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SEPTEMBER 1974

25p

IMAGE INTENSIFIERS: THE ELECTRONIC OWL

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Underwater Electronics

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DOUBLE READER OFFER INSIDE!!

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Cover: Image intensifiers are used with the Isaac Newton Reflector at the Royal Greenwich Observatory, Herstmonceux, Sussex for recording distant stars and galaxies. Photo courtesy of EMI.

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AC107	0·22	ADT140	0·55	BC153	0·31	BD136	0·44	BF188	0·44	MPF105	0·41	2G371B	0·13	2N2222	0·22	2N3392	0·16	2N4061	0·13
AC113	0·20	AF114	0·27	BC154	0·33	BD137	0·50	BF194	0·13	OC19	0·39	2G373	0·19	2N2368	0·19	2N3393	0·16	2N4062	0·13
AC115	0·22	AF115	0·27	BC157	0·20	BD138	0·55	BF195	0·13	OC20	0·70	2G374	0·19	2N2369	0·16	2N3394	0·16	2N4284	0·19
AC117K	0·32	AF116	0·27	BC158	0·13	BD139	0·61	BF196	0·16	OC22	0·52	2G377	0·33	2N2369A	0·16	2N3395	0·19	2N4285	0·19
AC122	0·13	AF117	0·27	BC159	0·13	BD140	0·66	BF197	0·16	OC23	0·54	2G378	0·18	2N2411	0·27	2N3402	0·23	2N4286	0·19
AC125	0·19	AF118	0·39	BC160	0·50	BD155	0·88	BF200	0·50	OC24	0·62	2G381	0·18	2N2412	0·27	2N3403	0·23	2N4287	0·19
AC126	0·19	AF124	0·33	BC161	0·55	BD175	0·66	BF222	£1·05	OC25	0·42	2G382	0·18	2N2646	0·52	2N3404	0·31	2N4288	0·19
AC127	0·20	AF125	0·33	BC167	0·13	BD176	0·66	BF257	0·50	OC26	0·32	2G401	0·33	2N2711	0·23	2N3405	0·46	2N4289	0·19
AC128	0·20	AF126	0·31	BC168	0·13	BD177	0·72	BF258	0·66	OC28	0·55	2G414	0·33	2N2712	0·23	2N3414	0·17	2N4290	0·19
AC132	0·16	AF127	0·31	BC169	0·13	BD178	0·72	BF259	0·94	OC29	0·55	2G417	0·28	2N2714	0·23	2N3415	0·17	2N4291	0·19
AC134	0·16	AF139	0·33	BC170	0·13	BD179	0·77	BF262	0·61	OC35	0·46	2N388	0·39	2N2904	0·19	2N3416	0·31	2N4292	0·19
AC137	0·16	AF178	0·55	BC171	0·16	BD180	0·77	BF263	0·61	OC36	0·55	2N388A	0·61	2N2904A	0·23	2N3417	0·31	2N4293	0·19
AC141	0·20	AF179	0·55	BC172	0·16	BD185	0·72	BF270	0·39	OC41	0·22	2N404	0·22	2N2905	0·23	2N3525	0·83	2N5172	0·13
AC141K	0·32	AF180	0·55	BC173	0·16	BD186	0·72	BF271	0·33	OC42	0·27	2N404A	0·31	2N2905A	0·23	2N3614	0·74	2N5294	0·60
AC142	0·20	AF181	0·55	BC174	0·16	BD187	0·77	BF272	0·88	OC44	0·17	2N524	0·46	2N2906	0·17	2N3615	0·82	2N5457	0·35
AC142K	0·28	AF186	0·55	BC175	0·24	BD188	0·77	BF273	0·39	OC45	0·14	2N527	0·54	2N2906A	0·20	2N3616	0·87	2N5458	0·35
AC151	0·17	AF239	0·41	BC177	0·21	BD189	0·83	BF274	0·39	OC70	0·11	2N598	0·46	2N2907	0·22	2N3646	0·1	2N5459	0·44
AC154	0·22	AL102	0·72	BC178	0·21	BD190	0·83	BFW10	0·66	OC71	0·11	2N599	0·50	2N2907A	0·24	2N3702	0·13	2N6121	0·75
AC155	0·22	AL103	0·72	BC179	0·21	BD195	0·94	BFX29	0·30	OC72	0·16	2N696	0·14	2N2923	0·16	2N3703	0·13	2S301	0·55
AC156	0·22	ASY26	0·28	BC180	0·27	BD196	0·94	BFX84	0·24	OC74	0·16	2N697	0·15	2N2924	0·16	2N3704	0·14	2S302A	0·46
AC157	0·27	ASY27	0·33	BC181	0·27	BD197	0·99	BFX85	0·33	OC75	0·17	2N698	0·27	2N2925	0·16	2N3705	0·13	2S302	0·46
AC165	0·22	ASY28	0·28	BC182	0·11	BD198	0·99	BFX86	0·24	OC76	0·17	2N699	0·39	2N2926(G)	0·14	2N3706	0·13	2S303	0·61
AC166	0·22	ASY29	0·28	BC182L	0·11	BD199	£1·05	BFX87	0·27	OC77	0·28	2N706	0·09	2N2926(Y)	0·12	2N3707	0·14	2S304	0·77
AC167	0·22	ASY50	0·28	BC183	0·11	BD200	£1·05	BFX88	0·24	OC81	0·17	2N706A	0·10	2N2926(O)	0·11	2N3708	0·09	2S305	0·86
AC168	0·27	ASY51	0·28	BC183L	0·11	BD205	0·88	BFY50	0·22	OC81D	0·17	2N708	0·13	2N2926(R)	0·11	2N3709	0·10	2S306	0·86
AC169	0·16	ASY52	0·28	BC184	0·13	BD206	0·88	BFY51	0·22	OC82	0·17	2N711	0·33	2N2926(B)	0·11	2N3710	0·10	2S307	0·86
AC176	0·22	ASY54	0·28	BC184L	0·13	BD207	£1·05	BFY52	0·22	OC82D	0·17	2N717	0·39	2N3010	0·77	2N3711	0·10	2S321	0·62
AC177	0·27	ASY55	0·28	BC186	0·31	BD208	£1·05	BFY53	0·19	OC83	0·22	2N718	0·27	2N3011	0·16	2N3819	0·31	2S322	0·46
AC178	0·31	ASY56	0·28	BC187	0·31	BDY20	£1·10	BPX25	0·94	OC139	0·22	2N718A	0·55	2N3053	0·19	2N3820	0·55	2S322A	0·46
AC179	0·31	ASY57	0·28	BC207	0·12	BF115	0·27	BSX19	0·17	OC140	0·22	2N726	[illegible]	2N3054	0·51	2N3821	0·39	2S323	0·62
AC180	0·22	ASY58	0·28	BC208	0·12	BF117	0·50	BSX20	0·17	OC169	0·28	2N727	0·31	2N3055	0·55	2N3823	0·31	2S324	0·77
AC180K	0·32	ASY73	0·28	BC209	0·13	BF118	0·77	BSY25	0·17	OC170	0·28	2N743	0·22	2N3391	0·16	2N3903	0·31	2S325	0·77
AC181	0·22	ASZ21	0·44	BC212L	0·12	BF119	0·77	BSY26	0·17	OC171	0·28	2N744	0·22	2N3391A	0·18	2N3904	0·33	2S326	0·77
AC181K	0·32	BC107	0·12	BC213L	0·12	BF121	0·50	BSY27	0·17	OC200	0·28	2N914	0·16			2N3905	0·31	2S327	0·77
AC187	0·24	BC108	0·12	BC214L	0·16	BF123	0·55	BSY28	0·17	OC201	0·31	2N918	0·33			2N3906	0·30	2S701	0·46
AC187K	0·25	BC109	0·13	BC225	0·28	BF125	0·50	BSY29	0·17	OC202	0·31	2N929	0·23			2N4058	0·13	40361	0·44
AC188	0·24	BC113	0·11	BC226	0·39	BF127	0·55	BSY38	0·20	OC203	0·28	2N930	0·23			2N4059	0·11	40362	0·50
AC188K	0·25	BC114	0·17	BC301	0·30	BF152	0·61	BSY39	0·20	OC204	0·28	2N1131	0·22			2N4060	0·13		
ACY17	0·28	BC115	0·17	BC302	0·27	BF153	0·50	BSY40	0·31	OC205	0·39	2N1132	0·24						
ACY18	0·22	BC116	0·17	BC303	0·35	BF154	0·50	BSY41	0·31	OC309	0·44	2N1302	0·16						
ACY19	0·22	BC117	0·20	BC304	0·40	BF155	0·77	BSY95	0·14	OCP71	0·48	2N1303	0·16						
ACY20	0·22	BC118	0·11	BC440	0·34	BF156	0·53	BSY95A	0·14	ORP12	0·48	2N1304	0·19						
ACY21	0·22	BC119	0·33	BC460	0·40	BF157	0·61	Bu105	£2·20	P20	0·55	2N1305	0·19						
ACY22	0·18	BC120	0·88	BCY30	0·27	BF158	0·61	C111E	0·55	P21	0·50	2N1306	0·23						
ACY27	0·20	BC125	0·13	BCY31	0·29	BF159	0·66	C400	0·33	P346A	0·22	2N1307	0·23						
ACY28	0·21	BC126	0·20	BCY32	0·33	BF160	0·44	C407	0·28	P397	0·46	2N1308	0·26						
ACY29	0·39	BC132	0·13	BCY33	0·24	BF162	0·44	C424	0·28	ST140	0·14	2N1309	0·26						
ACY30	0·31	BC134	0·20	BCY34	0·28	BF163	0·44	C425	0·55	ST141	0·19	2N1613	0·22						
ACY31	0·31	BC135	0·13	BCY70	0·16	BF164	0·44	C426	0·39	TIS43	0·33	2N1711	0·22						
ACY34	0·23	BC136	0·17	BCY71	0·22	BF165	0·44	C428	0·22	UT46	0·30	2N1889	0·35						
ACY35	0·23	BC137	0·17	BCY72	0·16	BF167	0·24	C441	0·33	ZN414	£1·20	2N1890	0·50						
ACY36	0·31	BC139	0·44	BCZ10	0·22	BF173	0·24	C442	0·33	2G301	0·21	2N1893	0·41						
ACY40	0·19	BC140	0·33	BCZ11	0·28	BF176	0·39	C444	0·39	2G302	0·21	2N2147	0·79						
ACY41	0·20	BC141	0·33	BCZ12	0·28	BF177	0·39	C450	0·24	2G303	0·21	2N2148	0·63						
ACY44	0·39	BC142	0·33	BD115	0·68	BF178	0·33	MAT100	0·21	2G304	0·27	2N2160	0·66						
AD130	0·42	BC143	0·33	BD116	0·88	BF179	0·33	MAT101	0·22	2G306	0·44	2N2192	0·39						
AD140	0·53	BC145	0·50	BD121	0·66	BF180	0·33	MAT120	0·21	2G308	0·39	2N2193	0·39						
AD142	0·53	BC147	0·11	BD123	0·72	BF181	0·33	MAT121	0·22	2G309	0·39	2N2194	0·39						
AD143	0·42	BC148	0·11	BD124	0·76	BF182	0·44	MJE2955	0·95	2G339	0·22	2N2217	0·24						
AD149	0·55	BC149	0·13	BD131	0·55	BF183	0·44	MJE3055	0·62	2G339A	0·18	2N2218	0·22						
AD161 & AD162 (MP)	0·75	BC150	0·20	BD132	0·66	BF184	0·28	MJE3440	0·55	2G344	0·20	2N2219	0·22						
		BC151	0·22	BD133	0·72	BF185	0·33	MPF102	0·46	2G345	0·18	2N2220	0·24						
		BC152	0·19	BD135	0·44	BF187	0·30	MPF104	0·41	2G371	0·18	2N2221	0·22						

DIODES AND RECTIFIERS

AA119	0·09	BY130	0·18	OA5	0·23
AA120	0·09	BY133	0·23	OA10	0·15
AA129	0·09	BY164	0·55	OA47	0·08
AAY30	0·10	BYX38/30	0·46	OA70	0·08
AAZ13	0·11			OA79	0·08
BA100	0·11	BYZ10	0·39	OA81	0·08
BA116	0·23	BYZ11	0·33	OA85	0·10
BA126	0·24	BYZ12	0·33	OA90	0·07
BA148	0·16	BYZ13	0·28	OA91	0·07
BA154	0·13	BYZ16	0·44	OA95	0·08
BA155	0·16			OA200	0·07
BA156	0·15	BYZ12	0·39	OA202	0·08
BA173	0·16	BYZ18	0·39	SD10	0·06
BY100	0·17	BYZ19	0·31	SO19	0·06
BY101	0·13	CG62		1N34	0·08
BY105	0·19	(OA91Eq)		1N34A	0·08
BY114	0·13		0·06	1N914	0·06
BY124	0·13	CG651-		1N916	0·06
BY126	0·16	(OA70-OA79)		1N414B	0·06
BY127	0·17		0·07	1S021	0·11
BY128	0·17	OA5	0·39	1S951	0·07

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U 4	40	Germanium Transistors like OC81, AC128	0·55
U 5	60	200mA Sub-Min. Silicon Diodes	0·55
U 6	30	Sil. Planar Trans. NPN like BSY95A. 2N706	0·55
U 7	16	Sil. Rectifiers TOP-HAT 750mA VLTG. RANGE up to 1000	0·55
U 8	50	Sil. Planar Diodes DO-7 Glass 250mA like OA200/202	0·55
U 9	20	Mixed Voltages, 1 Watt Zener Diodes	0·55
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U18	8	6 Amp Silicon Rectifiers BYZ13 Type up to 600 PIV	0·55
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U24	20	Germanium 1 Amp Rectifiers GJM Series up to 300 PIV	0·55
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U26	30	Fast Switching Silicon Diodes like 1N914 Micro-Min.	0·55
U27	12	NPN Germanium AF Transistors TO-1 like AC127	0·55
U29	10	1 Amp SCR's TO-5 can. up to 600 PIV CRS1/25-600	1.10
U30	15	Plastic Silicon Planar Trans. NPN 2N2926	0·55
U31	20	Silicon Planar Plastic NPN Trans. Low Noise Amp 2N3707	0·55
U32	25	Zener Diodes 400mW DO-7 case 3-18 volts mixed	0·55
U33	15	Plastic Case 1 Amp Silicon Rectifiers IN4000 Series	0·55
U34	30	Silicon PNP Alloy Trans. TO-5 BCY26 2S302/4	0·55
U35	25	Silicon Planar Transistors PNP TO-18 2N2906	0·55
U36	25	Silicon Planar NPN Transistors TO-5 BFY50/51/52	0·55
U37	30	Silicon Alloy Transistors SO-2 PNP OC200, 2S322	0·55
U38	20	Fast Switching Silicon Trans. NPN MHz 2N3011	0·55
U39	30	RF. Germ. PNP Transistors 2N1303/5 TO-5	0·55
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U44	20	Sil. Trans. Plastic TO-5 BC115/NPN	0·55
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Code No's. mentioned above are given as a guide to the type of device in the pak. The devices themselves are normally unmarked.

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Q5	4	OC 75 transistors	0·55
Q6	5	OC72 transistors	0·55
Q7	4	AC 128 transistors PNP high gain	0·55
Q8	4	AC 126 transistors PNP	0·55
Q9	7	OC 81 type transistors	0·55
Q10	7	OC 71 type transistors	0·55
Q11	2	AC127/128 Complementary pairs PNP/NPN	0·55
Q12	3	AF 116 type transistors	0·55
Q13	3	AF 117 type transistors	0·55
Q14	3	OC 171 H.F. type transistors	0·55
Q15	7	2N2926 Sil. Epoxy transistors mixed colours	0·55
Q16	2	GET880 low noise Germanium transistors	0·55
Q17	5	NPN 2 x ST.141. & 3 x ST.140	0·55
Q18	4	MADT'S 2 x MAT 100 & 2 x MAT 120	0·55
Q19	3	MADT'S 2 x MAT 101 & 1 x MAT 121	0·55
Q20	4	OC 44 Germanium transistors A.F.	0·55
Q21	4	AC127 NPN Germanium transistors	0·55
Q22	20	NKT transistors A.F. R.F. coded	0·55
Q23	10	OA 202 Silicon diodes sub-min	
Q24	8	OA 81 diodes	0·55
Q25	15	1N914 Silicon diodes 75PIV 75mA	0·55
Q26	8	OA95 Germanium diodes sub min 1N69	0·55
Q27	2	10A 600 PIV Silicon rectifiers 1S425R	0·55
Q28	2	Silicon power rectifiers BYZ 13	0·55
Q29	4	Sil. transistors 2 x 2N696, 1 x 2N697, 1 x 2N698	0·55
Q30	7	Silicon switch transistors 2N706 NPN	0·55
Q31	6	Silicon switch transistors 2N708 NPN	0·55
Q32	3	PNP Sil. trans. 2 x 2N1131, 1 x 2N1132	0·55
Q33	3	Silicon NPN transistors 2N1711	0·55
Q34	7	Sil. NPN trans. 2N2369, 500MHz (code P397)	0·55
Q35	3	Silicon PNP TO-5 2 x 2N2904 & 1 x 2N2905	0·55
Q36	7	2N3646 TO-18 plastic 300 MHz NPN	0·55
Q37	3	2N3053 NPN Silicon transistors	0·55
Q38	7	PNP transistors 4 x 2N3703, 3 x 2N3702	0·55
Q39	7	PNP transistors 4 x 2N3704, 3 x 2N3705	0·55
Q40	7	NPN transistors 4 x 2N3707, 3 x 2N3708	0·55
Q41	3	Plastic NPN TO-18 2N3904	0·55
Q42	6	NPN transistors 2N5172	0·55
Q43	7	BC 107 NPN transistors	0·55
Q44	7	NPN transistors 4 x BC 108, 3 x BC 109	0·55
Q45	3	BC 113 NPN TO-18 transistors	0·55
Q46	3	BC 115 NPN TO-5 transistors	0·55
Q47	6	NPN high gain transistors 3 x BC167, 3 x BC168	0·55
Q48	4	BCY 70 PNP transistors TO-18	0·55
Q49	4	NPN transistors 2 x BFY51, 2 x BFY52	0·55
Q50	7	BSY 28 NPN switch transistors TO-18	0·55
Q51	7	BSY 95A NPN transistors 300MHz	0·55
Q52	8	BY100 type silicon rectifiers	£1·10
Q53	25	Sil & Germ. trans. mixed all marked new	£1·65

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NEW LOW PRICE TESTED S.C.R.'s

PIV	1Amp TO5	3Amp TO66	5Amp TO66	5Amp TO64	7Amp TO48	10Amp TO48	16Amp TO48	30Amp TO48
50	0·22	0·27	0·39	0·39	0·52	0·55	0·58	£1·27
100	0·27	0·27	0·52	0·52	0·55	0·63	0·62	£1·54
200	0·27	0·32	0·54	0·54	0·62	0·67	0·67	£1·76
400	0·32	0·42	0·59	0·62	0·67	0·83	0·77	£1·93
600	0·42	0·52	0·75	0·75	0·84	£1·07	0·97	–
800	0·63	0·70	0·88	0·88	0·99	£1·32	£1·50	£4·40

SIL. RECTS. TESTED

PIV	300mA (DO7)	750mA (SO 16)	1Amp Plastic		1/5Amp (SO 16)	3Amp (SO 10)	10Amp (SO 10)	30Amp (TO 48)
50	0·05	0·06			0·08	0·15	0·21	0·60
100	0·05	0·07	1N4001	0·05	0·10	0·17	0·23	0·75
200	0·06	0·10	1N4002	0·06	0·12	0·22	0·25	£1·00
400	0·08	0·15	1N4003	0·07	0·15	0·30	0·38	£1·35
600	0·09	0·17	1N4004	0·08	0·18	0·36	0·45	£1·90
800	0·12	0·19	1N4005	0·10	0·20	0·38	0·55	£2·10
1000	0·14	0·30	1N4006	0·11	0·25	0·48	0·65	£2·50
1200	–	0·35	1N4007	0·12	0·30	0·58	0·75	£3·00

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GENERAL PURPOSE GERM. PNP

Coded GP100. BRAND NEW TO-3. CASE. POSSIBLE REPLACE:—OC25-26-29-30-35-36. NKT 401-403-404-405-406-430-451-452-453. T13027-3028, 2N250A 2N456A-457A-458A. 2N511 A & B. 2G220-222, ETC. VCBO 80V VCEO 50V IC 10A PT. 30 WATTS Hfe 30-170.

PRICE	1·24	25·99	100 up
	48p each	44p each	40p each

SILICON High Voltage 250V NPN
TO-3 case. G.P. Switching & Amplifier Applications. Brand new Coded R 2400 VCBO 250/VCEO 100/IC 6A/30 Watts. HFE type 20/fT 5MHZ.
OUR PRICE EACH:

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2N3055

115 WATT SIL POWER NPN 55p EACH.

SILICON 50 WATTS MATCHED NPN/PNP
BIP 19 NPN TO-3 Plastic. BIP 20 PNP. Brand new. VCBO 100/VCEO 50/IC 10A. HFE type 100/ft 3mHZ.
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75p PER PAIR

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Price each	49p	44p	38p

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2N3823	31p	MPF105	41p

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Plastic Encapsulated 2 Amp. BRIDGE RECTS.

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300mW	30	0·55
40PIV(Min.)	100	1·65
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VBOM	2A	6A	10A
	TO-5	TO-66	TO-48
	8p	8p	8p
100	33	55	83
200	55	66	99
400	77	83	1·21

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FOR USE WITH TRIACS
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Coded and guaranteed

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T3	8	D1216	OC81D
T4	8	2G381T	OC81
T5	8	2G382T	OC82
T6	8	2G344B	OC44
T7	8	2G345B	OC45
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T9	8	2G399A	2N1302
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All 55p each pak.

2N2060 NPN SIL. DUAL TRANS. CODE D1699 TEXAS. Our price 28p each.

120 VCB NIXIE DRIVER TRANSISTOR. Sim. BSX21 & C407, 2N1893 FULLY TESTED AND CODED ND 120. 1-24 19p each. TO.5 NPN 25 up 17p each.

Sil. trans. suitable for P.E. Organ. Metal TO-18 Eqvt. ZTX300 8p each. Any Qty.

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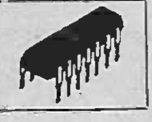

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	1	25	100+		1	25	100+		1	25	100+
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7402	0·18	0·17	0·16	7451	0·18	0·17	0·16	74141	0·85	0·82	0·79
7403	0·18	0·17	0·16	7453	0·18	0·17	0·16	74145	£1·65	£1·55	£1·45
7404	0·18	0·17	0·16	7454	0·18	0·17	0·16	74150	£2·90	£2·80	£2·70
7405	0·18	0·17	0·16	7460	0·18	0·17	0·16	74151	£1·10	£1·05	£1·00
7406	0·39	0·34	0·31	7470	0·32	0·29	0·27	74153	£1·30	£1·20	£1·10
7407	0·39	0·34	0·31	7472	0·32	0·29	0·27	74154	£1·98	£1·90	£1·75
7408	0·20	0·19	0·18	7473	0·41	0·39	0·35	74155	£1·50	£1·45	£1·35
7409	0·20	0·19	0·18	7474	0·41	0·39	0·35	74156	£1·50	£1·45	£1·35
7410	0·18	0·17	0·16	7475	0·50	0·48	0·46	74157	£2·00	£1·90	£1·80
7411	0·28	0·27	0·26	7476	0·44	0·43	0·42	74160	£2·10	£2·00	£1·90
7412	0·39	0·34	0·31	7480	0·74	0·71	0·64	74161	£2·10	£2·00	£1·90
7413	0·32	0·31	0·30	7481	£1·30	£1·25	£1·20	74162	£4·40	£4·15	£3·85
7416	0·48	0·44	0·42	7482	0·96	0·95	0·94	74163	£4·40	£4·15	£3·85
7417	0·48	0·44	0·42	7483	£1·20	£1·15	£1·05	74164	£2·20	£2·10	£2·00
7420	0·18	0·17	0·16	7484	£1·10	£1·05	£1·00	74165	£2·20	£2·10	£2·00
7422	0·55	0·53	0·50	7485	£3·50	£3·40	£3·30	74166	£3·20	£3·10	£3·00
7423	0·55	0·53	0·50	7486	0·35	0·34	0·33	74174	£2·50	£2·40	£2·30
7425	0·55	0·53	0·50	7489	£4·00	£3·75	£3·50	74175	£1·75	£1·65	£1·55
7426	0·50	0·46	0·44	7490	0·74	0·71	0·64	74176	£1·85	£1·75	£1·65
7427	0·50	0·46	0·44	7491	£1·10	£1·05	£1·00	74177	£1·85	£1·75	£1·65
7428	0·55	0·53	0·50	7492	0·74	0·71	0·64	74180	£1·50	£1·40	£1·30
7430	0·18	0·17	0·16	7493	0·74	0·71	0·64	74181	£5·00	£4·50	£4·00
7432	0·50	0·46	0·44	7494	0·85	0·82	0·75	74182	£2·00	£1·90	£1·75
7433	0·75	0·73	0·70	7495	0·85	0·82	0·75	74184	£3·20	£3·10	£3·00
7437	0·70	0·68	0·65	7496	0·96	0·93	0·86	74190	£2·15	£2·10	£2·00
7438	0·70	0·68	0·65	74100	£1·50	£1·45	£1·40	74191	£2·15	£2·10	£2·00
7440	0·18	0·17	0·16	74104	£1·07	£1·04	£1·00	74192	£2·15	£2·10	£2·00
7441	0·74	0·71	0·64	74105	£1·07	£1·04	£1·00	74193	£2·15	£2·10	£2·00
7442	0·74	0·71	0·64	74107	0·44	0·42	0·40	74194	£2·98	£2·86	£2·75
7443	£1·20	£1·15	£1·10	74110	0·60	0·55	0·50	74195	£2·00	£1·95	£1·90
7444	£1·20	£1·15	£1·10	74111	£1·38	£1·27	£1·21	74196	£1·95	£1·90	£1·85
7445	£1·98	£1·95	£1·90	74118	£1·10	£1·05	£1·00	74197	£1·95	£1·90	£1·85
7446	£1·20	£1·15	£1·10	74119	£1·50	£1·40	£1·30	74198	£5·00	£4·75	£4·50
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DEVICES MAY BE MIXED TO QUALIFY FOR QUANTITY PRICE& (TTL 74 SERIES ONLY) DATA IS AVAILABLE FOR THE ABOVE SERIES OF I.C.'s IN BOOK FORM. PRICE 35p.

NOW WE GIVE YOU 50W PEAK (25W R.M.S.) *PLUS* THERMAL PROTECTION!

The NEW AL60 Hi-Fi Audio Amplifier

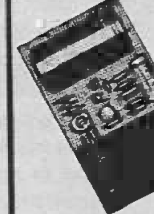
FOR ONLY **£3.95**

- Max Heat Sink temp 90°
- Frequency Response 20Hz to 100KHz
- 0.1% Distortion
- Distortion better than 1% at 1KHz
- Supply voltage 10–35 volts
- Thermal Feedback
- Latest Design Improvements
- Load – 3, 4, 8 or 16 ohms
- Signal to noise ratio 80dB
- Overall size 63mm x 105mm x 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.

FULLY BUILT - TESTED and GUARANTEED

STABILISED POWER MODULE SPM80 £3·25



AP80 is especially designed to power 2 of the AL50 Amplifiers, up to 15 watt (r.m.s.) per channel simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Mains Transformer MT80, the unit will provide outputs of up to 1·5 amps at 35 volts. Size: 63 mm × 105 mm × 20 mm. These units enable you to build Audio Systems of the highest quality at a hitherto unobtainable price. Also ideal for many other applications including: Disco Systems, Public Address, Intercom Units, etc. Handbook available. 10p.

TRANSFORMER BMT80 £2·15 p. & p. 25p

INTEGRATED CIRCUIT PAKS

Manufacturers "Fall Outs" which include Functional and Part-Functional Units. These are classed as 'out-of-spec' from the maker's very rigid specifications, but are ideal for learning about I.C's and experimental work.

Pak No. Contents	Price	Pak No. Contents	Price	Pak No. Contents	Price
UIC00=12×7400	0·55	UIC46=5×7446	0·55	UIC90=5×7490	0·55
UIC01=12×7401	0·55	UIC48=5×7448	0·55	UIC91=5×7491	0·55
UIC02=12×7402	0·55	UIC50=12×7450	0·55	UIC92=5×7492	0·55
UIC03=12×7403	0·55	UIC51=12×7451	0·55	UIC93=5×7493	0·55
UIC04=12×7404	0·55	UIC53=12×7453	0·55	UIC94=5×7494	0·55
UIC05=12×7405	0·55	UIC54=12×7454	0·55	UIC95=5×7495	0·55
UIC06=8×7406	0·55	UIC60=12×7460	0·55	UIC96=5×7496	0·55
UIC07=8×7407	0·55	UIC70=8×7470	0·55	UIC100=5×74100	0·55
UIC10=12×7410	0·55	UIC72=8×7472	0·55	UIC121=5×74121	0·55
UIC20=12×7420	0·55	UIC73=8×7473	0·55	UIC141=5×74141	0·55
UIC30=12×7430	0·55	UIC74=8×7474	0·55	UIC151=5×74151	0·55
UIC40=12×7440	0·55	UIC76=8×7476	0·55	UIC154=5×74154	0·55
UIC41=5×7441	0·55	UIC80=5×7480	0·55	UIC193=5×74193	0·55
UIC42=5×7442	0·55	UIC81=5×7481	0·55	UIC199=5×74199	0·55
UIC43=5×7443	0·55	UIC82=5×7482	0·55		
UIC44=5×7444	0·55	UIC83=5×7483	0·55	UIOXI=25 Assorted 74's	1·55
UIC45=5×7445	0·55	UIC86=5×7486	0·55		

Packs cannot be split, but 25 assorted pieces (our mix) is available as PAK UIC X1.

STEREO PRE-AMPLIFIER TYPE PA100

Built to a specification and NOT a price, and yet still the greatest value on the market, the PA100 stereo pre-amplifier has been conceived from the latest circuit techniques. Designed for use with the AL50 power amplifier system, this quality made unit incorporates no less than eight silicon planar transistors, two of these are specially selected low noise NPN devices for use in the input stages.

Three switched stereo inputs, and rumble and scratch filters are features of the PA100, which also has a STEREO/MONO switch, volume, balance and continuously variable bass and treble controls.

SPECIFICATION:

Frequency response	20Hz—20kHz ±1dB	Bass control	±15dB at 20Hz
Harmonic distortion	better than 0·1%	Treble control	±15dB at 20kHz
Inputs: 1. Tape head	1·25mV into 50KΩ	Filters: Rumble (high pass)	100 Hz
2. Radio. Tuner	35mV into 50KΩ	Scratch (low pass)	8kHz
3. Magnetic P.U.	1·5mV into 50KΩ	Signal/noise ratio	better than +65dB
		Input overload	+26dB
		Supply	+35 volts at 20mA
		Dimensions	292×82×35 mm

All input voltages are for an output of 250mV. Tape and P.U. inputs equalised to RIAA curve within ±1dB from 20Hz to 20kHz.

only £13·15

SPECIAL COMPLETE KIT MK50 COMPRISING 2 AL50's, 1 SPM80, 1BMT80 & 1 PA100 ONLY £25·30 FREE p.&p

LINEAR I.C's—FULL SPEC.

Type No.	Case		1	25	100+
72702	DIL	14	0.50	0.48	0.45
72709	DIL	14	0.25	0.23	0.20
72710	DIL	14	0.45	0.43	0.40
72741	DIL	14	0.40	0.38	0.35
72741C	TO-5	8	0.45	0.43	0.40
72741P	DIL	8	0.38	0.36	0.34
72748P	DIL	8	0.38	0.36	0.34
SL201C	TO-5	8	0.50	0.45	0.40
SL701C	TO-5	8	0.50	0.45	0.40
SL702C	TO-5	8	0.50	0.45	0.40
TAA263	TO-72	4	0.80	0.70	0.60
TAA293	TO-74	10	£1.00	0.85	0.60
TAA350A	TO-5	10	£1.85	£1.80	£1.70
µA703C	TO-5	6	0.28	0.26	0.24
µA709C	TO-5	8	0.35	0.33	0.30
µA711	TO-5	10	0.45	0.43	0.40
ZN414	TO-18	4	1.20		

DTL 930 SERIES LOGIC I.C's

Type	1	25	100+
BP930	0.15	0.14	0.13
BP932	0.16	0.15	0.14
BP933	0.16	0.15	0.14
BP935	0.16	0.15	0.14
BP936	0.16	0.15	0.14
BP944	0.16	0.15	0.14
BP945	0.30	0.28	0.25
BP946	0.15	0.14	0.13
BP948	0.30	0.28	0.25
BP951	0.70	0.65	0.60
BP962	0.15	0.14	0.13
BP9093	0.45	0.43	0.40
BP9094	0.45	0.43	0.40
BP9097	0.45	0.43	0.40
BP9099	0.45	0.43	0.40

DUAL-IN-LINE SOCKETS.

14 & 16 Lead Sockets for use with DUAL-IN-LINE I.C's TWO Ranges PROFESSIONAL & NEW LOW COST.

PROF. TYPE No.	1–24	25–99	100up.
TSO 14 pin type	33p	30p	27p
TSO 16	38p	35p	32p
TO 24	75p	70p	68p
LOW COST No.			
BPS 8 pin type	13p	13p	11p
BPS 14	16p	14p	12p
BPS 16	17p	15p	13p

NUMERICAL INDICATOR TUBES

Type	Description	
3015F	Minitron 7 Segment Indicator	£1.30
MAN 3M	L.E.D. 7 Segment Display 0.127" High Characters	£1.90
CD 66	Side Viewing 'Nixie Type' Tube 16 mm	£1.[illegible]
GR 116	Side Viewing 'Nixie Type' Tube 12 mm	£1.70

3 TERMINAL POSITIVE VOLTAGE REGULATORS

TO-3 Plastic Encapsulation O/P 1.5 Amps

µA7805	5V	(Equiv. to MVR5V)	£1.76
µA7812	12V	(Equiv. to MVR12V)	£1.76

BI-PAK CATALOGUE AND LISTS
Send S.A.E. and 18p.

AL10/AL20/AL30 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 car and at home.

Parameter	Conditions	Performance
HARMONIC DISTORTION	Po = 3 WATTS f=1KHz	0·25%
LOAD IMPEDANCE	—	8–16Ω
INPUT IMPEDANCE	f=1KHz	100 kΩ
FREQUENCY RESPONSE ≤ 3dB	Po=2 WATTS	50 Hz – 25KHz
SENSITIVITY for RATED O/P	Vs=25V. Rl=8Ω f=1KHz	75mV. RMS
DIMENSIONS	—	3" × 2½" × 1"

The above table relates to the AL10, AL20 and AL30 modules. The following table outlines the differences in their working conditions.

Parameter	AL10	AL20	AL30
Maximum Supply Voltage	25	30	30
Power output for 2% T.H.D. (RL = 8Ω f = 1 KHz)	3 watts RMS Min.	5 watts RMS Min.	10 watts RMS Min.
PRICE	£2·20	£2·59	£3·3

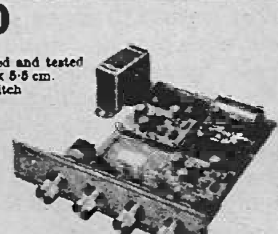
TEAK VENEERED CABINETS for:

STEREO 20
TC 20. £3·95 p&p 30p.

MK 50 KIT
TC 100. £6·50 p&p 40p.

E.M.I. LEK 350 Loudspeaker System Enclosure kit in Teak Veneer, including speakers. Rec Retail Price £45·50 per pr. OUR SPECIAL PRICE £35·50 per pair p&p £1. *ONLY WHILE STOCKS LAST!*

The STEREO 20



The 'Stereo 20' amplifier is mounted, ready wired and tested on a one-piece chassis measuring 20 cm × 14 cm × 5·5 cm. This compact unit comes complete with on/off switch volume control, balance, bass and treble controls, Transformer, Power supply and Power amps. Attractively printed front panel and matching control knobs. The 'Stereo 20' has been designed to fit into most turntable plinths without interfering with the mechanism or, alternatively, into a separate cabinet. Output power 20w peak. Input 1 (Cer.) 300mV into 1M. Freq. res. 25Hz-25kHz. Input 2 (Aux.) 4mV into 30K. Harmonic distortion. Bass control ±12dB at 60Hz typically 0·25% at 1 watt. Treble con. ±14dB at 14kHz.

£14·45

FRONT PANEL. 4 knobs, Headphone Socket, on/off switch and neon for PA 100/MK 50. FPK 100 £2·95.

TRANSFORMERS

T461 (Use with AL10) £1·33 P & P 15p
T538 (Use with AL20) £1·93 P & P 15p
BMT80 (Use with AL30 & AL50) £2·15 P & P 25p

POWER SUPPLIES

PS 12. (Use with AL10 & AL20) 88p
SPM 80. (Use with also AL30 & AL50) £3·25

PA 12. PRE-AMPLIFIER SPECIFICATION

The PA 12 pre-amplifier has been designed to match into most budget stereo systems. It is compatible with the AL 10, AL 20 and AL 30 audio power amplifiers and it can be supplied from their associated power supplies. There are two stereo inputs, one has been designed for use with *Ceramic cartridges while the auxiliary input will suit most †Magnetic cartridges. Full details are given in the specification table. The four controls are, from left to right: Volume and on/off switch, balance, bass and treble. Size 152mm × 84mm × 35mm. PRICE £4·35

Frequency response—
20Hz – 50KHz (–3dB)
Bass control—
± 12dB at 60Hz
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COMPONENTS GIANT ENTERS THE ENTHUSIAST MARKET

Sit back in your chair, close your eyes and let your mind wander. Think how nice it would be if there was a component supplier with a truly comprehensive catalogue and huge stocks who would have everything you needed for your projects. They would work with magazines to arrange for supply of unusual components for specific projects and would arrange a kit for the most popular ones.

Not only that, but they would guarantee same-day despatch and would automatically refund money on out of stock items if they couldn't supply within a week.

Just a dream? Not if a new company who are entering the field in a big way can live up to their plans.

The name is Doram and the reason why these aims should be taken seriously is that they are an off-shoot of R.S. Components (Radiospares as was) who have managed to fulfil this sort of service to the trade for several years.

Doram will be mail-order only and ETI have been one of the few to see early proofs of the 64-page catalogue that they are issuing and excellent is the only adjective that can be applied. A truly vast range of components are going to be stocked, clearly labelled and with all the information necessary.

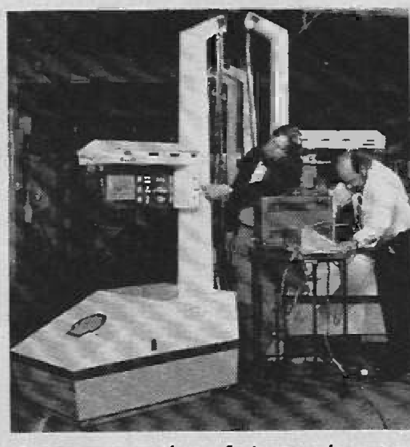
Frank Chable, who is responsible for this new venture, has really done his home-work. Months ago he discussed with ETI his plans and wanted to know what readers wanted in the way of service. The result has been that Doram know the problems and believe they can overcome them.

Closely associated with Frank Chable will be Andrew Dawes (G8HEW) who had built up several of the recent magazine projects from components which will be in the catalogue and showed these at a recent Press conference.

The catalogue will be available for 25p from September, while the company will open for business on October Ist. The address that Doram hope will be quickly remembered by heart is *P.O. Box TR8, Wellington Road Industrial Estate, Leeds, LS12 2UF.*

If Doram can live up to their promises, and they have not made these without their eyes open, they are going to get a big slice of the components market very quickly. We wish them well.

PETROL PUMP PREVIEW



A new generation of electronic petrol pumps made by Avery-Hardoll is shown in the photograph. The new equipment incorporates advanced electronic systems to provide computing, control and digital display functions.

Among the options available to customers when they place orders will be coin/note acceptors, bank card readers, pre-setting devices at the pump or kiosk for volume or price and data recording equipment.

NEW COLOUR TV TUBES

The latest advancements in colour television tube technology, which include the extension of the precision in-line concept to large screen colour tubes employing 110-degree deflection angles, were recently demonstrated by RCA. The company showed a complete line of the highly successful 90-degree matrix precision in-line tube system as well as 110-degree delta tri-colour-dot tubes in two sizes.

RCA plans to develop these non-matrix versions of the 19V and 25V 110-degree precision in-line tubes for production by RCA affiliate colour tube manufacturers within the European market in the near future.

Wide angle (110 degree) deflection colour tubes provide a smaller diameter electron beam spot size which results in improved picture resolution (sharpness). The wider deflection angle also reduces the over-all length of the colour tube by 4 to 5 inches, thus offering the potential for more attractive styling.

The extension of the precision in-line concept to 110-degree deflection colour tubes provides a system which, in addition to improved picture sharpness, offers the potential of cost savings through the elimination of complex circuit components and dynamic convergence adjustments. The RCA precision in-line system permits the permanent attachment of the deflection yoke to the tube, thus simplifying installation and eliminating costly and time consuming colour tube alignment at both the factory and the home.

GREAT FUTURE FOR LED'S

Speaking at a recent seminar in London, Stan Gage, Application Engineer of Hewlett-Packard predicted a considerable growth in the use of LED'S: "New materials and technology have produced high-efficiency LEDs and displays with greater light output for current consumed, and for a lower cost. When you take into account the other beneficial design requirements — high reliability, low mechanical mounting requirements, low heat dissipation and a wider range of colours for example — you get devices just crying out for new applications. In some fields, particularly the consumer products field, I expect to see usage increase by an order of magnitude very shortly. This applies, for example, to digital clocks, radios, home appliances, and automobiles."

LOW PRICE VERSION OF H-P 80

Our US correspondent tells us that Hewlett-Packard are planning to introduce a low-price version of their very successful H-P 80 financial calculator.

The unit is believed to have most of the H-P 80's functions except for the more specialised functions such as trend-line analysis etc.

Look for a price around £70 and an official announcement very soon.

US SAYS NO TO METRIC

It now seems virtually certain that the US will not go metric — at least not within the foreseeable future.

Supporters of the proposed metric conversion legislation were stunned when the House recently refused even to consider the Bill.

The proposed conversion was to have been voluntary, but would certainly have resulted in pressure being applied to many organisations in technology and commerce.

Surprisingly, the Bill has been killed, not because of any doubts about the rationale of the metric system but simply because agreement could not be reached about who was to pay the cost!

Fortunately the inch has been defined rather more accurately since its early beginnings when it was 'the length of three barleycorns, round and dry, laid together'.

SOLAR ENERGY PROJECTS

The search for a viable system to harness solar energy has taken a further step forward through two development projects currently being undertaken by Honeywell's Systems and Research centre.

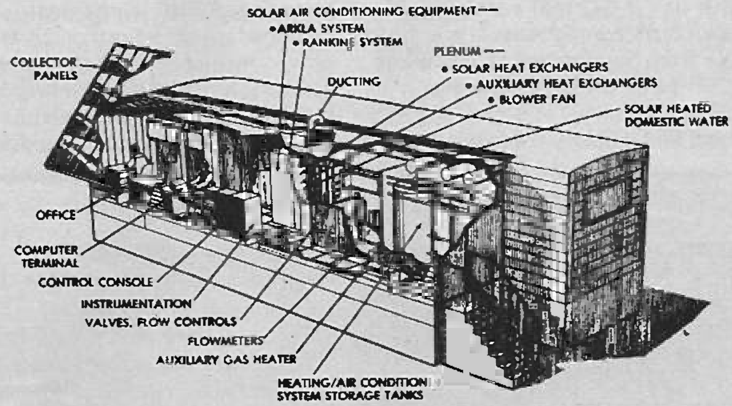
The projects are a solar energy heating system in a Minneapolis school and a mobile solar energy research laboratory. Both have attracted grants from the US National Science Foundation.

At the heart of the school project is a 5,000 square foot solar collector system made up of 36 inch by 96 inch collector units mounted on structural frames in an open area next to the school's playground. Each six-inch thick solar collector consists of tempered glass, a layer of translucent plastic, two absorber plates (which absorb the sun's thermal energy and between them a water-glycol mixture is circulated), a layer of insulation, and a metal outer frame.

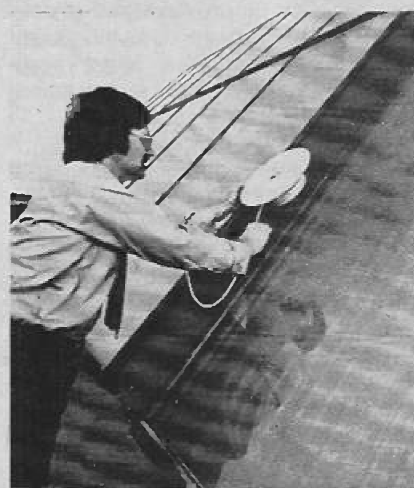
After the water-glycol solution in the collector system is heated to between 130° and 150°F, it is transferred to heat exchangers in the school's existing heating system. The system is expected to produce 1,320 million BTU's a year (6.3% of the total requirement) equivalent to saving 12,500 gallons of oil a year.

The second project is a mobile solar energy research laboratory which has recently reached the field test stage. Prime objectives of the laboratory are to collect climatic data to be used in the design of integrated solar heating and cooling systems and to carry out practical tests on the application of heating and cooling systems to buildings.

The laboratory consists of two units. A 45-foot trailer houses the solar heating and cooling test equipment and a complete weather station. A 50-foot 'office' van represents the building to be heated, cooled and supplied with hot water by sun power. It will also be used for on-tour solar energy briefings and discussions.



The Honeywell mobile solar energy research laboratory. The collector panels run the whole length of the unit.



A pyranometer check being made on the solar energy collecting plates. This measures the intensity of the sunlight to enable the overall efficiency to be calculated.

WORLD'S LARGEST SOLAR ARRAY

A photovoltaic solar cell demonstration system is being set up in McLean, Virginia, by the US Mitre Corp. on the roof of its building.

The system, designed to convert solar energy directly to electricity, will be completed by late summer and will generate 1500 kWh of electricity annually. Although the output isn't large by normal electricity consumption standards, the photovoltaic cell system is the biggest earth-based array of its type, Mitre says. The system is the first step in a continuing evaluation programme.

LOW COST SOLAR CELLS

A major advance toward producing low-cost solar energy was reported last month.

Researchers at USA's Tyco Laboratories (Waltham, Mass) and at Harvard University jointly reported that they had developed silicon ribbons up to two metres long — and of a quality sufficient to produce solar cells of some 10% efficiency.

The new technique may eliminate the present costly process in which thin wafers are cut from large single crystals.

Currently the new process operates by melting poly-crystalline silicon in a crucible. The disc crucible is equipped with a die into which the molten silicon rises — by capillary action. The silicon is then pulled through the die in ribbons about 2½ centimetres wide and 0.2 mm thick.

Tyco Laboratories have licensed RCA to use the new manufacturing process.

DOLBY FM BROADCASTING APPROVED

The US FCC (Federal Communications Commission) has given the go-ahead to FM stations in the United States to use a combination of Dolby B-Type noise reduction and reduced pre-emphasis (25 microseconds instead of the US standard of 75 microseconds). This technique was recently proposed by Dr. Ray M. Dolby as a compatible way to allow increased dynamic range in FM broadcasts, while substantially reducing noise and distortion.

The value of a reduction in pre-emphasis (i.e. the amount by which high frequencies are boosted during transmission) has long been recognised. This would reduce the danger of overmodulation, but present FM tuners and receivers would obtain a relatively dull sound if such a change were made independently. The B-Type noise reduction, on the other hand, results in brightened reception when applied to a signal received without decoding. By linking the two techniques, high quality compatible reception is obtained by all listeners. Those listeners with Dolby noise reduction circuitry will obtain an improvement which would otherwise require a substantial increase in transmitter power.

Dolby FM broadcasting has a number of advantages: firstly, no listener or station is *required* to convert. The change is purely optional. If a station transmits a Dolby FM signal, listeners with conventional equipment benefit by a reduction of high-frequency distortion, a possible increase in programme level, or both. With 75 microsecond reception, the result is difficult to distinguish from a normal signal, and is only slightly 'brighter' where 50 microseconds is the standard. Listeners equipped with 25 microsecond de-emphasis and B-Type noise reduction circuits obtain four benefits: improved signal-to-noise ratio; full programme dynamic range, even at high frequencies; better reception in weak-signal areas; and reduced likelihood of interference.

Dolby B-Type broadcasting has been carried out for some time by a number of US stations without alteration of pre-emphasis. Since the original experimental transmissions in 1971 several FM stations have been transmitting 75 microsecond B-Type broadcasts, under existing FCC regulations. As a result, some Dolby licensees have already produced tuners and receivers equipped to decode Dolbyized transmissions.

In 1972, investigations at Dolby Laboratories indicated that for optimum use in broadcasting B-Type noise reduction should be linked to a reduction in pre-emphasis time constant. The improvement in FM transmissions which the combined change brings about is so significant that the company ceased active promotion of the simple form of B-Type broadcasting. Early in 1973, Dolby Laboratories recommended to all its consumer equipment licensees that where they incorporate B-Type circuits for FM decoding, they should also include a time constant switch option, as it was hoped - and considered a likely possibility - that the FCC and other broadcasting authorities would eventually agree with the company's technical conclusions.

TV RECORDING BREAKTHROUGH

Researchers at Batelle (Washington USA) claim to have made a breakthrough in TV recording.

They have developed a method of using lasers to scan TV pictures and storing the resultant image on a photosensitive plate.

The pictures are converted to digital information which is then recorded as a series of dots, each one micrometre diameter. Data density is 200 million bits/sq. in.

Playback is achieved by an optical scanner.

The technique's main advantage is that of cost. Whereas a 30 minute magnetic tape recording normally costs about £20 Batelle claim that their method would enable the same material to be recorded on a 120 by 170 mm record for as little as 20p.

ORGAN TONE IC'S

Two IC's have been announced which will be of considerable interest to organ builders.

From General Instruments comes the AY-1-0212 MOS circuit. This requires a single input frequency to produce the full chromatic scale of 12 notes. Six stage dividers to accompany this (AY-1-6721/6) are also available. Both components are available from Semicomps of Wembley, Middx. Price of the tone generator is £5.55.

From ITT Germany there is news of another chip which generates the top 13 notes of an organ and it carries the coding SAH200. Supply voltage is 22V. Stability is claimed to be excellent and is within ±0.011 per cent.

WATTS RMS NOW OFFICIAL

The US Federal Trade Commission has now set a date for enforcing its new strict rules on audio power claims for home hi-fi equipment.

Legislation, effective November 4, 1974, specifies that amplifier power output must be quoted as continuous power capability (watts rms).

Other specifications, such as peak power or music power may still be used but must be based on recognised industry standards and must be subservient to the main rms disclosure.

'SCISSOR STYLE' CUTTING AIDS

A new range of production aids has been introduced by Adcola Products Ltd. They are designed to deal with a wide variety of wire cutting and sheet metal trimming applications. All the cutters feature 'scissor-type' operation and incorporate a special cutting edge to provide a positive, clean cut on copper and steel wire (up to about one mm diameter). The surgical scissor style is claimed to give easier and more accurate control. The tools are manufactured to precision standards in high quality chromium stainless steel.

Three models are available.

The FMI7 replaces conventional side cutters for use with single or multi-stranded wire. The serrated edge ensures a good clean cut eliminating burred wire edges, which in the past have created difficulties when removing components from printed circuit boards.

The FMI6 features a side-snips configuration allowing use as tin-snips to cut small radii. It is possible to successfully cut right to the very point of the cutting edge making the cutter ideal for fine work.

The FMI7 is spring loaded and leaves a standard finished wire length termination of l.2mm from the PCB, making it ideal for solder flow bath applications. The finished wire cut is clean without burred edges and the tool is suitable for use after soldering too. The tools are specifically designed for use as ancillary aids to soldering in the electrical and electronics industries and are priced from £5.l0p plus VAT and details may be obtained direct from: *Adcola Products Ltd., Adcola House, Gauden Road, London, SW4.*

Continued on page 70.

WE'RE ALL AT SEA...

But where are we?

This side-scan sonar unit is used by the US National Institute of Oceanography to obtain data about sea floors. The 5 m long transducer array operates at 6.5 kHz (at 60 kW power). Over 3000 of sea floor km² can be studied each day.

In recent years, man has taken to the sea as never before. In this article, Dr. Sydenham deals with sub-surface operations.

VISUAL means of measuring distance and position under the sea are not satisfactory because the visibility is too poor.

With ocean depths running to many kilometres, the 50 m or so that daylight penetrates is relatively insignificant. Even at the bottom of the Continental Shelves (where most of the present underwater human activity takes place) artificial light is necessary.

With the exception of VLF radio transmissions (which lack adequate precision anyway for most sea floor work) radio location methods are of no use, as water rapidly attenuates the signal.

Fortunately acoustic waves, in contrast to electro-magnetic waves, travel well in water so radar-like principles can still be used, but with different hardware. Furthermore, the acoustic velocity of waves in water is considerably slower than that of electro-magnetic propagation so it is possible to gain finer detail of structure and position — the problems of interval timing are not as severe at the reduced velocity.

Positional sensing devices are needed in oil-drilling control, in hydrographic surveys where the sea floor is charted, in fishing, in exploration and in military operations. Decompression and compression effects alter rapidly due to the high density of water compared with air and any man or machine venturing well below the surface needs to know the depth if only for reasons of safety. Many undersea measurements can be made from the comfort of the surface — others must be made from below.

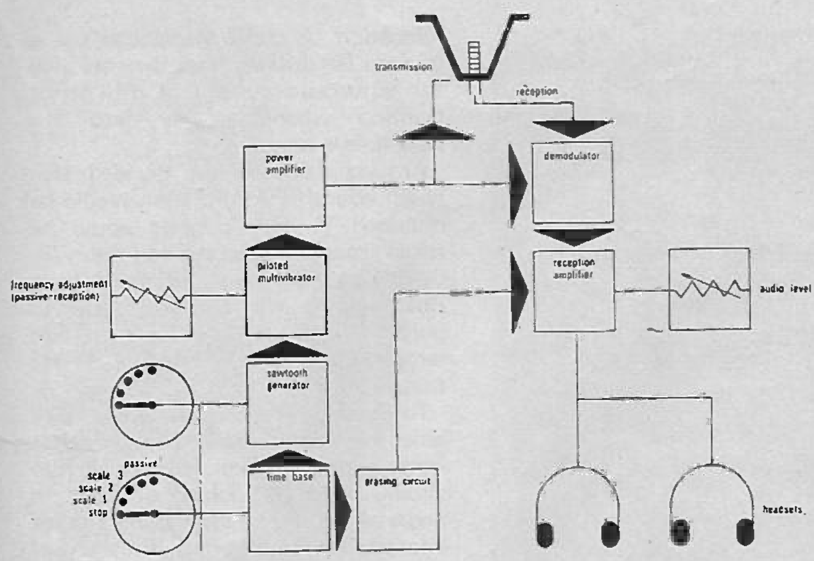
Acoustic Sensors — The basic elements of a sonic underwater ranging or communication system are the transmitter transducer that sends out the acoustic signal; a receiver (which may be the same transmitter transducer) and a data processing and display system — see Fig. 1.

Most systems operate in the ultra-sonic region making use of electric spark discharge, piezo-electric or magnetostrictive modulation methods to couple electrical energy to the water medium as acoustic energy waves. Various names are in use — echo sounders, sonar (short for sonic radar), hydrophones and acoustic sounders — there is little specific meaning in each.

Sonar ranging systems use the same principles as electro-magnetic radar — that is, they may measure the time of flight of a pulse or they may use continuous wave methods.

The Freid Krupp Atlas-Elektronic echo-sounder operates simultaneously with 30 kHz and 210 kHz carrier frequencies to cover the depth range from zero to 300m.

The varying velocity of sound waves in water limits the accuracy of sonic methods to about 0.1 percent and 18



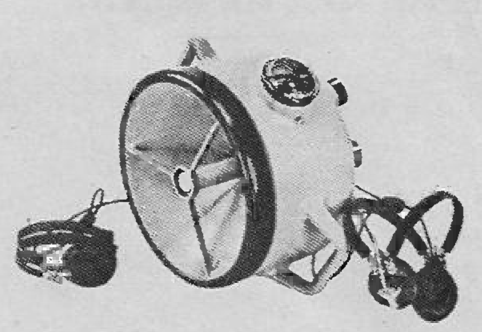


Fig.1. Schematic and actual photograph of the Thomson – CSF portable sonar used by divers to locate obstacles whilst underwater. The unit uses a reflector cone of 140 mm diameter to enhance the gain.

switched ranges are used to obtain resolution at the respective depths.

This system can resolve increments down to 50 mm, depending on range, sending the sounding pulses of carrier at 60 per second. The higher frequency in this system is for charting the upper surface of the sea-floor mud, the lower frequency penetrates as deeply as 8 m down into the mud.

Many sonar devices now include a display that provides a picture of the sea bottom. Depending on the type of sensing arrangement, this will be either a cross-sectional profile or a plan view.

If the sensor is hull mounted the ship's noise, especially while the ship is under way, will seriously restrict the attainable resolution. More sensitive systems, for example the E,G & G side-scan sonar have the sensing transducer in a towed hydrodynamic 'fish' that hangs as much as 600 m down. In this side-scan device the 'fish' transmits short acoustical bursts of carrier at right angles to the path of movement: the beams slant slightly downwards to impinge on the bottom below. Time interval differences between sent and received pulses enable a picture of the bottom to be built up on a ship-mounted display. This display is clear enough for fine sea-floor detail to be studied out to 450 m on each side. (See Fig. 2).

Seismic sounding is another acoustic method. This is used to explore the structure, rather than surface details, of the rock and mud below the floor. Explosive charges, compressed air releases, spark discharges and other methods propagate a soundwave down into the floor. (Explosives used range in size from tens of grams to tens of tonnes). These waves eventually emerge out of the rock because of reflections from the interface of rock layers or from diffraction effects that curve the rays. Arrays of floating or floor-placed hydrophone pickups detect the emergent sound waves. The strength of the signal and its arrival time at each sensor are then combined with the known acoustic wave velocities to give a cross sectional picture of the structure being studied. The example shown in Fig. 3. is part of a survey of the English Channel made for the Channel Tunnel project.

Acoustic methods are also used in

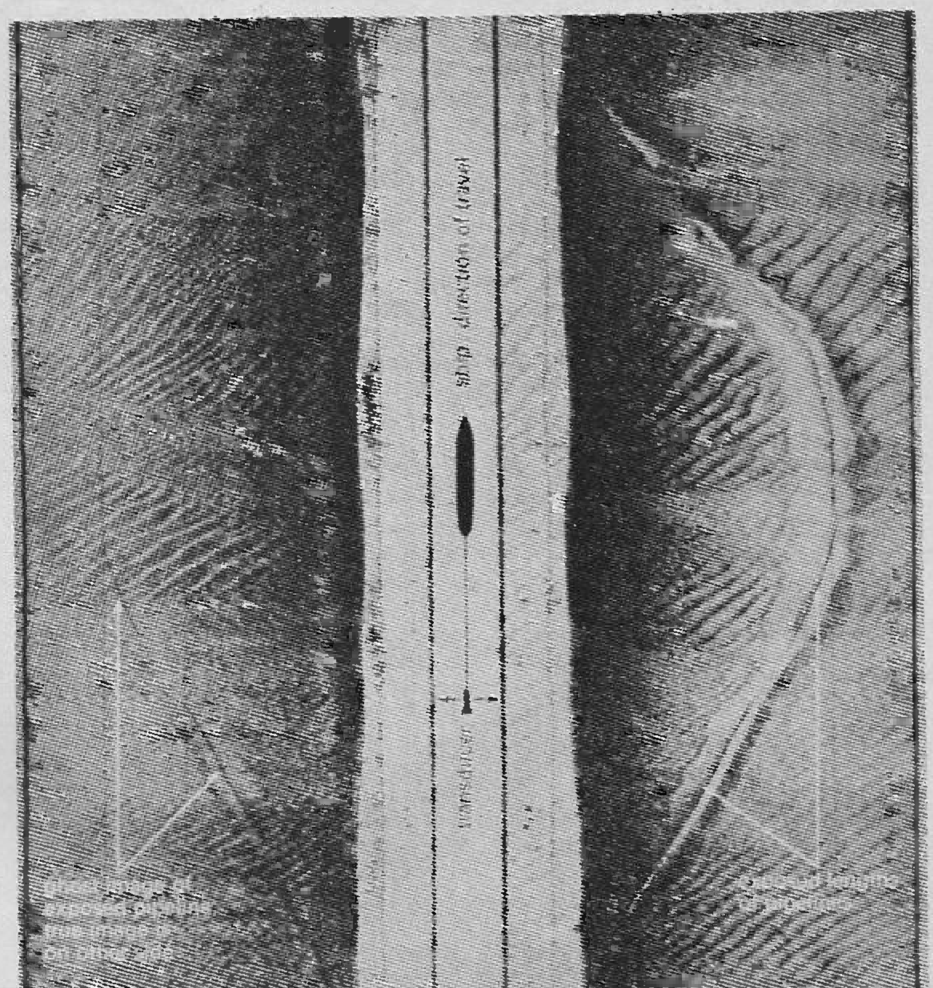


Fig.2. Side-scan sonar was used to provide this view of the sand floor in which the sandwaves and an exposed pipe-line can be seen.

WE'RE ALL AT SEA...

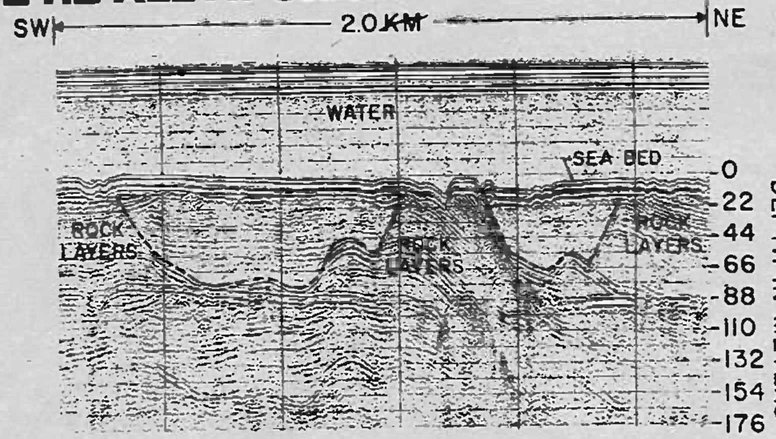


Fig.3. Seismic sounding enables the cross-section of sea floor structure to be obtained.

the search for underwater objects. In one military system, a listening head is lowered into the water from a helicopter. Figure 4 shows a piece of commercial equipment. This is a scanning sonar that is lowered on a cable. Its sensing head rotates to view a circle perpendicular to the cable; a 1 m sphere can be detected at 120 m range, an acoustic marker at 500 m.

Acoustic markers are active devices deployed at a datum point — they transmit a closely omnidirectional, equal intensity acoustic carrier. The Thomson-CSF 7011 unit sends out 50 ms bursts of 38 kHz each 0.5 s. Its battery pack operates the marker for 10 days. The Thomson 7021 unit operates for six months unattended.

As with radio-location methods, some acoustical methods make use of transponders. This technique reduces the battery drain, as the transponders only transmit at full power when instructed to by the incoming energy.

Divers use acoustic markers for relocation. A more spectacular use is in deep sea drilling. Here they are used for automatic control of drill string position when re-entry into the bore-hole is required.

Around 1965 it was decided that much scientific information would be obtained if core samples could be taken from the deep sea-bed floor. An oil-drilling rig — renamed the Glomar Challenger — was converted for this purpose and was put into service sampling line after line across the sea floor.

To collect these samples, exploratory holes must be drilled in the sea floor at water depths of 7 km. It is not hard to visualize the difficulties of such an undertaking. For a start using a seven kilometre long supported drill string of just some 150 mm diameter is like feeding the end of a long piece of cotton into a needle hole that can't be seen. The drilling rig must remain above the hole during drilling regardless of sea state and it must be possible to reinsert the end of the drill string into the hole with reasonable ease.

Sonar is used to re-enter the bit into a 5 m diameter concrete cone that sits on the sea bottom. Acoustic sensors, mounted around the edge, provide signals to power the string thruster (a water-jet from the side of the string at 20 m up from the bit) until the bit is over the cone.

Commercial companies have since developed somewhat similar systems for use in shallower water. A re-entry sonar unit by Thompson-CSF, is shown in Fig. 5. Their system eliminates the entry cone to the well head and lessens the chance that the string or drilling operation will damage the sensors. The unit is set on the bottom near to the hole and the rotating search sonar gives a panoramic display of the sea-bed. The surface operators can then manoeuvre the ship accordingly. The small cone at the top is the outlet of a taut-wire inclinometer (discussed later in this article). The unit will operate in depths to 300 m enabling its surface operators to see out to 80 m.

Undoubtedly acoustic methods are at present the most powerful means available for seeing underwater. Few vessels can do without one form or another.

To round off this description of sonic methods let us look at what is probably the biggest acoustic 'fish' yet made. This is the Geological Long Range Asdic (GLORIA). It was built by the British National Institute of Oceanography at Guildford for making side-scanned sonar maps of the bottom. The device is 50 m wide, some eight tonnes in weight and 10 m long.

It is towed at 10 knots at a depth of 200 m. Inside are automatic steering

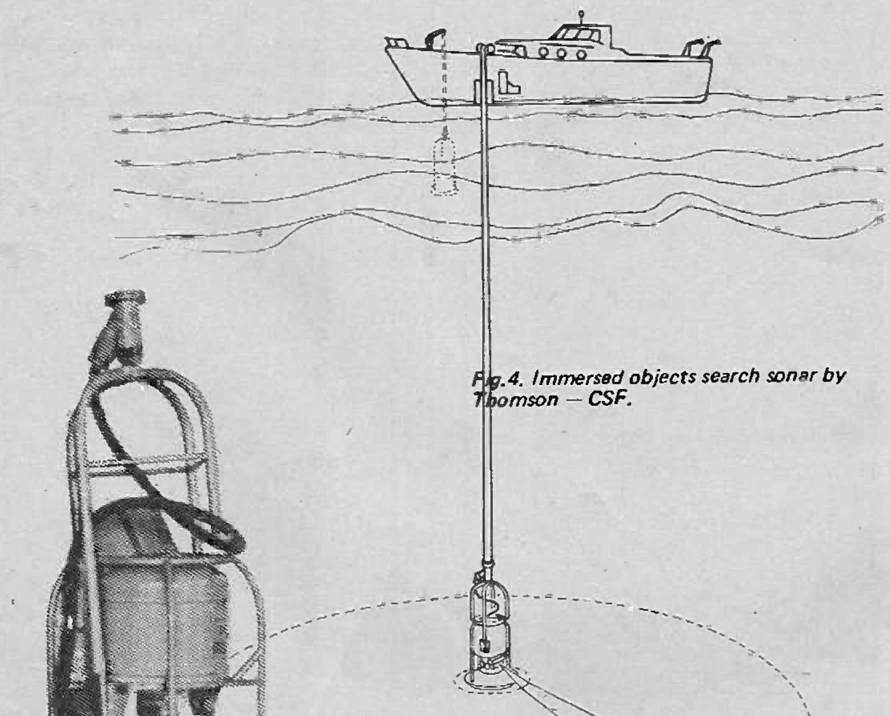


Fig.4. Immersed objects search sonar by Thomson — CSF.

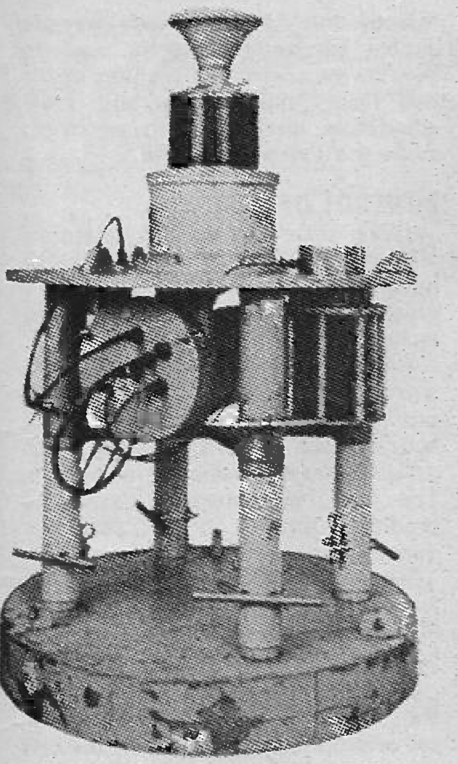


Fig.5. Acoustic methods of measurements make it possible to thread a drill-string into the bore-hole by remote control from the ship.

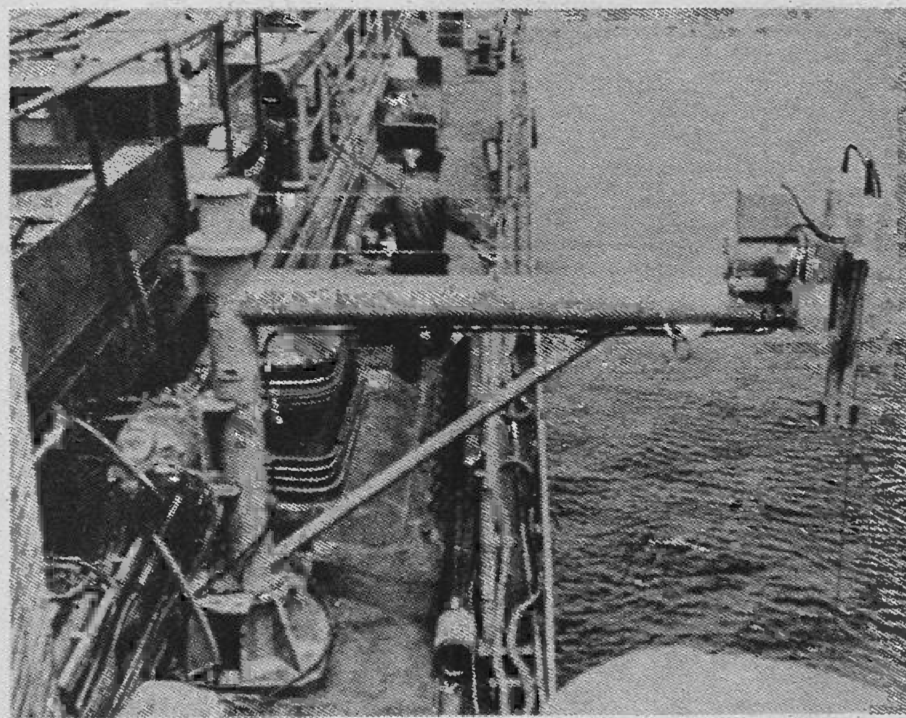


Fig.6. Inclinometer control of ship position. The cable goes to a bottom location and is held tensioned. Inclinometers measure the tilts of the wire in each horizontal direction.

units to control altitude and depth — a map would be meaningless without control of the direction of the sensors. One hundred and forty four transducers look out 20 km each side. With a maximum design depth of 9 km this device should add considerably to our knowledge of the sea floor.

Underwater acoustics are versatile but other methods often provide a more economical solution or solve a problem outside the capability of sonar.

TAUT WIRE INCLINOMETERS

Possibly the easiest way to locate position on the bottom from a ship is to stretch a wire between both points, using its length and angle to the vertical to relate the two.

TSM 9101 is the code number of the Thompson-CSF inclinometer used in oil well drilling. It is shown installed on 'Toucan' in Fig. 6. A five to 10 mm diameter high-tensile cable is secured to the bottom with a dead-weight (the sonar re-entry unit mentioned earlier, for instance). The shipboard end is held under constant tension by an electric winch which has automatic control over the pull exerted. Outboard from the hull, where the cable enters the water are the inclinometer units in which two damped pendulums (driving transducers) monitor tilt in mutually perpendicular directions. This method is not as accurate in defining position as some sonic procedures but suffices to hold the ship (using feedback control — see later) within a cone of diameter of five per cent of the depth; the sensors measure to within one per cent. Greater accuracy would require corrections to allow for the catenary shape in which the cable hangs when not truly vertical. This has been investigated by a North American team.

TELEVISION

Another way to position objects is to lower a television system and lights so that relative positions can be seen from the surface. CCTV has been used to look into drill holes, to drop grabs when a worthwhile bite can be made, to close fish nets when a shoal swims in.

The ill-fated 'Thresher' submarine was finally identified this way in 1963 but even before that this method identified the underwater wreck of the 'Affray' — back in 1951. You probably remember the saga when the US Airforce lost an H-bomb off the coast of Spain in 1965. The remote-controlled submersible CURV was lowered to find and retrieve the bomb. Television and sonar sensors were used in the operation.

Recent advances in low-light television have greatly improved the seeing power of CCTV in underwater exploration.

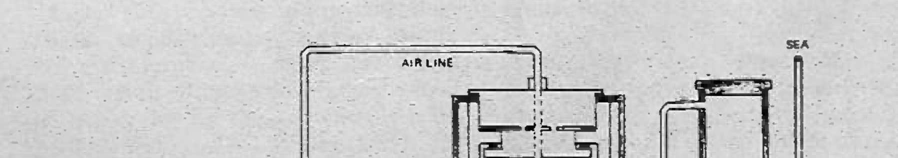


Fig.7. Basics of a differential-pressure sensor designed to monitor wave heights.

WE'RE ALL AT SEA...

FREE-FALL CAPSULES

So far we have looked at methods that are tied, either physically or by an information carrier link, to the mother ship. Another class of devices are released from the surface to fall freely — collecting data during the descent, or when in position at the bottom.

These are particularly useful for extended periods of measurement as it is costly to keep a surface vessel in place for a long time. One example is the measurement of wave and swell heights when records of many months duration are needed and measurements often must be made in quite inaccessible places.

Two methods are used for collecting the data transmitted by the capsule. The capsule may have an acoustic data link to a surface buoy and the data is retransmitted from there, or, as is more common, the capsule will contain recorders that are interrogated upon retrieval of the capsule.

Recovering a free-fall capsule requires some ingenuity. Some capsules have an inbuilt time-switched trigger to float them back up at the right time. In others a surface-sent sonar pulse activates the flotation device. Still the loss of free-fall capsules is a major problem. Even tethered capsules go astray.

WAVE HEIGHT MEASUREMENT

It is difficult to measure wave-height from a surface location for there is no stable-altitude platform from which to measure the height changes. The Air-borne laser terrain profiler can provide a measure but is not the most economical way if wave-height time variations at a fixed point are needed over long periods. Instead, it is easier to make use of a sensitive pressure-gauge that monitors sea floor pressure; the height of water at any moment governs the hydrostatic pressure below.

In wave-height meters the design must incorporate automatic pressure balancing to counter the absolute pressure as the device descends. In the Horace Lamb Centre system, shown in Fig. 7, the tyre inner tube compresses with depth producing a pressure balance between the inside and outside of the measuring bellows. When the end of the hanging chain touches the bottom it reduces the weight on the valve shutting off the air-cock. The differential-pressure transducer is thus balanced on each side at the ambient pressure and is then ready to record the small pressure changes brought about by the changing water-head.

Absolute pressure is, of course, a measure of absolute depth and this principle is used to gauge depth — in the same way as the aircraft altimeter measures height. The design of depth gauges is, however, quite different from that of altimeters for sea pressures run to kilograms per square millimetre. Skin divers use small wrist-watch size pressure gauges to give them a depth reading.

HOLOGRAPHY

Holography is a universal method capable of utilizing any coherent wave source and is now being adapted for use in sea-floor mapping. The object of interest is illuminated with a broad wave-front of coherent acoustic radiation. The subsequent reflections are received at the surface where they are mixed with coherent radiation taken directly from the source. An interference pattern is created where they meet on the surface. This is the hologram (the name usually associated with laser radiation) or phasigram (for acoustic holography). The plane hologram contains enough information for the scene to be recreated as a 3-D image — achieved by looking through the hologram at a similar coherent source.

Acoustic holography seems best underwater, for the coupling and attenuation problems are less than at other radiation wavelengths. This is, however, not necessarily so. Laser radiation, especially at green wavelengths, is also suitable. The earlier preoccupation with sonic methods has led to greater experience with acoustics but recent events now show laser methods to be applicable in water.

In the sonic technique, use has been made of an oil film on the surface that forms in a 3-D shape related to the acoustic interferences. This can then be recorded as an optical hologram using laser radiation. Still water is, however, essential so other workers are researching the use of scanned signal or multiple hydrophones as a way to record the phasigram in a moving surface situation.

Both methods are still in their infancy but in this decade we can expect to see holography used to produce reconstructed pictures of the sea floor, thus giving still more alternative methods with which to study the underwater world.

CONTROL OF POSITION

Having seen how we can determine position and produce a control signal, it is appropriate to conclude with a quick look at automatic positioning techniques used at sea.

Automation requires first a position sensor, then instrumentation to process the positional and time data and produce the error signals which drive the vessel's manoeuvring system. The final requirement is devices to produce thrust in a particular direction.

Automation can be used either to guide a moving vessel (navigation) or hold a vessel stationary (dynamic positioning).

AUTO NAVIGATION

Provided the input to a rudder accepts the form of signal produced by the processor, and a rudder position-feedback transducer exists, then auto navigation can be arranged by assembling the various units as illustrated in Fig. 8. Radio location methods can be switched into the system to give actual position data; the system will also work from a magnetic compass output or a gyro unit. The auto-pilot unit accepts the positional data, compares it with the desired position data and produces an error signal if there is a difference. The steering gear is then driven accordingly to reduce the error and hold it close to zero. A rate-gyro is also incorporated to assist turning operations — it provides a precise short-term directional reference.

Several manufacturers offer facilities that automatically plot position (to the appropriate map-scale) as a course is followed. These can be used as a check of the autopilot or as a manual

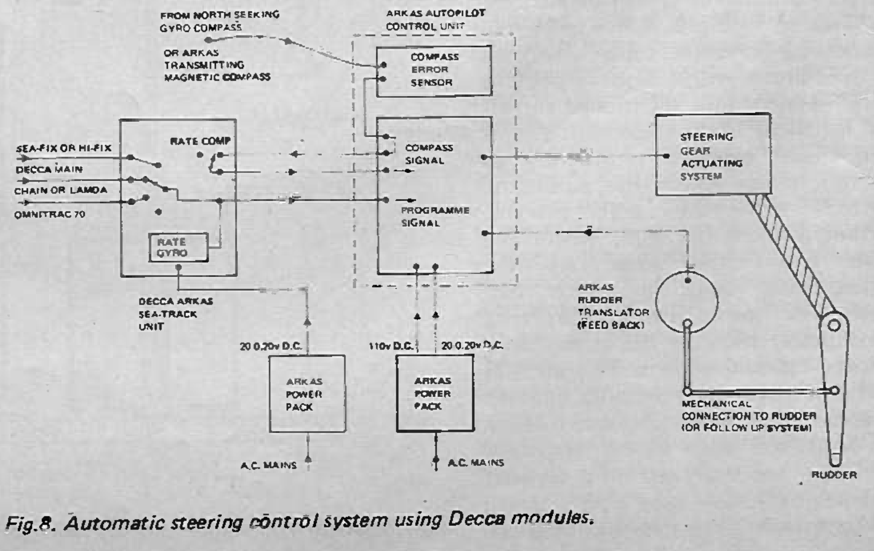


Fig.8. Automatic steering control system using Decca modules.

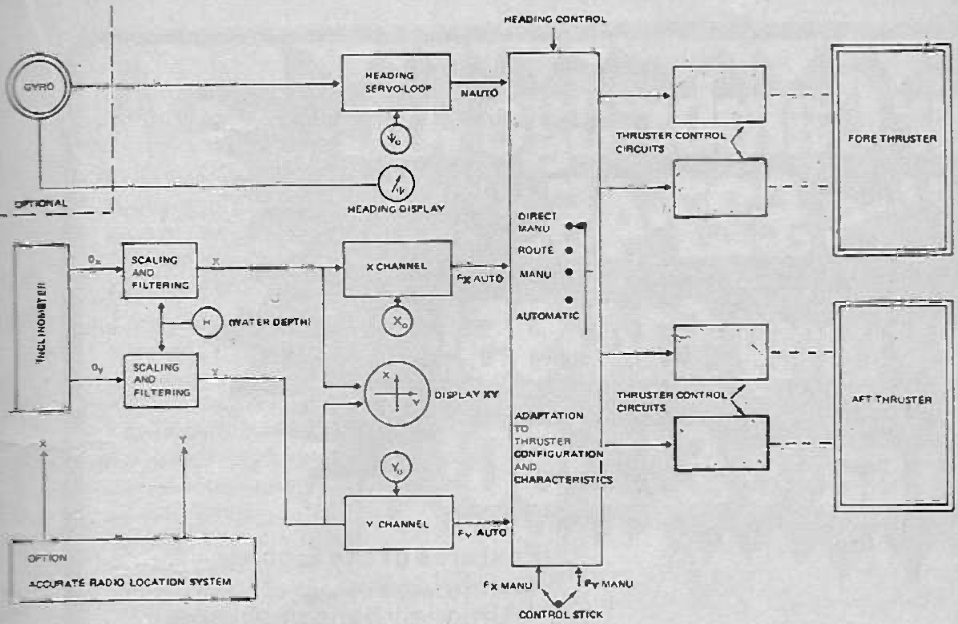


Fig.9. Block diagram of system, based on the taut-wire inclinometer, to hold a ship in a constant position regardless of sea-state.

aid to semi-automatic navigation. The Del Norte equipment, for example, has a general-purpose processor to convert navigational instrument signals into a form compatible with a programmable desk calculator having a coupled x-y plotter. This equipment also provides left/right steer indication for manual control.

In hydrographic survey the aim is to chart the sea-depth in order to plot maps. It has been suggested that the use of a number of slaved sounding launches covering the area around the mother ship would be advantageous. One institute has already built a remote-controlled unmanned launch to test the feasibility of the concept.

DYNAMIC POSITIONING

In the main, it is the oil rigs that need motion stabilisation. Consequently many drilling ships now have advanced position-control mechanisms. As the vessel is not making way, rudder control is not applicable. Instead oil rigs use thruster units, placed fore and aft in the hull. These may be water jets using pumps or additional, conventional, propellers; in each case their compounded effect can thrust the ship sideways as well as forward or backward. Having many more variables of thruster control than the simple rudder (for example, there may be four units each having variable power and direction in a full circle) the processor of this kind of control is more complex. Not only must the position be held constantly but in many cases the heading must also be maintained to reduce rolling in heavy seas.

The exploration ship 'Terebel' of the Institut Francais du Petrole had this control fitted in 1964; since then many other ships have been fitted out in this way. The latest is probably the 'Pelican', fitted with the Thompson-CSF system (illustrated in Fig. 9). A taut-wire inclinometer (or radio location system) provides x and g inputs to the processor from which error signals control the thrusters. In some 1968 tests with this equipment the 'Terebel' was positioned to within 2 m at a depth location of 40 m with the sea-state at 4 m high waves. In quieter seas it controlled to within a metre.

It can be seen that positioning at sea is a vital problem and that numerous solutions have been developed. What the future holds is hard to predict — already it has been demonstrated that an airborne laser ground-profiler can see down many fathoms to, in fact, profile the sea-floor. Coupled with the scanner principle the elements of a rapid sea-floor mapping method appear.

Laser light-houses all round the coasts may have modulated beam information giving a ship's master his position to within centimetres when he views the light-house with special binoculars. The revolution in equipment size and reduced cost that integrated circuit technology has brought to bear will undoubtedly alter the scene as yet another special-purpose LSI chip is developed.

One thing certain is that we will soon see ships travelling as remote unmanned slaves to a master vessel.

Later we should see the advent of unmanned ships navigating themselves across the globe. Just *when* these ideas become economically viable is the question. Our technology can cope already — the great cost of high reliability and the attitudes of labour organisations are our current limitations. ●

PROJECT 310

IGNITION TIMING LIGHT

The ignition timing light complete with battery leads and spark-lead transducer.

Obtain maximum performance and economy from your car.

A CAR'S performance and fuel consumption is affected quite drastically by the condition of the ignition system and upon correct ignition timing.

Before the advent of high performance engines and high octane fuel, ignition timing could be optimized by adjusting it until 'pinking' could just be heard under heavy load at low speed in top gear.

But these days have long since gone. In fact if an engine, running on high octane fuel, can be heard 'pinking' then it is grossly over-advanced and bearing damage will be caused.

Despite this there are still garage mechanics who blithely set ignition timing 'by ear'.

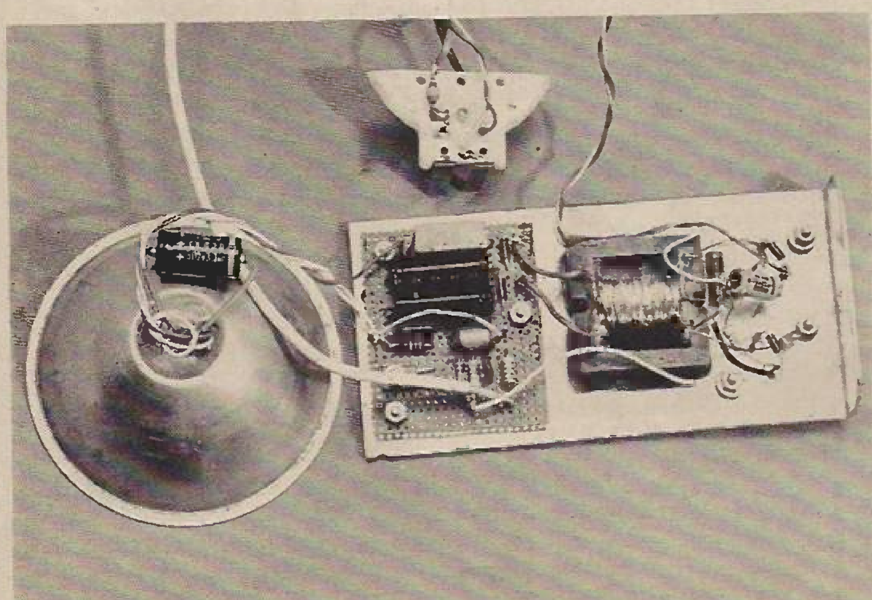
There is only one way to set ignition timing accurately. That is with a timing light specifically designed for that purpose.

Timing lights in common use range from a simple neon to the complex units used by auto electricians.

Neon timing lights are barely acceptable. Their light output is necessarily limited – to the extent that most have to be used in darkness. And, due to their low light output, they become a safety hazard as one attempts to hold them close to the timing mark – and to the rapidly turning fan blades.

Timing lights incorporating a Xenon flash tube are a much better proposition. As with neon lights, they are triggered by the firing of the first sparking plug in the engine firing order, but, as their flash energy is supplied directly from the vehicle battery they have a much greater light output.

The simple unit described in this project operates in this way.

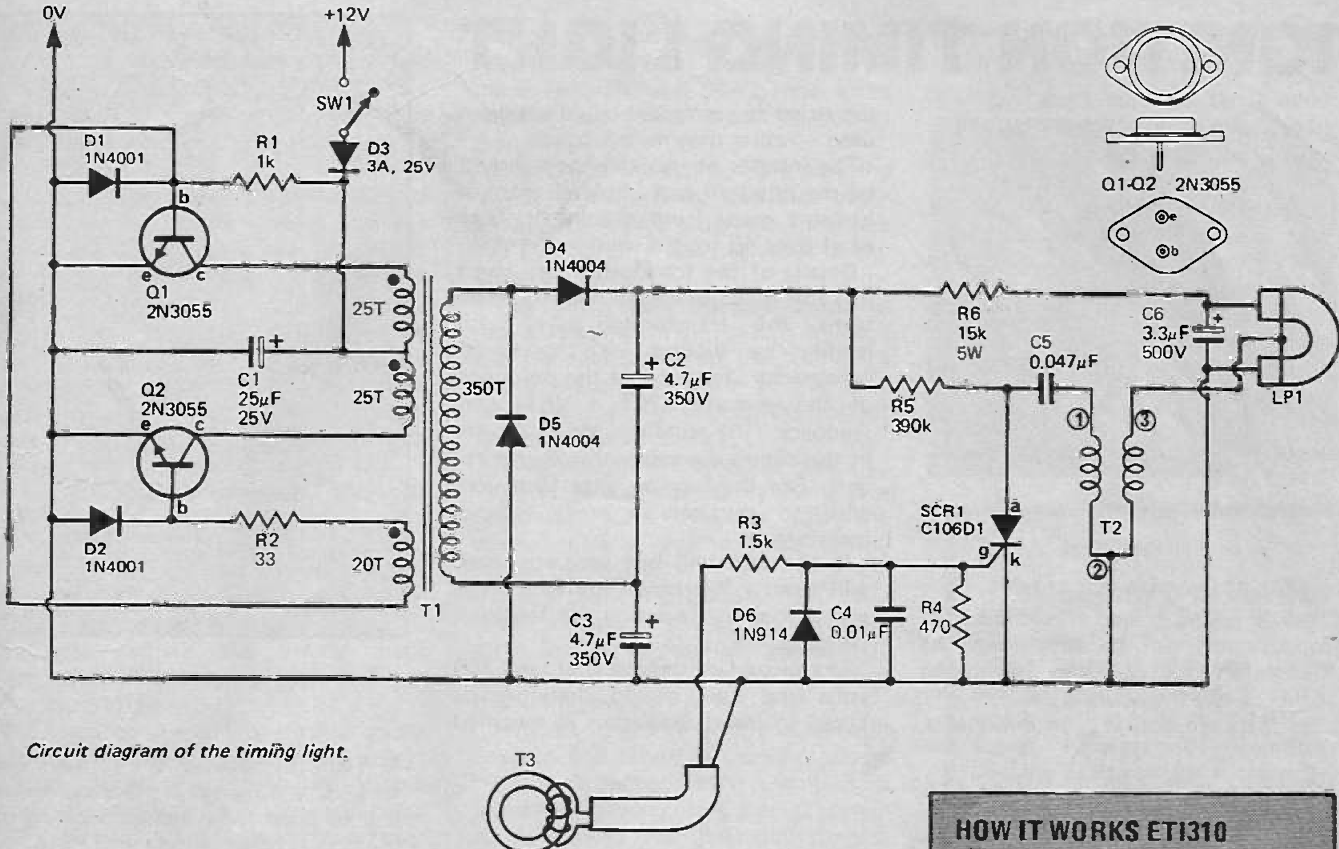


The completed electronics of the timing light. Note that diode D3 is mounted on the rear of the switch assembly and C6 on the rear of the reflector.

CONSTRUCTION

The layout and construction of the timing light will vary depending on the housing.

We purchased a cheap torch which



Circuit diagram of the timing light.

TABLE 1. Transformer Winding Details

WINDING	TURNS	GAUGE	NOTES
Primary 1	25	24 s.w.g.	Bifilar wound
Primary 2	25	24 s.w.g.	
Feedback	18	30 s.w.g.	
	0.01" insulation between primary and secondary windings.		
Secondary	350	30 s.w.g.	

For those readers wishing to use a ready-made transformer specifically designed for this project, ETI have made arrangements with R.C.S. Products Ltd, 31 Oliver Road, London E.17 for the supply of these at £2.37 including VAT and postage.

TABLE 2. Transformer Winding Details
Wound on Ferrite Ring, 1" inside diameter (Mullard FX1588 or similar). 20 turns of the inner of screened audio cable. Details in text and photo.

Arrangements have been made with Henry's Radio (Disco), 303 Edgware Road, London W.2 for the supply of the Xenon flash tube (ZFT-8Z) together with the ~~Trigger Transformer T2~~ for the reduced price for ETI readers of £4.84 including VAT and postage. The ZFT-8Z is slightly different to that shown in the photographs but the mounting method described still applies.

X wc 1) 3·3 uF 500V CAP

SPECIFICATION

Energy per flash	0.2 joule
Maximum flash rate	>50/sec (6000 rpm)
Trigger method	current transformer on No 1 spark lead.
Input voltage	10-14 volts dc

HOW IT WORKS ETI310

The flash tube used requires a supply of 300 to 400 volts. This is obtained by stepping up the vehicle 12 volts supply by means of an inverter.

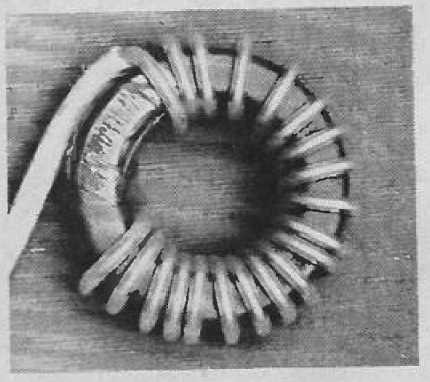
Transformer T1, together with transistors Q1 and Q2 form a self oscillatory inverter. The frequency of operation, 2 kHz on 12 volt supply in our case, is primarily determined by the core material, the number of primary turns and the supply voltage. Protection against reversed supply leads is afforded by diode D3.

Output from the secondary of T1 is voltage doubled by D4, 5 and C2, 3 to provide about 350 volts dc which charges C5 via R5.

The pickup coil T3, which is fitted over number one spark-plug lead, generates a pulse when the spark plug fires and draws current through the lead. This pulse is used to trigger SCR1 into conduction thus discharging C5 into the pulse transformer. The secondary of the pulse transformer provides a high voltage pulse, to the trigger electrode of the flash tube, causing the gas to ionize. The tube becomes a low resistance and C6 discharges through the tube providing the flash energy. Whilst the flash tube is in a virtual "short circuit" condition, current from the inverter is limited by resistor R6.

When capacitor C6 is fully discharged, the tube reverts to a high impedance allowing C6 to be recharged via R6. The current in R5 is not sufficient to hold SCR1 on and it too ceases to conduct. The maximum flash rate is in excess of 50 per second corresponding to 6000 RPM on a four cycle engine.

IGNITION TIMING LIGHT



How the transducer is made.

takes four HP-2 batteries.

Our layout and method of construction can be seen from the illustration but this can readily be varied to suit the housing used.

As there are only a few components, tag strips or veroboard could easily be used — rather than matrix board.

The inverter power transistors should be mounted on, but insulated from, a heatsink made from aluminium sheet of at least 40 square centimetres area.

Details of the transformer are given in Table 1. As there are relatively few turns, this transformer may quite readily be wound by the home constructor. Ensure that the polarities of the primary (25T + 25T) and feedback (18) windings are as shown in the circuit diagram - this is important! See the box on page 19 if you wish to purchase a ready wound transformer.

If the unit will not oscillate, (you will hear a 2 kHz whistle when it is oscillating) try reversing the feedback winding.

The secondary voltage is around 350 volts and care should therefore be taken to insert insulation as specified in Table 2, between the primary and secondary windings in the transformer, and to keep the windings separate on the matrix board.

PARTS LIST
Ignition Timing Light ETI 310

R1	Resistor	1k	½ watt 5%
R2	"	33	5 watt 5%
R3	"	1.5k	½ watt 5%
R4	"	470	½ watt 5%
R5	"	390k	½ watt 5%
R6	"	15k	5 watt 5%
C1	Capacitor	25µF	25 volt electrolytic
C2,3	"	4.7µF	350 volt electrolytic
C4	"	0.01µF	polyester
C5	"	0.047µF	400 volt polyester
C6	"	3.3µF	500 volt electrolytic
Q1,Q2	Transistor	2N3055 with mounting kit.	
D1,2	Diode	1N4001 or similar	
D3	"	3A, 25V silicon	
D4,5	"	1N4004 or similar	
D6	"	1N914 or similar	
SCR1	SCR	C106D1 or similar	
T1	Transformer (see table 1)		
T2	Pulse transformer (Henry's Radio)		
T3	Pickup coil (see table 2)		
LP1	Flash tube	ZFT-8Z (Henry's Radio)	

Reflector box, aluminium heat sink etc. see text.

The reflector of the torch may be modified to house the flash lamp in the following manner.

Remove the existing socket, using a pair of pliers or cutters, and file the opening until it is large enough to accept the flash lamp with about one millimetre clearance all round.

Insert the lamp from the front and use modelling clay at the rear of the reflector to hold the lamp and seal the opening. Then pour quick-dry epoxy cement into the reflector until there is sufficient around the base of the tube to secure it in place. Be careful not to get epoxy elsewhere on the reflector. When dry, remove the clay and use more epoxy to fill any recesses in the rear.

If and when the tube is to be replaced a hot soldering iron may be used to destroy the epoxy thus permitting removal.

The discharge capacitor, C6, should be mounted on the rear of the flash-tube/reflector assembly as shown in the photograph. Note also that we mounted diode D3 on the rear of the torch switch assembly.

The transducer is wound on a toroidal ferrite core, as shown in the photograph, using screened audio cable as follows. Remove about 0.8 metres of the inner cable from its shield and wind 20 turns of this around the ferrite core. Then solder the end of the inner conductor to the screen thus creating a complete loop. Finally tape up the whole assembly as shown in the photograph.

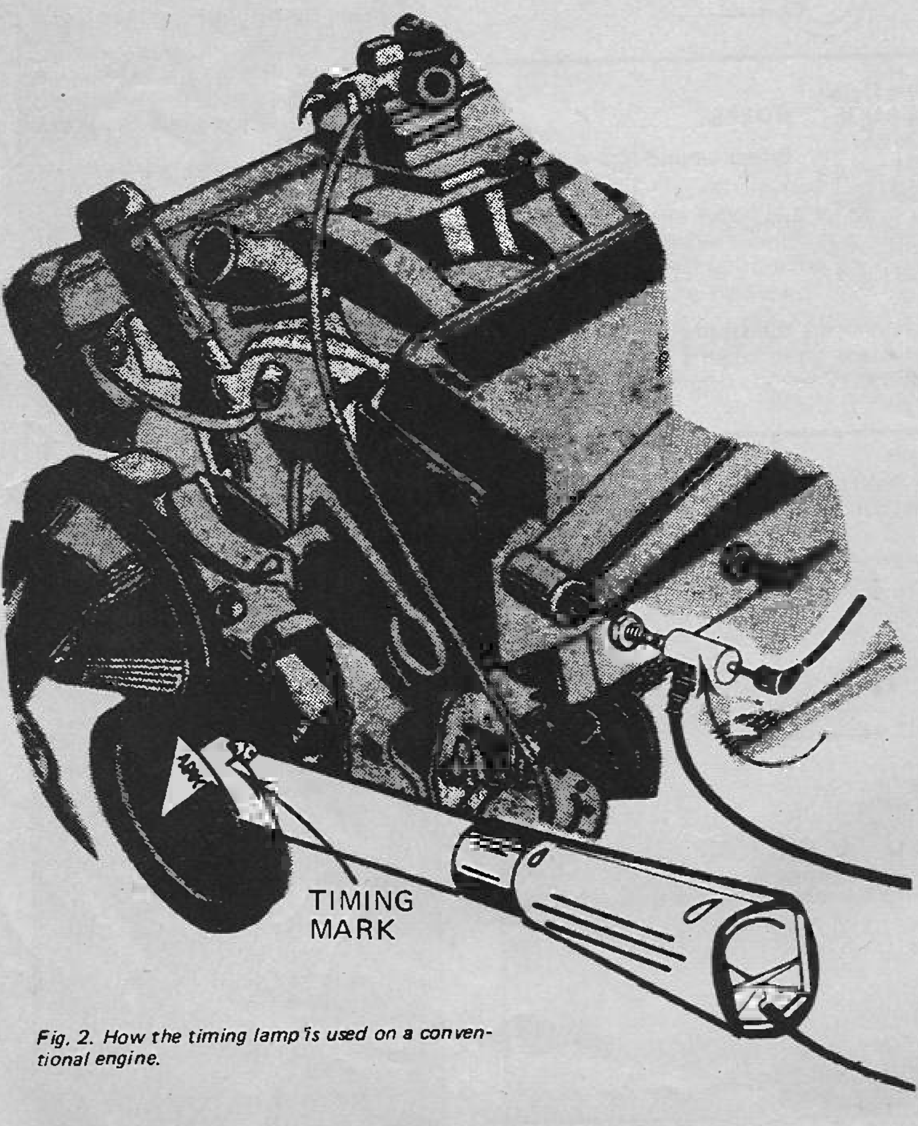


Fig. 2. How the timing lamp is used on a conventional engine.

USING THE TIMING LIGHT

To time an engine, first establish the position and *significance* of the ignition timing mark. This information will be found in the manufacturer's handbook.

The timing mark — usually displayed as an engraved '0' or straight line — is generally located on the crankshaft pulley or occasionally on the engine flywheel.

On nearly all modern cars the timing mark is engraved the appropriate number of crankshaft degrees before TDC. Certain others have a complete scale starting at TDC and extending to 40 degrees before TDC.

A few vehicles have the mark at TDC.

Some form of pointer will be found attached to the engine block — or flywheel housing — to act as a datum point for the timing mark.

Except where the timing mark indicates TDC only, ignition timing is a simple affair.

Firstly clean off any dirt or grease that might obscure the timing mark, then connect the timing light power leads to the vehicle battery and place the pick-up transducer over number one spark plug lead. Now start the engine.

The light should flash — note that the transducer produces more stable flashes with one side facing the engine block than the other. Establish which is the best way and mark the transducer accordingly.

Remove the rubber pipe to the vacuum advance mechanism (if fitted) and set engine tick-over to the speed recommended in the vehicle handbook. (If you don't have a rev counter set idling speed to lowest possible).

Now shine the timing light onto the timing mark. With the distributor clamp loosened slightly, slowly rotate the distributor a few degrees in either direction.

The timing mark will now appear to move relative to the datum pointer. Set the distributor so that the mark aligns exactly with the pointer and retighten the clamp once the correct setting has been obtained.

A very similar method is used for vehicles where the timing mark is a calibrated scale. In this case the manufacturer's recommended setting should be used.

Where the mark indicates TDC only it is necessary firstly to place a chalk mark at the appropriate number of degrees before TDC and to use this as the timing mark.

A quick check that the automatic advance and retard is working can be made by speeding up the engine. If all is well the timing mark should appear to move away from the datum pointer as engine speed increases.

If the timing mark appears to oscillate to and fro by more than a degree or so this is an indication that the timing is actually changing in this fashion. This is a fault generally caused by a worn distributor spindle, and/or sloppy drive to the distributor offtake.

Remember to re-connect the vacuum line when timing is completed. ●

WARNING

On some cars the fan blades rotate close to or at a multiple of the crankshaft speed. When strobed by the timing light, the fan may appear to be stationary or rotating slowly.

This is common to all strobe light timers and failure to remember this can result in serious personal injury, or a wrecked timing light.

ALWAYS — keep well clear of the fan.

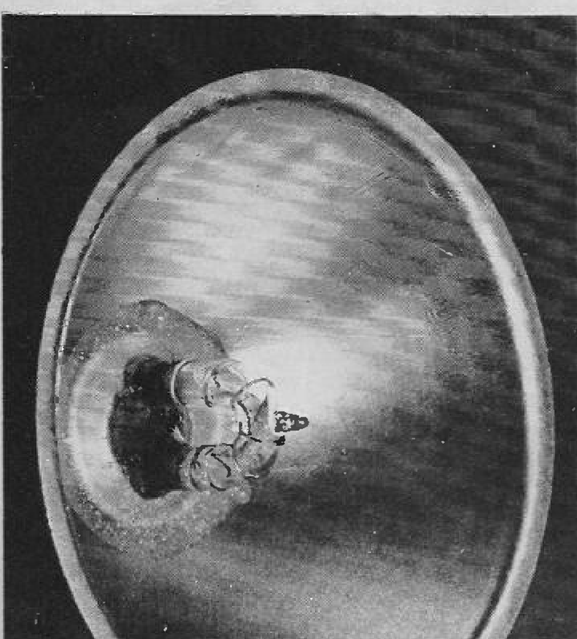
NEXT MONTH

A more complex version of this timing light will be described in ETI in the near future.

This more advanced unit incorporates a calibrated delay which indicates on a meter the actual degrees of ignition advance at any engine speed.

This not only allows very accurate timing to be obtained regardless of the timing mark form of indication, but enables the serious motoring enthusiast to check out the complete distributor advance curve.

The more advanced unit uses all parts specified for this month's project. Why not build now and update later!



◀ *Method of mounting the flash tube in a torch reflector with epoxy resin glue.*

A typical method ▶ of marking top dead centre on the crank-shaft pulley.

BYTING THE SCENE

. . . optical data digitizers enable computers to communicate with visual scenes. Dr. Sydenham reports on the latest developments.

TECHNOLOGICAL progress is very much controlled by our ability to communicate with computers. Although there is still a long way to go with the use of computers themselves, a lot more can be achieved with given computing power if the data describing the real-world process can be obtained in a signal form that is compatible with computers and at a rate that suits the high-speed capability of modern machines.

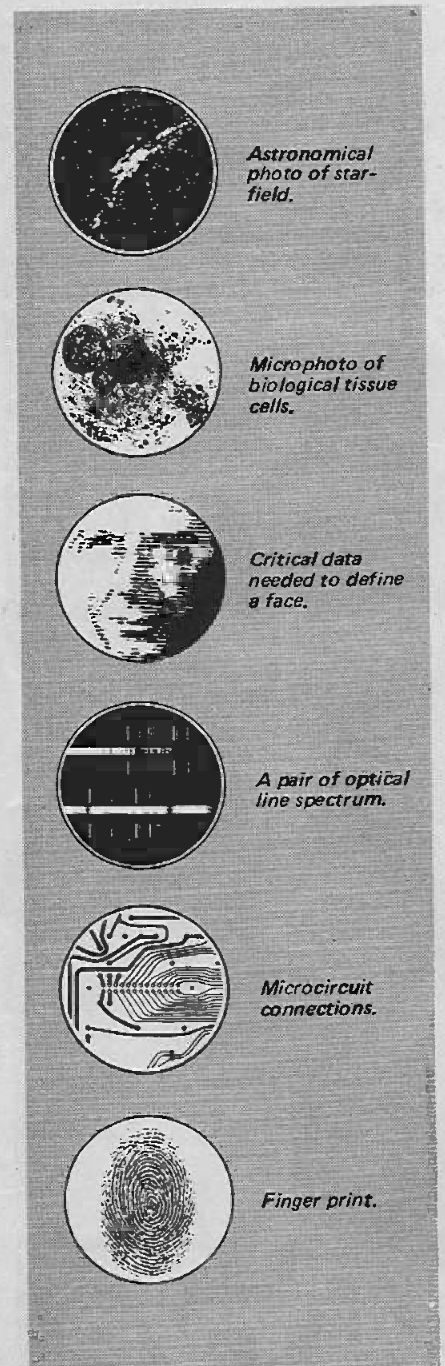


Fig.1. Images come from many sources.

THE NEED TO TAKE BYTES

It is now old hat to converse with the computer through punched-paper cards, paper tape and magnetic tape interfacing. These media are quite satisfactory for many applications . . . data input for complicated scientific calculations, for payrolls and accounts, for statistical calculations and the like . . . for there it does not really matter if the work is performed sometime after the event to which the data pertains.

There are, however, many processes that need immediate data processing as the related events occur. If the process is already instrumented to provide equivalent electrical signals these can be fed into a computer . . . used solely for this one purpose (known as a dedicated computer) one of the many commonly used minis or special purpose units . . . via the appropriate interface circuitry. The majority of transducers outputs occur in analogue signal form so the need is usually for analogue-digital converters that provide equivalent digital signals ready for use by the computing machine. Such a generated sequence of adjacent binary digits are called (in computer jargon) bytes; several bytes form a computer 'word'.

One class of process that constantly crops up as needing conversion to digital bytes is the two-dimensional (and three dimensional but less often) scene or picture, the latter being a permanent record of transient scenes. It is beyond our resources to list the areas of application in detail (see Fig.1) for they must surely run to thousands. To illustrate the need here are just a few well-defined uses for optical data digitizers (ODD's for short).

Astronomy — Astronomical observers use telescopes to catch 'pictures' of phenomena in space.

These may be photographs (visible and other wave-lengths) of star fields for mapping purposes; spectroscopic line sets formed by dispersing the radiation received from a chosen region; galactic radio signal intensities transposed into two-dimensional chart record or CRO pictures.

Once the data is procured in this form it then needs to be processed to extract the information sought.

A few decades ago, visual examination, with the aid of special purpose measuring machines, was regarded as the most satisfactory way to process the pictures, for their rate of production was relatively slow. In these times computing ability is such that machines can consume data at enormous rates . . . if they can be fed fast enough. Astronomers operating in large teams employ computers in force, so techniques that produce bytes from scenes are indeed valuable provided they have the desired speed and accuracy capabilities. An astronomical group at Cambridge University is currently developing a system that can process 10 000 000 images a day!

Medicine — even though this discipline seems far removed from astronomy, similar basic techniques are required.

It is not so long ago that the best way to take a blood count or to analyse and classify biological cells was to make a slide for the microscope and laboriously observe it by eye for considerable periods.

Today we can do a lot better although, of course, the cost prevents everyone from having sophisticated optical data digitizers that can characterize criteria of cell count, shape, colour, fluorescence and movement.

Many of the 'visual' processes used in medicine are limited in usefulness by the allowable exposure time for the radiation used. Over-doses of radiation, X-rays and ultrasonics will cause permanent damage, so the length of time spent obtaining and studying the picture produced must be kept short unless the brightness of the display can be enhanced by external means . . . image intensifiers etc.

By storing the two-dimensional picture in a computer as it is produced, the exposure time can be reduced in certain modes of use and the picture can then be restored at the will of the diagnostic operator. ODDs can play a part in this task.

Spectroscopy — when substances are made gaseous they emit or absorb the various wavelengths of radiation — to varying extents. By studying this process the composition of the substance can be broken down into the elements forming it . . . this is spectroscopy.

Today analysers can be deployed with on-line processes; gases from exhaust stacks that need monitoring; metals in a refinement process to be checked; chemicals in production and air to be tested for purity. The task of identifying the composition from the special line 'code' is laborious, so human methods tend to include error. Furthermore the human eye and brain system is often not fast enough, nor accurate enough, for the task. Optical data digitizers can act as the interface between the optical spectrometer and the computer.

Criminology — Spectroscopy and bio-chemical analysis form the main part of the modern forensic scientist's toolkit but there are many, relatively new, areas where ODD could become invaluable.

Finger-print identification is one such. The usual method is visually to compare the matching of the many prints found at the scene of the crime with those held in the police record files. This can take a considerable period and faster methods are being studied. One method makes use of direct optical correlation using Fourier methods, another the use of computer matching. Every minute that the criminal is not identified is valuable, for tracing him becomes more difficult as time proceeds. Similar arguments apply for the matching of photographs and Identikit buildups. The detection limits are not set by intrinsic computer ability but by our ingenuity at programming and data conversion.

Interpretation of photographs — Quality photographs contain an enormous amount of information but most of it is redundant for normal purposes. Optical data digitizing methods enable this to be studied in an attempt to extract the vital data relevant to the experiment being performed. The versatility of the centralised computer on an ODD system design enables many different transfer functions to be used. Fig. 2 shows a few treatments of the same basic portrait photograph.

In bubble-chamber research, high energy particles under study are made to form vapour trails in a volume of gas. These trails are photographed in plane and stereo for further study.

CERN, in Europe, produces millions of these bubble-chamber photographs each year and each one has to be analysed for track direction, branching, length, brightness, and location in the vapour chamber. Clearly, as with star-plate reading, the task is laborious and operators are assisted where finançe permits with automatic ODDs.

Inspection — Any process that uses human inspection is prone to error for no one can maintain 100% inspection accuracy for long. Our biological optical data transducer is just not up to it! It is however, an easy task for an ODD to seek out and detect disconnects in a micro circuit with extreme reliability.

Printing — The above examples are mainly concerned with measurement problems but here is one closer to most of us . . . the composition of pages in magazines and the like. A system on sale today, (see Fig.3), enables the editor to feed characters, symbols, art shapes, galley copy, and even illustrations of line or half-tone form into a mini computer using an ODD input facility. Once there, software is used to instruct the output film-writer to arrange the page as a complete unit with all words and pictures balanced within the required format. In the publishing world it is common practice to use typewriters that justify (or stretch) the words to just fill the line, but pictures must be photographically doctored to obtain the size needed for a given space. This computer based method does away with this for the programme automatically decides the final size of the rewritten pictures. It can also be used to remove sections of the picture and filter out noise to clean it up. The page produced by the film writer is directly ready for offset printing thus eliminating the stage known as pasting up wherein each page is carefully composed by sticking the text, illustrations and adverts into the page format. The film-writer unit offered can put down 60,000 points each second so it only takes a matter of minutes to write out a complete page once the computer has been fed with basic data.

Although few such systems are in use as yet they clearly are turning

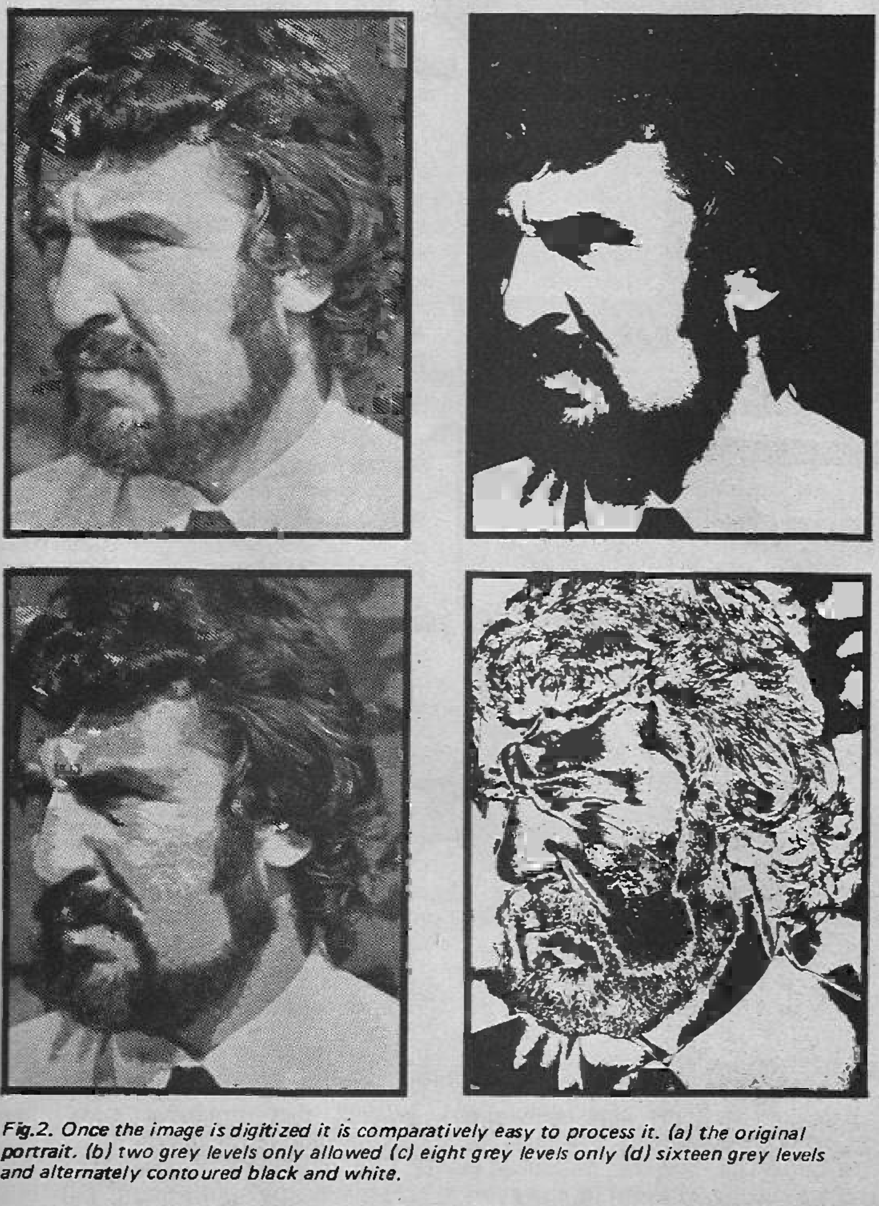


Fig.2. Once the image is digitized it is comparatively easy to process it. (a) the original portrait. (b) two grey levels only allowed (c) eight grey levels only (d) sixteen grey levels and alternately contoured black and white.

BYTING THE SCENE

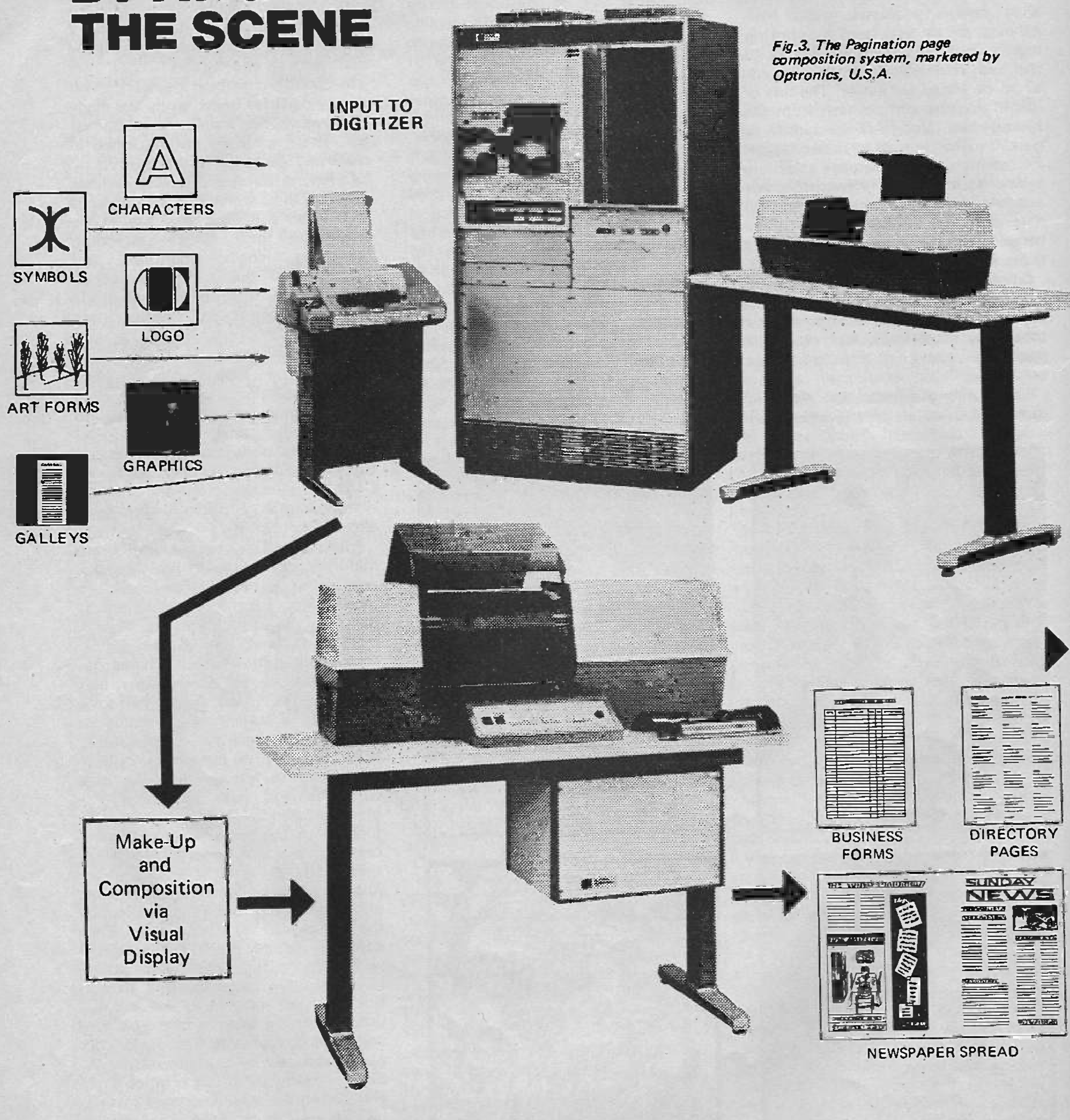


Fig.3. The Pagination page composition system, marketed by Optronics, U.S.A.

yesterdays fantasy into todays reality.

So much for where ODDs can be used; now to a quick look at what the state of our knowledge tells us about the workings of the human system.

THE BIOLOGICAL OPTICAL DATA DIGITIZING PROCESS

In hardware terms, the human eye consists of an automatic lens system that provides focussing, an automatic iris to stop down the light intensity and a detector matrix on which the image of the scene is formed (upsidedown). The system design is given in Fig.4.

It is hard to know what really goes on in the brain for there is little to see. The retina can, however, be looked at and we know a lot about its operation. It consists of many individual sensor elements that stand perpendicular to the retinal surface. These come as rods or cones and are shaped as the names imply. They see radiation colour and intensity by an electro-chemical process that produces signals for transmission to the brain.

The signals generated are predominantly pulse-trains but this

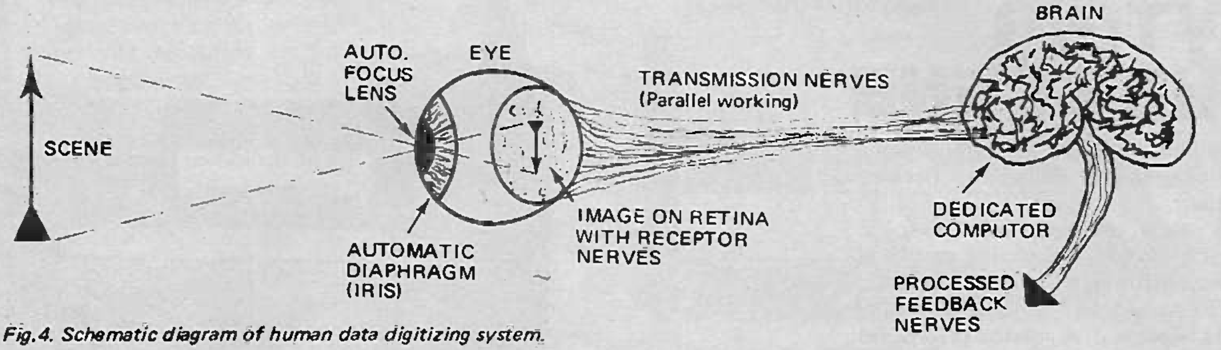


Fig.4. Schematic diagram of human data digitizing system.

simple concept might be misleading, for the signals are really quite complex. There are about 20 000 000 receptor nerves in the human retina and these paralleled channels feed to the brain via some 2 000 000 outgoing nerves. (How's that for parallel working!)

Other 'facts' (but much is still conjecture) about the human ODD system is that 1% of the 10^{10} neurons (the brains digital storage elements) are dedicated to *seeing* processes and that 60% more help on a time-sharing basis. It has been estimated by one person that the eye can transmit information to the brain at 4 000 000 bits per second. (There are several bits in a byte). Another research worker estimates the figure to be 1 000 000 000 bits per second if the illumination level is high. To give some idea of what these figures mean, this is more data than is contained in a t.v. picture but less than in a cinema screen frame.

Colours are differentiated by the cone detectors which are found mainly in the centre of the retina. Retinal acuity is greatest in the centre.

Looked at this way the human ODD is rather fantastic but for all of its apparent power it is not reliable enough for many of our desired tasks and lacks acuity. The best it can do unaided is about 0.5 minutes of arc resolution.

OPTICAL VERSUS MECHANICAL METHODS

Classification of optical digitizing systems can be made on many different criteria. For instance, they can be divided into those that view images in free space and those that look at permanent images on some form of media . . . photographs, films and chart plots.

In each, there is always a need to provide the two-dimensional information as a serial signal. (Systems do exist that read out the data in parallel channels but they are still in their infancy compared with serial methods). The human ODD operates in parallel. Most of our own devised techniques, however, read out the data bit by bit in sequence, using some form of repetitive scanning motion.

This scanning process largely controls the capability of the now many different means of digitizing images. Each has its merits and disadvantages and no one method is superior in all ways to the others.

MECHANICAL METHODS OF SCANNING

In all methods an image of the scene is formed by an optical system. This scales the scene to the appropriate size ready for scanning. This stage may, or may not, be incorporated in the scanner unit; it depends on the application. A very small part of the total image is then sampled with a sensitive radiation detector; photomultiplier tubes, silicon photocells, phototransistors and many options exist. The thing to note is that these detectors can sense the amplitude of radiation but cannot give information about its spatial qualities. To cover a two-dimensional scene the detector is made to move relative to the image, with some form of scanning arrangement such as those illustrated in Fig. 5.

The scanner can have many forms. It may use a combination of two mirrors or mirrored drums that nod or rotate continuously (Fig. 5a), another

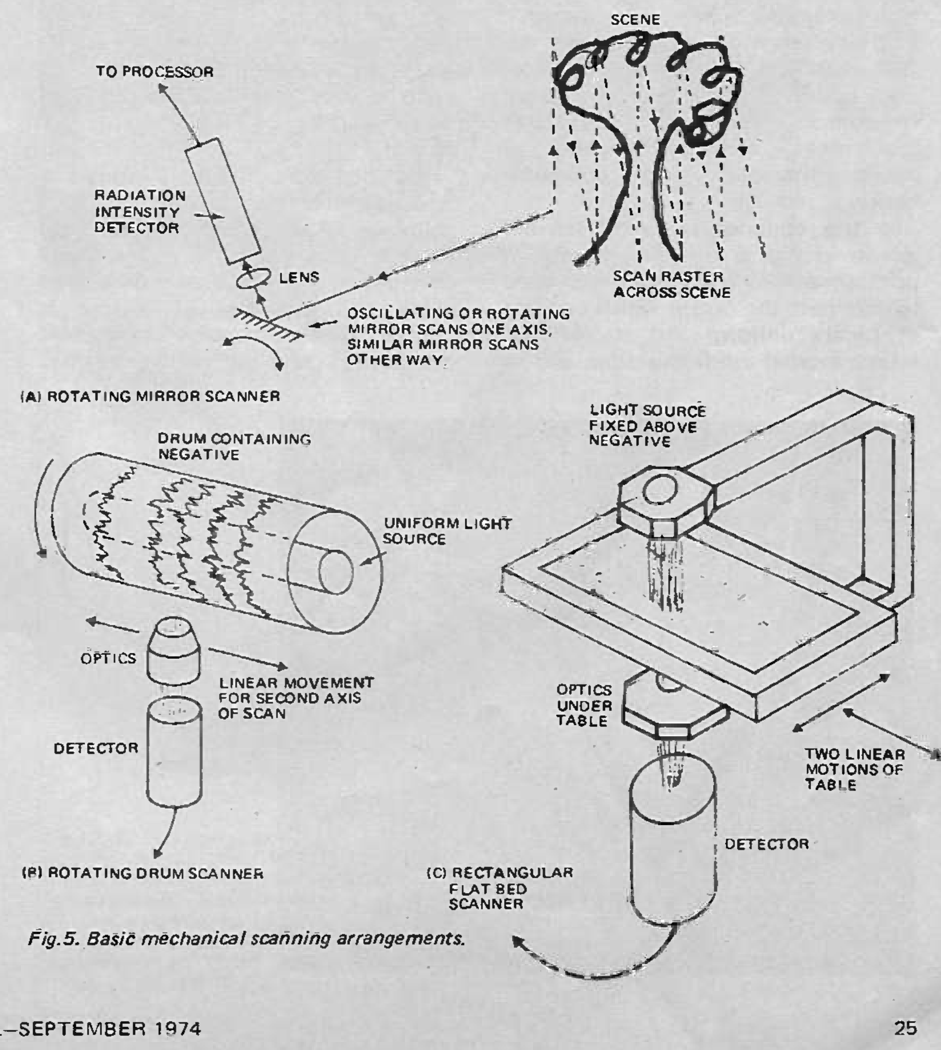


Fig.5. Basic mechanical scanning arrangements.

BYTING THE SCENE

method uses straight X-Y translations (Fig. 5c), this is called the flat-bed processor.

One early method uses a spiral scanning motion and similar to this is the, now historic, Nipkow disk scanner used in early television developments. As the Nipkow disk rotated (at around 8000 rpm) the scene to be scanned was viewed by a photocell through a series of minute holes drilled through the disk in the shape of a spiral. As the disk moved around, the scene was progressively sampled by the holes each one being a little higher than the previous one. At the end of each scan the next scan repeated the process. There were considerable difficulties of technology in their design for the data rate needed for the (then) smallest holes possible required the disk to run at a speed close to flying apart . . . the viscous drag alone produced significant heating of the disk so it was contained in an evacuated enclosure that also acted as an explosion shield. It was far from the portable t.v. cameras of today!

Mechanical systems now can provide high raster scan speeds, wide dynamic intensity range cover and, above all, the ultimate in positional accuracy. They are, in principle, highly accurate controlled movement inspection machines combined with a microdensitometer and computer backing.

In the commercial drum scanner shown in Fig. 6 the film negative is positioned on the drum. It then rotates past the optics which consists of highly uniform and stable light source located inside the drum and an outside photodetector that sees a tiny section of the film through the optical objective (seen in the middle lower part of the unit).

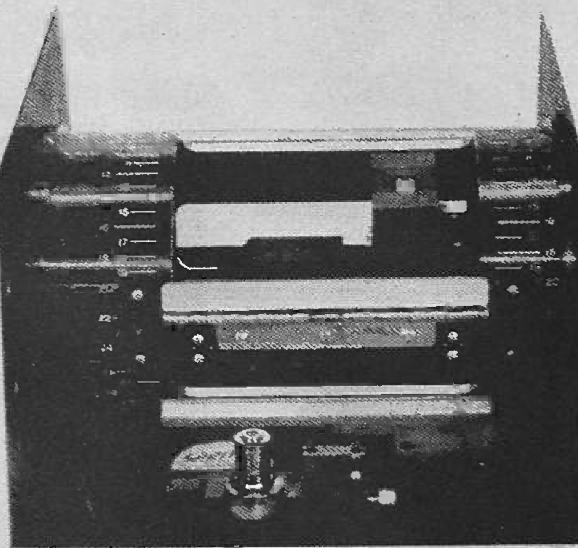


Fig.6. Rotating drum scanner.

The signal is then converted to 256 levels of greyness and finally digitized ready for display, recording or computer interfacing. After each complete revolution of the drum the cross-slide is incremented across by one scan resolution width. In this way the second dimension of the picture is recorded. Signals are synchronised by a shaft-angle encoder that is driven from the scanner-drum shaft. Such systems can resolve 10 micrometre dots, sampling at 60 000 points per second.

Flat bed units, (Fig. 7 shows a micro-densitometer that can be coupled to a mini-computer) also move the image past the optics. These generally are capable of finer detail . . . a spot size of 300 nm is quoted in one manufacturer's sales literature . . . and can resolve greyness to 1024 levels at rates of 1000 points per second. The most recent designs incorporate laser interferometers for positional control and measurement. It is probably clear that the sensitivity largely depends upon the detector used, but in general if integrational methods are used to enhance the radiation sensitivity there must be a corresponding loss of time-response.

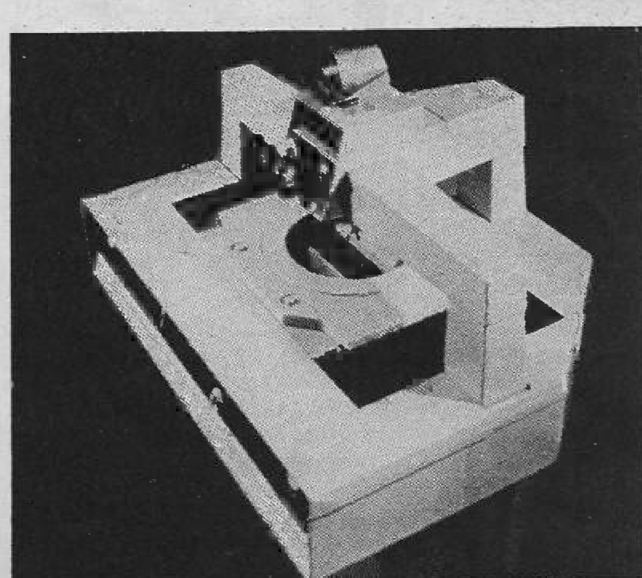


Fig.7. This Joyce-Loebel scanning microdensitometer is of flat-bed design.

ELECTRO OPTICAL METHODS OF SCANNING

The general feeling is that a system devoid of moving mechanical parts is superior in the long run, for less faults can develop. There are a number of devices that can scan an image using electro-optical techniques but in general these are unable to match the accuracy of mechanical counterparts. On the other hand they are smaller, lighter, more robust and have greater flexibility of use.

Figure 8 shows the schematic block diagram of a typical optical data digitizer that uses electro-optical principles. The input image impinges on the faceplate of a sensor. The illumination level on the target of the sensor is read off with electronic methods, point by point, as a continuous scan process. The intensity function detector provides a signal to the encoder that converts it into the appropriate computer-compatible digital signal, binary in the case shown. The computer, in this system, has the ability to drive the scanner deflection system in any way that is desired. For example, if the computer decided there is a particular part of the image that needs more carful attention it can cause the scan to cover that area only, ignoring the rest of the image. Packaged, the unit couldn't look more like a theoretical black box — Fig. 9!

Way back in the sixties, there was considerable general interest in television trackers for tracking missiles in flight. The operator viewed the scene in real-time watching for targets. Once a target was identified on his monitor he placed what are called gates around the missile. These were, in fact, signals that told the computer to recognise the image contained in a small area of the total area and hold the anti-missile onto this target and no other. These are still current in military warfare but now they can handle many targets at once remembering which are 'friend' and which are 'foe'. Figure 10 shows a recently 'released' unit.

A number of sensors can be used, the most common being based on the vidicon principle. In these the target acquires charge in proportion to the light intensity falling on it. The charge magnitude at each point on the target is read out by monitoring the beam current of an electron beam generated by an electron gun. The beam is deflected by electrostatic or electromagnetic fields to scan across the image charge-pattern in the required manner.

The choice of sensor depends upon the image needs . . . is it transient and, therefore, requires high speed data capability, or is it very low in intensity such as for seeing in the night, or, does the system need maximum available spatial resolution? The outcome will be a compromise. Image dissector sensors can resolve to 2048 by 2048 elements, addressing a small step in 2 micro-seconds and seeing light levels of 5-50 footcandles. Silicon vidicons, (a vidicon with enhanced sensitivity) can see down to 3 10^{-5} foot candle seconds (the sensitivity depends on the integration time used) and the silicon-intensified vidicons can go three orders of magnitude better than this. Generally, however, the more sensitive the tube the more likely the chance of damaging the target with ambient light.

In all cases the best accuracy of electro-optic scanners is around 2%, with repeatability a little better, so it is clear that these do not compete with mechanical ODDs where the best can provide only 0.0001% error. On the other hand random access can be made in the electro-optical methods in about 50 microseconds; the inertia of the necessarily rigid slideways and drums of mechanical scanners does not allow speeds such as this to be obtained.

No doubt you can see numerous uses for optical data digitizers and it is not hard to see that they will be used more and more as time goes by. Our computing capability is advancing at least as fast as our inputing capability so there will be no slackening in demand for cheaper, faster, lighter and more robust ODDs. ●

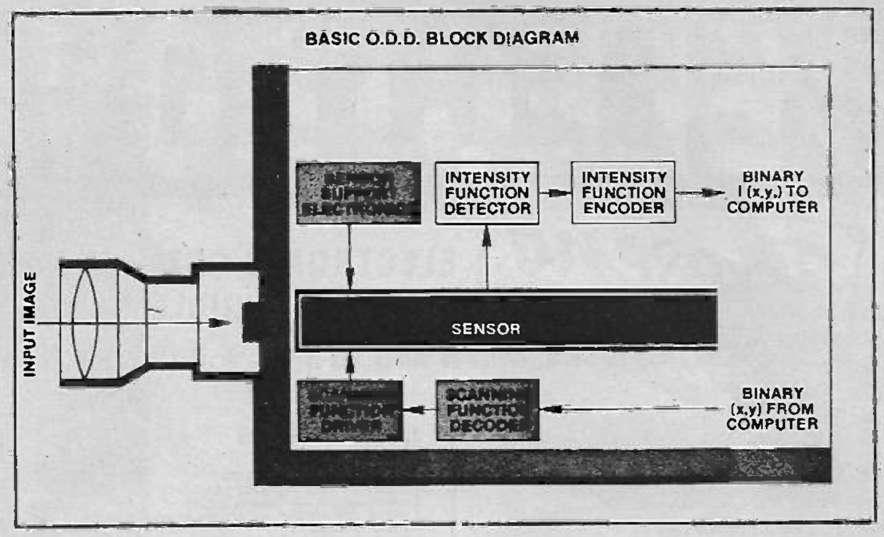


Fig.8. Basic optical data digitizer block diagram.

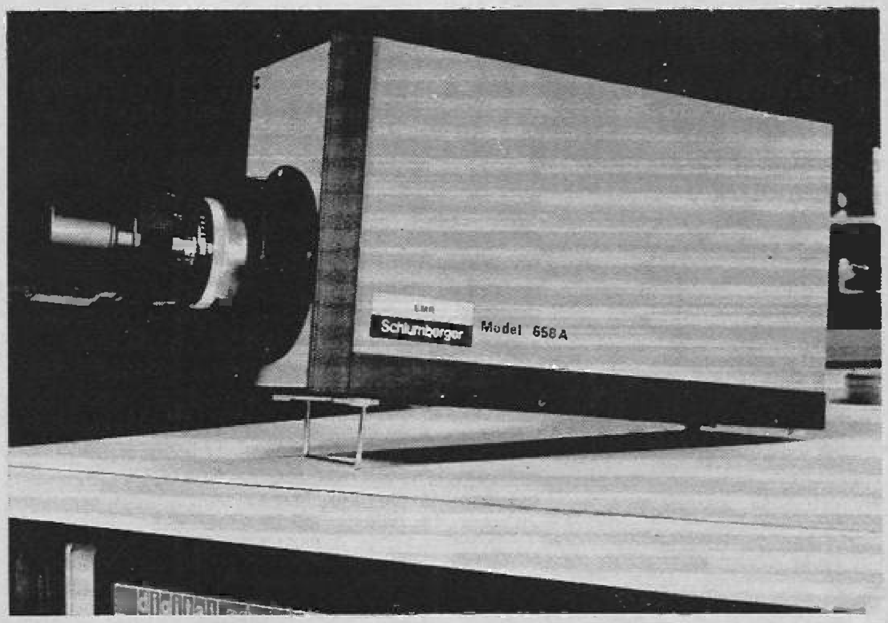


Fig.9. Electro-optical data digitizers contain no moving parts. This unit is intended for use with the mini-computer it is sitting on.

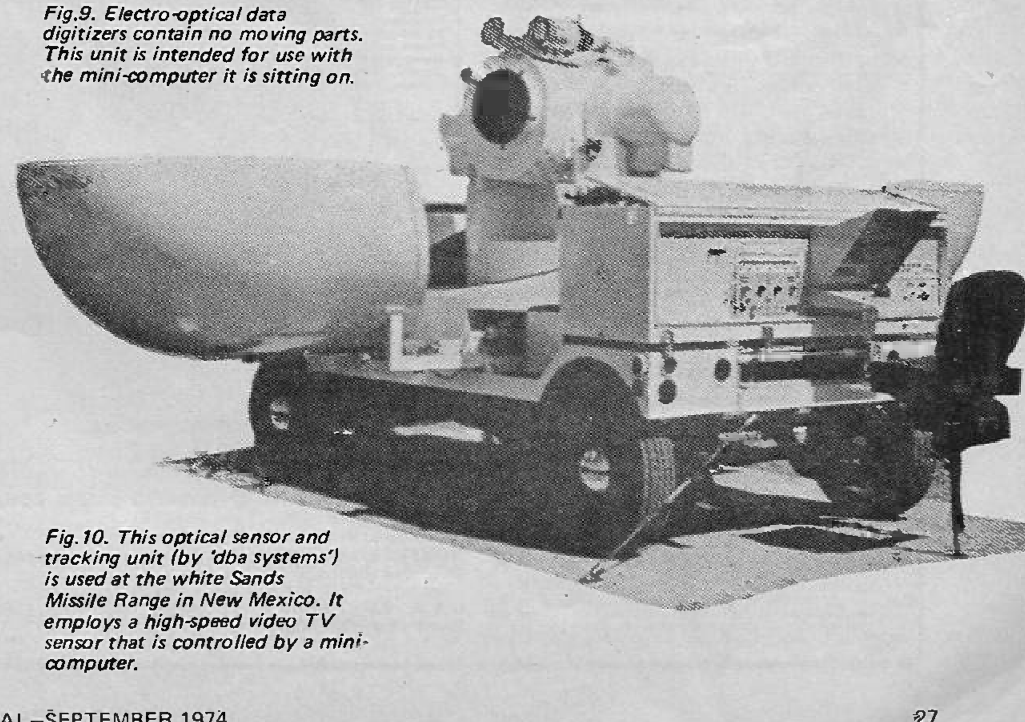


Fig.10. This optical sensor and tracking unit (by 'dba systems') is used at the white Sands Missile Range in New Mexico. It employs a high-speed video TV sensor that is controlled by a mini-computer.

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I.C.s

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Suitable BCD decoder driver 7447 **£1·15**
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CAPACITORS
POLYESTER C.280

Radial leads for P.C.B. mounting. Working voltage 250V d.c.
0·01, 0·015, 0·022, 0·033, 0·047 ea. **3p**
0·068, 0·1, 0·15 ea. **4p**
0·22, **5p**; **0·33, 7p**; 0·47, **8p**; 0·68, **11p**; 1·0, **14p**; 1·5, **21p**; 2·2, **24p**

TANTALUM BEAD
0·1, 0·22, 0·47, 1·0 mF/35V, 1·5/20V ea. **14p**
2·2/16V, 2·2/35V, 4·7/16V, 10/6·3V ea. **14p**
4·7/35V, 10/16V, 22/6·3V ea. **18p**
10/25V, 22/16V, 47/6·3V, 100/3V, 6·8/25V, 15/25V ea. **20p**

POLYCARBONATE
Type B32540 Working Voltage—250V d.c.
Values in mF: 0·0047; 0·0068; 0·0082; 0·1; 0·012; 0·015 ea. **3p**
0·018; 0·022; 0·027; **0·033**; **0·039**; 0·047; 0·056; 0·068; 0·082; 0·1 ea. **4p**

Working voltage 100V d.c.
0.1; 0.12; 0.15 4p; 0.18 5p; 0.22 **8p**
0.27 7p; 0.33 8p; 0.39; 0.47 **9p**
0.56 12p; 0.68 **13p**

SILVERED MICA
Working voltage 500V d.c.
Values in pFs—2·2 to 820 in 32 stages ea. **6p**
1000, 1500 **7p**; 1800 **8p**; 2200 **10p**; 2700, 3600 **12p**; 4700, 5000 **15p**; 6800 **20p**; 8200, 10,000 **25p**

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1000pF/500, 2000/500, 5000/500, 0·01mF/50; 0·02mF/50, 0·1mF/3—each 2p; 0·05mF/50V—3p

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P.20 SINGLE log. 4·7Kohms to 2·2megohms ea. **14p**
JP.20 DUAL GANG lin. 4·7Kohms to 2·2megohms ea. **48p**
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JACKS AND PLUGS
SOCKETS
2 circuit unswitched S1/SS **12p**
2 circuit 2 break contacts S1/BB **15p**
3 circuit unswitched (Not GPO) S3/SSS **17p**
3 circuit with 3 break contacts S3/BBB **20p**
2 circuit with chrome nut and black/white/red/green or grey unswitched S5/SS **15p**
with 2 break contacts S5/BB **20p**
Miniature 3.5mm 2 circuit, (black) 2 break contacts S6/BB **9p**

PLUGS
2 circuit screened top entry P1 **24p**
side entry SEP1 **38p**
Line socket mono 231 **40p**
Line socket stereo 244 **48p**
3 circuit unscreened, black/grey/white P4 **46p**
2 circuit, unscreened, black/white/red/black/green/grey P2 **18p**
3 circuit screen top entry P3 **53p**
side entry SEP3 **55p**
Miniature 3·5mm 2 circuit screened P5 **13p**
Miniature 3·5mm 2 circuit unscreened various colours P6 **10p**

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In moulded polypropylene, with nickel plate on brass. With insulating set, washers, tag and nuts. 15A/250V in black/brown/red/yellow/green/blue/grey/white. Type TP.1 ea. **14p**

DIN CONNECTORS

2 way loudspeaker	Socket 10p	Plug 12p
3 way audio	Socket 10p	Plug 12p
5 way audio 180°	Socket 12p	Plug 15p
5 way audio 240°	Socket 12p	Plug 15p
6 way audio	Socket 13p	Plug 15p

RESISTORS

Code	Watts	Ohms	1 to 9	10 to 99	100 up (see note below)
C	1/3	4·7–470K	1·3	1·1	0·9 nett
C	1/2	4·7–10M	1·3	1·1	0·9 nett
C	3/4	4·7–10M	1·6	1·2	0·97 nett
C	1	4·7–10M	3·2	2·5	1·92 nett
MO	1/2	10–1M	4	3·3	2·3 nett
WW	1	0·22–3·9Ω	11	10	8 nett
WW	3	1–10K	9	8	6 nett
WW	7	1–10K	11	10	8 nett

Codes:
C = carbon film, high stability, low noise.
MO = metal oxide, Electrosil TR5, ultra low noise.
WW = wire wound, Plessey.
Values: All E12 except C ⅓W, C ¾W, and MO ½W.
E12: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and their decades.
E24: as E12 plus 11, 13, 16, 20, 24, 30, 36, 43, 51, 62, 75, 91 and their decades.
Tolerances:
5% except WW 10% ±0·05Ω below 10Ω and MO ½W 2%.
Prices are in pence each for quantities of the same ohmic value and power rating. NOT mixed values. (Ignore fractions of one penny on total value of resistor order.) Prices for 100 up in units of 100 only.

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Full range E24 values: 400mW: 2·7V to 36V, **14p** each; 1W: 6·8V to 82V, **21p** each; 1·5W: 4·7V to 75V, **67p** each. 20W 7·5V to 75V **94p**. Clip to increase 1·5W rating to 3 watts (type 266F), 5p.
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CATALOGUE 7

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0·47	—	—	—	—	—	—	11p	8p
1·0	—	—	—	—	—	11p	—	8p
2·2	—	—	—	—	11p	—	8p	9p
4·7	—	—	—	11p	—	8p	9p	8p
10	—	—	—	—	8p	9p	8p	8p
22	—	—	8p	—	9p	8p	8p	10p
47	8p	—	9p	8p	8p	8p	10p	13p
100	9p	8p	8p	8p	9p	10p	12p	19p
220	8p	8p	9p	10p	10p	11p	17p	28p
470	9p	10p	10p	11p	13p	17p	24p	45p
1,000	11p	13p	13p	17p	20p	25p	41p	—
2,200	15p	18p	23p	28p	37p	41p	—	—
4,700	26p	30p	39p	44p	58p	—	—	—
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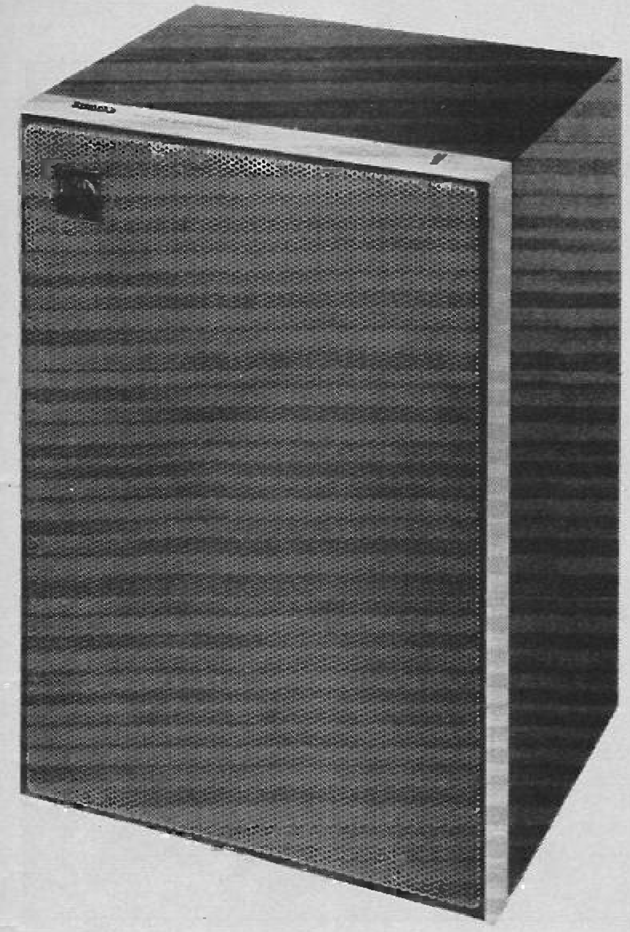
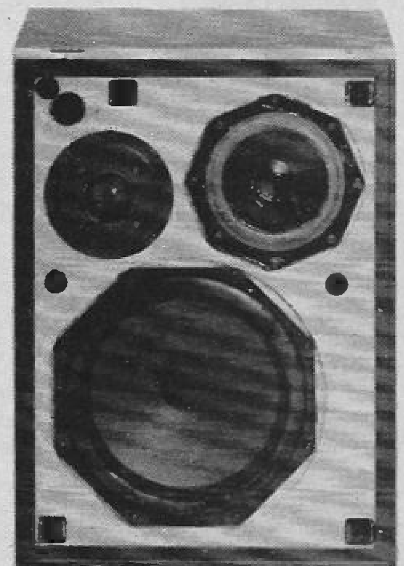
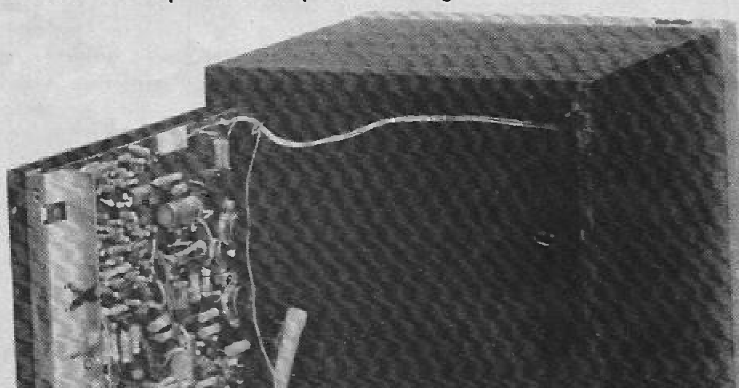


MOTIONAL FEEDBACK



Our January issue contained a short article describing Philip's Motional Feedback Loudspeaker.

The article attracted a great deal of reader interest and many people asked us for further details. Here then is the full story on this new concept in loudspeaker design.



Main amplifiers and associated power supply are housed on this swing-out panel at the rear of the speaker enclosure.

NEGATIVE FEEDBACK has been used to reduce distortion in audio power amplifiers since well before World War II.

It functions by feeding back to the input a small sample of the output signal. The feedback signal is in opposite sense to the input (180° out of phase) and hence opposes the input signal. Thus the overall gain of the amplifier is reduced substantially.

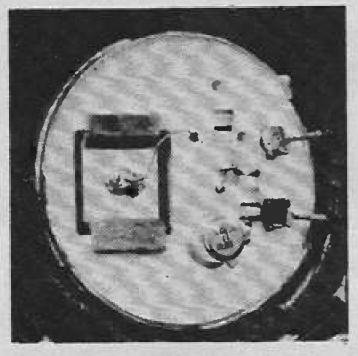
This loss in gain is more than compensated by three major advantages obtained by using feedback.

Firstly negative feedback tends to make the gain of the amplifier less dependent on the gains of the individual transistor stages within the amplifier, which can, and do change from device to device and with time. The bandwidth of the amplifier is also extended at both the low and high frequency ends.

Secondly, as the distortion components are also subject to feedback, they are reduced in the same proportion as the amplifier gain. Thus a power amplifier without feedback may have a distortion of 3%. With feedback this may well be reduced to 0.02% or less.

Thirdly, the input impedance is also increased by the same factor as the gain is reduced. Thus the operation of previous stages will be less affected by loading.

Thus the overall effect of feedback is to increase input impedance, increase bandwidth and reduce distortion.



This is the acceleration transducer — it is mounted at the apex of the bass driver speaker cone.

Although overall gain is also reduced, this can readily be compensated for in the pre-amplifier stages which are inherently less prone to distortion.

The use of negative feedback is absolutely essential with present-day amplifier technology — without it it would be impossible to reduce distortion to acceptable levels.

But in a conventional hi-fi system, negative feedback does not include within its 'loop' the very component that most needs it.

That is the loudspeaker.

Currently, the loudspeaker is very much the weak link in the hi-fi equipment chain.

HOW IT WORKS

The input signal to the enclosure is fed to an active high-pass filter and an active low-pass filter via the sensitivity switch SW2.

Both filters have a slope of 18 dB/octave.

The low-pass filter (base-emitter circuitry of Q1) passes signals from 35 Hz – 500 Hz. The signal is taken from the emitter of Q1 and then fed into a high-pass filter. This attenuates all frequencies below 35 Hz (at 12 dB/octave) thus preventing the feedback control loop from attempting to force the speaker cone into long excursion very low frequency movements.

The 35 Hz – 500 Hz signal, together with the feedback signal derived from the acceleration transducer, is now passed on to an adding circuit (Q3) which has a gain of approximately unity.

The combined signal is then fed to the power amplifier.

FEEDBACK CIRCUIT

As described briefly in the main text, the feedback transducer is a ceramic acceleration-conscious device clamped directly onto the bass driver voice coil.

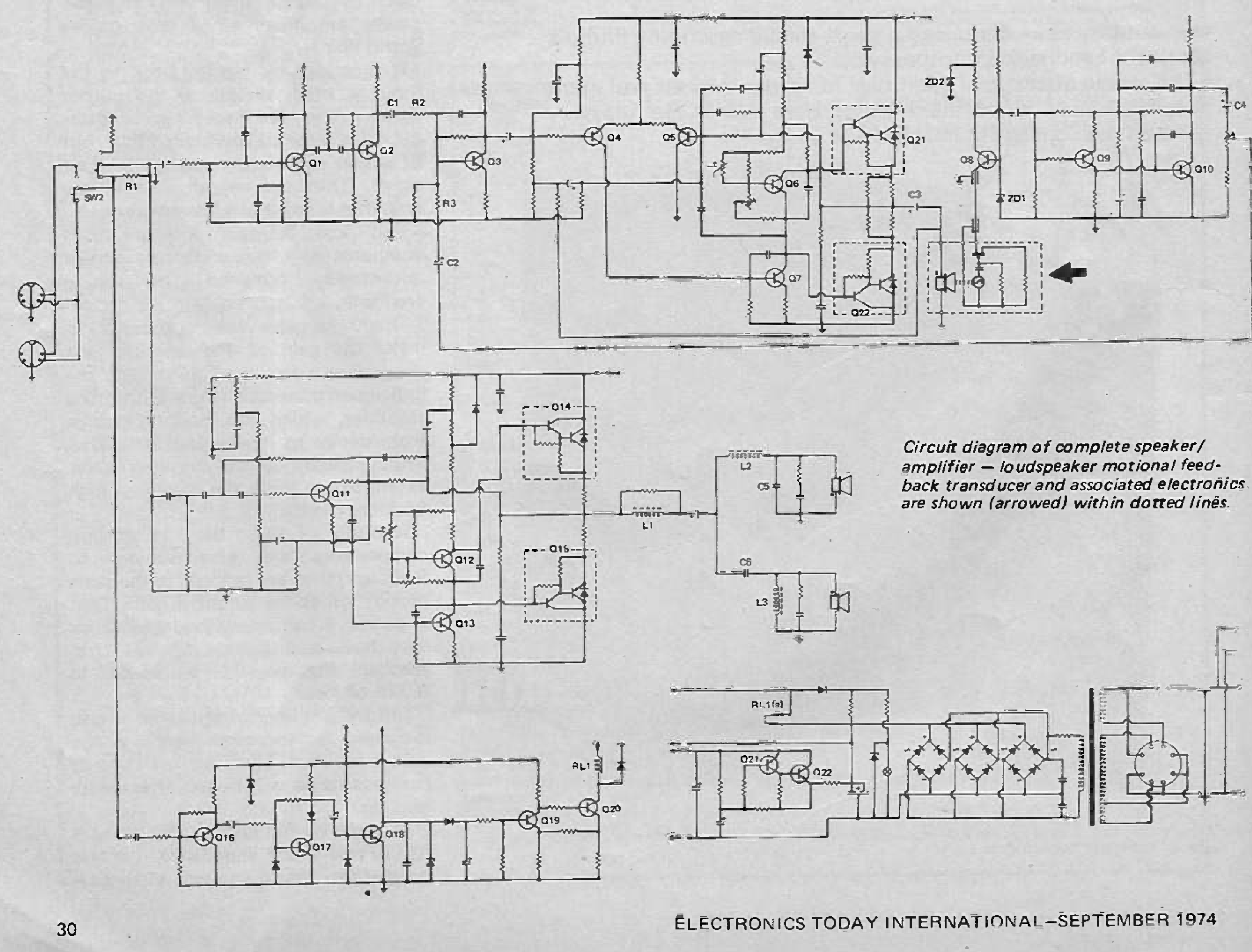
Transducer output is taken via Q8 to frequency correction stage Q9 and Q10. This stage has a flat response down to 80 Hz. Below that the signal has a slope of 6 dB/octave. Purpose of this correction stage is to 'tailor' the amplifier to suit the characteristics of the speaker itself.

MID AND HIGH FREQUENCIES

Signals above 500 Hz are handled by a second amplifier. This unit is of fairly conventional design. In order to eliminate cross-over distortion, operation is in class A up to one watt. Above that, the amplifier switches to class AB. The output stage is a fully complementary Darlington power amplifier.

The RC networks across both tweeter and mid-range drivers are for correcting impedance at high frequencies. The small coil (L1) at the amplifier output is for stabilisation.

Transistors Q16 – Q20 and associated components are an automatic switching circuit that disconnects power to the amplifier circuits if there is no input signal to the enclosure.



Circuit diagram of complete speaker/amplifier — loudspeaker motional feedback transducer and associated electronics are shown (arrowed) within dotted lines.

It is by far the most prominent source of distortion — particularly in the bass and lower bass regions — indeed the lowest usable frequency is often limited by harmonic distortion rising to unacceptable levels.

This fact has long since been realised by audio engineers — in fact a number of commercial hi-fi systems using overall negative feedback have been marketed in the past two decades.

Common to all these systems is the need to obtain an electrical signal proportional to the loudspeaker cone movement i.e. — the feedback signal.

Several ways of doing this have been tried.

Early techniques involved sensing the signal across the voice coil — or taking the signal from a second winding on the voice coil. Neither was wholly satisfactory.

Philips have used a new approach. They use a small transducer clamped to the cone of the bass driver itself.

The transducer used is a ceramic device which produces an electrical signal that is proportional to the acceleration of the cone.

Connected to the output of this transducer is a small amplifier stage which is used to correct minor frequency non-linearities inherent in the loudspeaker.

This arrangement — shown in dotted lines in Fig. 1 ensures a flat frequency response. The junction FET included in this circuit is an impedance matching device — Zener diode ZD1 ensures that the drain-source voltage of the FET does not exceed a predetermined value.

So far, Philips have used their new feedback technique in just one application. This is a small loudspeaker/amplifier combination — which they have named the '532 — Electronic'.

Although this is a physically small unit (380 x 286 x 21.6mm) it contains considerably more than would at first appear. Not only does it contain bass, mid-range and tweeter but two 40 watt amplifiers as well! The bass driver is a 203mm (8") unit. Motional feedback is applied to this unit alone — over the frequency range 35-500 Hz.

Power for this driver is supplied by a class AB 40 watt (into 4 ohms) amplifier.

The mid and upper ranges are covered by a 127mm (5") and a 25.4mm (1") driver. Both of these units are powered by a second amplifier.

This second amplifier is of similar design to the bass unit but is terminated in 8 ohms so that power output is limited to 20 watts. Sliding operation is used for this unit — it being class A at low levels and class AB at higher levels. This is done to minimize cross-over distortion.

Included within the enclosure is a complete regulated power supply, all that is required externally is a programme source and a pre-amplifier with an output of one volt or so — and a mains 50/60 Hz supply.

Clearly what Philips have done is to concentrate on obtaining improved performance from a small enclosure rather than using the new technique to improve performance per se.

The results are excellent. Low frequency performance is very good right down to 40 Hz, and distortion, at average sound levels is at least no worse than that normally generated by much larger enclosures.

Basically the end result is the type of performance that one would normally expect from a big enclosure — but Philips' new devices are small enough to sit on a bookshelf. ●

This Philips turntable/tuner/pre-amplifier combination has been specifically designed to match the motional feed-back speaker/amplifier enclosures.

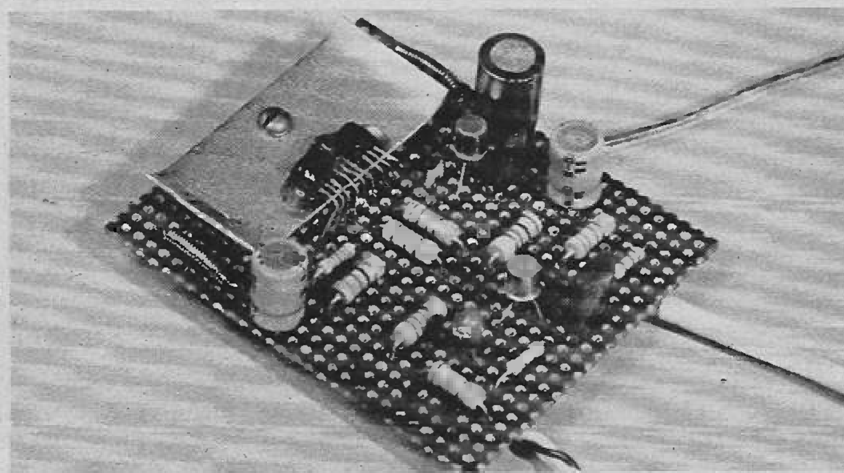
SIMPLE AMPLIFIER

A SMALL AMPLIFIER is an almost indispensable aid to the experimenter It may be used to amplify, and make audible, signals from oscillators operating in the audio range, to trace signals through another audio amplifier that is faulty, to amplify any other signal to a reasonable power level for metering or relay operation etc. etc.

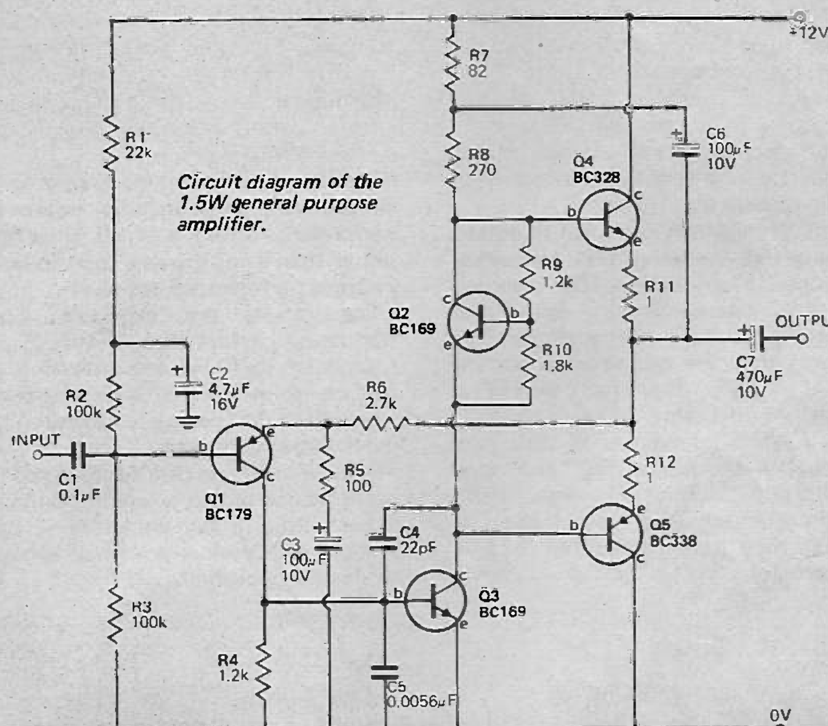
There are at present on the market many integrated circuit power amplifiers providing outputs of from 1 to 3 watts but most of them require very careful layout of the circuit in order to prevent instability (an unstable amplifier may oscillate and be damaged as a result). Additionally, a discrete transistor amplifier is far more educational in that voltages can be measured in order to gain a better understanding of its operation.

Hence the ETI 225 amplifier has been designed using discrete transistors which beside being much more stable than integrated designs, is ideally suited to the needs of the experimenter.

Transistors Q2, Q4 and Q5 are glued to a piece of aluminium which acts as a heatsink (use epoxy resin). These transistors must be the plastic types specified. Metal can types usually have the collector connected to the case and would be shorted by the heatsink.



The completed amplifier. Note the aluminium heatsink to which Q2, Q4 and Q5 are cemented. These transistors must be plastic TO92 types as per parts list.



Circuit diagram of the 1.5W general purpose amplifier.

PARTS LIST
AMPLIFIER ETI 225

R11,R12	Resistor	1Ω	½W 5%
R7	"	82Ω	" "
R5	"	100Ω	" "
R8	"	270Ω	" "
R4,R9	"	1.2k	" "
R10	"	1.8k	" "
R1	"	22k	" "
R2,3	"	100k	" "
C4	Capacitor	22pF ceramic	
C5	"	0.0056μF polyester	
C1	"	0.1μF polyester	
C2	"	4.7μF 16V electrolytic	
C3,6	"	100μF 10V electrolytic	
C7	"	470μF 10V electrolytic	
Q1	Transistor	BC179 or similar	
Q2,3*	"	BC169 or similar	
Q4*	"	BC328 or similar	
Q5*	"	BC338 or similar	

* must be TO92 plastic types.

piece of matrix board

piece of aluminium approx. 1" x ½" for heat sink.

HOW IT WORKS ETI 225

This circuit is fairly typical of a large number of audio amplifiers.

The main voltage amplifier transistor Q3 drives the complementary pair (NPN plus PNP) Q4 and Q5 which are buffers providing high current gain but less than unity voltage gain.

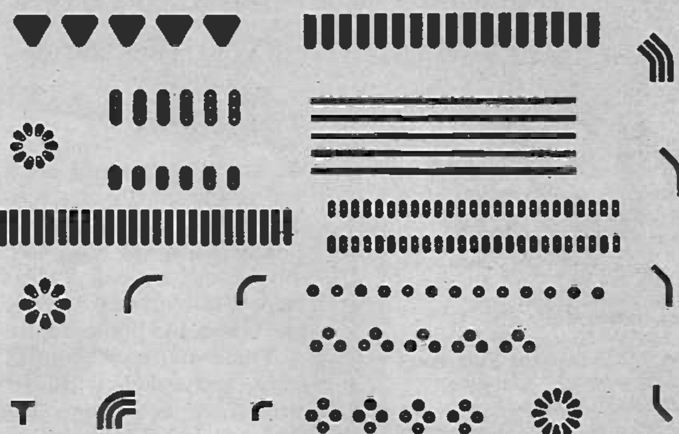
As the bases of Q4 and Q5 are effectively two base emitter junctions apart, Q3 is used to set the bias voltages for these transistors.

Transistor Q1 operates as an error amplifier which compares the input voltage and a divided down version of the output voltage. If there is any difference it provides a control voltage to Q3 in such a way that the error is corrected. The output voltage is divided down by the ratio of (R6 + R5)/R5 and hence the calculated gain will be 28 although the measured gain will be slightly less.

The dc bias point of the amplifier is also set by Q2 and this is unaffected by R5 and it is isolated by means of C3. To maintain an approximately constant current in Q3, capacitor C6 is used to keep the voltage across R8 (and hence the current through it) constant.

Capacitors C4 and C5 are used to provide frequency compensation.

PRINTED CIRCUIT BOARD TRANSFER SYSTEMS



Acid resistant transfers for direct application to P.C. Board. This is a new approach to printed circuit board manufacture, giving a professional finish with all details that an electronics engineer would require, including all drilling positions automatically marked.

Ideal for single unit boards or small quantities. All at a very low cost—for example an average 6" x 4" layout would cost less than 30p, and the time taken under one hour, including etching to complete.

The system is simple, briefly it consists of 10 sheets of self adhesive acid resistant transfers made in required shapes—i.e. edge connectors, lines, pads, dual in line I.C.'s, 8-10-12. T.O.5 Cans, 3-4 lead transistors, etc., etc., which only require pressing into the required positions on the printed circuit board before etching.

The printed circuit transfer system is a genuine offer to the public and industry. A full money back guarantee is sent with each order, trade prices on application.

List of Prices

Complete system including post and VAT	£2·00
Individual sheets	22p
Sample sheet	22p
Copper laminate (boards) size 6" x 4½" 6 sheets	50p

Printed circuit board PCB transfer systems patent applied for.

E. R. NICHOLLS, 46 LOWFIELD ROAD, STOCKPORT, CHESHIRE

TELEPHONE NUMBER: 061-480-2179

LINEAR IC's

		Price
LM 380	Audio 2W amplifier	1.00
LM 381	Dual Audio Preamp	1.85
TBA 810S	Audio 7W amplifier	1.50
LM 3900	Quad Op-amp (audio)	0.68
TBA 120A/ SN 76660N	FM IF and demodulator	1.00
CA 3089E/ TDA 1200	FM IF and demodulator	1.94
CA 3053	FM IF amplifier	0.52
μA 753	FM gain block	0.99
TBA 651	AM Radio chip	1.81
μA 720	AM Radio chip	1.45
TAD 100	AM Radio chip (obsolete)	1.47
MC 1310	PLL Stereo Decoder	2.80
CA 30900	PLL Stereo decoder	2.80
μA 7805UC	3 Terminal 5V Regulator (TO3)	2.05
μA 7805KC	3 Terminal 5V Regulator (Plastic)	1.75
NE 550A	Voltage Regulator	0.80
μA 723	Voltage Regulator	0.80
μA 710	Comparator	0.55
μA 741CV	Op-amp	0.40
NE 560B	Phase Lock Loop	3.19
NE 561B	Phase Lock Loop	3.19
NE 562B	Phase Lock Loop	3.19
NE 565A	Phase Lock Loop	2.75
NE 566V	PLL VCO Function Generator	2.55
NE 567V	PLL Tone Decoder	2.75
NE 555V	Timer/Monostable/Astable	0.78
ICL 8038 CC	Sine/Square/Triangle function Generator with voltage control	3.10
LM 1496	Doubled Balanced Modulator	1.02
9582	Preamp for 95H90 (see logic IC's)	2.50

READY BUILT UNITS

		Price
EF 5603	Toko Varicap Timer	8.50
ET 703	TOKO FM tunerhead with AM Gang	3.30
7231	Larsen Varicap tunerhead and CA 3089E IF. Uses ceramic filters with AFC AGC Mute Field strength and tuning meter outputs.	17.70
7265	Larsen Stereo decoder (CA 30900)	6.80
1100	Litronix 8 digit 4 function pocket calculator. 2 and 4 decimal places, clear last entry, leading zero suppression.	19.45

TOKO COILS and FILTERS

		Price
MFH 41T	4KHz 455KHz Mechanical Filter	1.35
MFH 71T	7KHz 455KHz Mechanical Filter	1.35
CFT 455B	8KHz 455KHz Ceramic Filter	0.45
CFT 455C	6KHz 455KHz Ceramic Filter	0.45
CFU 050D	6KHz 470KHz Ceramic Filter	0.50
CFT 470C	6KHz 470KHz Ceramic Filter	0.45
CFS 10.7	200KHz 10.7MHz Ceramic Filter	0.40
CFK 10.7	200KHz 10.7MHz Ceramic Filter with high input impedance	0.60
220K	22μH choke for use with CA 3089E	0.15
KACS K586 HM	Quadrature coil for CA 3089E	0.30
TKACS 34342BM / TKACS 34343AU	Double quadrature coil for CA 3089A (pair required)	pair 0.55
YXNS 30450 NK	2mH Choke for CA 30900	0.30
BLR 2011	19 and 38KHz notch filter	1.75
BLR 2007	19 and 38KHz notch filter	1.50
YHCS1A 590R	455KHz 1st IF transformer	0.27
YHCS1A 589R	455KHz 2nd IF transformer	0.27
YHCS11100AC2	455KHz 3rd IF transformer	0.27
YHCS pack	Set of 3 IF transformers	0.60
YXNS6A 140HM	LW oscillator loading coil	0.27
YXNS6A 139BA	LW atenna loading coil	0.27
YMRS 16726	MW oscillator coil	0.27
KALS 4520A	10.7 IF transformer	0.30
146LY 433K	43mH choke	0.27
146LY 512K	5.1mH choke	0.27
2A 20ST7	265+265pF Plastic variable cap.	0.55

TRANSISTORS

BC 183L	0.14	TIP 3055	0.60	BF 256LB	0.34
2N 3704	0.14	TIP 2955	0.99	MEM 615A	0.38
				MEM 616	0.50

AMBIT MODULES & KITS

	Price
FND 70M	4.50
NBFM Mini	3.00
NBFM Maxi	4.20
MC 1310K	5.10
LS 8038K	3.70
LM 380NK	2.80
LM 380NKT	3.50
TTL Clock	5.90
1MHz Xtal	3.00
561 basic kit	5.00
PW FERRET	9.50
	8.50

LOGIC IC's

We can supply the full range of 74N TTL to order. Standard stock items as follows:

7400	0. 0.18
74S00	0.74
7404	0.23
7413	0.38
7446	1.10
7447	1.07
7473	0.31
7490	0.71
7496	0.99
74121	0.38
95H90	9.90

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PLEASE ADD 8% TO ALL UK ORDERS
CWO PLEASE, P & P 15p,
FULL CATALOGUE 20p INC. POST

ambit INTERNATIONAL

(Dept. ETI3) 37 High Street, Brentwood, Essex. Tel: (0277) 216029.

INPUT GATE

LETTERS FROM OUR READERS

HELP WANTED

We are attempting to set up a small (unfunded) museum and would greatly appreciate donations of any early radio or electrical equipment, prior to 1930.

Eventually we hope to display a few receivers spanning the period, a small transmitter, a range of components - radio and electrical, service sheets and periodicals, plus a few books and photographs.

These would enable us to show the student of to-day the early, and essential, development from magnets to micro-circuits, while allowing their occasional use as demonstration models. All contributions will be acknowledged and recorded.

C. H. Matthews,
School of Engineering Science,
University of Edinburgh,
King's Buildings,
Mayfield Road,
Edinburgh EH9 3JL.

READER QUESTIONNAIRE

Your questionnaire was a really good idea, it's good to know that there is a magazine that wants to give its readers the best. How about letting the readers know the findings or is this secret? R. J. Macmillan, Stoke-on-Trent.

To date we have had well over 2,500 replies, an excellent response, and we are very grateful to those readers who filled it in. The proper analysis is such a major job that we are going to have the replies coded onto punch-cards and run through a computer.

However we have done a preliminary survey of random batches and as these batches tally extremely closely we do have some early indications.

Projects, Tech-Tips, Electronics Tomorrow and the Electronics Features came out as by far the most popular features with Tech-Tips rated highly by 95% of readers.

In the comments column, the overwhelming message was that readers wanted more low-cost projects and this is already being acted upon – look for a new projects feature in the next month or two.

One smaller point was that 97% of you keep your ETI copies for more than three months and we hope to introduce a binder in the near future as a result of this.

READER OFFERS

Your reader offers have so far been excellent value and I have bought everyone of them so far but if you can arrange with companies for these specially low prices for a short period, why can't they do this all the time?

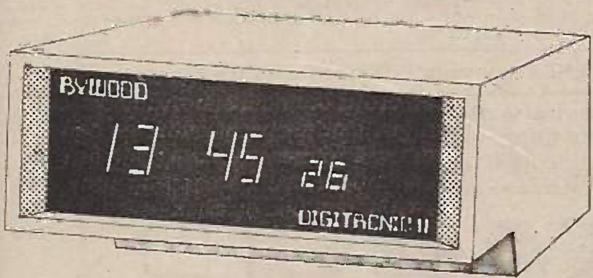
S. Jacobs, Dartmouth.

There are a number of reasons why we can arrange these low prices. The large number of sales which a company obtains means that prices can be cut well back and the companies do not have to pay for advertising as ETI gives all publicity free. Some of the participants are quite willing to operate on a no-profit or minimal profit basis, regarding the resulting publicity as the reward. We see nothing wrong with this. So far the offers have been good for the readers, good for the participating companies and good for ETI sales.

TWO GREAT READER OFFERS

The prices of these offers are lower than those given in the last issue due to the reduction of VAT from 10% to 8%.

Digital Clock Kit: £27·00



Recently we published a review of Digital Clock Kits as these are becoming extremely popular.

When we heard of Bywood's plans for introducing a new model in an extremely attractive case, we discussed with them an offer on this recently introduced kit and this is the result.

The Digitronic II is based on a custom-designed chip only recently released. The Digitronic II is the kit version of one of the best selling digital clocks and is housed in an extremely attractive case (which incidentally has won a Design Award).

The kit is for a 12 or 24 hour clock with a 6-digit readout working from the 50Hz mains. The 12/24 hour option can be switched without having to reset.

The display comprises four 0.55" and two 0.33" LED's with a pleasing orange coloured readout.

All you need to build it up is a soldering iron, sidecutters and a mains plug. If you decide that the kit is too complex you can return it and obtain a built model for an additional £4.40.

---------- Cut ----------

To: ETI/Bywood Digital Clock Offer
181 Ebberns Road,
Hemel Hempstead,
Herts, HP3 9RD.

Please find enclosed my cheque/P.O. for £27.00 for my Digitronic II Digital Clock Kit. (Cheques etc to be made payable to Bywood Electronics.)

Name ....

Address ....

....

....

Offer closes September 30th, 1974

This offer is strictly limited to one order per coupon. Readers may order more than one Digitronic II Kit but a separate coupon must be enclosed for each.

This saving of £4.65 applies to all versions of the Digitronic Clock Kit - see Bywoods advertisement for details.

7-Segment 0·3" LEDs: 5 for £3·25

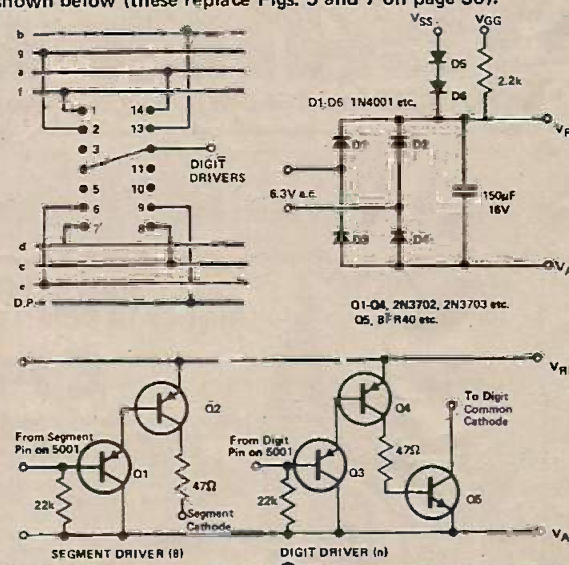
Five - yes Five - 0.3" LED Numeric displays for the price you would normally expect to pay for two. These devices are from a famous maker (we cannot mention the name due to this low price).

They are common cathode devices with right-hand decimal point and red display giving maximum brightness with 10mA per segment but can be used with only 5mA.

These devices are not rejects and are ideal for use in calculators, frequency counters, digital clocks etc but the price is so low so that they can even be used as on-off indicators for equipment etc.

They are supplied in 14-pin DIL packages. Each order will receive a data sheet.

For those who have taken advantage of last month's CT5001 offer, the modified power supply, segment and digit drivers are shown below (these replace Figs. 5 and 7 on page 36).



---------- Cut ----------

To: ETI/Ambit Int. LED Offer
37 High Street,
Brentwood,
Essex, CM14 4RH.

Please find enclosed my cheque/P.O. for £..... for ..... 0.3", 7-Segment LED Numeric Displays (Minimum £3.25 for 5, 59p each for additional devices). Cheques etc to be made payable to Ambit Int. I also enclose a self-addressed, stamped envelope for the return of my money should the offer be over-subscribed.

Name ....

Address ....

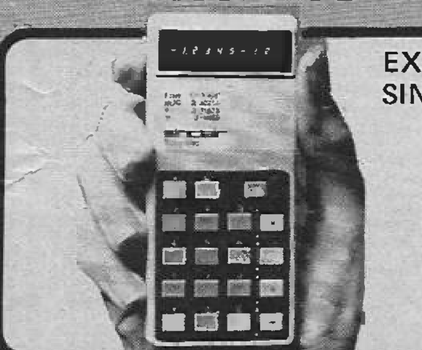
....

....

Offer closes September 30th, 1974

This offer is strictly limited to one order per coupon. Readers may place more than one order but a separate coupon must be enclosed for each.

What to look for in October's ETI



EXCLUSIVE ETI READER OFFER SINCLAIR SCIENTIFIC KIT FOR:

£14.95

Until recently the Sinclair Scientific was only available ready-built at over £50. This month it has become available as a kit for £19.95 but next month ETI readers only will be able to purchase it for £5 less for a limited period.
This calculator has not 4 but 12 functions including logs, trig and arithmetic, all in a pocket-sized format. (No orders can be accepted before September 20th.)

ELECTRONICS IN CRIME

Today both criminals and the police are using more and more sophisticated techniques in their never-ending battle.
Image intensifiers now make night surveillance practical and a variety of methods - both photographic and electronic - are used for the macabre job of finding hidden graves.
Laser interferograms enable detectives to see where someone has walked even hours beforehand.
Read all about it in October's ETI.

SCOPE DUAL-TRACE PROJECT

A straightforward project using I.C.s enables you to convert a single-beam 'scope into a dual-trace version up to about 1MHz.

VIDEO DISC COLOUR TV

The Decca/Telefunken TelDec system is now ready for production and it looks like a serious competitor to videotape. How it works is described in next month's ETI.

PLUS:
AMBISONICS
ADVANCE SCOPE REVIEW
PROJECTION COLOUR TV

OCTOBER ISSUE ON SALE SEPTEMBER 20th – 25p
The features mentioned here are, at the time of this issue going to press, in an advanced state of preparation. However, circumstances, including highly topical developments, may affect the final contents.

electronics today INTERNATIONAL

eti REACTANCE CHART

TO USE

Lay a ruler between any two parameters and read off the third eg. to find the reactance of a 10mH choke at 2000Hz. Lay a ruler between the two known parameters and read the answer (120 ohms) on scale A.

Note also that 0.7µF has the same reactance and a 0.7µF capacitor and a 10mH choke will resonate at 2000Hz. Resonance may only be read using scale A (values of inductance).

If inductance scales B or C are used, the corresponding reactance scale B or C must also be used.

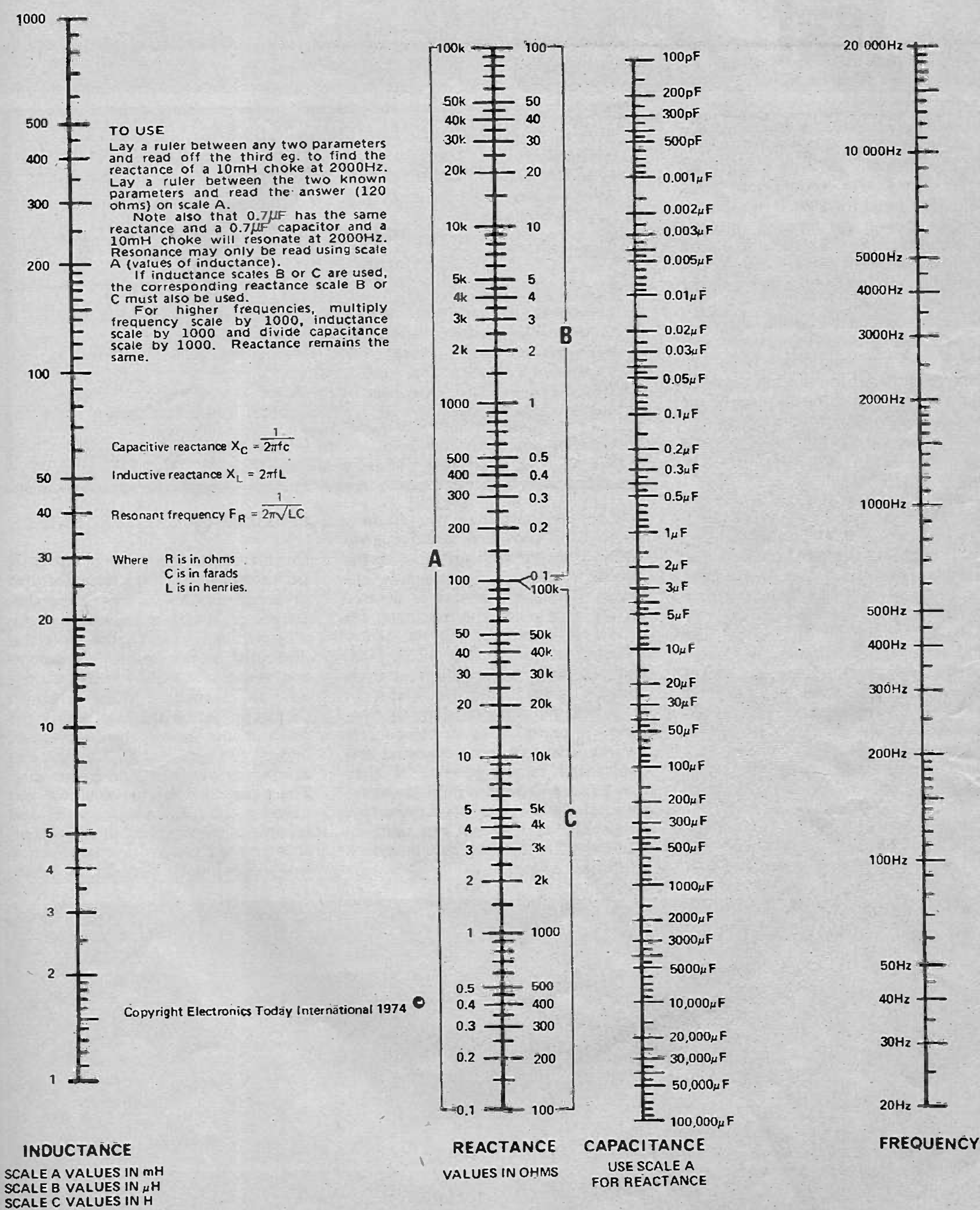
For higher frequencies, multiply frequency scale by 1000, inductance scale by 1000 and divide capacitance scale by 1000. Reactance remains the same.

Capacitive reactance $X_C = \frac{1}{2\pi fC}$

Inductive reactance $X_L = 2\pi fL$

Resonant frequency $F_R = \frac{1}{2\pi\sqrt{LC}}$

Where R is in ohms
C is in farads
L is in henries.



eti product test

EAGLE AA6 STEREO AMPLIFIER

THE EAGLE AA6 has become well known mainly because of the five way tone control system which Eagle call SEC, or *Sound Effects Controllers*. It is otherwise a conventional stereo amplifier rated for 20W (r.m.s. based) output power per channel into an 8 ohm load. It has a smart appearance with a matt teak finished case and is available with either a black or silver control panel.

Inputs are provided for magnetic or ceramic pickup cartridges, radio tuner and tape and there is an off-tape re-entry for monitoring recorded signals. Four push buttons select the inputs and another four select stereo/mono operations, the sound effects controllers, loudness and the tape/source facility. With the sound effects controllers out of circuit the bass and treble lift, or cut, controls and loudness can be used in the normal way.

With the SEC in circuit, the regular tone controls and the loudness control do not operate. All inputs, the loudspeaker sockets, a pair of mains supply sockets, the circuit protection fuse and an earthing terminal are located on the rear panel. There is a socket for stereo headphones on the front panel which can be used without the loudspeakers operating. There are no separate HF or LF filters as the SEC facility will cope with any rumble or record surface noise filtering required.

THE SOUND EFFECTS CONTROLLERS

There are five slider controls and each one operates within a specific frequency band providing approximately 10dB lift or cut with reference to the middle frequency. For example, the lowest frequency control is centred on 40Hz at which the maximum lift or cut, is obtained. The five centre frequencies are 40, 200, 1200, 6000 and 15,000Hz. The object of these controls is to enable the listener to make fine adjustments to overall frequency response so as to compensate for the effect of room acoustics and unbalanced recordings etc., or they may be used to provide more presence, to vocals for instance. It is important however, that they are not used indiscriminately as they *can* introduce unpleasant effects.

MEASURED PERFORMANCE OF EAGLE AA6

Power Ouput: 20W per channel into 8 ohms, both channels driven.
Power Bandwidth: 20Hz (–1dB) to 25kHz (–1dB)
Frequency Response: See graph

Total Harmonic Distortion:

	100Hz	1kHz	10kHz
At 20W	0.15%	0.08%	0.25%
At 10W	–	0.12%	–
At 5W	–	0.13%	–
At 1W	–	0.2%	–

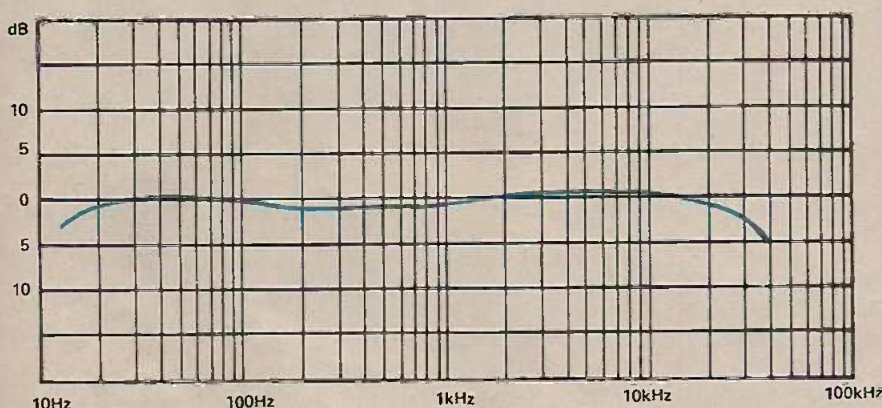
Signal-to-Noise Ratio:
(unweighted) Tape, Tuner –58dB. Mag. P.U. –51dB. Ceramic P.U. –52dB.
Crosstalk: –54dB (all inputs)
Pickup overload margin: 38dB
Tone Controls and SEC: See graph
Loudness Control: See graph
Inputs: Mag. P.U. 3mV 47ohm. Ceramic P.U. 80mV 100kohm
Tuner 180mV 100kohm. Tape 180mV 100kohm
Outputs: Speakers 8–16ohms. Tape 180mV 100kohm
Recommended Retail Price: £74.80 including VAT.

PERFORMANCE

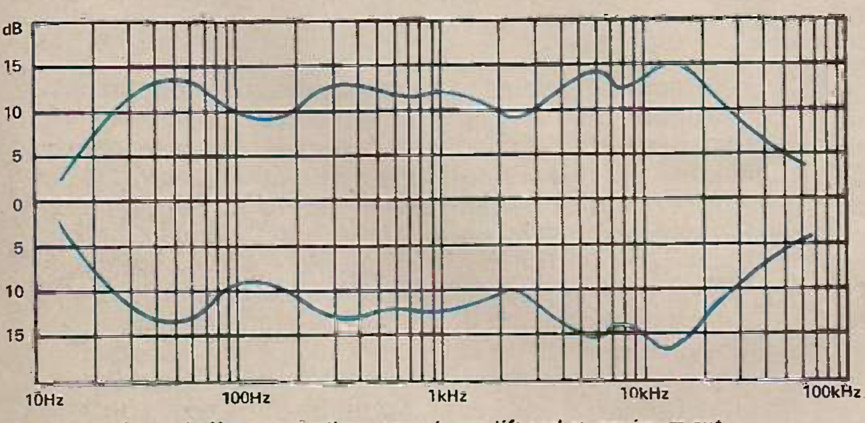
On the whole the AA6 has a good performance and with a recommended price of £74.80 is not expensive. Details of the tests to which it was subjected are given in the table and illustrated by the various oscillograms and response curves. Power output was, as claimed, 20W per channel. Distortion factor also was within the claim made: better than 0.2%, not only at full power at 1000Hz but also at other power levels and frequencies. The signal to noise (unweighted) was down a little for the magnetic and ceramic pickup inputs but still acceptable and the pickup overload margin (magnetic input) a generous 38dB.

SUMMARY: All in all a very good amplifier the price and one that offers maximum flexibility in use. The SEC facility has its merits but should be used only with discretion.

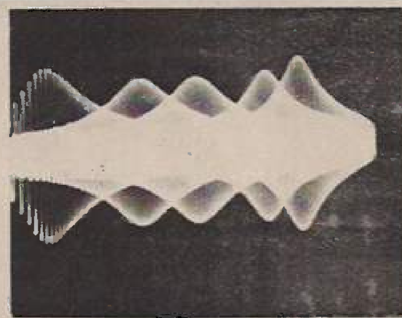
Overall frequency response (A-A). Response of Loudness Control (L-L).



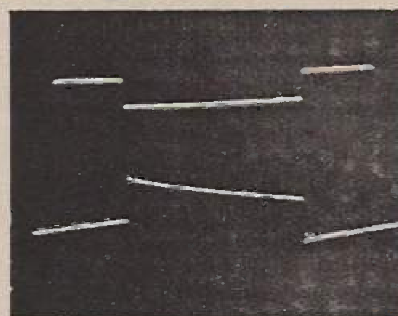
Deviation from RIAA response.



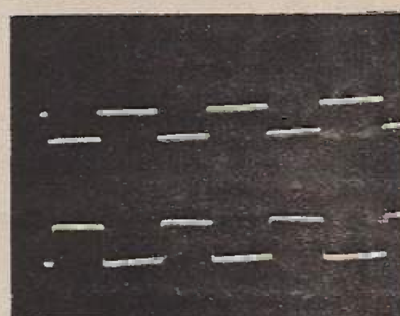
Responses of sound effects controllers at maximum lift and at maximum cut.



Response contours of the sound effects control by frequency sweep test. From left to right the peaks are at 40Hz, 200Hz, 1200Hz, 6kHz and 15kHz.



Tests at 100Hz. Input at the top, output at the bottom.



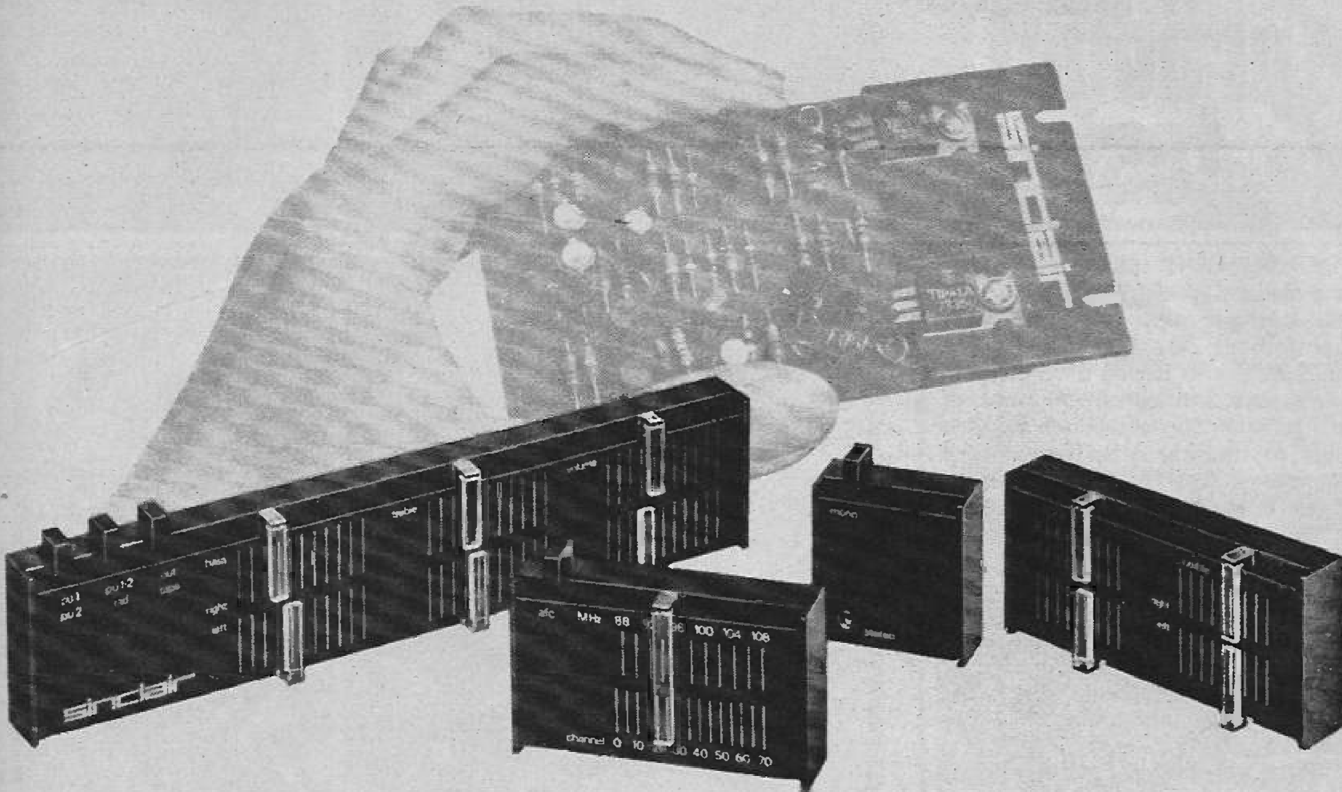
1000Hz square-wave tests. Input at the top, output at the bottom.

The overall frequency response is shown in Fig. 1 together with the response of the loudness control (at about 0.1W) and the limits of the regular bass and treble controls at 50 and 10,000Hz respectively. The response from the magnetic pickup input with RIAA equalized input signal is shown in Fig. 2. Frequency response generally is supported by the 1000 and 100Hz square-wave tests shown in the photographs.

The response of the sound effects controls were as specified and the separate contours are shown by the sweep frequency responses, superimposed one upon the other as illustrated. The result of using them together e.g., all at maximum, or at minimum, is also shown which, either way, results in a somewhat objectionable response. Furthermore with all the controllers at maximum lift, distortion can arise with a high degree of ringing from a square-wave input signal. ●


Project 80
a brilliant new concept in modular hi·fi
sinclair
Project 80 is going to be the ultimate in modular hi-fi construction for a very long time to come. It combines the qualities most demanded of any modern domestic system – good circuitry, reliability and fine performance – with other features to be found nowhere else in the world. For example, *compactness* – Project 80 control units are ¾″ deep × 2″ high, and each one is completely self-contained. *Elegance* – all of Sinclair's design leadership has been concentrated on producing designs of outstanding functional elegance unsurpassed for styling and simplicity. *Flexibility* – the size and styling of Project 80 modules makes them the most versatile units ever. Combine them how you will, where you will, the Project 80 System of your choice gives you the best.
sinclair

Sinclair Project 80



technically the world's most advanced

Project 80 gives you choice from a range of 9 different modules for combining in a variety of ways to suit your requirements. The Stereo 80 is a versatile pre-amp control unit designed to meet all domestic hi-fi requirements including tape monitoring, high sensitivity magnetic cartridge input, and of course, individual slide controls on each channel for precise output matching. By separating the F.M tuner and stereo decoder, useful economies can be effected where stereo radio reception is not needed. Two power amplifiers – Z.40 (18 watts RMS continuous into 4 ohms using 35V) and Z.60 (25 watts RMS continuous into 8 ohms using 50V) are available with choice of 3 different power supply units. The PZ.8 with its virtually indestructible circuitry is particularly recommended. For the final word in system building, the Active Filter Unit puts the finishing touch of quality to what are easily the world's most technically advanced hi-fi modules. Any further units likely to be added to Project 80 range will be compatible with those already available.

Stereo 80 Control Unit Size – 260 × 50 × 20mm (10$\frac{1}{4}$ × 2 × $\frac{3}{4}$ins) Finish – Black with white indicators and transparent sliders Inputs – Magnetic pick-up 3mV RIAA corrected. Ceramic pick up 350mV Radio 100mV; Tape 30mV Signal/noise ratio – 60db Frequency range – 20Hz to 15KHz ± 1dB; 10Hz to 25KHz ± 3dB Power requirements – 20 to 35 volts Outputs – 100mV ; AB monitoring for tape Controls – Press button tape radio and P.U. Sliders on each channel for volume bass treble R.R.P. (add £1·19 V.A.T.) **£11.95**

Project 80 FM Tuner Size – 85 × 50 × 20mm (3$\frac{1}{2}$ × 2 × $\frac{3}{4}$ins) Tuning range Dual varicap – 87·5 to 108MHz Detector – I.C. balanced coincidence One I.C. equal to 26 transistors Distortion – 0·2% at 1KHz for 30% modulation 4 pole ceramic filter in I.F. section Aerial impedance – 75 Ω or 240-300 Ω Sensitivity – 5 microvolts for 30dB S/N ratio Output – 300mV for 30% modulation Power requirements – 25 to 35 volts R.R.P. (add £1·19 V.A.T.) **£11.95**

Project 80 Stereo Decoder Size – 47 × 50 × 20mm (1$\frac{7}{8}$ × 2 × $\frac{3}{4}$ins) One 19 transistor I.C. Channel separation greater than 30dB Power requirements – 25V Output 150mV per channel R.R.P. (add 74p V.A.T.) **£7.45**

Active Filter Unit Separate controls on each channel. Size – 108 × 50 × 20mm (4$\frac{1}{4}$ × 2 × $\frac{3}{4}$ins) Voltage gain – minus 0·2dB Frequency response – 40Hz to 22KHz controls minimum. Distortion – at 1KHz – 0·03% using 30V supply H.F. cut off (scratch) – 22 KHz to 5·5KHz. 12dB/oct slope L.F. cut off (rumble) – 28dB at 20Hz. 9dB/oct. slope R.R.P. (add 69p V.A.T.) **£6.95**

Z.40 Power Amplifier Size – 55 × 80 × 20mm (2$\frac{1}{8}$ × 3$\frac{1}{8}$ × $\frac{3}{4}$ins) 9 transistors Input sensitivity – 100mV Output 18 watts RMS continuous into 4 Ω (35V) Frequency response – 30Hz-100KHz ± 3dB S/N ratio – 64dB Distortion – at 10 watts into 8 Ω less than 0·1% Power requirements – 12 to 35 volts; built-in protection against overload. R.R.P. (add 54p V.A.T.) **£5.40**

Z.60 Power Amplifier Size – 55 × 98 × 15mm (2$\frac{1}{8}$ × 3$\frac{3}{4}$ × $\frac{3}{4}$ins) 12 transistors Input sensitivity – 100-250mV Output – 25 watts RMS continuous into 8 Ω (50V) Distortion – typically 0·03% Frequency response – 15Hz to more than 200KHz ±3dB S/N ratio – better than 70dB Built-in protection against transient overload and short circuiting Load impedance – 4 Ω min. safe on open circuit R.R.P. (add 69p V.A.T.) **£6.95**

Power Supply Units PZ.8 Stabilised. Re-entrant current limiting makes damage from overload or even direct shorting impossible. Normal working voltage (adjustable) 50V R.R.P. £7·98 + 79p V.A.T. Without mains transformer PZ.6 35V stabilised R.R.P. £7·98 + 79p V.A.T. PZ.5 30V unstabilised R.R.P. £4·98 + 49p V.A.T.

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GARRARD 86SB

THE GARRARD 86SB is designed as a medium quality disc playing unit and it shares much with the more sophisticated Zero 100 model. The 86SB differs in having a simple gimbaled tone arm constructed out of triangular section aluminium alloy in place of the articulated tone arm of the Zero 100. The cartridge carrier of the module 86SB, as well as most of the ancillary parts of the tone arm, are made of plastic. Garrard have been for many years the masters of high precision plastic injection mouldings with high quality plastic parts finding their way into most of their recently designed record playing decks and they have been none the worse for that.

The drive motor of the 86SB is coupled to the platter by a flat rubber belt. This arrangement is used in place of the idler wheel drive used in earlier models of the Garrard module 86. Speed change is by the use of a plastic fork which pushes the belt from one section of the motor shaft to another section of different diameter. The pulley and belt assembly is visible for inspection through a cut-out in the platter, exposed by removing the rubber turntable mat. Only two speeds are catered for, this now being common on modern record playing decks.

The motor itself is a four pole type, known by Garrards as a "Syncro-lab" motor in which the rotor has been magnetised permanently to a small degree, this causes the motor to act like a synchronous motor once it has reached running speed but to have starting characteristics similar to those of an induction motor.

The turntable platter is made of an alloy die casting 11½in. in diameter and showed no signs of having been balanced after manufacture. However precision castings of this type have, as with plastic parts, been a keynote of Garrard's for many years. One Zero 100 which I had the opportunity to inspect seemed to be virtually identical as far as platter design but to have been balanced after casting by drilling a series of small depressions in the underside of the platter rim. The slight over-hang of a twelve inch record on the 11½in. platter was found to be beneficial in aiding their removal from the turntable without touching the playing surfaces.

The functions of the 86SB are controlled by a row of small plastic levers below the tone arm at the right of the base-plate, the most left hand lever controlling the Auto Start/Stop functions of the deck, the centre lever selects Auto or Manual operation of the deck, the last lever at the right is the arm lifting and lowering control used when the deck is under manual control. The existence of the automatic functions does to my mind remove this deck from the very front rank of record playing decks but for those without steady hands or who have to put up with their record playing equipment being used by the family at large, then the ability of the 86SB to select the run-in groove of a record, lower the arm placing the stylus in the run-in groove, play the record, lift-off the arm and return it to the parked position after use must be a considerable benefit in preventing stylus and record damage.

As supplied for review, the 86SB was fitted with a Sure M75 6/SB cartridge which is a mid-range cartridge having a spherical stylus. This complement is considered by Garrard's to give a reasonably optimum balance between cost and performance but it may be considered that Garrard have under-estimated the type of buyer to whom this module might appeal and that a somewhat better cartridge might with advantage be used on the 86SB, if this is so then the unit can be purchased without the cartridge.

The turntable main bearing design of the 86SB is slightly unusual and of an inverted design where the weight of the turntable platter is taken on a hardened steel ball at the top of a pillar and almost level with the record surface. The necessary side location of the platter is provided by a bronze sleeve inserted in the casting of the platter and forming a plain bearing

SUMMARY: For somebody who wants a semi-automatic record playing deck we have little hesitation in recommending this unit as very good value for money.

MEASURED PERFORMANCE OF GARRARD 86SB

Signal-to-Noise and Rumble: (ref 1kHz at 10cm/sec)	40dB	(good)
Wow and Flutter (R.M.S.)	0.06%	(very good)
Speed Accuracy:	Under 1%	(good)
Accuracy of Play Weight Scale:	+6%	(fair)
Arm Friction Lateral	65mgrm	(fair)
Vertical	40mgrm	(fair)
Start-up Time:	2.7sec	(good)
Platter Rock:	±15 thou	(poor-see text)
Dimensions:	17 7/8 x 15 15/16 x 7 1/8"	
Recommended Retail Price:	£47.90 inc. VAT (less cartridge)	

round the pillar holding the steel ball. Though this bearing did allow a fair degree of platter 'edge rock' (which was measured as ±15 thousandths of an inch the centre of rotation of the rocking couple also being the centre of the record seemed to reduce the untoward effect that might be expected to occur.

The bias compensator is fabricated out of a number of plastic mouldings and works on a see-saw principle with adjustment of the amount of bias compensation being provided by varying the distance of a small weight from the fulcrum of the see-saw. This worked very well and again illustrated Garrard's mastery of mass production methods.

The performance figures measured with the test sample confirmed the subjective opinion that the unit was of high quality even though "mass produced". Both wow, flutter and rumble plus noise was at a low level and the overall operation of the unit was satisfactory. The finish was good but gave a rather "plastic" feel to the 86SB which went as far as the rather bad mock teak veneer on the plinth.

Assembly of the unit should hold no terrors for even the most non-mechanically inclined of us - the only tool required is a small screw-driver with which to screw down the transit screws and release the deck spring suspension. What might take a little time is locating the parts hidden in their cubby holes in the packaging material of the module. Even the cartridge supplied with the unit could be fitted without the use of any tools. Setting the stylus weight was simple following the instructions given and the result was fairly accurate being some 6% high.

In conclusion the Garrard 86SB is good value for money though a better cartridge would be advisable. The one supplied requiring marginally over 2.5grams to track the Sure test record TTR 103. Finally the plastic dust cover, while allowing records to play with it closed, only opened 9in. which caused difficulty with putting records on and taking off the deck when it was installed below eye level, on say a coffee table.

SINCLAIR SYSTEM 4000 AMPLIFIER

We reviewed this unit in the July issue but the price given to us, and that which was printed in Sinclair's advertisement on the back cover was incorrect.

This should have read in both cases £49.95 + VAT and not £69.95 + VAT.

We apologise for any inconvenience resulting from this.

IMAGE INTENSIFIERS -the electronic owl

BY IAN SINCLAIR

"AMPLIFIER" AND "AMPLIFICATION" are terms which we use every day without much regard to their meaning. Certainly, 'amplify' means 'make larger', and this is what an amplifier appears to do to the amplitude of a signal. It is not what actually happens, though, and our use of words blinds us to what is actually happening, which is the *creation* of a new signal of greater amplitude under the control of the old signal. This is what actually takes place in the action of a transistor or valve: the input is used to modulate a current, and a new signal is obtained by passing the modulated current through a load resistor. True amplification is achieved only in a resonant circuit at the resonant frequency; for even a transformer depends on an intermediate conversion to a magnetic field.

It is important to realise exactly what we usually mean by amplification when we come to speak of image amplifiers, devices which are of great importance in optical astronomy, military night-sights, and in low-light television. The 'amplifiers' to which we are accustomed work reasonably well at low frequencies, but, when the time of one cycle of signal becomes comparable to the time which the charge carriers in the 'amplifier' take to cross the space between electrodes, the amplifying action fails. For example, if the time of one cycle of signal is comparable to the time taken for electrons to cross from the emitter to the base of a NPN transistor, signals of that frequency will not be amplified, for the control action fails. It is impossible to control anything which has changed in the interval of control; this is probably most clearly illustrated by the action of a triode valve at high frequency. A signal makes the grid more positive so that electrons are attracted from the cathode, but, by the time the electrons have actually reached the cathode, the signal is negative, and the electrons are being repelled again. This is shown in Fig. 1.

Another way of looking at this difficulty is to compare the wavelength of the signal with the dimensions within the amplifying device. If the wavelength is anywhere near the distance between electrodes, then amplification is unlikely to work.

What, then, do we do about amplifying light images, where the wavelength is around 0.0005mm? This is very much less than any spacing we can make between electrodes with existing technology. Yet light waves, which are identical in every respect apart from wavelength and frequency to radio waves, carry a large amount of energy, and ought to be capable of some sort of controlling action. The answer lies in the interaction between light and atoms.

LIGHT AND MATTER

Atoms consist of protons, neutrons and electrons. The protons and neutrons make up most of the mass of the atoms, and the protons are positively charged. The electrons are of much lower mass, about 1/2000 of the mass of the proton or neutron, but have a negative charge equal in size (but not sign) to the charge on the proton. The number of protons in the normal atom always equals the number of electrons. One of the early visualisations of the atom, long superseded but still useful, is of a hard core of protons and neutrons with the electrons spinning round like satellites, so that the diameter of the atom, which is the diameter of the electron orbit is about a thousand times greater than the diameter of the core or nucleus. The diameter of the electron orbit can be increased by feeding in the correct amount of energy, in the form of raised temperature or as electromagnetic radiation of the correct frequency, to the atom. This same amount of energy will be given off when the

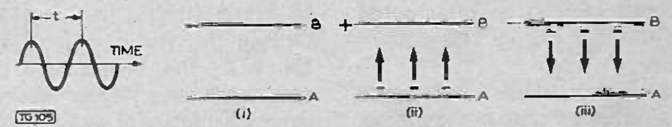


Fig. 1. Most electronic amplifiers depend on electrons (or holes) moving from some part A to another part B. If B is positive electrons move but if the signal at B is reversed before the electrons reach it, then this is not possible.

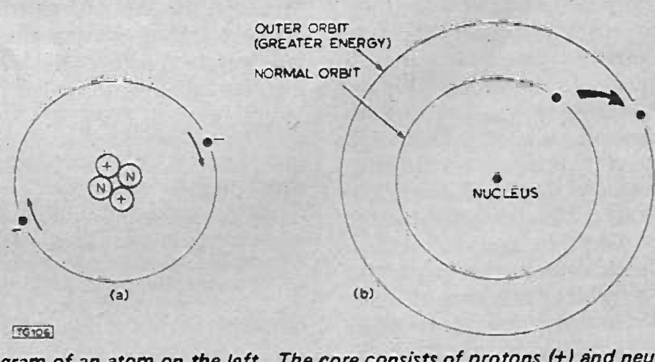
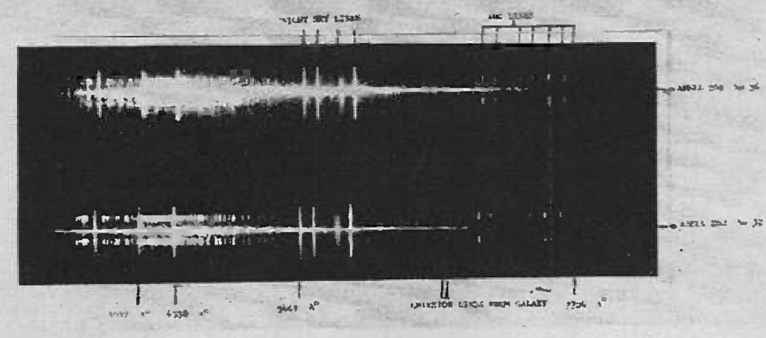


Fig. 2. Diagram of an atom on the left. The core consists of protons (+) and neutrons (N) with negative electrons moving around it. Right: If energy can be transferred to the electron its orbit moves out. If it returns, the energy difference is released.



ASTRONOMICAL OBSERVATION USING EMI THREE–STAGE IMAGE INTENSIFIERS

A study of the missing galactic matter by the Royal Greenwich Observatory, Herstmonceux.

To aid the recording of the images of distant stars and galaxies the Royal Greenwich Observatory at Herstmonceux, Sussex, (shown on the cover) uses a three-stage image intensifier supplied by the Electron Tube Division of EMI Electronics.

The photograph shows the spectra of two galaxies taken with the unit spectrograph of the Isaac Newton telescope using the EMI tube. The photograph is a reversal of the original in the sense that "white" corresponds to where light fell on the original plate. In each case, the central thin horizontal strip is the spectrum of the galaxy. Dispersion on the original was 250 A°/mm.

The numerous emission lines above and below the galactic spectrum are from a copper-argon arc comparison source. There are a few emission lines which are very long and pass through the galactic spectra. These arise from the night sky. Although there are not many features visible in the spectra of the galaxies themselves on the reproduction, there are two quite clear emission lines which are marked.

The upper spectrum is a 30 minute exposure on galaxy Abell 262 No. 36 and the lower spectrum is a 10 minute exposure on galaxy Abell 262 No. 32.

Photograph by courtesy of the Royal Greenwich Observatory.

electron returns to its own orbit, as it always does when conditions permit. If sufficient energy is applied to the atom, the outermost electrons can be torn away from their orbits and removed completely from the atom to which they belong. This is shown in Fig. 2.

This last effect, when it is caused by light, is the **photoelectric effect**, investigated by Lenard in the 1880's, and explained later by Einstein (work which earned him his 1921 Nobel Prize). Einstein's theory explains the observed fact, that electrons are torn away only by light whose frequency is greater than a critical value, the 'threshold: frequency. Brighter light of a lower frequency has no effect, it is the frequency which decides whether or not the electrons will be removed; though the *numbers* removed per second are dependent on the brightness of the light. Einstein's explanation was that the energy carried by any electromagnetic wave, radio or light, is decided by its frequency, and that the energy itself was contained in units, one unit being called a quantum. Brighter light means more units arriving per second, but the energy of a unit decides whether or not an electron will be liberated. This led to the very satisfactory picture of a unit of light liberating a unit of atom, and accounted totally for the measured effects. The photoelectric effect is most noticeable with light and the frequencies close about it, such as infra-red and ultra-violet. Radio waves have too little energy per unit to have any effect on electrons in materials, which is why we have to liberate electrons by valve or transistor action to enable radio waves to affect them. Very short wave radiation, such as X-rays, has a wavelength of about the same dimensions as the atom itself, and so has very little electron liberating effect despite its great amount of energy per unit.

By using a natural substance whose electron energy levels are matched to the light frequency which we wish to amplify, we have solved part of the problem of amplifying light images.

PHOTOCATHODES

Not many materials are suitable for this purpose, and most depend on the metal Caesium. Caesium is a metal of low density (about 1.8 times as dense as water), low melting point (it is usually liquid on a hot day), and very great chemical activity, so that it cannot be kept in air, nor allowed to come into contact with water. It can be stored and used only in a vacuum or in an atmosphere of gas with which it does not react. The same properties which make it an easy emitter of electrons also confer this high reactivity, so that this is a problem we must learn to live with.

The usual way in which it is used is in the photocathode, in which the sensitive materials, antimony and caesium are formed in a thin transparent layer over a glass plate in a vacuum. Fig. 3. shows how a connection is made to the film, which is an electrical conductor, and a separate electrode acts as an anode. With a positive potential of a few hundred volts on the anode, current in the form of

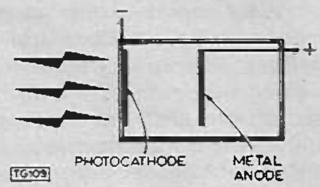


Fig. 3. Action of a simple photocell with photocathode and anode.

electrons will flow whenever the photocathode is illuminated. The problem of keeping the materials away from air is neatly solved by evacuating the apparatus and generating the caesium from a mixture of chemicals in a nickel tube (caesium chromate plus silicon powder) when the caesium is wanted. Since the mixture is not sensitive to air, it can be stored until needed, and the caesium released in the tube by heating electrically.

This solves part of the problem - converting a light signal into an electron signal with the number of electrons flowing being proportional to the strength of the light signal at any point on the photocathode. The other part of the problem is that of getting a light signal out which is of greater power than that of the input; the problem is made greater by the losses in the photocathode, which converts only a fraction of the light energy into electron energy.

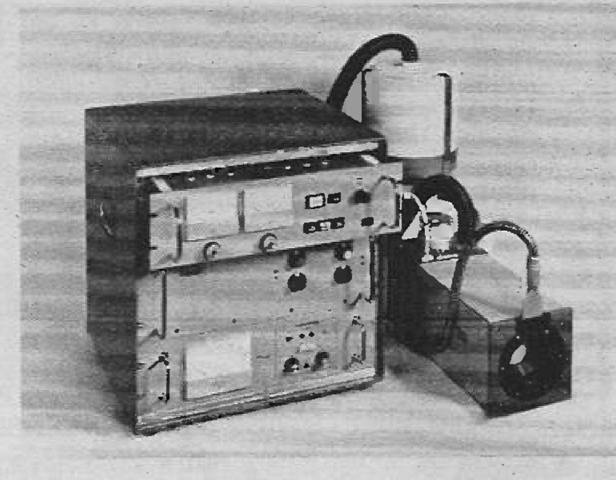
PHOSPHORS

Once again, we have to make use of the behaviour of atoms in specially selected materials, in this case the group of materials termed **phosphors**. Phosphors (not to be confused with the element *phosphorus)* are materials which emit light when struck by energy of other types, and a great variety of substances of this type are known. Some emit light on heating, some when struck by ultra-violet, most when hit by electrons. The last group contain the phosphors which are of greatest interest to us for this purpose. These perform exactly the opposite of the photocathode function, but they are completely dissimilar materials, being mainly sulphides of metals such as zinc and cadmium. The action is that the energy of incoming electrons raises the energy levels of a large number of the orbiting electrons within the phos-

IMAGE INTENSIFIERS -the electronic owl

phor atoms. After this excitation, the electrons return to their normal energy levels giving off light to release the surplus energy. The amount of light given off depends on the number of electrons hitting the phosphor and also on the speed of the electrons hitting the phosphor. Once again, the efficiency is low, so that the energy of light given out is much less than the energy of the electrons striking the phosphor, the remaining energy being dissipated as heat.

What happens if we assemble the photocathode and the phosphor in one glass bulb and apply a few volts potential differences? Nothing worthwhile, unfortunately, for the electrons released by the light hitting the photocathode have less total energy that the light; they then hit the phosphor, with more loss of energy and release the output light which has less total energy than the electron stream. The net result is a loss of light energy rather than a gain, but one important principle is proved: the image of the outgoing light is much the same as the image pattern at the input, proving that the conversion does at least work.



EMI Type 2001 Image Intensifier System.

IMAGE INTENSIFIERS

To obtain a gain in light intensity from such a system of photocathode and phosphor, we have somehow to step up the energy of electrons which are the controlling factor. There are two ways in which this can be done. One is to increase the energy of each electron by accelerating it to a much higher speed by means of a large potential difference applied between the photocathode and the phosphor. The other method is to increase the total number of electrons reaching the phosphor by making each electron from the cathode release a greater number of electrons from an intermediate stage. This latter method is called electron multiplication, and is similar to the method used in photomultipliers.

The problem in an image intensifier is made more difficult by the fact that we do not simply wish to increase the strength of a light signal but also to preserve the shape of an image. Any process which we carry out on the electrons must therefore preserve their relative positions so that the electrons hitting the phosphor must be arranged in the same pattern as the electrons leaving the photocathode.

The two different types of image intensifiers using these different methods are the phosphor/photocathode type and the secondary emitting film type.

PHOSPHOR-PHOTOCATHODE INTENSIFIERS

This type of intensifier has quite a long history, originating in World-War II as the infra-red night-sights. These were rudimentary phosphor-photocathode cells with a photocathode whose sensitivity extended slightly into the infra-red (a difficult task, as the low frequency of the infra-red compared to visible light means that infra-red carries less energy). Fig. 4 shows reconstruction of a photocathode/phosphor cell.

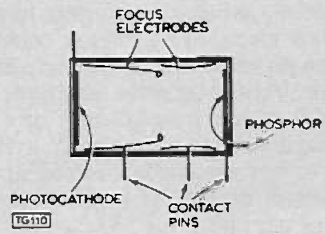


Fig. 4. A photocathode/phosphor cell.

With 20kV between phosphor and photocathode, the output was a visible light image for an invisible infra-red input, with a small gain in power. The applications were gun aiming and night driving (in convoys, with infra-red headlamps on the leading vehicle, and the rest following the infra-red tail "lights"). This type of night-sight, vastly improved by better photocathode and phosphor materials and recent improvements in materials and construction, is still in production and in use. From it multiple cell units have developed, using the principle that a greater voltage between photocathode and phosphor will cause the losses to be overcome and establish some overall gain in energy. The multiple cell units consist of several photocathode-phosphor units coupled together, as one might cascade stages in a conventional amplifier. With a high accelerating voltage across each portion, the total light gain can be very large, approaching 100,000 in some examples; this enables the user to view, as if fully lit, scenes in conditions where the only light source is the stars.

The problems of construction are, however, immense. Each photocathode has to be made in position, and the caesium vapour used for the processing of the cathode will ruin the properties of the phosphor if allowed to land on the phosphor surface. Since the phosphor surface is always in the same vacuum space as the photocathode, contamination would seem to be difficult to avoid. The usual technique is to keep the phosphor end hot and the photocathode end cool, so that the caesium vapour condenses on the cool photocathode surface, where it is wanted, and avoids the hot phosphor surface. Overheating the phosphor, however, destroys its properties, so that a very fine balance has to be struck. The easiest approach has been to make individual cells with fibre-optic end windows and to stack them together, rather than to attempt to form several phosphors and photocathodes on surfaces within one tube.

SECONDARY EMITTING MULTIPLIERS

The other approach to amplification involves multiplying the number of electrons landing on the phosphor, and this is most easily achieved by secondary emission. When electrons accelerated by any voltage between about 100V and 5kV land on a material their energy is sufficient to knock off, on average, more electrons than have landed. With some types of material, among which caesium is again prominent, the ratio of electrons released to electrons landing can be quite high (8 to 10), so that several stages of multiplication of this type can raise very considerably the number of electrons in a beam. For example, if the secondary emission ratio is 8, and four stages of multiplication are used, the total gain in terms of electron numbers will be 8^4, which is 4096; four thousand times in round numbers.

Most secondary electron multipliers use reflected electrons, however, and have no need to keep the electrons in any image pattern. For image intensifier use, reflection is undesirable since the direction of the secondary electrons cannot be well controlled, as shown in Fig. 5a, and it is greatly preferable to increase the electron numbers with no change in the direction of the beam. This is achieved by 'through-multiplication', using the secondary-emitting material in the form of a thin film, bombarding it with electrons from one side and obtaining, if all goes well, an enhanced stream of electrons from the other side. This method is shown in Fig. 5b.

a thin layer of potassium chloride by placing the aluminium film in a vacuum jar and heating the potassium chloride, placed in a molybdenum tray, to a temperature at which it evaporates, and the vapour lands on the aluminium oxide. The resulting layers have then the properties which are needed, and can be mounted in the intensifier.

The complete secondary emission intensifier consists of a photocathode, several secondary emitting films, and a phosphor arranged in sequence in a tube of uniform diameter, as shown in Fig. 6. The films are produced outside the tube, as described, and the only processing which has to be carried out within the tube, during pumping, is the formation of the photocathode. Since this is carried out at the end of the tube opposite the phosphor, it is fairly easy to arrange that the caesium vapour from the photocathode has little or no effect on the phosphor; it seems to have little effect either way on the secondary-emitting films. Using such a system, gains in light image intensity of several hundred thousand are possible.

USING IMAGE INTENSIFIERS

In each type of image intensifier, a magnetic field must be used to keep the electrons in the correct relative position. This focusing field is provided by a long coil (solenoid) completely surrounding the intensifier. In addition, accelerating voltages of several kV per stage must be applied to each type of intensifier, and this requires good insulation, since the overall voltage may be 50kV or more.

The phosphors used have to be aluminised. One reason for this is that it improves the efficiency of the phosphor by reflecting more light forward, another is that it helps to make the phosphor more resistant to caesium. An even more important reason in image intensifiers is that it prevents light from being fed back to earlier stages. This is not quite so important in phosphor-photocathode cells, as the gain per cell is not so very high, but in the secondary emitting tube type, it would be possible for the light from the phosphor to feed back to the input photocathode (since the secondary emitting films are partly transparent) causing full light output for no input. Similar precautions must be taken with the optical system to prevent feedback.

In astronomy, multi-stage image amplifiers have enabled us to achieve spectacular advances in the sighting of very distant or dim stars; the observatory at Kitt Peak has in particular specialised in the use of image amplifiers in astronomy. For night surveillance, whether for the study of nocturnal animals in the biological sense or for the detection of the less welcome nocturnal burglar, image amplifiers of the simpler type have been most useful. Their military applications are obvious; their non-military applications are continually expanding, enabling us to leave the owl far behind in our ability to see in the 'dark'. ●

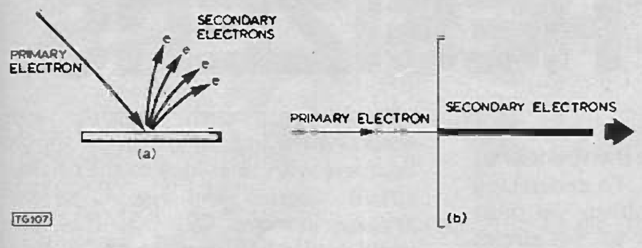


Fig. 5. (above) a. Secondary emission of electrons by reflection. b, secondary emission by transmission.

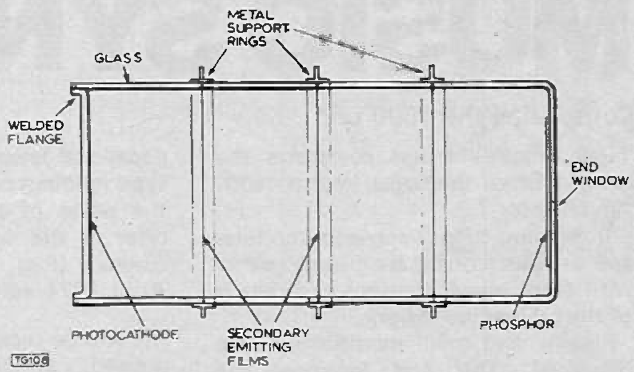
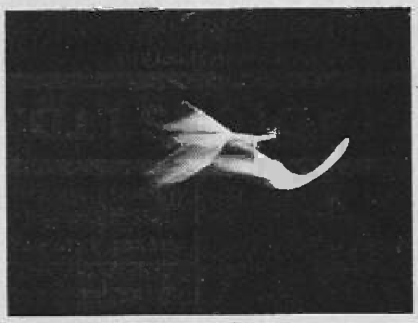


Fig. 6. (right) Transmission secondary emitting intensifier.

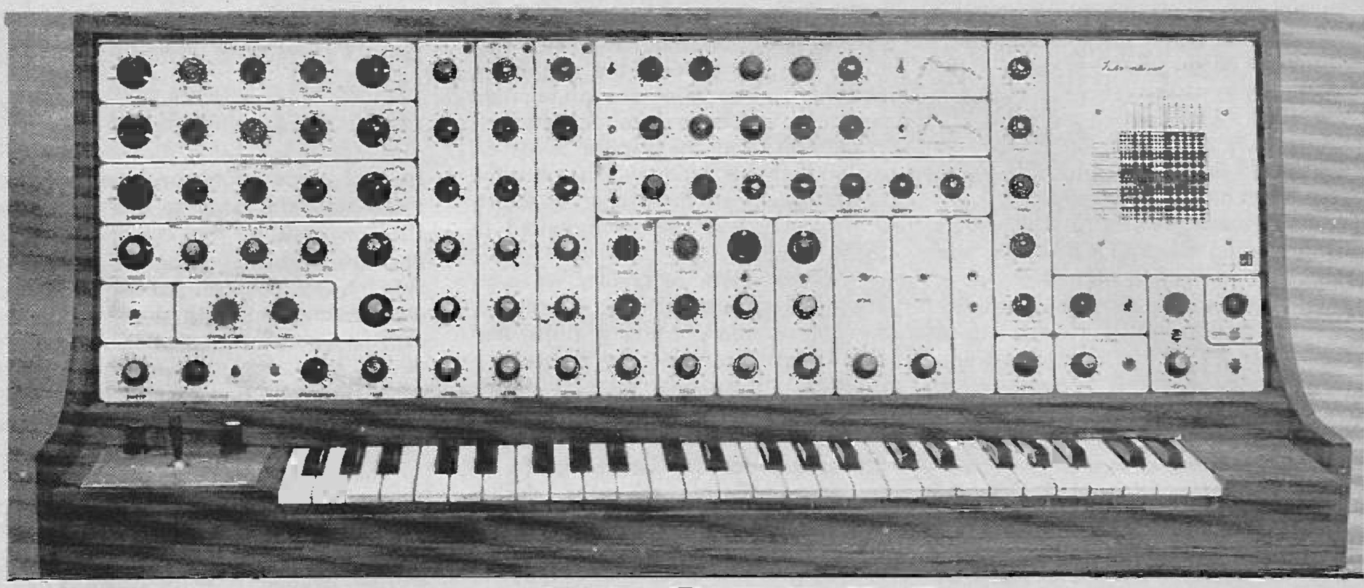
For such a film we need material which can be produced in thin-film form, conducts electricity so that we can apply voltage to it and replace the electrons it loses, has a good secondary emitting ratio, and is strong enough to be self-supporting. This last point is important. Any material could be used supported on a metal mesh, but each mesh would cut down the electron flow (due to the number of electrons which would land on the metal of the mesh), and the combination of several meshes would cause a coarse pattern, a moiré pattern, to be visible at the output. It is much better if the material chosen can be attached to a metal ring at its edges and needs no other support.

Not surprisingly, no single material is suitable, and the films have to be made of several layers. They start off as aluminium foil, very similar to the foil used in cooking, stretched over metal rings. Some of the thickness of the aluminium is then converted to aluminium oxide by treatment in sulphuric acid (passing a current between the aluminium and another electrode). The oxide surface is then coated with



Ultra-high speed recording with a John Hadland IMACON 600 camera using an EMI multi-stage image intensifier tube. Streak record of plasma formed in nitrogen by carbon dioxide TEA laser. Radiation focused by 15cm f.1. germanium lens. Note: modulation of forward going filament at 60 nanosecond intervals caused by partial mode-locking.

Photo by courtesy of Canadian Armament and Research Development Establishment, Valcartier, Canada.



INTERNATIONAL MUSIC SYNTHESIZERS

The completed International 4600 synthesizer.

Completing the 4600 unit.

THIS month's article completes the description of the larger (model 4600) synthesizer.

Interconnections between modules and the patch board are given together with front panel drawings and details of the cabinet woodwork.

Finally, two small modifications are described. The first improves the reliability of the power supply, and the second eliminates a small inconsistency in the operation of the transient generators.

POWER SUPPLY

The power supply is protected against short-circuit to ground of any of the output voltages (except +13.4 volts) and this is normally entirely adequate. However during test procedures on our unit, the +14 volts was inadvertantly shorted to the +7 volts. This caused the +7 volts to be taken to +14 volts, and correspondingly, the tracking -7 volt rail to go to -14 volts, damaging some of the CMOS IC's.

Whilst the occurrence of such a fault is considered to be a remote possibility, we feel it is advisable to fit Zeners (8.2 volt 1.5 watt) from the plus and minus 7 volt supplies to ground, and also from the +5 volt supply (5.6 volt 1.5 watt) to ground, to protect against any such fault condition.

TRANSIENT GENERATOR 1

The Transient Generator I and Envelope Control modules work well and are very reliable. However, over a long period of use, it was found that occasional latch-ups of the Transient I type modules occurred. To understand the cause of this problem we must refer to the operation of the circuit diagram (Fig. 1) on page 44 of the April 1974 edition.

It will be recalled that, when a key is pressed, a 3-millisecond pulse is generated at point A, which resets IC2, discharges C8 and toggles the flip-flop IC6/3/4. This initiates the attack and causes the output to go to +5 volts. On reaching this level the output of IC4 (via IC6/2/1) toggles the flip-flop IC6/3/4 and initiates the first decay. However, if a new trigger occurs at that same instant, the flip-flop receives two commands and may be set either way, depending on which pulse ends first.

To prevent such latch-up ever occurring the following changes should be made with reference to the original circuit diagram and Fig. 1. of this article. Remove C9, D3, R24 and instal a wire link in place of C9. Next cut the copper PC board track between pins 1 and 2 of IC6 and connect pin 1 to pin 13.

The output of IC6/1 is now a level, not a pulse, and therefore cannot be lost. Thus the trigger pulse into IC6/1 will restart the sequence at any time.

To improve the stability of the circuit, when using fast decay times, it is recommended that R14 be reduced to 100 k and C6 to 10 pF.

TRANSIENT GENERATOR 2

The stability of Transient Generator 2 may be improved by reducing R21 to 100 k. No other changes are necessary on this module.

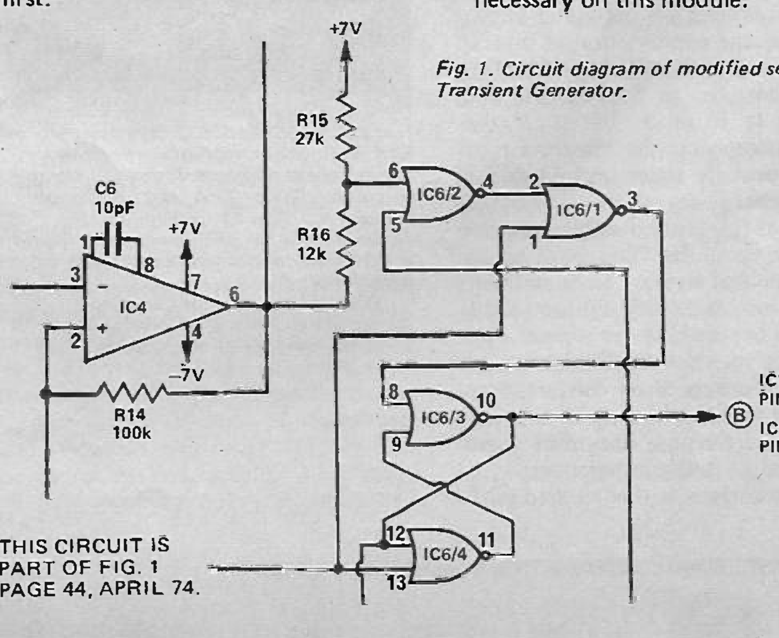


Fig. 1. Circuit diagram of modified section Transient Generator.

THIS CIRCUIT IS PART OF FIG. 1 PAGE 44, APRIL 74.

MODULE/PATCHBOARD—INTERWIRING

MODULE	INPUTS	OUTPUTS	DESTINATION
Oscillator 1	Input		Patchboard 1H
		Output	Mixer point 2
Oscillator 2	Input		Patchboard 2H
		Output	Mixer point 4
Oscillator 3	Input		Patchboard 3H
		Output	Mixer point 6
Oscillator 4	Input		Patchboard 4H
		Output A	Mixer point 8
		Output B	Mixer point 10
Keyboard Controller	Transient 2 Patchboard		Patchboard 14V
			Patchboard 11H
		Trig. Output	Patchboard 12V
		Key Output	Patchboard 16V
		Mod Input	Patchboard 17V
Noise and Controller	Controller Input		Patchboard 10H
		Noise Output	Osc 4B selector
		Noise Output	Patchboard 11V
		Cont. Output	Osc 4B selector
		Cont. Output	Patchboard 20V
Mixers	2		Osc 1 Output
	4		Osc 2 Output
	6		Osc 3 Output
	8		Osc 4 Output
	10		Osc 4B Output
	RV61		Patchboard 18H
	RV62		Patchboard 19H
	RV81		Patchboard 20H
	RV82		Patchboard 21H
		Output 1	Patchboard 1V
		Output 2	Patchboard 2V
		Output 3	Patchboard 3V
		Output 4	Patchboard 4V
		Output 5	Patchboard 5V
Envelope	Keyboard Output		Not used
	Ext. Output		Ext. Input mod-10
	Key Trigger		Patchboard 12V
	Signal		Patchboard 13H
	Control		Not used ext.
		Output	Patchboard 6V

MODULE	INPUTS	OUTPUTS	DESTINATION
Transient 1	Key Output		Patchboard 16V
	Ext. Trigger		Ext. Input mod-10
	Key Trigger		Patchboard 12V
		Output	Patchboard 13V
Transient 2	Ext Trigger		Ext. Inp. mod-10
	Key Trigger		Patchboard 12V
		Output	Patchboard 14V
VCF 1	Signal Inp.		Patchboard 14H
	Control Inp.		Patchboard 5H
		Output	Patchboard 7V
VCF 2	Signal Inp.		Patchboard 15H
	Control Inp.		Patchboard 6H
		Output	Patchboard 8V
Amp 1	Signal Inp.		Patchboard 16H
	Control Inp.		Patchboard 7H
		Output	Patchboard 9V
Amp 2	Signal Inp.		Patchboard 17H
	Control Inp.		Patchboard 8H
		Output	Patchboard 10V
Output Module	Input 1		Patchboard 22H
	17		Horiz. Joystick
	19		Vert. Joystick
	21		Patchboard 9H
		Output 18	Patchboard 18V
		Output 20	Patchboard 19V
		Output SW1	Rear phone jack
		Output 22	Patchboard 15V
		Phone Out.	Phone jack
External Inputs	Ext. Input 1		Rear phone jack
	Ext. Input 2		Rear phone jack
	Ext. Trigger from patch-board		Patchboard 12H
		Ext. 1 Out.	Patchboard 21V
		Ext. 2 Out.	Patchboard 22V
		Ext. Trigger (10) Out.	Envelope Transient 1 Transient 2

Notes: The patchboard is numbered 1H to 22H left to right and 1V to 22V top to bottom.

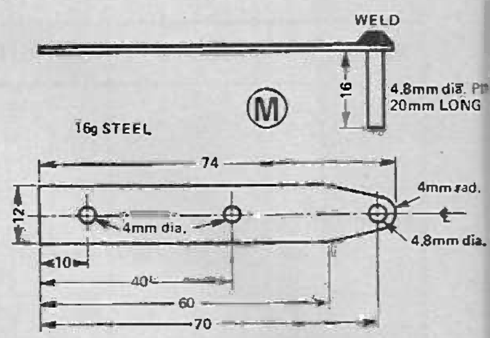
WOODWORK

The cabinet, detailed herein, is designed for the keyboards described last month. If different keyboards are used, some dimensions will need to be changed.

The stops (part K) and the hinge (part M) should be assembled to the case with the aid of the front panel. Stand the unit on end and place the front panel in its normally closed position with about 2 mm clearance at the top, and 1 mm clearance at the bottom, of the panel. Mark the pivot hole position and the rear edge of the front panel. Repeat the procedure for the other end. Drill the pivot holes 4.8 mm diameter and 10 mm deep. With the unit upright, fit the panel (using the parts M as pivots) and support it so that it is open and horizontal. Parts K can now be glued in position such that they rest on the edges of the front panel and are aligned with the pencil marks previously made. When the glue is dry parts M may be screwed into position.

The front panel may be secured in the closed position by a self-tapping screw countersunk into each side of the cabinet. The pivots and securing screws should be individually fitted on each unit to ensure proper alignment.

All material, unless otherwise specified, is 13mm (½") chip-board. ●



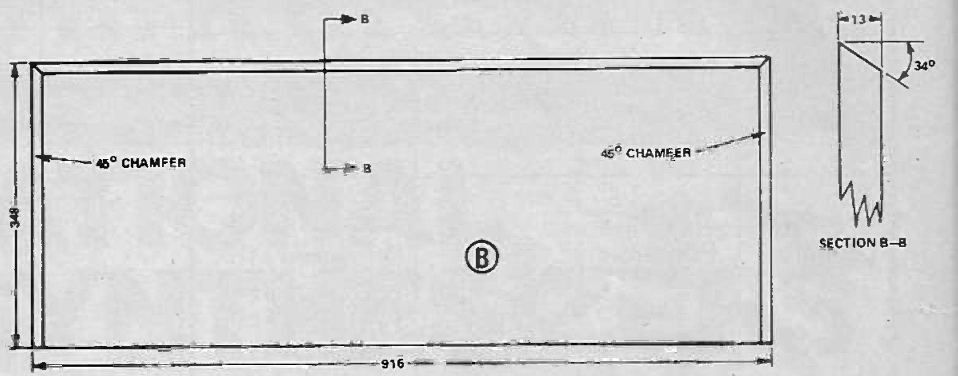
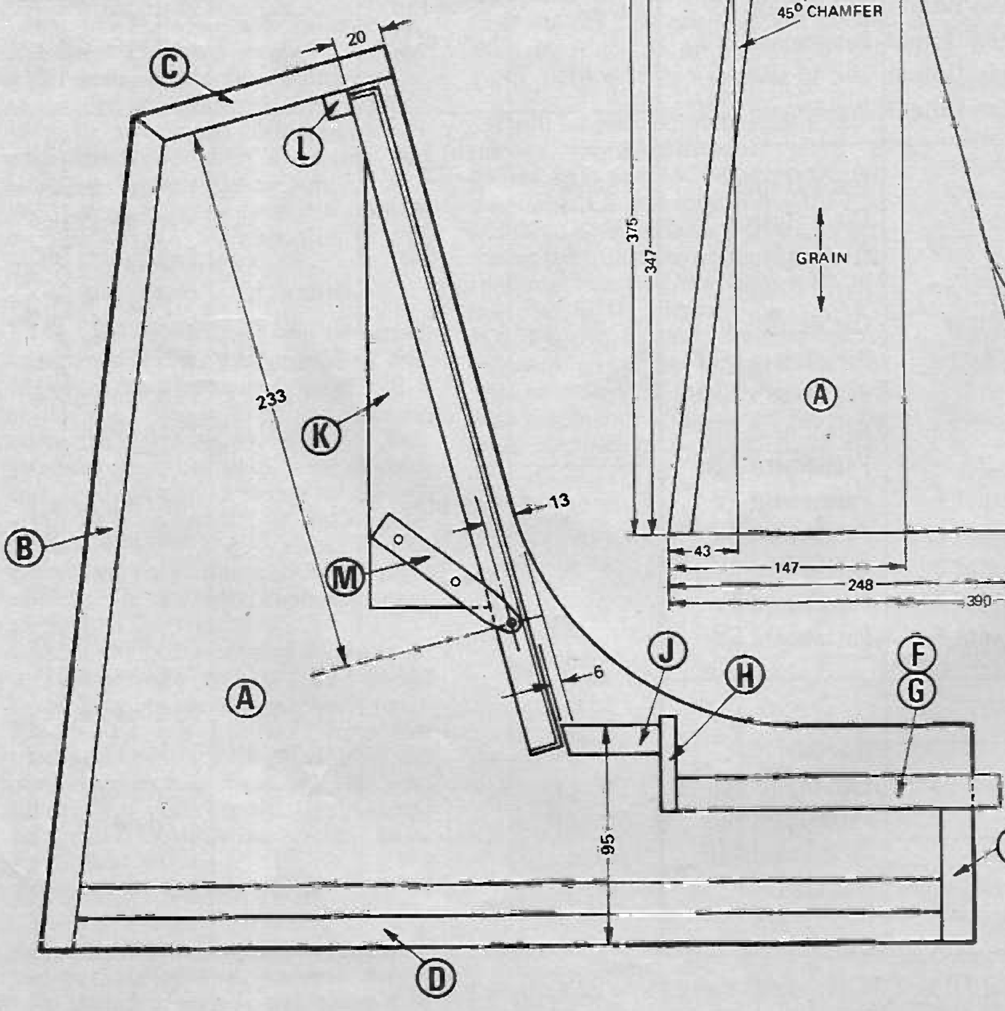
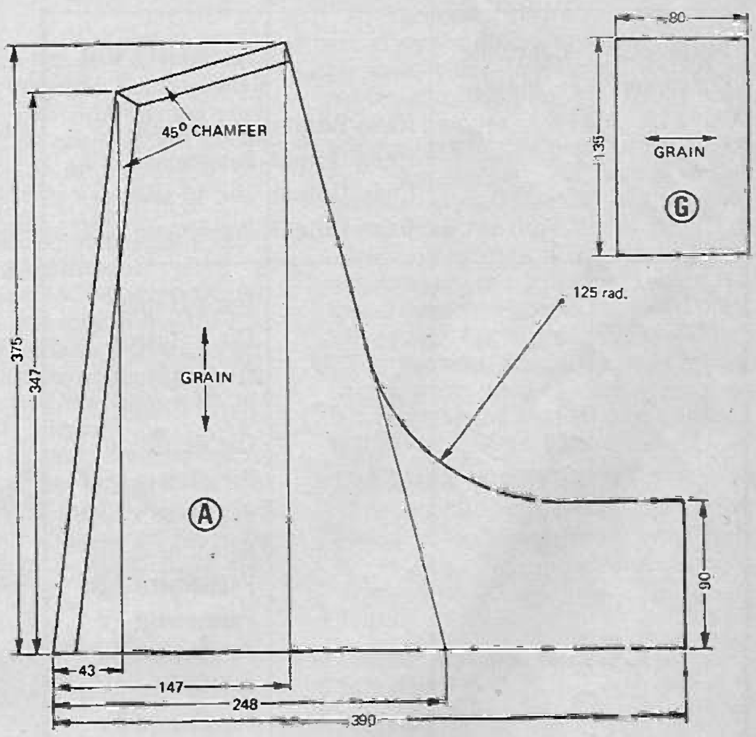
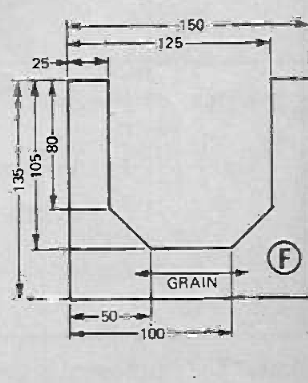


Fig.2. Cabinet assembly. Letters designate pieces described in separate drawings.

ALL DIMENSIONS ARE IN MILLIMETRES







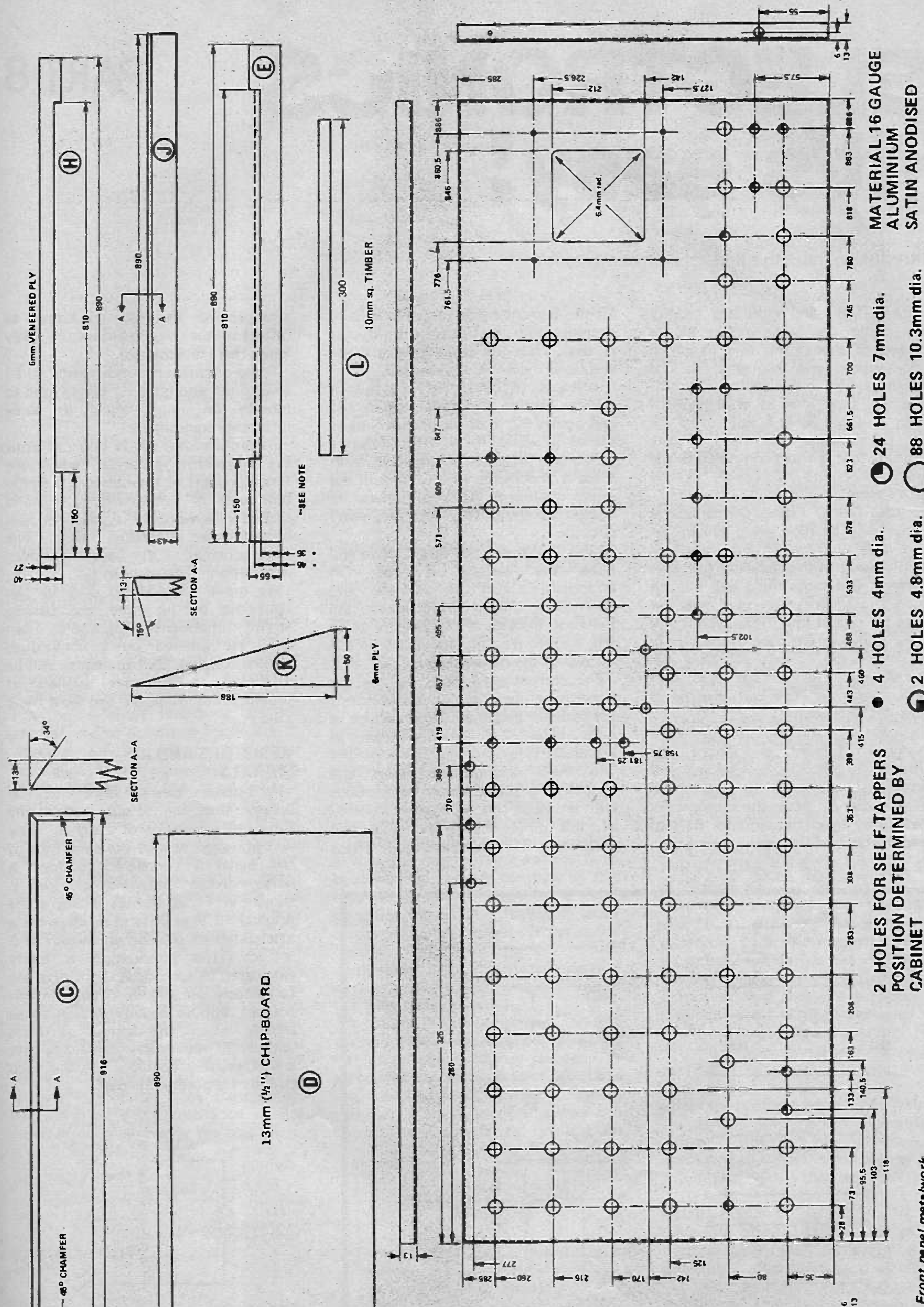


Fig. 3: Front panel metalwork

ELECTRONICS -it's easy!

PART 8

Introducing inductive and capacitive reactance.

CAPACITORS and inductors modify any sudden change in voltage that is applied to them. The way in which this happens was explained in last month's article in this series.

We will now look at what happens when a square wave is applied to CR and LR circuits that have a time constant that is short compared to the duration of one half cycle of the square wave.

In case (A) of Fig. 1, the capacitive current will be high when the square wave goes positive (time t_1), and will rapidly lessen as the capacitor becomes charged. The same thing will happen when the square wave goes negative (time t_2) except that the capacitor will now supply current back to the supply and hence the current will flow the other way. The current waveform through the network will thus be as shown in waveform 2.

In case (B) the inductor resists a change of current, and hence, the current will initially be low and will increase slowly until the maximum value is reached. When the square wave goes down again the inductor tries to keep the current flowing.

The current will thus gradually decrease until the field of the inductor is zero. Thus the current wave shape will be as shown in waveform 3.

In cases (A) and (B) the output voltage (across the capacitor in (A) and across R2 in B) for both will be as shown in waveform 4. Thus, in terms of voltage-in versus voltage-out, both these arrangements tend to smooth the input waveform. They are therefore known as smoothing (or integrator) circuits.

Now in circuits (C) and (D) we still have the series LR and CR arrangements but this time we have taken the output from across the inductor instead of the resistor as in (B), and from across the resistor in (D) instead of the capacitor as in (A).

The current waveforms will be the same as before as shown in waveforms (5) and (6), and the output voltage in both cases will be as shown in waveform (7).

In these arrangements then, the output is a pulse which corresponds with an input change, and the polarity of the pulse is the same as the direction of the change. These arrangements therefore are known as differentiator circuits (output only when there is a change).

These circuits are fundamental to all electronics and are extensively used to modify an input signal to some different requirement.

As an exercise, see if you can draw the waveforms generated when the time constant of the network is firstly one tenth of the time t, t_1, t_2, and secondly, ten times t, t_1, t_2. You will obtain some interesting results. The time constant in the waveforms given is about one fifth of t_1 to t_2.

We move on now to consider the behaviour of the three basic passive circuit components (R, L and C) when they are excited by a continuous sinewave signal. Our discussion will be restricted to sinewave signals at present — as these are the most basic kind.

RESISTORS AND AC SIGNALS

As resistors cannot store electrical energy, they cannot *alone* affect the time characteristics of a signal. They will however, change the amplitude of the signal if connected to form a voltage-divider network such as is shown in Fig.2. In this example the original 10 V peak to peak sinewave is attenuated to provide an output of 5 V p.p. The attenuation is easily calculated in such cases, for Ohms law (previously used in dc circuits in this course), applies equally as well to ac signals when the circuit is built entirely of resistors — or devices that are effectively resistors. We say such circuits are purely resistive.

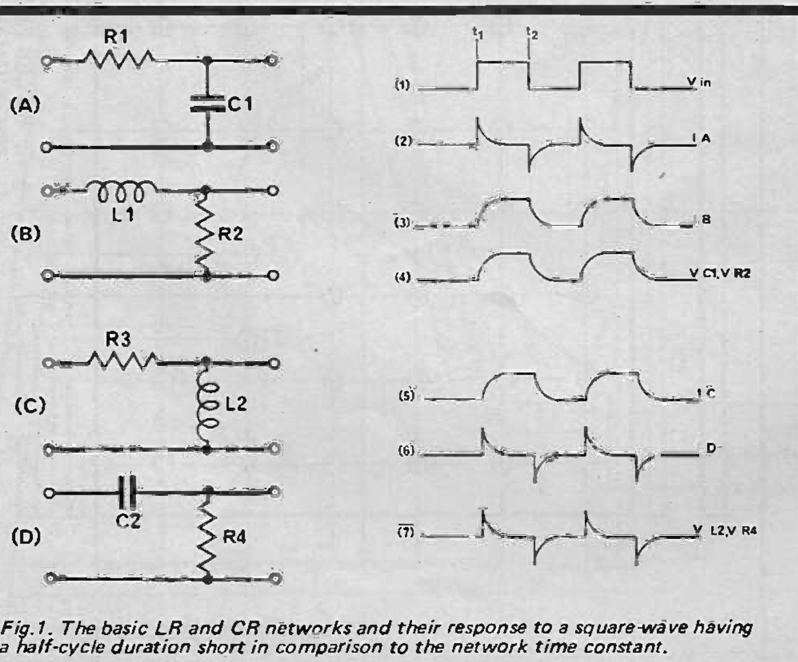


Fig.1. The basic LR and CR networks and their response to a square-wave having a half-cycle duration short in comparison to the network time constant.

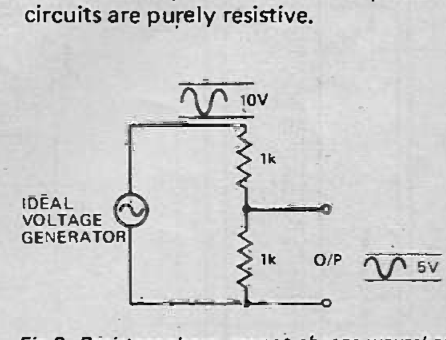


Fig.2. Resistors above cannot change waveshape, they can only reduce the amplitude.

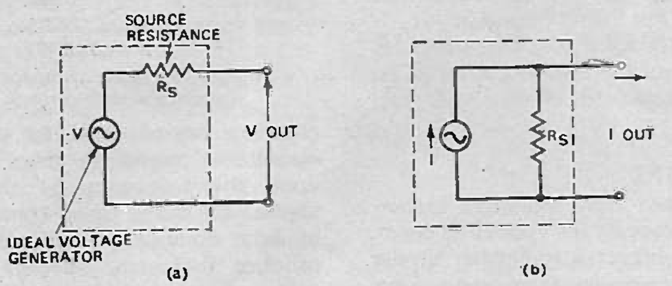


Fig.3a. Equivalent circuit of a practical voltage generator. (3b). Equivalent circuit of a practical current generator.

Note that the voltage-divider cannot provide signals of greater amplitude than the input. This may seem an obvious statement but we will see in the next part that storage elements, when connected in certain ways, can, in fact, magnify the voltage.

INTERNAL RESISTANCE OF SUPPLIES

In Fig.2 the two resistors forming the voltage divider are obvious. In many other cases they are not so easily recognised.

The ideal or perfect source of voltage has no internal resistance and is represented as shown in Fig.2. But in practice all sources have internal resistance so our equivalent circuit is more realistically the ideal voltage generator together with a series-connected internal or source resistance — represented in Fig.3 by Rs. The source resistance Rs is, in fact, the value that is measured (or would be) looking back into the source, and this applies no matter how complicated the power supply is.

Mostly we tend to think in terms of voltages when seeking an understanding of circuitry. But it is sometimes more convenient to make use of currents instead. The perfect current source, again representable as a black box, provides constant value of current regardless of load value. However, practical current generators always have shunt resistance — that seen looking back into the black box. As with voltage sources we must tolerate resistive losses, this time as a shunt that diverts current from the load. The equivalent circuit of a practical current generator is shown in Fig. 3b.

With a few exceptions, we can regard voltage and current sources as purely resistive devices comprising a perfect lossless generator and a suitably connected source resistor: it is however, not possible to separate the two.

LOADING OF SUPPLIES

In Fig.4 a resistor is connected across a voltage supply. It is clearly forming a voltage-divider chain with the internal supply resistance. In this example the output voltage, will be attenuated to half of that value provided by the supply in the unloaded condition.

The internal resistance of a supply is a vital parameter if the voltage is to hold up and remain constant as the load is changed. A varying load condition imposed on the supply (such as occurs in, say, a hi-fi system as the loudness demand varies would continually alter the system voltage supplying the circuits, with subsequent loss of correct operation.

A little thought reveals that a source resistance very much lower than the minimum load resistance reduces this attenuation effect; at least ten-times less is a good yardstick. Simple power supplies, like that specified earlier as a project, are unable to provide an adequately low internal resistance and, therefore, suffer from loading effects. Special stabilised supplies, although complicated in construction, simply provide a more ideal source by effectively providing a much reduced source resistance — tenths of ohms downward.

Similarly the current supply ideally should provide a constant current with load demand variation, but the inherent shunt resistor diverts the current from the load. The stabilised current supply, therefore, is designed to reduce this effect to a minimum.

It is possible, then, to regard voltage and current sources as black boxes with an internal resistance — in other words as resistive circuits. When studying the coupling of black boxes (stage-to-stage in a circuit or complete sub-system to the next) the preceding one is regarded as the source of voltage or current as is preferred — and the loading effect of that following is easily found from the above reasoning. Fig. 5 illustrates this: it is quite similar to the problem of meter loading discussed in Part 3.

In summary then, when the equivalent resistance of stages has been assessed, or measured, the coupling or loading effect is easily calculated using Ohms law. This concept applies to both dc and ac signals if the circuit is purely resistive.

The voltages and currents flowing in inductors and capacitors can also be handled this way if we use a simple calculation (discussed next) to obtain their effective resistance before using the various circuit laws.

THE CAPACITOR, INDUCTOR AND AC SIGNALS

We have seen how the storage of energy in the electric field of a capacitor, or in the magnetic field of an inductor, modifies the nature of a transient signal impressed across them. It can be said that the capacitor or inductor opposes the transient and tries to prevent its transmission.

If the applied signal is continuously varying from positive to negative — that is, it is an ac signal — it is, in effect, providing a continuous train of transients. We would, therefore, expect storage components to attenuate ac signals in some way. And this in fact is what they do.

INDUCTORS

As just pointed out an inductance opposes sinusoidal current flow. It does not change the time character of the waveform but does reduce the amplitude. The effective resistance is calculated from the formula.

$$X_L = 2\pi fL$$

where X_L is the inductive *reactance*, f

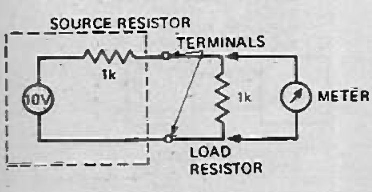


Fig.4. The source resistance, and the load resistance together make a voltage divider. Thus the voltage delivered to the load is less than the maximum available from the generator; and depends on load current.

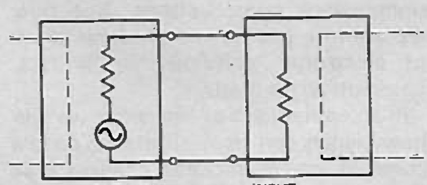


Fig.5. When coupling black boxes, the loading effects must be taken into account. Thus the output and input resistances must be taken into account.

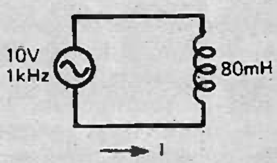


Fig.6. Current in this circuit is limited by the reactance of the inductor.

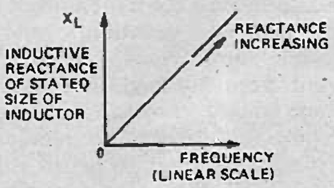


Fig.7. Variation of inductive reactance with frequency.

the frequency of the sinewave signal and L the inductance in Henries.

Reactance is a term used to describe this particular kind of circuit opposition. It is sometimes called *apparent* resistance. The effect must not be confused with that of pure resistance, for reactance, although limiting current flow and producing voltage drops, *does not dissipate energy*.

The term $2\pi f$ is often replaced by a simple symbol ω.

Thus $X_L = 2\pi fL = \omega L$.

A simple exercise illustrates how the formula is used. In Fig.6 an 80 mH inductor is energised by a 10 V rms, 1 kHz source. We wish to calculate the current flowing in the loop.

The formula gives the reactance as

$$X_L = 2\pi \times 10^3 \times 80/10^3 = 500 \text{ ohms}.$$

Knowing the effective resistance to such a signal we can now apply Ohms law to obtain the current

$$I = \frac{V}{X_L} = \frac{10}{500} = 20 \text{ mA}$$

Study of the X_L formula shows that it is frequency dependent so the current will be different if the frequency is changed. For example, if in this example we alter the frequency to 10 kHz, X_L increases to 1000 ohms and the current falls to 10 mA. The frequency effect can be portrayed graphically — see Fig. 7 — showing that X_L increases linearly with increase in frequency.

Practical inductors are made of wire — hence they have resistance as well as reactance. This resistance will deter

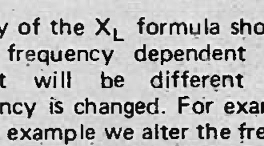


Fig.8. Current in this circuit is limited by the reactance of the capacitor.

the current flowing by a small amount. So do not be disturbed if calculations do not exactly agree with any measurements made of such circuits. As our background develops further we will see how to take this into account. For the moment it is sufficient to say that — *the resistance value and reactance value CANNOT be directly added to obtain the total resistance.*

CAPACITORS

Having seen how inductors behave when a sinewaves are applied to them, we would expect a somewhat similar pattern of behaviour to occur with capacitors. Capacitive reactance X_C is calculated from the expression

$$X_C = \frac{1}{2\pi fC}$$

where C is in Farads and the other terms are as in the inductive reactance formula given above.

In Fig.8 the capacitive reactance is

$$X_C = 1/2\pi \times 10^3 \times 2 \times 10^{-6} = 80 \text{ ohms}$$

and the current I is $V/X_C = 10/80 = 125$ mA.

This time if the frequency is raised to 10 kHz, X_C becomes 40 ohms and the current *rises* to 250 mA. Thus as the frequency rises the capacitive reactance falls whereas the inductive reactance rises. Put another way, at very high frequencies the capacitor may be considered as a low-resistance link, the inductor on the other hand is a low resistance link only at dc.

Fig.9 shows the variation of X_C with frequency. Note that in contrast with the frequency versus reactance characteristic of the inductor, that for a capacitor is not linear, but hyperbolic.

Although the calculation of X_L and X_C is straightforward it can become tedious when many values are to be found. To ease this task a reactance chart may be used from which the reactance at any frequency may be directly determined. A reactance chart is included for your future reference on page 37.

INVALUABLE ELEMENTS

Compared with the simplicity of dc circuits it might seem that the introduction of ac signals makes unnecessary complications. But now we are in a position to see how much of electronic technique is, in fact, based on ac methods.

In an earlier part of this series we saw how signals can be multiplexed onto a common communication channel if ac forms were used. The system design to accomplish this needs circuit techniques that can separate frequencies into individual channels. That is where the inductor and

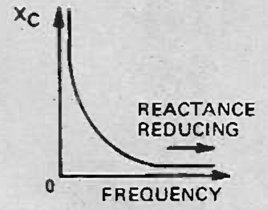


Fig.9. Variation of capacitive reactance with frequency.

capacitor are of value, for the signal magnitude passed by them depends upon the frequency of the signal applied to them. Using combinations of both components we are able to produce frequency selective circuits that let selected frequency signals through without loss, whilst attenuating those lying either side of the chosen frequency. This is the way in which radio tuners separate the desired programme from all the others picked up by the antenna.

In the power supply project the capacitor was used to smooth out pulsations of the rectified waveform. Thus the capacitor may be seen to provide us with a means of averaging varying signals.

These examples illustrate why its absolutely essential to have a solid grounding in the behaviour of inductors and capacitors. Like Ohms Law, a knowledge of reactance is absolutely essential. Take time to make sure you understand it thoroughly.

COUPLING BLACK BOXES

Two basic methods may be used to couple circuits together. These are ac coupling and dc coupling.

Where the signal from black box (A) Fig.10 is to be coupled into black box (B), we must first examine the signal to see what frequency range it covers. If it extends down to zero, that is dc, then direct coupling must be used.

In this method the output of (A) is simply joined by means of a wire link or a resistor, to the input of (B).

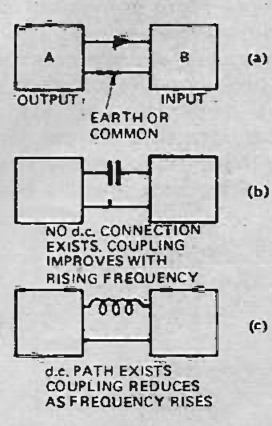


Fig.10. Coupling methods.
(a) direct
(b) capacitive
(c) inductive

However if the mean dc voltages at the output of (A) and the input of (B) are different, a current will flow between them, which may upset the operation of either or both. Thus where dc coupling is required, the black boxes must be designed so that the dc voltage at the output of (A) is the same as that at the input to (B).

Where it is not necessary to operate down to dc, an ac link may be used. This usually takes the form of a series capacitor which blocks dc (and thus allows the dc operating points of (A) output and (B) input to be different) but offers negligible impedance to the ac signal.

It is only necessary to use a capacitor in one lead, in order to block dc, the other can be left as a direct coupling. The capacitor is nearly always wired into the non-grounded (non-earthed) lead.

Ac coupling may however change the signal that is being transferred from A to B.

A signal containing many frequencies – a square-wave, for example – may arrive at B as seen earlier, with shape changed and possibly its amplitude reduced. This is because the various sinusoidal waveforms that compose the signal are each attenuated by differing amounts (for X_C varies with frequency). The net result is a new wave shape. The extent to which the shape is changed depends upon the frequencies present and the value of the capacitor.

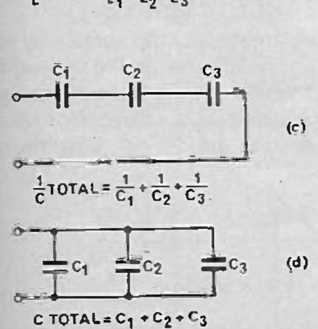
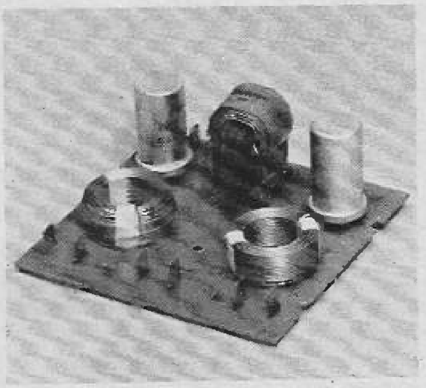


Fig.11. Rules for combining series and parallel inductors or capacitors to an equivalent single value.



Inductors and capacitors are used to form this Philips loudspeaker crossover network.

By suitable choice of components this effect may be minimized. Referring back to the section on LR and CR networks, if circuit D is used to couple circuits, and the time constant is chosen to be long in comparison with a half cycle of the signal, then the signal will be little changed by the network. Do some sums on this for yourself and see what effects different time constants have. For example assuming that a circuit has an input resistance of 10 k ohm (R4) what value of C2 would be required to pass a 20 Hz square wave without too much change in shape?

A single frequency sinusoidal signal passes with its shape unchanged. Its amplitude, however, will be altered in accordance with the reactance of the capacitor at that frequency, and any other resistances in the circuit that go with the capacitor to form a voltage-divider chain.

Zero frequency dc signals, as said before, will not pass at all, for the capacitor has no direct coupled path – it only "passes" current when the charges are moving. The capacitor, therefore, provides us with a means to *block* dc whilst allowing ac to flow. This means the steady-state dc voltage level at A can be quite different from that at B yet there is no danger in connecting them together provided a capacitor is in series.

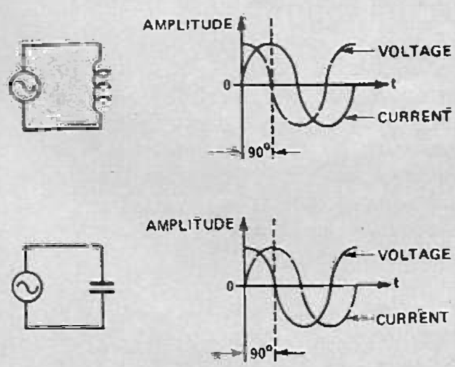


Fig.12. Amplitude – time graphs for voltage and current in an inductor, and in a capacitor.

The higher the excitation frequency the lower is the capacitive reactance. The capacitive coupling therefore, becomes lower in effective resistance as the frequency rises. By appropriate choice of component value (relative to the circuit resistance) it is possible to provide a coupling that is as good as a direct lossless link yet still blocks dc.

Inductors, see Fig. 10c, have the opposite effect (reactance increasing with frequency whilst providing a good dc path). Thus they are commonly used where it is desired to allow dc current flow whilst blocking ac signals. They are also extensively used in combination circuits which separate a signal, or group of signals, from all others. More about this in the next part of the course.

Inductors, then provide increasing coupling resistance with frequency increase and do not block dc. In this role they are able to smooth out fluctuations in a signal: the higher frequencies are attenuated more than lower frequencies. Inductors are often used in this role in which case they are termed chokes.

STORAGE COMPONENTS IN SERIES AND PARALLEL

It is often necessary to calculate the combined effect of inductors or capacitors when they are wired in series or in parallel. The discussion of this section applies only to connections having only inductors, or only capacitors. We will see later that combinations of the two provide vastly different behaviour.

Inductors – the total inductance of series-connected inductors is equal to the sum of each – refer to Fig. 11a.

The total inductance of paralleled inductors obey the reciprocal law found with paralleled resistors – refer to Fig. 11b. Inductors, then, follow the laws of resistors in this respect. It might be helpful if you remember that inductors in series provide a "bigger" inductor. These rules apply *only when the magnetic fields of each are not interacting.*

Capacitors – these follow the same law but in reverse. Series capacitors obey the reciprocal law, paralleled capacitors obey the additive law – refer Fig. 11c and 11d. An easy way to remember this is that parelleled capacitors effectively increase the plate area thus increasing the capacitor size.

These rules are used to calculate the total component value. From this it is easy to obtain the total reactance as though only one component existed.

But do remember *the laws apply only to groups of similar components.*

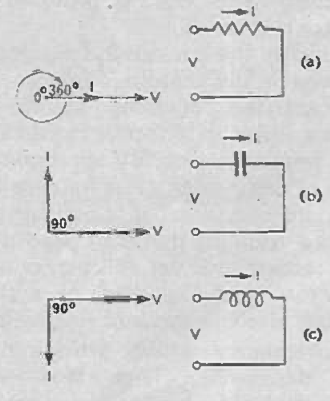


Fig.13. Vector (or phasor) diagrams for resistance, capacitance and inductance.

If you have a circuit with many capacitors and many inductors the rules work to reduce series or parallel groups of either component to an equivalent, but may not be applied to combinations of different component types.

PHASE RELATIONSHIPS

The voltage developed across an inductor reaches its maximum value when the rate of change of current passing through it is a maximum. This occurs in sinewaves when the current magnitude is zero.

We, therefore, have two distinct components of the signal to consider – current and voltage. They are both sinewaves but they pass through their various levels at different times. A good way to comprehend this is to draw a small piece of the amplitude-time graph of each (as in Fig. 12a). It is clear that the current curve reaches its maximum 90° (or one quarter of a full cycle) behind the driving voltage. In electrical jargon we say the current *lags* the voltage by 90°. (We do not say it leads by 270°: it would only complicate the issue).

The phase effect is opposite with capacitors, for maximum current flows when the charging rate is maximum; this occurs when the applied voltage is zero. Again then, the current and voltage are not in phase and the current leads the voltage by 90° as shown in Fig. 12b.

VECTORS

In order to assess the total effect of combinations of resistors, capacitors and inductors, we need to combine their respective signals, making allowance for the different phase shifts in each case.

Special mathematics (called *complex algebra*) can be used to calculate the resultant effect but it is an approach devoid of intuitive feeling for what is happening. It also needs special training to understand it.

Instead we can manage quite well using a purely graphical method in which the length of a line is used to represent longitude of the voltage or current and the *direction* of the line to represent phase. These lines are called vectors (or phasors) to differentiate them from normal lines in which direction is unimportant.

As a sinusoidal signal repeats continously, there is no need to draw each sinewave and add them step by step to see the combined total – this does work but is completely unnecessary. We, in fact, disregard the cyclic changes in instantaneous amplitude and represent the rms or peak value of the signal amplitude by the length of a line. This line is drawn in a certain direction, related to its phase difference. Fig. 13a is a vector diagram for the voltage and current in a purely resistive circuit: the current and voltage are in phase so each vector lies along the same direction. The right-hand, horizontal position shown is always taken as zero phase angle.

The vector diagrams of the basic capacitive and basic inductive loop are also given in Fig.13b and 13c. The 90° phase difference between voltage and current results in the current vector being 90° around from the datum

When interpreting such diagrams, convention says that the observer moves around the diagram in a clockwise direction – it is wrong to rotate the diagram past the observer.

The reference vector is chosen to be the circuit parameter that is common to each component – current in a series circuit, voltage in a parallel circuit.

VECTOR ADDITION

If two or more compatible signals (eg, a pair of voltages, or a pair of currents, but *not* a voltage and a current) exist with a phase difference they *must* be added as vectors – it is wrong to add their amplitudes directly unless they are in-phase.

Referring to Fig. 14, the vector diagram shows two voltages V_1 and V_2 where V_2 leads V_1 by 90°. They are scaled to represent 10 V and 15 V respectively. The net resultant of the two is not 10 plus 15 because they are not in phase.

The correct sum is, instead, found graphically by drawing lines (at 90° at each axis) out to their intersection point V_r. The distance from the origin to the intersection is the resultant voltage. The resultant phase angle is given as the angle θ also shown in Fig. 14. If they are 180° out of phase they can be arithmetically subtracted.

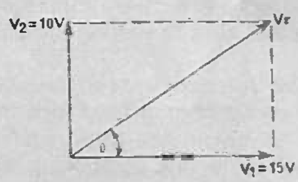


Fig.14. Graphical addition of vectors.

RESISTANCE AND INDUCTANCE IN SERIES

When resistors are used with inductors or capacitors, the signal across them is similarly involved with phasing problems. To find out what happens requires vector addition of voltages and currents.

The vector diagrams of a resistor and inductor in series is given in Fig. 15. The reference signal is current (common to all components) and the voltage developed across the resistor is in-phase with the current. That across the inductor, however, leads the current by 90° (it leads rather than lags this time as our reference is now current – be careful about which leads or lags what). The parallelogram has been completed to give V_r and θ.

In practice, inductors always possess measurable resistance so the phase angle of the practical inductor never quite reaches 90°. Ignoring this though, when the phase angle is 90° in these diagrams (as can be reasonably assumed for inductors and capacitors) we do not need to draw the vector diagram but, instead, make use of the rules of right-angle triangles to calculate the unknowns. The Pythagoras rule tells us that

$$V_r^2 = V_R^2 + V_L^2$$

from which we can show that the apparent resistance of two combined elements (called the *impedance* Z) is given by

$Z^2 = R^2 + X_L^2$ for inductors.

ie. $Z = \sqrt{R^2 + X_L^2}$

Hence the impedance of a circuit containing inductors is only calculable if the frequency is stated (since X_L is frequency dependent).

The phase angle in degrees is found from the trigonometric formula

$$\tan\theta = \frac{X_L}{R}$$

RESISTANCE AND CAPACITANCE IN SERIES

These are treated in the same way as inductors and resistors giving the same Z (impedance) formula but where X_L is now X_C. Here is an example of how impedance is used to determine

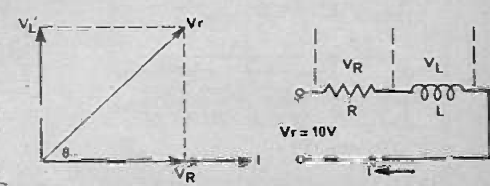


Fig.15. Vector diagram of current and voltages in a series RL circuit.

ELECTRONICS -it's easy!

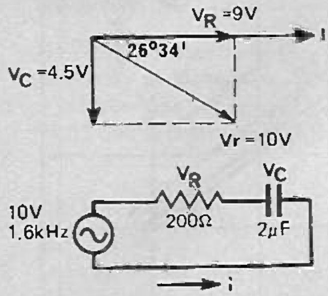


Fig.16. An RC circuit and its vector diagram.

currents and voltages in a circuit fed from ac.

In Fig. 16 a 200 ohm resistor is in series with a 2 μF capacitor. It is required to decide what voltage is across each component and what value phase angle is seen at the terminals.

Knowing the frequency, first calculate X_C (it will be about 100 ohms). The impedance is then found as

$$Z = \sqrt{R^2 + X_C^2} = 223 \text{ ohms}$$

The phase angle is tan θ $\frac{X_C}{R}$ = 0.5 and the tables give the angle as 26° 34'. Finally, we reason out that the phase angle is leading.

The current flowing in the series loop is found from Ohms law but here we take impedance as the total circuit resistance.

$$I = V/Z = 10/223 = 45 \text{ mA}.$$

Ohms law can now be applied (ignoring that we have vector quantities in the current for this is now allowed for) to arrive at the voltage across each element. Across the resistor will be

$V_R = 45 \times 10^{-3} \times 200 = 9$ V across the resistor

$V_C = 45 \times 10^{-3}\ 100 = 4.5$ V

Note that these do not add up to 10 V (as might be expected) and that the sum is always more than the source.

Finally, as a check, it is sound practice to draw a scaled vector diagram. This should agree with your figures. This is done in Fig. 16.

Practical capacitors can be made closer to the ideal than inductors so in most capacitor circuits we do not need to make allowances for their internal resistance.

Q-FACTOR

Practical inductors possess both storage and dissipative capabilities at the same time. As they are intended to *store* energy not waste it, it is useful to form a criterion to express their goodness.

A perfect inductor has no resistance, only reactance. The ratio of these two (for a particular frequency, therefore) is a measure of quality. This ratio $\frac{X_L}{R}$ is called the quality factor or simply the Q-factor (or Q) of the coil.

Practical coils can reach Q's of several hundred. To go higher, special circuits have been developed in which the effective Q is many times higher.

Use of the Q-factor is not confined to inductors. It is used to express the quality of many types of energy storage systems — capacitors, mechanical systems, acoustic cavities, etc.

In the next part of this series we will look at inductors and capacitors in parallel circuits with resistors and then study what happens when both are used together. There we will see some quite astounding effects. ●

ELECTRONICS -in practice

A RELAXATION OSCILLATOR

THE circuit of Fig. 17 shows how the charge-discharge behaviour of an LC circuit and a neon lamp (note the circuit symbol) may be used to produce a continuous ac signal. Such a circuit, capable of producing a continuous ac waveform is called an oscillator. The circuit provides, when the correct component values are used, an audio-frequency tone that may be heard in headphones.

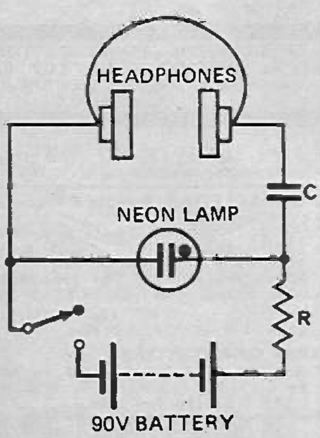


Fig.17a. Relaxation oscillator circuit for Morse Code practice.

Neon lamps are small lamps having two metallic elements spaced a short distance apart and enclosed in neon gas at fairly low pressure. At a voltage dependent on electrode spacing and lamp pressure, a glow discharge (due to ionization of the gas) will occur and the current though the lamp will rise to a level limited only, in the main, by the external circuit resistance. This voltage for small neons is typically around 75 to 80 volts. The lamp will continue to conduct until the supply voltage falls below a point called the maintaining voltage. This typically will be 60 volts or less.

To return to our circuit, the operation is as follows:— When the switch is closed, capacitor C will charge relatively slowly (via resistor R and the headphones) from the battery in a time equal to roughly three times the total resistance in Ohms times the capacitance in Farads (remember T = RC). When the voltage across the capacitor reaches approximately 80 volts, the neon lamp ionizes and draws current from C, discharging it. Were it not for the resistance of the headphones, this discharge would be almost instantaneous. The discharge continues until the voltage across the capacitor falls to 60 V, the neon lamp de-ionizes (thus is again a high resistance) and the capacitor will again charge towards 80 volts. A waveform will thus be generated having a shape similar to that shown in Fig. 17b.

This waveform is obviously not sinusoidal — it is more like a sawtooth. The sound heard in the headphones will therefore be quite harsh because of the harmonics which are present in addition to the fundamental frequency.

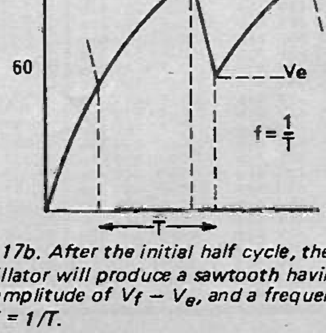


Fig.17b. After the initial half cycle, the neon oscillator will produce a sawtooth having an amplitude of $V_f - V_e$, and a frequency of f = 1/T.

It is impossible to predict, accurately, the frequency at which the circuit will oscillate because of variations in firing and maintaining voltages of the neon and gas ionization and de-ionization times. Below 200 Hz the approximate formula is

$$f = \frac{1}{2.3\ RC \log \frac{V - Ve}{V - Vf}}$$

For your guidance the graph of Fig. 17c shows frequency of oscillation of a typical neon with various RC values.

Using values of series resistance below one megohm may shorten the life of the neon due to arc discharges. Values above 15 megohm may prevent oscillation occurring at all. Maximum frequency of oscillation is around 20 kHz being limited by the ionization and de-ionization times of the neon gas. The only limit to low frequency oscillation is obtaining capacitors having high capacitance and low leakage.

The headphones used should be around 2 kohm impedance. Alternately, if high impedance crystal type are used, these should be shunted by a resistor of 2 k ohm in parallel. Remember that the headphone impedance is part of the charge/discharge circuit and will affect the frequency of operation.

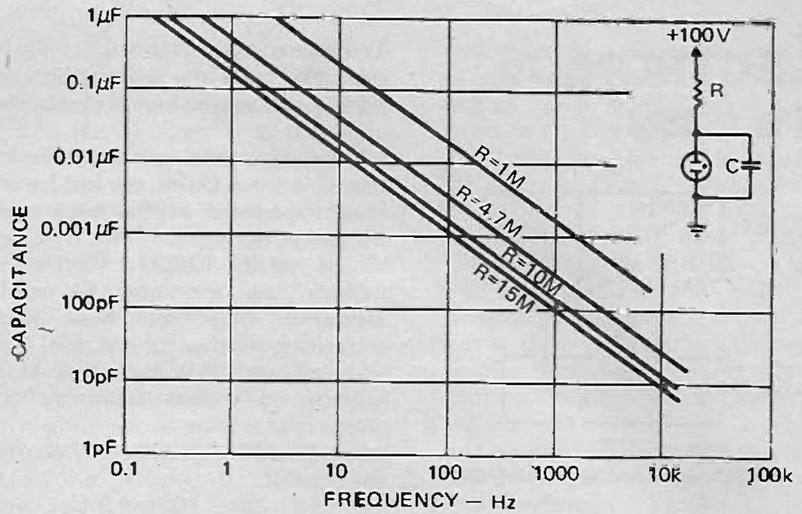


Fig. 17c. Operating frequency of a typical neon oscillator with various values of resistance and capacitance (approximate only).

Note that some small neon lamps are specially designed as indicators for 240 volt ac applications. Such lamps have a built in resistor of high value to limit current through the lamp. These are unsuitable for use in oscillator circuits unless the resistor can be removed.

It is interesting to note how such a simple circuit as this has so many factors which must be taken into consideration. Indeed there are even more factors than have been mentioned here — only the important ones have been listed.

Lesson — never take anything for granted, even in simple circuits. ●

ERRATA
Graphs 6b and 9b on pages 54 and 55 of ETI August 1974 should be transposed

BYWOOD

– THE DIGITAL PEOPLE?

BYWOOD have the largest range of digital clock chips, calculator chips, and seven segment readouts available anywhere. We deal only in these types of devices so that we can offer an expert advisory service to your advantage.

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CLOCK CHIPS

		Price	Pin count
MM5311	Basic clock chip, BCD outputs	£ 9.00	28
MM5314	As MM5311, no BCD outputs	£ 7.20	24
MM5309	As MM5311 plus reset to zero.	TBA	28
MM5316	4 dig alarm chip, Liq. Crys. drive.	£15.00	40
MM5375	6 dig alarm, Sperry drive.	TBA	24
MK5017AA	6 dig alarm, sleep and snooze.	£14.00	24
MK50250	6 digit alarm.	£ 7.60	28
CT7001	Alarm/date/sleep/snooze/etc.	£16.50	28
CT7002	As CT7001 but BCD outputs.	£16.50	28
TMS3952	Alarm/stopwatch.	£20.00	28
CT6002	CMOS,Liq.Crys. drive, for battery clock.	£22.65	40

DIGITAL WATCHES

The CT6002 chip is available built into a complete digital watch module complete with everything except case - no soldering to do, the module is actually running when you get it! CT6001/M **£92.60.**

MHI DIGITAL CLOCK KITS

Our MHI range of kits is intended to allow the building of virtually any type of digital clock. The range was announced in May with the MHI-5314/C kit and is now supplemented by four new additions.

MHI-5314/C is based on the MM5314 chip, it gives a basic digital clock suitable for driving any of the MHI display units. **£8.40**

MHI-5025 kit uses the Mostek MK50250 alarm chip, it gives a six digit display with an alarm tone circuit to drive a small speaker. The kit is suitable for any of the MHI display boards. **£11.35**

MHI-7001 kit uses the fantastic CAL-TEX CT7001 chip with time, date, alarm, sleep, snooze and many other features. We would advise the use of a six digit MHI readout for this kit. **£19.00**

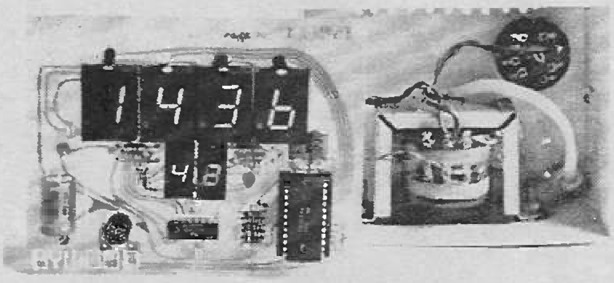
MHI-D707 display kit uses the DL707 0.3" LED display digits, available as a four digit or six digit kit.
MHI-D707/4 £7.60, MHI-D707/6 £11.40

MHI-D747 display kit uses the DL747 0.6" LED digits, these give a display which is readable at over 25 feet.
MHI-D747/4 £10.25 MHI-D747/6 £15.35

MHI-D3IN is specifically designed for advertising type displays, the digits are made up from discrete LED lamps and form digits about 3" high. These are readable at distances of well over 50 yards. Available as four or six digits with colons between each pair of digits.
MHI-D3IN/4 £24.00 MHI-D3IN/6 **£36.00**

The clock kits contain clock chip, CA3081 segment driver, PCB (4" x 2"). The MHI-5314/C kit does nor contain a socket for the clock chip (£1.00 extra) but all other kits have a socket as standard. The display kit contains the LEDs and a four or six digit PCB.

MHI is a modular approach to building digital equipment and all present and future kits are interchangeable wherever possible. The simplicity of the kits makes them ideal for small production runs of clocks or for teaching and training. For details of quantity prices please contact us at Hemel Hempstead (0442) 62757.



5314 - JUMBO EVALUATION KIT

Our most popular kit so far is our 5314 - JUMBO Evaluation Kit, due to the large orders that we have received from amateurs and from industrial users we are able to offer this kit at a new price of £22.80.

The MM5314 is a 24-pin LSI chip containing all the logic necessary for a 12/24 hour, 4/6 digit, 50/60Hz digital clock. The new 0.6" LED display from Litronix (the Jumbo) is readable from distances of over 25ft. We supply MM5314, socket, 4 Jumbo's, 2 DL707 0.3" digits, CA3081 driver and a 5" x 4" fibreglass PCB. You supply 16 resistors, 3 capacitors, 2 diodes, 6 transistors, transformer and switch.

KIT PRICE: £22.80

DISPLAY READOUTS

DL707	Common Anode 0.3" LED.	£ 1.70
DL704	Common Cathode DL707.	£ 1.70
DL747	Common Anode 0.6" LED.	£ 2.45
DG10A	Phosphor-diode 8.5mm.	£ 1.10
DG12H	Phosphor-diode 12.5mm (0.5").	£ 1.20
LC823440	Field effect Liq.Crys. four digits.	£16.00
3015F	Minitron filament, 9mm digit.	£ 1.25
3016F	Minitron type filament, 12mm digit.	£ 1.25
3017F	Minitron type filament, 16mm digit.	£ 2.00
SP752	Sperry high voltage, 0.5", 2 digits.	£ 4.00

CALCULATOR CHIPS

CT5002	Four function, 12 digits.	£ 5.00
CT5031	8 digit, Constant, 'timer' option.	£14.55
CT5032	12 dig, cons, mem, averager, etc.	£19:36
CT5037	8 dig, cons, mem, internal mpx.	£15.49

SOCKETS

We advise the use of sockets with the above chips. 24 or 28 pin £1.00, 40 pin £1.35.

CLOCK DATA SHEETS –SAE. **ADVICE** – PHONE 0442-62757
POST & PACKING – 10p. OVERSEAS (AIRMAIL) 50p. VAT – ALL PRICES EXCLUDE VAT.
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INTERNATIONAL 422 STEREO AMPLIFIER

PART TWO.

PROJECT 422

Details of metal and woodwork.

THIS month we present the metal and woodwork drawings, for those people wishing to construct their own chassis and cabinet.

The amplifier, because of its wide frequency response, will reproduce pops and clicks, etc, introduced into the mains by equipment (such as refrigerators) switching on and off. Some protection against this is given by C18 (across the primary of the power transformer). If this is insufficient, 0.0047 microforad capacitors may be fitted between the live end of C18 and earth, and also between the neutral end of C18 and earth. If used, these components must have a rating of at least 600V.

Fig. 11. Artwork for front-panel escutcheon

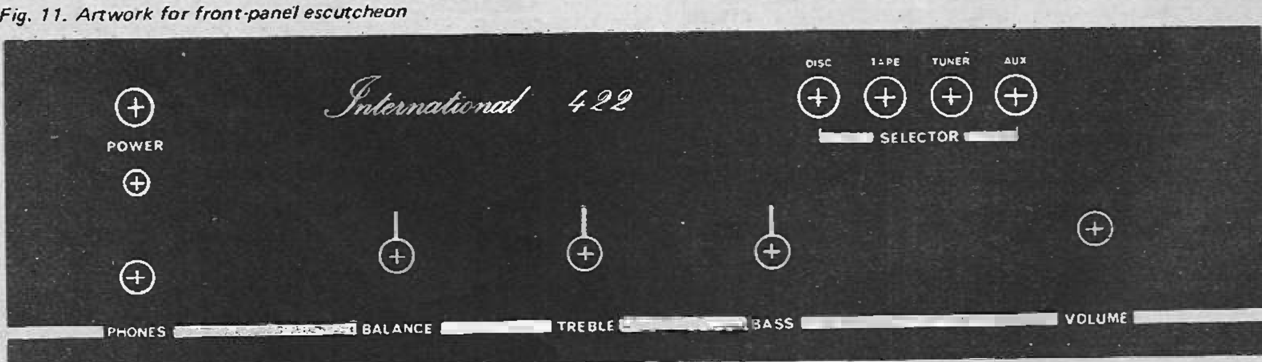
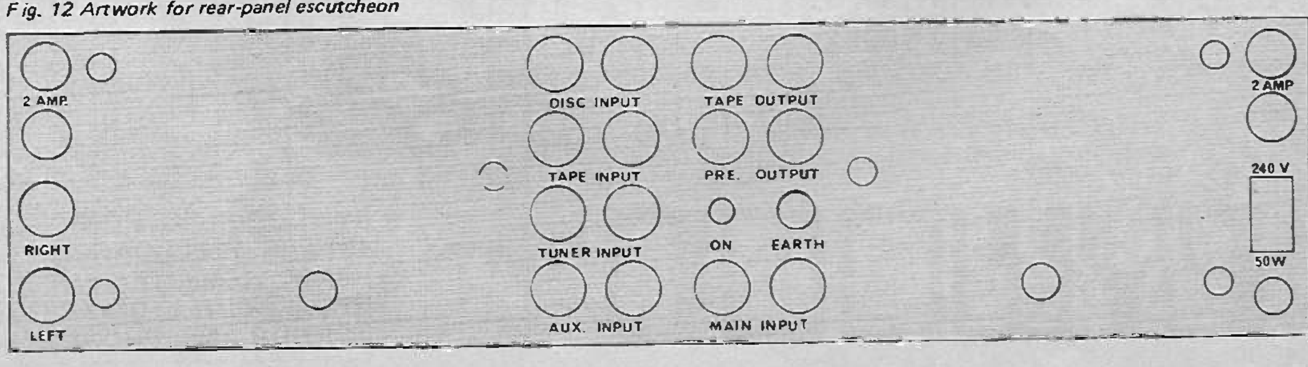


Fig. 12 Artwork for rear-panel escutcheon



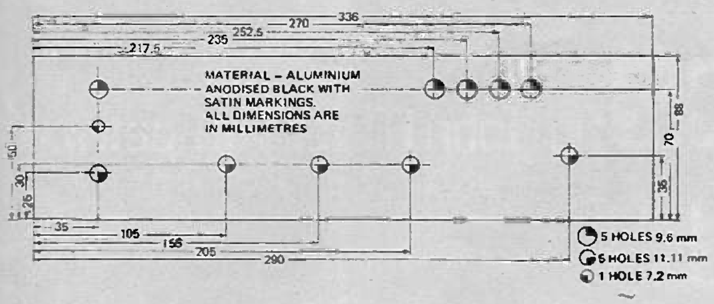


Fig. 13. Drilling details of the front panel escutcheon.

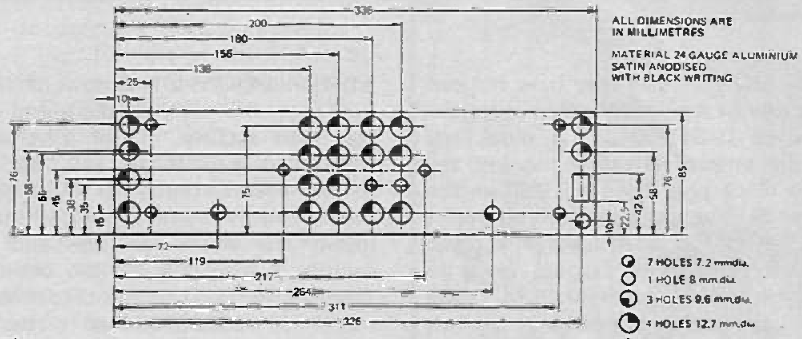


Fig. 14. Drilling details for rear-panel escutcheon.

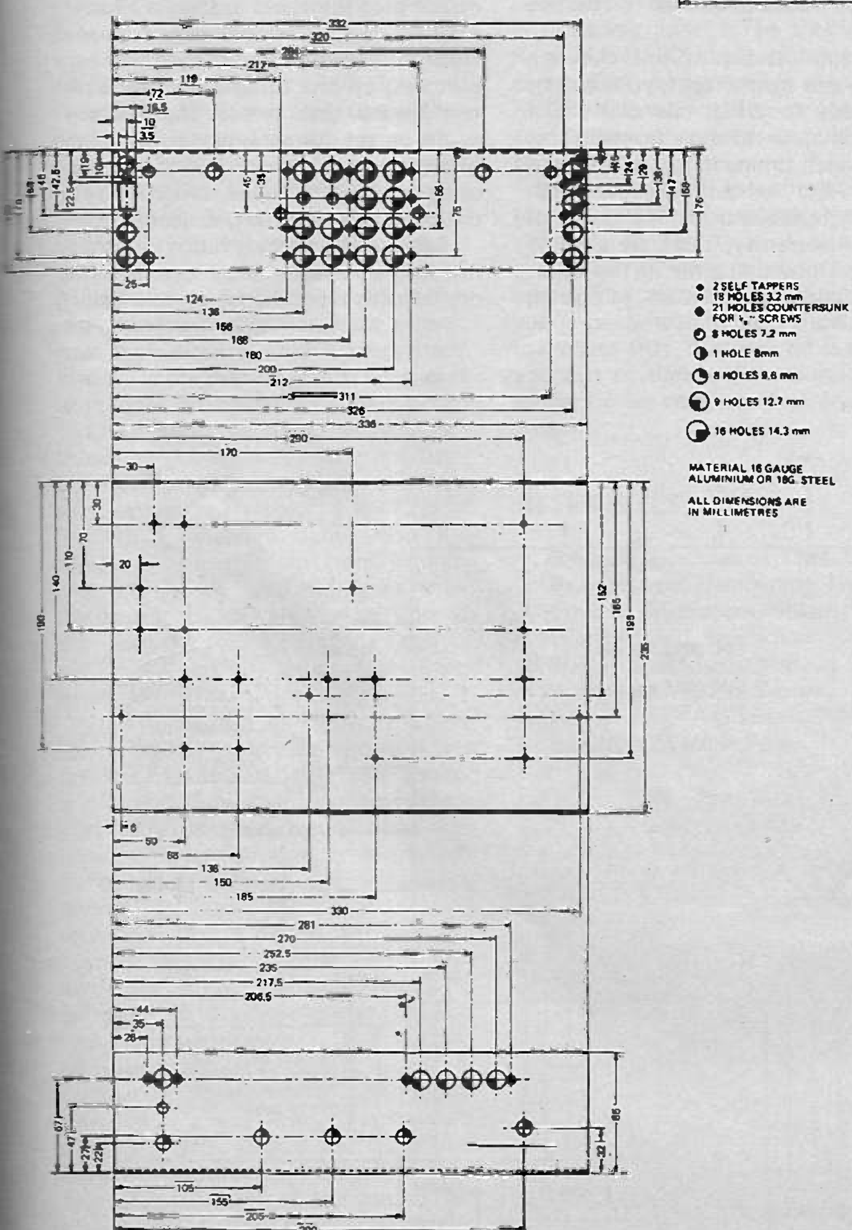


Fig. 15. Drilling details and dimensions of the chassis.

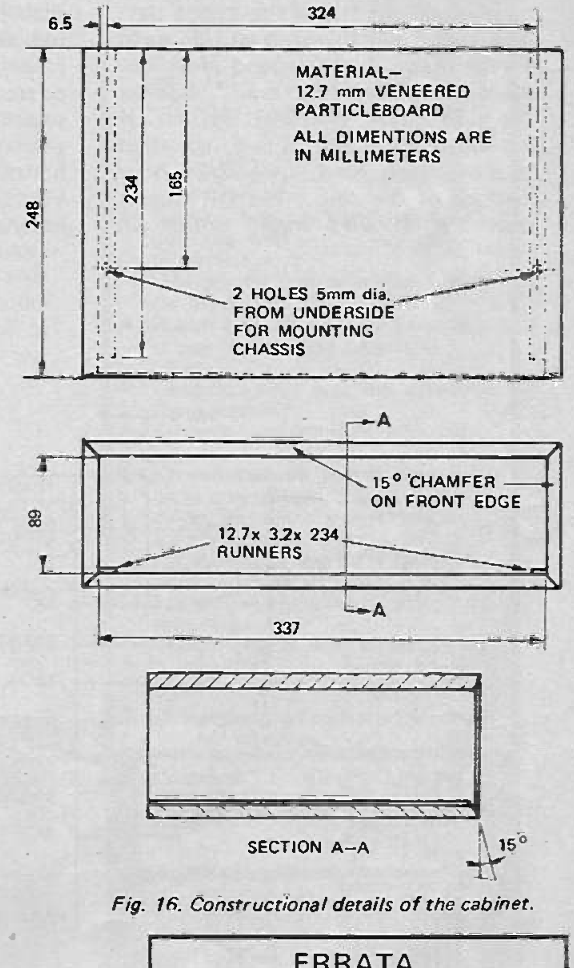


Fig. 16. Constructional details of the cabinet.

ERRATA

Lines six and seven in the third column of the parts list on page 28 last month should read as follows:

ZD1 Zener diode BZY88C5V6
ZD2 Zener diode BZY88C5V6
ZD3 Zener diode BXZ70C18 (16V or 20V will do).

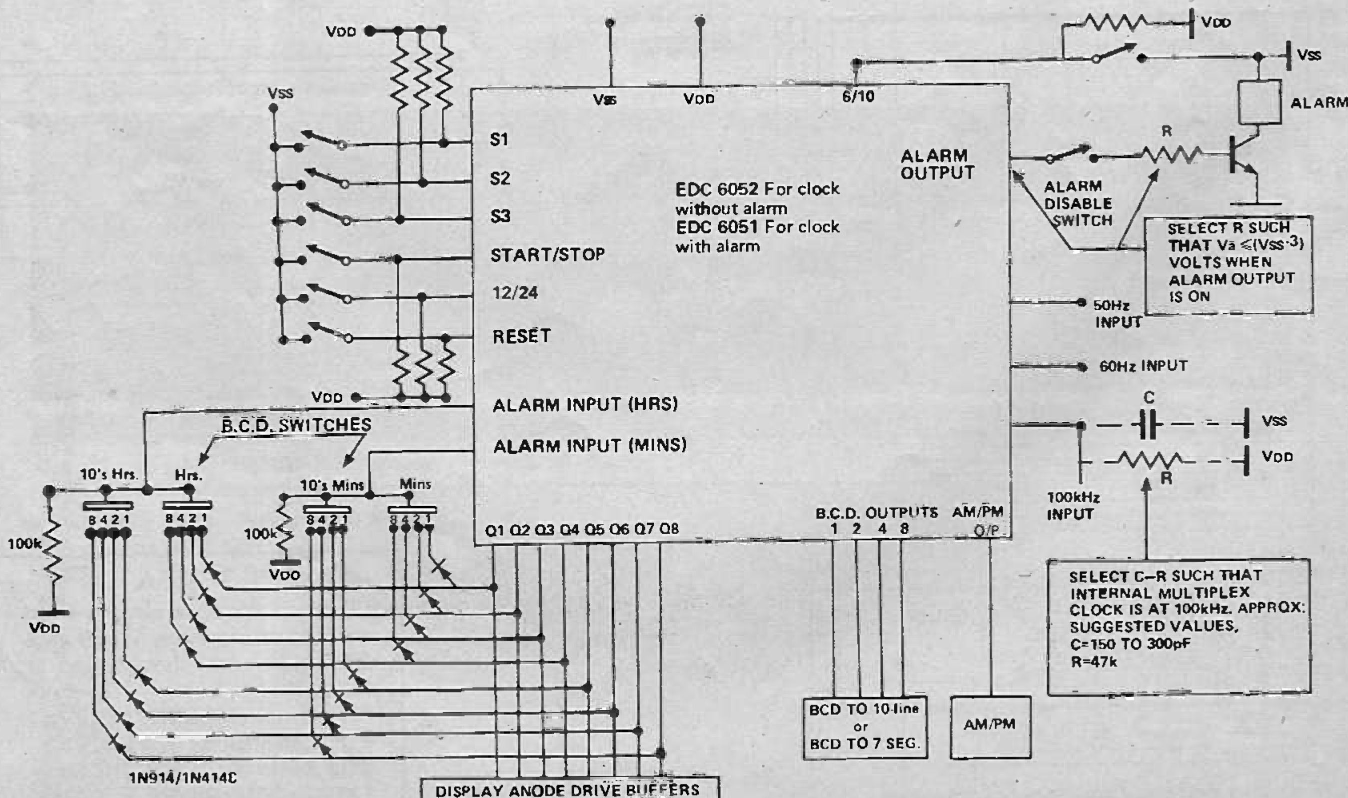
Electronics Tomorrow

by John Miller-Kirkpatrick

THIS MONTH you may have noticed that one of the special offers is for the Bywood DIGITRONIC II clock kit. At the time of releasing this kit, the main clock chip used was still on the secret list; we can now tell you that it was a chip developed for a large clock manufacturer as a custom chip by Emihus Microcomponents Ltd. The chip has now been released by Emihus as the EDC6051 and the EDC6052 MOS clock chip, and a data sheet arrived on my desk the other day. The tricks that this chip will do must surely make it the second most versatile clock chip now available (after the CT7001). The DIGITRONIC II kit uses the 50Hz input, six digit output, reset, hold, and 12/24 hour options of the chip. The DII Quartz uses the 100kHz input option in addition and the DII Stopwatch version uses the seventh digit and the stop/start facility. Quite a versatile little chip you might say, but we haven't even started yet! We have not mentioned the eighth digit (1/100 secs) input, the alarm facilities, and the option of changing all the counters from 24.59.59.00 to count to a maximum of 99999999 as a decade counter.

The applications of this chip are multiple and magnificent, your author has already modified one of the DII stopwatch clock to show normal time, or stopwatch timing in hours, minutes, seconds and tenths, or stopwatch timing in hours and decimal parts of hours. Apparently there are a lot of yachting clubs that time in this latter manner and the number of racing clubs that use normal HHMMSSs timing for races is very large. Now we have a clock chip (or a clock) that will do either and will act as a clubroom clock when not used as a timer. The alarm setting on the chip uses BCD decade switches which strobe the 8 digit output lines and pass the alarm data into two alarm input pins. This means that the alarm system is expensive for ordinary commercial alarm clock because of the high cost of these switches, on the other hand this system means that several alarm times could be set for each day either each switching for a short period or (by using a flip-flop) one switches on, the next off, then on, then off, etc.

Because the alarm is set by switches rather than programmed into a memory as with most digital alarm clocks,



the alarm time can be hard-wired to switch at the same time each day. A simple switch could be added to give for example alarm times at 1400 or 1430 or 1500 and 2200 or 2230 or 2300, (some of you might recognise these alarm times from personal experience of trying to get a drink after them).

So far we have a chip to build a commercial clock, a race timer, an industrial time switch or a pub 'time' alarm. What else has it got? Well it has BCD outputs and it is TTL compatible, the alarm outputs could be changed by TTL. If you drive the hours data into a simple adder, you can make a world time clock to show time in various time zones at the push of a button. It can be a batch counter, or an event counter. As the data and control inputs are TTL compatible external control signals can be easily debounced using a 7474 or latching bistable, this can be very important in counting and race timings to ensure that only the first signal is accepted and the bounces are ignored. Possibly one of the best things that could be done with this chip is to hard-wire the alarm for 23.59, arrange for the alarm to switch on a radio tuner which is tuned into a station giving GMT pips at midnight, make a tone decoder to recognise the last of the pips and use this to activate the reset function. We now have a clock that will automatically correct itself to GMT time every night as long as it is no more than a minute slow.

I am sure that most of you can think up completely different applications for such a chip, the component diagram is shown as Fig. 1. The EDC6052 (without alarm) and the 6051 (with alarm) are from Emihus and should be available from their distributors. The custom version of the chip, the HEEC2 and the Digitronic clocks and kits are available from Bywood.

It is somewhat satisfying to know that some of the people who read this feature have taken ideas and applications and produced for themselves a part time (in a couple of cases full time) business producing specialised custom-built units for non-electronics people. It usually starts with building something for a friend for just the cost of the components, the friend mentions it to someone else who mentions it to someone else, etc and eventually you are in the custom electronics business.

In our electronics minded world this can be a very interesting business as it is mostly design and constructional work with *very* varied and various applications. One of the outlets for this type of business is in display advertising, just think of the number of flashing lights and ringing bells units that you have seen at exhibitions and in shops and offices and pubs and even in the street outside offices. Most of these are commissioned by an advertising or publicity agency and are made by small one or two man electronic firms, very often as a part-time/hobby business.

With this in mind and having mentioned the versatile clock chip above we have come across some beautiful large seven segment displays. They are made in Japan by Itoka and come in 2½", 5" or 10" digits, the 10" is a standard item but to special order only. The 2½" and 5" are now stocked by Walter Scott Industries and Bywood. The construction of the smaller digit is a single filament lamp set into a very efficient white reflector with a strip lens at the front. Seven such units are set into a metal casing in a seven segment format, the casing is intended for mounting into a cutout in a display panel. The smaller digit is visible at 40 yards and the 5" at about 100 yards making them ideal for large advertising signs or for timing or data announcements at public halls and arenas.

If you haven't got an application for either of this months products yourself or for your local sports, racing or yachting club, how about contacting the local advertising or publicity agencies in the Yellow Pages - the worst that they can do is to kick you out of their offices but it could suddenly become another source of income.

REFERENCES

1. Bywood Electronics, 181 Ebberns Road, Hemel Hempstead, Herts.
2. Emihus Microcomponents, 12-18 Queens Road, Weybridge.
3. Walter Scott Industries, 35 Malden Way, New Malden, Surrey.
4. Advertising Agencies - see your local GPO Yellow Pages.

VAT CHANGES

The standard rate of VAT was reduced from 10% to 8% just before this issue went to press.

Some advertisements state that 10% should be added to all prices: this should now read 8%.

Other advertisers quote VAT inclusive prices: some have been corrected. Where VAT is included at 10%, the correct price can be derived by dividing the total by 55 and subtracting that amount.

Magazines do not carry VAT and therefore the cover price of ETI remains unchanged.

CT5001 OFFER

The calculator chip offer in the August issue has proved extremely popular. Fortunately more than the original 500 are now available and readers who did not apply, due to the small number may do so before August 31st.

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SN7401AN	0·38	0·38	0·33
SN7402N	0·20	0·18	0·16
SN7403N	0·20	0·18	0·16
SN7403AN	0·38	0·30	0·33
SN7404N	0·24	0·21	0·18
SN7405N	0·20	0·18	0·16
SN7405AN	0·44	0·44	0·38
SN7406N	0·40	0·38	0·35
SN7407N	0·40	0·38	0·35
SN7408N	0·25	0·22	0·19
SN7409N	0·33	0·33	0·29
SN7409AN	0·44	0·44	0·38
SN7410N	0·20	0·18	0·16
SN7411N	0·25	0·23	0·21
SN7412N	0·28	0·28	0·25
SN7412AN	0·38	0·38	0·33
SN7413N	0·30	0·27	0·25
SN7414N	0·72	0·72	0·63
SN7416N	0·30	0·27	0·25
SN7417N	0·30	0·27	0·25
SN7420N	0·20	0·18	0·16
SN7422N	0·28	0·28	0·25
SN7422AN	0·38	0·38	0·33
SN7423N	0·37	0·34	0·32
SN7425N	0·37	0·37	0·32
SN7427N	0·37	0·37	0·32
SN7428N	0·43	0·43	0·37
SN7430N	0·20	0·18	0·16
SN7432N	0·37	0·37	0·32
SN7433N	0·43	0·43	0·38
SN7433AN	0·57	0·57	0·50
SN7437N	0·43	0·43	0·37
SN7438N	0·43	0·43	0·37
SN7438AN	0·57	0·57	0·50
SN7440N	0·20	0·18	0·16
SN7441AN	0·85	0·79	0·73
SN7442N	0·85	0·79	0·73
SN7443N	1·50	1·27	1·13
SN7444N	1·50	1·27	1·13
SN7445N	2·16	2·16	1·89
SN7446N	2·16	2·16	1·89
SN7447AN	1·80	1·80	1·57
SN7448N	1·50	1·27	1·13
SN7450N	0·20	0·18	0·16
SN7451N	0·20	0·18	0·16
SN7453N	0·20	0·18	0·16
SN7454N	0·20	0·18	0·16
SN7460N	0·20	0·18	0·16
SN7470N	0·33	0·30	0·27
SN7472N	0·38	0·38	0·34
SN7473N	0·44	0·41	0·37
SN7474N	0·48	0·48	0·42
SN7475N	0·59	0·55	0·51
SN7476N	0·45	0·38	0·32
SN7480N	0·80	0·70	0·50
SN7481N	1·25	1·10	0·96
SN7482N	0·87	0·80	0·72
SN7483N	1·20	1·10	1·00
SN7485N	1·87	1·87	1·63
SN7486N	0·50	0·50	0·44
SN7489N	4·32	4·32	3·79
SN7490N	0·75	0·70	0·63
SN7491AN	1·10	1·00	0·90
SN7492N	0·75	0·70	0·63
SN7493N	0·75	0·70	0·63
SN7494N	0·85	0·80	0·73
SN7495N	0·85	0·80	0·75
SN7496N	1·00	0·90	0·83
SN74100N	2·10	1·89	1·69
SN74104N	0·60	0·53	0·45
SN74105N	0·60	0·53	0·45
SN74107N	0·51	0·51	0·45
SN74110N	0·57	0·57	0·50
SN74111N	0·86	0·86	0·75
SN74116N	2·16	2·10	1·89
SN74118N	1·00	0·90	0·83
SN74119N	1·92	1·92	1·68
SN74120N	1·05	1·05	0·92
SN74121N	0·57	0·57	0·50
SN74122N	0·80	0·80	0·70
SN74123N	1·44	1·44	1·26
SN74125N	0·60	0·60	0·60
SN74126N	0·60	0·60	0·60
SN74132N	0·72	0·72	0·63
SN74136N	0·63	0·63	0·55
SN74141N	1·00	0·90	0·80
SN74142N	2·88	2·88	2·52
SN74145N	1·44	1·44	1·26
SN74147N	2·30	2·30	1·83
SN74148N	2·01	2·01	1·63
SN74150N	2·30	2·30	2·01
SN74151N	1·15	1·15	1·00
SN74153N	1·00	1·00	0·95
SN74154N	2·30	2·30	2·01
SN74155N	1·15	1·15	1·00
SN74156N	1·00	1·00	1·00
SN74157N	1·00	1·00	0·95
SN74158N	2·44	2·44	2·14
SN74160N	1·58	1·58	1·38
SN74161N	1·58	1·58	1·38
SN74162N	1·58	1·58	1·38
SN74163N	1·58	1·58	1·38
SN74164N	2·01	2·01	1·76
SN74165N	2·01	2·01	1·76
SN74166N	2·10	2·10	1·89
SN74167N	4·10	4·10	2·59
SN74170N	2·88	2·88	2·52
SN74172N	5·75	5·75	5·04
SN74173N	1·66	1·66	1·45
SN74174N	1·80	1·80	1·57
SN74175N	1·29	1·29	1·13
SN74176N	1·44	1·44	1·26
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SN74190N	2·30	2·30	2·01
SN74191N	2·30	2·30	2·01
SN74192N	2·30	2·30	2·01
SN74193N	2·30	2·30	2·01
SN74194N	1·72	1·72	1·51
SN74195N	1·44	1·44	1·26
SN74196N	1·58	1·58	1·38
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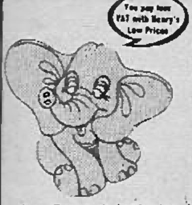

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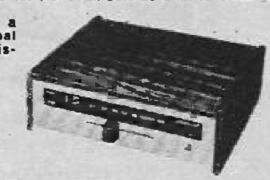

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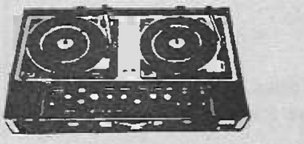

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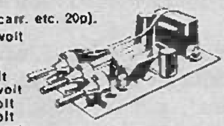

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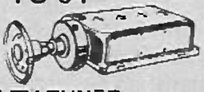

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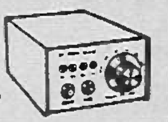

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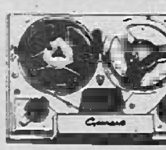

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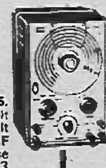

OTHER EQUIPMENT

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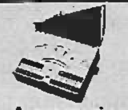

price £18·50

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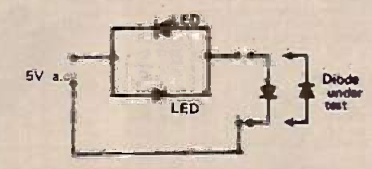
Tech-Tips

DIODE TESTER



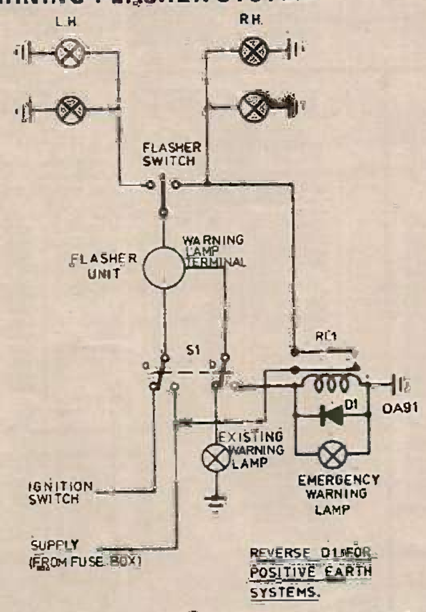
This is a diode tester with light emitting diodes.

If we change the polarity of the diode under test the appropriate LED will light.

If both of the LEDs go on, this means that the diode is shorted.

If neither light, this means that the diode under test is open circuit.

CAR WARNING FLASHER SYSTEM

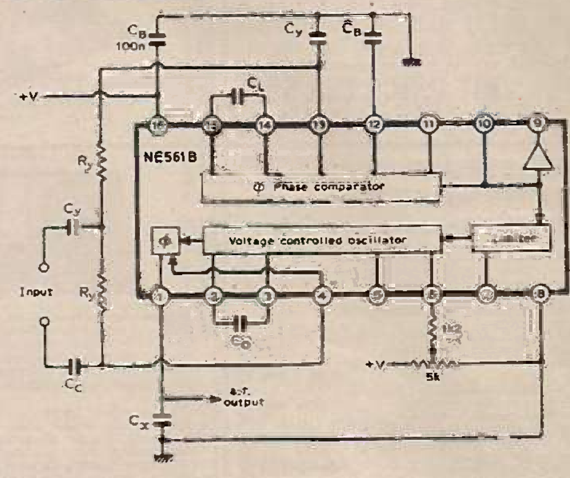


S1a is fitted between the ignition supply and flasher unit and S1b between flasher warning lamp terminal and warning lamp so that with S1 in the *off* position the system is normal. When S1 is *on*, the flasher is supplied from an independent supply, so as to operate with the ignition off, and RL1 coil is connected to the flasher warning lamp terminal.

Now when the flasher switch is put in the **LEFT** position, the left hand lamps will flash and at the same time RL1 will be energised, so lighting the right hand lamps through RL1 contacts. The existing warning lamp will light under normal conditions but the lamp across RL1 coil will flash with the emergency system in use. D1 provides a path for the back e.m.f. to protect the contacts in the flasher unit.

The bulbs should be 12V, 2.2W types.

PLL AM RECEIVER



It is possible to construct a simple a.m. receiver using a single off-the- shelf phase-locked-loop integrated circuit, together with a few external components. A major advantage of this approach is that no tuning coils are needed. Sensitivity can be improved with the addition of a wide-band r.f. amplifier front end, but it is important that the input of the phase-locked-loop should not exceed 0.5V r.m.s.

In the circuit the phase-locked-loop is locked to the incoming amplitude modulated carrier and the voltage controlled oscillator signal. The amplitude of the demodulated signal at the output is a function of the phase relationship between the carrier and the local oscillator, being a minimum when the two are in quadrature and a maximum when either an in-phase or 180^{o} degree out-of-phase condition exists. As the phase-locked-loop will always lock onto the input signal with a constant 90^{o} phase error, it is necessary to add a 90^{o} phase shift to compensate (C_yR_y).

For a receiver intended for use in the medium wave band from 550kHz to 1.6MHz, the 90^{o} phase shift is set to be correct at the geometric mean of the frequency limits (=0.94MHz). Assuming a value of 3kΩ for Ry, Cy is then:

$$C_y = \frac{1.3 \times 10^{-4}}{0.94 \times 10^{6}} = 135\text{pF}$$

The low-pass filter for the loop, C_L, is non-critical in this application since no information is being derived from the loop error. It is only necessary to ensure loop stability. A value of 10nF was found to be perfectly satisfactory for this component.

Tuning is accomplished by setting the voltage controlled oscillator frequency to the frequency to be received. Ignoring the tuning potentiometer for a moment, the voltage controlled oscillator frequency is set by C_o and is determined by the formula:

$$C_o = \frac{300\text{pF}}{f_o}$$

where f_o is in MHz.

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 the Editor, Electronics Today International 36 Ebury Street, London SW1W 0LW.

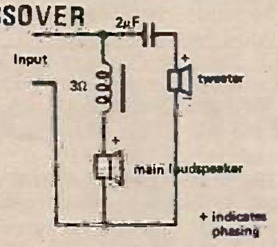
Fine tuning can be achieved by varying the amount of current flowing into or out of pin 6. When this current is zero - corresponding to the potentiometer being set in the centre of its travel - the voltage controlled oscillator frequency is determined by C_0. A value of 330pF will set the frequency close to 0.94MHz, which is the centre of the required tuning range. The resistor in series with the potentiometer wiper is selected to provide the desired tuning range - about 1.2kΩ when an 18V power supply is employed.

Capacitor Cx is intended to roll-off the audio output to provide the desired bandwidth and should be calculated on the basis of an output resistance of 8kΩ. Obviously the load resistance must also be taken into account for this calculation.

The receiver requires a good earth, as mentioned earlier, sensitivity is improved by a wide-band r.f. amplifier.

Submitted by SDS Components Ltd, Hilsea Trading Estate, Portsmouth who can supply the NE 861B from stock.

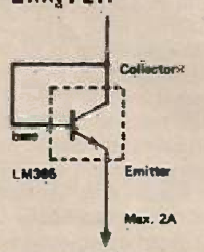
SIMPLE CROSSOVER



The construction of an inexpensive crossover for improving the performance of a cheap loudspeaker need not be complicated. The crossover enables a tweeter to be used; in the prototype an 8Ω miniature speaker from a pocket-type transistor radio was used, these make good tweeters.

The crossover can be built using the 3Ω secondary of a sound output transformer from a scrap T.V. set, the primary is left unconnected. The capacitor is a 2µF 63V polyester (non-electrolytic type).

SIMPLE CURRENT LIMITER



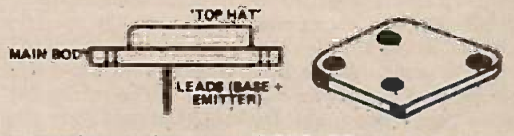
An extremely simple current limiter can be made using the new National Semiconductor LM395K. This looks like a power transistor, but is actually an IC which is fully protected against thermal overload and excessive current.

The device can be used in the circuit shown with a heat sink for limiting at just under 2A. No damage will occur if no heat sink is employed, but if the device gets really hot, the current will automatically fall to about 0.5A or less.

The case of the device is the emitter and *not* the collector as in a normal power transistor.

If the base is disconnected from the collector and is returned to the emitter, the device will be switched off.

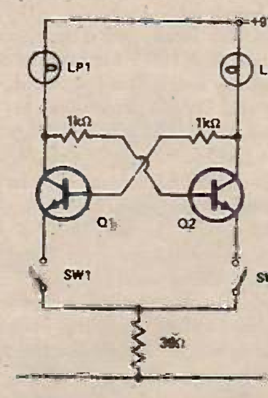
TEMPLATE AND HEAT SINKS FOR POWER TRANSISTORS



Power transistors similar to OC35, 28 etc., can be useful even when there is a complete electrical breakdown. They can be modified and utilized as either a power transistor heat sink, or as a making out and drilling template. Just remove the 'top hat' part of the transistor by squeezing it in the jaws of a vice.

The top hat should fully detach itself from the main body and the main body can be modified further by filing it flat. Then remove the ceramic insulators and base and emitter leads by pulling with a pair of pliers. Little effort is required to do this.

REACTION COMPARATOR



The circuit above can be used as an independent arbiter of which two people can throw a switch first. With both switches off the circuit is completely open and so neither bulb lights. If SW1 is made - even the tiniest fraction of a second before SW2 - Q1 will conduct and LP1, acting as the load, will light up. At the same time the voltage at the collector of Q1 falls meaning that even if SW2 is made there is insufficient bias current to drive Q2 on.

If SW2 is made first the converse is true. The bulb should be 6V, 40mA or 60mA types. The transistors can be almost any silicon NPN type (BC107 etc).

DX MONITOR

Compiled by Alan Thompson

If there's a large expanse of white in the top right-hand corner of this page, then that's where you *should* be seeing a picture of my re-shaped shack. However, a package of prints having gone astray in the post and deadlines being as inflexible as the proverbial brick wall, I am afraid that the official unveiling will have to await next month's offering.

The arrival of earlier sunset times means that the DXing season is with us once again, and this is the time of year when it is relatively easy to add a good number of African countries to one's log book so here's a country by country run-down of what should be audible given tolerably good conditions. It is, perhaps, as well to say that it is a DX feature-writer's nightmare that all the stations he mentions will have changed frequency between the time that an article is written and its appearance on the bookstall. The frequencies mentioned were all in operation early in July and should not have changed: however, if you should find that they have then, *please*, don't write and tell me - I shall already have discovered the fact for myself and will be cursing the unknown people responsible for the alterations! Here then is Part I of a country-by-country guide to African DX:-

ALGERIA: The Radio of the Democratic People's Republic of Algeria operates short-wave (SW) services in Arabic, French and Kabyle on a bewildering number of frequencies, which appear to change with ever-increasing frequency. An English service is broadcast 1900-1930 GMT on 11910kHz and is directed to East and West Africa and the Mediterranean area, but frequently audible in the U.K.

ANGOLA: More than a dozen SW outlets are used by various radio organisations in Angola. Best heard is usually the Emisora Oficial on 3375kHz from dusk until it closes at midnight, although on Saturday night it runs until 0200, usually with a pleasant programme of light music. A nice catch, but not easy, is the Radio Clube de Cabinda on 5033kHz, whose 1kw is sometimes heard until about 2300: Cabinda is the small enclave in Zaire which forms part of Angola although geographically separate from it.

ASCENSION ISLAND: Really just a question of being on the right channel at the right time! The high-power outlets of the B.B.C.'s Atlantic Relay are located on the island. Try 9695kHz carrying the special World Service programme for Africa and signing-on at 1700. An alternative is 6005kHz which joins the main World Service at 1645 GMT.

BOTSWANA: Not reported for some time in U.K! Best bet is probably 3356kHz on Friday, Saturday or Sunday when it signs-off at 2100 GMT.

BURUNDI: "La Voix de la Revolution" appears from time to time through the strange noises which occupy 3300kHz. Best bet for this hard-to-hear country is the missionary station, Radio Cordac, recently heard on 4901kHz shortly before sign-off around 1930. Closes with a long vocal rendering of the Hallelujah Chorus - a useful check on whether you really heard it.

CAMEROON: Fairly easy, although the regional station, Buea, which uses English for much of its programming (on 3970kHz) has recently been drowned out by Deutsche Welle using that channel (and 3905kHz) for its German service to Africa around 2100. Try now for Radio Yaounde on 4972.5 or Radio Garoua on 5010kHz: Yaounde which closes at 2300 is said to have English programmes but they have not been reported for some time; Garoua closes at 2200.

CANARY ISLANDS: A relay station of RNE Madrid operates here and you ought to have little difficulty in catching it signing-on at 2000 on 15365kHz.

CAPE VERDE ISLANDS: Most regularly heard of the three private radio stations is Radio Barlavento on 3931kHz: it's listed 1kw often puts in a huge signal in late evening until it signs-off at 0100 GMT.

CENTRAL AFRICAN REPUBLIC: Only problem is to find where Radio Bangui is at the moment as it is generally the strongest African station on the 60 metre band. Listed frequency is 5035 but it varies between about 5033 and 5040kHz so listen for the ID as "Radiodiffusion Nationale Centrafricaine".

CHAD: Or Tchad - recently changed the name of its capital to Ndjamana, and can be heard with a potent signal on 4904.5kHz from as early as 1800 GMT until 2230 or 2300 GMT.

COMORO ISLANDS: An infrequent visitor just before its 1930 sign-off on 3331kHz. A good catch for any DXer this one.

CONGO: You'd have to try hard to miss this one! A good signal comes from the 5kW transmitter of Radio Brazzaville on 4765kHz throughout the evening. It's also worth trying 15190kHz in the evening hours but the frequency varies.

DAHOMEY: When it's good it's very very good . . . . The transmitter is listed as 30kw on 4870kHz but reception is irregular.

EGYPT: Numerous Home Services but easiest is English for Europe 2145-2300 GMT usually on 9805 (try 9475 as an alternative).

EQUATORIAL GUINEA: Two ways of catching this one. Easier is Radio Santa Isabel, 6250kHz, usually fairly good until 2300 sign-off, but beware of a clandestine station, Radio Libertacao, varying around that frequency. Harder one is Radio Ecuatorial, 4926kHz, often not heard for long periods.

ETHIOPIA: ETLF, The Radio Voice of the Gospel, has a bewildering schedule in which frequencies and languages change constantly. Try 7130kHz where it was recently reported with an English programme from 1645-1710: failing that try on 9695 or 9705 for another English service 1755-1810.

GABON: 7270kHz ought to be the easiest channel as the 100kw transmitter at Libreville is listed here; however, the channel tends to be a pretty noisy one. 4777kHz is usually more reliable, most evenings.

GAMBIA: Nice work if you can get Radio Banjul (formerly Bathurst)! Only channel is 4820kHz and the programming is in English and a variety of local tongues. It's only 3.1kw so don't expect an S9 signal.

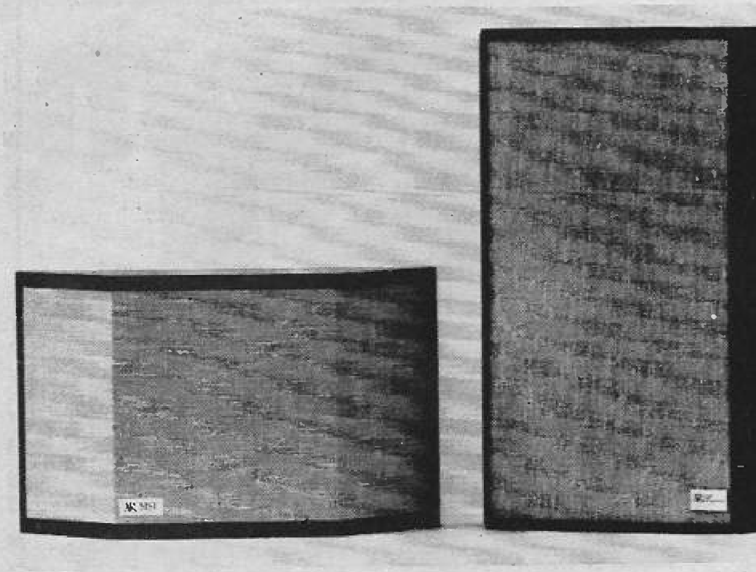
GHANA: If you can't hear the Home Services on 4915 and 4980kHz in the mid-to late-evening there is something wrong with your radio or antenna. On the international bands, you ought to catch the English service to West Africa from 1400-2215 last reported on 6130kHz. Other English segments in that time slot go out on 9760, 11850 and 15285kHz.

IVORY COAST: The last of the "Top Twenty" in this African Survey! Easy on 11920kHz from dusk to 2400 signoff; also on 4940kHz after 2200 GMT when Radio Kiev clears the frequency for the night. One of the more easy-to-enjoy African stations with a nice blend of African and Western music. Not too easy to QSL though!

The second half of this round-up of African stations will follow in the October issue and then we'll turn our attentions to the Far East. Just in case it isn't clear from the above notes, the 60 and 90 metre band channels are likely to be audible from about 1800 right through until the South American stations start to occupy the band - usually around 2200. Times are, of course, very approximate and on some evenings there is a "dead period" when little African reception occurs for an hour or two about 2000. Similary, South American stations vary greatly in the time of fade-in: under good SA conditions they may start to appear about 2100 (or even earlier) but a more frequent time is in the 2200-2300 'slot'. What's a reasonable score on these 20 countries? Well, with average luck you ought to manage 12 of them in average time in a month. To manage 15 is good, 18 is excellent and the whole 20 - well, *that's* luck!

 Continued from page 8.

NEW SPEAKERS



In the past ETI has given excellent reviews of the speakers made by Acoustic Research. We have just received news of two new models — the AR-3a/improved and the AR-MST.

The AR-3a has been on the market for seven years now and whilst even by today's standards it has excellent performance, the makers have now incorporated further developments. Improvements are a reduction in colouration in the mid-range crossover region. A switch enables the output to be tailored for either reverberant or relatively damped rooms. Another improvement has been to get rid of a slight response irregularity in the lower mid-frequency which was caused by diffraction effects from the cabinets. Recommended retail price is £110 including V.A.T.

A price has not yet been announced for the second speaker, the AR-MST, but Mr. Farrow of Acoustic Research speaking to ETI said it would lie between the AR-6 and the AR-2ax indicating about the £50 region. The AR-MST is shown on the left in the photograph and is a miniature version of the company's LST.

LOW COST TEMPERATURE INDICATOR RANGE

A new British made temperature indicator has recently been announced. The manufacturers claim a major breakthrough in automated production of low cost self adhesive temperature indicator 'labels'. Automated production techniques have allowed a unit cost as low as 3.7p each combined with an accuracy of better than ± 1%.

Under the brand name *Hermet*, the range includes 41 separate temperature ratings from 40°C - 260°C. They are available in bookmatch packs of multiple increment 'labels', 5 increments to one label, or in single increment tabs.

Because of their low cost, these new indicators are expected to have wide application in the laboratory, in industry and in domestic use. For instance, heatsinks can be tested for temperature, this is difficult using conventional methods.

When subjected to their rated temperature, the indicators turn from silver to jet black, this chemical change being viewed through a clear plastic window. The complete label is self-adhesive and can easily be fixed on to most clean, dry surfaces. Once attached, the indicators can be submerged in many water or oil-based liquids without impairing their accuracy.

'Q' LATEST

Columbia have just licensed Philips to manufacture and market the SQ quadraphonic system.

Prototype samples of Philips' SQ equipment were shown at the recent Paris Festival du Son.

Meanwhile RCA have announced the release of fifty CD-4 LP's "before the end of 1974". Unlike RCA's earlier CD-4 releases, their new 4-channel LP's will be marketed specifically as discrete four-channel.

Although RCA still insist that their CD-4 products will not be harmed by playing on cheap mono players, dealers invariably placed their 'compatible' recordings in the "four-channel' sections of their displays.

Other four-channel developments include news of a titanium Shibata stylus from Panasonic. JVC are also understood to be working on a ceramic CD-4 cartridge which should be far cheaper than the present magnetic devices.

LIFE OUT THERE

Another radio-astronomical search for intelligent life within our Galaxy began on May 8.

Astronomers P. Feldman and A. Bridle (York University, Ontario, and Queen's University, Kingston, Ontario, respectively) will spend up to two years using the 30 metre Algonquin telescope monitoring frequencies appropriate to emission in water.

Previous efforts, such as Project Ozma 15 years ago, concentrated on searching hydrogen frequencies. The rationale was that as hydrogen was the most abundant element in the Universe this would be the frequency chosen by extraterrestrial intelligences for communication.

However feeling is now growing that any really intelligent lifeform would leave the hydrogen frequency open because of its importance to radio-astronomers — hence the choice of water-related frequencies.

LASER FUSION SUCCESS

A major advance toward controlled nuclear fusion was made last month by KMS Industries Inc. (Ann Arbor, Mich).

The company announced that they had (four times) succeeded in obtaining high energy neutrons from laser-driven compression and heating of a deuterium pellet.

As far as we are aware, this is the first time that thermonuclear neutrons have been produced by laser fusion.

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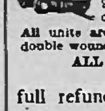

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