect them up so that correct phasing of the whole system is maintained. If there are no speaker polarity indications, they can be determined by using a small dry battery such as a 4.5 or 6-volt lantern type. Connect the battery across the terminals momentarily, and observe whether the loudspeaker cones moved forward or backward. The terminals should be marked indicating the battery polarity that produced forward cone-motion.

Another cause of blind-spots is just lack of coverage from any loudspeaker, the intended one may be angled too high or low thus missing the affected area. Care in installing the speakers should prevent this from the start. Roof-supporting pillars in the auditorium can cause blind-spots by producing a sound-shadow. Usually this affects only those seated close to the pillar, as the sound converges around it at a greater distance. Loudspeakers should be so positioned that the sound-shadow from one is filled in by another not-too-far-distant speaker. It is often an advantage to mount the columns on the pillars rather than the side walls.

EQUIPMENT BREAKDOWN

The most prolific cause of breakdowns is a cable fault. Loudspeaker feeders should be run where they can come to no harm. Wherever possible they should be mounted high and out of reach, never across exit doors or through doorways unless there is clearance to allow for the door to be closed. They should always be supported at frequent intervals; never just hung in a long loop across any open space, or even along a side-wall without any intermediate support. They should not be bridged across a corner, but run into the corner and supported. Connections should be carefully made with particular attention to odd whiskers of wire that could stray to an adjacent terminal. Cables should never be run along the floor with the one exception of microphone cables on the platform or stage, as these are usually under the surveillance and control of the p.a. operator.

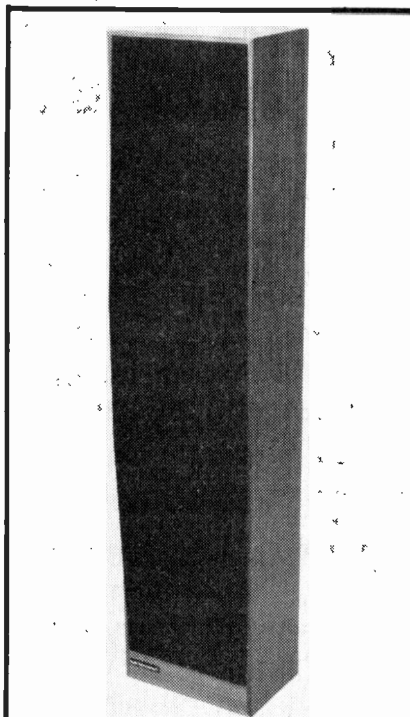
Loudspeakers rarely give trouble unless damaged, and even if one did develop a fault, it would only mean a partial breakdown. None-the-less, many p.a. installers like to have a spare column with them on any important job. Several microphones are often needed at many functions, so there will always be a spare available. These too are generally trouble-free unless dropped, or in the case of ribbons, blown-into as a test. (To test a microphone never knock it or blow into it, speech is the best test, but if one wants to surreptitiously test a mike while the programme is in progress, gently scratch the end).

The amplifier is usually the most vulnerable item, and a spare, even if of lower output, should be available. It is a recommended practice to have two or more amplifiers feeding separate sets of speakers so that volume levels can be independently adjusted. If this is done then a spare will be already connected and ready for immediate substitution in the event of a failure.

The Eagle PRO T20 Sound Level Meter

Faults can occur in mixers although they are not so common. A spare can be carried though, even if of a more modest specification but if the worst comes to the worst, a microphone can be plugged directly into the microphone socket of the amplifier and so by-pass the defective mixer.

The final problem that we shall deal with in this article is that arising from the way in which microphones are used. Microphone output is proportional to the square of the distance from the sound source. Doubling the distance from the speaker's mouth, reduces the output to a quarter. If the critical feedback level is rather low, the gain cannot be turned up far enough to compensate before encountering feedback, hence it is necessary to keep the microphones close to the speakers. But if they are *too* close, explosive consonants such as "P" and "B", will produce shattering effects from the loudspeakers. About nine inches to a foot is a good average microphone/speaker distance, so if the rostrum or speaker's desk is deep, a boom-arm or swan-neck is a useful accessory.


Eagle's CL1300 Column Speaker

The microphone should not be positioned level with the speaker's mouth because not only will this obscure him from the view of the audience, but this is not where maximum sound pickup from the human voice is obtained. Sound tends to be reflected downward from the palate, and this can be further accentuated by the speaker looking downward from the platform to a seated audience. The most satisfactory angle is with the microphone positioned about 45° from the horizontal.

Speakers should be instructed, in advance, of the optimum microphone distance, as some like to step back and ignore the microphone completely, while others lean so close that they appear as if they are going to swallow the thing. An extended hand-span is a good rough measure of the optimum distance, and one that is reasonably easy to estimate by the speaker. It would be as well to warn him not to measure the distance literally by this means while speaking, as the audience may misinterpret the gesture!

It can be seen that there are many pitfalls, and installing p.a. (even a temporary system) is not just a case of connecting up a few speakers, an amplifier and microphone. But attention to the points here described should enable one to avoid some of the worse problems. ●

SOME METHODS OF KEEPING THINGS BLOOMING IN YOUR PLOTS WITHOUT REALLY TRYING!

GARDEN WATERING

THIS ARTICLE is really intended for use by wives, to get their electronically-oriented men out of the workshop and into the garden!

The project provides an arrangement for checking comparative moisture levels in soil, and an arrangement responsive to a predetermined level of moisture. Further development allows for automatic watering or sounding of an alarm. A particularly attractive application takes the form of automatic watering of valuable indoor plants.

The circuits are almost ridiculously simple, and yet provide considerable interest in their preparation, construction and use.

OPERATING PRINCIPLE

Soil conductivity varies with moisture content, so that an absolute or a comparative measurement of conductivity can be translated into a corresponding measurement of moisture content. Elaborate instrumentation has been used for years in places like agricultural research stations to provide very accurate determination of soil moisture content and to control plant environments. However, intelligent use of a very simple arrangement providing only comparative indications can be very useful.

One arrangement to be described generates a tone, the frequency of which is dependent on soil conductivity, that is, on moisture content. Another arrangement triggers an external function when the soil conductivity falls below a predetermined level. The reader can gain useful experience to facilitate use of these arrangements by researching his own soil conditions.

SOIL CONDUCTIVITY

If an ohmmeter is connected to two wires pushed a few centimetres into the ground, a resistance reading will be obtained. This resistance varies with the dampness of the soil. However, this is an over-simplification, as will be found if the ohmmeter connections are reversed almost inevitably a different reading will be obtained.

The situation becomes even more interesting if a high impedance voltmeter on a low range is connected to the wires, as a reading will usually be obtained. This potential may arise in various ways or in a combination of ways. Stray currents will usually be found, particularly near dwellings, arising from earth returns of power reticulation systems, galvanic action at buried waterpipes, and so on. Furthermore, because the soil almost certainly will not have a neutral pH balance, but will be either acidic or alkaline, two electrodes will themselves produce a battery action.

In addition to all this, soil characteristics vary a great deal. In the author's case, resistance (reciprocal of conductivity) readings which formed part of a preliminary exercise to get the "feel" of things varied

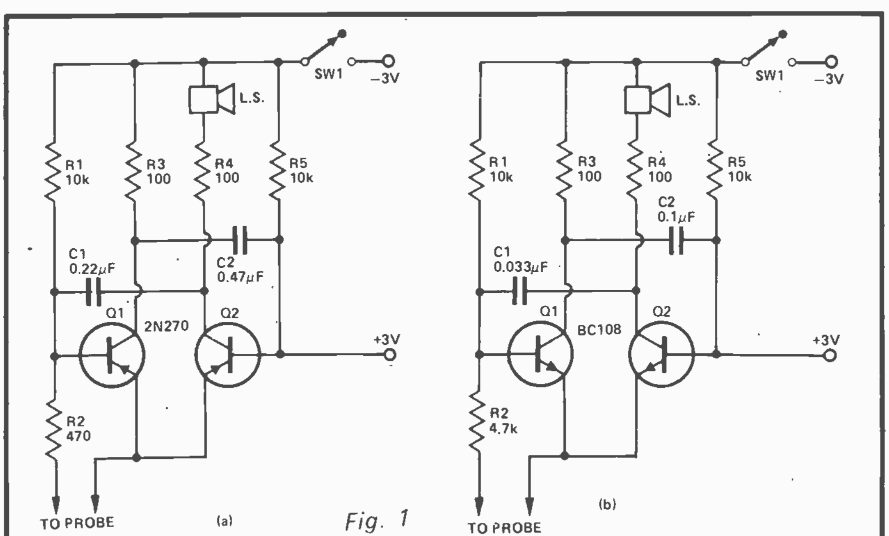


Fig. 1

GARDEN WATERING

considerably in apparently similar soils measured at the same time. For example, comparatively thin wires, about 18 gauge tinned copper, showed readings varying between 15 k and 200 k for what appeared to be a reasonable range of dampness in good, "imported" garden soil. The use of thin wires was found less reliable and consistent than the use of flat electrodes or substantial rods.

Flat electrodes with effective surface areás of, say, 3-4 square centimetres in similar conditions produced a range of 10 k to 25 k. In an open yard with a heavy clay sub-soil and little dirt on top, two 8 gauge rods about 25 mm apart gave readings of 800-2000 ohms the day after a good rainstorm, and up to 15 k (on average) after a few dry days.

Indoor plants are a special case as they have only a finite amount of water available, that is, the soil being restricted to a pot, cannot call up sub-surface moisture as happens in the open garden. Potting soils can dry out to produce quite high resistance values, say several hundred thousand ohms even when substantial electrodes are used. Of course this represents a condition in which a plant will already have permanently wilted.

THE PROBE

The probe can take a variety of forms, being basically two spaced electrodes inserted into the soil. However, the most successful form comprises at least two flat electrodes, rather than wires, although wires become more acceptable over 12 gauge and merging into rods. In either case a reasonably substantial exposed surface area of, say, 3-4 square centimetres produces acceptable operation in most soils.

For permanent insertion and for use with soft, friable soils, flat electrodes will probably be found most attractive, whilst for portable use with heavier soils, rod electrodes are probably best. Whilst the details are optional and dependent on the constructor's workshop resources,

The electrodes should be made of material which will not corrode. Monel metal or stainless steel are suitable. Short term experiments with tin plate are fine, but something better is needed for long-term use.

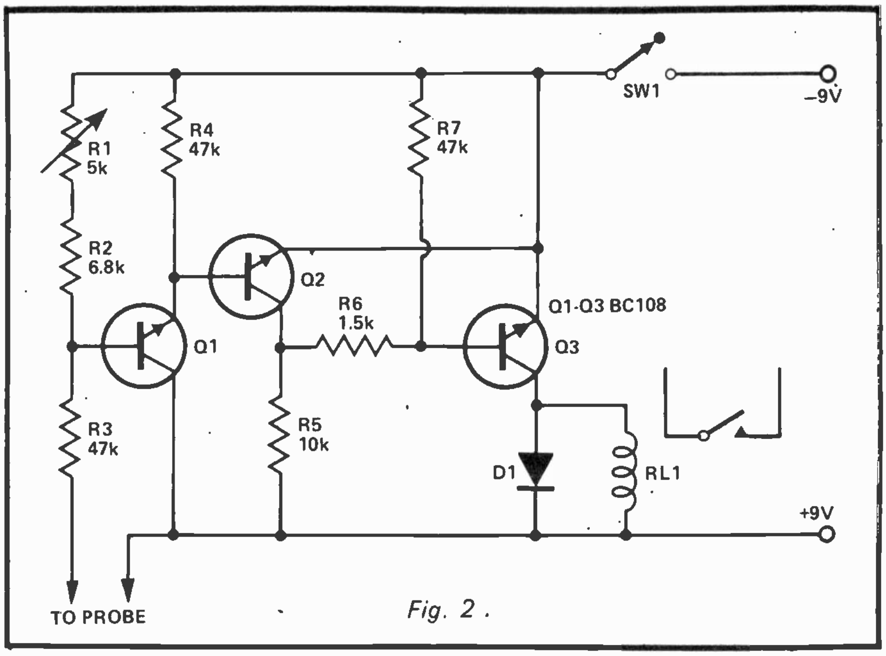


Fig. 2.

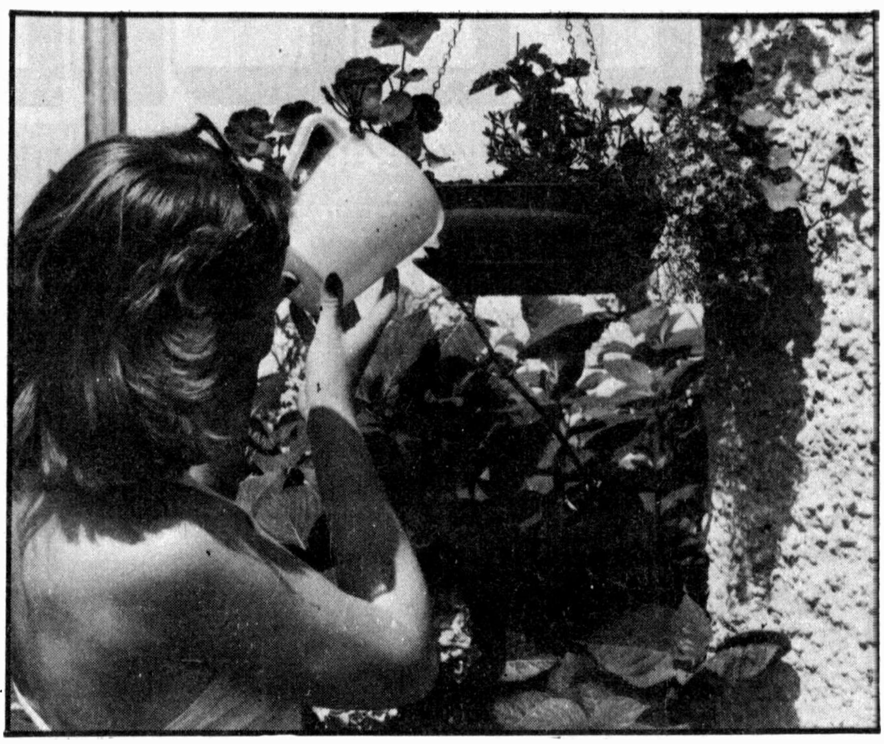
THE MOISTURE MOOD

In rather light-hearted vein the first arrangement to be described has been given a fancy name to make up for the fact that it really needs no description at all! One example using junk-box parts and two re-cycled 2N270 Ge pnp transistors is seen from Fig.2a to be a simple multivibrator, with the addition of a small speaker. Alternatively a low impedance ear plug could be used in lieu of the speaker.

With the probes in air, the circuit delivers a continuous low-pitched tone, which then increases in pitch as the probe is inserted in the soil. The higher the pitch the higher the moisture content. In cases of very high soil conductivity the note may rise above the level of hearing; in this case ~~incrase~~ the 0.22 mfd capacitor until the highest audible pitch is obtained with a saturated area of soil.

THE WATER TRIGGER

The second device is shown in Fig.3. Its function is primarily the continuous monitoring of soil moisture content responding to a fall below a predetermined level to initiate an action. This circuit comprises a simple trigger, which operates the relay RL for values of soil conductivity below a level preset by the 5 k variable resistor. The soil



The circuits will also cater for house plants conductivity is sensed by a probe connected to the terminals shown. The circuit is very simple and reliable, and will operate anywhere between 6 and 12 volts or more, provided the supply voltage provides sufficient energisation for the relay. If a very low current relay is used, an appropriate limiting resistor can be inserted in the common emitter leads of Q2, Q3.

The only point really requiring attention in this circuit is the base circuit of Q1, here comprising the probe terminals, two fixed resistors (47 k and 6.8 k) and a 5 k variable resistor. There are two possible approaches. One can insert a large value of variable resistor (say 250 k – 500 k) in place of the 6.8 k fixed and 5 k variable shown. This produces a circuit which will accept a wide range of values across the probe terminals, but will in general result in the adjustment of the variable resistor being far too wide, and all cramped at one end. The alternative is to decide the probable range of values across the probe terminals, based on tests of the kind described earlier, and then select values to suit. To see how this is done, the author's case will be worked through.

The triggering point of the circuit is with about 1.25 volts at Q1 base, but do not try to measure it with a low impedance voltmeter. This voltage corresponds to a supply voltage division at Q1 base of 1.25:7.75, so that the voltage between Q1 base and the positive supply rail is 6.2 (7.5 ÷ 1.25) times the voltage between Q1 base and the negative rail. Therefore the resistances in the two parts of the circuit need to have the same relationship. This ignores Q1 base current, which has fallen to a negligible value near the triggering point.

Initially a range of 500-25 000 ohms across the probe terminals was chosen as being correct for the application intended, based on tests plus a margin. For the 500 ohm case, therefore, 47 k + 50 = 6.2x, where x is the resistance Q1 base to supply negative. This produces x = 7661 ohms. Similarly for the 25 k case, 47 k + 25 k = 6.2x, so that x = 11613 ohms. This shows a variation in x of 11613 – 7661 = 3952 ohms. However, this is an awkward value, the nearest reasonable value being 5 k. Then 11613 – 5 k = 6613, the obvious choice for the fixed resistor being 6.8 k. Checking back then with these values, for 5 k + 6.8 k = 11.8 k, so that + 47 k = 73.16 k (11.8 x 6.2), so that the probe resistance is 73.16 k – 47 k = 26.16 k. For 6.8 k alone and the 5 k variable all out of circuit, the probe + 47 k = 42.16 k (6.8 x 6.2), giving a negative value for the probe resistance (42.16 – 47 = 4.84). Thus the chosen values provide for a probe variation of zero to 26.16 k ohms, slightly wider than required. Similar simple calculations will provide values suitable for any other range of probe values.

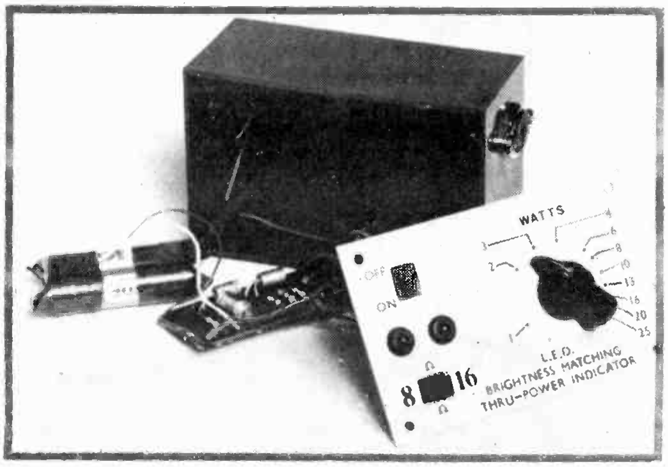
WATER TRIGGER APPLICATIONS

One of the circuits of Fig.2, less the probe connections, can be connected into the circuit of Fig.3 in place of the relay and protective diode. A resistor of about 1 k would also be needed in the common emitter lead of Q2, Q3 and Fig.3. This combination draws about 8-10 mA in the alarm condition.

However the most important application of the trigger circuit is as an automatic waterer. Consider the case of an indoor planter box. The probe will indicate water content in the soil and trigger the circuit at a preset point. The relay is used to operate a low-voltage water pump, such as an aquarium pump, to pump water from an available supply into the plant container. If the water is well distributed over the surface, for example using a meandering tube with many small holes, the soil moisture content will be increased fairly evenly until the probe decides the minimum level has been left behind. At this stage the circuit resets and awaits further transpiration and evaporation. ●

POWER METER

BY D. KING



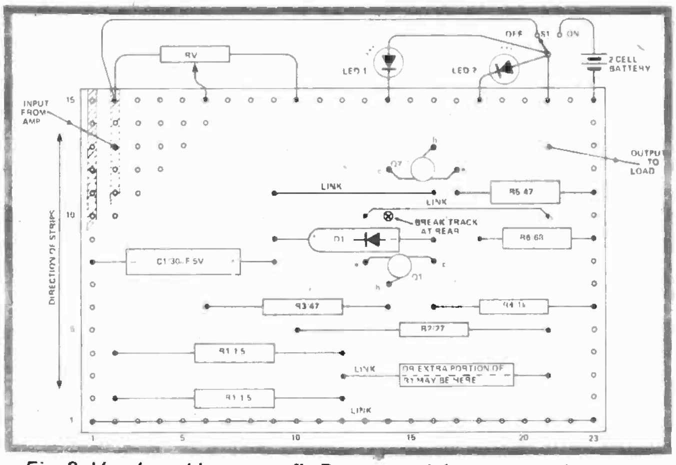


Fig. 3. Veroboard layout to fit Doram module case. Top (non-stripe) side.

WHEN USING OR TESTING a power amplifier, a very common question is, "What is the power output?" Power might be fed to a loudspeaker or load for very short periods as when a voice is being reproduced, or continuously if using an audio generator to provide a steady tone input. Measurements then involve knowledge of (i) the load resistance R and (ii) the current into or the voltage across the load so that the equation $P = V.I$ or V^2/R or $I^2.R$ watts may be completed. The formula assumes that a sinusoidal test signal is used, the instrument giving an rms voltage or current reading (usually) and the true power is thus calculated. However if a non-sinusoidal waveform were used, the 'hang' or inertia of the pointer would give an incorrect reading 50% or more low and the calculations would be wasted.

Considering these points, a 'measuring' instrument was decided against in favour of an instantaneous indicator of power using an LED and connected in series with the load or loudspeaker so that speech, music or steady tone in excess of a preset power level is indicated by flashes of the LED. Accuracy of indication is adequate, bearing in mind the fact that normal hearing only realises that there is a change of power (or volume) for a 1:2 change in power level. A bonus is that the completed and boxed indicator has a cost comparable with that of a moving-coil movement alone, not including its housing and associated electronics.

CONSTRUCTION

The indicator is contained in a small plastic box about 110 × 70 mm, sockets for input and output being fitted at either end. The front panel is fitted with S1, RV, the control knob for RV and the power scale calibrations. The circuit is constructed on Veroboard which is then located in slots within a Doram Module Case (but of course the individual layout and housing may be easily varied). The Veroboard layout is shown in Fig 3, which also shows the wiring between the board and S1, RV and the LEDs. The two-cell battery rests in the bottom of the box, held in place by Foam plastic beneath RV1. In the prototype S1 is a slide-switch fixed with a quick-setting resin adhesive; the absence of screws maintains a neat panel appearance.

CALIBRATION

Assuming that a power output meter is not available for connection

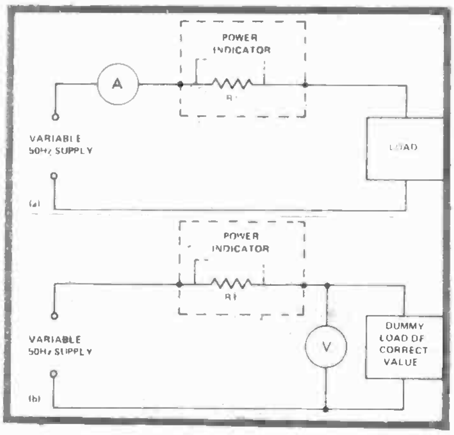


Fig. 1. Circuit of Power Indicator.

to the load, valibration may be completed using only an ac ammeter or voltmeter and a 50Hz supply. With the ammeter in series with the indicator and any suitable (resistive) load as in Fig 4(a), vary either the supply voltage or the load value to obtain the various current values shown in Table 1 and mark the dial or scale of the indicator at the point where adjustment of RV1

TABLE ONE

Load	4Ω		8Ω		16Ω		32Ω	
Power	Current	Voltage	Current	Voltage	Current	Voltage	Current	Voltage
1W	0.5A	2.0V	0.35A	2.8V	0.25A	4.0V	0.18A	5.7V
2	0.71	2.8	0.5	4.0	0.35	5.7	0.25	8.0
3	0.87	3.5	0.61	4.9	0.43	6.9	0.31	9.8
4	1.0	4.0	0.71	5.7	0.50	8.0	0.35	11.3
6	1.2	4.9	0.87	6.9	0.61	9.8	0.43	13.9
8	1.4	5.7	1.0	8.0	0.71	11.3	0.50	16.0
10	1.6	6.3	1.1	8.9	0.79	12.6	0.56	17.9
13	1.8	7.2	1.3	10.2	0.90	14.4	0.66	20.4
16	2.0	8.0	1.4	11.3	1.0	16.0	0.71	22.6
20	2.2	8.9	1.6	12.6	1.1	17.9	0.79	25.3
25	2.5	10.0	1.8	14.1	1.3	20.0	0.88	28.3
30	2.7	11.0	1.9	15.5	1.4	21.9	0.97	31.0
R1 for 20W	0.5Ω	25W	0.71Ω	1.8W	1Ω	1.3W	1.4Ω	0.9W

POWER METER

gives a brightness of LED1 matching that of LED2. In fact LED1 will start glowing at lower current (and hence power) values, but 'full glow' should be reached at one particular setting of RV1 and then any increase in current (or power) or RV1 sensitivity should give virtually no further increase in glow. If an ammeter is not available, a voltmeter across the correct value load resistor may be used as in Fig 4(b). The supply voltage must now be varied to obtain the wanted power levels in the load as shown in Table 1.

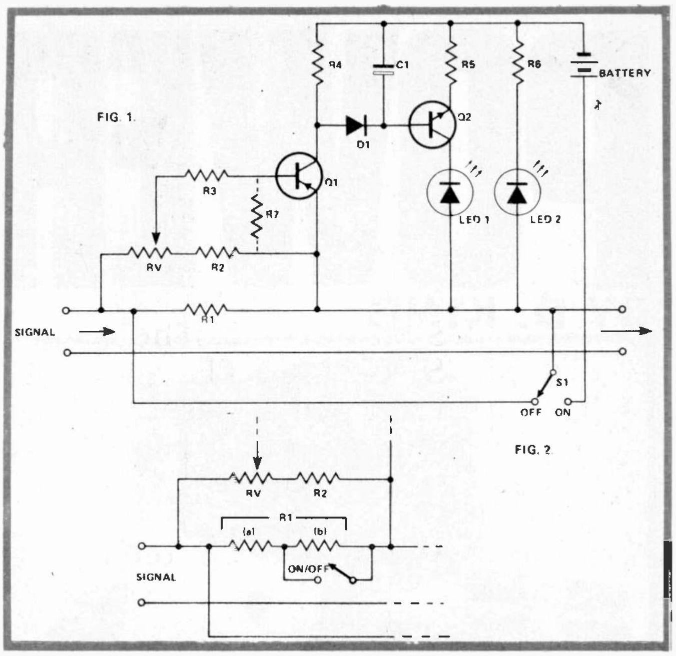


Fig. 2. Circuit modification allowing for two differing load impedances.

Fig. 4. Calibration arrangements.

MODIFICATIONS AND CALCULATIONS

(i) R1; using a germanium Q1, the 'turn-on' base-emitter voltage is about 0.25V. The gain of Q1 then determining the rate-of-charge of C1. Now if the load value is R, the power in R is I^2.R watts. Hence for a maximum sensitivity of indication for P watts, the current flowing through R1 is given by $I = \sqrt{P/R}$ amps. The value of R1 needed to produce about 0.25V for this current is thus given by $R1 = V/I = 0.25/\sqrt{P/R}$ ohms. For a 1W maximum sensitivity then $R1 = 0.25/\sqrt{1R} = 0.25 \times \sqrt{R}$ ohms.

The value of R1 needs to be increased if the value of the load R is increased. Either separate resistors may be switched (or plugged) into circuit or R1 may be made of two or more resistors in series with those not in use being short-circuited by a 'load impedance' switch. Such a circuit is shown in Fig 2 to allow for two different load impedances.

(ii) Calibration values; the current value has already been shown to be $I = \sqrt{R/R}$ amps. The voltage across the load is derived from $P = V^2/R$ watts, i.e. $V = \sqrt{R.R}$ volts.

(iii) Power rating of R1; R1 is sharing a proportion of the power fed to the load and must therefore have an appropriately high rating. If the load is, say 8 ohms and R1 of 0.75 ohms has been chosen so that a power range of up to 20 watts may be indicated, then the power rating of R1 must be at least 0.75/(0.75 + 8) times 20, i.e. about 2 watts. This may seem high but remember that the total load current must flow through R1 without overheating it.

(iv) R7; this resistor may not be needed since it allows for the use of transistors Q1 of widely differing gain characteristics. With RV set fully clockwise to the minimum sensitivity position (i.e. 20W in prototype), R7 was found during calibration to be 75 ohms for one particular transistor and yet was not required when using a different, lower gain transistor. Without R7 it is likely that the maximum sensitivity will be from about 0.5 to one watt, depending very much upon the actual values of resistors used to make up R1.

(v) Accuracy of indication; even though calibrated with the utmost care it must be remembered that an indication of power is not the same as a measurement. A consolation however is that whether the indicator is in circuit or disconnected, the resulting change in load power is only in the order of 0.5dB; the ear cannot distinguish an error of even one decibel.

In use the indicator has quickly shown the power capabilities of various amplifiers and it is interesting to see how voice and music peaks of, say 3-4 watts may be produced by a record or tape and yet the more average passages of sound fail to make the LED glow even at maximum sensitivity. ●

PARTS LIST

RV1 100Ω wirewound	D1 G.P. silicon diode
R1 See text and Table 1	Q1 G.P. germanium pnp transistor e.g. OC 71
R2 27Ω: see text	
R3 47R	Q2 G.P. NPN transistor e.g. AC127
R4 1k	LED1, 2 light emitting diodes, red
R5 47R	C1 30µF 3V working
R6 68R	Battery Two 1.5V cells in series, supply needed is about 60 mA, intermittent rating.
R7 See text	
	S1 SPDT see text.
⅛ or ¼W	Input and output jack or DIN sockets or plugs.

HOW IT WORKS

This indicator monitors the current to the load rather than the voltage across the load. Voltage (peaks) of the correct polarity developed across the current-sampling resistor R1 in Fig 1 turns on Q1 (pnp), RV1 setting the sensitivity and R3 acting as base-current limiter. Via D1, the positive-going voltage at Q1 collector charges C1 and turns on Q2 (npn) which thus illuminates LED1. D1 stops C1 from discharging via R4, the charge on C1 only being used to supply a diminishing current to Q2 base.

The value of C1 determines the length of time for which LED1 remains illuminated; increasing C1 to 100uF or more results in long flashes of light that tend to average over different peaks of sound. Decreasing C1 below about 5uF results in very fast indication but equally fast decay of LED flashes, which may make the indication too brief and not easily seen in a well-lit room.

R6 and LED2 are included to show that the internal battery of two 1.5V cells is in fact working and also to allow a direct comparison of brightness; without LED2 there may be some uncertainty about when LED1 is the correct brightness for a particular setting of RV against its power scale. When switched off, S1 short-circuits R1 so that the apparatus may be left in series with the load and yet dissipate no power. For high powers S1 needs to be of ample current rating.

R2 determines the maximum power indication when using a particular value of R1. With the suggested 100 lhm RV and R2 of 27 ohms, a range of one to twenty watts is obtained. If R2 is increased in value, the power range is reduced, so the value of R2 may be chosen by the constructor to suit his needs.

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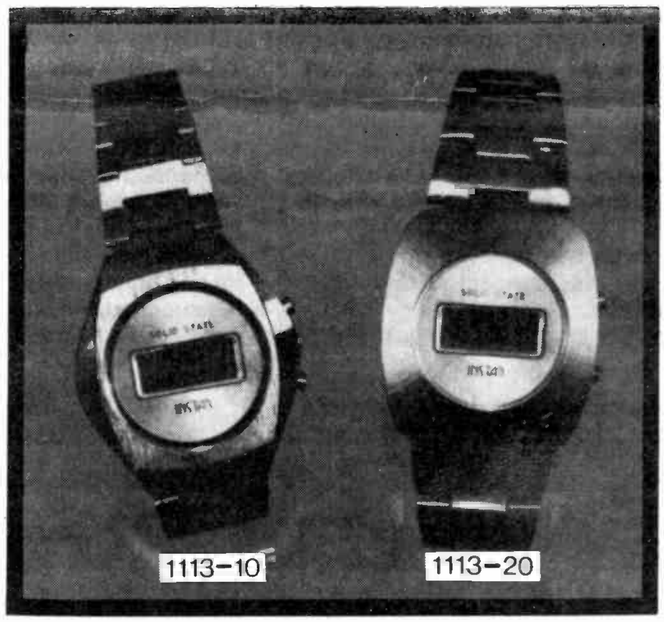

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A LOOK AT ONE OF THE EARLIER VERSIONS OF THE MODERN GRAMOPHONE — TAKEN BY BARRY QUEST

THE AUXETOPHONE

AN EARLY TALKING MACHINE

IN 1903 Sir Charles Parsons patented an improvement to the gridiron valve designed to improve its efficiency and reliability. A gridiron valve consists of a number of parallel slots in a fixed diaphragm, and a pivoted comb shaped member for closing the slots. When used with the phonograph the valve member was connected directly to the needle.

In this and other Patents taken out over the period 1903-5 he also introduced various auxiliary modifications including: the use of velvet lining in the horn to dampen scratch sounds, a 'viscous body' interposed between the needle and control valve to give a more mellow tone, and a compensating piston arranged to adjust the valve to allow for any fluctuation in the pressure of the supplied compressed air.

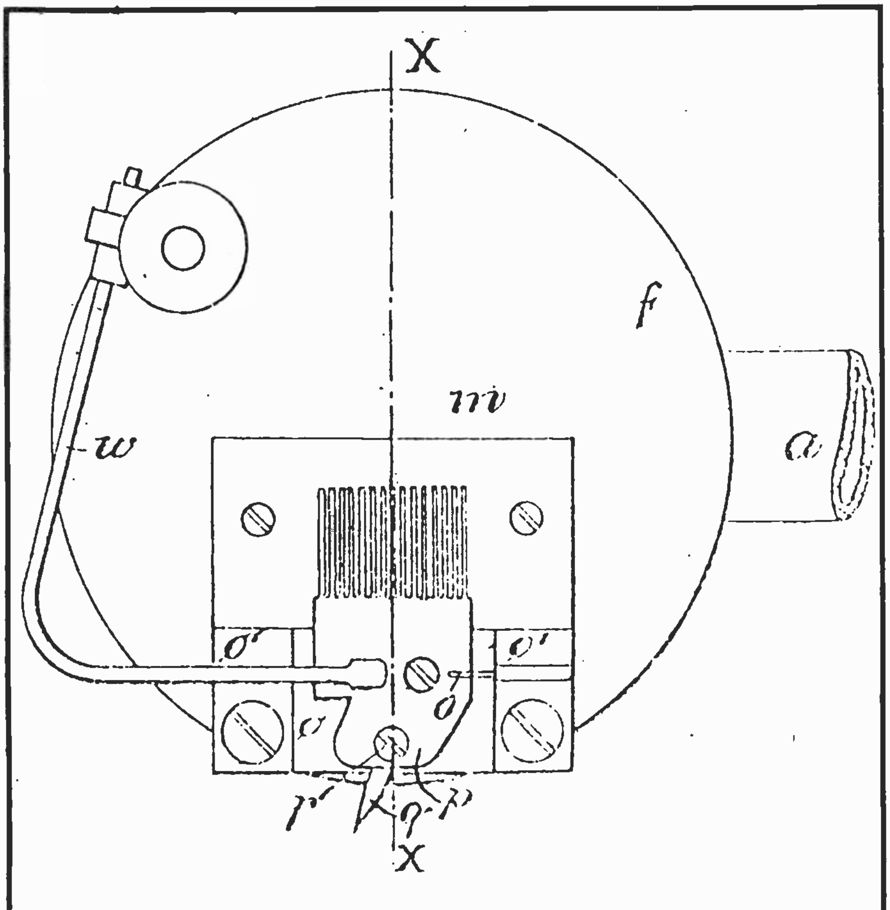

Fig. 1. The pneumatic amplifying valve developed by Sir Charles Parsons in 1903 for use with the Gramophone. The needle moves a comb in front of a slotted diaphragm through which air is blown under pressure to the acoustic horn.

PUBLIC DEMONSTRATION

By 1905 the amplified gramophone, or Auxetophone as Parsons called it, was in an advanced form and public demonstrations were arranged. One such demonstration was held for the benefit of the Press in London on the 20th March and the reporters were assured that the sound on a calm day could be heard for 2 to 3 miles. There was also a significant

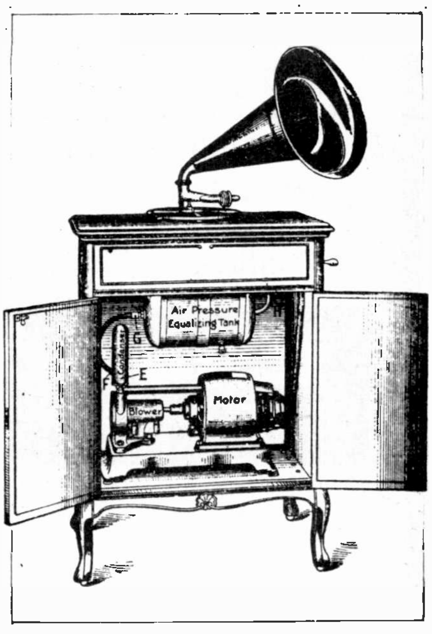

Fig. 2. Avxetophone as marketed by talking machine company in 1906.

improvement in quality — a richer, fuller tone was obtained — and this was explained by the fact that amplification was non-uniform and harmonics and higher frequencies were enriched.

The velvet horn lining and the viscous link also seemed to have a real effect on quality. The Times reported that there was 'a reinforcement of the upper partials giving fuller and rounder tones'. More picturesquely, the Scientific American compared the effect to

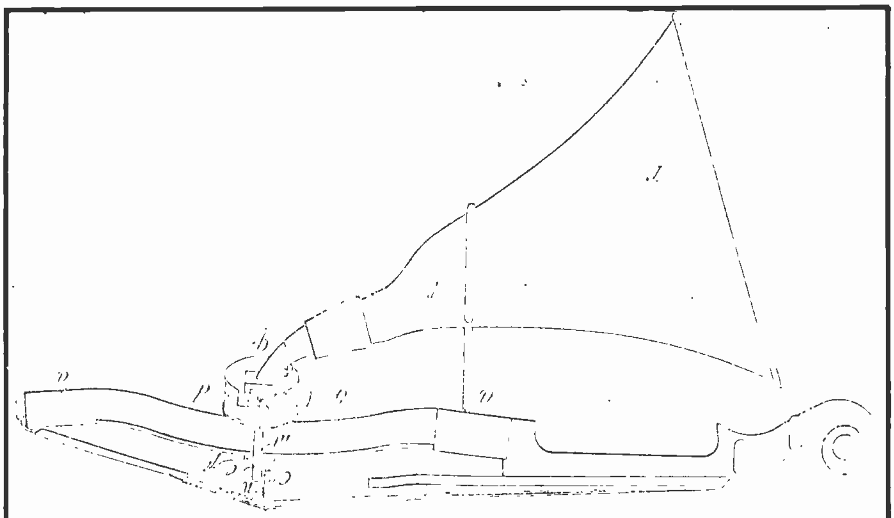

Fig. 3. An auxetophone violin — the forerunner of the modern amplified guitar — Patented in 1903 by Sir Charles Parsons.

'moisture in the throat of the singer' or 'like age and playing in loosening the fibres of the wood in the violin'.

TALKING MACHINE COMPANY

Parsons patents were brought by the Gramophone and Typewriter Co. Ltd. and the Auxetophone was subsequently marketed. In 1906 the Victor Talking Machine Co. was selling an Auxetophone in the United States. Contemporary observers were taken with the possibility of using the machine for public entertainment in large concert halls, and in fact the Auxetophone was used for this purpose.

CUMBERSOME AND COMPLICATED

Despite the interests shown by many contemporary observers the Auxetophone was never widely accepted and the reason for this is easy to understand. The machine was cumbersome and complicated. Compressed air was obtained from an electric motor-driven blower via a condenser, air pressure equalising tank and filter, and the user had to learn how to operate and maintain these devices and in particular take every precaution to see that the delicate gridiron valve was not damaged or blocked by dust particles or moisture getting into the system. It was also necessary to have a supply of mains electricity to power the motor and this in pre-First World War times was far from common.

TRIODES

By 1915 triode amplified gramophones were being developed, progress was halted by the war but shortly afterwards electronic amplifiers became generally available and the Auxetophone became a largely unknown invention of interest only to the historian and collector.

FOOTNOTE

Christies auctioneers, in South Kensington, recently sold an early phonograph made in Hamburg in 1877. This was a tinfoil machine by A. Kruscs. The date of production places it within a few years of Edisons original invention. The price? A mere £2,100. ●

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2N711	0.50
2N718	0.23
2N718A	0.28
2N720	0.57
2N914	0.22
2N916	0.28
2N918	0.32
2N929	0.25
2N930	0.26
2N1302	0.19
2N1303	0.19
2N1304	0.26
2N1305	0.24
2N1306	0.31
2N1307	0.30
2N1308	0.47
2N1309	0.47
2N1671	1.54
2N1671A	1.67
2N1671B	1.85
2N1711	0.27
2N1907	0.60
2N2102	0.60
2N2147	0.78
2N2148	0.94
2N2160	0.90
2N2218A	0.47
2N2219	0.42
2N2219A	0.52
2N2220	0.25
2N2221	0.18
2N2221A	0.21
2N2222	0.20
2N2222A	0.26
2N2368	0.17
2N2369A	0.22
2N2369	0.22
2N2646	0.55
2N2647	0.98
2N2904	0.40
2N2904A	0.45
2N2905	0.47
2N2905A	0.50
2N2906	0.33
2N2906A	0.42
2N2907	0.22
2N2907A	0.24
2N2924	0.20
2N2926	0.20
2N3053	0.28
2N3054	0.60
2N3055	0.65
2N3390	0.45
2N3391	0.28
2N3391A	0.29
2N3392	0.15
2N3393	0.15
2N3394	0.15
2N3402	0.18
2N3403	0.19
2N3414	0.20
2N3415	0.24
2N3416	0.21
2N3417	0.29
2N3440	0.59
2N3441	0.97
2N3442	1.40
2N3638	0.15
2N3638A	0.15
2N3639	0.27
2N3641	0.17
2N3702	0.12
2N3703	0.12
2N3704	0.15
2N3705	0.15
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2N3707	0.18
2N3708	0.14
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2N3712	1.20
2N3713	1.20
2N3714	1.38
2N3715	1.50
2N3716	1.80
2N3771	2.20
2N3772	1.80
2N3773	2.65
2N3779	3.15
2N3790	2.40
2N3791	2.35
2N3792	2.60
2N3794	0.10
2N3810	0.37
2N3820	0.29
2N3823	0.78
2N3904	0.19
2N3906	0.19
2N4036	0.67
2N4037	0.42
2N4058	0.18
2N4059	0.15
2N4060	0.15
2N4061	0.15
2N4062	0.15
2N4126	0.21
2N4289	0.34
2N4919	0.95
2N4920	1.10
2N4921	0.83
2N4922	0.83
2N4923	1.00
2N5190	0.92
2N5191	0.96
2N5192	1.24
2N5195	1.46
2N5245	0.29
2N5294	0.48
2N5295	0.48
2N5296	0.48
2N5298	0.50
2N5457	0.29
2N5458	0.26
2N5459	0.29
2N5492	0.58
2N5494	0.58
2N5496	0.61
2N6027	0.45
2N5777	0.45
3N128	0.73
3N139	1.42
3N140	1.00
3N141	0.81
3N200	2.49
40361	0.40
40362	0.45
40363	0.88
40389	0.46
40394	0.56
40395	0.65
40406	0.44
40407	0.35
40408	0.35
40409	0.52
40410	0.52
40411	2.00
40594	0.74
40595	0.84
40601	0.67
40602	0.61
40603	0.58
40604	0.56
40636	1.10
40669	1.00
40673	0.73
AC126	0.20
AC127	0.40
AC128	0.35
AC151V	0.27
AC152V	0.49
AC153	0.35
AC153K	0.40
AC154	0.25
AC176	0.41
AC176K	0.40
AC187K	0.35
AC188K	0.40
AD142	0.57
AD143	0.68
AD149V	0.74
AD150	0.63
AD161	0.64
AD162	1.58
AF106	0.40
AF109R	0.40
AF114	0.35
AF115	0.35
AF116	0.35
AF117	0.35
AF118	0.35
AF124	0.30
AF125	0.30
AF126	0.28
AF127	0.28
AF139	0.65
AF186	0.46
AF200	0.65
AF239	0.65
AF240	0.90
AF279	0.70
AF280	0.79
AL102	1.00
AL103	1.00
BC107	0.14
BC108	0.14
BC109	0.15
BC113	0.15
BC115	0.17
BC116	0.17
BC116A	0.18
BC117	0.21
BC118	0.14
BC119	0.29
BC121	0.35
BC125	0.16
BC126	0.23
BC132	0.30
BC134	0.13
BC135	0.13
BC136	0.17
BC137	0.17
BC140	0.68
BC141	0.68
BC142	0.23
BC143	0.25
BC147	0.10
BC148	0.09
BC149	0.11
BC153	0.18
BC154	0.18
BC157	0.16
BC158	0.16
BC160	0.78
BC167B	0.15
BC168B	0.15
BC168C	0.15
BC169B	0.15
BC169C	0.15
BC170	0.15
BC171	0.16
BC172	0.12
BC177	0.19
BC178	0.18
BC179	0.21
BC182	0.12
BC182L	0.12
BC183	0.12
BC183L	0.12
BC184	0.13
BC184L	0.13
BC207	0.27
BC208	0.11
BC212	0.16
BC212L	0.16
BC214L	0.18
BC237	0.16
BC238	0.15
BC239	0.16
BC251	0.25
BC253	0.25
BC257	0.15
BC258	0.16
BC259	0.17
BC261	0.25
BC262	0.25
BC263	0.25
BC300	0.38
BC301	0.34
BC303	0.54
BC307	0.17
BC308A	0.15
BC309C	0.20
BC317	0.12
BC318	0.12
BC337	0.20
BC338	0.20
BCY30	0.80
BCY31	0.85
BCY32	1.15
BCY33	0.85
BCY34	0.79
BCY38	1.00
BCY39	1.50
BCY40	0.97
BCY42	0.28
BCY58	0.30
BCY59	0.32
BCY70	0.17
BCY71	0.22
BCY72	0.18
BD115	0.75
BD116	0.75
BD121	1.00
BD123	0.82
BD124	0.67
BD131	0.40
BD132	0.50
BD135	0.21
BD136	0.22
BD137	0.24
BD138	0.26
BD139	0.71
BD140	0.87
BD529	0.80
BD530	0.80
BDY20	1.05
BF115	0.29
BF117	0.55
BF121	0.35
BF123	0.35
BF125	0.35
BF152	0.20
BF153	0.25
BF154	0.15
BF159	0.27
BF160	0.23
BF163	0.32
BF166	0.40
BF167	0.25
BF173	0.27
BF177	0.29
BF178	0.35
BF179	0.43
BF180	0.35
BF181	0.36
BF182	0.35
BF183	0.55
BF184	0.30
BF185	0.30
BF194	0.12
BF195	0.12
BF196	0.13
BF197	0.15
BF198	0.18
BF200	0.40
BF225J	0.23
BF244	0.21
BF245	0.45
BF246	0.58
BF247	0.65
BF254	0.19
BF255	0.19
BF257	0.47
BF258	0.53
BF259	0.55
BFR39	0.24
BFR79	0.24
BFS21A	2.30
BFS28	1.36
BFS61	0.27
BFS98	0.25
BFX29	0.35
BFX30	0.35
BFX84	0.30
BFX85	0.35
BFX87	0.28
BFX88	0.30
BFX89	0.90
BFY50	0.30
BFY51	0.28
BFY52	0.30
BFY53	0.18
BFY90	1.27
BRY39	0.48
BSX20	0.28
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BU104	2.00
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C106D	0.65
CA3080A	1.08
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CA3052	1.62
CA3046	0.70
CA3048	2.11
CA3089E	1.96
CA3090Q	4.23
LM301A	0.48
LM308	1.17
LM309K	1.88
LM380	0.98
LM381	2.07
LM702C	0.76
LM709T099	0.48
LM741CAN	0.40
8DIL	0.38
14DIL	0.40
LM710	0.47
LM3900	0.61
LM723C	0.66
LM741T099	0.40
LM709CAN	0.48
8DIL	0.40
14DIL	0.38
LM747	1.00
LM7488DIL	0.44
8DIL	0.44
LM7805	1.88
14DIL	0.73
LM7805	2.50
LM7812	1.99
LM7815	1.99
LM7824	1.99
MC1303	1.50
MC1310	2.50
MC1330P	0.90
MC1351P	0.80
MC1352P	0.80
MC1466	3.50
MC1469	2.75
ME0402	0.20
ME0404	0.13
ME0412	0.18
ME4102	0.11
ME4104	0.11
MJ480	0.95
MJ481	1.20
MJ490	1.05
MJ491	1.45
MJ2955	1.00
MJE340	0.48
MJE370	0.65
MJE371	0.75
MJE520	0.60
MJE521	0.70
MJE2955	1.20
MJE3055	0.75
MP8111	0.32
MP8112	0.40
MP8113	0.47
MPF102	0.39
MPSA05	0.25
MPSA06	0.31
MPSA12	0.35
MPSA55	0.21
MPSA56	0.31
MPSU05	0.65
MPSU06	0.58
MPSU55	0.63
MPSU56	0.80
NE555V	0.70
NE556	1.30
NE560	4.48
NE561	4.48
NE565A	4.48
OC23	1.35
OC28	1.48
OC35	1.16
OC42	0.50
OC45	0.32
OC71	0.17
OC72	0.25
OC81	0.25
OC83	0.24
ORP12	0.80
R53	1.80
SL414A	2.35
SL610C	2.35
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SL640C	4.00
SL641C	3.10
SN76003N	2.92
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ST2	0.20
TAA300	1.84
TAA263	1.20
TAA350	1.96
TAA550	0.32
TAA611C	2.18
TAA621	2.03
TAA661B	1.03
TBA641B	2.25
TBA651	1.69
TBA810	0.98
TBA820	0.80
TBA920	1.79
TIL209	0.35
TIP29A	0.49
TIP30A	0.58
TIP31A	0.62
TIP32A	0.74
TIP33A	1.01
TIP34A	1.51
TIP35A	2.90
TIP36A	3.70
TIP41A	0.79
TIP42A	0.90
TIP29c	0.80
TIP30c	0.65
TIP31c	1.00
TIP32c	1.25
TIP33c	1.45
TIP34c	2.60
TIP41c	1.40
TIP42c	1.60
TIP49	0.70
TIP2955	0.98
TIP3055	0.50
TI543	0.28
ZTX300	0.13
ZTX301	0.13
ZTX302	0.20
ZTX500	0.15
ZTX501	0.13
ZTX502	0.18
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CD4029	1.06
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CD4043	.83
CD4044	.77
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SN7407	0.36
SN7408	0.19
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SN7411	0.20
SN7412	0.22
SN7413	0.28
SN7416	0.28
SN7417	0.28
SN7420	0.16
SN7423	0.23
SN7425	0.23
SN7427	0.23
SN7430	0.15
SN7432	0.22
SN7437	0.28
SN7438	0.28
SN7440	0.16
SN7441	0.68
SN7442	0.65
SN7445	0.78
SN7446	0.84
SN7447	0.80
SN7448	0.90
SN7450	0.16
SN7451	0.16
SN7453	0.16
SN7454	0.16
SN7460	0.16
SN7470	0.29
SN7472	0.21
SN7473	0.31
SN7474	0.31
SN7475	0.45
SN7476	0.30
SN7480	0.42
SN7481	1.00
SN7482	0.65
SN7483	0.82
SN7484	0.95
SN7485	1.00
SN7486	0.29
SN7490	0.42
SN7491	0.75
SN7492	0.45
SN7493	0.45
SN7494	0.75
SN7495	0.68
SN7496	0.68
SN74100	1.10
SN74107	0.30
SN74118	0.86
SN74119	1.75
SN74121	0.32
SN74122	0.42
SN74123	0.65
SN74141	0.75
SN74145	0.72
SN74150	1.20
SN74151	0.88
SN74153	0.68
SN74154	1.20
SN74155	0.78
SN74157	0.76
SN74160	0.88
SN74161	0.88
SN74162	0.68
SN74163	0.88
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BC108	9p	*MPSA12	50p	*2N3705	11p
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BF173	25p	ZTX502	18p		
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BF178	28p	2N698	30p		
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BF184	22p	2N918	40p	**FETs**	
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*BF197	15p	2N1304	35p	*MPF104	30p
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16A400V	Plastic		180p
16A600V	Plastic		220p

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2N4444 8A 600V	Plastic	185p
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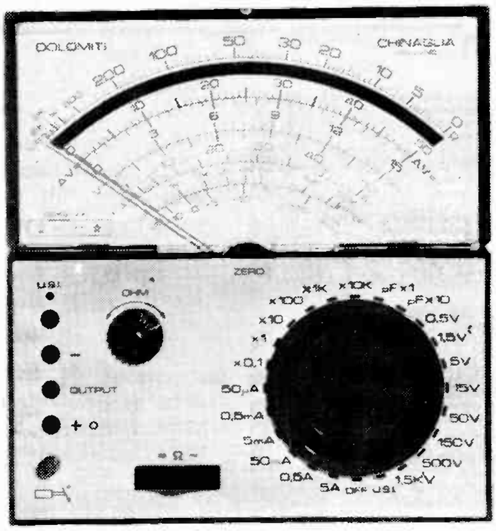

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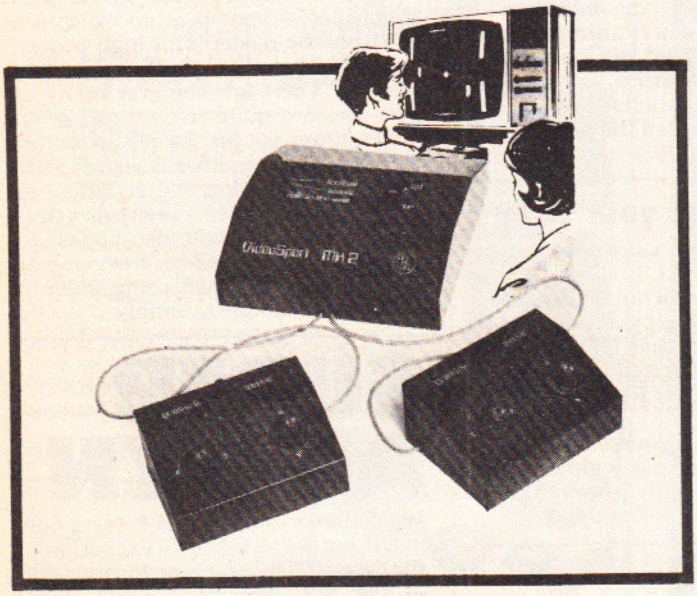


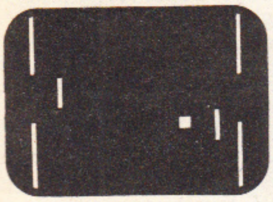
Here's a chance to save yourself a fortune at the pub, and it doesn't involve giving up drink! Just imagine how all those 10p's you've always spent playing TV tennis could be put to more productive use -- like another pint or two -- if you had a game at home.

Our reader offer this month gives you the chance to do just that — and not only tennis — but football and 'squash' as well!

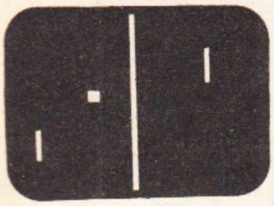
The unit needs no external circuitry, it plugs straight into the aerial socket of a UHF television as it contains it's own modulator. The games appear as a signal to which the television is tuned. With a push-button tuner you've got a games channel!

Each Videosport is fully tested before dispatch, there is no alignment to be done plug it in and away you go. The diagrams on the left show what each game looks like on the TV screen, and gives you an idea of the unit's sophistication.

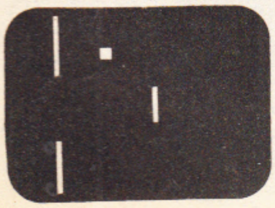
To lay hands on a Videosport unit, send the coupon direct to Henry's Radio at the address shown, *not* to ETI — then buy yourself a pint to celebrate!



FOOTBALL
A game for two people. The bats have full movement in horizontal and vertical directions.



TENNIS
As with football, a two person game, although a little harder to play.



HOLE-IN-THE-WALL
Can be played by either one or two people. In the latter case, one player attempts to prevent the other scoring by moving the wall around.

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JULY ISSUE ON SALE JUNE 4th 30p

CB for UK?

Citizen's Band radio (CB) is now a part of the American way of life and is legal in many other countries. Should CB be introduced in Britain? There are vested interests on both sides — and good arguments on both sides.

Next month, ETI puts CB under the microscope. We give you an outline of what has happened in countries where it has been introduced, we look at the attitude of the authorities, we've asked potential manufacturers for their views and investigated the problem of frequency availability.

At the moment Britain's CB operators are pirates — but will it always be so?

Make sure of your copy

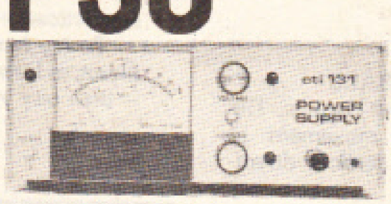
Many readers tell us they find it difficult to find ETI in their newsagents. True. You will not be surprised to that we are unhappy about this as well. The reason is that ETI is one of the fastest growing circulation magazines in Britain in *any* field – and that sets problems.

Make it easier for yourself and your newsagent by placing a regular order – he'll almost certainly reserve you a copy : then we'll *all* be happy!

DIGITAL WATCHES

We have to confess something: this feature is not in an advanced state of preparation. The reason is that the digital watch market is moving so fast with new models and ever-falling prices that early preparation would make the survey out-of-date. We plan to give you an idea of what is available and tell you what features to look for.

PSU



A versatile PSU which produces up to 2.5A from zero to 20V or up to 1.25A from zero to 40V. Current limiting is adjustable over the entire range for either output option.

SWEET SIXTEEN

There's a tendency for electronics magazines — and we're no exception — to ply the reader with high power, super-high-quality audio amplifier projects. There are however many of you who are quite happy, and even prefer, lower output. Sweet Sixteen is an 8W + 8W amplifier designed with ease of construction and economy in mind — it's ideal for a teenager (thus the name) — but will also appeal to anyone who wants a low power amplifier. It's designed using modern ICs for truly simple assembly.

SUPER AVILYN

We don't do too many hi-fi tests now in ETI but we've made an exception in the case of TDK new tape formulation — the next step from CRO_2 tape. We've really put it through its paces and the results are — well, let's quote you our summary: "Super Avilyn tape looks as though it is one of the most important advances in tape formulations . . ."

COMPUTER MIXING

Today your records may have had the audio signals mixed using a computer: This controls the levels, etc, and takes away much of the hard work from the engineer.

ELECTRONICS & PRINTING

These words that you are reading — and come to that the production of this entire page — are set using highly sophisticated electronic techniques. The input keyboard produces a punched tape which couples with a computer and a photo-type setter — corrections are done on a VDU. Doesn't mean much to you? In next month's issue we have a major article describing some of the modern techniques which are replacing traditional methods.

Heathkit Education Course

In May's ETI we gave you the first news about Heathkit's entry into the direct educational field. At the moment, one of ETI's staff is working his way through one of the more advanced courses on digital techniques. We're not going to comment until he has finished but we'll give you full details next month — and tell you if he passed the final exam!

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tech-tips SPECIAL

WINDOW DECTOR CIRCUIT

This circuit de-energises a normally energised relay if an input voltage goes above or below two individually set voltages.

It consists of one IC and one transistor driving the relay. The transistor is normally turned on by R4, so the relay is normally energised. If the cathode of D1 or D2 is taken negative, Q1 will turn off and the relay will de-energise.

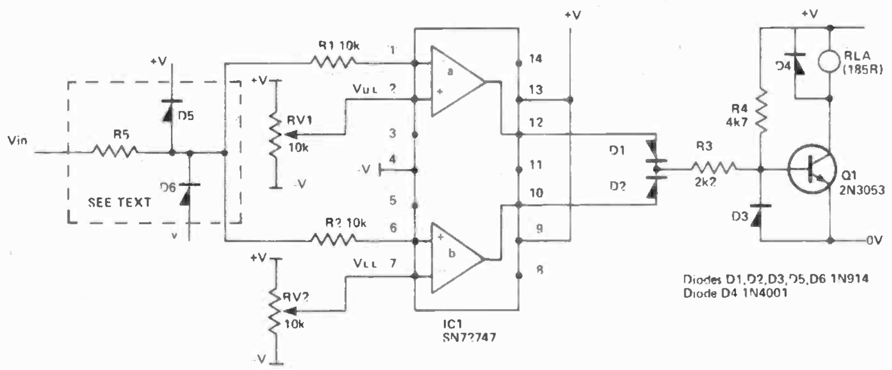
The IC is a 72747 (dual op amp). The op amps are used without feedback, so the full gain (about 100dB) is available. The amplifier output will thus swing from full positive to full negative for a few mV change at the input.

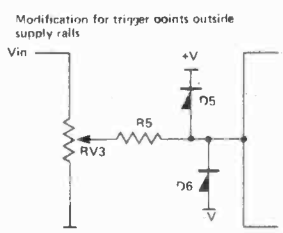
The relay is therefore only energised if Vin is between V_{UL} and V_{LL}. The two limits can be set anywhere between the supply rails, but obviously V_{UL} must be more positive than V_{LL}.

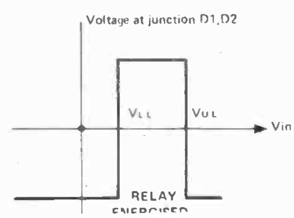
If Vin can go outside the supply rails D5, D6 and R5 should be added to prevent damage to IC1.

If V_{UL} and V_{LL} are required to be outside the supply rails, Vin can be reduced by RV3.

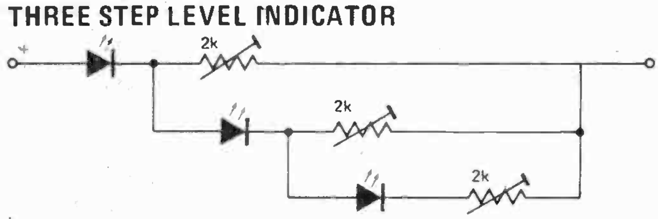
The supplies can be any value providing the voltage across them is not more than 30V.







THREE STEP LEVEL INDICATOR



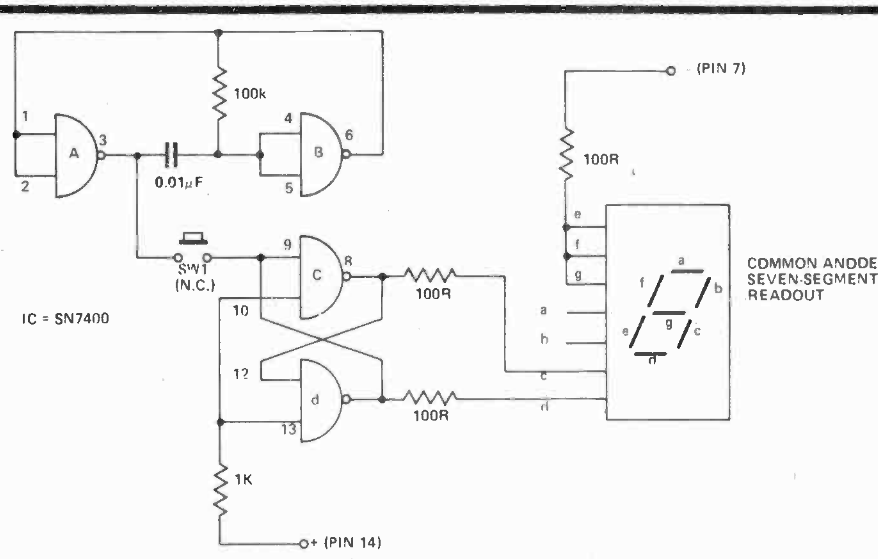
This device makes a very compact and robust level indicator where a meter would be impractical due to lack of space, or not justified due to cost.

Resistor values will depend on type of LED used. In the prototype, the LED's were MV50's and the resistors were 2kΩ ½watt. This gave steps of approx 2V and the current drain with all three LED's on was 5mA. The chain can be extended but current drain increases rapidly and the first LED carries all the current drawn from the supply.

HEADS OR TAILS CIRCUIT

The two gates (A) and (B) of the SN7400 IC are connected as a astable multivibrator, whilst (C) and (D) are connected as a bistable.

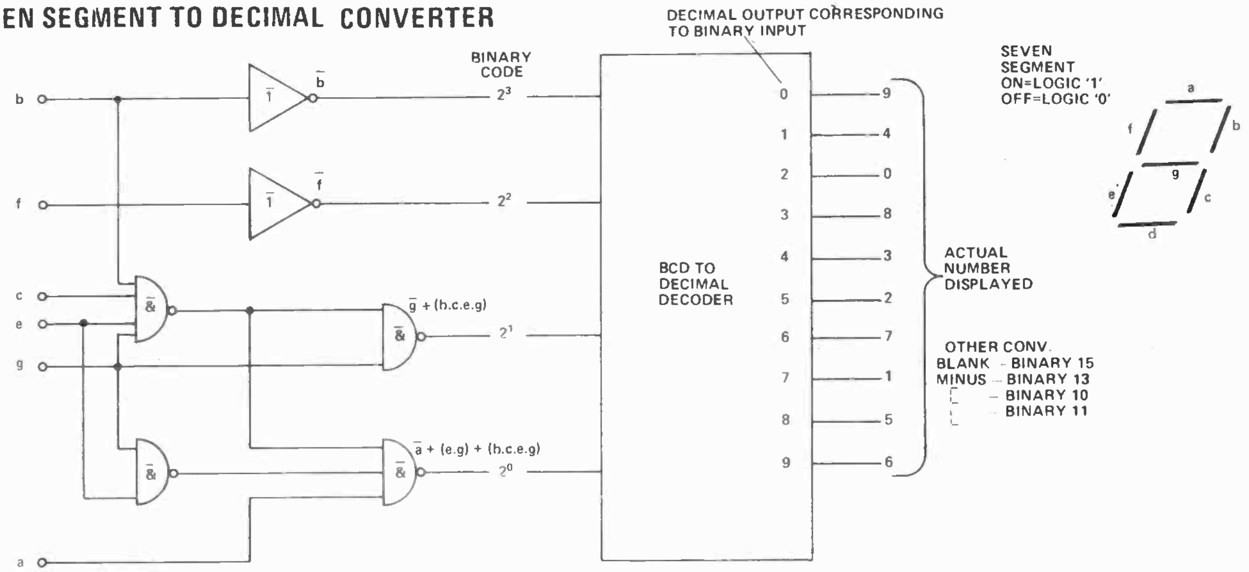
Output from the multivibrator is taken via a 'spin' switch (SW-1) to pin 9. If the input to this pin 9 is high, and since pin 10 is already connected to a logic-1 through the 1kΩ resistor, the output at pin 8 will be at logic-0. This causes segment "C" of the readout to light forming the letter "h" for heads. Since the output of pin 8 is at logic-0 and connected to pin 12, the output of pin 11 will be at logic-1 which will light segment "d" to cause it to indicate the letter "ヒ" for tails.



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.

SEVEN SEGMENT TO DECIMAL CONVERTER



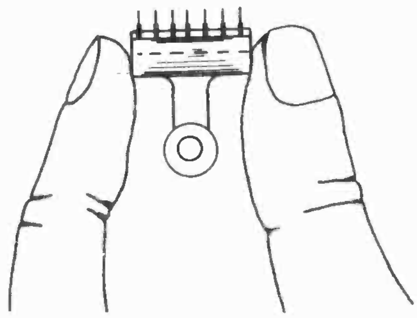
This circuit probably is the most economical means of converting seven segment outputs to decimal. Applications include interfacing clock or calculator chips to Nixies, relays or lamps. It may be implemented in TTL or CMOS (e.g. 7400, 7420, 74141). Note that the output from the gates is not 'straight' BCD so the outputs from the BCD to decimal decoder are transposed. It will convert 6's and 9's with or without the top and bottom bars respectively but not 'hooked' 7's (which are rare anyway). The BCD to decimal decoder should be the 'fully decoded' type with blanking for BCD inputs over 9 since a blank is encoded as binary 15, hence a 74141 instead of 7441. Some other conversions which result from this circuit are shown.

CMOS DIL HANDLING DEVICE

For those of us that get into a cold sweat when handling CMOS devices, we can all now sign with relief. A cheap solution in the form of a spring clip can be obtained from a well-known stationery chain-store. The clips are called "letter clips" and cost 30p for a card containing 12 clips.

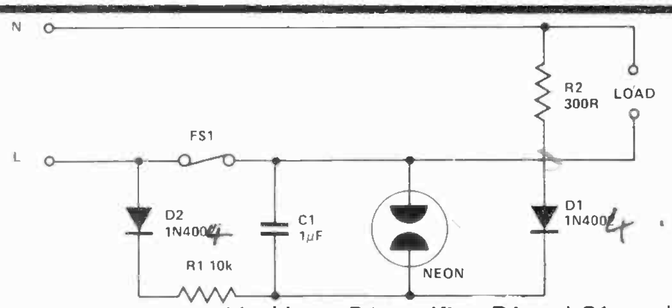
In the light of experience the following points are worth noting.

1. Before using the clips any internal burrs should be removed, as these will prevent a good contact being made with the IC pins.
2. NEVER remove the IC from the impregnated foam until the clip has been fitted.



3. When fitting the clip, ensure that it 'shorts out' ALL the IC pins.
4. During IC insertion or removal from a PCB or socket, the IC and clip are gripped TOGETHER across their ends, with the thumb and forefinger (see sketch). This proceedure should remove any chance of the clip accidentally releasing the IC.
5. If the IC is to be soldered into a PCB, the clip should be left in place during the soldering process, as it will also act as a heat-sink. If several IC's are to be soldered into a board, it is worth while leaving all the clips attached until the last IC has been soldered in position.

BLOWN FUSE INDICATOR



Most power supplies contain at least one fuse and a neon pilot light. With the addition of two diodes, two resistors and a capacitor, the neon light can serve a dual purpose.

As shown in the circuit diagram, if the fuse is OK, the neon functions as a normal mains indicator. However, when the fuse blows, the neon indicates the fact by flashing on and off.

When the fuse is OK, the diode D2 acts as a rectifier and applies current to the neon, D1 acts as a blocking diode, thus precenting a short. In this mode the light is continuously on. When the fuse blows, D2 blocks while D1 rectifies. R1 and C1 are the timing components that control the neon flash rate. R2 and the forward resistance of D1 increase neon life.

tech-tips SPECIAL

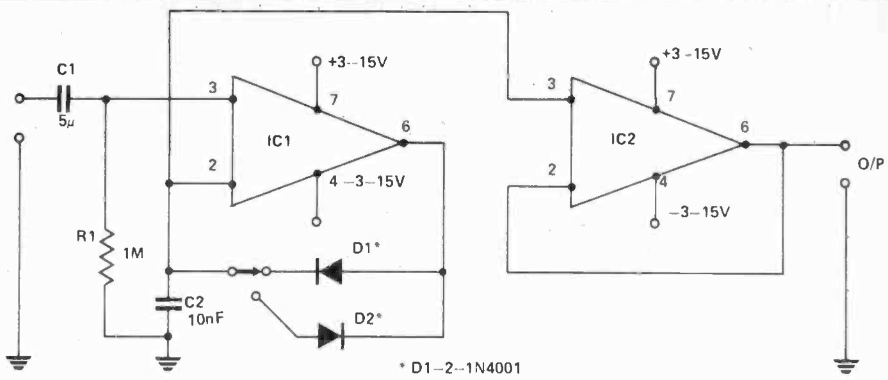
PEAK PROGRAM DETECTOR

The circuit shown will allow a multimeter to display the positive or negative peaks of an incoming signal.

A 741 is used in the non-inverting mode with R1 defining the input impedance. D1 or D2 will conduct on a positive or negative peak charging C2 until the inverting input is at the same DC level as the incoming peak.

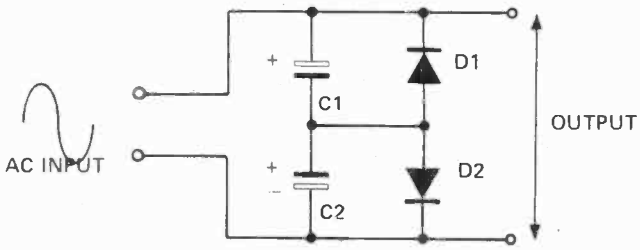
This will maintain the voltage until a higher peak is detected, when this will be stored by C2.

In order to prevent loading by the multimeter another 741, (IC2) is employed. This is also connected in the non-inverting mode as a unity gain buffer, output impedance is less than 1Ω, low enough to feed the most insensitive meter.



As shown the instrument has a useful response from 10Hz–100kHz (±1dB). High linearity is ensured by placing the diodes in the feedback loop of IC1, effectively compensating for the 0.6V bias that these components require.

CAPACITOR SUBSTITUTION



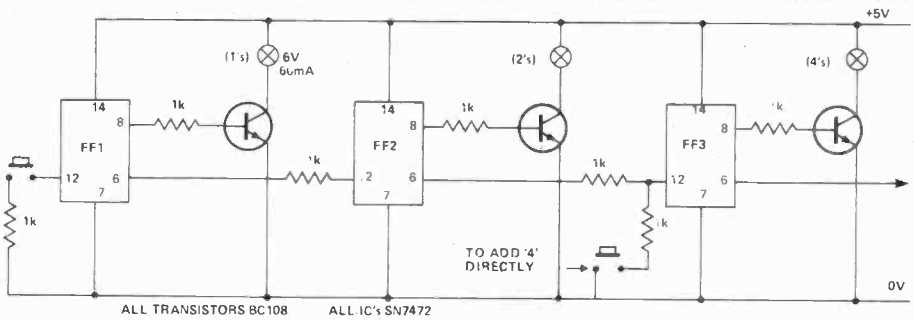
Quite often, especially when constructing operational amplifier circuits, capacitors of several μFarad values are required and they must be of the non polarised type (non electrolytic). One may not have these readily available and as a short term measure I suggest the use of two tantalum capacitors to replace one non-electrolytic, as in circuit diagram.

One can use any diodes, bearing in mind voltages in use, especially maximum reverse voltage that the tantalum will stand. Normal circuit criteria will of course apply to type and value of capacitors chosen. (Two capacitors in series will give a total capacitance of only half the capacitance of one of the capacitors, providing there are of the same value).

The actual operation of this circuit I think is self evident. A negative going voltage would be shorted out across C1 by D1 and applied across C2. A positive going voltage would be applied across C1 and D2 will short C2.

BINARY CALCULATOR

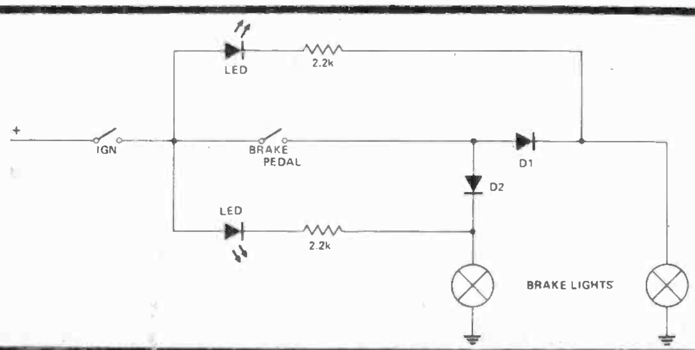
This simple circuit allows infinite addition in binary (base 2). The circuit can be split into many identical stages, each consisting of a flip flop and lamp driver. An input of 'state 1' initiates the first flip flop. Hence the 1's lamp is on. A second pulse alters the first F.F to switch off the lamp and send a pulse to the second flip flop which illuminates the (2's) lamp. The third pulse causes F.F1 to light its lamp without altering the second. This means that the 1's and 2's lamps are on (1+2+=3) a total count of three. This on/off process continues for all the stages.



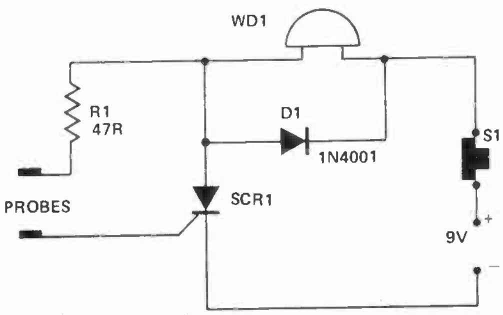
There is no limit to the total count of the circuit, Each additional stage doubles the count. i.e: 9 stages, total count is 511. To enter large numbers a press button shorts the input of the intermediate stage to 0V via a 1k resistor.

DC LAMP FAILURE INDICATOR

The very simple circuit here provides an on-if-good function for a lamp. D1 and D2 should be generously rated as they are outside the warning loop. On a car type DO4 is recommended for mechanical support. If all the lights on a car are to be monitored the diodes can be mounted in blocks behind the lamp housing that the wiring harness reaches first. A 'line of light' type LED makes a convenient display.



WATER LEVEL INDICATOR



This simple circuit provides an audible warning of the liquid level between the probes a current is in a tank or alternatively may be used as a touch or rain alarm. When a liquid is present between the probes a current is allowed to flow, limited by R1, which triggers the thyristor on. The current drawn by the warning device WD1 is above the holding current of the thyristor alarm and so the alarm continues to sound. R1 should be chosen to suit the thyristor used, D1 provides protection from current surges. The circuit may be reset by pressing S1 which is a push to break type, SCR1 should be a 25V low current type.

VOLTAGE/POLARITY PROTECTION CIRCUIT

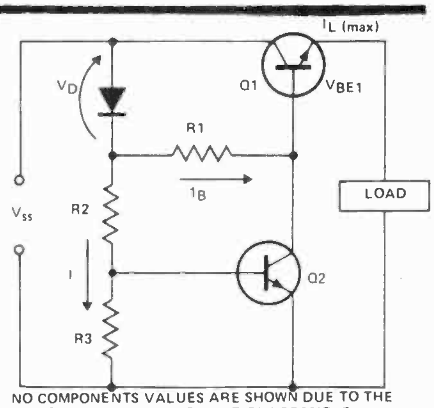
Many circuit, i.e., car radios, can be destroyed if improper voltage or polarity is applied. A simple yet effective technique using only two transistors avoids this possibility.

The circuit shown prevents accidental destruction of a load circuit caused by incorrect supply voltage or polarity. This is accomplished without shorting the supply as in SCR and zener protectors. Under normal supply voltage, Q1 is on and Q2 is off provided that:

$$R_1 \leqslant \frac{\beta_1 [V_D + V_{BE1}]}{I_{L(max)}}$$

$$I \geqslant \frac{I_{L\,(max)}}{\beta_1 \beta_2}$$

$$R_3 \leqslant \frac{V_{BE2}}{I}$$

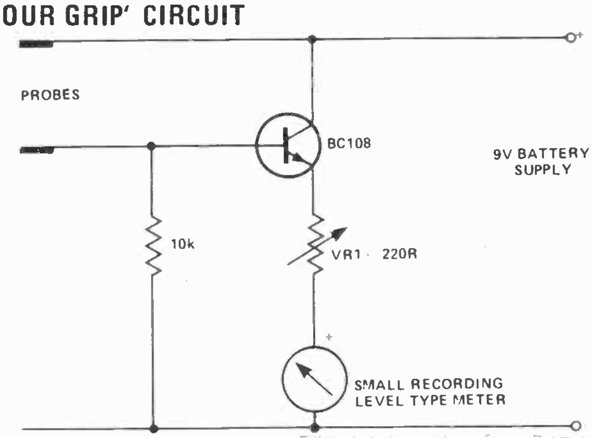


NO COMPONENTS VALUES ARE SHOWN DUE TO THE NUMEROUS CIRCUIT APPLICATIONS POSSIBLE

$$R_2 = (V - V_D)I - R_3$$

In case the supply voltage exceeds V, Q2 turns on, diverting the base current I_B to ground thus turning off Q1. In the case of wrong polarity, Q1 does not turn on due to the absence of base current I_B which is blocked by diodes D.

SIMPLE 'TEST YOUR GRIP' CIRCUIT



As can be seen there is little that needs explaining but it should be noted that care should be exercised when using the unit. It is unsuitable for use with a battery eliminator due to the risk of mains shock as some of these units are incorrectly earthed.

The probes must have a fairly large surface area for the satisfactory operation of the device. Short (20cm.) lengths of *clean* copper pipe have been used with good results. VR1 is used to adjust the circuit to the age of the user; low for children, higher for adults. The meter may be replaced by a small LED and suitable series resistor.

LDR Protection. Some, like the ORP12, are a push-fit in soft plastic DIN plug cases and when they are so fitted form a watertight seal suitable for use outdoors. This method also neatens the appearance of the device and helps to stop the flow of complaints about nasty, ugly electronic gadgets. Before fitting the LDR the leads must of course be lengthened.

CURRENT-FLOW INDICATOR

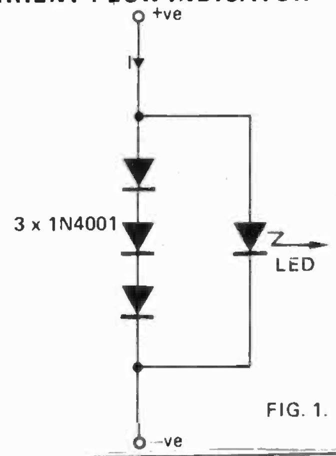


FIG. 1.

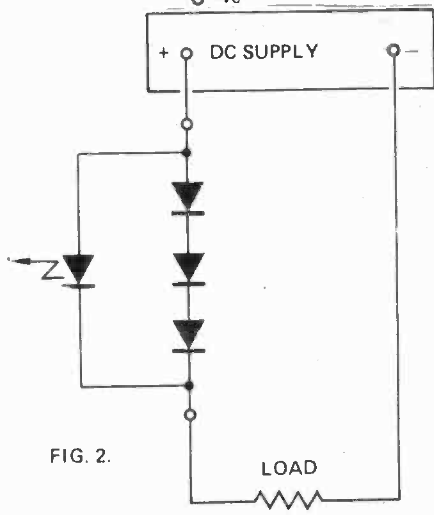


FIG. 2.

This circuit was designed for use with the ETI Ni-cad Battery Charger. It gives a positive indication by means of an LED that the battery is receiving current. The current I (at any applied voltage from 3–45V) causes a more-or-less constant p.d. of 1.8–2.2V across the 3 silicon diodes. This causes the LED to light up. The circuit is very sensitive and the LED starts to emit at 1.5mA, growing to its maximum brightness at about 10mA. This brightness is maintained over the full current range up to 1A (I_{max} for the diodes used). No current limiting resistor was found necessary for the LED.

The indicator is very cheap – about 30p – and reliable. Although 2V is 'lost', in many cases this is not important. In practice the unit is connected in series with the load (Fig. 2). It is important to note that no indication of the magnitude of the current is given; the whole idea of the circuit is to give a purely qualitative signal.

tech-tips SPECIAL

FREQUENCY DOUBLER

This is a simple three transistor circuit to raise an audio frequency by a factor of two i.e., one octave. Q1 is connected as a phase splitter with anti-phase signals appearing at it's collector and emitter. These signals are fed to two emitter followers Q2 and Q3, which have a common emitter resistor, and thus add the two anti-phase signals. A degree of distortion is inevitable as shown in Fig. 2, but is acceptable for speech and soloists and produces a sound similar to the Chipmunks or Pinky and Perky.

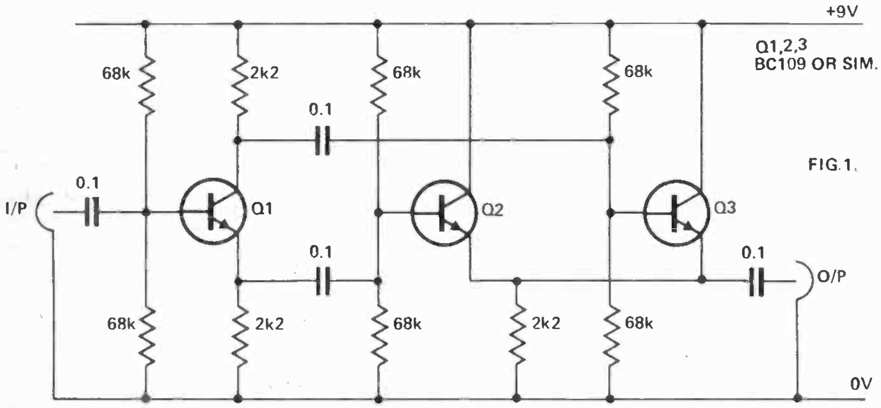


FIG.1.

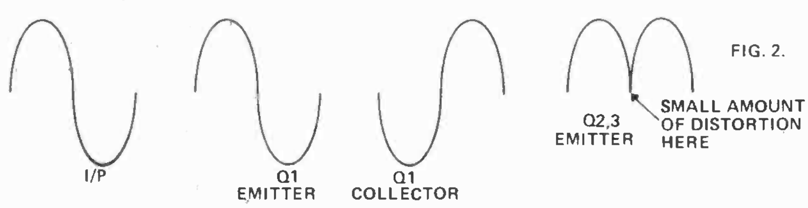
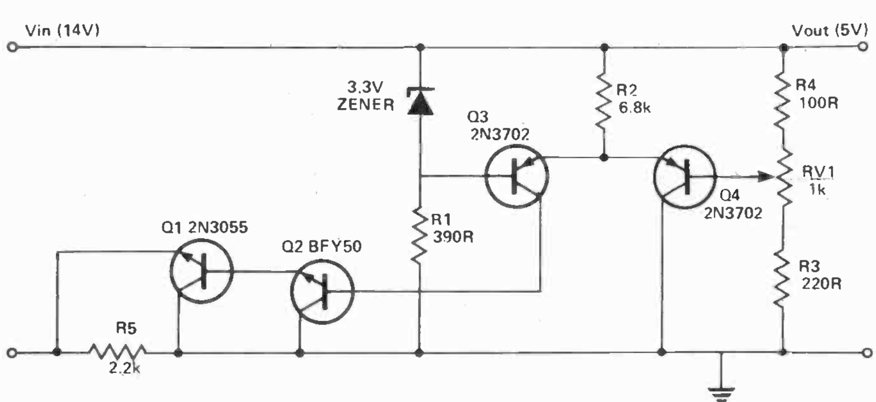


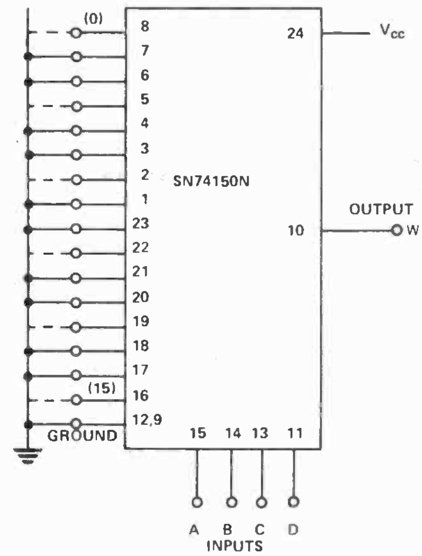
FIG. 2.

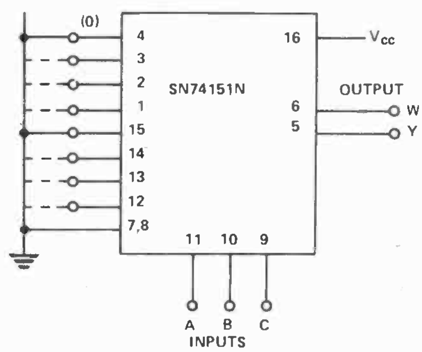
VOLTAGE REGULATOR AND ELECTRONIC FUSE

This circuit improves on those previously published (Tech-Tips, April and September 1975) in that current cut-off is achieved, it is self-resetting once that overload is removed and it is an efficient voltage regulator. Choose Z to be about $2/3V_{out}$ and R_1 to supply enough current for stabilization of the Zener voltage. Choose R_2, which determines the cut-off current, I_{max} such that $I_{max}R_2 = (V_Z - 0.5) \times (\beta Q1{+}Q2)$ and the values of R_3, RV_1 and R_4 so that the base of Q4 is at the same voltage as the base of Q3 and a large current (100 times) passes down the resistor chain compared to the base current of Q4 which is $(V_Z - 0.5)/R_2\beta Q4$. Altering RV1 gives fine control over V_{out}. R5 (200 ohms to 2.2k) allows switch-on under no load conditions. Component values are given for a 5V supply with a 2A cut-out. For low current applications, Q1 can be a BFY50 with Q2 omitted.



SELECTOR MULTIPLEXER HINTS





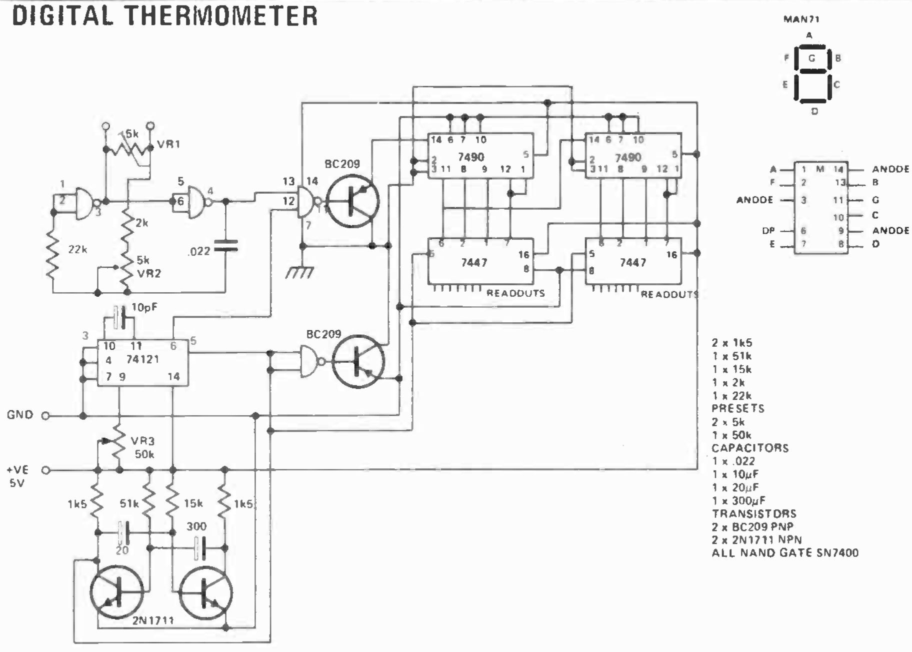
This is a method of implementing arbitrary logic functions with an absolute minimum of wiring up and maximum reliability.

The circuits are based on logic data selector/multiplexers, either TTL or CMOS (TTL shown). The first diagram shows the arrangement for producing a function of four variables. The four input variables are decoded by a 74150 16-line to 1-line data selector and used to govern which of sixteen data inputs is used to control the output state of the selector. The output is the complement of the selected input. This in effect forms a low cost, hard-wired PROM (Programmable Read-Only-Memory) which is programmed by wired links or switches as shown, (or by inputs from other logic gates).

To programme the inputs, for a given set of variables, the input, number corresponding to the binary number formed by variables ABCD, (1-2-4-8) is connected high for a low output or low for a high output. In practice only connections to low need be made if it is more convenient, although it is good practice to tie the high inputs to Vcc (or VDD) via a 1k resistor. (The links as shown in the example implement a function to produce an output only if the binary number ABCD is exactly divisible by three.) If it is preferred, each input may be tied to a high level via its own resistor which may then be left in circuit even if required to short the input down to earth.

An ideal form of switch for programming infrequently changed functions which must nevertheless be easily changed is the modern PCB mounting dual-in-line switch which takes up little room. A typical application of this might be for adjusting clock rate timers. A similar arrangement is shown for a function of three variables using the SN74151 IC. In this case the output is available in both true (Y) and complement (W) forms. (In the example shown the majority function is produced. Output is high if two or more inputs are high, otherwise low.)

DIGITAL THERMOMETER



DESCRIPTION

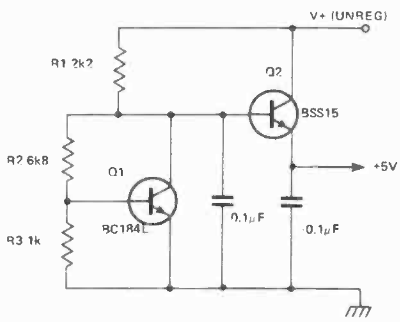
The frequency of the CMOS Multivibrator depends on the resistance of the thermistor, which is determined by the ambient temperature. Thus, if the temperature increases, the frequency of the multivibrator goes up and vice vèrsa. Trimmer pot VR1 is used to adjust linearity.

The two transistor multivibrator automatically resets the 7490 decade counters and triggers the monostable 74121. When the 74121 operates, it closes the CMOS 'NAND' gate and allows the output of the temperature dependent multivibrator to pass to the counters. The length of time that the 74121 is on, is determined by the value of C2 and the setting of trimmer VR3.

CALIBRATION

Fill a glass with ice cubes and top it up with cold water. Fill another glass with water that is as close to 90°F as possible. (Use an accurate thermometer). Place the thermistor in the ice water, adjust VR3 until display reads 32. Place the thermistor in the 90°F water, adjust VR2 until display reads 90°F. Repeat adjustment until accurate. Adjust VR1 for linearity. The digital thermometer is accurate to within 1°F between 32°F and 90°F.

SIMPLE SUPPLY FOR TTL



When it is necessary to power a few TTL packages, a simple zener diode — emitter follower stabliser is often used. If a zener of the appropriate value is not available, then the circuit shown may be used instead. Q1 is a standard V_{BE}-multiplier; the current through Q1 increases until its V_{BE}-drop is established across R3. Hence about 8 times V_{BE} is established across Q1, and this voltage is used as a reference for emitter follower Q2.

The unregulated input voltage may be between 20 and 8V; many different types of transistor will work satisfactorily.

VIRTUAL EARTH MIXER

This mixer was developed for mixing high quality audio signals prior to recording on a tape recorder.

Q1 is operated as a high gain common emmitter amplifier. Noise is kept low by operating this transistor at the very low collector current of 30μA.

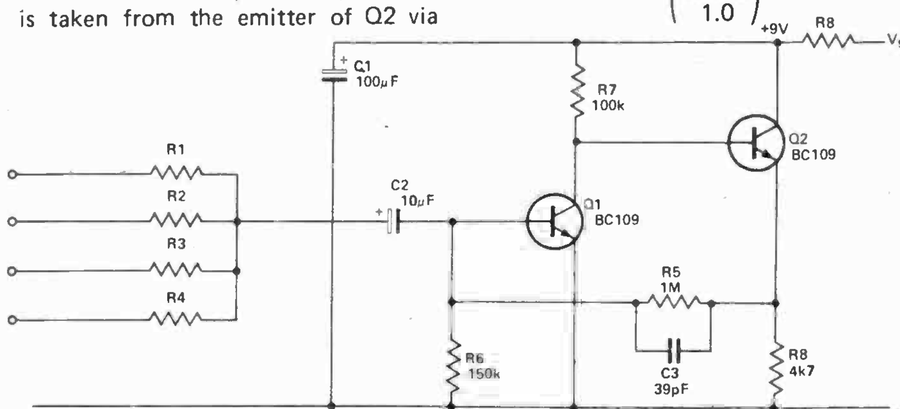
Q2 is connected as an emmitter follower offering a high input impedance at its base to prevent loading on Q1.

Overall feedback, both AC and DC is taken from the emitter of Q2 via R4 and R5. C3 rolls off the response above 40kHz to prevent RF pickup.

The signals to be mixed are introduced via the input resistors R1—4. C2 isolates unwanted DC from Q1's base whilst coupling the input signal to it.

Overall voltage gain is equal to $\frac{R5}{R1 + Rin}$ 20dB if R1—4 are as shown.

R8 and C1 decouple the mixer from the supply voltage employed. The value of R8 in kΩ is determined from the formula $\left(\frac{Vs - 9}{1.0}\right)$.



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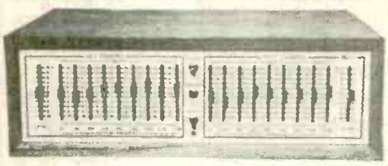
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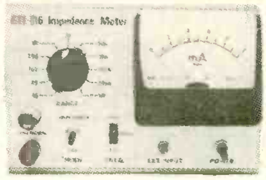
IMPEDANCE METER


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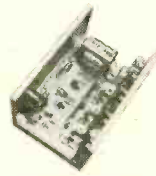
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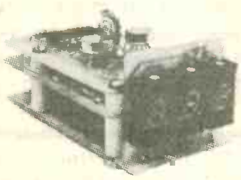
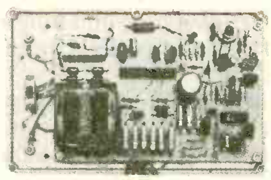
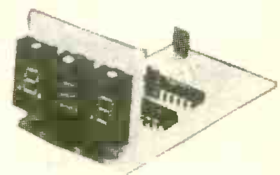

DIGITAL VOLTMETER

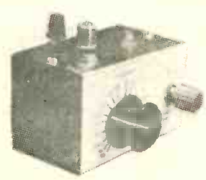

STEREO FM TUNER


LINE AMPLIFIER


LIGHT DIMMER


ELECTRONIC IGNITION


DIGITAL DISPLAY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MM5312 7 seg + BCD. 4 digit only	4.88
MM5313 7 seg + BCD	5.69
MM5314 7 segment	4.88
MM5315 7 seg + BCD with reset	5.69
MM5316 Non-mpx alarm clock	10.17
MM5318 7 seg + BCD (external digit select)	3.36
MM5371 Alarm clock 50Hz	8.14
MM5377 Car clock, crystal controlled, LCD	7.21
MM5378 Car clock, crystal controlled, LED	6.73
MM5379 Car clock, crystal controlled. Gas discharge	6.73
MOSTEK	
MK50250 Alarm clock (12Hr+60Hz/24Hr+50Hz)	5.60
MK50253 Alarm clock (12Hr+50Hz/24Hr+50Hz)	5.60
MK50204 Stopwatch/Calculator	11.19
MK50395 UP/DOWN Counter—6 Decade	14.50
MK50396 UP/DOWN Counter—HHMMSS	14.50
MK50397 UP/DOWN Counter—MMSS.99	14.50
CALTEX	
CT7001 Alarm/calender. 7 segment	7.30
CT7002 Alarm/calender BCD	7.30
CT7003 Alarm/calender 7 seg. Gas discharge	7.30
CT7004 Alarm/calender 7 seg	7.30
CT6002 LCD/CMOS. Clock/watch chip	15.00
GENERAL INSTRUMENTS	
AX5-1202 4 digit 7 seg.	4.76
AY5-1230 on-off — alarm, 7 seg.	5.25

MHI CLOCK KITS

	1-9
MHI-5309	7.35
MHI-5311	7.35
MHI-5314	6.60
MHI-5318	7.35
MHI-5378	15.10
MHI-50250	8.35
MHI-50253	8.35
MHI-50204	14.00
MHI-50395	19.50
MHI-50396	19.50
MHI-50397	19.50
MHI-7001	10.00

MHI CASE Please include 25p post + packing) 2.95

SOCKETS	
18 pin	0.60
24, 28 or 40 pin	1.00
Soldercon strip sockets	0.30

DISPLAYS

	1-9
LITRONIX	
DL707, 704, 701	1.48
DL727, 728, 721	3.75
DL747, 746, 750	2.45
LITRONIX CLASS 11 PRODUCTS	
DL707E, 704E	0.70
DL727E, 728E	1.80
DL747E, 750E	1.50

FUTABA PHOSPHOR DIODES	
5LT01	5.80
5LT03	5.80
FILAMENTARY DISPLAYS	
Minitron 3017F	2.00
Itoka 2.5"	8.00
Itoka 5"	24.80
LIQUID CRYSTAL	
Swarovski 3½ digit watch disp	10.00

MHI DISPLAY KITS

	1-9
MHI-707/4 (digit) 0.3"	6.60
MHI-707/6 0.3"	9.50
MHI-727/4 0.5"	8.50
MHI-727/6 0.5"	12.00
MHI-747/4 0.6"	9.80
MHI-747/6 0.6"	14.70

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FISHIN' FOR A CHIP?

ETI CLOCK CHIP SURVEY HANDS IT TO YOU ON A PLATE!

DETAILS ON OVER 40 WAYS TO KEEP TIME

THERE USED to be only one way of building yourself a clock, and this required you to assemble large numbers of gears, wheels, pivots and other mechanical nasties. The next stop was a long arduous trip around the Swiss Alps seeking an unemployed gnome. Sometime later if you were lucky, and the pound hadn't fallen so much that you couldn't afford to pay for it, you got your clock. It probably lost more time than it kept — and the chemist around the corner is selling them five pounds cheaper anyway.

Perhaps this explains why digital clocks are becoming so popular, or perhaps it's just that MOS techniques make clocks so easy to build and cheap to buy. Single chips now contain the entire digital 'movement', and interface displays is at worst one transistor per digit. In some cases interfacing is dispensed with altogether, and the chip drives the displays directly.

ONE CHIP LOOKS MUCH LIKE ANY OTHER

It seemed to us that the market was quickly reaching the point where a new device arrived with each moon. Enough to drive a man to drink they all look alike, but are all totally different. Well almost. We felt is was time we took a hand and sorted out the bulk of the chips into something vaguely connected with order. Information is of course freely and profusely forthcoming from the manufacturers, and if we haven't answered yout specific questions on a particular device, you'll find the addresses of the guilty parties at the end of this article. This survey doesn't cover all the clock IC's available, for one thing someone is bound to have released something else somewhere since you started reading this, but we've got most of them.

I DON'T KNOW HOW TO SAY THIS BUT . . .

The main problem with compiling a listing of information like this is how you present for perusal. Originally we planned to use a large table, with the chips listed along the y axis, and the features and facilities along the x axis, cross indexed to the first. Like most 'good ideas' it semmed fine at the time, until we tried to actually do it! There were just too many special features indigenous to too many chips for a table to be viable. Hence the method adopted here.

Each chip is covered by a single paragraph all to itself, which gives a run-down of what all those pins can do, and what appears on the display while they're doing it.

COMING TO TERMS

There are a few abbreviations and terms that we've employed in the article and unless you speak initial-ese as do the inhabitants of our larger colony, we'd better explain them.

MPX: mulitplexed. In this context usually refers to the rapid (≈60kHz) switching on and off of the display segments by the chip to save power.

RFI: — radio frequency interference. Caused by the MPX display switching.

BCD: — A connection within which outputs the time in complemented Binary Coaded Decimal form. Could be used to drive latches etc. Sometimes multiplexed with other information onto shared pins.

SNOOZE: — a facility which allows the alarm to sound respectively, with a cycle time of around 5 mins, from the time set onto the chip. This allows the clock to persist in dragging you back to reality. Say for example the clock is set for 7.40 am, and the snooze is on. At 7.45 it goes off again — just as you're sinking back into

SIMPLE CLOCKS	ALARM CLOCKS	DIRECT LED DISPLAY FACILITY	NON-LED DIRECT DRIVE DEVICES	CHIPS WITH A RADIO OUTPUT	T.V. DISPLAY CHIPS	NON-MPX OUTPUT TO DISPLAYS
AY-5-1224A	MK 50250 (series)	MK 50380	AY-5-1200 (series)	CK 3300	AY-5-1230	MK 50380
AY-5-1200 (series)	MK 50380	MK 50381	CK 3200 (plasma)	MK 50380	MM 5318	MK 50381
MM 5309	MK 50381	3817 A/D		MK 50381		FCM 7001
MM 5315	FCM 7001 (series	CK 3300		3817 A/D		AY-5-1230
MM 5311		CK 3400	CK 3000 (fluorescent)			MM 5377
MM 5312				MM 5316		MM 5385
MM 5313	CK 3300	MM 5385		MM 5386		MM 5386
MM 5314	CK 3200	MM 5386	AY-5-1230 (fluoroscent)	MM 5370		
MM 5318	CK 3400			MM 5371		
MM 5377	CK 3000		MM 5370			
MM 5378	MM 5370		MM 5371 (gas discharge)			
MM 5379	MM 5371					
	MM 5376 (series)					
	MM 5385		MM 5377 (L C.D or fluorescent)			
	MM 5386					

FIG 1 QUICK SELECTION TABLE

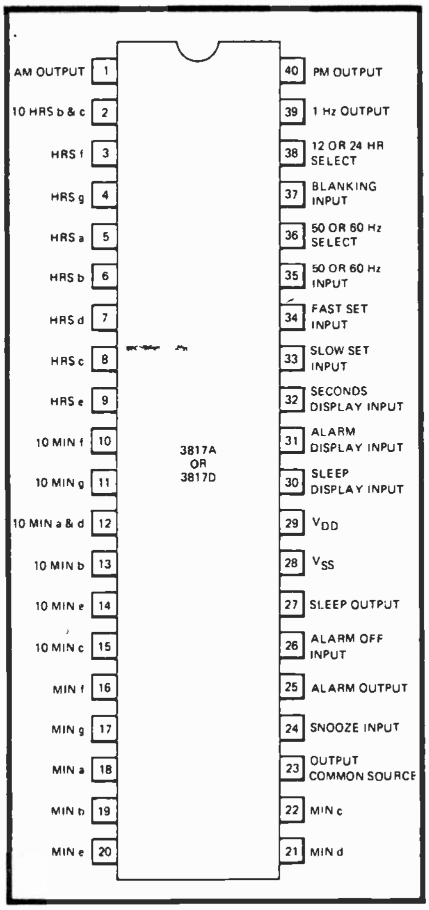
the arms of — but you'll never know because at 7.50 the alarm is back again. But don't blame the chip — you set it up in the first place.

RADIO (OR SLEEP): — output which will change state at the end of an elapsed period, usually with a maximum of 59 mins. Can be used to switch off a radio or appliance (!?) as you drift off to sleep, lulled by the dulcet tones of John Peel. That is if you can sleep, knowing that damned snooze is set and waiting.

POWER FAILURE INDICATION: — shows that at some time power to the clock has been interrupted, and the time is now wrong. Normally the display will flash at 1 Hz.

FAIRCHILD.

3817A/3817D 4-A-20



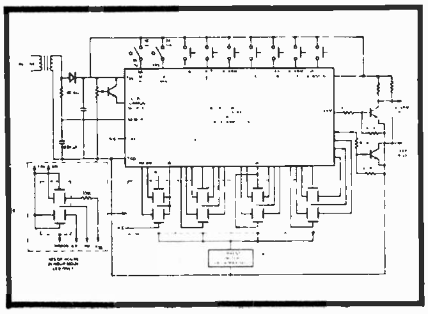
An alarm chip which is capable of driving L.E.D. displays directly, at a max current of 8mA per segment. The display can be switched to read hr/min or min/sec. Either 50 or 60 Hz clock input is permissible, and 12/24hr mode is selected externally. Features: radio output, snooze alarm, leading zero blanking, power failure indication and brightness control.

Options

3817A: 700Hz alarm oscillator output

3187D: d.c. alarm switch output

Direct (pin-pin) replacement to National MM5316.



FCM 7001 series (ALL: £7.30). 6-A-28

The main feature of this six-digit clock series is the inclusion of a calendar facility, for those of us who never know what day it is. All devices include the usual facilities of snooze alarm, radio output, 12/24hr option and a PM indicator. Special attractions — facility for mains or Xtal 'clocking' and to wire — OR the outputs enabling the display to be shared. Not to forget that (4yr) calendar.

Options

7002: replaces the 7-segment outputs of the 7001 with four-line binary clock outputs, and data strobe outputs.

7003: differs only in that the 7-segment outputs are 'active level-low' instead of high, as in 7001 i.e. when activated that segment output will go to logic law.

7004: the calendar display is in 'European' format i.e. 'day-month' ('3-12' etc) rather than the 7001 American month-day (12-3) display. The FCM 7001 series is in fact the CT 7001, once produced by Caltec.

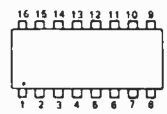
GENERAL INSTRUMENTS

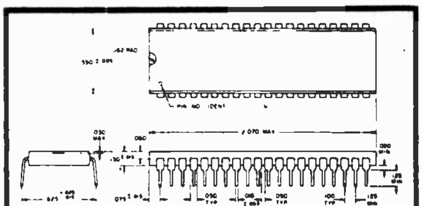
AY-5-1224A (£3.66) 4-C-16

Perhaps the best known basic clock chip. Interfaces to L.E.D. through 4 transistors, has leading zero suppression in 12hr mode (can run as 24hr clock), both 7 segment and BCD outputs and 50/60 Hz capability.

Provides a very easy way to produce a basic 4-digit clock.

1. Segment A output/2° output/Set Hours input
2. V_{SS}
3. Multiplex oscillator
4. 50/60 Hz input
5. V_{GG}
6. Strobe output
7. Mx 4 output (Tens Hours)
8. Mx 3 output (Unit Hours)
9. Mx 2 output (Tens Minutes)
10. Mx 1 output (Unit Minutes)
11. Segment G output/BCD or 7 segment select
12. Segment F output/50 or 60 Hz select
13. Segment E output/12 or 24 hour select
14. Segment D output/2^3 output/Complement input
15. Segment C output/2^2 output/Reset input
16. Segment B output/2^1 output/Set minutes input



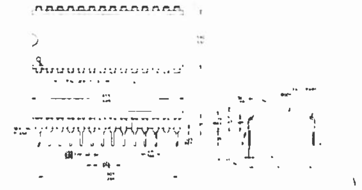


PIN	FUNCTION	PIN	FUNCTION	
1	V_N	21	Digit 3 Segment d	
2	50 60 control	22	Digit 3 Segment c	
3	Alarm cancel	23	Digit 3 Segment b	
4	Alarm tone out	24	Alarm condition)	Second indication
5	Set frequency	25	Clock condition)	flashing colons
6	Set time	26	Digit 2 Segment f	
7	Set alarm	27	Digit 2 Segment e	
8	Increment mins	28	Digit 2 Segment d	
9	Increment hours	29	Digit 2 Segment c	
10	50/60 Hz input	30	Digit 2 Segment g	
11	V_P	31	Digit 2 Segment b	
12	Segment control (Brightness)	32	Digit 2 Segment a	
13	Stand off voltage (VSO)	33	Digit 1 Segment f	
14	Morning indication (AM)	34	Digit 1 Segment e	
15	Digit 4 Segment b	35	Digit 1 Segment d	
16	Digit 4 Segment c	36	Digit 1 Segment c	
17	Digit 3 Segment a	37	Digit 1 Segment g	
18	Digit 3 Segment f	38	Digit 1 Segment b	
19	Digit 3 Segment g	39	Digit 1 Segment a	
20	Digit 3 Segment e	40	Display common (V_A) – Anode	

Direct drive to fluorescent display, and direct output to a loudspeaker for the alarm.(1kHz)The multiplex oscillator is on chip, and facilities number snooze seconds colon, power failure indicator, activity' on alarm and snooze modes, PM indicator and brightness control should you wish it. 50 or 60 Hz input is in order.

CK 330 (£5.00) 4-A/T-28

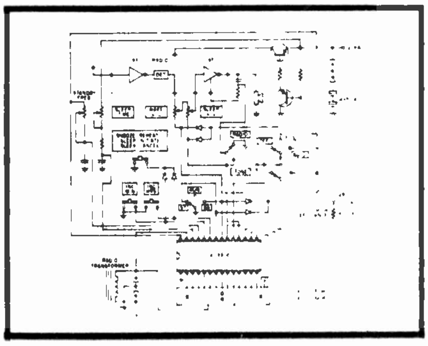
A 'clock-radio' chip which will drive L.E.D. displays directly. The CK 3300's main claim to fame lies in the versatile alarm. Several variations on a wake-the-worker theme are provided, and an alarm tone or radio sound can perform the



PIN	FUNCTION	PIN	FUNCTION
1	V_N	15	c
2	Colons	16	g — digits 3 & 4
3	PM indicator sleep indicator	17	b
4	f	18	Sleep Out
5	g	19	Wake 2 output
6	e	20	Wake 1 output
7	d — digits 1 & 2	21	S A Set Alarm
8	c	22	S T Set Time
9	b	23	Inc Mins (S C S R)
10	a	24	Inc Hours (S I N)
11	a	25	OSC 2 (Sleep timing)
12	f — digits 3 & 4	26	OSC 1 (standby timing)
13	e	27	10 60 count input
14	d	28	Vp

task. Another of the outputs can be used to switch on an appliance 5 mins before the alarm sounds.

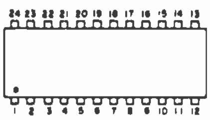
By judicious wiring of the output pins, a tape machine can be made to record for a preset time, up to 120 mins, from any given starting point. Indicators included are:



power failure, PM, and alarm, snooze and sleep operating. Leading zeros are suppressed in the 24hr mode, whilst the PM indicator functions in 12hr display.

AY-5-1200 series (1202:£2.99)) 4-C-24

Pin	Function	Pin	Function
1	V_{SS}	13	NC
2	V_{DD}	14	NC
3	MX4 Digit Outputs	15	NC
4	MX3 Digit Outputs	16	2^3 BCD Output
5	MX2 Digit Outputs	17	2^2 BCD Output
6	MX1 Digit Outputs	18	2^1 BCD Output
7	NC	19	2^0 BCD Output
8	12/24 Hour Select	20	Strobe Output
9	NC	21	Set Minutes
10	50/60Hz Select	22	Set Hours
11	NC	23	Multiplex Clock
12	Reset	24	Clock Input

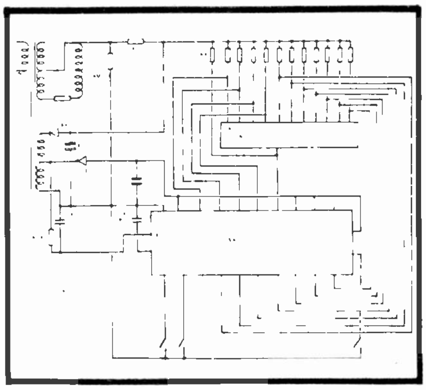


Designed to drive fluorescent displays directly i.e. 5-LT-01, this series features 50/60 Hz option on all chips, and is equipped so as to be able to invert or inhabit the MPX segment outputs should you so desire.

Options

1200—7 segment output with leading zero blanking

1202—as 1200, but with flashing seconds output

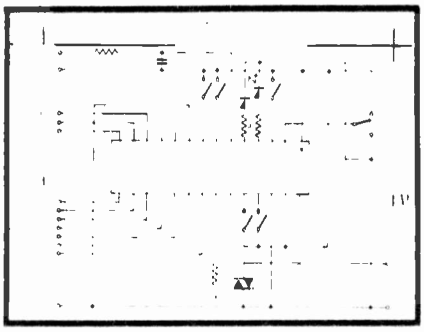


1203—replaces 7-segment output with 4-line BCD

1204—as 1200, but in full possessions of its zeros.

AY-5-1230 (£10.00 inc displays) 4-A/t-28

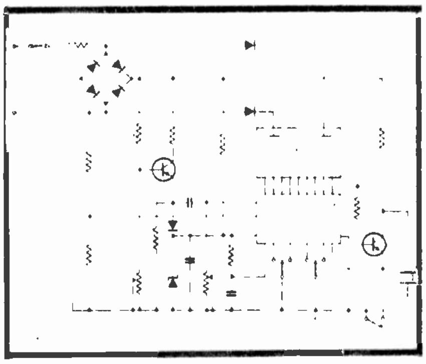
Not so much a clock, more a T.V. timer. The 1230 is intended to drive into either 7-segment flourescent displays or the AY-3-8320 T.V. display I.C. when used with the latter it puts up a clock display on the T.V. screen, and can switch the



set on or off at any desired time. As such it would be of great value used in conjunction with a video recorder (would that it were that we could all afford such items).

As a straightforward clock it drives a 4-digit flourescent display with the facility of brightness control. The output is not multiplexed.

CK 3200 CK 3400 (—) 4-A-28



Alarm clocks to directly drive either L.E.D. or gas plasma displays. Indication is provided for alarm, setting, snooze on, seconds (colon pulsed) and power failure. Snooze is incorporated as is PM indicator in the 12hr mode, which is switchable to 24hr. Zeros are blanked if leading.

Options

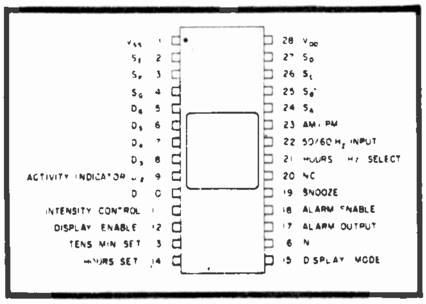
CK 3400—L.E.D. drive

CK 3200—Plasma display drive.

MOSTEK

MK 50250 series (53 £5.00) 6-A-28

A basic alarm clock with snooze output, and which lets you turn-down the display if it keeps you awake. The inevitable PM indicator is present, and either 50 or 60 Hz input will work the device.



Options

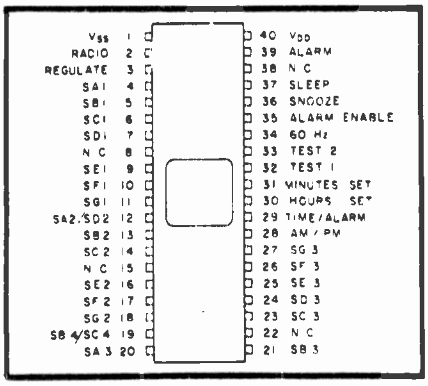
MK 50250—12hr/60Hz or 24hr/50Hz

MK 50253—12hr/50Hz or 24hr/60Hz

MK 50254—12hr/60Hz or 24hr/60Hz

MK 50380 50381 (—) 4-A-40

Non-mpx output which will directly drive four L.E.D. displays at a current of up to 10mA per segment. Current regulation for this is on



chip. The radio output has a maximum time of 1hr. A novel feature is the independent setting of each digit, as opposed to the usual hr/mins 1Hz advance.

Options

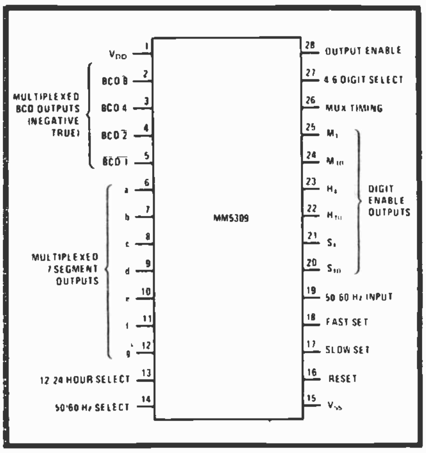
MK 50380—12hr/60Hz 24hr/50Hz

MK 50381—12hr/50Hz 24hr/60Hz

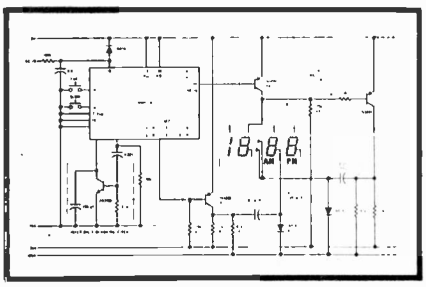
NATIONAL

MM 5309 MM 5315 (Both £5.69) 4/-C-28

Simple clock chips, with switch selectable 4/6 digit display. Other features are the BCD and 7-segment outputs, output enable, hold count facility and select option for 50/60 Hz timing input. Twelve, or twenty-four hour, mode of display is available, and the chip will forget to display leading zeros in the 12hr mode.



MM 5311 MM 5313 (Both £5.69) 4/6-C-28
MM 5312 MM 5314 (Both £4.88) 4/6-C-24



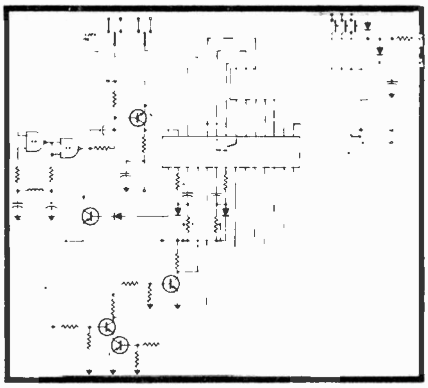
A short series which provides a good range of features by the options available. Outputs from these chips consist of MPX 7-segments BCD and output enable. Options on 12/24 hour display or 50/60 Hz.

Options

PART NUMBER	PACKAGE	FUNCTIONS: HOLD COUNT	OUTPUT STROBE	1 PPS OUTPUT	7 SEGMENT OUTPUT	BCD OUTPUT	NO. OF DIGITS
MM5311D	28 Pin Ceramic	x	x		x	x	4/6
MM5312D	24 Pin Ceramic			x	x	x	4/6
MM5313D	28 Pin Ceramic	x		x	x	x	4/6
MM5314D	24 Pin Ceramic	x	x		x		4/6

MM 5318 (£3.36) 4/6-C-28

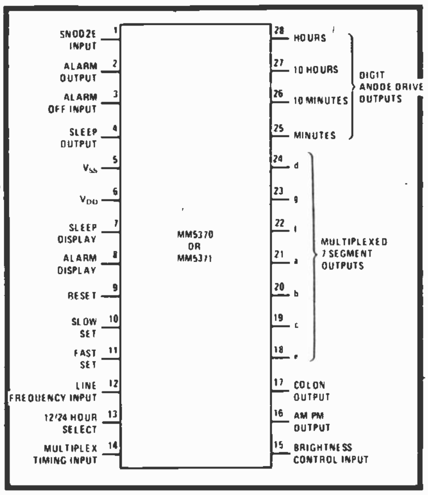
Television time display interest you? If not read no further. Do not pass 'go'. Do not collect £200. When driving a MM 5841 the MM 5318 will put a 6 digit display on the T.V. screen. This can be shifted in position using the controls provided



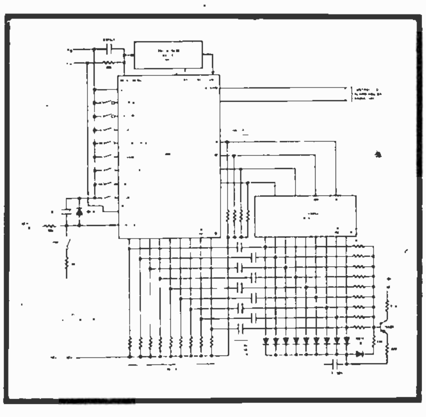
by the 5841. The circuit to do this is not simple, and the complexity should be weighed against the benefits reaped. Three digit select lines will enable the outputs individually or collectively according to digital states on the lines.

MM 5370 MM 5371 (£8.14) 4-A-28

An alarm chip to drive a gas discharge display without interface, although a handful of diodes are in fact needed additional to the chip itself. Provision is made for 12/24hr display with the appro-



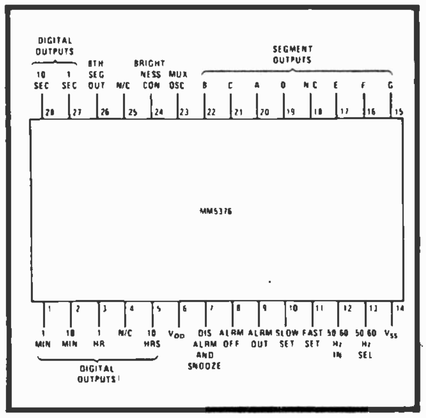
priate zeros amputation, and indication of seconds (flashing colon) and PM. Naturally all the facilities of the opposition are included — sleep, snooze, power failure indication and brightness control.



Options

MM 5371 50Hz mains
MM 5370 60Hz mains

MM 5376D series (8.25) 6-A-28



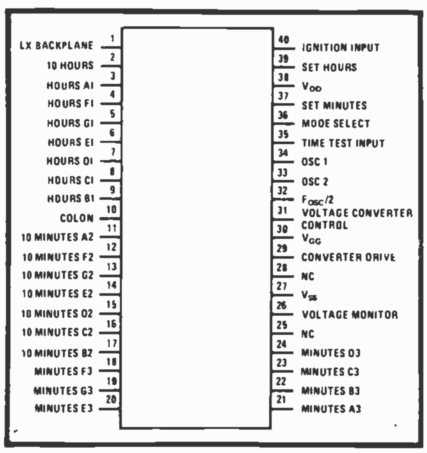
National themselves describe the series thus: '4/6 digit . . . 12/24hr . . . leading zero blanking. Inputs include time setting, 50/60Hz input select, brightness control alarm set, snooze, alarm off and MPX freq control. Outputs consists of 7 segment (MPX) (and colon) selects, digit enables and alarm signals. This consists of a 500Hz to 1kHz square wave, gated on and off at 2Hz. Power failure indicator is included to inform the user that the incorrect time is being displayed.'
Anything else you want to know?

Options

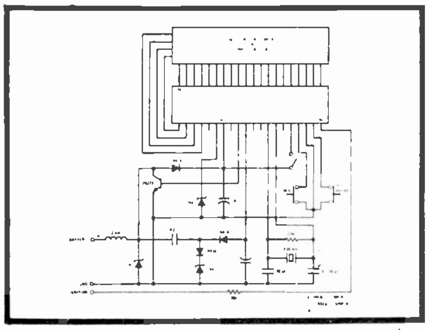
		AA	AB	AD	AE	AG	AH
Input	60	•	•	•	•	•	•
	50 Hz	•	•	•	•	•	•
Time Display	12	•	•	•		•	•
	24 Hours				•		
Duplicate Register	Alarm	•	•			•	
	Date						•
	Minute			•			
	Second				•		
Alarm Signal	Tone	•	•			•	
	d.c. Level						
Alarm Output	Modulated	•	•	•	•	•	•
	Not Modulated						
Alarm at Power Failure	On	•	•	•		•	
	Off			•			
Segment Polarity	Vss		•	•		•	•
	Vdd	•					

MM 5377 (£7.21) 4-C-40

A change this time from the almost universal mains frequency input. This takes us into the elevated realms of crystal controlled count-



ing. This does provide a much greater accuracy, but at the cost of much greater complexity. The MM 5377 will drive either L.C.D. or fluorescent tubes directly. Intended primarily as a clock for the car, it will function equally well as a home chronometer displaying in the 12hr mode, with no leading zeros.

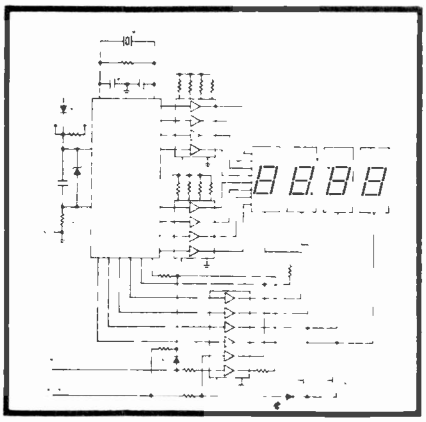


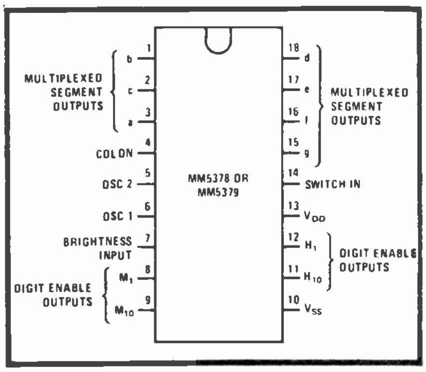
MM 5378 MM 5379 (both £6.73) 4-A-18

These chips are really refined versions of the 5377. Both feature MPX 7-segment and a colon output. Brightness control is also incorporated. Timekeeping is from a 2MHz crystal, and both display in the 12hr mode. Also usable as car clocks. Display drive is direct in both cases.

Options

MM 5378—for use with L.E.D. displays
MM 5379—for use with gas discharge display



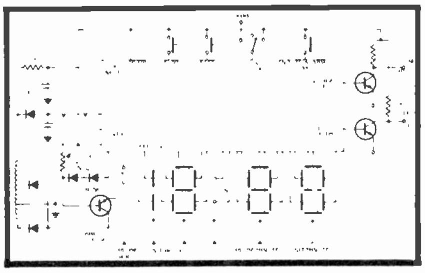


MM 5385 MM 5386 (—) 4/6-A-40

How about an alarm clock with possible use as a stopwatch? Both these chips will display min — 10xsec — sec if required. Both alarm and 'sleep' count-down can also be displayed. Oh yes, they are also capable of showing the time of day. Either mains frequency will suffice. Output is to L.E.D. displays without interface, with a power failure indicator.

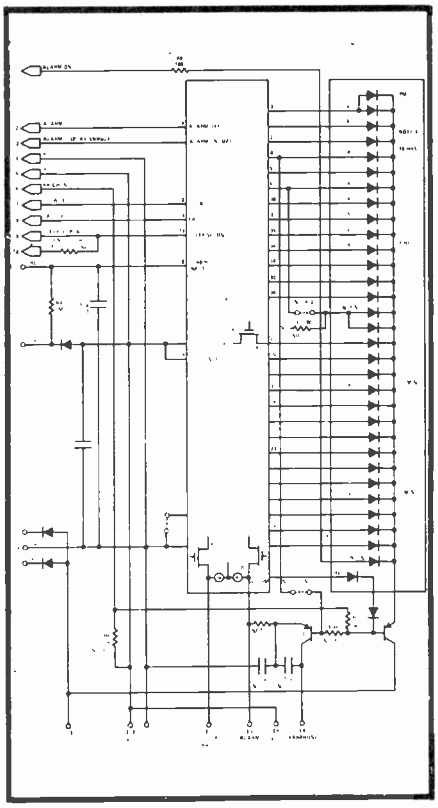
Options

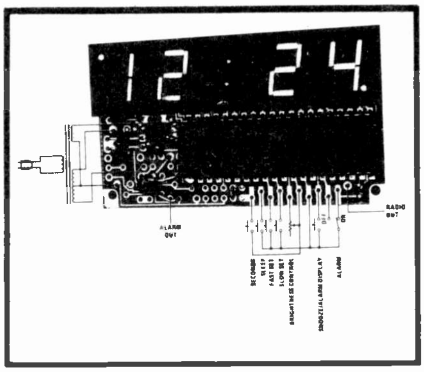
MM 5385—12hr display with PM indicator and seconds colon
MM 5386—24hr display with leading zero ignorance



MA 1001 (Module) (prices: see below) 4-A-Module

Regular readers will have heard all about this last month in 'Electronics Tomorrow'. Briefly this is a complete clock module, including displays (0.5in) leaving only switches, case and transformer to be supplied by the builder. As to prices, we





know that both Bywood and Maplin stock these devices, and Maplin have really gone to town! It is their belief that this device will eventually push most other methods of clock building aside. Timekeeping can be either 50 or 60Hz, and the output is non-MPX, which does eliminate RFI troubles.

50Hz Options

MA 1001B—12hr-switched alarm output
MA 1001D—24hr—switched alarm output
MA 101F—12hr—alarm tone output
MA 1001H—24hr—alarm tone output
Maplin are selling the module in kit form and their prices are:
1 Module alone:- £8.60
2 + P.C.B. + switches + transformer (simple clock kit) — £9.80
3 All 2 + L.D.R. + speaker + components (alarm clock with display dim) — £10.90
4 All 3 + drivers to switch radio (clock radio kit)
A case will be available in four weeks time, at £1.99.

MANUFACTURERS

1 Fairchild: Kingmaker House, Stn. Road, New Barnet, Herts.
2 General Instruments: 57/61 Mortimer Street, London, W1N 7TD.
3 Mostek: 240 Upper Street, London N.1.
4 National Semiconductors: Larkfield Industrial Estate, Greenock, Scotland.

SUPPLIERS

A large number of firms who supply some, or most, of these chips advertise in ETI. Firms specialising in these goods include Sintel, Bywood, Imtech, Pulse and Greenbank. Addresses can be easily had by flicking through the magazine you're now holding! ●

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Type B 17-0-17V 250MA; 8-0-8V 250 MA; 0-12.5-13.5V 5 Amps; 0-1.5-2V 5 Amps; **£1.50 ea.** P&P £1.
Type C 19-0-19V 250MA; 8-0-8V 250MA; 0-7.5V 5 Amps; 0-1.4V 5 Amps; **£1.25 ea.** P&P £1.25.
Type D 34V 4 Amps; 19V 4 Amps; 17V 4 Amps; **£3 ea.** P&P £1.25.
Type E 3V 1 Amp. **25p ea.** P&P 50p.
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Type G 20-0-20V 200MA; 0-6V 100MA; **75p ea.** P&P 75p.

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SOFTWARE PART FOUR

WE HAVE NOW BRIEFLY gone over the hardware involved in a microcomputer system, but have only touched upon the key to the importance of microprocessors — software. In operation, the MPU executes a series of instructions stored in memory, so that if the application is changed, the expensive hardware need not be altered, but only the program in memory. If this is in RAM, there is hardly any expense involved and if it is in ROM, only the ROM chips have to be replaced.

For example, if an MPU is in a system for traffic light control and an extra set of lights has to be added, the control program is rewritten and, if necessary, an extral parallel I/O port or two is added, by simply dropping it on the bus (no pun intended!). So let's look at programming techniques in relation to micros.

LANGUAGES

Computer programming is a fairly widely understood skill these days; indeed, it is taught in many schools. But the most widely known languages such as FORTRAN, ALGOL and BASIC were not written with microprocessors in mind — they are in fact designed to 'hide' the hardware from the programmer whereas micros thrive on a symbiotic relationship between hardware and software which demands engineering ability of both programmer and program language.

Consequently, the engineer/programmer working with all but fairly large microcomputer systems which have sufficient memory space to cope with high level languages will work in *Assembly Language* or even *Machine Code*.

Machine Code is the 'binary' code used by the machine internally and is usually represented by pairs of hexadecimal digits e.g. a NOP (no-operation) instruction is represented by 01 or CLR (clear) by 6F. Obviously to think in this manner for any length of time calls for a particular breed of individual; in fact anybody who tries to write programs of more than around 300 steps like this is never the same again (as callers at ETI's offices may have discovered)! But it is a good way to start and is very educational as it is the closest representation of the machine's operation.

Rather than train monkeys to perform this laborious task it is more humane (and cheaper) to employ the microprocessor itself to process the program down from a more comprehensible form such as Assembly language to Machine Code, as this is a task it is admirably suited to do. Assembly Language consists of 3 or 4 letter mnemonics such as TST, ROL, ADDA, together with appropriate punctuation and grammatical rules for their use. The Source Program, in the form of a sequence of these mnemonics is loaded into the microcomputer along with the Assembler program. Running the Assembler will now convert the source program to machine code which can be directly executed by the MPU.

Note that there is a one to one correspondence between mnemonic instructions in the source program and the hex codes which make up the object program, and so we haven't saved much effort. But if we extend this idea of 'program processing' we can use a program called a *Compiler* which will convert a high level language such as BASIC to machine code, and will thus perform multi-step sequences of instructions upon a single command, such as PRINT or INPUT, or evaluate mathematical expressions such as

LET Q=P*(1+R/100)↑N

even to the extent of handling multi-dimensional matrix operations automatically (e.g. MAT PRINT in BASIC).

ANY MINUTE NOW LADY — THESE NEW AUTOMATIC MONITOR SYSTEMS ARE PRETTY CUTE AT PREDICTING MAJOR FIRES

A compiler will probably only be used in a 'microcomputer' situation where the MPU has plenty of memory attached and is not dedicated to a particular job — in other words a minicomputer or 'super-programmable' calculator. As previously mentioned, the big drawback of high level languages is that they do not permit the programmer absolute control over the machine, and they are not as efficient in use of program memory or as fast at run time as a program written by an experienced assembly language programmer. The two high level languages available at present for micros, Motorola's MPL and Intel's PL/M, get round this by allowing the programmer to embed assembly language routines.

STACKING INSTRUCTIONS

An important concept in computer science is that of the *stack* — you'll

TABLE 1 — MEMORY MAP FOR INTERRUPT VECTORS

Vector MS	Vector LS	Description
FFFE	FFFF	Restart
FFFC	FFFD	Non-maskable Interrupt
FFFA	FFFB	Software Interrupt
FFF8	FFF9	Interrupt Request

even come across it in pocket calculators. Basically a stack is an area of memory which is used to hold a list of temporary results and is always accessed in a serial *Last in, first out* (LIFO) manner.

A stack can be set up anywhere in memory, and is limited only by the amount of memory available. The lower end of the stack which is the one data is added to or read from is pointed to by the Stack Pointer; in fact the SP points to the next free memory location. Let's look at the Push and Pull instructions which manipulate the stack of the 6800 MPU.

When the MPU encounters a PSHA instruction (opcode 36), it will latch the address bus to the SP value and write the contents of accumulator A into that location in memory. It will then *decrement* the value of SP and move to the next instruction. The SP is now pointing at the vacant memory location immediately below the bottom of the stack, ready to repeat the process. This sequence is reversed by a PULA (32) which will increment SP, latch the address bus to this value and reads the contents of this location.

Stacks are tremendously useful at all levels of computing. To take an example we can now elaborate on the oft-mentioned subject of interrupts. When the 6800 MPU encounters an interrupt (either hardware or software) it completes the current instruction and then automatically pushes the contents of its registers onto the stack in the following order:

1) the address of the next instruction it would have executed, i.e. PC+1, by taking the 16 bits in two bytes
2) the index register, again in two bytes
3) ACCA
4) ACCB
5) the CCR.

It then looks at the top of memory for the *interrupt vector*, which directs it to an interrupt program. When this program has been run and the MPU comes to a *Return from Interrupt (RTI)* instruction, it simply pulls these values from the stack in reverse sequence and continues where it left off. Not beautifully simple, at first sight anyway, but a beautifully elegant way of doing things.

As we have said, the Index Register may be used as a form of pointer for similar operations where rapid jumps around memory are required. A group of instructions such as DEX, INX, LDX, STX enable the Index Register to be decremented, incremented, loaded and stored respectively, while similar instructions (DES, INS, etc.), perform these functions for the Stack Pointer. In addition, either of these registers can be loaded with the value of the other (see TSX, TXS).

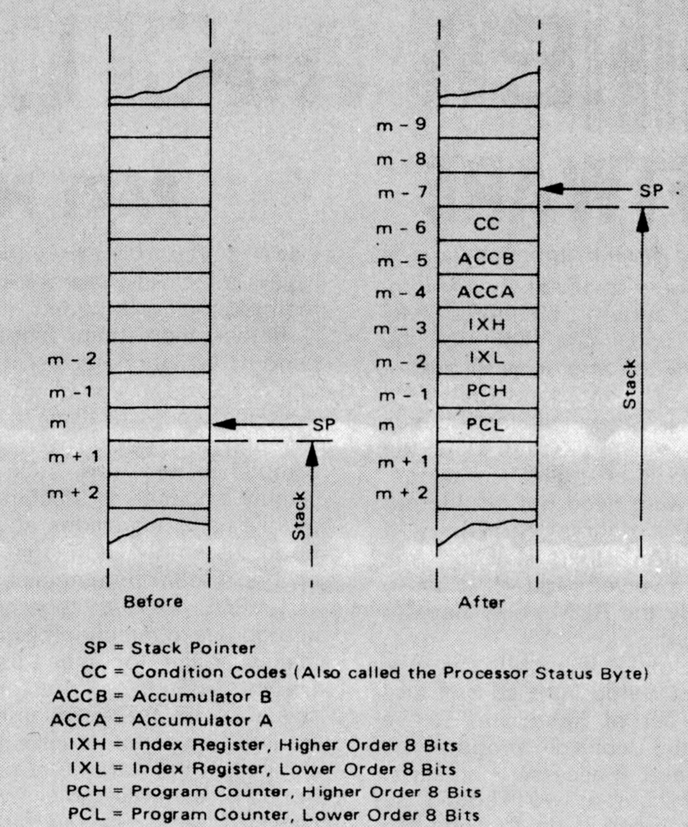


Fig. 1. Saving the MPU status on the stack.

JUMP AND BRANCH INSTRUCTIONS

The jump and branch instructions are used to transfer operation from one point to another in the program. If the MPU encounters a 6E (JMP) instruction, it will look in the following location for the offset which it will add to the value in the Index Register and use the resultant value as the address of the next instruction to be executed. If the Jump instruction is 7E it will use the Extended Mode of addressing and jump directly to the address contained in the two bytes following the JMP instruction.

The *Branch Always (BRA)* instruction is similar but, always uses the relative addressing mode so that it can jump ± 127 with respect to the next instruction. Other Branch instructions allow tests on the Condition Codes Register to be carried out — the MPU will only jump if a particular condition is satisfied. For example, *Branch If Minus (BMI, 2B)* will cause the MPU to test the CCR N-bit to see if it is set. If it is the program will jump forward or back the value in the following byte. If the N-bit is not set program execution will continue normally.

Other instructions can be used to perform tests. For example, the TST instruction will test either accumulator or a memory location to see if it is negative or zero. If either of these conditions is true, the N or Z bit of the CCR is set. Similarly the *Compare* instruction (CMP) performs a 'dummy run' of the subtraction of a memory location from either accumulator and sets the CCR bits N, Z, V and C according to the result. However, it does not actually produce a result and the contents of accumulator and memory are unaffected.

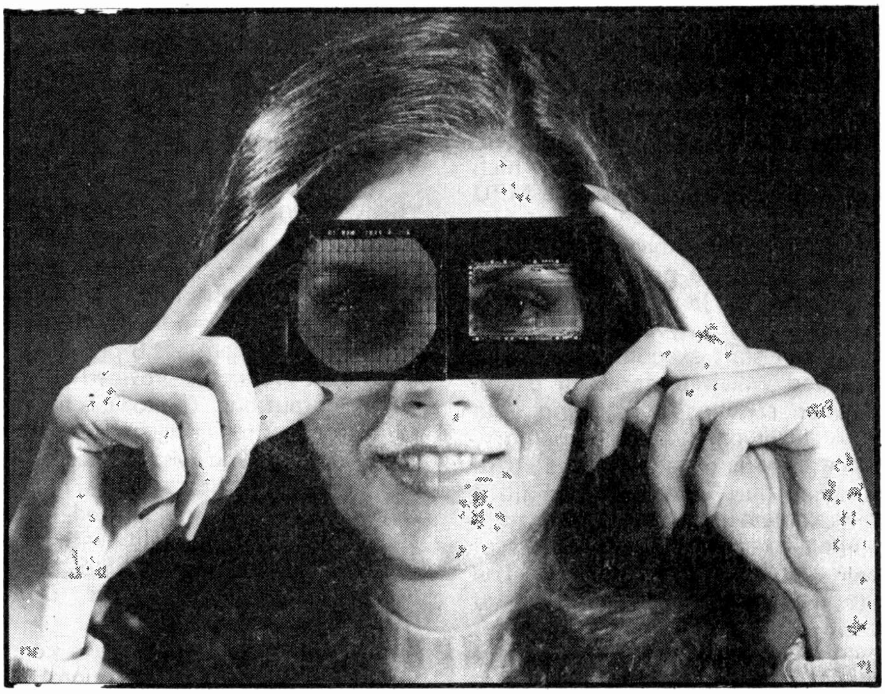
SHIFTIN' AND ROLLIN'

Two other useful instructions are ASL (or ASR) and ROL (or ROR). The ASL instruction *(Arithmetic Shift Left)* will shift all the bits of an accumulator or memory location one place to the left just like a shift register, and bit 7 (the MSB) is shifted into the carry bit of the CCR. The ASR instruction will shift the accumulator or memory contents to the right, but in this case, bit 7 is duplicated into bit 6 repeatedly, and bit 0 goes to the C bit.

A similar effect is given by the ROL and ROR instructions but in this case, the accumulator or memory is looped back on itself through the C bit, so that it is, in effect, a recirculating shift register. Let's meander off to look at a typical application of this instruction.

If an eight bit output is required to drive a sequence of eight digit drivers for a seven-segment display, it could possibly be done in the following way: the peripheral lines of the B half of a PIA should be set to outputs by storing FF in the Data Direction Register. The Output Register B should be loaded with 01. Now, if the PIA ORB is at address 8004 the instruction ROL 8004 will shift the contents to the left, i.e. changing 00000001 to 00000010. Repeating the ROL 8004 instruction will therefore repeatedly shift the 1 to the left, and thus strobe the display.

The interval at which this process is repeated could be set by using a 555 timer to pull the $\overline{IRQ}$ line via the CB1 control input of the PIA. This would cause the MPU to execute an interrupt service routine which might, for instance, output a new seven segment character from a buffer store onto the other half of the PIA (ORA) and then shift the single bit in ORB. Note that since the PIA output register 'looks' like a memory location, it's quite legitimate to use this trick of strobing an output.



These masks are used by NCR in the manufacture of MPUs. The negative on the left is photographically reduced to produce the small rectangles in the circular negative. Eventually it will find it way into a microcomputer in one of NCRs products.

ROUTINES AND SUBROUTINES

We've just used the phrase 'interrupt service routine' so it's about time to review a few more aspects of programming, such as subroutines. Basically a *routine* is a major chunk of program, such as an input routine. Most programs can be split up into such blocks for convenience of writing — it's easier to follow and more logical that way. There are often routines which are called up for special purposes such as fault finding or debugging or executive routines which sort out which routines should be run when.

Subroutines are small routines which are often stored separately from the main program and used when required. For example, it may be necessary several times during a program, to multiply two sixteen bit binary numbers together. In that case, it makes sense not to write out the whole subroutine each time it is required, but instead to write a subroutine called BIMULT which will perform the required multiplication and stick it at the end of the main program. Now each time you have to do this multiplication in the main program, you simply jump to BIMULT, which performs the calculation and then returns to where you left off. In assembly language it goes: JSR BIMULT, and the assembler, knowing where BIMULT actually is, say A057, will assemble this to: BD A057. When the program is actually run, the JSR instruction will cause the MPU to save a return address (i.e. that of the next instruction it has to perform) on the stack and go to A057, where it will commence execution of the subroutine. When it reaches the end of the subroutine, it will find this point marked by an RTS (Return from Subroutine) instruction which will cause it to retrieve the return address from the stack and continue about its business.

The interrupt service routine referred to above would be entered by a special method, however — via an interrupt pointer. There are four of these pointers located in ROM at the top of memory. They work like this: on power first being applied to the system, it has to be reset. This is done by applying a positive-going edge to the $\overline{Reset}$ input of the MPU, which forces the higher order address lines high and the MPU will now load the Program Counter with the contents of locations FFFE and FFFF. It will then commence operation at this address — usually it will be the start of an initialization program which will set up PIAs etc. Since this occurs at first power-up the restart vector, at least, has to be in ROM. The pointers for other interrupts work in a similar way, with the Non-Maskable Interrupt Pointer at FFFC and FFFD, the Software Interrupt Pointer at FFFA and FFFB, while the Interrupt Request Pointer located at FFF8 and FFF9. So when our 555 timer pulls CB1 as above the MPU will save its status on the stack, shoot up to the top of memory and load the PC from FFF8 and FFF9, then execute the routine that starts where the pointer indicated. The routine will usually end with an RTI instruction, which will cause the MPU to reload its registers from the stack.

Using a stack, subroutines can be 'nested' almost indefinitely. For example, a subroutine may be called up by a maths routine to raise one number to the power of another. This subroutine will perhaps call a logarithm-finding routine, which in turn will call division and addition routines, and to cap it all, the MPU may have to service a non-maskable interrupt. No problem, the stack will save all the return addresses and status information to be pulled again by the RTI and RTS instructions in the reverse sequence. No problem!

RESIDENT FIRMWARE

We said above that the restart vector directs the MPU to commence executing a program imme-

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diately upon switch-on. So how do you get this program into memory beforehand? The prime method of placing information in RAM is to transfer it through the MPU accumulator and store it — which requires a program to get the MPU to do it — a real chicken and egg situation! The simplest way to do this is to have a program in ROM (you have to have ROM for the restart vector anyway) which the MPU can start executing immediately and which performs a useful function such as transferring data from a keyboard input to memory. Since there is probably some spare space in our ROM, we can fill it with routines for outputting to a printer, examining the contents of memory, reading in tapes, etc. The simplest and most important of these routines is called a loader program, while the more sophisticated versions (almost all) are monitor/debug programs Motorola's M6800 MIKBUG ROM is typical. The MIKBUG program is supplied on a preprogrammed MCM6830 ROM and performs all the functions mentioned. It enables one to type in programs, examine them, change the contents of memory, run programs and punch tapes for re-use when a program is developed.

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NEWS AND PRODUCTS

The MA8807A for GEC Semiconductors is a multiply peripheral for use in all systems requiring an 8 bit by 8 bit multiply capability. The multiplier and multiplic are inputted to the MA8807A on a separate 8 bit bus and the 16 bit product is provided on the 16 pin output bus. The logic is totally asynchronous, requiring no externally supplied clock, and was designed to be compatible with Intel's 8080A, but its three-state output and latched input should ensure compatibility with most MPUs. Multiply time is 5µS. *GEC Semiconductors Ltd., East Lane, Wembley, Middx.*

Several good new books have come out on micros in the past month or so; probably the most important (and massive!) is the Electrical Research Associations report — "Microprocessors — their Developments and Application". This publication is aimed at the engineer who has to select an MPU for a particular application, and covers some 80 devices from 40 manufacturers, as well as providing a vast amount of background information on the evolution of the micro, the fabrication techniques used, as well as design techniques such as microprogramming. Plenty of useful, detailed information here and as a bonus, it's presented in an extremely readable form. Thankfully, the authors weed out the 'curiosities' and the devices it's only possible to buy if you're a major US manuafacturer who wants a million devices (but Europe might see eventually), and have instead concentrated on the devices which are on the distributor's shelves. Only drawback is the price — £39 — but the professional user will find this good value. It's available from: ERA Systems, ERA Ltd., Cleeve Road, Leatherhead, Surrey KT22 75A.

Another new publication is McGraw-Hill's "Microprocessors" Because this is a set of reprints from 'Electronics' magazine in the USA, it lacks continuity and natural development, but provides a lot of information on MPU chips generally. The development of MPUs can be seen in the articles which were written as each device was announced. In general the articles on particular MPUs are written by engineers from the companies concerned who tend to concentrate on their products good points which tend to be peculiar to one types only, and not generally applicable. But a good read, nonetheless.

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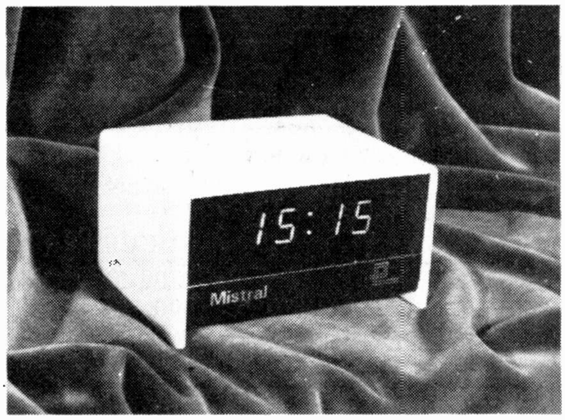

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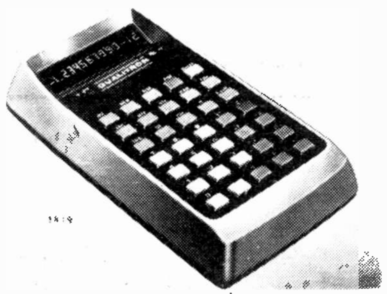
1419 — ADVANCED



1419

SPECIFICATION
- 14 digit LED display
- 10 digit mantissa with sign and 2 digit exponent with sign for data entry or results
- Automatic selection of correct notation for result display (scientific or floating point)
- Dome keyboard for excellent response and preventing double entry input

BASIC FUNCTION AND MEMORY
- Algebraic mode operation
- Constant operations
- Repeat operations
- Chain operations
- Change sign operation
- Display and Y register exchangeable
- One accumulating memory
- Display and memory exchangeable

SPECIAL FUNCTION
- Trigonometric functions sin cos tan
- Inverse trigonometric functions
- Hyperbolic functions sinh cosh tanh
- Inverse hyperbolic functions sinh cosh tanh
- Radian or degree selectable
- π constant
- Logarithms
- Antilogarithms
- Power function
- Reciprocal
- Square root

PRICE £25.89
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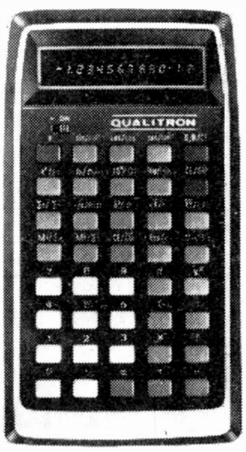
1420 — SENIOR



- 14 digit LED display
- 10 digit mantissa with sign and 2 digit exponent with sign for data entry or results
- Automatic selection of correct notation for result display (scientific or floating point)
- Dome keyboard for excellent response and preventing double entry input
- Algebraic mode operation
- Chain operations
- Change sign operation
- Three memories
- Display and memory exchangeable
- Trigonometric functions sin cos tan
- Inverse trigonometric functions
- Radian or degree selectable
- π constant
- Logarithms
- Antilogarithms
- Combinatorial functions
- Normal distribution
- Gamma function
- Group operation
- Group controls
- Power function
- Reciprocal
- Square root
- Square

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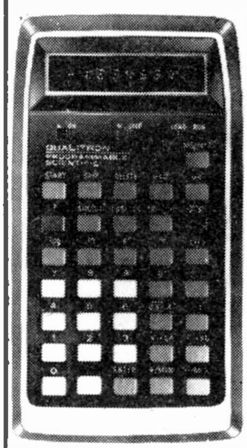
1421 — PROGRAMMABLE



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ETI DATA SHEET

FX209 AD DA CONVERTER — CONSUMER MICROCIRCUITS LTD

GENERAL
The FX-209 digital analogue encoder decoder replaces all active components in existing audio frequency "Delta Modulation Systems". The device using a Nitride PMOS process incorporates specially designed analogue circuitry along with the necessary digital circuits.

OPERATION
When encoding, the logic output supplies amplitude (power) and slope information to a local decoding system, which produces an approximation to the input signal. The locally decoded signal is fed back to the inverse input cycle and determines the logic output.

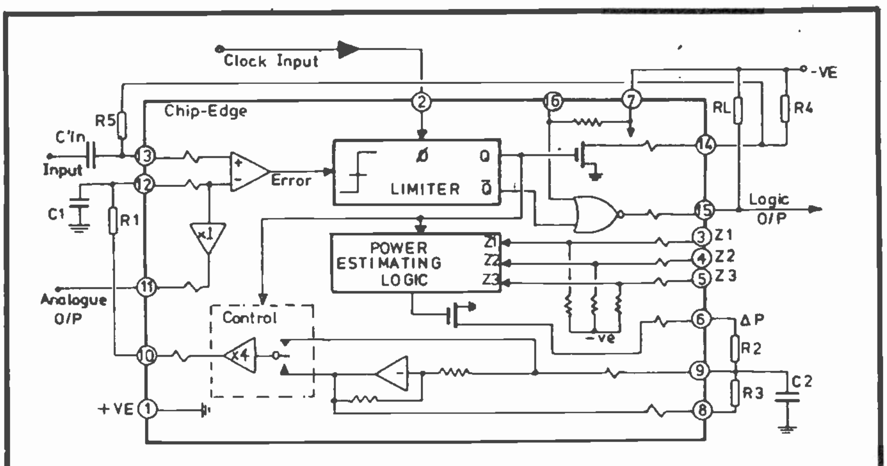
When decoding, the device performs the inverse function by producing analogue information from a digital signal using a similar circuit.

The logic level input of the encoder is suitable for digital processing. Operations such as delay, storage and filtering, are easily performed with the aid of shift registers. If the power level is assumed constant and the logic signal demodulated with a single RC, a substantially constant amplitude signal results, so that the device performs an automatic gain control function. The AGC Voltage is used internally and may be observed at pin 9.

ABRIDGED SPECIFICATION

VOLTAGE SUPPLY: 10V TO –15V — V.SELF BIAS: 45% V.SUPPLY
DYNAMIC RANGE: 0dBm TO –15dBm — INPUT HYSTERESIS: <1mV
CLOCK FREQUENCY RANGE: 1kHz TO 125kHz

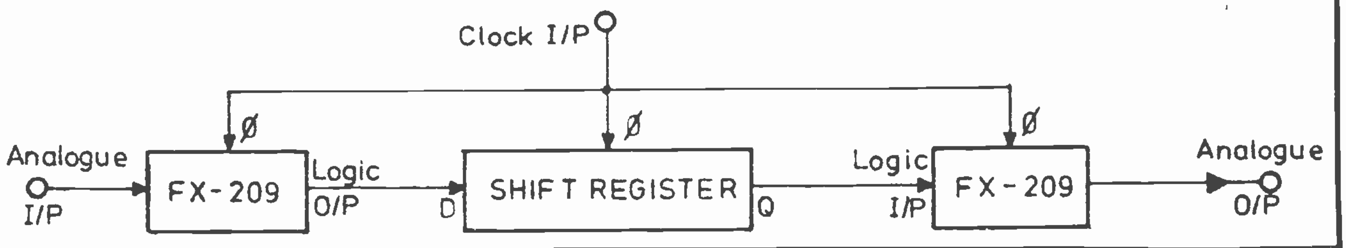
The FX-209 is available from Consumer Microcircuits Limited, Wheaton Road Industrial Estate, East Witham, Essex, CM8 3TD. The price is £5.94 inc.VAT.



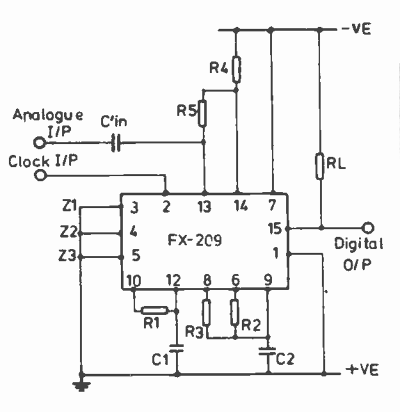
BLOCK SCHEMATIC FX-209

AUDIO DELAY
Audio Delay is a useful function in the construction of audio effect units and digital filters. This delay is easily achieved using a shift register and two FX-209's. Since signals are encoded as a stream of binary levels synchronised to the input clock. The logic O/P of the FX-209 may be directly interfaced to MOS and CMOS shift registers.

A complex waveform, such as a spoken word, may be stored in a shift register, recycled and demodulated at a different rate for analysis.



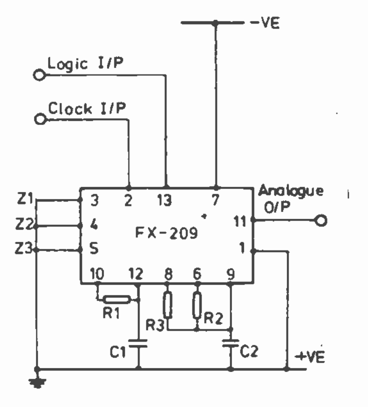
FX-209 Connected for ANALOGUE to DIGITAL conversion



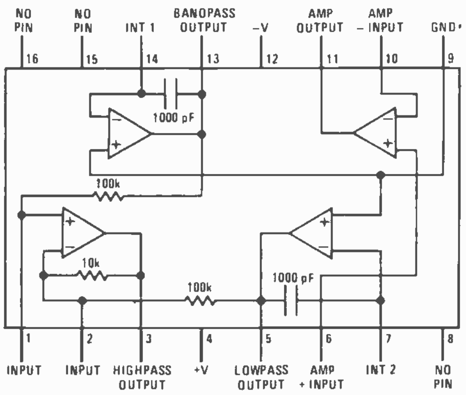
COMPONENT VALUES FOR BOTH EXAMPLES

R1=100k: R2=220k: R4=270k: R5=1M2: RL=10k: C1-2200pF: C2=0.47μF: C'in=0.047μF.

FX-209 Connected for DIGITAL to ANALOGUE conversion

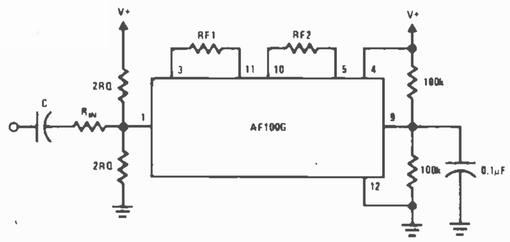


The AF100 state variable active filter is a general second order lumped RC network. Only four external resistors program the AF100 for specific second order functions. Lowpass, highpass, and bandpass functions are available simultaneously at separate outputs. Notch and allpass functions are available by summing the outputs in the uncommitted output summing amplifier. Higher order systems are realized by cascading AF100 active filters with appropriate programming resistors.
Any of the classical filter configurations, such as Butterworth, Bessel, Cauer, and Tschebycheff can be formed.



electrical characteristics

PARAMETER	CONDITIONS	MAX	
Frequency Range	$f_C \times Q \leq 50{,}000$	10k	Hz
Q Range	$f_C \times Q \leq 50{,}000$	500	Hz/Hz
f_O Accuracy			
AF100-1, AF100-1C	$f_C \times Q \leq 10{,}000$, $T_A = 25°C$	±2.5	%
AF100-2, AF100-2C	$f_C \times Q \leq 10{,}000$, $T_A = 25°C$	±1.0	%
f_O Temperature Coefficient		±150	ppm/°C
Q Accuracy	$f_C \times Q \leq 10{,}000$, $T_A = 25°C$	±7.5	%
Q Temperature Coefficient		±750	ppm/°C
Power Supply Current	$V_S = \pm 15V$	4.5	mA

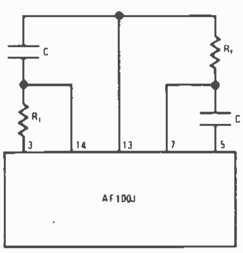


FREQUENCY TUNING

To tune the AF100 two resistors are required for frequencies between 200 Hz and 10 kHz. For lower frequencies "T" tuning or addition of external capacitors is required. Using external capacitors allows the user to go as low in frequency as he desires. "T" tuning and external capacitors can be used together.

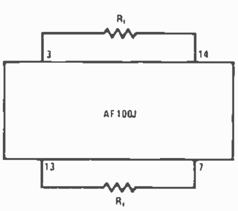
RC tuning for $f_O < 200$ Hz

$$R_f = \frac{0.05033}{f_o\,(C + 1 \times 10^{-9})}$$



Two resistor tuning for 200 Hz to 10 kHz

$$R_f = \frac{50.33 \times 10^6}{f_o}\ \Omega$$



National Semiconductors,
19 Goldington Road,
Bedford
MK40 3LF

TUNING PROCEDURE

Center Frequency Tuning

Set oscillator to center frequency desired for the filter section, adjust amplitude and check that clipping does not occur at the lowpass output pin 5 (AF100J).

Adjust the resistance between pins 13 and 7 until the phase shift between input and bandpass output is 180°.

Q Tuning

Set oscillator to upper or lower 45° frequency (see tuning tips) and tune the Q resistor until the phase shift is 135° (upper 45° frequency) or 225° (lower 45° frequency).

Zero Tuning

Set the oscillator output to the zero frequency and tune the zero resistor for a null at the output of the summing amplifier.

Gain Adjust

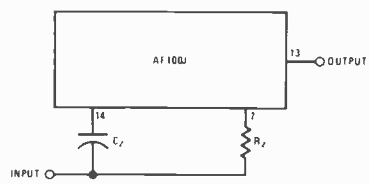
Set the oscillator to any desired frequency and the gain can be adjusted by measuring the output of the summing amplifier and adjusting the feedback resistance.

NOTCH TUNING

Two methods to generate notches are the RC input and lowpass/highpass summing. The RC input method requires adding a capacitor and resistor connected to the two integrator inputs. The capacitor connects to "Int 1", and the resistor connects to "Int 2." The output summing requires two resistors connected to the lowpass and highpass output.

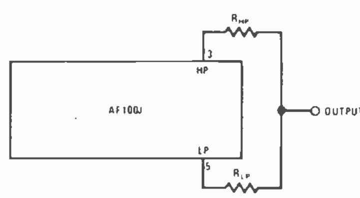
Input RC notch tuning:

$$R_Z = C_Z\, R_F \times 10^9 \left(\frac{f_O}{f_Z}\right)^2$$



Output notch tuning:

$$R_{HP} = \left(\frac{f_Z}{f_O}\right)^2 \frac{R_{LP}}{10}$$



TUNING TIPS

In applications where 2 to 3% accuracy is not sufficient to provide the required filter response, the AF100 stages can be tuned by adding trim pots or trim resistors in series or parallel with one of the frequency determining resistors and the Q determining resistor.

When tuning a filter section, no matter what output configuration is to be used in the circuit, measurements are made between the input and the bandpass (pin 13) output.

Before any tuning is attempted the lowpass (pin 7) output should be checked to see that the output is not clipping. At the center frequency of the section the lowpass output is 10 dB higher than the bandpass output and 20 dB higher than the highpass. This should be kept in mind because if clipping occurs the results obtained when tuning will be incorrect.

Frequency Tuning

By adjusting the resistance between pins 7 and 13 the center frequency of a section can be adjusted. If the input is through pin 1 the phase shift at center frequency will be 180° and if the input is through pin 2 the phase shift at center frequency will be 0°. Adjusting center frequency by phase is the most accurate but tuning for maximum gain is also correct.

"Q" Tuning

The "Q" is tuned by adjusting the resistance between pin 1 or 2 and ground. Low Q tuning resistors will be from pin 2 to ground ($Q < 0.6$). High Q tuning resistors will be from pin 1 to ground. To tune the Q correctly the signal source must have an output impedance very much lower than the input resistance of the filter since the input resistance affects the Q. The input must be driven through the same resistance the circuit will see to obtain precise adjustment.

The lower 3 dB (45°) frequency, f_L, and the upper 3 dB (45°) frequency, f_H, can be calculated by the following equations:

$$f_H = \left(\frac{1}{2Q} + \sqrt{\left(\frac{1}{2Q}\right)^2 + 1}\right) \times (f_O)$$

where f_O = center frequency

$$f_L = \left(\sqrt{\left(\frac{1}{2Q}\right)^2 + 1} - \frac{1}{2Q}\right) \times (f_O)$$

When adjusting the Q, set the signal source to either f_H or f_L and adjust for 45° phase change or a 3 dB gain change.

Notch Tuning

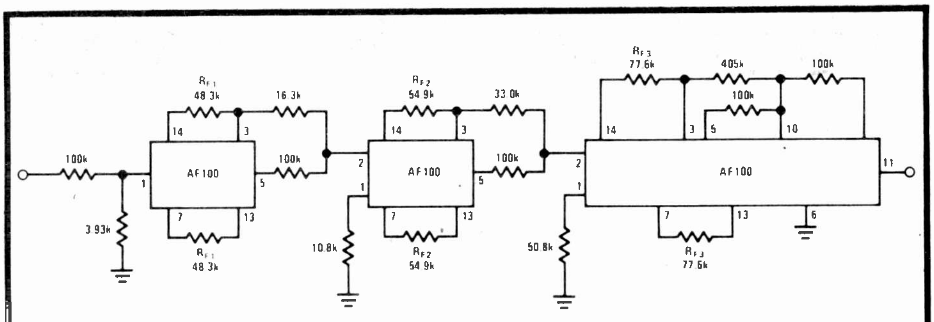
If a circuit has a jw axis zero pair the notch can be tuned by adjusting the ratio of the summing resistors (lowpass/highpass summing) or the input resistance (input RC).

In either case the signal is connected to the input and the proper resistor is adjusted for a null at the output.

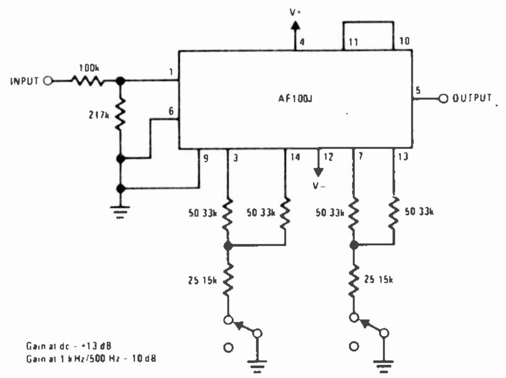
Special Cases

When using the input RC notch the unit cannot be tuned through the normal input so an additional 100k resistor can be added at pin 1 and the unit can be tuned normally. Then the 100k input resistor should be grounded and the notch tuned through the normal RC input.

An alternative way of tuning is to tune using the Q resistor as the input. This requires the Q resistor be lifted from ground and connecting the signal source to the normally grounded end of the Q resistor. ●



Lowpass Elliptic Filter



Switchable Filter Example: 500 Hz/1000 Hz Butterworth Lowpass

Q TUNING

To tune the Q of an AF100 requires one resistor from pins 1 or 2 to ground. The value of the Q tuning resistor depends on the input connection and input resistance as well as the value of the Q. The Q of the unit is inversely proportional to resistance to ground at pin 1 and directly proportional to resistance to ground from pin 2.

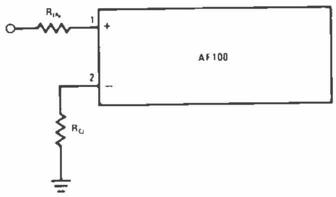
The highest "Q" pole pair should be paired with the zero pair closest in frequency.

If highpass and lowpass stages are cascaded the lowpass sections should be the higher frequency and highpass sections the lower frequency.

In cascaded filters of more than two sections the first section should be the section with "Q" closest to 0.707 and then additional stages should be added in order of least difference between first stage Q and their Q.

$Q < Q_{MIN}$ in non-inverting mode:

$$RQ = \frac{10^4}{0.3162\,\frac{\left(1 + \frac{10^5}{R_{IN}}\right)}{Q} \quad 1.1}$$

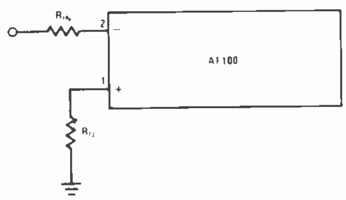


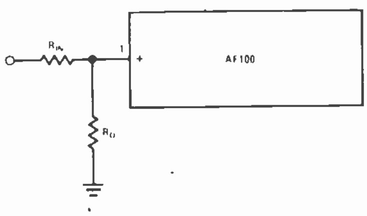
For $Q > Q_{MIN}$ in non-inverting mode:

$$RQ = \frac{10^5}{3.48Q - 1 - \frac{10^5}{R_{IN}}}$$

Q in inverting mode:

$$RQ = \frac{10^5}{3.16Q\left(1.1 + \frac{10^4}{R_{IN}}\right) \quad 1}$$





[CMOS]

In the fifth and final part of this series, T. Bailey looks at more sophisticated versions of many of the devices already discussed.

MULTI-STAGE COUNTERS

We will now begin a brief trip back through several of the topics we have already covered, looking at some more sophisticated ICs in each group.

The first two devices in fig. 1 share a common pin-out diagram. They are both dual counters (labelled "A" and "B") with reset operating when high. The 4518 operates in BCD and the 4520 works in binary. Both devices are capable of counting at at least 2.5MHz when V_{DD}= 10V. The clock and enable inputs are interchangeable in that a positive edge triggered counter may be realised by holding enable at "1" and using the clock input, or a negative edge triggered device may be obtained by holding the clock high and using the enable input.

The 4553 is altogether a more advanced I.C. It is a three stage decade counter with latches and it provides a multiplexed output. The counters advance on the trailing edge of the clock pulse providing that "disable" is low. It will also advance on the rising edge of a disable pulse if the clock is high. The outputs are multiplexed, which means that one digit is given at a time on the four BCD output lines. The three digit outputs show which digit is being presented (digit 1 is most significant). The BCD outputs are high when active, the digit select outputs are low. The multiplexing is driven by an internal oscillator whose frequency is determined by the value of capacitor (1000pF is about right) connected between pins 3 and 4. Alternatively, this can be overridden by leaving the capacitor out and driving the multiplexing by feeding pulses to pin 4. The carry out signal may be used to clock succeeding counters and in this case a capacitor may be used to control the multiplexing of the first counter and succeeding ones driven by connecting their pin 4 to pin 3 on the preceeding device. The reset input sets all the counters to zero and disables all the digit outputs hence blanking the display when it is taken high. The only other thing to note is the latch enable input. On the rising edge of the input to this pin the output from the counters is stored in latches and thus the conventional three decade counter ICs and three latch ICs are replaced by a single device. Use of this device is well illustrated by the ETI counter module and also by fig. 2 which shows a six decade version.

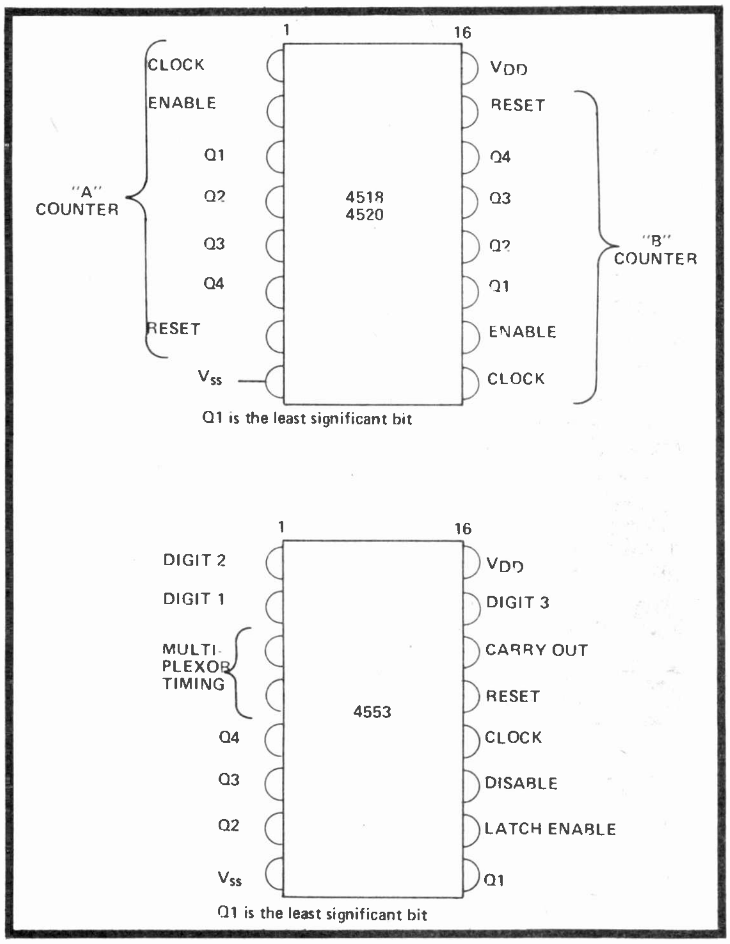


Fig. 1. Three multistage CMOS counters.

The two seven segment decoders used in these two counters, the 4543 and the 4511 have their pin-out given in fig. 3. The 4511 is a straightforward device with Q1-Q4 BCD inputs and a-g segment outputs. The three additional connections are simply a lamp test which lights all segments when it is taken low, a blanking input which turns off all segments when it is taken low (unless lamp test is low as well) and a latch which stores the current input when it is taken high. The segment outputs will source up to 25mA.

CMOS

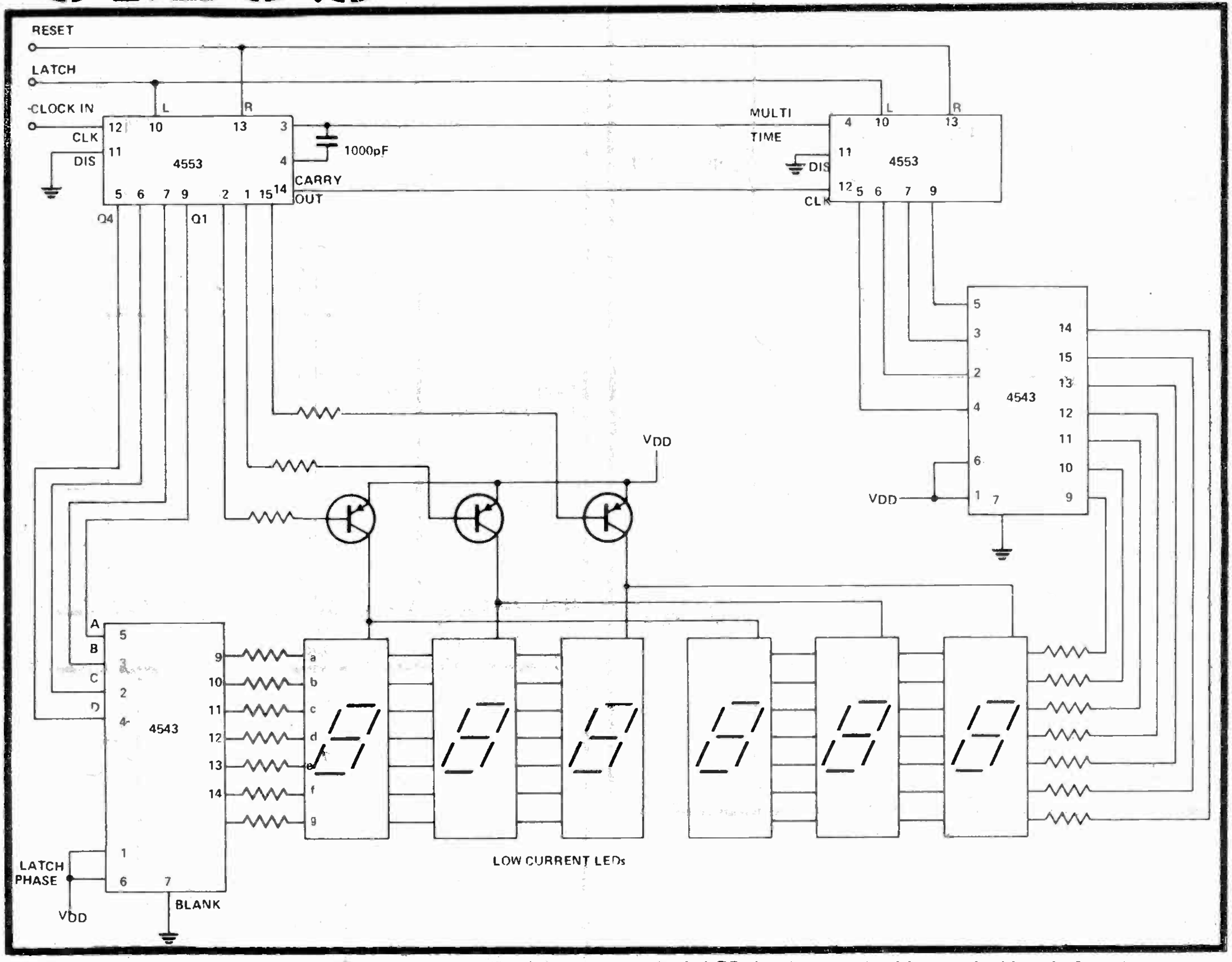


Fig. 2. A six decade counter using CMOS. It may be adapted for common cathode LEDs by changing the drivers and taking pin 6 on the 4543's to V_{SS}.

The 4543 is more advanced, the latch operates when taken low and the blanking operates when high. The device operates conventionally when the phase input is low (i.e. is suitable for directly driving common cathode L.E.D.s) but when phase is high, the outputs are all inverted which is useful for driving common anode L.E.D.s. If this input is fed with a square wave which is also fed to the common connection of the segments, liquid crystal displays may be driven in the manner described in part one. The 4056A mentioned there is a pin for pin equivalent of this device except that the blanking is dispensed with and pin seven used as a second V_{SS} pin for the display output part of the circuitry. Thus pin 16 could be at OV, pin 8 at −3V and pin 7 at −15V giving maximum economy while still providing full drive at the output.

There is also a five decade counter of a similar type but there is not space to describe it here. Its type number is 4534 and it comes in a twenty-four pin DIL case.

MONOSTABLE MULTIVIBRATOR

The 4098B is a dual monostable multivibrator. Its pin diagram in fig. 4 is accompanied by a table showing the connections needed for every combination of edge triggering and retriggerability. The reset operates when low in this device whose period is, to a first approximation given by T=RC (ohms and Furads), where C is connected getween the RC and C pins and R is connected from RC to V_{DD}. The specification of the 4528 is similar except for minor details.

MORE GATES

We can now claim to have covered a fair cross-section of devices and so to conclude we shall say a little more on the subject which we started with, simple gates. As well as the NOR and NAND gates we mentioned at the time there is a range of AND and OR gates available at comparable prices. The 4071B, 4075B, 4072B are quad, triple and dual OR gates respectively with identical connections to the NOR gates (4001A, 4025A, 4002A) that were discussed in the first part of this series. Similarly, the 4081B, 4085B, 4082B are the AND gates corresponding to the 4011A, 4023A, 4012A we mentioned then.

The 4030A quad exclusive-OR gate was also listed there and it is worth mentioning that types 4070B and 4077B are exclusive-OR and exclusive-NOR gates with identical pin connections. As the 4070B has slightly superior specification to the 4030A and is usually cheaper it

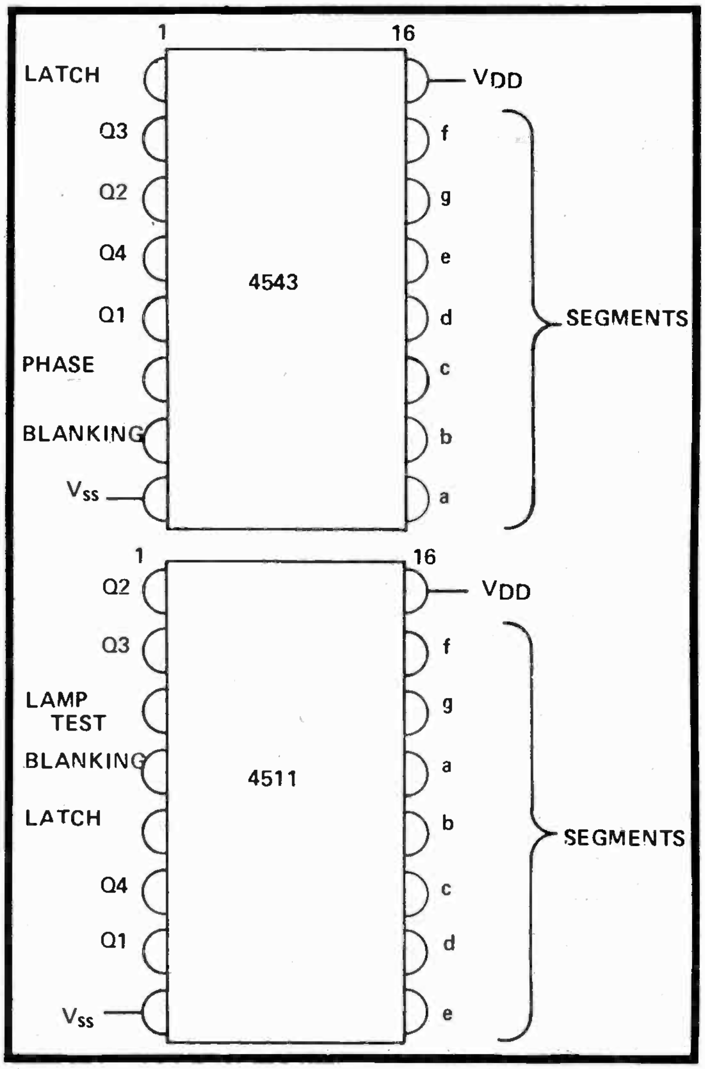
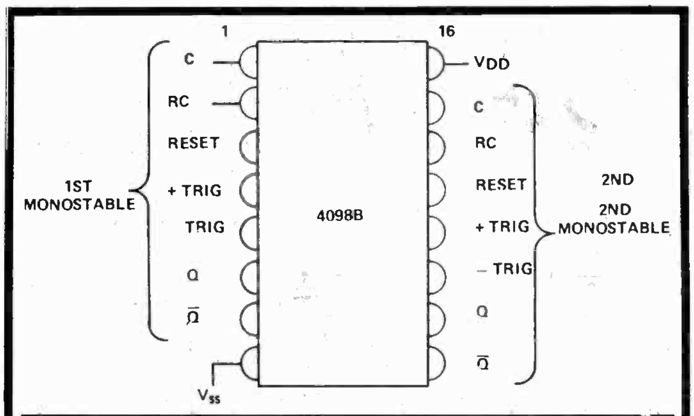


Fig. 3. Two BCD 7 segment decoders and drivers with latches. Q1 is the least significant bit.



MODE OF OPERATION	CONNECT TO VDD	CONNECT TO V_{SS}	INPUT PULSE TO	OTHER CONNECTions
+EDGE TRIG RETRIG	−TRIG RESET	–	+TRIG	–
+EDGE TRIG NON-RETRIG	RESET	–	+TRIG	−TRIG TO Q̄
+EDGE TRIG RETRIG	RESET	+TRIG	−TRIG	–
−EDGE TRIG NON-RETRIG	RESET	–	−TRIG	+TRIG
UNUSED SECTION	−TRIG	RESET +TRIG	–	–

Fig. 4. The 4098B dual monostable multivibrator and method of achieving different modes of operation.

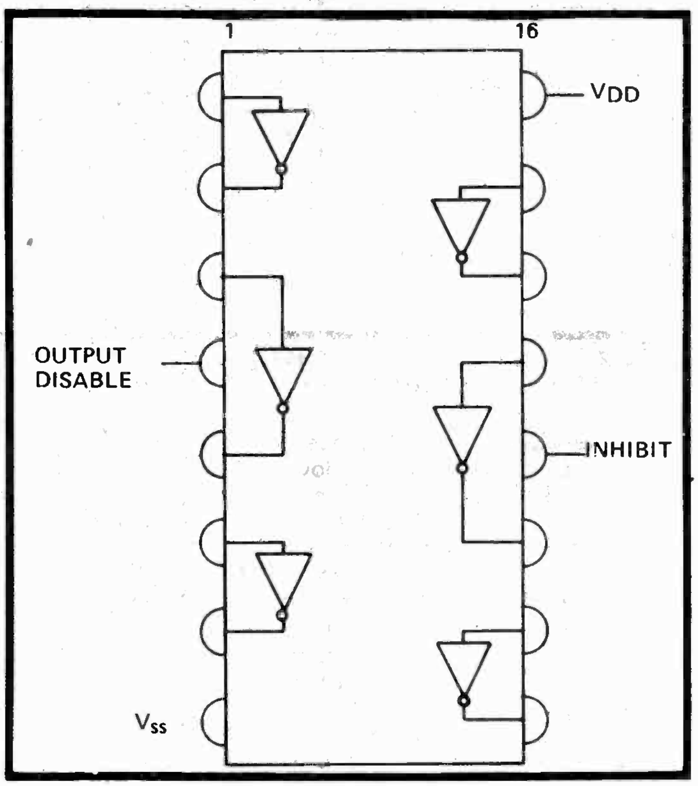


Fig. 5. Pinout of the 4502 strobed hex inverting buffer.

may generally replace it. Also, for almost all purposes the 4507 is equivalent to the 4030A and 4070B.

The 4093B is a quad NAND Schmitt trigger with about 0.6 volts hysteresis (at V_{DD}= 5V) and a pin-out identical to the 4001A. The 4583 is a dual Schmitt trigger in which the hysteresis may be adjusted by external resistors. There can be few uses for these which have not already been realised with the T.T.L. SN7413N but it is worth noting that larger time constants could be used on the inputs.

Fig. 5 shows a hexinverter and buffer with the extra options of an inhibit input which makes all the inverters have low outputs when it is taken high and an output disable which sets all the outputs in a high impedence state. This also operates when it is taken high. The chief use of these circuits is in applying one of two lines of data to an input. They are both wired in but only one disable is low at any one time. The disable overrides the inhibit.

RANGES OF CMOS

Throughout this series, devices have been known by a four digit code number beginning 40 and ending with A or B, or beginning 45 and possessing no suffix. Most of the devices beginning 40 are available from RCA in the CD range with a type number CD40xxAE or CD40xxBE. The A signifies that the maximum supply voltage is 15v, B signifies 18v. In general, A and B versions are not both provided. Most of this range is also available from Motorola as the MC140xxCP range which will tolerate up to sixteen volts. The 45 devices are often available only in the MC145xxCP range. In general other combinations of suffices indicate a ceramic packages or the like. Generally these are more expensive and have slightly superior specifications.

OPTICAL COMMUNICATIONS CIRCUITS

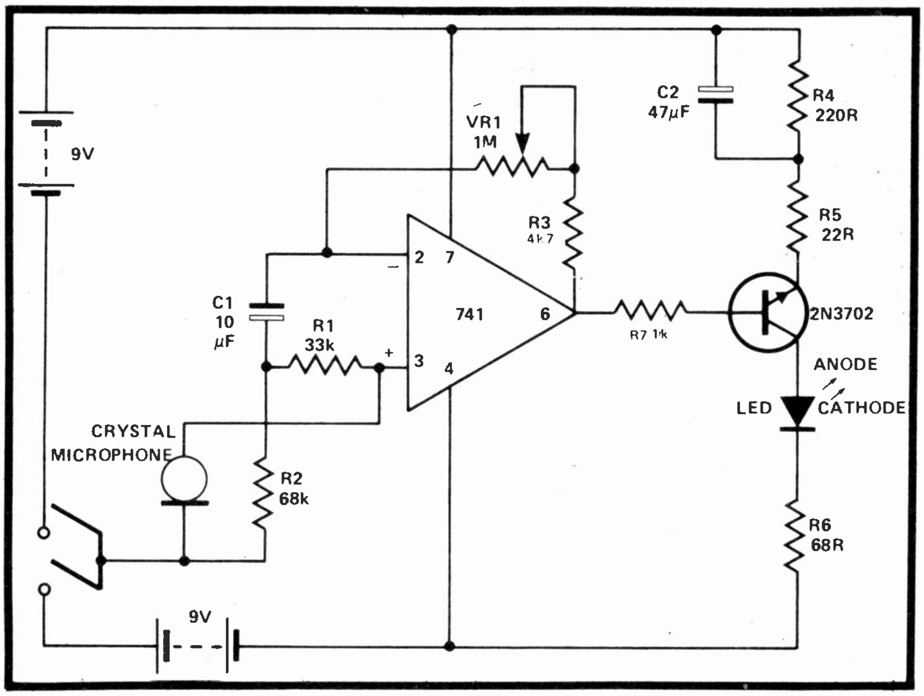
By Malcolm Plant

Prototype transmitter circuit for optical communications.

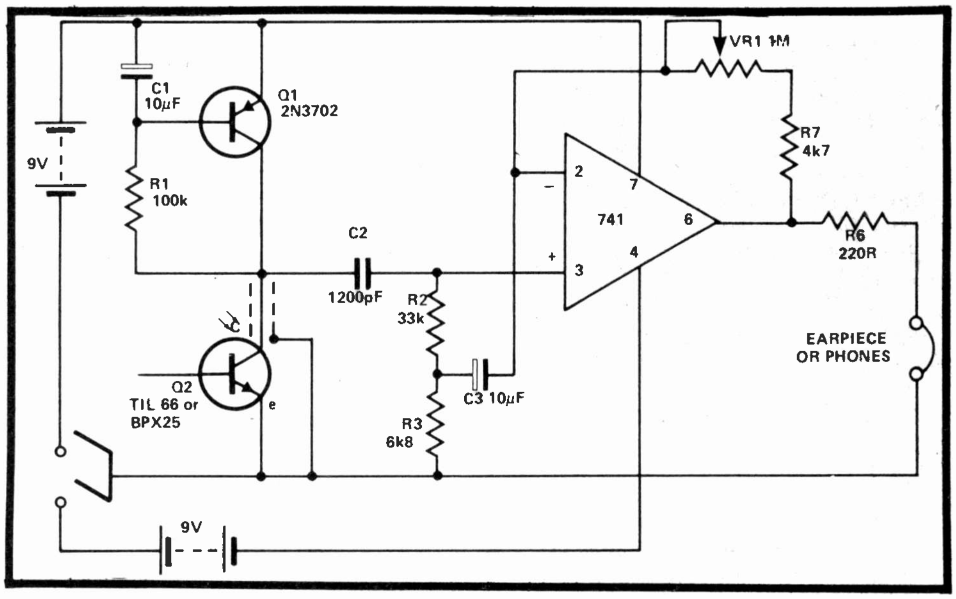
THE CIRCUITS shown enable an optical communications system to be built which, governed principally by the choice of lenses, provides communication over a distance of at least 500 metres.

The transmitter uses an LED (light-emitting diode) to produce an a.f. modulated, infra-red or visible beam of radiation which is detected by the phototransistor in the receiver circuit. This phototransistor should have a peak sensitivity at the peak emission wavelength of the LED if optimum efficiency is to be obtained. Should the LED be infra-red emitter TIXL26 radiating most of its radiation at 0.9μm, the phototransistor TIL66 provides a good match. However, visible red-emitting LEDs are suitable with this type of phototransistor, and both may be lower cost types than the ones suggested for an infra-red sensitive system. Note that the use of the infra-red emitting diode does not preclude the use of ordinary glass (borosilicate) lenses which are transparent to a radiation of 0.9 μm.

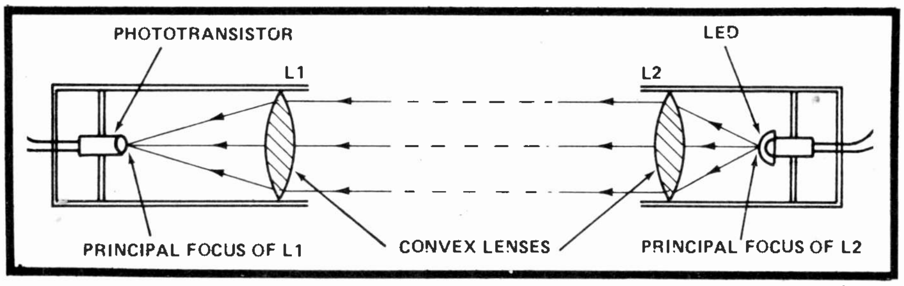
Note that each circuit employs a general purpose op amp (the 741) as a sensitive preamplifier of the signals from the microphone and the phototransistor. The input circuits to the op amps employ bootstrapping to increase the input impedance enabling, in the transmitter circuit, a crystal microphone to be used. The earpiece may be any type having an impedance in the range 200Ω to 2kΩ. The gain of each circuit is conveniently controlled by making the feedback resistor (RVI) variable. Should the circuits be unstable in operation



TRANSMITTER CIRCUIT



RECEIVER CIRCUIT



OPTICAL SYSTEM

upon examination of the output signals, this can be cured by connecting a 470pF capacitor between the pins 6 and 2 of the op amp. The constructor might consider modifying the circuits to operate from a single-ended supply; this necessitates using a voltage divider to raise the voltage at the noninverting terminal to about half the supply voltage on which is impressed the signal voltage.

The principle of the optical system employed is shown in the figure. To reduce the problems associated with alignment and focusing, when setting up the units at differing distances from each other, the transmitter is arranged to provide a parallel beam and the receiver to receive this beam. This collimation procedure is achieved by ensuring that the LED and phototransistor are at the principal focus of the relevant lens.

The diameters of the lenses should be such as to fully exploit the radiation contained in the radiating cone of the LED. In practice, 50mm diameter and 150mm focal length lenses were found to be suitable. Thicker (shorter focal length) lenses may be used thereby reducing the diameter required. However, the possibility arises that adjustment for collimation becomes more difficult with decreasing focal length partially due to the increase in lens aberrations. ●

ELECTRONICS —it's easy! PART 28

Digital sub-systems — counters and shift registers.

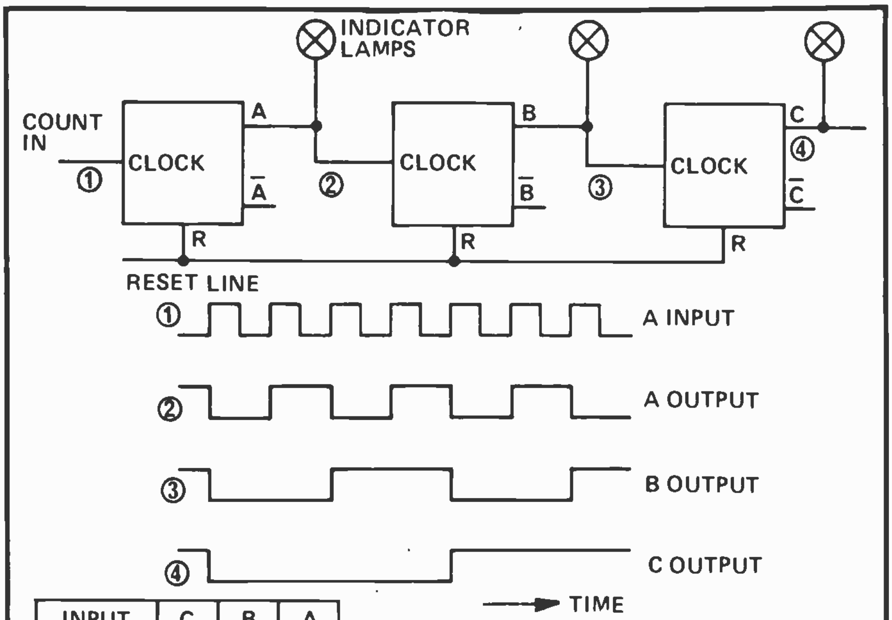


Fig. 1. The asynchronous or ripple-through binary counter is the simplest to implement with flip-flops.

INPUT	C	B	A
0	0	0	0
1	0	0	1
2	0	1	0
3	0	1	1
4	1	0	0
5	1	0	1
6	1	1	0
7	1	1	1
8 = 0	0	0	0

TRUTH TABLE

IN THE preceding articles of this series we have described the basic building blocks of digital systems. To summarize, there are the various gates, the flip-flop, the monostable, the Schmidtt trigger, the inverter and the square-wave clock source — a surprisingly few basic elements from which all the countless different forms of digital equipment are constructed. We are now in a position to examine how digital signal systems are put together using these basic building blocks.

DIGITAL NUMBERS INTO DIGITAL SIGNALS — COUNTER SUB-SYSTEMS

Not long ago digital systems were invariably built up from individual blocks where each of the above functions could be clearly identified in the system. But not so now. Many of the blocks now marketed as basic building elements are complex systems in themselves. The most extreme example is probably the micro-processor system (it provides the bulk logic requirement of a powerful computing system) which is now available as a 'throwaway' element for around £40 or less.

We have already become involved in small systems — the exclusive OR and the half-adder of Part 22, for instance. The next step to take is to form sub-systems with the fundamental blocks that provide us with the facility to form and manipulate digital numbers, because many (but not all) digital systems operate with numbers either to provide means of calculation, or to provide a display of numbers. Thus we need to know something of digital counters and the somewhat similar units known as registers.

We saw in the previous part how the flip-flop provides a counting action by virtue of its ability to switch states for each pulse appearing at its input. However nowadays it is a level change rather than a complete pulse which causes the transition.

BINARY COUNTING

Cascaded flip-flops, such as shown in Fig. 1, form the simplest type of counting system. Each time the input changes state, the A flip-flop toggles back and forth delivering a state change to flip-flop B for each second input change — and each fourth change to C and eighth change to D and so on.

At any instant (where the input is presumed stationary, at least for the interrogation period) the outputs A, B, C, etc. will either be at a 0 or 1, as shown in the truth table. For example, a count of five (decimal) will be registered at 101 for CBA respectively. Note that the truth table appears to be written back to front — the reason is simply that we write numbers (by convention) with the most significant digit to the left hand of the number and this corresponds with the furthest right-hand flip-flop, its position on the schematic arising from the drawing convention used for the signal-flow through information systems. Thus a stream of input pulses with time are converted into a multi-element digital number. This form of input is often referred to as a "crazy-digital" number system when applied to systems incorporating measuring sensors. Such sensors generate pulses not having any clearly obvious relationship with time — examples are digital-position sensors wherein a pulse is generated for each unit displacement occurring.

Clearly, if the state of A, B, C, etc. is to represent a number the count must start from some clearly defined initial condition for each stage — often, but by no means always, stages are reset to 000 — by applying a level to the reset R line. In some applications the number must begin at a specific value. This is achieved by operating the preset lines accordingly for each stage, the value being arranged, say, by the setting of numeric dial switches usually operating through solid-state gates. Once these are set, a single command signal can preset the whole counter to that chosen number. Figure 2 shows how this is achieved using gates.

It is often desirable to display the digital value for visual interrogation. An indicator lamp (light emitting diodes LEDs are now used) driven from the A, B, C, etc., will show the positive logic binary number. Driven from $\bar{A}$, $\bar{B}$, $\bar{C}$, etc., it would show the negative logic number.

Waveforms for this form of counter (called the ripple-through type) are shown in Fig. 1. Although we refer to pulses flowing through, the waveforms are actually square-wave trains in the dynamic state, or levels in the static state, that have frequencies divided down in the ratio 1:2:4:8 etc. This 'pulse' form of expression is a hangover from the early days of digital technique (just a decade ago) where actual pulses, not levels, were used to trigger flip-flops. Each square-wave transition was differentiated by a simple RC circuit to provide a pulse of energy that triggered the next stage. Today, this method is unnecessary and is seldom used.

ASYNCHRONOUS AND SYNCHRONOUS COUNTING

Once an input pulse has occurred, it sets the chain in action, each flip-flop passing each second input pulse on, to the next stage. As each stage has a finite delay time — nanoseconds with TTL, microseconds in older forms of logic — each stage triggers at a later time than the one before it. Hence the form of action of each stage is said to be asynchronous with the others. Thus whilst the pulse is rippling through the counter the outputs are in an undefined and changing state between the previous and next correct states. The output cannot therefore be read until the whole thing has settled.

It is quite common to have binary counters with over 20 stages — at 100 ns delay in each, the maximum input pulse counting rate (if the outputs are to be used whilst it is in a counting transition mode) would be limited to 2μs between incoming pulses, that is, 500 kHz. Faster logic is available that provides around 20 ns delay but this still seriously restricts the data-transmission rate where the ripple-through design is used.

This disadvantage can be overcome by increasing the circuit complexity somewhat to form what is known as a SYNCHRONOUS counter. Each stage in the cascaded chain is fed a clock pulse simultaneously via control gates. The control gates for each stage also receive inputs from all previous stages such that the particular stage only operates at the correct count.

By this means all stages operate synchronously and the propogation delay is reduced to that for a single stage only. Synchronous counters are essential where the outputs of all stages must be decoded in parallel, eg, where a display of the count is required. However for straight frequency division applications, where the output is taken only from the last stage, a ripple counter is normally faster than the synchronous type.

The logic-gate inputs of the JK flip-flop allow them to be connected for synchronous counting as shown in Fig. 3. It is not important to know how JK flip-flops work internally for counters are now built by cascading ICs as per application note instructions — it takes a specific type of mind to realise digital counting

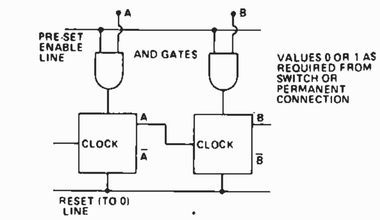


Fig. 2. Counting stages require their initial conditions to be set — either to O or to desired values.

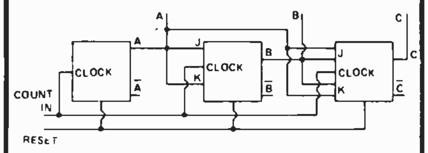


Fig. 3. Synchronous binary up-counter with JK flip-flops.

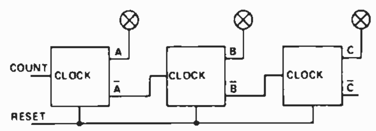


Fig. 4. Reverse counting is simple — use complement outputs instead to trigger the next stage. (a) Ripple-through count-down.

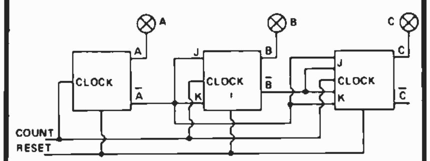


Fig. 4 (b). Synchronous count-down.

systems without effort! Fortunately for those of us without this ability it is rarely needed except, of course, by IC designers.

UP, DOWN AND REVERSIBLE COUNTERS

So far we have only looked at counters that increase up the binary number scale for each additional input. To make the same system count down is incredibly simple — we merely re-connect them so that the complemented outputs are fed to the next stage — see Fig. 4 — instead of using the normal output, that is, feed Ā, B̄, C̄, etc. to the count inputs. It will then count down in binary sequence. Intuitively we would expect this because of the two-state complementary nature of binary numbers. If you are worried about numbers passing through zero, try your digital arithmetic on a count-down case starting at 000.

In many applications needing counters, one-way counting is satisfactory. Examples that come to mind are nucleonic pulse-event counters, counter-timer units and counts of objects passing a given point. In some requirements, however, the need is to add or subtract pulses to provide at any time the instantaneous sum or difference between two inputs, or to give the nett value from a single measurement parameter that alternates in sign. Examples here are digital-position indicators where the direction of movement reverses, integration of reversible variables such as the flow of solid or liquid past a point the number of vehicles in a car park, and situations where the difference between two pulse-train variables is needed.

Several methods may be used to construct up-down or reversible counters. The most common method is to use a common pulse-count input that accepts both 'up' and 'down' pulses, the decision to add or subtract each individual pulse being decided by the simultaneous voltage levels applied to control lines. The control lines select whether the pulse is routed through the A, B, C, etc., or Ā, B̄, C̄, etc. paths. Switching is accomplished using logic gates as shown in Fig. 5a and 5b — these provide adequately fast switching. In the ripple-through variety the direction-line commands must be held stationary until the counter stages have settled in order to preserve accurate counting. The delay is less pronounced in synchronous designs. Within certain limitations it is

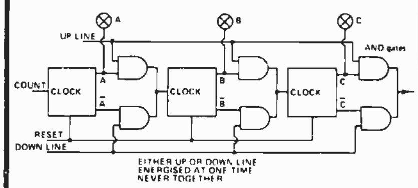


Fig. 5. Reversible counting uses fast switches to select which output of each stage feeds the next. (a) Asynchronous-line controlled.

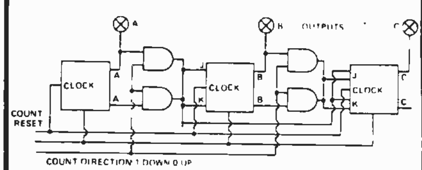


Fig. 5 (b). Synchronous-line controlled.

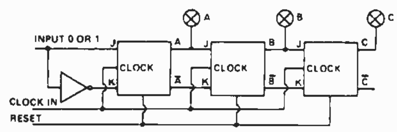


Fig. 6. The shift-register is also built from flip-flops but with different connections (a) JK type.

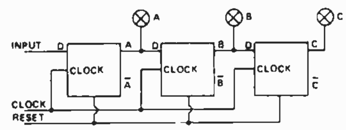


Fig. 6 (b) D type.

also possible to design counters that will accept a new pulse while the system is still in transition. This is done by 'holding' the pulse (by applying a delay) until the counter is ready to accept it.

SHIFT REGISTERS

Although not a counter in the same sense as above, the shift register also consists of a cascaded chain of flip-flops but with different connections. The purpose of the register is to hold a binary number but allow it to be shifted as a whole to the left (toward the most significant digit – called a forward shift register) or to the right (toward the least significant digit – the reverse shift register) one step for each input pulse.

As shown in Fig. 6, the incrementing signal, which is more usually a free-running clock signal than a one-at-any-time instruction, feeds the count inputs causing all stages to toggle in synchronism. The state of each following stage, being tied to the output of that preceding, goes to that of the one before with each clock pulse. Thus a number can be fed into one end in serial fashion and will be caused to pass through the register. The whole is cleared to zeros or reset to any desired value via the reset input line. Using D-type counters outputs A etc., go to D inputs. Whereas when using J-K counters A, etc. go to J inputs.

Registers perform three main functions in digital systems. Firstly a digital number can be delayed in time by the additive propagation time (divided by the clock frequency) of the number of stages it passes through, or stored indefinitely (provided the power is held on).

Secondly, one digital number can be successively offered up to another for digital summation of the two – a basic step of multiplication by digital means. One number remains in position, the other increments across, the two being added at each step by the half-adder (part 22). Binary multiplication and division follow decimal number procedures but are much simpler – see Fig. 7.

A third use for shift registers is for the conversion of digital data from serial to parallel form and vice versa. For example it may require a group of eight pulses to define the position of a shaft with sufficient accuracy. The group of eight pulses is called a word and each individual pulse is called a bit. To transmit this word we would normally need eight lines. However a single line may be used if the information is transmitted one bit at a time, with synchronizing pulses to tell the receiving equipment where each word starts and ends. If the data when received is fed into a shift register serially, eight bits at a time, each word will appear in parallel at the output of the shift register, providing synchronism is maintained, where it may be decoded.

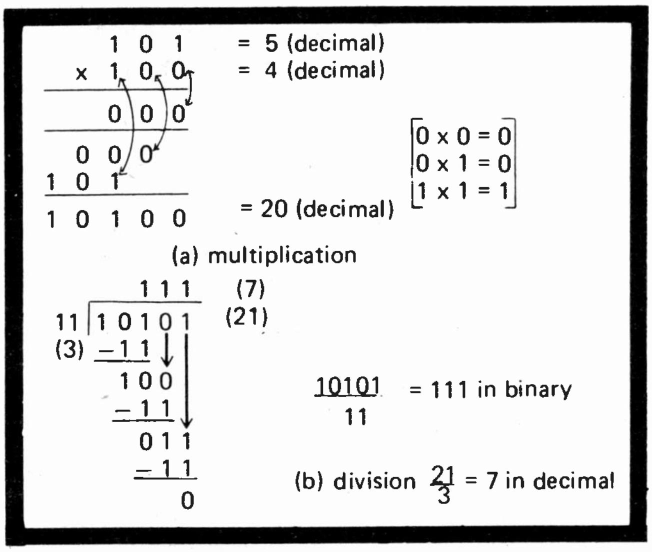


Fig. 7. Binary multiplication and division follows the same rules as decimal numbers but note how simple multiplication becomes – a process of shifting and adding 0 or 1.

In reverse, a register can be set up to the desired number by the appropriate choice of stage inputs. Once set the register is incremented to feed out the number in serial manner to a single line.

Many forms of binary counters and registers are available in integrated-circuit packages. Figure 9a shows the schematic of a binary counter having two bits on the chip – that is it contains two flip-flops ready to be connected to count. Figure 9b is an eight-bit shift register. Both can be cascaded with like units to extend the bit capacity to virtually any length of binary word needed.

COUNTING IN OTHER THAN BINARY

In the binary counting system each bit position requires a counter element that has two stable states. In the decimal counter each digit needs 10 states to describe the individual numbers. Similarly three states are required for a ternary system, five for quinary, eight for octal and so on. Ten is not the limit – we use 12s and 60s in time and angle subdivision.

From the hardware realisation viewpoint, binary numbers are the simplest to hold because of the existence of the two-stage flip-flop. (Three state devices exist but have not gained favour). From the user's viewpoint, however, we are more familiar with decimal numbers – a few people can read and work with binary displays but more would agree that values like 1025 decimal, which when displayed in binary form required 10 bits (1000000001), is difficult to read and interpret as a magnitude.

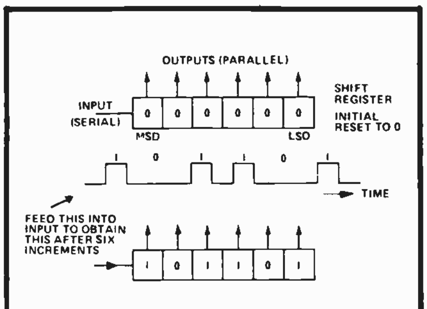


Fig. 8. Registers can provide serial to parallel conversion as well as the converse.

Flip-flops ideally count in powers of two – 2, 4, 8, 16, etc. – so any other value such as three or 10 requires modification to the counting procedure.

The flip-flop chain must be made to skip the required number of unwanted states in the truth table in order to return to the zero position. It is probably evident that this implies a waste of counting capacity when states are not used. In 10s counting, four flip-flops are needed to create 10 states – the other six of the 16 possibles go unused. Similarly, with three's (called modulo-3) two flip-flops are needed wasting one of four states, and with modulo-5 counters three flip-flops are needed with three wasted states.

Although a decade counter uses only 10 out of the possible 16 states, of its four flip-flops, this is not necessarily as wasteful as it may at first appear. For example if we wish to count up to 9999 with decade counters we will need a total of four counters containing 16 flip-flops. To count to the same number with straight binary counters we need 14 flip-flops – only two less. Additionally the ease of obtaining an easily interpretable display results in a system cost that is less than if an all-binary system were to be used.

In computers, information handling capacity is at a premium and the need to display the internal numbers negligible. In such cases the octal-number system comes into its own because three flip-flops provide eight states without any waste of states, and without need for the extra components required to skip unwanted states. The octal range is 0, 1, 2, 3, 4, 5, 6, 7 and then back to 0. A number 312 (octal) is $3.8^2 + 1.8^1 + 2.8^0 = 3.64 + 1.8 + 1 = 202$ decimal. Note that the decimal number requires roughly the same number of bit positions as the octal number but to implement decimal in digital hardware would need four (compared with three for octal) flip-flops for each bit position. However, where output is needed for human use – printouts and readout in numbers – the decimal system is best.

DECIMAL COUNTING

To obtain the 10 states 0 to 9 we must begin with enough flip-flops to provide them. Decimal or decade-counting stages, therefore, need four flip-flops which count in some form of code over just 10 states. The most straight-forward realisation is to let them count through the normal binary code and to apply interconnections between stages which prevent illegitimate states occurring and, often equally important, prevent the system locking up (as can happen in some counting systems).

Decade counters using straight binary are denoted Binary Coded Decimal – BCD. As there is no real reason why a stage should start with decimal 0 and binary 0 coinciding, it is feasible to construct a large number of different BCD counter stages using different code sequences. If the zeros do coincide it is called normal BCD (NBCD).

As we shall see in the next part, it is important to know that BCD code is used when the system needs a display in decimal. This is because the circuitry of the decoder depends upon the logic sequence of the counter as well as the requirements of the display method – more of that later.

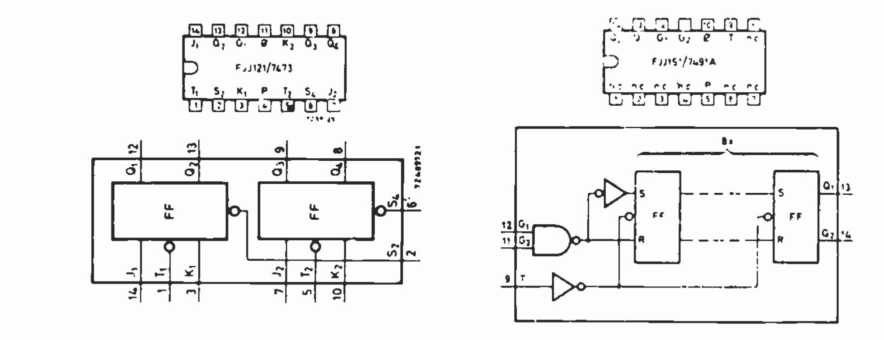


Fig. 9. Schematics of IC units. (a) Binary stages for counting or other purposes. (b) 8-bit shift register.

At this stage design becomes a matter for the expert but fortunately ICs are available with the whole counter and BCD unit constructed ready to act as one decade. To obtain multiple-position decade numbers we merely cascade decade counter ICs in accordance with manufacturers' data sheets. Figure 10 shows how four JK flip-flops can be connected to provide NBCD counting. Note the need for an additional NAND gate and inverter. Comparing costs, it would usually be illogical to build a counter this way for the cost of ICs to build such a system is higher than that for a ready-made decade stage such as that shown in Figure 11.

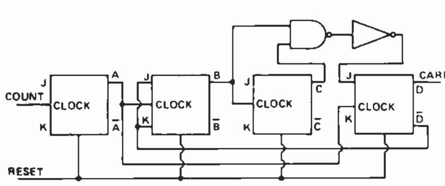


Fig. 10. Four JK flip-flops connected to count as a normal binary coded decimal stage.

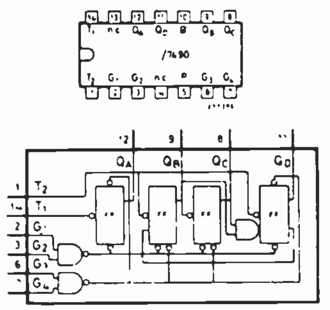


Fig. 11. Ready-made IC decade counter (SN 7490)

Many applications require visual display with each decade: it is now possible to purchase an IC with count and decode functions combined in the one chip.

The question of synchronous versus asynchronous counting in decimal stages still applies. As there are, however, only four stages in each decade, the ripple-through time is not usually as vital an issue as with binary counting. However, this time must be compounded with the ripple-through time for all decades – 12 or more are common on calculators. The fastest decade system is one where all decades are synchronised, not just individual stage flip-flops. The practical catch is, however, that synchronous designs require many extra connections as the number of stages increases.

Reversible decade counters are built in a similar fashion to the binary types – using A or $\bar{A}$ etc., as needed. The problem is complicated by the need to lose states but once again few people would be called upon to design one from scratch as single –IC systems are marketed ready-made. Figure 12 shows the schematic of a reversible synchronous NBCD counter.

USING COUNTERS IN PRACTICAL CIRCUITS

Application Notes explain the connections and any special conditions to be observed in using IC counters. The electronic designer today regards the appropriate IC as a black-box with pins which are wired accordingly – what is inside is of little consequence. Figure 13a shows how an IC counter is represented in a circuit diagram and Figure 13b shows how it is wired onto a printed-circuit board. The internal complexity is seen in the circuit schematic given in Figure 14.

OTHER COUNTERS

The register becomes a counter by joining the output to the input to form a ring-counter. This system passes a pattern around the loop one step at a time for each input pulse. Hence the logical state of the elements at any time represents the number of counts accepted. This is also a convenient way to recirculate a digital word which needs constant re-use. A faster version is the twisted ring-counter.

Counters are also used frequently as frequency dividers. For example, a 1 MHz clock source passed through one BCD decade provides a source at 100 kHz; through two decade counters

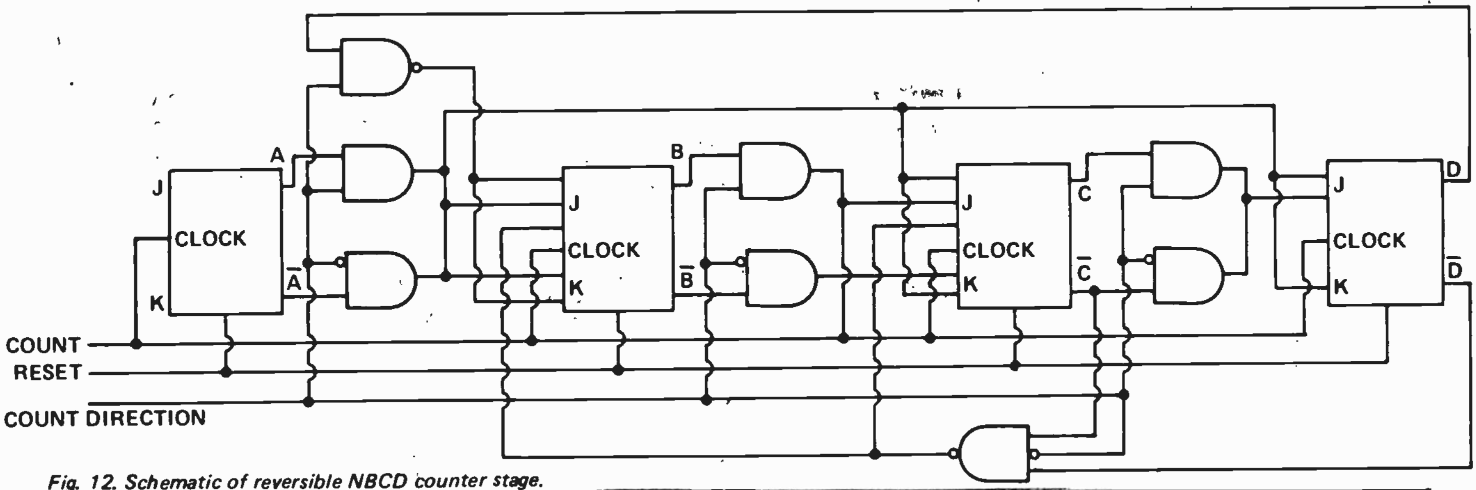
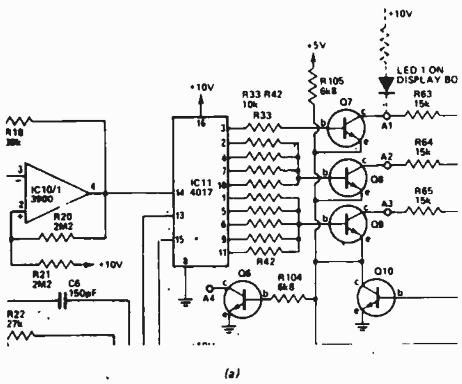
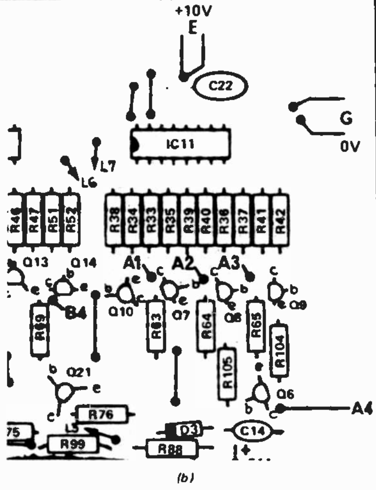


Fig. 12. Schematic of reversible NBCD counter stage.

Fig. 13. In use IC counters are used as black boxes. (a) How it appears in a circuit schematic. (b) How it appears on a circuit board.





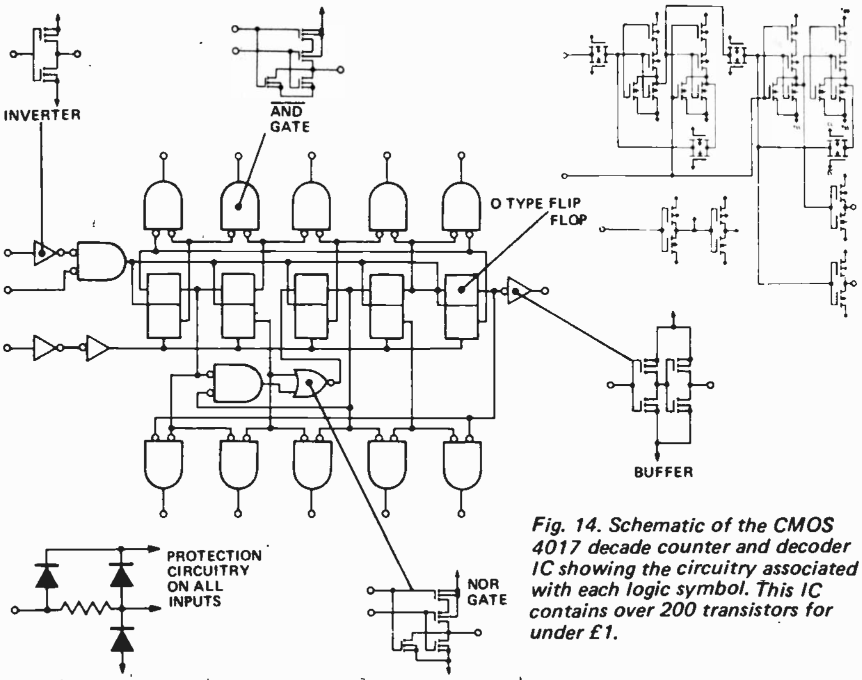


Fig. 14. Schematic of the CMOS 4017 decade counter and decoder IC showing the circuitry associated with each logic symbol. This IC contains over 200 transistors for under £1.

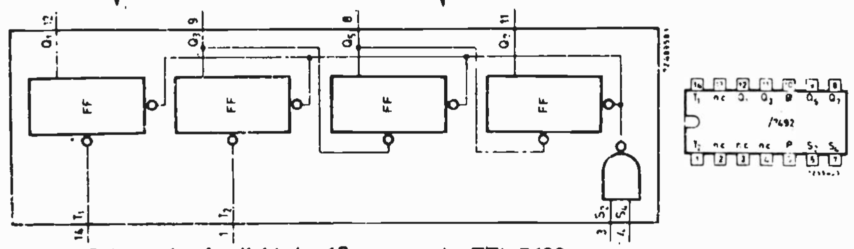


Fig. 15. Schematic of a divide by 12 counter the TTL 7492.

10 kHz and so on. As it is more convenient to provide stable high frequencies than stable low frequencies, precise low-frequency pulse trains are best produced by this subdivision process.

As four flip-flops will provide up to 16 states they can also divide by 12 by the use of stage interconnections. Figure 15 is the schematic of a divide by 12 counter. These are used in timing systems to provide two seconds, minutes and hours units. A divide by five plus divide by two is also available in the same IC.

Just eight years ago my technician and I built one of the fastest up-down decade counters reported at the time. It used discrete components, it took several months to build, could reverse at about 400 kHz, cost about £180 in components alone, needed a shoe-box size container and a hefty power supply. Today a match-box size unit, including a battery, virtually indestructible in normal use, can be reversible at (at least) 10 MHz rates and is available 'off the shelf'. It costs a mere few dollars and is vastly more reliable. We have reached the point where the mechanicals — the knobs, dials, case and boards cost more than the electronics circuitry. At the time of writing £50 buys a 100 step programmable pocket-size calculator. We are truly in a systems, rather than components, age of electronic capability.

FURTHER READING:

An excellent inexpensive book worth purchasing is: "Digital Instruments Course — Part 1, Basic Binary Theory and Logic Circuits" — A.J. Bouwens, N.V. Philips Gloeilampenfabrieken, Eindhoven, Netherlands, 1974. (Available from Philips offices).

This gives a little more depth than this course can allocate and is recommended for those people who are involved with building digital systems routinely. ●

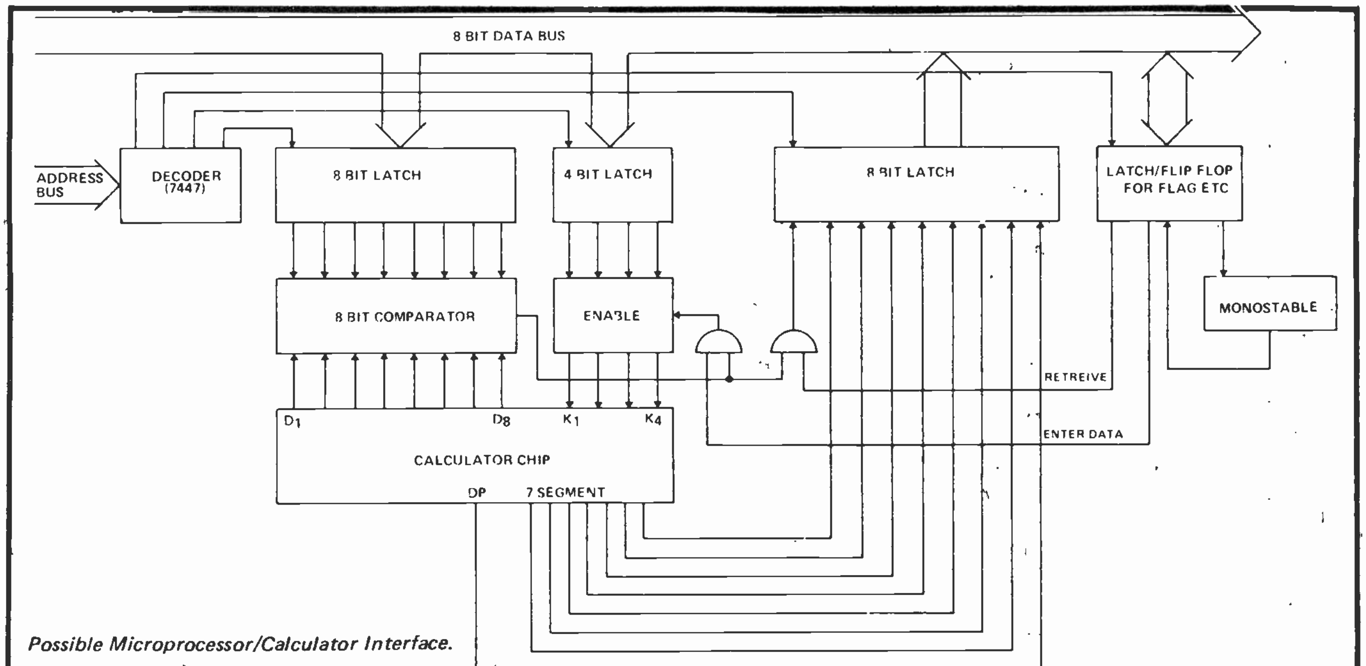
ELECTRONICS TOMORROW

by John Miller-Kirkpatrick

CALCULATORS and calculator chips are idiot devices, in most cases even programmable calculators are by themselves. What I mean by this is that a calculator needs a human to drive it as it cannot make decisions, thus even a very simple calculation which requires a comparison with a previous result or a constant needs a human to do that comparison — there are no true calculators with an 'IF' key. Most of the calculators which do have comparison features are not true calculators, they are more a microprocessor, but a straight microprocessor chip does not usually have the fast and efficient mathematical facilities of a calculator built into it. Most calculators with these complex functions use a ROM look-up system in order to retrieve the correct answer, and once programmed these ROMs offer a faster way than calculation. Each chip, therefore, has its limitations until you introduce them to each other, when you find that each can do what the other cannot. In such a system the MPU must be the boss chip as it can control the calculator chip by an internal program designed to do just that. Let us examine the case of a MPU requiring complex calculations in its program, instead of performing an instruction such as LOG X,A (find the log of A and put the result into X) it will put A into a predefined RAM area, set aside a similar area for X and JUMP to FINDLOG. The subroutine FINDLOG will do any necessary tests on A to check that it is within the valid ranges and that it will not overload the capabilities of the calculator nor cause an overflow in the result field X. It will now take the first digit of A, convert it to the necessary output coding and output it to the calculator interface. If a flag is set to indicate that the MPU is now waiting for the calculator then the MPU can do other work until the calculator interface resets this flag.

CALCULATOR INTERFACE

Most of today's calculator chips work on the basis that a key closure connects one of the digit drive lines to one of three or more K inputs, logic inside the chip decodes which digit line is high at the time of receiving a K signal and uses this to decide which function key was pressed. In this way an eight digit machine with up to 32 keys needs only 12 lines connected to the keyboard, 8 digit drives and 4 K lines. Our MPU has set up 12 bits of latched data for the calculator, only two of these 12 bits will be in the logic '1' state, all others being in logic '0' status. The 12 bits are split up into an eight bit digit address and a four bit K address, the former is compared to the digit strobes and when the correct digit drive line goes high a set of 7486 gates (one per digit line) will all go to logic '1' to indicate that the calculator is now in the status required by the MPU. These eight '1's are ANDed to give an enable pulse to the gating to the K lines, until this time all of the K lines have been receiving logic '0's from the interface but now one (and only one) K line will be gated high by the enable pulse. This means that the K input has received a logic '1' pulse at a particular digit time which is in effect the same signal that it would have obtained from a keyboard. This whole system is kept going by a monostable for a short time (defined by the timing requirements of the calculator) to confirm the entry. After the time-out of the monostable the flag to the MPU is reset to indicate that the calculator is now ready for the next entry. On checking this flag and finding it reset the MPU now moves the second digit of A into the interface and sets the flag. When all of the digits of A have been entered



Possible Microprocessor/Calculator Interface.

the MPU puts the code for the LOG key depression into the interface and waits for the flag to be reset.

GETTING AT THE RESULT

After the last 'key entry' flag has been reset the MPU may need to issue a wait command to enable the calculator to work out the result. This wait time would differ with different calculators and with different calculations and so each software subroutine may issue different wait time commands. Eventually the MPU can safely assume that the calculator display now contains the correct answer and can start to read it back into the MPU. This is done in a similar manner to that of outputting a number except that the MPU will start from digit 1 (MSD) and when the 7486's comparison is true will latch the eight sement lines (7 seg plus DP) and reset the flag. The MPU can now access the data in the latch, convert it internally or externally into a digit, and store it in RAM. When all of the digits have been read in the result is in byte decimal form in RAM, the MPU now converts that number from decimal to Hexadecimal or Octal whichever it uses for internal calculations, put the result into aréa X and indicate the main routine that FINDLOG has completed its job.

This may sound like a complicated way to a result when using anything as powerful as a MPU but it is cheaper and easier than programming the MPU to do the same job, and is also faster as the MPU can do other work whilst waiting for the calculator.

SORRY, I'VE GOT THIS PROGRAM IN ME EAROM!

Although I have solved a problem in the above paragraphs there are those problems that have to be solved by putting a program into storage for the MPU to operate on. Storage comes in RAM, ROM, PROM, EPROM and now in EAROM, RAM is lost if you remove the power supply, ROM is preprogrammed by the manufacturer, PROM you can program yourself — but don't make a mistake, EPROM or EAROM are reprogrammable — so you can make a mistake. The difference is that EPROMs require a dangerous short-wave UV lamp to clear the memory before reprogramming and this clears all of the memory which could mean reprogramming 8096 bits just because one of them is wrong. EAROMs are Electrically Alterable ROMs, that is they can be reprogrammed by a voltage rather than a UV lamp. Data is written into the device by tunnelling a charge into the oxide-fitride interface at the gate insulator of MNOS memory transistors. This is accomplished by applying a —24v 10mS row input pulse, data is erased by applying a +30v 100mS pulse to the row inputs.

The resulting charge after programming is trapped in the gate insulator and causes a change in the threshold voltage of the memory transistors which is sensed by the subsequent readout. Apart from the obviously easier method of erasing offered by EAROMs only one row of data is erased at a time rather than the whole memory, this means that if one word of data is incorrect then only 32 words are erased and reprogrammed instead of 1024 words.

EAROMs are made by General Instruments and are available from *Semiconductor Specialists, Premier House, Fairfield Road, Yiewsley, Middx. Phone West Drayton 46415.* Two version are available at present, the ER-1105 offers 256 x 4 bits and the ER-2401 gives 1024 x 4 bits, both are in 24 pin packages with chip select inputs and tri-state outputs. Prices for EAROMs in one-offs are £13.10 for the ER-1105 and £16.55 for the ER-2401, apparently ex-stock. ●

news digest

Continued from page 8.

ETCHING IN A BAG

Decon Laboratories have designed their new Seno GS PCB etching system specifically to solve the safety and convenience problems involved in etching one-off or small numbers of PCBs.

The problems of obtaining potent etchants such as ferric chloride and making up solutions are well known to hobbyists. The kit offers an ingenious sealed system where the user never comes into contact with the acid, but can maintain visual checks on the etching.

The whole process takes place in a heavy-duty polythene bag with re-moveable water-tight seals that enclose the etchant (separate from the pre-pared copper board). The seal is released, commencing etching, and the system agitated manually to pro-mote speedy action. The whole unit can be warmed under a hot tap to further the process. When etching is complete, the acid is re-sealed, the board rinsed and removed ready for drying.

When the solution is exhausted, a bag of neutralising powder, supplied with the kit, is mixed in. This produces a harmless semi-hard com-pound suitable for disposal straight into the dustbin.

The etching system is available at a post and VAT inclusive price of £4.00 per unit or £3.45 per unit in lots of six. Detailed data sheets are free of charge from Decon Laboratories Ltd., Ellen Street, Portslade, Brighton, Sussex, BN4 1EQ.

DORAM INTRODUCE NEW RANGE OF KITS

Doram, the RS Components subsid-iary formed just under two years ago for the amateur enthusiast have announced a new range of simple kits.

Included in the range are a 'Car Flasher Unit': £6.25, 'IC Signal Injector': £2.20, 'Lights-on Alarm': £2.65. 'Darkroom Exposure Meter': £4.75, 'Cassette Power Supply': £3.20, 'Soil Moisture Meter': £2.00. All prices are plus VAT.

Doram Electronics Ltd., P. O. Box Tr8, Wellington Road Industrial Estate, Wellington Bridge, Leeds LS12 2UF.

IRISH DEVELOP 'INTELLIGENT REPORTER' BASED ON MINICOMPUTER

Medical and Scientific Computer Services Ltd. (MSCS) have recently developed a minicomputer-based medical laboratory equipment that is proving its worth in biochemistry, haematology and pathology laborat-ories in several leading hospitals in the UK and other EEC countries.

The equipment, called 'Intelligent Reporter', is a refinement of the company's previous 'Reporter 7' machine, which was developed in consultation with the UK's Depart-ment of Health and Social Security (DHSS) for use with the Coulter S blood analyser in haematology lab-oratories. This automatically provides clinicians with a digital display and print out of test results (at over 1000 tests per hour on high speed together with patient identification; it thus streamlines procedures and reduces considerably the possibility of transcription errors that can occur with manual methods.

CAI Ltd., Naked Mini Division.

The Proprietors of British Patent No. 1304662, for "Electrical equipment for the automatic control of a Threading Machine" desire to negotiate for the sale or licensing of the patent. Particulars from Marks & Clerk, 57-60 Lincoln's Inn Fields, London, WC2A 3LS.

Greenbank Electronics

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Data and suggested circuits for AY-5-1224 and MK 50253 clock chips, details of PCB's and component kits for AY-5-1224, data sheets for LED 0.3" and 0.6" displays.

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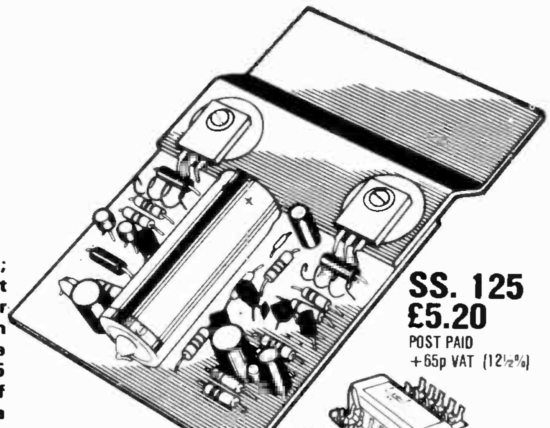

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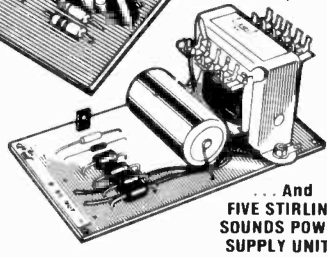

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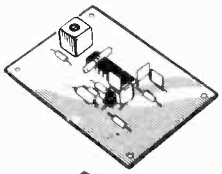

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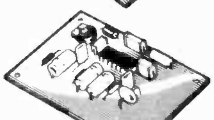

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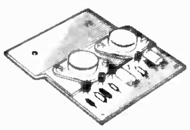

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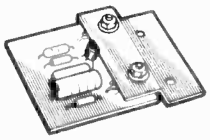

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