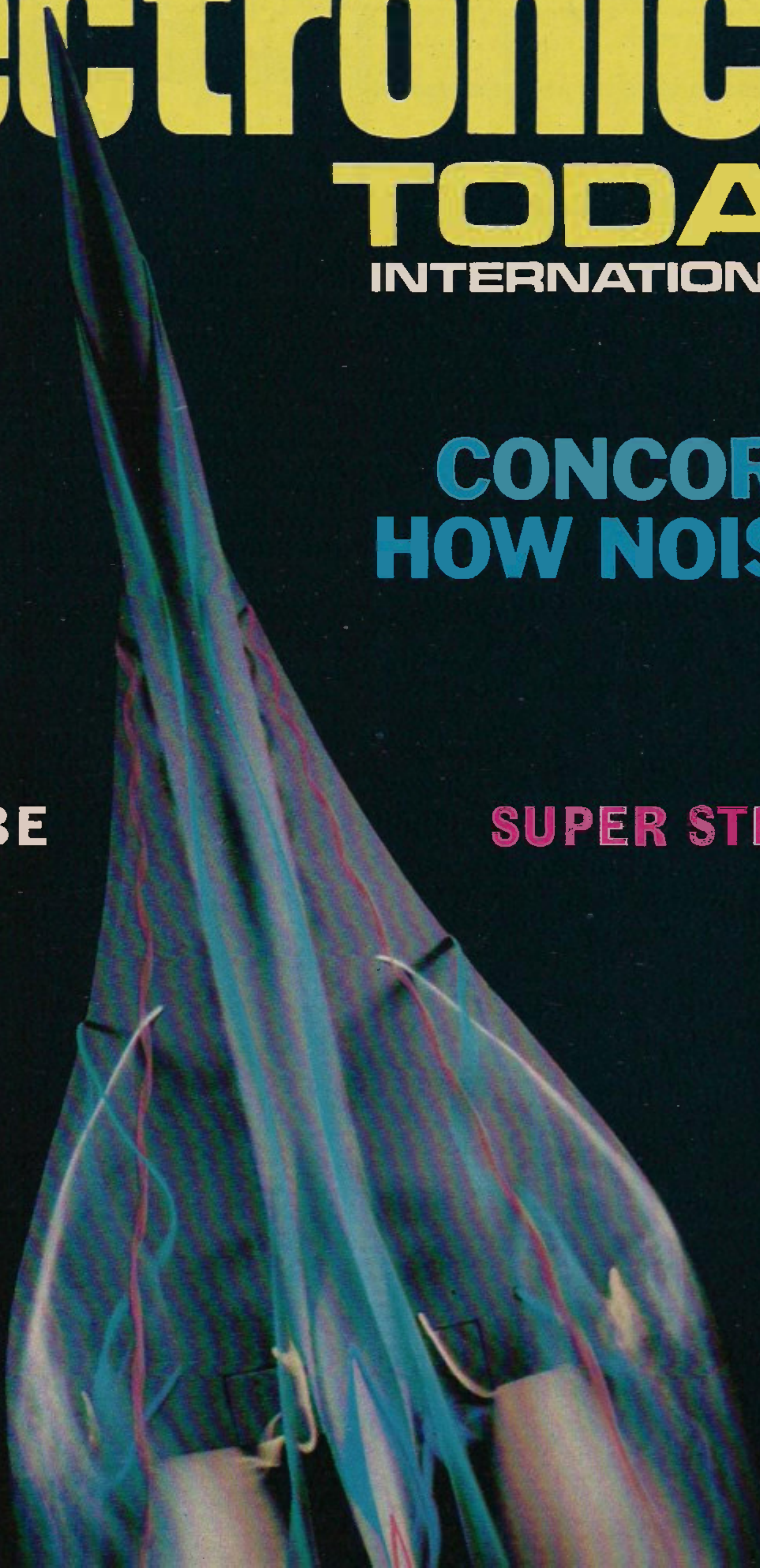
BRITAIN'S DYNAMIC MONTHLY

SEPTEMBER 1972 20p

electronics TODAY INTERNATIONAL



CONCORDE HOW NOISY?

LOGIC PROBE

SUPER STEREO

Semiconductor Supplies

55, Whitehorse Road, Croydon, Surrey. CRO 2JG
Tel. 01-689 0676 7 DEPT. E.T.I/1

TRADE ENQUIRIES WELCOME

CASH and CARRY COUNTER OPEN
9.30 – 5.30
MON – FRI

DON'T FORGET THE £1 VOUCHER ON PAGE 63

Send Large SAE for new Summer '72 free Catalogue

TTL Series I.C.'s 7400 Series

Type No.	1–24	25–99	100+	Type No.	1–24	25–99	100+
SN 7400N	.18	.16	.14	SN 7486N	[illegible]	.37	.32
SN 7401N	.18	.16	.14	SN 7489N	7.00	6.10	4.40
SN 7401AN	.20	.18	.16	SN 7490N	.60	.52	.45
SN 7402N	.18	.16	.14	SN 7491AN	.80	.80	.67
SN 7403N	.18	.16	.14	SN 7492N	.70	.62	.54
SN 7403AN	.20	.18	.16	SN 7493N	.60	.53	.48
SN 7404N	.18	.16	.14	SN 7494N	1.10	1.00	.85
SN 7405N	.18	.16	.14	SN 7495N	1.25	1.10	.90
SN 7405AN	.21	.19	.17	SN 7496N	1.40	1.20	1.00
SN 7406N	.40	.37	.33	SN 7497N	5.50	4.95	3.85
SN 7407N	.40	.37	.33	SN 74100N	2.50	2.20	1.70
SN 7408N	.26	.24	.21	SN 74104N	.80	.74	.62
SN 7409N	.26	.24	.21	SN 74105N	.80	.74	.62
SN 7409AN	.33	.31	.27	SN 74107N	.62	.55	.38
SN 7410N	.18	.16	.14	SN 74109N	.95	.85	.60
SN 7411N	.23	.21	.18	SN 74110N	.75	.67	.48
SN 7412N	.28	.26	.23	SN 74111N	1.60	1.20	.94
SN 7412AN	.30	.27	.24	SN 74118N	.78	.72	.67
SN 7413N	.26	.24	.21	SN 74119N	1.75	1.50	1.10
SN 7416N	.36	.34	.30	SN 74120N	1.00	.90	.63
SN 7417N	.36	.34	.30	SN 74121N	.40	.37	.33
SN 7420N	.18	.16	.14	SN 74122N	1.25	1.05	.80
SN 7421N	.28	.26	.22	SN 74123N	2.50	2.20	1.70
SN 7422N	.38	.35	.28	SN 74126N	.75	.66	.47
SN 7423N	.42	.38	.30	SN 74141N	1.15	1.05	.75
SN 7425N	.38	.35	.28	SN 74143N	7.00	6.20	4.40
SN 7426N	.26	.24	.20	SN 74144N	7.00	6.20	4.40
SN 7427N	.38	.34	.26	SN 74145N	1.50	1.30	1.00
SN 7428N	.42	.39	.34	SN 74150N	2.25	2.10	1.90
SN 7430N	.20	.16	.14	SN 74151N	1.00	.90	.75
SN 7432N	.33	.30	.26	SN 74153N	1.50	1.35	1.00
SN 7433N	.42	.39	.34	SN 74154N	1.95	1.80	1.60
SN 7433AN	.46	.42	.36	SN 74155N	1.00	.90	.75
SN 7437N	.40	.37	.33	SN 74156N	1.00	.90	.75
SN 7438N	.40	.37	.33	SN 74157N	1.10	1.00	.85
SN 7438AN	.50	.45	.40	SN 74160N	3.20	2.80	2.00
SN 7440N	.18	.18	.14	SN 74161N	3.20	2.80	2.00
SN 7441AN	.80	.76	.70	SN 74162N	3.40	2.85	2.20
SN 7442N	.78	.74	.69	SN 74163N	3.40	2.85	2.20
SN 7443N	1.40	1.25	1.00	SN 74164N	4.00	3.60	2.50
SN 7444N	1.40	1.25	1.00	SN 74165N	4.00	3.60	2.50
SN 7445N	1.80	1.60	1.45	SN 74166N	4.00	3.55	2.50
SN 7446N	1.85	1.65	1.50	SN 74167N	6.00	5.30	3.75
SN 7446AN	2.00	1.75	1.60	SN 74170N	3.95	3.10	2.50
SN 7447N	1.40	1.20	1.00	SN 74174N	1.85	1.70	1.20
SN 7447AN	1.70	1.50	1.25	SN 74175N	1.30	1.15	.88
SN 7448N	1.80	1.60	1.30	SN 74176N	1.85	1.60	1.20
SN 7449N	.95	.90	.80	SN 74177N	1.85	1.60	1.20
SN 7450N	.18	.16	.14	SN 74178N	2.50	2.70	1.55
SN 7451N	.18	.16	.14	SN 74179N	2.50	2.20	1.55
SN 7453N	.18	.16	.14	SN 74180N	1.30	1.15	.95
SN 7454N	.18	.16	.14	SN 74181N	7.25	6.50	5.50
SN 7460N	.18	.16	.14	SN 74182N	1.80	1.60	1.10
SN 7470N	.30	.28	.25	SN 74184N	2.00	1.80	1.40
SN 7472N	.26	.24	.21	SN 74185AN	2.00	1.80	1.40
SN 7473N	.38	.35	.31	SN 74190N	4.00	3.50	2.80
SN 7474N	.35	.31	.27	SN 74191N	4.00	3.50	2.80
SN 7475N	.80	.56	.50	SN 74192N	1.75	1.60	1.45
SN 7476N	.40	.37	.32	SN 74193N	1.75	1.60	1.45
SN 7480N	.90	.80	.70	SN 74194N	2.25	2.00	1.55
SN 7481N	1.30	1.15	1.05	SN 74195N	1.55	1.40	1.20
SN 7481AN	2.60	2.30	1.80	SN 74196N	2.25	2.00	1.40
SN 7482N	.90	.80	.70	SN 74197N	2.75	2.00	1.40
SN 7483N	1.25	1.10	.90	SN 74198N	4.80	4.25	3.20
SN 7484N	1.40	1.25	1.00	SN 74199N	4.80	4.25	3.20
SN 7484AN	2.60	2.30	1.60	SN 74200N	21.00	18.50	13.40
SN 7485N	3.50	2.00	2.00				

QUANTITY MIX *Other types available. Prices on Request.*

LINEAR INTEGRATED CIRCUITS

Type No.	1–24	25–99	100+	Type No.	1–24	25–99	100+
101A	2.60	2.20	1.90	ML 747	2.40	2.20	1.75
201A	2.30	2.10	1.70	ML 747C	.80	.70	.56
301A	.45	.40	.35	ML 748	1.20	1.05	.85
LM 304	2.42	1.95	1.67	ML 748C	.38	.34	.27
LM 305	2.42	1.95	1.62	ML 1437	1.10	1.00	.80
ML 307	.83	.56	.45	ML1458	1.10	1.00	.80
ML 308	5.80	5.20	4.10	ML 1537	3.50	3.10	2.50
ML 308A	6.70	6.00	4.80	ML 1558	3.50	3.10	2.50
LM 309	1.87	1.50	1.25	ML 3045	2.30	2.00	1.65
LM 309K	1.87	1.50	1.25	ML 3046	.76	.68	.54
SL 702	.65	.50	.36				
ML 709	.90	.68	.72				
ML 709A	2.10	1.90	1.50				
ML 709C	.30	.27	.22				
ML 710C	.45	.36	.30				
ML 711C	.52	.42	.35				
ML 723	2.60	2.30	1.90	UC 4250	15.90	15.90	10.60
ML 723 C	.84	.75	.60	UC 4250C	5.91	5.91	3.91
ML 741	1.20	1.10	.90	ML 6503	3.50	3.10	2.50
ML 741C	.36	.30	.24	ML 7503	1.12	1.00	.80

The following devices from the MILITARY range are also available: ML 101, ML 201, ML 107, ML 207, ML 108, ML 208. Prices on request.

PLEASE STATE T099, D.I.L. 14 PIN OR 8 PIN

PLASTIC RECTIFIERS 1 AMP

Type No.	1–24	25–99	100+
IN 4001/SD 05	.05	.04	.03
IN 4002/SD 1	.06	.05	.04
IN 4003/SD 2	.07	.06	.05
IN 4004/SD 4	.08	.07	.06
IN 4005/SD 6	.09	.08	.07
IN 4006/SD 8	.10	.09	.08
IN 4007/SD 10	.12	.11	.10
2 AMP RECTIFIERS			
2A 100	.09	.08	.07
2A 200	.10	.09	.08
2A 400	.12	.10	.09
3 AMP RECTIFIERS			
3A 050	.10	.09	.08
3A 100	.11	.10	.09
3A 200	.12	.11	.10
3A 400	.13	.12	.11
3A 600	.16	.14	.12
3A 800	.24	.22	.20
3A 1000	.40	.38	.36

SMALL SIGNAL DIODES

Type No.	1–24	25–99	100+
BA 156	.09	.08	.07
BAX 16	.06	.05	.04
OA 5	.30	.25	.20
OA 10	.50	.42	.35
OA 47	.08	.06	.05
OA 90	.05	.04	.03
OA 91	.05	.04	.03
OA 200	.08	.06	.05
OA 202	.07	.06	.05
IN 914	.05	.04	.03
IN 916	.06	.05	.04
IN 4009	.05	.04	.03
IN 4148	.05	.04	.03
IN 4149	.06	.05	.04

TRANSISTORS

Type No.	1–24	25–99	100+	Type No.	1–24	25–99	100+
AC 107	.35	.32	.28	BD 131	.36	.32	.28
AC 126	.20	.18	.16	BD 132	.44	.40	.38
AC 127	.16	.14	.12	BD 133	.47	.44	.42
AC 128	.15	.14	.12	BD 135	.28	.26	.23
AC 176	.23	.21	.18	BD 136	.29	.27	.24
AC 187	.19	.18	.16	BD 137	.33	.29	.27
AC 188	.17	.16	.14	BD 138	.34	.32	.29
ACY 17	.30	.25	.20	BD 139	.37	.35	.32
ACY 18	.18	.15	.13	BD 140	.41	.38	.35
ACY 19	.22	.18	.15	BD 155	.80	.76	.72
ACY 20	.18	.15	.13	BF 115	.18	.14	.13
ACY 21	.17	.14	.12	BF 167	.21	.16	.14
ACY 22	.14	.12	.10	BF 173	.24	.18	.16
ACY 40	.15	.13	.11	BF 178	.35	.30	.27
ACY 41	.16	.14	.12	BF 179	.40	.35	.32
AD 149	.40	.38	.35	BF 180	.35	.28	.25
AD 161	.30	.27	.24	BF 181	.35	.28	.25
AD 162	.30	.27	.24	BF 194	.08	.07	.06
AF 114	.22	.20	.18	BF 195	.08	.07	.06
AF 115	.22	.20	.18	BF 196	.10	.09	.08
AF 116	.22	.20	.19	BF 197	.11	.10	.09
AF 117	.22	.20	.18	BFX 12	.25	.20	.15
AF 118	.42	.37	.32	BFX 13	.25	.20	.15
AF 124	.24	.19	.15	BFX 29	.30	.25	.20
BC 107	.12	.10	.07	BFX 30	.32	.25	.22
BC 108	.10	.08	.06	BFX 84	.23	.20	.16
BC 109	.13	.11	.09	BFX 85	.30	.26	.22
BC 113	.18	.15	.12	BFX 86	.24	.21	.17
BC 114	.18	.15	.12	BFX 87	.27	.23	.18
BC 115	.18	.15	.12	BFX 88	.21	.18	.15
BC 116	.18	.15	.12	BFY 39	.90	.80	.70
BC 118	.18	.15	.12	BFY 50	.18	.14	.10
BC 125	.18	.15	.12	BFY 51	.18	.14	.10
BC 126	.24	.20	.16	BFY 52	.18	.14	.10
BC 132	.20	.15	.13	BFY 53	.16	.13	.10
BC 134	.20	.15	.13	BSX 20	.11	.10	.09
BC 135	.20	.15	.13	BSY 11	.32	.24	.18
BC 136	.20	.15	.13	BSY 26	.17	.15	.12
BC 137	.20	.15	.13	BSY 27	.20	.16	.14
BC 139	.28	.24	.21	BSY 38	.18	.15	.13
BC 140	.28	.25	.20	BSY 39	.18	.15	.13
BC 142	.21	.18	.15	BSY 95	.15	.12	.09
BC 143	.23	.20	.17	BSY 95A	.14	.11	.08
BC 147	.08	.07	.06	BU 105	1.75	1.65	1.56
BC 148	.09	.07	.06	C 424	.15	.12	.10
BC 149	.10	.08	.07	C 450	.15	.12	.10
BC 157	.11	.09	.08	OC 20	1.60	1.40	1.10
BC 158	.09	.07	.06	OC 22	1.10	.90	.70
BC 159	.12	.09	.08	OC 25	.40	.30	.24
BC 167	.12	.10	.08	OC 26	.70	.50	.44
BC 168	.12	.09	.07	OC 28	.75	.60	.48
BC 169	.13	.11	.09	OC 35	.56	.48	.38
BC 177	.16	.13	.10	OC 36	.62	.50	.40
BC 178	.14	.12	.09	OC 44	.40	.35	.28
BC 179	.18	.15	.12	OC 45	.38	.32	.26
BC 182L	.10	.08	.07	OC 71	.32	.28	.20
BC 183L	.10	.09	.08	OC 72	.32	.28	.20
BC 184L	.10	.09	.07	OC 83	.20	.16	.13
BC 212L	.12	.11	.09	OC 139	.45	.36	.28
BC 213L	.12	.10	.09	OC 140	.70	.55	.46
BC 214L	.14	.12	.10	OC 141	.90	.80	.70
BC 257	.14	.09	.08	OC 170	.24	.22	.20
BC 258	.12	.09	.07	OC 171	.26	.24	.21
BC 259	.15	.11	.09	OC 200	.45	.35	.28
BCY 30	.35	.30	.25	OC 201	.80	.64	.52
BCY 31	.45	.40	.35	OC 202	.85	.75	.60
BCY 32	.90	.80	.70	OC 203	.45	.40	.32
BCY 33	.35	.28	.23	OC 204	.45	.36	.30
BCY 34	.35	.30	.24	OC 205	1.13	.90	.70
BCY 70	.16	.12	.10	OC 206	1.00	.86	.68
BCY 71	.22	.14	.13	OC 207	1.00	.82	.60
BCY 71A	.23	.20	.15	OCP 71	.80	.70	.60
BCY 72	.13	.10	.08	TIS 43 (SS 43)	.35	.30	.25
BD 115	.80	.72	.65	U 435	.15	.12	.10
BD 121	1.21	1.12	1.00				
BD 123	1.21	1.12	1.00				

Type No.	1–24	25–99	100+	Type No.	1–24	25–99	100+
2N 696	.14	.12	.10	2N 3693	.15	.12	.10
2N 697	.14	.12	.10	2N 3694	.15	.12	.10
2N 706	.10	.08	.07	2N 3702	.11	.10	.08
2N 706A	.11	.09	.08	2N 3703	.10	.08	.07
2N 708	.12	.09	.07	2N 3704	.11	.10	.08
2N 743	.15	.12	.10	2N 3705	.10	.08	.07
2N 744	.16	.12	.10	2N 3706	.09	.08	.07
2N 914	.16	.12	.10	2N 3707	.10	.09	.08
2N 918	.42	.35	.29	2N 3708	.08	.07	.06
2N 920	.18	.15	.12	2N 3709	.08	.07	.06
2N 929	.20	.16	.13	2N 3710	.09	.08	.07
2N 930	.24	.19	.16	2N 3711	.09	.08	.07
2N 1100	1.82	1.78	1.22	2N 3715	1.60	1.40	1.00
2N 1131	.24	.20	.17	2N 3716	1.70	1.45	1.10
2N 1132	.24	.20	.17	2N 3740	1.24	1.24	.83
2N 1540	.96	.84	.64	2N 3741	1.35	1.35	.90
2N 1613	.15	.12	.10	2N 3771	1.44	1.44	1.19
2N 1711	.20	.15	.12	2N 3772	1.45	1.45	1.20
2N 1890	.38	.34	.30	2N 3773	2.45	2.45	2.05
2N 1893	.45	.40	.35	2N 3790	3.82	3.82	2.54
2N 1899	.30	.28	.26	2N 3792	4.08	4.08	2.73
2N 1990	.40	.35	.30	2N 3866	.58	.52	.44
2N 2102	.80	.65	.50	2N 4036	.52	.46	.40
2N 2017	.50	.44	.34	2N 4037	.48	.42	.35
2N 2218	.22	.17	.14	2N 4058	.12	.11	.09
2N 2218A	.25	.13	.15	2N 4059	.09	.08	.07
2N 2219	.23	.17	.14	2N 4060	.10	.09	.07
2N 2219A	.36	.27	.22	2N 4061	.10	.09	.07
2N 2221	.23	.17	.14	2N 4062	.11	.10	.08
2N 2221A	.25	.18	.15	2N 4140	.15	.12	.10
2N 2222	.23	.17	.14	2N 4141	.16	.13	.11
2N 2222A	.25	.18	.15	2N 4142	.18	.15	.12
2N 2646	.42	.37	.34	2N 4143	.20	.17	.13
2N 2904	.18	.16	.14	2N 4227	.16	.13	.11
2N 2904A	.32	.24	.20	2N 4228	.18	.15	.12
2N 2905	.32	.24	.20	2N 4248	.15	.12	.10
2N 2905A	.35	.27	.23	2N 4249	.15	.15	.10
2N 2906	.24	.20	.16	2N 4250	.16	.13	.11
2N 2906A	.33	.25	.20	2N 4286	.15	.12	.10
2N 2907	.30	.22	.18	2N 4287	.18	.15	.12
2N 2907A	.35	.28	.23	2N 4288	.15	.12	.10
2N 2923	.12	.10	.08	2N 4289	.18	.15	.12
2N 2924	.12	.10	.08	2N 4290	.15	.12	.10
2N 2925	.12	.10	.08	2N 4291	.15	.12	.10
2N 2926 Red	.08	.06	.04	2N 4292	.15	.12	.10
2N 2926 Org.	.091	.07	.05	2N 4293	.15	.12	.10
2N 2926 Yel	.10	.08	.06	2N 4964	.15	.12	.10
2N 2926 Grn	.10	.08	.07	2N 4965	.15	.12	.10
2N 3053	.18	.15	.12	2N 4966	.15	.12	.10
2N 3054	.60	.50	.40	2N 4967	.15	.12	.10
2N 3055	.60	.50	.40	2N 4968	.15	.12	.10
2N 3442	1.30	1.20	.98	2N 4969	.15	.12	.10
2N 3563	.15	.12	.10	2N 4970	.18	.15	.12
2N 3564	.15	.12	.10	2N 4971	.15	.12	.10
2N 3565	.15	.12	.10	2N 4972	.18	.15	.12
2N 3566	.18	.15	.11	2N 5126	.15	.12	.10
2N 3567	.15	.12	.10	2N 5127	.15	.12	.10
2N 3569	.18	.15	.11	2N 5129	.15	.12	.10
2N 3611	.48	.40	.35	2N 5131	.15	.12	.10
2N 3612	.55	.45	.37	2N 5132	.15	.12	.10
2N 3613	.60	.50	.40	2N 5133	.15	.12	.10
2N 3614	.50	.42	.35	2N 5135	.18	.15	.12
2N 3615	.60	.50	.40	2N 5136	.15	.12	.10
2N 3616	.65	.58	.52	2N 5137	.15	.12	.10
2N 3617	.70	.60	.54	2N 5138	.15	.12	.10
2N 3618	.70	.60	.54	2N 5139	.15	.12	.10
2N 3632	5.46	5.46	3.59	2N 5142	.15	.12	.10
2N 3638	.15	.12	.10	2N 5143	.15	.12	.10
2N 3638A	.15	.12	.10	2N 5172	.10	.07	.05
2N 3641	.15	.12	.10	2N 5180	.15	.12	.10
2N 3642	.15	.12	.10	2N 5294	.28	.28	.23
2N 3643	.16	.13	.10	2N 5296	.28	.28	.23
2N 3644	.18	.15	.12	2N 5298	.32	.32	.27
2N 3645	.18	.15	.12	2N 5490	.33	.33	.27
2N 3646	.25	.20	.15	2N 5492	.35	.35	.30
2N 3691	.15	.12	.10	2N 5494	.35	.35	.30
2N 3692	.15	.12	.10	2N 5496	.40	.40	.33

FET DEVICES

Type No.	1–24	25–99	100+	Type No.	1–24	25–99	100+
KE 4091	.44	.44	.29	2N 3958	1.07	1.07	.71
KE 4092	.44	.44	.29	2N 4044	2.75	2.75	1.92
KE 4093	.44	.44	.29	2N 4045	1.65	1.65	1.29
UC 200	1.41	1.41	1.01	2N 4221	1.04	1.04	.69
UC 220	1.46	1.46	.96	2N 4302	.44	.44	.29
UC 400	1.98	1.98	1.32	2N 4303	.44	.44	.29
UC 714	.68	.68	.46	2N 4304	.41	.41	.17
UC 734	.69	.69	.46	2N 4391	1.18	1.18	.79
UC 734E	.38	.28	.25	2N 4392	.94	.94	.62
2N 3819	.25	.21	.18	2N 4393	.88	.88	.58
2N 3819E	.25	.21	.18	2N 4416	1.18	1.18	.79
2N 3823E	.40	.34	.26	2N 5105	1.95	1.95	1.29
2N 3955	2.73	2.73	1.81	2N 5163	.82	.82	.55
2N 3956	1.68	1.68	1.12	2N 5666	3.00	3.00	2.00
2N 3957	1.29	1.29	.85				

THYRISTORS

Type No.	1–24	25–99	100+	Type No.	1–24	25–99	100+
				2N 681	.90	.80	.70
				2N 682	1.10	1.00	.80
BTX18-100	.50	.45	.40	2N 683	1.50	1.30	1.10
BTX18-200	.55	.50	.45	2N 684	2.00	1.80	1.50
BTX18-300	.60	.55	.50	2N 685	2.40	2.00	1.80
BTX18-400	.70	.65	.55	2N 686	2.50	2.40	2.10
BTX18-500	.80	.75	.60	2N 687	2.80	2.60	2.40
BTX18-600	1.00	.90	.80	2N 688	3.00	2.80	2.50
BTX18-800	1.20	1.00	.90	2N 689	3.20	2.90	2.60
				2N 690	3.40	3.00	2.70
BTY79-100R	.90	.85	.80	2N 691	3.60	3.40	3.00
BTY79-200R	1.00	.90	.85	2N 692	3.80	3.60	3.20
BTY79-300R	1.20	1.10	.95	2N 2595	.36	.31	.30
BTY79-400R	1.40	1.20	1.10	2N 1596	.45	.42	.38
BTY79-500R	1.50	1.30	1.20	2N 1597	.65	.55	.46
BTY79-600R	1.75	1.50	1.25	2N 1598	.70	.60	.50
BTY79-800R	2.60	2.40	2.20	2N 1599	.75	.65	.60
BTY79-1000R	4.50	4.00	3.50	2N 3525	.75	.65	.50

ZENER DIODES

BZY 88 SERIES (400 mW)
2.7 volts to 33 volts

Prices:	1–24	25–99	100+
	.13	.11	.08

IN 746—IN 759 & IN 957—IN 976 series (400 mW)

Prices:	1–24	25–99	100+
	.21	.16	.12

1 WATT ZENER DIODES

Type	1–24	25–99	100+
25 Series	.24	.18	.15

3 WATT ZENER DIODES

DL Series	.36	.33	.30

METAL RECTIFIERS

Type No.	1–24	25–99	100+
6 AMP STUD TYPE (DO.4)			
6A 50	.36	.30	.27
6A 100	.42	.42	.32
12 AMP STUD TYPE (DO.4)			
12A 50	.62	.62	.41
12A 100	.69	.69	.47
40 AMP STUD TYPE (DO.6)			
40A 50	.70	.70	.53
40A 100	.76	.76	.59

Reverse type available (suffixed R)

OTHER RECTIFIERS

Type No.	1–24	25–99	100+
BY 100	.18	.15	.12
BY 126	.10	.09	.08
BY 127	.12	.11	.09
BY 164	.40	.36	.32
BYX10	.10	.09	.07

DIACS

	1–24	25–99	100
BR 100	26p	23p	20p

TRIACS

	1–24	25–99	100
2 AMP 400V	90p	85p	75p
6 AMP 400V	£1.10	£1.05	95p
10 AMP 400V	£1.50	£1.40	£1.25

E.F. Electronics

Dual-in-Line sockets

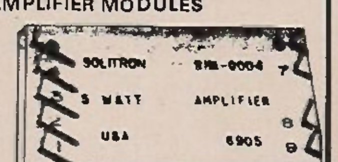
Beryllium Copper Contacts

	1–24	25–99	100 Plus
8 pin	.26	.25	.20
14 pin	.28	.26	.21
16 pin	.30	.27	.22
24 pin	.90	.70	.60
40 pin	1.15	.95	.88

AUDIO POWER AMPLIFIER MODULES

HYBRID AMPLIFIER CIRCUITS

Type No.	1–24	25–99	100+
(2 Watts) BHA 0001	3.45	2.95	2.45
(15 Watts) BHA 0002	3.95	3.45	2.95
(5 Watts) BHA 0004	3.75	3.10	2.85



electronics TODAY INTERNATIONAL

SEPTEMBER Vol. 1 No 6

main features

product tests

projects

reviews

news & information

COVER: Wind tunnel tests on model of Concorde.

OCTOBER ISSUE ON SALE 23 SEPTEMBER 1972

PART 5 of Transducers in measurement and control will appear in the October 1972 issue.

mini - features

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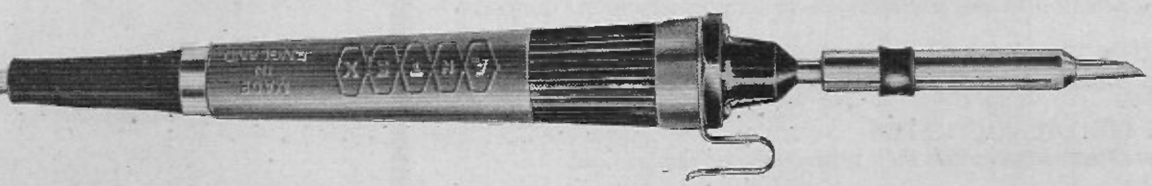
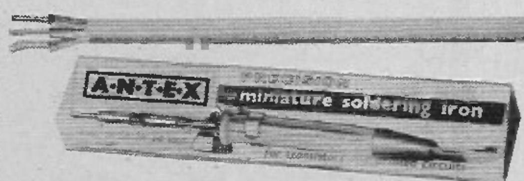
Antex X25

for people who want perfection



This new 25 watt model combines near-perfect insulation with exceptionally high heat-capacity. Leakage under working conditions is only 3-5 microamps and there is no risk of damage to transistors and delicate components. Every iron is tested at 1500 volts A.C. and fitted, as standard, with a 1/8" long life iron-coated bit. **Price £1.75**



CN.240/2 Miniature soldering iron 15 watt 240 volts, fitted with nickel plated 3/32" bit and packed in transparent display box. Also available for 220 volts. **Price £1.70**

CN.240 Miniature soldering iron 15 watt 240 volts, fitted with iron coated 3/32" bit. Up to 18 interchangeable spare bits obtainable. This iron can also be supplied for 220, 110, 50 or 24 volts. **Price £1.70**

G.240 Miniature soldering iron 18 watt 240 volts extensively used by H.M. Forces. Suitable for high speed soldering and fitted with iron coated 3/32" bit. Also available for 220 volts. Spare bits 1/8", 3/16" and ¼" are obtainable. **Price £1.83**

CCN.240 New model 15 watt 240 volts miniature soldering iron with ceramic shaft to ensure perfect insulation (4,000 v A.C.) Will solder live transistors in perfect safety: fitted with 3/32" iron coated bit. Spare bits 1/8" 3/16" and ¼" available. Can also be supplied for 220 volts. **Price £1.80**

CCN.240/7 The same soldering iron fitted with our new 7-star high efficiency bit for very high speed soldering. The triple-coated bits are iron, nickel and chromium plated. **Price £1.95**

SK. 2 SOLDERING KIT

This kit contains a 15 watt 240 volts soldering iron fitted with a 3/16" bit, nickel plated spare bits of 5/32" and 3/32", a reel of solder, Heat Sink, 1 amp fuse and booklet "How to Solder"

Price £2.40.

SK. 1 SOLDERING KIT

The kit contains a 15 watt 240 volts soldering iron fitted with a 3/16" bit, nickel plated spare bits of 5/32" and 3/32", a reel of solder, heat sink, cleaning pad, stand and booklet "How to Solder". Also available for 220 volts.

Price £2.75

A N T E X

from electrical, radio or car accessory shops or from Antex Ltd., Freepost (no stamp required) Plymouth PL1 1BR Telephone 0752 67377/8

☐ Please send the Antex colour catalogue.

Please send the following:

____

I enclose cheque/P.O./Cash (Giro No. 2581000)

Name __________

Address __________

E.T.9.

Who stands to gain?

IT is both right and proper that the implications of technological development should be closely scrutinized by those in any way affected by the consequences of resultant change.

And in many areas, subjective observations from lay people have as much validity as similar observations from those expert in any particular field. Equally there are occasions when valid criticism can only be based on objective measurement and expert opinion, factually presented by non-interested parties.

The extraordinary brouhaha surrounding the Far Eastern tour of the Anglo-French Concorde supersonic airliner is in this category.

Here the extraordinary statements of those anxious to flog the thing are exceeded only by those with a vested interest in otherwise competitive non-supersonic aircraft. Such statements range from BAC's "Concorde will be one of the greatest steps forward in world transportation since the invention of the wheel", to the opposition's claim that "Ozone poisoning will kill all the Concorde's passengers".

But in the assessment of the two major criticisms of the aircraft — firstly that it will upset the atmospheric balance of the stratosphere, and secondly that its noise level will be excessive — the layman is clearly out of his depth, for neither parameter can be evaluated subjectively. They are both matters for measurement and calculation.

In these areas the layman can only attempt to assess data that are available to him, and which are within his understanding.

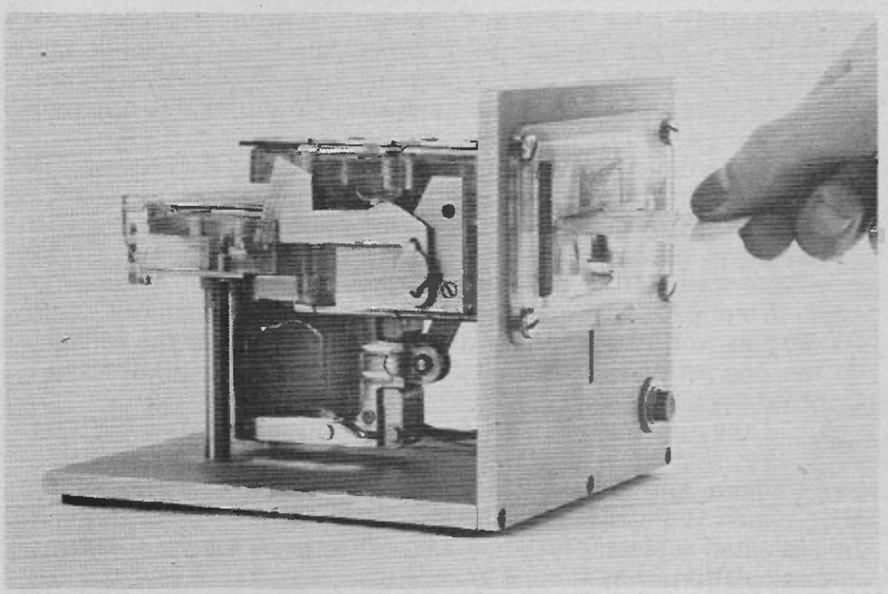
Even then caution is necessary. For example few of those groups concerned with the preservation of the environment have realized the extent to which their 'facts' have been supplied by those whose interests have little to do with ecology.

When such data is presented all one can do is to ask — as did Socrates — "Who stands to gain?"

If historians are correct in their belief that travel is the catalyst of civilization, then an aircraft that is capable of reaching practically any part of the world within twelve hours must be judged rationally and dispassionately, using evidence not obfuscated by issues vital only to those with rival commercial or political interests.

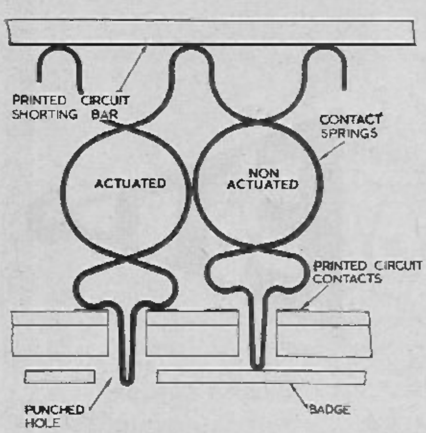
news digest

LOW-COST BADGE READER



Sealectro Ltd have introduced a new low-cost badge reader — the MBR 131 Series — which incorporates printed circuit techniques in conjunction with a unique wire-contact system. The sensing head accepts and reads alternatives of three standard punch-hole plastic badges.

Tripping of the 'read' mechanism is actuated by pushing the badge fully home and an interlock prevents operation if the badge is incorrectly inserted.



Reading is static by means of mechanical sensing probes which operate dual-contact switches. The probe contacts, mounted on a single carrier, are of the normally-open type manufactured from high-grade, hardened beryllium copper, plated with 0.0002" thickness of gold. They are of a patented design and said to combine a self-cleaning action with robust mechanical characteristics.

The presence of a hole in the badge causes a corresponding pair of switch contacts to close. Conversely, when there is no hole the contacts remain open. The fully mechanical sensing principle has been adopted to give a low-cost system without any of the disadvantages which often result in misreads with magnetic, optical or other systems. The electrical switching function is essentially remote from the hole-sensing action, and this guards the system against grease, fluff or other contaminants which might enter with the badge and lead to malfunction.

The readers sense up to 264 data bits in any matrix of 12 rows up to 22 columns and connections are made via printed circuit boards which terminate at gold-plated edge-connectors. Switch contacts are internally connected in a buss/buss configuration but are also available for other coding formats such as Hollerith.

The units are normally supplied in skeleton form for directly mounting into system equipments and are easily adapted for mounting into a door, wall or purpose-designed piece of equipment such as a computer peripheral. Initially, two versions of the MBR 131 Series are offered: one with a hand-operated eject and reset lever; the other with electric solenoid automatic retrieve operation.

Sealectro envisage a vast range of applications from data collection to security, clock-in and 'flex-time' working period systems.

Further information from: Sealectro Ltd., Walton Road, Farlington, Portsmouth PO6 1TB. (1)

COMPUTER COP

Incorporating amendments from many countries, a Code of Practice compiled by the British Computer Society has at last been approved in the revised draft form and been passed. The document, due to be published in January 1973, has already aroused great interest in the computer industry in UK and elsewhere.

With the recently published Younger Committee report much in mind, the Society is reported to have adopted the Committee's ten principles for handling of personal information in data banks.

ENERGY VIA SPACE

An 'old story' to science fiction addicts many years ago could become a reality in a few years, viz., using large satellites in 'earth stationery' orbits to harness solar energy and beam it to earth. The US National Aeronautics and Space Administration is reported to have given a $ 200,000 contract to a four-member consortium (Raytheon, Textron, Grumman and A.D.Little) to study, as a first stage, the technical problems associated with such a station. Accuracy of beam steering and station logistics are seen as two of the main problems.

The proposal, understood to have been initially put forward by the first three members of the team, is that the station will convert solar energy to electrical energy by devices on-board and beam it to earth via microwave links. This concept is being examined by NASA as one of several alternatives of using solar energy to supply large amounts of earth-demand power.

It is encouraging to note that ADL's brief is not only to identify areas where further investigation and research are necessary but also simultaneously to assess the impact on environment of such a rotation.

news digest

MARINE ELECTRONICS

The most complete marine electronics package and supporting services available from any one company anywhere in the world have been specified for each of two new Sugar Line bulk carriers, numbers 723 and 733, being built at Scott Lithgow.

Each vessel will have a full range of communications equipment from Marconi Marine, including the most powerful commercial marine single-sideband transmitter to be introduced to the British market. Marconi Marine will also supply two radars, incorporating the very latest in electronic circuit and component technology; latest solid-state echo-sounders; weather facsimile equipment; a radio direction finder; a major talk-back, crew-call and sound powered telephone system; broadcast radio and television receivers and a communal aerial system. In addition, Marconi Marine will provide a full planning and installation service, radio officers, radio traffic accounting, and world-wide service back-up from over 350 depots and agencies. (3)

DIY LABORATORY

As a service to small companies for whom a full-scale environmental testing programme may be too expensive, Product Assessment Laboratories have announced the opening of a well-equipped laboratory which can be hired at an inclusive cost of £25 per day.

In the do-it-yourself laboratory, customers can simulate world climatic conditions involving heat, cold, humidity and altitude, and carry out tests and experiments on their products under conditions of complete security.

It is claimed that this service will prove cost-effective for small companies since, although environmental testing is a vital part of a product development programme, particularly where export markets are involved, the cost of setting up an environmental testing facility is high. If, due to the nature of the firm's business, the test equipment is only used infrequently, then the cost could become prohibitive and testing may be deferred until customer complaints about poor performance make it essential and result in excessive 'fire-fighting' expense to correct product deficiencies.

By using this new facility, however, basic tests can be carried out at low cost to prove whether the prototype of a new product is satisfactory and any weaknesses can then be corrected before production begins.

Further information from the Customer Liaison Manager, Product Assessment Laboratories, The Plessey Company Limited, Abbey Works, Titchfield, Hants. (4)

OPTIC CABLES

It looks like a Roman candle spurting sparks. In fact, hardly anything is moving in this picture. The effect was obtained by passing light along a bunch of special glass fibres which, in years to come, could be carrying telephone calls more cheaply and efficiently than cables do at present. Each pinpoint of light represents a hair-thin strand of glass capable of carrying as many as 2,000 simultaneous telephone conversations. This entirely new transmission concept, being developed by the Post Office at its research station in Dollis Hill, London, employs laser beams to carry calls along the fibres. (5)

MASTER FILE

From March '73, all the 16 million or so telephones used by the 10 million or so GPO subscribers are to be listed and kept in a national master file. The system is expected to be fully operational a year later and will yield information to PO management on what types and numbers of PO equipment are in service. The project at the PO Computer Centre in Bristol will centralise the work currently undertaken by the 6 regional telephone managers' offices. GPO will use an ICL 4—70 computer and four Computer Machinery Co's CMC 10 key-processing systems with 112 key-stations.

BIO—TRONIC WATCH

Biorhythms are predictable and rhythmic (so they say) periods of increased or diminished performance potential. And here is an electronic watch that not only tells you the time but also tells you whether you are on form — physically, psychologically and intellectually. An arm on its dial has three bands, the green band indicating your psychological form, the blue your intellectual and the red your physical. If you are off-colour or under par in any of these aspects, that arc in the watch will be white.

Certina, who are selling the Biostar Electronic watch through Watches of

news digest

Switzerland, say that the watch has been carefully tested by bus, taxi and automobile companies with remarkable reduction in accident rate by using the high-form periods for critical or demanding jobs.

Further information from: Watches of Switzerland, 16 Old Bond Street, London W1. (6)

OLYMPIC ORACLE

Programmers in Munich have fed one of their NCR Century 100 computers with facts and figures of Olympic achievements going as far back as 1896 and it, in turn, has disgorged predictions for the forthcoming Munich Olympics. From the data it was given, the computer calculated the rise in performance over the years and drew the logical conclusion that, for instance, for the finals of the Women's 200 metres in Munich, a time of 22.1 seconds must be achieved.

Compared with those achieved in the 1968 Mexico Olympics, times and distances in Munich, according to the computer, generally will be better, as should be expected with the lower altitude of the German City; but significantly the computer forecasts slower times for the Men's 400 metres (45 seconds against 43.8 seconds in 1968) and for the Men's 400 metres hurdles (48.6 seconds against 48.1 seconds). It also forecasts a poor result in the Men's Long jump — 8.2m in Munich against the 8.9m achieved in Mexico.

It will be interesting to see whether the computer's prophesies for the Munich Olympics will, in fact, prove true in these, the most unpredictable of human endeavours.

P–B DIAL SETS

In years to come, telephone dials are likely to disappear altogether and will be replaced by push-buttons. The size and arrangement of these buttons — or keys — will depend largely on the result of tests such as the one pictured here which are being conducted by engineers at the Post Office Research Station at Dollis Hill, London. The sets differ from one another in design and layout but simulate possible future telephone instruments. As an assistant keys a series of numbers on each set, speed and accuracy of operation are measured by a computer and the analysed results are helping to further the international standardisation of button layouts. Whereas the ordinary telephone dial has

ten positions, all but one of the push-button sets pictured here have more than that. The extra capacity will be needed to keep pace with the demands of an expanding network — and to perform additional tasks at present outside the scope of the conventional phone. Earlier this year the Post Office started market trials of push-button phones in selected areas. (7)

COMPUTERISED TESTING AT RF

The Autotest Division of Marconi Instruments Limited have announced a new computer-based control system for RF testing, which forms the basis of a new range of Computer Controlled Automatic Testing Systems. It is also available in unit form for those wishing to build their own automatic test system.

The equipment is applicable to both AM and FM operating up to 500 MHz. The measurements performed by the system include all of those normally encountered in testing RF communication equipment, such as voltage, current, RF power, frequency, modulation, sensitivity, signal/noise ratio, etc. An Automatic Knob Actuator sets the controls of the unit under test so that the testing sequence is carried out without the need for any operator participation. Operator actions are thus reduced to connecting and removing the unit under test. The test time for a four-channel mobile radio telephone is reduced to a few minutes.

Special features are simple programming by the test engineer himself and the ability to expand or modify the system at any future date with minimal cost and disruption. M.I.—BASIC, the computer language employed, is a special test-orientated extension of simple BASIC. With minimal training and with the manual which goes with each system, the test engineer has all he needs to prepare his own programmes. The language is sufficiently close to English to be easily understood.

An extensive range of test instruments, a variety of plug-in interface cards and a comprehensive software library enables new systems to be tailored to individual requirements and allows existing systems to be expanded or modified at any time to cater for changing needs. (8)

AEH: THE DREADED BOUNDARY

We cannot see black holes (see feature on page 20) but our spaceships can fly into one of them. If this did happen, the powerful gravitational force in the hole would go on collapsing the spaceship until its density became infinity and it just disappeared. Nothing can escape from a black hole; even light is dragged back and can never re-emerge into the 'white' space.

As far as an observer outside the black hole is concerned, the spaceship will have ceased to exist. And even the travellers in the spaceship will never know what happened to them.

This is the fascinating, yet terrifying, question speculated by astronomers today. The boundary of a black hole is called the Absolute Event Horizon, (AEH). It is terrifying because a spaceship will never know whether (or even when) it has crossed the AEH and entered a black hole region. If the region is small, it will be torn to pieces (as all matter is in a black hole) in a fraction of a second. But if a spaceship crossed the AEH of a large region, it could survive for minutes or even hours without realising that it is being dragged to the centre where the intense gravitational forces will eventually, and quite definitely, destroy it (as the outsider observer and possibly the people on the ship, knew it).

According to theory, matter inside a black hole continues to collapse to a point in space-time (known as 'singularity') where no known law of 'white space' physics is relevant. What happens to matter in such conditions is anyone's conjecture. By definition, no one knows anything about it.

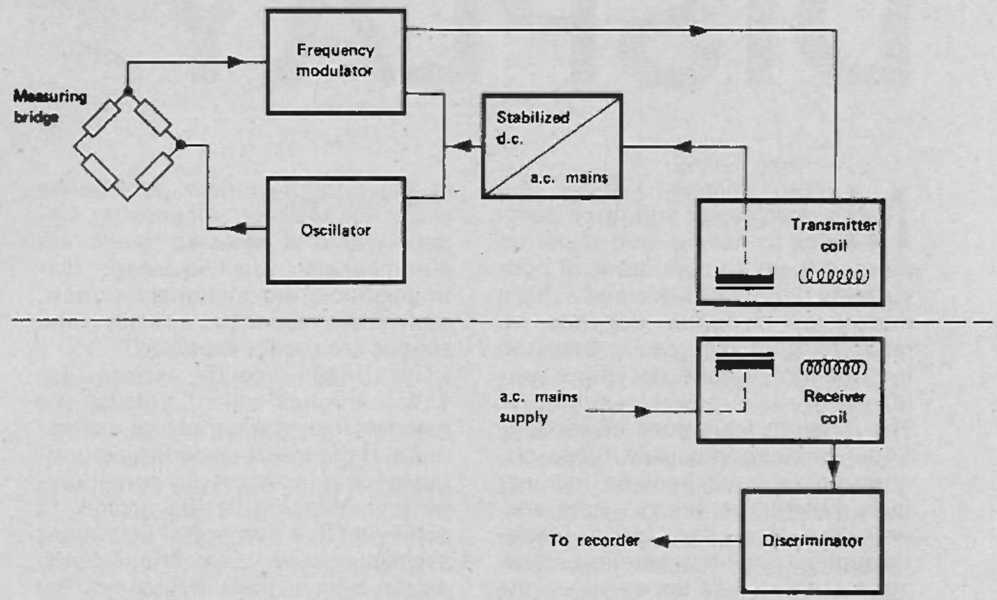
But the more fascinating aspect of this question is that theory cannot still preclude the possibility of such a phenomenon being formed without the benefit of a 'black hole' (so-called 'naked singularity'). The implications of this are very disturbing indeed.

WANTED: 1000 mHn

We understand that two shipyards are desperately combing the market for some 1000 or so mHn. If you have some or know where they can be obtained, let us know and we will pass on the information. If you don't know what a mHn is, turn to page 79. ●

ELECTRONIC TORQUE-MEASURING SYSTEM

New torque measuring system uses inductive signal transmission to avoid slip-ring problems.



A NEW torque measuring system that permits continuous monitoring of both static and dynamic torque values up to 500 mkg without any physical contact between rotating and static components of its transmission section, has just been introduced by Philips.

The system, (type PR 9372), can be used at shaft speeds up to 10,000 rev/min and eliminates problems of brush wear and tear and continual cleaning experienced with the commonly used slip-ring measurement system. Variations in contact resistance are thus avoided and the transducer system gives a consistently high measuring accuracy of better than 1%. A further advantage over the slip-ring system is that there is no difficulty in changing the direction of shaft rotation during measurements.

STATIC AND ROTATING SECTIONS

The PR 9372 system consists of two parts – a rotating section which is mounted within the shaft whose torque is being measured, and a static section mounted in close proximity to the rotating section.

The rotor's measuring shaft contains strain gauges cemented to it in a Wheatstone-bridge configuration, and the body of the rotor contains two LF-FM units and a rectifying unit which constitute the information transmission system. The surface of the rotor is fitted with two coil systems, the outer one constituting a power induction coil and the centre one being the information-signal transmission coil.

The static section consists of two parts: a unit mounted adjacent to the rotating section and a discriminator. The former contains both the primary power-induction coil (from which power for the rotor unit is obtained) the information receiving coil, and the latter signal-conditioning circuits.

FREQUENCY-MODULATED SIGNALS INDICATE TORQUE CHANGES

Variations in the bridge's resistance (proportional to changes in torque) are translated into frequency deviations of a fixed-frequency signal by the LF-FM units, the resulting frequency modulated signals being fed to the transmitting coil on the rotor surface. The discriminator within the static section demodulates signals from the receiving coil, its output being fed to the recording or indicating unit used.

A wide range of recording/indicating instruments can be used with the PR 9372 which provides the following outputs:

1. A carrier-frequency signal for use with magnetic-tape recorders.
2. A demodulated signal for use with high-speed chart recorders or oscilloscopes.
3. A demodulated signal for use with ultra-violet recorders or moving-coil instruments.

IMPROVED EFFICIENCY AND VERSATILITY

The PR 9372 system, which is available in six versions to suit different measuring ranges and shaft diameters, can be used with any type of recorder, moving-coil instrument or oscilloscope for the testing of all types of motors, car engines and gearboxes. They can also be used to deduce the power output of machines by measuring their speed, for measuring torque variations up to 1.5 kHz, for checks on car-engine piston balancing, for measurements during blending of chemicals, and for accurate measurements where high rotational speeds are involved (up to 10,000 rev/min compared to the slip-ring system maximum of 6,000 rev/min).

Linearity and hysteresis deviations are both less than 0.2% with PR 9372 units, and zero-point variation less than 0.05% per 10°C in the range 10 – 70°C. ●

'REAL WORLD' RADAR DISPLAY

A revolutionary system that has won the almost unanimous approval of navigators and ships' masters.

Modern marine vessels are bigger, faster and more complex to handle, and there are more of them. In conditions of poor visibility, the over-worked ship's master or navigator depends on radar to give him easily assessed information to take decisions rapidly and avoid possible collisions. The inherent limitations of conventional radar in precisely these circumstances have become increasingly obvious in recent years and, with the time ripe for a breakthrough in radar presentation, 'Situation Display' has appeared on the scene.

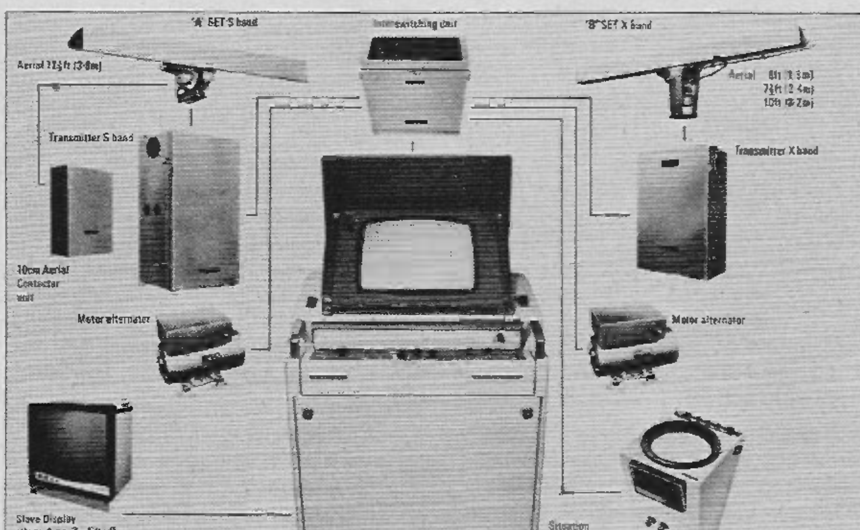
Of particular value in conning and anti-collision roles in congested waters, 'Situation Display' presents radar information as a visual display of the situation exactly as it would appear to the navigator looking out of the bridge window, and hence easier to interpret. All moving targets within a selected range are automatically tracked and distinguished from stationary targets, and their aspects, courses and speeds are readily assessed.

This 'Real World' picture (as Kelvin Hughes call it) enables the navigator to make a visual assessment of the traffic pattern surrounding his ship, in all visibility conditions, by just glancing at the screen. In achieving it, a number of limitations associated with conventional radar displays have been overcome. For instance, although it is compass stabilised, the picture is always ship's head up – a mode which has been confirmed, in actual trials at sea, to be more suited to the requirements of the man conning the ship because it is orientated to the actual direction of ship's travel. The officer-on-watch does not have to orientate himself to the system, e.g, if the ship is going south, he does not have to think 'upside-down' as he would with a conventional compass-stabilised radar.

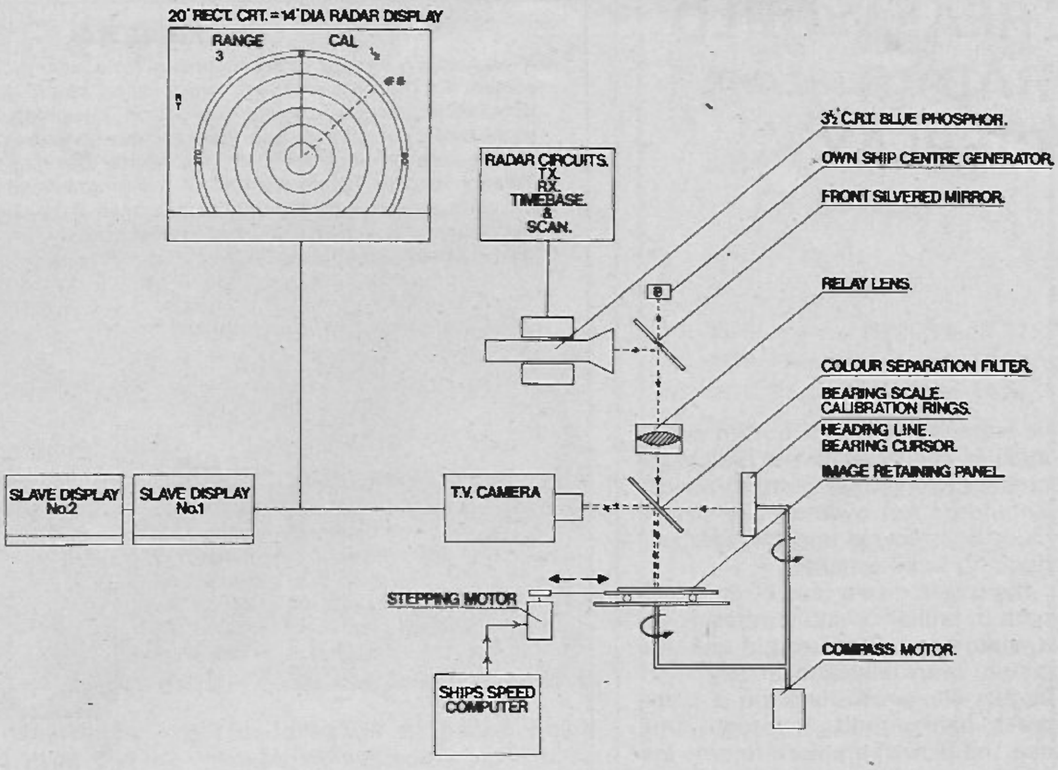
Again, although the tracks can be 'true', the picture has the familiar relative form; own ship always remains in the centre, and the operator does not have the difficulties associated with conventional true-motion radar, viz., own ship moving across the screen and the view ahead progressively reducing. Land and stationary objects also move relative to own ship, but do so in the "true track" mode without smearing. Not only is the bearing scale compass-stabilised, but so is the bearing cursor; this means that a bearing on a target is maintained

The British coast guard organisation is said to be deeply concerned at the apparent continued lack of lane discipline on the part of vessels using the English Channel. The US Coast Guard has given a contract to Computer Service Corporation to carry out a study into marine traffic systems, navigation aids and communication networks in ports and harbour approaches.

In the meanwhile, expressions such as "radar-controlled collisions" are voiced at one extreme in shipping circles whilst, at the other extreme, there are those who insist that all marine collisions are the result of human, not equipment, error.



S band – and X band interswitched dual radar system



in spite of any changes in own ship's course.

The picture is presented on a 20" television screen requiring no visor, and can thus be viewed in broad daylight or at night and by several observers simultaneously and from many angles. Up to four 'slave' displays with either 20" or 24" screens can be fitted to present the same pictures in any other protected position within a 60-metre cable run of the main display.

HOW IT WORKS

Situation display is designed to operate in conjunction with standard KH aerials and transmitters in the X or S band, and can be integrated in the 3cm or 10cm, single or dual radar systems.

The basic radar picture appears on 3½" (89cm) cathode-ray tube with blue phosphor and a very short afterglow. A mirror, lens and colour-separation filter are used to focus the radar picture on to a panel which, when electrically energised, retains the image and re-emits it as an orange-coloured image. Thus the normally transient radar picture is 'fixed' on to this panel. Successive sweeps on the CR tube build up a composite picture on this panel, moving objects being continuously tracked and leaving comet-like trails behind them. This enables the navigator to assess not only ranges and positions but also (in the true track mode) the aspects, courses and approximate speeds of all ships on the screen.

The image retaining panel is held in azimuth by the compass motor and hence stabilised for changes in ship's course. If the panel is also moved in proportion to the own ship's speed, the radar echoes from other ships produce persistent tracks indicating their true courses and speeds. Alternatively, if 'ship's speed' movement is not applied to the panel, the tracks left by other ships will be relative.

The colour-separation filter lets through blue light in one direction (from the CR tube to the panel) and simultaneously reflects the orange image from the panel to the TV camera. The Heading line, Bearing Cursor, and other markers are printed on transparent discs and optically superimposed on the radar picture. Special arrangements monitor their alignment with the radar presentation. Own ship's track is produced by permanently illuminating a spot on the panel at the position corresponding to the radar origin.

The TV camera televises the complete picture (together with the compass-stabilised azimuth ring) on to the main display screen and the slave displays.

DISPLAY MODES

Either relative or true track mode can be used. In the relative track mode, own ship does not leave a track and other ships' tracks are relative to own ship. Therefore assessment of courses and speeds of other vessels (relative to own ship's) requires normal plotting procedures but since tracks appear automatically wherever there is a movement relative to own ship, computation is made easier than with conventional radar.

In the true track mode, the image retaining panel is moved according to own ship's course and speed; the necessary information is fed in from the compass and from either the ship's log or an estimated speed control on the set. In this mode, the track left by any moving target will now indicate its true course whilst the target itself is shown relative to own ship. The target's speed, course bearing and range can be easily assessed and its potential as a collision threat quickly and accurately gauged by the navigator.

Target plots are continuously updated through a time cycle related automatically to the range selected and in use. In the true track mode, there are three different plotting periods covering six range scales: on the ¾ and 1½ mile ranges it is 1½ minutes; on the three mile range, three minutes; and on the 6, 12 and 24 mile ranges it is six minutes. Twenty seconds before the end of the period, a warning indicator appears; if for any reason the operator wishes to continue the plot,

(Continued on page 12)

'REAL WORLD' RADAR DISPLAY

he presses an override button which enables him to retain the picture for at least one further plotting period. Should he not override, the equipment will recycle and the plot will begin to build up anew.

The screen display can be adjusted, both in brilliance and contrast, over a wide range. For daylight use, the picture is usually a radar negative; targets show up black on a pale-green background. For night-time use, the flick of a switch returns the picture to the more familiar 'radar positive'. Compensation for variations in ambient light is by means of the brightness control; at night this can be set so that, because there is no obtrusive rotating trace, the screen is completely black except for the small spots of light of targets.

To make the fullest posible use of the rectangular television screen, the radar picture is off-centred towards the bottom, giving a 60% view astern. This gives maximum view ahead, abeam or from the quarters (the areas from which collision risks are most likely to come) as well as a good view astern. The areas at the top, right and left of the screen are used to indicate the range scale, the true or relative mode and the calibration ring interval, and to display the indicator which shows when the plotting time cycle is due to end.

Situation Display is based on the idea of visual assessment and is oriented with the actual view from the bridge. Apart from range and bearing, no numerics are involved. It gives a clear, informative presentation. The Master, in poor visibility conditions, can obtain from it the same essential information on which to base his decision for an anti-collision manoeuvre that he would usually derive from his conventional radar coupled with visual inspection (when possible) of the clear weather scene. Because it does this in a manner recognisably akin to conventional radar, any special operator-familiarisation required is minimal. ●

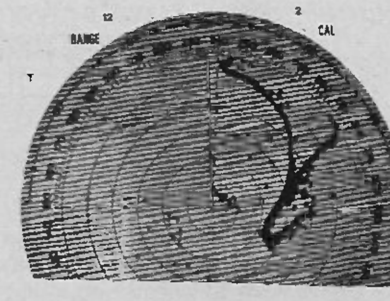
THE PLOT CYCLE

The first few sweeps of the scanner gives a radar picture build-up on the TV screen. As the plot proceeds, any moving target develops a "tail" whose direction indicates the target's true-course; the length of the tail is proportional to the target's speed. The time taken to develop tracks of useful length depends on the display range selected; the shorter the range, the shorter the time. Twenty seconds before the end of the programmed plot-period, a warning indicator appears at the top right of the screen. If the operator does not over-ride the programme within this 20-second period, the image disappears from the screen briefly and another cycle starts afresh. At the end of each cycle, the old picture is erased on the image retaining panel and the panel itself is reset to the "start" position.

A typical plot sequence is illustrated below.

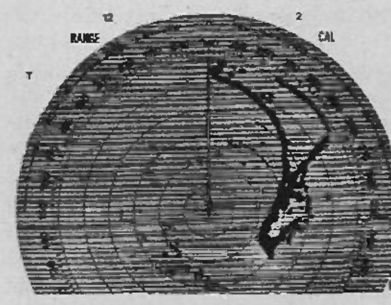
● START OF FIRST PLOT-PERIOD

Heading line shows own course is 236°. With 12 miles as the selected range (see top left), each calibration ring interval is 2 miles and plot cycle is 6 minutes. The bearing cursor (dashed line) is set on the nearest "danger" target "A", at about $1\frac{1}{2}$ miles and approaching fine on the starboard bow.



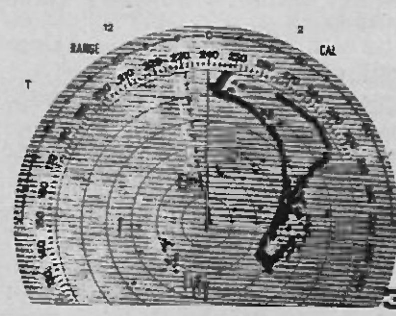
● 2 MINUTES INTO FIRST PLOT-PERIOD

All moving targets have developed tracks. Own ship's course has been adjusted to 240° since, although target "A" is now on the heading line, it is obviously on a safe course down our starboard side. Note also how the land has "turned" relative to own ship with no smearing of the picture. Bearing cursor is compass-stabilised and remains on a target despite changes in own ship's course.



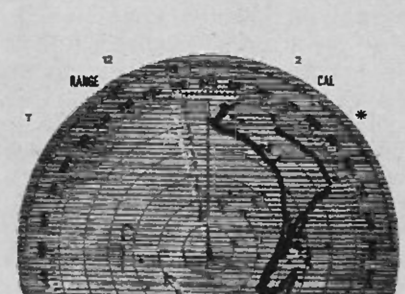
● 4 MINUTES INTO FIRST PLOT-PERIOD

All moving targets are automatically tracked and distinguished from stationary ones. With target "A" safely clear of own ship, the bearing cursor is re-aligned on to "B", the most immediate threat, $3\frac{1}{4}$ miles to port.

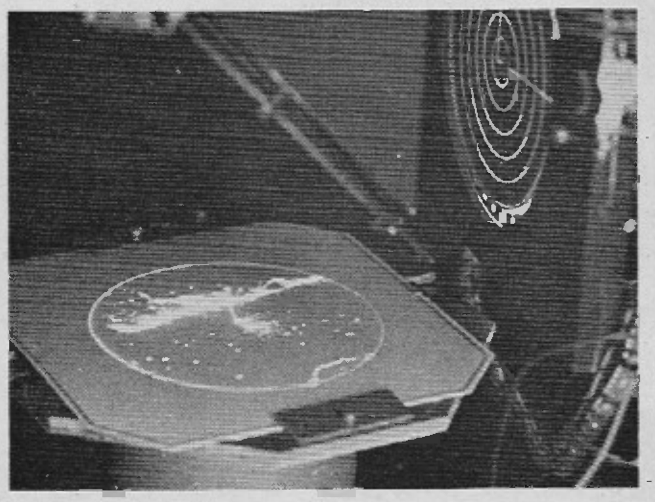


● NEARING END OF FIRST PLOT-PERIOD

*Note 20-sec warning * on top right of screen. "B" is seen to turn to starboard and will pass safely down our port side. Note ship "C" whose speed is clearly seen to be $1\frac{1}{2}$ times that of own ship.*



The image retaining panel



The heart of Situation Display—the Image Retaining Panel. Note the assembly, at top right, which projects the calibration rings, compass azimuth circle and bearing and heading markers.

THE Image Retaining Panel originated in 1963 and was the subject of a paper(1) in the British Journal of Applied Physics in 1969. It consists of a sheet of iron which forms the back plate and negative electrode, on which are successively deposited two layers of vitreous enamel, a thin layer of magnesium-doped zinc cadmium sulphide phosphor, and a transparent tin oxide layer which forms the positive electrode. The device is rugged and stable.

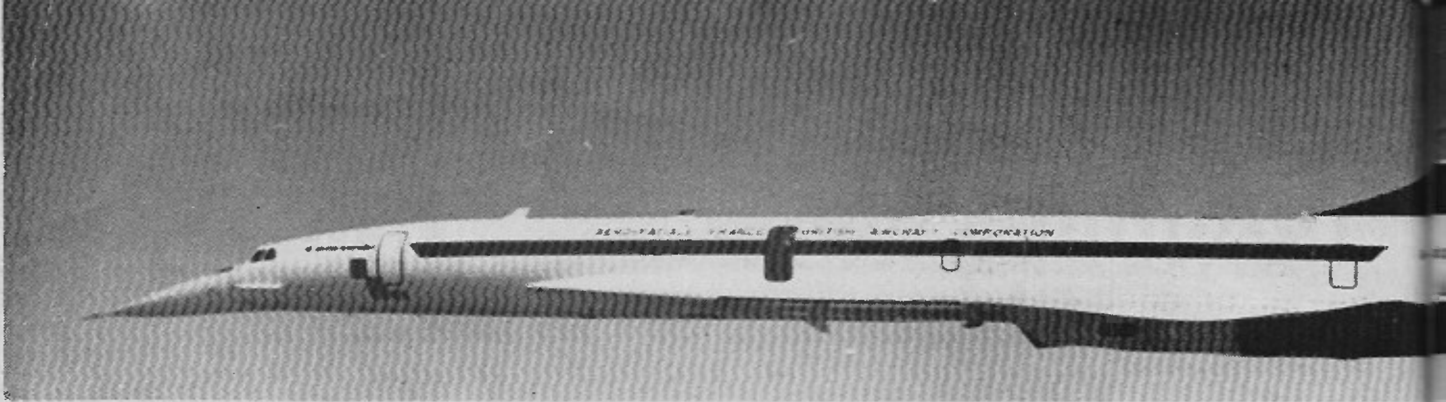
When a voltage is applied to the panel, a current flows but no electroluminescence is produced. When external light falls on the panel, the current increases and the panel starts to emit light which persists (subject to a slow decay) when the external illumination ceases. The emission of light ceases when the supply voltage is interrupted and is not recovered when the voltage is restored. The light is emitted only where external light has fallen on the panel. So an image can be formed and retained in this way. The light output is directly proportional to the current (neglecting the dark current).

The panel may be regarded as a CRT screen divorced from the tube, with a long persistence (memory) which can store data for a number of minutes, but capable of instant erasure. Since it is sensitive to light, it can only be viewed directly in the dark, but its properties make possible the achievement of some new display features unattainable on a normal CRT. In the marine radar field, especially as used in Situation Display, they are:

- The formation of tracks which can be viewed easily for 6 to 12 minutes but erased immediately when desired.
- A radar picture of nearly uniform overall brightness, the rotating time-base line being virtually invisible. In conjunction with the CCTV system, this provides a display whose brightness and contrast can be adjusted for use in any ambient lighting from indirect bright sunlight to complete darkness.
- Movement of the panel (from log and compass) to correspond to ship movements gives further advantages. First the *tracks* formed by projecting a relative radar picture on the panel are true, but the *positions* of all targets remain relative to own ship. Second, own ship remains in the centre of view of the TV viewing system.

This last remarkable result could – just – be achieved in other ways. For example, a two-gun memory CRT could store a true-motion radar picture on the memory screen (i.e. a radar picture ground- or water-stabilised and compass-stabised and read it off with a TV raster which was also ground- or water-stabilised and compass-stabilised). Such a system would however only achieve the third point (above) at considerable expense. One of the advantages of the panel is the cost-effectiveness of the new solutions it presents to known problems.

(1) 'Studies of the mechanism of the Thorn Image Retaining panel'. Garlick, Harvey, Clewer and Ranby. B.J.A. Phy./ 1969, Ser. 2, Vol. 2. (13)



HOW NOISY IS THE CONCORDE?

In this article, Louis Challis describes the latest methods of evaluating aircraft noise and details the results of his noise survey undertaken on the recent Concorde's Far Eastern tour.

IF our present experience is any to go by, the more prosperous that a country becomes, the greater the incidence of noise producing devices and the greater the stress for that minority of the population most adversely affected by these devices.

Of the noise producers, possibly the most objectionable is the modern jet aircraft, and the people who suffer the greatest annoyance are those living adjacent to airports.

The problem of airport noise presents aviation authorites with one of the greatest technical headaches of this decade, for whilst it is possible to produce quieter subsonic jets, the rate at which aircraft movements are growing, together with the probable introduction of supersonic transports, creates an almost insurmountable problem.

Complaints of annoyance from aircraft are dependent on two factors; these are:-

a. the peak level of aircraft noise

b. the number of aircraft movements taking place on a short term or long term basis.

These two factors are particularly interesting as, apart from aircraft such as the Concorde, the noise power per pound of thrust for most newly developed jet engines is being reduced at a very satisfactory rate. Thus, the first of the factors is being tackled on a rational and scientific basis.

The number of aircraft using most modern large airports is increasing at a rate that (typically) doubles the number of movements every seven years. Surprisingly, this is about the same rate of increase as motor vehicles registered in this country and the result is the same in both cases; saturation limiting the capacity of both forms of transport. Whilst the road authorities may find this problem a limitation, the airport authorities have to some extent been presented with a solution — in the form of larger aircraft carrying more and more people. Thus, whilst the total number of aircraft movements double every seven years, the number of passengers carried doubles in a far shorter period of time, typically four yours.

Until 1970 it was a safe bet that each

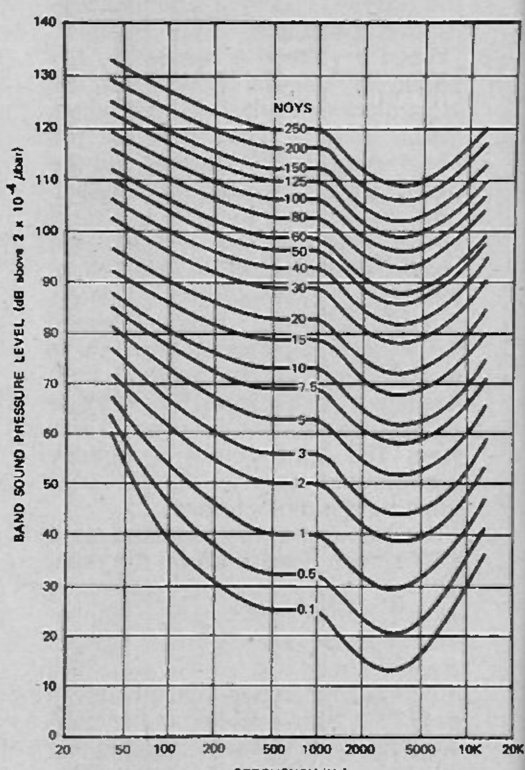


Fig. 1. Curves for determining noisiness of bands of sound used in Kryter's method of calculating perceived loudness.

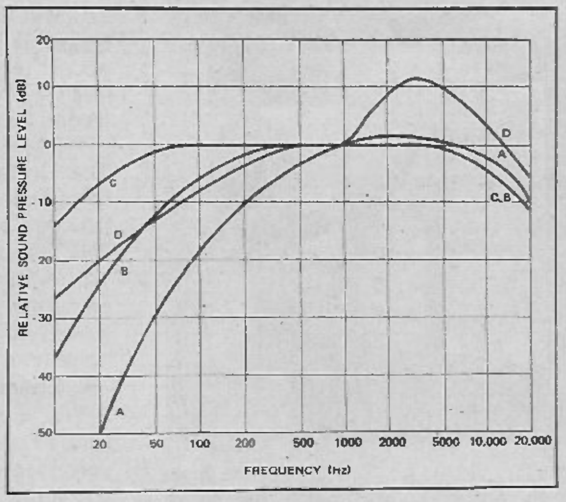
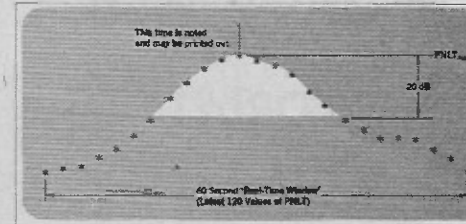


Fig. 2. International standard A,B, and C weighting curves for sound level meters. Also shown is the recently accepted D weighting curve for monitoring jet aircraft noise.

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   THIS PROGRAM PERFORMS A COMPUTATION ON READINGS OBTAINED
FROM THE HP 8054A REAL TIME AUDIO SPECTRUM ANALYZER.
THE PROCEDURE ADOPTED CONFORMS TO THE ISO RECOMMENDATIONS
507 FOR DESCRIBING AIRCRAFT NOISE AROUND AN AIRPORT.


CORRECTION FACTOR ?                       (+ OR -) XX.X DB
1.5
INTERVAL BETWEEN MEASUREMENTS ?                 X.X SECONDS
0.5
TO START MEASUREMENTS HIT RUN
PAUSE

MAXIMUM PNLT OCCURED AFTER 10.5 SEC.
MAXIMUM TONE CORRECTED PERCEIVED NOISE LEVEL= 123.2 DB
EFFECTIVE TONE CORRECTED PERCEIVED NOISE LEVEL=121.# DB

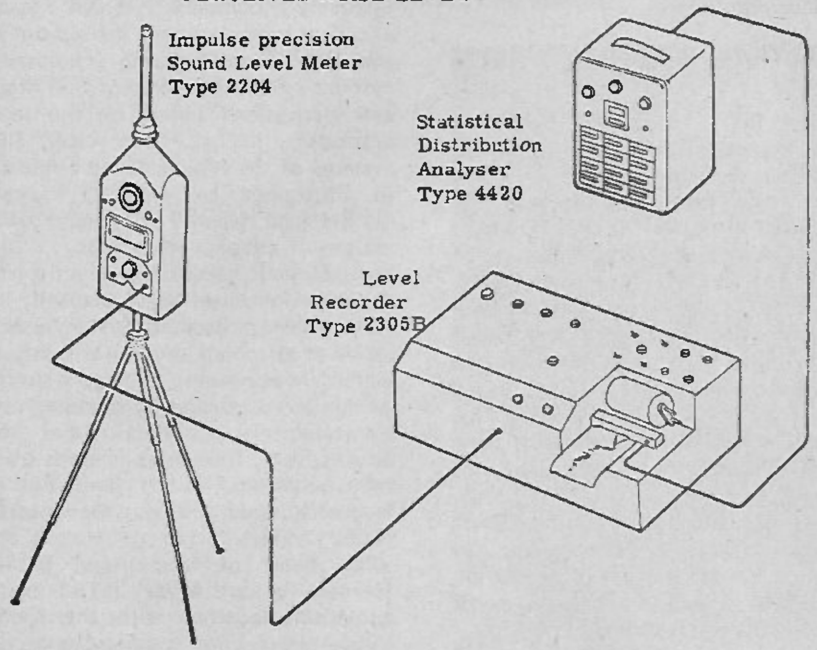

HISTOGRAM OF PNLT VALUES..


05.5  111.2
06.0  111.8
06.5  114.2
07.0  116.3
07.5  116.5
08.0  116.9
08.5  117.1
09.0  118.2
09.5  119.9
10.0  120.0
10.5  123.2
11.0  121.2
11.5  121.2
12.0  120.7
12.5  122.1
13.0  123.1
13.5  122.8
14.0  122.5
14.5  122.3
15.0  122.2
15.5  120.6
16.0  119.0
16.5  117.4
17.0  116.1
17.5  114.9
18.0  111.5
18.5  109.7
19.0  103.4
19.5  106.8
20.0  105.4
20.5  104.5
21.0  103.6
```

Fig. 4 Aircraft certification requires computation of effective perceived noise level (ENPL). Computation of tone-corrected noise levels (PNLT) every 0.5 second is part of this procedure. A Hewlett Packard audio data processor computes PNLT and stores the latest 120 values until the maximum PNLT occurs as the aircraft flies over the test point. The system then computes the EPNL using the PLNT values inside the white area.

After computing the EPNL is printed out and also PNLT values or a PNLT histogram like the one shown here.

STATISTICAL ANALYSIS SYSTEM FOR MEASUREMENT OF AIRCRAFT PERCEIVED NOISE LEVEL



new aircraft was noisier than the last and that each new aircraft introduced resulted in the replacement of an aircraft which was generally smaller, and invariably much quieter. The Boeing 747 B was the first aircraft to reverse the trend and, although its noise level is far from satisfactory it does represent a turning point in the technological quest for quieter aircraft.

THE MEASUREMENT OF NOISE

Because the human ear responds to noise in a non-linear manner, the units used for measuring noise are also non-linear. Thus, the unit of the decibel is used for sound measurement and it is defined as —

Sound Pressure Level in decibels = 20 $\log_{10} \beta_o)$

where P is the root-mean-squared pressure, and Po is the reference pressure of 0.0002 microbars (or dynes) per square centimeter.

This is a physical measure of sound intensity. It follows the ear response (roughly) in being logarithmic, but fails to allow for variation in response with pitch.

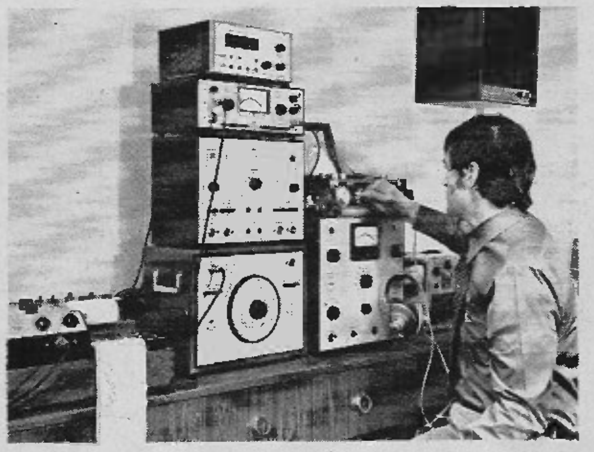
There have been many systems proposed for the measurement of noise, including the simple A, B, and C Scale weightings, and the more complex Phons and Sones. Most of these systems are intended to correct for the subjective human response to pitch. But, because of the unusual characteristics of aircraft noise, only one has gained a reasonable degree of acceptance for the measurement of aircraft noise, and that is the "Perceived Noise Level".

Within the last decade the perceived noise level abbreviated to NBdB has largely replaced the physical decibel as a measure of the subjective "noisiness" of aircraft and certain other noises. It has arisen as the outgrowth of a large number of listening tests, especially fly-over tests, conducted in the United States of America.

The research which led to the development of the Perceived Noise Level scale was initated by the Port of New York Authority. The Authority concluded that jet aircraft could operate at Kennedy Airport and they set a limit of 112 PNdB for take-off noise at communities under the take-off path. (Heathrow Airport has set a limit of 110 PNdB).

Stevens and Rosenplinth, the two acousticians primarily involved in this work, developed a set of curves called "NOY Curves" *(Fig.1) which presented intensity against frequency used to determine the *annoyance* of the noise rather than its loudness. This

HOW NOISY IS THE CONCORDE?



is particularly important as annoyance and loudness are not synonomous.

The specification has been defined and redefined as more data has accumulated. The result is a weighted average over a spectrum such that the PNdB rating of a complex sound should approximate the decibel rating of a 1000Hz (1000 cycles/second) octave band of noise that sounds equally noisy.

The simplest method available for the measurement of Perceived Noise decibels is to use a sound level meter fitted with a "D" weighting network. (See Fig. 2). This "D" network has been specifically designated as the curve to be used for the measurement of aircraft noise and is the inverse of the "40 – Noy contour". To obtain the approximate noise level in Perceived Noise Decibels the D scale reading is increased by 7 decibels, i.e.

$$L_{PN} \simeq L_{D\ max} + 7$$

The advantage of this form of measurement is that a rapid determination of the *approximate* Perceived Noise Level can be made with relatively simple instrumentation without recourse to the complex calculations which have been a feature of such measurements in the past.

More important, the approximately perceived noise level can be continually monitored and recorded by existing equipment for more detailed analysis.

Whilst this form of measurement is not as accurate nor as desirable as the more complex automatic perceived noise analysers which have recently been developed in Germany, this approach provides a practical method of evaluating the long term statistical perceived noise level.

EFFECTIVE PERCEIVED NOISE LEVEL

The first problem with a measurement of the type performed by the above technique – or any other which only takes into account the peak level of noise – is that it ignores the vital factor of the *time duration* of the noise exposure. (More specifically, the instantaneous sound pressure level in each of 24 one-third octave bands of the noise is required for each one half second increment of time during the aircraft fly over). Hence the Effective Perceived Noise Level scale which takes noise duration into account.

The calculation procedure which utilizes physical measurements of noise to derive the EPNL evaluation measure of subjective response consists of the following five steps:

a. The 24 one-third octave bands of sound pressure level are converted to perceived noisiness by means of a noy table. The noy values are combined and then converted to instantaneous perceived noise levels, PNL(k).

b. A tone correction factor, C(k), is calculated for each spectrum to account for the subjective response to the presence of spectral irregularities.

c. The Tone correction factor is added to the perceived noise level to obtain tone corrected perceived noise levels, PNLT(k), at each one-half second increment of time,

$$PNLT(k) = PNL(k) + C(k)$$

The instantaneous values of tone corrected perceived noise level are derived and the maximum value, PNLTM, is determined.

d. A duration correction factor, D, is computed by integration under the curve of tone corrected perceived noise level versus time.

e. Effective perceived noise level, EPNL, is determined by the algebraic sum of the maximum tone corrected perceived noise level and the duration correction factor,

$$EPNL = PNLTM + D$$

The subsequent data required for this is even more complex than indicated here and even the NOY curves are relatively complex. Whilst some excellent work has been carried out all over the world using equipment systems similar to that shown in Fig. 3 and derivations based on the same approach, it has been clear that systems of the type installed originally in Stuttgardt by Hewlett Packard GMBH (and recently in Sydney), offer much more flexibility and instantaneous processing directly into Effective Perceived Noise Decibels.

The Hewlett Packard System uses a series of terminals at remote locations which are connected back to a central computer controlled processing unit by means of data lines or, alternatively, from mobile units using tape recorders. (Each land line is frequency equalized over the range 50 Hz to 12 kHz)

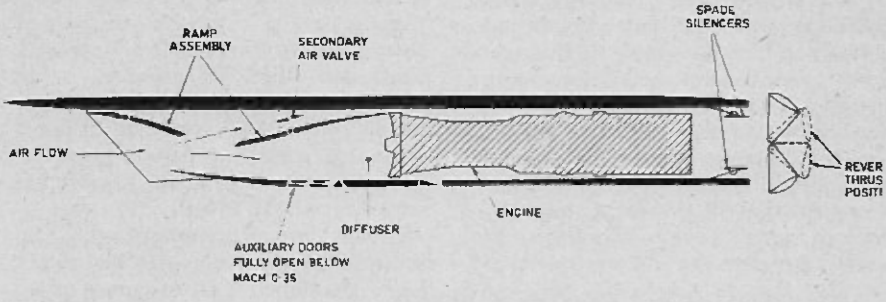
The heart of the system is the Hewlett Packard Model 2114A digital computer together with the Model 8054A Real Time spectrum analyser, which provides the 24 one-third octave band filters between 50 Hz and 10 kHz.

The computer is capable of being programmed to provide a read out (Fig. 4), or of converting the data into other internationally accepted Aircraft Noise Rating systems.

ASSESSMENT OF AIRCRAFT NOISE DISTURBANCE

In order to give a numerical value to the degree of annoyance caused to the community by aircraft, many researchers have put forward equations for determining the degree of annoyance. An equation which gives an annoyance index for aircraft noise will include terms involving some or all of the following quantities:-

a. The relative effect of a loud noise occasionally compared with a quieter noise over a long period.



A cross section of engine nacelle of Concorde.

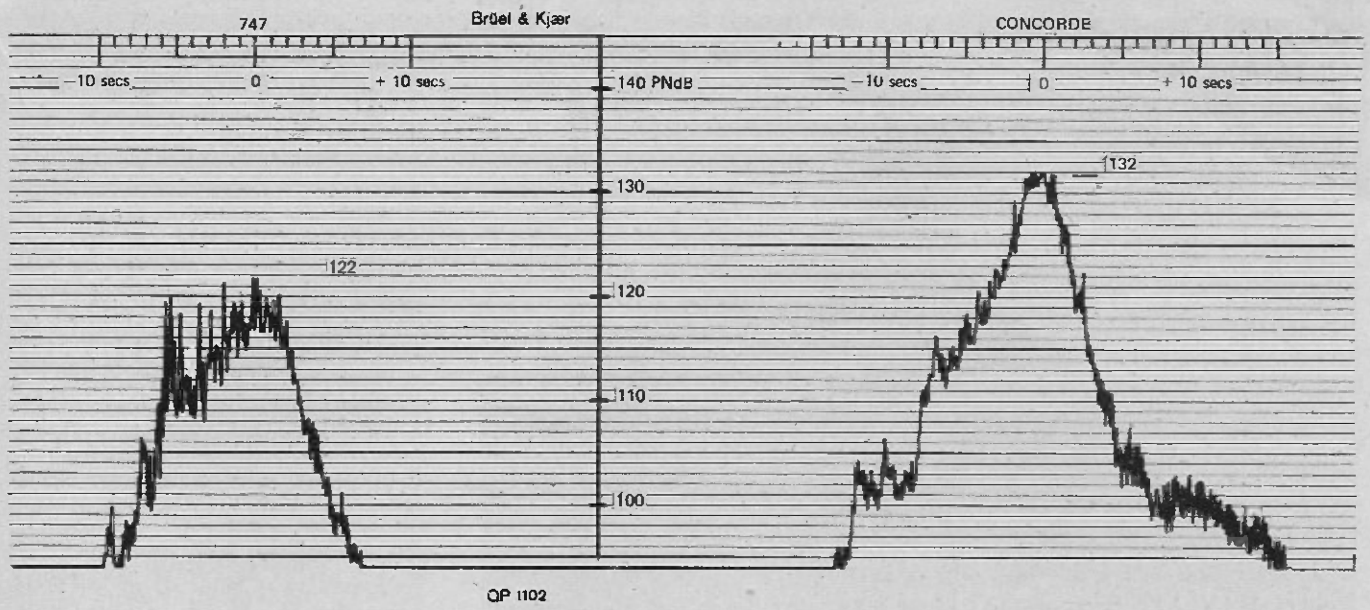


Fig. 6. PNdB curves for 747 and Concorde fly-overs. Chart speed 3mm/sec. Maximum levels 747 122PNdB Concorde 132 PNdB.

b. The number of aircraft movements in a given period.

c. A lower tolerance to noise occuring during the night, compared with during the day.

NOISE AND NUMBER INDEX

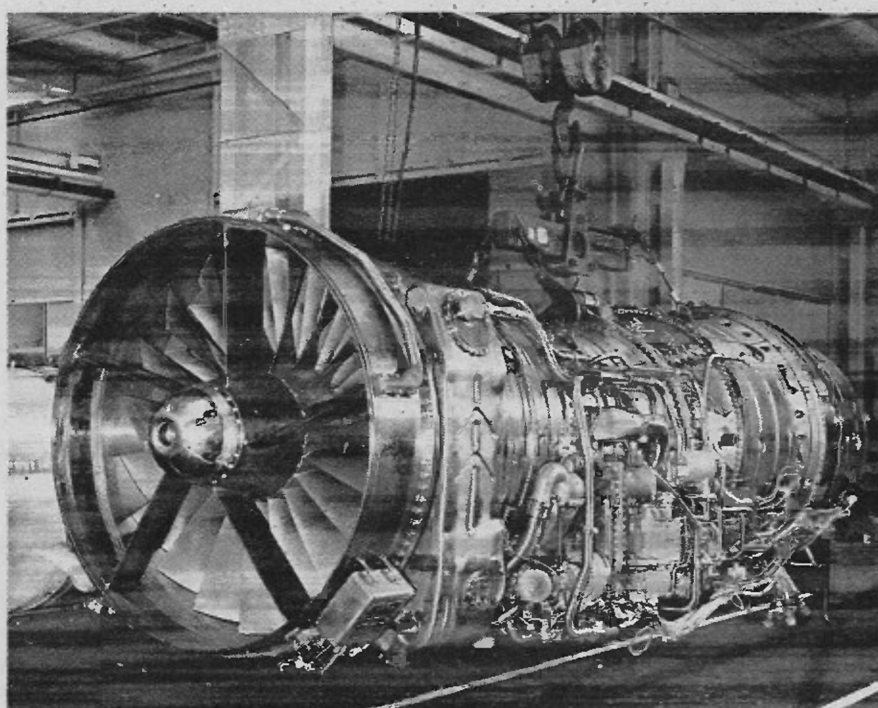
This index is historically important since it is one of the earliest attempts to derive an annoyance index for aircraft noise and has subsequently gained wide acceptance. The concept of a Noise and Number Index, N.N.I., resulted from the work carried out by the famous Wilson Committee in England which correlated measurements at Heathrow Airport with a social survey on the reactions of the population to noise. Two of the several conclusions that were drawn are as follows:-

Firstly, the survey gave a scale by which the degree of annoyance caused by aircraft noise could be assessed. This was of fundamental importance because it meant that numerical investigations could be made of the relationships between annoyance and other measurable factors, notably the physical characteristics of the noise. Second, the survey provided a tentative basis for establishing a combined "noise and number index" defining the total noise exposure which caused annoyance. The Wilson Committee concluded from the data that, in causing annoyance, a four fold increase in the number of aircraft heard was very approximately equivalent to a rise in average peak noise level of 9 PNdB.

The resulting equation is:-

$$N.N.I = L_e + 1.5 \log_{10} N - 80$$

where L_e is obtained from equation 3 with q equal to 6, L equal to the peak noise level in PNdB, and N, the total number of aircraft movements in the given period.



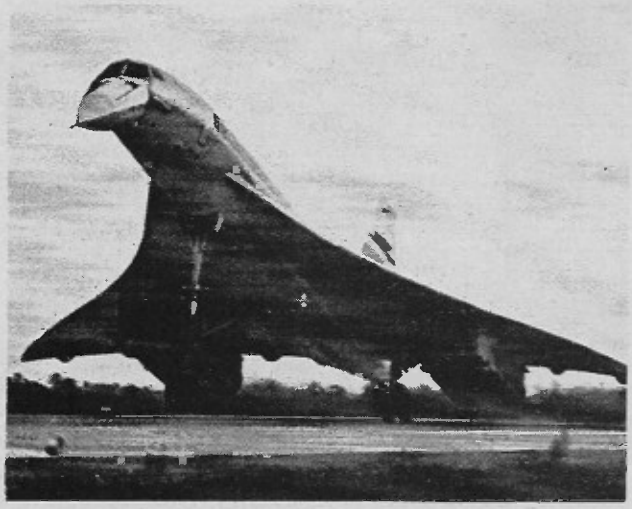
The Concorde engine.

NOISE EXPOSURE FORECAST

The U.S. Federal Aviation Administration recently proposed the use of Noise exposure Forecasts (N.E.F.) as a method of rating aircraft annoyance. This system is similar in many ways to the Noise and Number Index. The major difference is that the N.E.F. is based upon the use of Effective Perceived Noise Level rather Perceived Noise Level. The Effective Perceived Noise Level takes into account the duration of the noise and represents the most accurate method of determining the subjective effect of aircraft noise currently available, and the Noise Exposure Forecast appears to give the most accurate assessment of the annoyance caused to individuals by aircraft fly-overs. Whilst such assessments are of untold value for planning of new airports, the primary problems facing the airlines and civil aviation authorities of the world are those at existing airports, and this is where the Concorde's problem arises; for here is the first large aircraft which may change the current trend to bigger and *quieter* aircraft.

You might well ask at this juncture why should some aircraft by very much noisier or quieter than other aircraft. The reasons are associated with the main noise sources of an aircraft. See summary next page.

HOW NOISY IS THE CONCORDE?



	Source of Noise
1. Jet Noise	The turbulence aft of the jet nozzle Interaction of turbulence and shocks in jet.
2. Axial-flow compressor	Turbulence or unsteady flow passing over blades Boundary-layer pressure Fluctuations on blades. Wake of compressor blades.
3. Turbine Noise	Turbulence and fluctuating flow over turbine blades. Turbulence separated flows, and unsteady flow over vanes.
4. Propellers	Rotation effect of blades (thickness of blades). Rotation effect of blades passing with lift and torque forces.

The initial problem is associated with the velocity of the jet exhaust for, as has been shown by Lighthill in 1952, the acoustic power P varies as

$$p^2 D^2 V^n$$

where p is the jet density
D is the exhaust diameter
V is the exhaust velocity
n is a factor varying between 5 and 9

Whilst the noise increases by a power of velocity raised to the 5th power or greater, thrust is directly proportional to the velocity raised to the 2nd power.

The earliest jet engines also produced very high levels of inlet compressor noise, particularly during landing, but this could be adequately controlled by simple redesign of the compressor stages.

Now the jet engines proposed for the seventies produce larger jet exhaust areas, together with lower exhaust velocities and very high levels of by-pass flow which effectively shield the high velocity mixing region around the jet exhaust. As will be readily realised, techniques such as these are not technically capable of being utilized in an aircraft which is intended to travel at Mach 2.2. The manufacturers have, therefore, developed a whole new range of engine silencing techniques that are intended to reduce the noise level of supersonic aircraft to that produced by normal aircraft.

THE CONCORDE

Visually the Concorde is a beautiful combination of grace and symmetry. However this does not impress conservationists, who dislike it because it brings problems of sonic boom and higher noise levels into the residential domain. When the Concorde prototype 002 came to Sydney in mid-June we took the opportunity, which was relatively unique and unlikely to be repeated for some years, of measuring its noise.

These measurements, unlike the previous surveys which we have conducted, were aimed at determining the Effective Perceived Noise level, rather than PNdB alone. Our original surveys used the system shown in Fig. 3, whilst this survey used a large number of precision sound level meters, Kudelski Nagra tape recorders and acoustical calibrators for accurately recording the calibration level on the tape.

The technique utilized was, firstly to record the calibration level from a 'pistonphone' which produces a precise acoustical level corresponding to 124 decibels on the tape recorder, with the sound level meter set to 124 decibels and the level control of the tape recorder locked, so as to produce a modulation level corresponding to −10VU. Then, if the sound to be measured is substantially louder or quieter, the attenuation of the sound level meter can be adjusted up or down by the desired number of steps of 10 decibels and the equivalent level of the calibration signal is similarly (automatically) adjusted up or down with reference to the recorded noise signal.

The equipment that we used to analyse the noise of the Concorde is shown in Fig. 5. It consisted of a Measuring Amplifier, (Bruel and Kjaer type 2607) a one-third Octave Band Filter set (Bruel and Kjaer type 1614) and a High Speed Level Recorder (Bruel and Kjaer type 23058).

Each fly over was analysed into a series of sequential one-third octave band components on the level recorder, between 50 Hz and 12 kHz. These were then digitised and fed into a computer, which was pre-programmed to compute out the value of the EPNdB.

The measurements were taken at the internationally accepted positions — of 1 mile and 2 miles from the point of touch down under the glide path — at 0.35 nautical miles on both sides of the centre line of the runway for side line noise, and (in our case unsuccessfully) 3½ miles from start of roll on the extended centre line of the runway.

Some of the results do not agree with the previously published data which has been disseminated in the press.

(Continued on page 85)

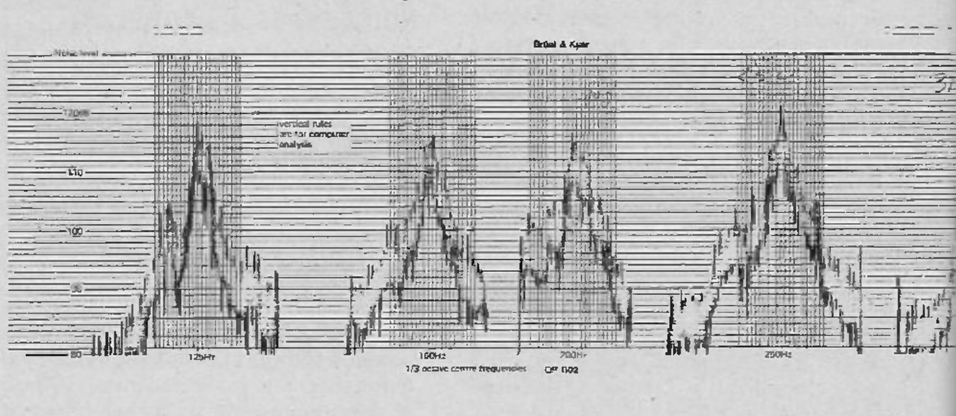


Fig. 7. Concorde 002: Approach Noise at 2 miles.

AUDIO NEWS

FOUR-CHANNEL SOUND

One fact emerged from our four-channel survey (July issue) and the ensuing mail – hardware to play the four-channel discs is still sparse in UK. Matsushita Electric's National and Panasonic brands have four-channel tape cartridge players, and the Onkyo Corporation's disc systems, Model X-1 and Model Y-2, are handled in Great Britain by J. Parkar & Co. (London) Ltd. If you already own a good stereo system, Sansui's QSP 10 package has compact decoding matrix, plus two speakers, for around £80, to provide a four-channel format. Pioneer's Quadralizer is another means of getting four channels from conventional two-channel stereo. JVC/Nivico, through Denham & Morley in the UK, have a package deal for an add-on system, to play their discrete discs, for just under £100. **(46)**

NEW PARTNERSHIP

E. J. Wilkinson, E. W. Form and J. Halliday have launched Wilkinson/Form Electronics whose Quartet 20 Amplifier/Decoder has switching for three modes: (1) matrix, using stereo input material and designed to replay coded discs of all types; (2) concert hall (using a derived differential channel and special phase networks) aimed at recreating the acoustic or ambience of the original auditorium, in the listening room, from stereo inputs; (3) spatial stereo (for mono records) in which front and back speakers act as identical pairs.

The record player is fitted with Goldring G 101 transcription turntable and Acos PZT 104 ceramic cartridge. The loudspeakers are four Wilkinson/Form Bookshelf models LS 25, 17" × 10" × 9" with 25 watts rating per speaker.

These systems will first be heard at the Northern International Hi-Fidelity Festival, Harrogate, Yorkshire (September 1 to 3). (47)

Quartet 20

QUAD-WRANGLE AGAIN!

At this year's (Los Angeles) West Coast Convention of the Audio Engineering Society, quadraphonic systems were discussed and criticized by Louis Dorren (of the Dorren Quadraphonic Broadcast System, allowing four discrete signals to be transmitted) and B. B. Bauer (whose critics say that the back out-of-phase signals produce confused localizations of sound sources and unpleasant pressures of the ears). British audio engineer John Mosely (consultant for the Sansui QS system) then questioned Mr. Bauer about the rear-channel phase shift and its significance; his paper on "A Scientific Comparative Study of Different Quadraphonic Matrices" was (no one knows why) withdrawn and pre-print papers destroyed.

A controversial paper, "Is Four Channel A Fraud?", by J. Robert Ashley of the University of Colorado, argued that, from subjective analysis, many concert halls and auditoria could be approximated sonically by simply delaying the sound to the two rear channels. He even argued that, if one liked a back seat in a hall for example, the rear channels could be dispensed with altogether! **(48)**

UNIVERSAL CHIP

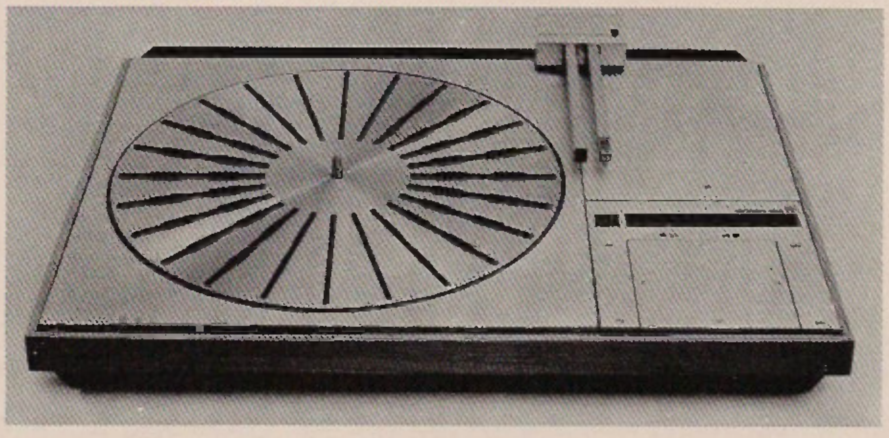
Electro-Voice Inc., Gulton's electro-acoustics group, has produced, for original equipment manufacturers, the E-V Universal Chip, an integrated circuit chip that contains the decoding elements to process all the current matrix encodings. Could be a step to the standardization of four-channel techniques.

RADIAL TRACKING

Due for formal launching at the International Audio Festival and Fair (Olympia, October 23 to 28) is an ingenious turntable unit with radial tracking arm, known as the Beogram 4000. Enthusiasts will be able to handle it for the first time at the Northern Audio show in Harrogate this month, on the Bang & Olufsen exhibit.

Another innovation is a pair of high quality stereo headphones, operating on an electromagnetic system that distributes the drive over the diaphragm and so minimizes the break-up occurring in conventional designs. The transducer capsule employs a lightweight high-temperature plastic film diaphragm to which an etched 4-micron thick copper conductor is bonded. The total dynamic mass of the diaphragm is around 100 milligrams and the upper frequency response is said to extend to 20 kHz. The actual magnetic system uses a newly-developed anistropic cermaic-synthetic rubber material offering good flux density with low weight. The design is rugged and the 40 ohms capsules can be connected directly to the loudspeaker terminals of an amplifier rated at 35W into 8 ohms. Price, we understand, will be about £20, and this all-British design will come out at Audio Fair time. **(49)**

Beogram 4000 Type 5215



OF UTMOST

By Mort La Brecque, New York Academy of Sciences

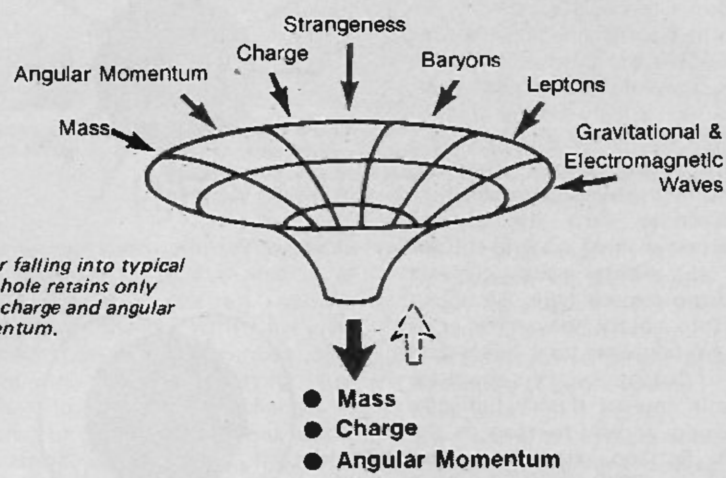
DESPITE its complexities, the *General Theory of Relativity* is as simple in essence as all great creations of mankind: a mathematical poem about the nature of gravity and its profound influence upon the universe. Rather than the Newtonian force that attracts small objects to larger ones, Einstein said, gravity is a curvature in the space around objects similar to an indentation in flexible material; without their angular momentum, for example, the planets would literally roll into the Sun's deep gravitational pit.

All forms of mass and energy are subjects of their own gravitational majesty. Four elementary forces account for known physical phenomena: the strong force and the weak force, both limited to atomic nuclei; electromagnetism and gravity, both of infinite range. In elementary particle interactions, electromagnetism is 10^{40} times more powerful than gravity. Because there are an equal number of positive and negative electric charges in nature, electromagnetism is largely neutralized beyond atomic dimensions; possessing a single charge, gravity's effects increase with mass. Its domain cosmological, gravity is the master field of existence.

GRAVITY

Black holes are stars, so dense that even light cannot escape the gravitational pull. A single cubic inch may weigh several billion tons. Here are the latest theories.

The most dramatic display of gravitional force in the universe is the death of stars twice as massive as the Sun which have become at least a million times more dense. Stars, extraordinarily hot hydrogen vapours held together by their own gravity, are self-sustaining fusion reactors that convert mass-hydrogen atoms — into energy: heat and gravitational pressure produce fusion, which produces heat and gravitational pressure. After billions of years, the hydrogen fuel is consumed and stars begin to cool and contract. According to Newton's inverse square law of gravitation, a one per cent decrease in all dimensions increases all gravitational forces by two per cent; ultimately, gravity overwhelms the stars.



Matter falling into typical black hole retains only mass, charge and angular momentum.

The resulting convulsions in stellar interiors, inaccessible to telescopic observation, have been computer-simulated at Lawrence Radiation Laborator by J. M. Leblanc and J. R. Wilson. If stars have twice the Sun's mass, their cores become denser than their outer portions, until they collapse, squeezed, in less than a tenth of a second, to a density comparable to that of an atomic nucleus. Simultaneously heated by the intense pressure to even higher temperatures — 10^{12}°K —collapsed cores then reverse implosion, acting as charges to set off supernova explosions in the stars' outer portions.

Such celestial fireworks, observed by Chinese astronomers in July, 1054, produced the Crab Nebula, a cloud of gas that still writhes and glows 6,000 light years from Earth and that may be a source of galactic cosmic rays. Quasars, quasi-stellar bodies that lie at enormous distances from the Earth, may be many supernovae exploding one after another to produce fairly regular light and radio waves, says Sterling Colgate, Socorro Institute of Mining and Technology, New Mexico.

The strong force, which binds the particles of atomic nuclei, halts gravitational collapse in supernovae stars, leaving objects that are several miles in diameter, weighing billions of tons per cubic inch and composed entirely of neutrons. Such properties as regular crystal lattices, superfluidity and superconductivity, ordinarily found only at very low temperatures, may characterize this superdense material, and normallv short-lived particles may be stable in their cores. Spinning very rapidly at first, neutron stars emit energy, probably from their magnetic poles, and slow down; theoreticians have proposed such energy emissions as the source of the pulsar radio waves first discovered in 1967. Of the more than 60 known pulsars, NP-0532 in the Crab Nebula produces the most frequent signals — thirty per second — indicating that it is of comparatively recent origin and that it may be the remnant of gravitational collapse.

Small dying stars — less than 1.4 times as massive as the Sun — meet a different fate. Collapsing with neither a bang nor a whimper, they become white dwarfs, dense cold bodies whose mass is similar to Earth's. Pressure caused by electrons, spinning very near light's speed, successfully opposes gravity for small collapsing stars as the strong force does for medium-sized stars. Even in combination, however, these two most powerful physical forces cannot prevent the collapse of stars with more than double the Sun's mass. Because energy is equivalent to mass, dying stars that produce internal pressures to fight gravity increase their mass and gravitational attraction; the more massive the star, the greater its collapse. According to a prediction by J. Robert Oppenheimer and H. Snyder, made in 1939 and based on the principles of general relativity, very large cold stars collapse completely — beyond the neutron star stage to smaller and denser objects, whose stupendous gravitational curvatures are deathmasks that stretch deep in the structure of space.

Black holes, the systems produced by complete collapse of large stars and, perhaps, by matter accreting to white dwarf and neutron stars, have neither size nor shape in the conventional sense. Some are characterized only by mass, others by mass and charge or mass and angular momentum, and most by mass, charge and angular momentum — the basic constitutents of matter. According to theory, charged and uncharged objects revolving about completely collapsed stars reveal these three parameters, allowing one black hole to be distinguished from another. Although the diameters of all such systems are about 15 kilometers, the precise value depends upon mass, which may range from that of the Sun up to 10^{10} solar masses or more. However, no way is known to determine the original forms of matter and energy from which black holes are constructed. Irresistable whirlpools, they draw in additional particles passing their horizons. Matter, antimatter, neutrinos or gravitons, all are squashed in one direction and stretched in another by violent tidal forces until they fall apart, losing their identities forever as curvature of space.

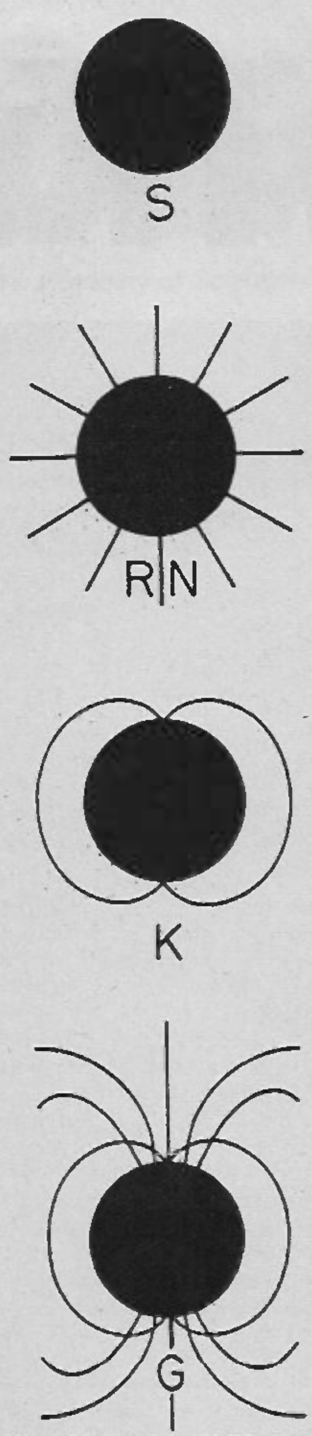
Complete collapse is the source of bizarre relativistic phenomena that do not disobey but transcend familiar physical laws. Relativity defines time as an extension by three-dimensional space created by the active presence of matter in the universe; matter's gravitational curvature warps space into spacetime, a geometrical manifold representing the history of physical events. Four-dimensional spacetime is so strongly distorted by a black hole's gravity that space and time exchange their characteristic properties; because the radius of their curvature is infinite, they become spacetime singularities. Under normal physical conditions, an object can remain in one place as time advances, but it must move forward in one direction in a black hole, occupying increasingly smaller areas of space. It can neither reverse its course nor regain its size, because space has unsurped time's progressive motion.

The spacetime warp also distorts time, in effect making it stand still for observers who witness events at a safe distance from a black hole. An object that falls into a black hole arrives at its centre in finite proper time — less than a second; if distant observers could see the object's travels, theory indicates that it would appear to stop at the black hole horizon, remaining poised there forever. "All signals and all information from the later phases of collapse never escape; they are caught up in the collapse of the geometry itself," write Drs. John Wheeler and Remo Ruffini of Princeton. *Physics Today*, Jan., 1971) Even with the most powerful telescope, observers could not actually see the object because light photons are also vulnerable to a black hole's suction; shifting infinitely to the red end of the spectrum as they fall in, they render the black hole black.

RELATIVISTIC THEORIES

Theoretical studies of gravitational collapse began soon after Einstein published his *General Theory of Relativity*. In 1916, Karl Schwarzschild developed the geometry of certain collapsed objects, a pioneer and classic work. According to the Schwarzschild radius equation, which relates mass to density, any gravitating mass compressed inside its Schwarzschild radius will curve space so much that light cannot escape: the universe fits this definition of a black hole, Dr. Ruffini told the writer.

However, Schwarzschild's geometrical formulations were much more restricted, limited to objects that are both spherically symmetric and non-rotating. Many stars show minor departures from symmetry and some are highly asymmetric. The question of whether such large departures might save a star from complete collapse has not yet been answered; however, using different methods, the Russian physicist Ya. B. Zel'dovich, and the



FAMILY OF BLACK HOLES: four states of completely collapsed stars, characterized by mass (Schwarzschild), mass and charge (Reisner/Nordstrom), mass and angular momentum (Kerr), mass, charge and momentum (Generalized). Black holes may alter from one state to another.

team of Steven Hawking, Roger Penrose and Robert Geroch have proved that black holes inevitably develop despite minor stellar asymmetries. Schwarzschild's geometry, also incomplete regarding the non-rotation of collapsed stars, was supplemented in 1963 by the rotational geometry of Roy Kerr, University of Texas. All stars have angular momentum; recently, James Bardeen, University of Seattle, proved that most have sufficient momentum to evolve into "living" black holes rotating at surface velocities equal to or near the speed of light.

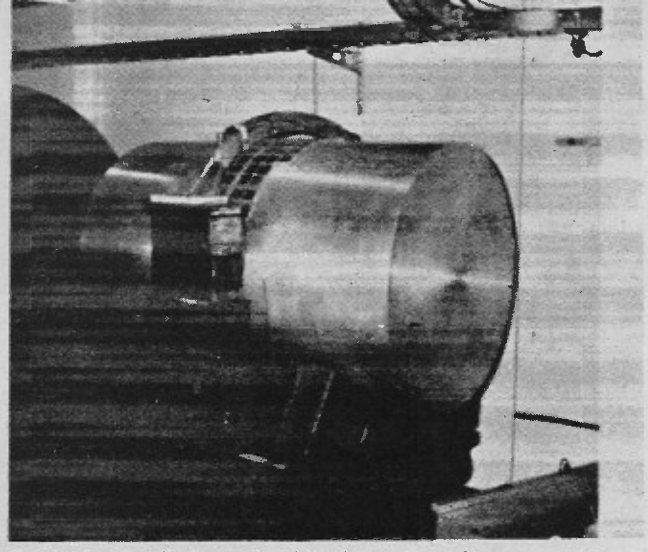
THE LARGEST POWER PLANTS

Rotating black holes are alive in that they can emit energy as well as absorb it and may provide mechanisms superior to fission and fusion for converting mass into energy. Dr. Bardeen has recently shown that, before they fall in, particles co-rotating with black holes will emit 42.3 per cent of their mass as gravitational energy.

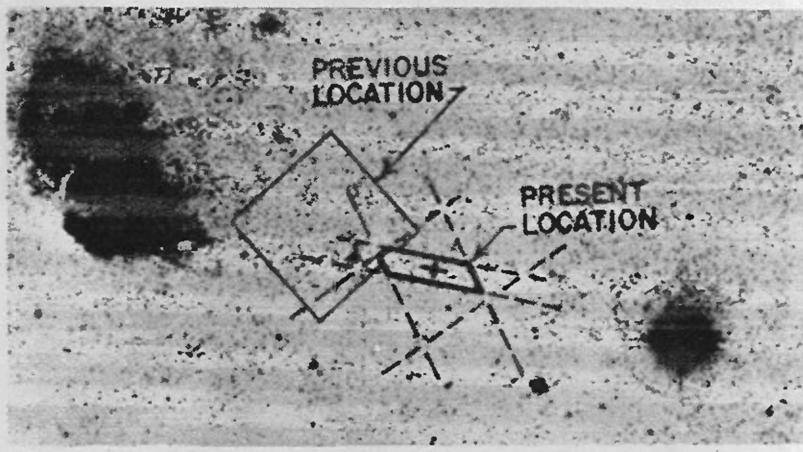
Drs. Ruffini and Demetrios Christodoulou, a 19-year-old theoretician who was recently awarded his Ph.D, propose in a paper submitted to *Physical Review Letters* that if rotating black holes are also charged, captured particles will emit all their energy, in a manner analogous to matter-antimatter annihilation. Charged rotating black holes are the largest storehouses of energy in the universe, they say, and up to 50 per cent of the rest-masses of these systems can be extracted.

An inventive proposal for easing hypothetical extraterrestrial power crises is proposed by Roger Penrose, mathematician at London's Birkbeck College, who says that black holes' phenomenal rotational energy could be used as a power source. Object masses could be totally converted to highest-grade energy in black hole ergospheres — regions between the surface of infinite red shift and the horizon, where particles can still escape black hole suction. Energy produced in ergospheres could then be retrieved. A more elaborate system of two stabilized structures, one rotating slightly with the black hole, would permit extraction of black hole rotational energy as well as energy contained in object masses: particles lowered into ergospheres would be split in half, one half escaping with more energy than the original particle.

Black holes are copious energy sources because they may contain most of the mass in the universe. According to general relativity, the closed and spherical universe will reach a maximum dimension and re-contract; sufficient matter must now exist to slow down and stop the present expansion by gravitational attraction. The density of matter predicted by theory is greater than the observed density in the dust and stars of galaxies by a factor of from 10 to 100. The missing matter may have been swallowed up by large numbers of black holes scattered throughout the universe, suggest Zel'dovich and I. D. Novikov and, more recently, A. G. W. Cameron of Yeshiva University's Belfer Graduate School of Science, New York. The high mass-to-light ratio of galactic clusters, deduced from their



Gravitational radiation emitted by destruction of enormous quantities of matter in the universe is detected by Joseph Weber's aluminium cylinder.



Is Cygnus X-1 a black hole? Negative astronomical map shows its 1967 location (square), and its present location (heavily outlined figure) inside area from which unusual X-ray emissions were detected by Uhuru satellite (four dashed intersecting lines).

motions and luminosities, has been attributed to the presence of unseen gas: such gas must be close to 10^6°K because it would emit radio waves at lower temperatures and X-rays at higher temperatures. And clusters of different sizes are unlikely to have gas at similar temperatures, Dr. Cameron told a recent meeting of the American Physical Society. The chemical history of the universe indicates that the earliest stars were very massive and would be expected to evolve into black holes, accounting for the observed mass-to-light ratio.

Because Einstein's ten non-linear partial differential equations for general relativity are time-symmetric, complete gravitational collapse demands a time-reversing, complementary event. Theoreticians are now trying to conceptualize white holes, stars that explode and emit matter and energy while black holes implode and absorb matter and energy. White holes are mandatory, according to the Einstein equations, but how they express themselves in the real physical world and what role they play in stellar energy phenomena is unknown. Determination of their boundary conditions – those physical conditions that they must fulfill at every point on their boundaries in space – may resolve these questions, says Dr. Raffini.

Although black hole theory is much more advanced than white hole theory, astronomical detection of black holes has proven extremely difficult. Since 1966, Joseph Weber of the University of Maryland, has experimented with antennas – instrumented bars of solid aluminium suspended by wires inside shielded chambers – to detect waves of gravitational radiation reaching the earth from events in space. ("Gravity Waves," *The Sciences*, Sept., 1968). His detection of many events indicates the large-scale destruction of matter in the universe. Any mass of asymmetrical shape whose configuration changes with time gives off gravitational radiation, but only gravitational collapse, involving large masses and very rapid change, is expected to provide an obvious source of radiation. Unfortunately, the newly developed gravitational radiation measurements are too crude for precision, but other techniques for discovering black holes have been put forward recently, leading to proposals of specific black hole sites.

The difficulties of finding black holes alone in space can be circumvented when matter falls into them, according to Professors Zel'dovich and Novikov; gas funnelled into the black hole heats by compression and radiates either in the visible part of the spectrum or in the X-ray and gamma-ray region, depending on the black hole's mass.

DIAGNOSING DISTANT X-RAYS

Uhuru, a NASA Small Astronomy satellite designed to detect stellar X-radiation, recently discovered three X-ray sources generating regular X-ray pulses of variable intensity: Cygnus X-1 in the Constellation Cygnus, Centaurus X-3 in the Constellation Centaurus and Lupus X-1 in the Constellation Lupus. Data for Lupus X-1 have not yet been analyzed, but Cygnus Z-1 pulses very rapidly – second in rate only to NP-0532 in the Crab Nebula, an X-ray and radio pulsar; Centaurus X-3 pulses slower than any known pulsar by a factor of two, but unexpectedly discharges as much energy as the Crab pulsar. Unlike conventional pulsars, Cygnus X-1 and Centaurus X-3 emit no radio waves and have no detectable gas clouds, properties presumed inherent in neutron star remnants of supernovae. These X-ray sources are rotating collapsed objects which may be peculiar neutron stars, a new class of objects, or black holes producing great quantities of radiation when matter funnels into them.

An alternative means of black hole detection arises when they are members of binary systems of co-rotating stars, close enough to their normal companions to draw in matter. Epsilon Aurigae, an eclipsing binary system, has a super-giant primary star 35 times as massive as the Sun, and a very mysterious secondary component nearby. Only the primary's light is ordinarily visible; the secondary's mass of 23 Suns should be 40 per cent as luminous as the primary. During eclipses lasting 700 days, "additional absorption lines associated with the secondary appear in the spectrum, indicating the presence of small amounts of dilute gas along the line of sight with an excitation temperature similar to that of the primary star," says Professor Cameron. (*Nature*, Jan. 15, 1971) He suggests that gas particles emitted from the primary are pulled into orbit around the secondary in the form of a large disc and then spiral downwards; because the secondary's present mass is too large for a white dwarf or a neutron star, it may originally have been more massive than the primary and collapsed into a black hole. Dr. Cameron recommends increased infrared observation of Epsilon Aurigae, improved orbit determinations and continued photometric coverage during eclipses to confirm his proposal.

Discovery and study of black holes has the greatest cosmological significance: complete gravitational collapse of stars may offer small scale models of complete collapse of the universe, according to relativistic theoreticians. Einstein published general relativity believing, as did most of his colleagues, in a closed universe of constant size. In 1922, however,

Continued on page 84

THE DIGITAL

Voltmeters were once simple things. They worked well enough providing they were used to measure equally simple voltages — like the anode potential of an 807.
And it probably didn't matter if the meter was 5% out and drew a few milliamps from the source it was measuring.
But in most branches of electronics these days have long since gone, and it is becoming increasingly necessary to measure low voltages, often across high impedances, and to greater accuracies than ever before.
Hence the digital voltmeter — a product of the technology it is used to assist.
In this article, Brian Chapman describes the various types of digital voltmeters and their uses and limitations.

Fluke digital multimeter is guaranteed to maintain 0.01% accuracy (on dc ranges) for at least six months.

An analogue measurement is essentially one that is made continuously. A digital measurement on the other hand is made as a series of discrete steps.

In many instances the same basic quantity can be measured by both digital and analogue methods. A conventional clock has a pair of hands traversing a calibrated dial in a continuous sweep, and there is theoretically an infinite number of intermediate steps between any two points on the clock face. Measurement is continuous and it is therefore an analogue process.

A desk calendar on the other hand is essentially digital. It indicates the date in discrete steps, each of 24 hours.

There is no ambiguity of reading. It either is the 3rd. of June or it isn't. One cannot misread it as June 2¾ or 4½.

This is one of the great advantages of digital readout. There are no reading errors due to parallax or scale resolution, and in the case of electronic digital instruments, no friction or hysterisis to cause mechanical errors.

Even the cheapest of digital voltmeters has better than 1% accuracy whereas an analogue meter with a mechanical movement of 1% accuracy is expensive and still subject to further reading errors caused by parallax and scale resolution.

SPECIFICATIONS

Specifications of digital voltmeters rarely quote accuracy just as such and such a percentage. For if they did it would in effect be a blanket statement implying that at no time due to any combination of factors such as drift, temperature, humidity, linearity, zeroing, etc would the error exceed 1% of the quoted figure.

As digital voltmeters are precision instruments capable of far higher accuracies and resolution than hitherto obtainable, the specifications must include factors which now become of much greater importance.

It is also essential to appreciate that the various types of digital voltmeters have quite individual characteristics and that a meter suitable for one application might be totally useless in another. These different types and characteristics will be described later in this article.

ACCURACY

The figure normally quoted as an instrument's accuracy is really a statement of the percentage error — in fact a digital voltmeter that was 0.01% accurate would have value only as a random number generator. The accuracy should really be stated as 99.99% but as in the case of 'rms' watts, common usage has defeated correct terminology.

There are several different ways of expressing the accuracy of digital voltmeters, and because of this it is necessary to pay particular attention to each manufacturer's specifications and to determine the true implications — especially when comparing instruments that have accuracies specified by different methods.

The most common ways of expressing dvm accuracy are 'constant error', 'proportional error' and 'combinational error'. These are again subdivided as follows:-

VOLTMETER

Constant Error

(1) ± ------ % of full scale
(2) ± ------ digits
(3) ± ------ millivolts
(4) ± ------ % of full scale ± ···· digits

Proportional Error

(5) ± ------ % of reading

Combination Error

(6) ± ------ % of reading ± ···· digits
(7) ± ------ % of reading ± ---- digits (whichever is greater)
(8) ± ------ % of reading and/or digits
(9) ± ------ % of reading ± ---- % of full scale

Of these methods of expressing accuracy the ones in most common use are (4), (5) and (9).

But a constant error statement alone does not sufficiently define the performance of instruments in which the main error is proportional to input voltage.

five digits in the least significant decade. The total uncertainty of reading would therefore vary from five digits at zero voltage input to 10 digits for full scale reading.

Now consider the second accuracy statement; ± 0.01% of reading or ± 1 digit gives a one digit uncertainty in the least significant decade at readings from 0 to 10,000, the uncertainty then increases linearly until it is 10 digits at the full scale reading of 99,999.

Note that both statements indicate the same error at full scale reading, but *only* at full scale reading. They vary considerably at other points depending on range and reading.

The second statement looks better to the uninitiated purchaser — but implies a higher error on the lower readings. It is nevertheless the most realistic method.

Another very relevant factor is the drift of calibration due to humidity, temperature, and component aging. Top quality dvms usually have included in their specifications, figures for both short and long term accuracy — the latter is

Hewlett-Packard's 3462A digital voltmeter uses potentiometric-integrating principle.

Nor is the proportional error statement sufficient in itself as it does not allow for the constant error which is present in most digital voltmeters, especially when reading low input voltages.

Hence in 1963 the American Standards Association (in Standard C 39.6) proposed that accuracy should be stated as a percentage of full scale, plus percentage of reading. This method is now used by many manufacturers, but by no means all of them.

The following example illustrates the difference between two accuracy statements for a five digit voltmeter.

(1) ± 0.01% of reading .... or ± 1 digit
(2) or ± 0.005% of full scale ± 0.005% of reading

If full scale reading on this five digit meter was 99,999 then 0.005% of full scale would represent an uncertainty of

generally quoted for a 90 day period within specified temperature and relative humidity limits. In addition a coefficient is often quoted for wider temperature ranges.

SENSITIVITY and RESOLUTION

Sensitivity should not be confused with resolution.

Sensitivity is the value of the least possible change in signal input to which the meter can respond on the most sensitive range. This will generally be the value of the least significant digit on that range. Thus on the one volt range a five digit dvm would have a sensitivity of 10 microvolts.

Resolution, on the other hand, is the value of the smallest change that can be measured on any range and is normally quoted as a percentage of full scale reading. Thus if the full scale reading is 10,000, the resolution is a maximum of one part in 10,000, i.e. 0.01%.

THE DIGITAL VOLTMETER

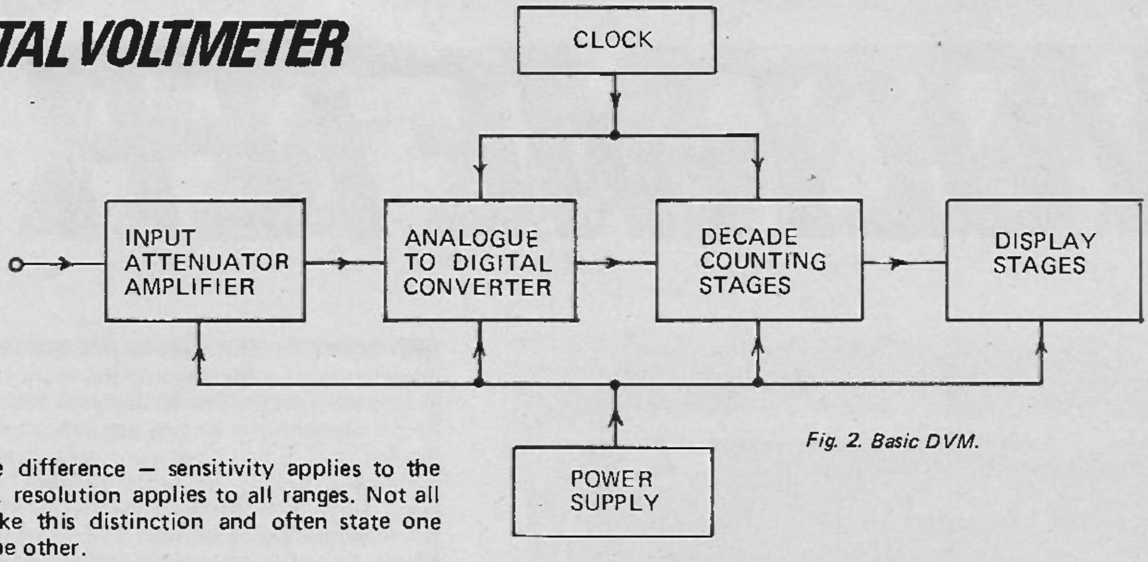


Fig. 2. Basic DVM.

Here then is the difference — sensitivity applies to the lowest range only, resolution applies to all ranges. Not all manufacturers make this distinction and often state one when they mean the other.

The resolution of any dvm must always be equal to or exceed its accuracy, for example an instrument with a conversion accuracy of 0.01% must have a readout of at least five digits, and preferably six, to make use of it.

REJECTION OF SUPERIMPOSED NOISE

The high accuracy and resolution of a dvm cannot necessarily be used unless it can also reject superimposed noise. In many applications this factor may determine the final choice of instrument, as with some types of circuitry the presence of electrical noise may make measurements impossible or inaccurate.

Superimposed noise may be considered to arise from two major sources. These are:-

(1) Common mode noise
(2) Normal mode noise

Common mode noise is only applicable to instruments which have a floating input, or in which the low side of the input terminals can be disconnected from ground.

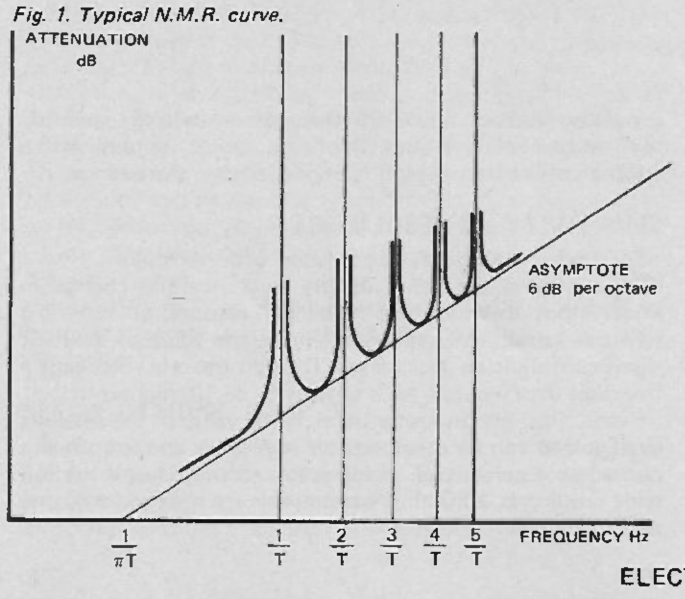
Common mode voltages can have dc as well as ac components and arise due to ground loop currents which produce potential gradients across earthing systems. These voltages can be quite high in the vicinity of heavy power equipment.

Digital voltmeter specifications quote the 'Common Mode Noise' in dB, as 20 log the ratio of the common mode voltage, to the instrument indication due to this voltage.

The ratio is usually measured with a one Kilohm unbalance in either lead.

As an example consider an instrument that when tested with a 100 volt common mode voltage gave a meter reading of 100 microvolts. This is a ratio of $10^6:1$ and the common mode rejection is therefore:- $20 \log 10^6 = 120$ dB. (this is a fairly typical figure for instruments that have floating inputs and use the guard technique).

Fig. 1. Typical N.M.R. curve.



NORMAL MODE REJECTION

Normal mode rejection is noise in series with the input signal. It is primarily due to induced pick-up and is therefore predominantly of mains frequency.

Normal mode noise rejection (NMR) is specified as 20 log the ratio of the normal mode noise voltage to the instrument indication due to this voltage, and it is expressed in dBs.

In digital voltmeters this figure is mainly determined by the type of analogue to digital conversion.

Instruments of the ramp or successive approximation type are particularly susceptible to noise and may have very low NMRs — typically — 30-60 dB.

Yet for reasons which are explained later in this article, instruments of the integrating type have almost infinite rejection of frequencies which are directly related to the sampling time of the meter.

Non-integrating instruments may be protected against normal mode noise by an input filter, but this lengthens the instrument's response time and hence reduces the conversion rate. For instance a successive approximation converter is theoretically capable of 40,000 readings per second, but when a filter is added the reading rate is reduced to approx. 100 per second.

A typical ramp type meter fitted with a filter would have a NMR of 30 dB at 50 Hz and would take 450 milliseconds to reach a reading of 99.95% of the applied voltage.

By contrast a good quality integrating type dvm could have a common mode rejection of 145 dB, and a theoretically infinite normal mode rejection at multiples of 50 Hz. Common mode rejection and normal mode rejection are often presented in graphical form (as shown in Fig. 1).

INPUT IMPEDANCE

All voltage sources have internal resistance. Any current drawn from the source will thus cause a voltage drop across the source resistance. Hence in any voltage measuring instrument the input impedance must be kept as high as possible to reduce loading on the source and error in the resulting readings.

In a typical (analogue type) voltmeter the input impedance may be 20,000 ohms per volt. Thus on the 100 volt range the input impedance is two megohms. If a voltage was being measured that had a source resistance of 20,000 ohms — the reading error due to loading would be:-

$\frac{100\ Rs}{Rs+Rin}$ per cent.

Thus when Rs = 20,000, Rin = 2M error = $\frac{100 \times 2 \times 10^4}{(2 \times 10^6)+(2 \times 10^4)}$

$= \frac{10^6}{10^6+10^4}$. = loading error approx. 1%

The situation is much worse on the lower ranges, e.g. the one volt range would have an input impedance of only 20,000 ohms and if a voltage measurement were to be taken across the 20,000 ohms source impedance quoted above there would be a loading error of 50%. (How many technicians take this into account?)

All digital voltmeters are superior to their analogue counterparts in this respect. Even moderately priced instruments may have input impedances of 100 Megohms on the lower voltage ranges, and 10 Megohms on the higher ranges. Other dvms have input impedances as high as 10^{10} ohms.

Nevertheless one should always bear in mind that even a 10 Megohm input impedance can cause loading errors which are far greater than the instrument error if the source resistance is high.

OVERRANGING

Overranging is a feature peculiar to digital instruments. The majority of digital instruments have a quoted full scale reading plus an overrange figure of perhaps 25%. The limit of the overrange capability is not always clearly defined and may vary from one range to another.

The manufacturer's overrange specification is merely the reading to which he claims that the percentage full scale accuracy will be maintained. In fact most instruments can be driven beyond this point, but accuracy falls off dramatically.

In many instruments an indicator lamp will show when the display is in the overrange region. However some digital meters are made on which the most significant digit is capable of displaying only a '1' or a '0'. (In other words the highest reading that can be obtained on a five digit instrument of this type is not 99999 but only 09999 plus whatever overrange the manufacturer will permit).

This type of instrument is often referred to as having 4½ or 5½ digits, but in reality it is only really 4 1/8 or so.

STABILITY

Short term stability refers to an instrument's variations over a short period of time (usually 24 hours). It is specified in the same way as accuracy.

Short term stability is mainly a function of random component variations.

Long term stability is quoted over periods of 30 to 180 days. It is primarily a function of aging of components such as oscillator crystals and precision resistors. It is enumerated in the same way as short term stability.

Sometimes a separate figure is quoted for oscillator crystal aging. This is usually specified as 'less than so many parts per million per month'. (A typical specification is <3 parts in 10^7/month.)

THE BASIC DVM

In basic form a dvm consists of an input amplifier/attenuator stage, an analogue to digital converter, a counting and display section, a clock pulse generator and a power supply. (Fig. 2).

The input amplifier/attenuator stage uses conventional electronic techniques, but as the input stage can be one of the main sources of error, the resistive dividers use components having tolerances from 0.01% down to 0.0015% and with temperature coefficients of a few parts per million per degree centigrade.

The input amplifiers (if used) must also be extremely stable, they are usually matched FETs located in an oven and operating as a differential pair.

Drift, short term and long term stability must all be kept to very low levels otherwise it is impossible to maintain calibration.

This digital voltmeter from Solartron has variable sampling speeds.

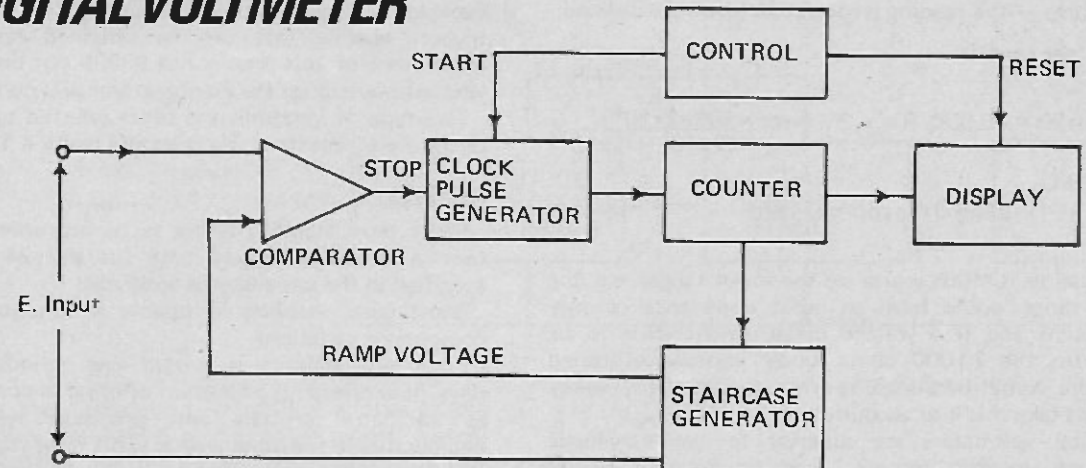


Fig. 3. Ramp type A/D converter.

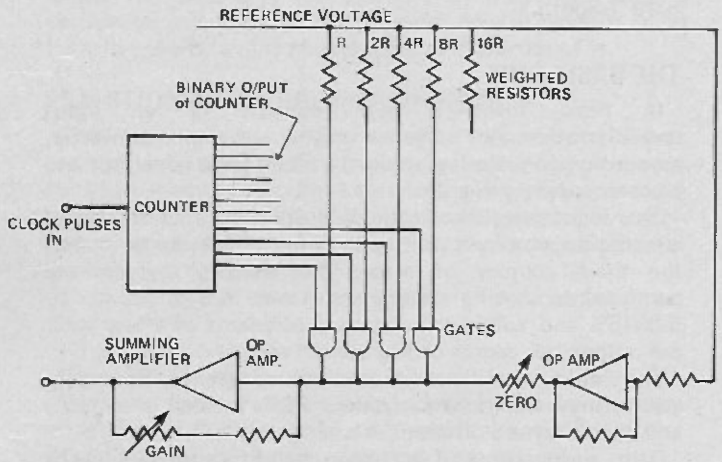


Fig. 3A. Staircase generator.

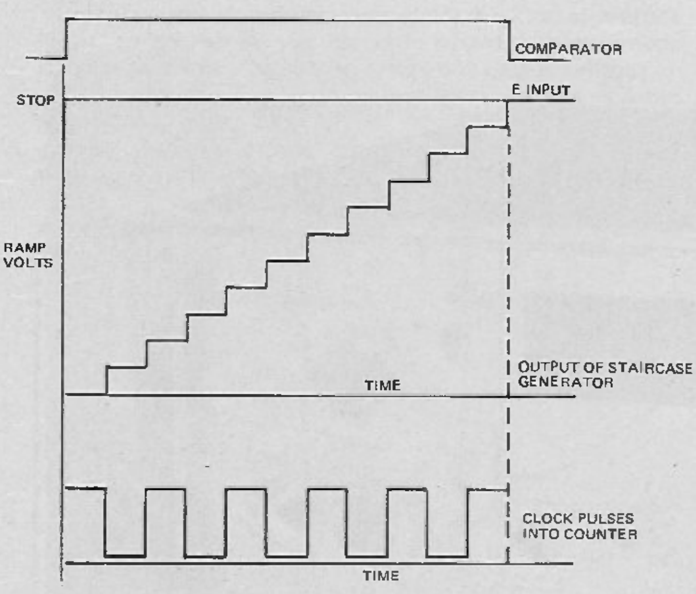


Fig. 3B. Wave forms.

TYPES OF DIGITAL VOLTMETERS

Digital voltmeters are classified according to the type of analogue to digital converter used. The most common types are:-

Staircase Ramp
Voltage to Time Ramp
Continuous Balance
Successive Approximation
Integrating
Potentiometric Integrating
Recirculating Zero
Dual Slope

STAIRCASE RAMP

In the staircase ramp type of converter (Fig. 3), when a voltage step is applied to the input, a clock pulse generator is started which supplies pulses to binary counter stages.

The outputs of the counters are sampled by AND gates which connect weighted resistors to an amplifier, the output of which is proportionate to the sum of the inputs. (This is known as a summing amplifier).

As the resistors are weighted according to the binary values of the counter output lines, the output of the summing amplifier is a voltage ramp which is proportional to the digital input and increases by small equal amounts at each clock pulse.

The so-called staircase ramp voltage is then compared with the input voltage by a comparator amplifier. When the voltages are equal the comparator switches off the clock pulse generator. The counter thus holds a count of clock pulses which is proportionate to input voltage and this count, which is in binary form, is then decoded to decimal and displayed on the readout.

The staircase ramp technique is relatively simple and cheap. Disadvantages are the relatively long time required to take measurements, and the sensitivity to normal mode noise.

In the presence of normal mode noise (Fig. 3C) a series of measurements may result in a number of different readings. Low frequency noise will cause the readout to 'jitter', and high frequency noise may cause the meter to read the peak value of the superimposed noise.

VOLTAGE to TIME RAMP

The basic voltage to time ramp converter is similar to the staircase ramp converter with the exception that the circuit uses an operational amplifier integrator to generate an analogue ramp with an accurately controlled slope. This type of converter is generally cheaper than the staircase method but additional errors can arise due to ramp non-linearity.

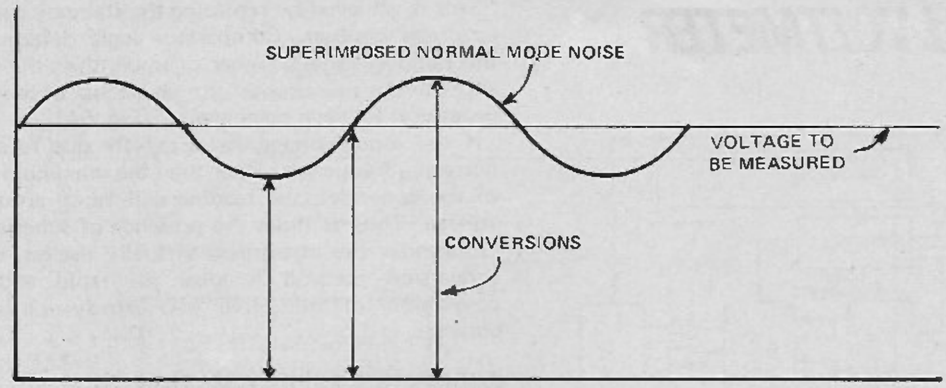


Fig. 3C. Effect of noise on ramp type A/D converter.

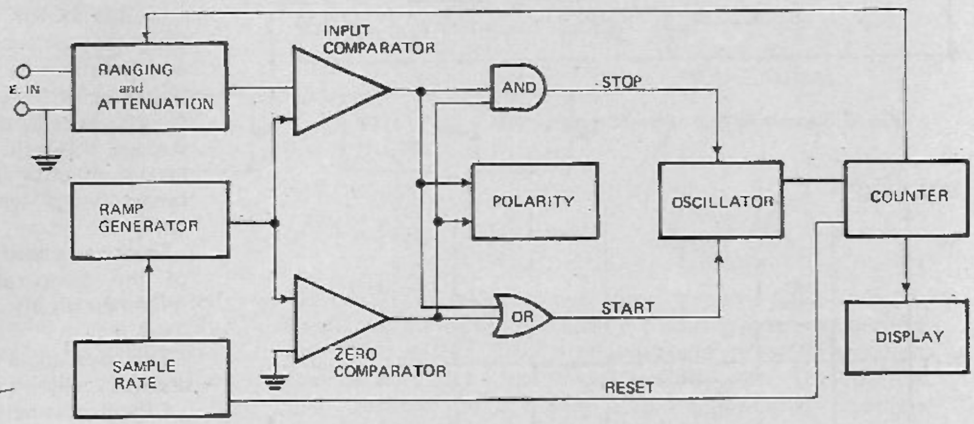


Fig. 4. Voltage to time ramp converter.

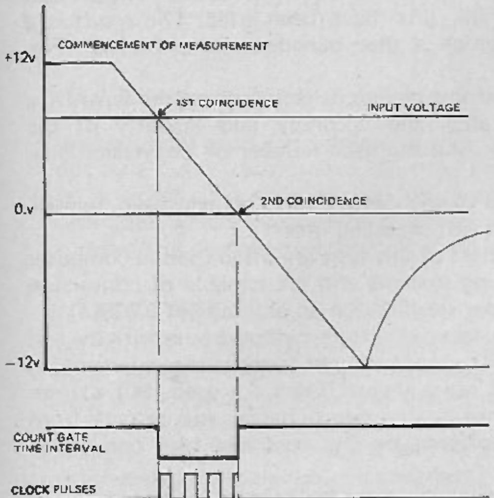


Fig. 4A. Voltage to time conversion cycle.

A typical voltage to time dvm is shown in Fig 4. This circuit has the added facility of automatic polarity sensing.

The ramp voltage is normally maintained at + 12 volts but can be driven down through zero to − 12 volts. When an input signal is applied, the ramp voltage is driven down until a comparator senses that the ramp voltage equals the voltage of the signal to be measured. At this point a gate is enabled thus allowing clock pulses to be totalled by the counting and display stages.

A second comparator disables the gate when the ramp voltage reaches zero. As the ramp voltage has a controlled constant slope, the time period between the two transitions is proportionate to the applied voltage. The number of clock pulses gated to the counter stage will also be proportionate to this time and, hence, voltage. (Fig. 4A).

Logic circuitry detects the order of the transitions and thus polarity of the input signal, and this is displayed visually on the front panel of the instrument.

CONTINUOUS BALANCE

Another form of staircase ramp is the continuous balance converter. (Fig. 5). This instrument uses the staircase ramp principle for its initial measurement period (which in this case is known as the settling time) but once coincidence has been reached the converter will follow slow input variations at a rate which can be as low as one clock pulse per conversion.

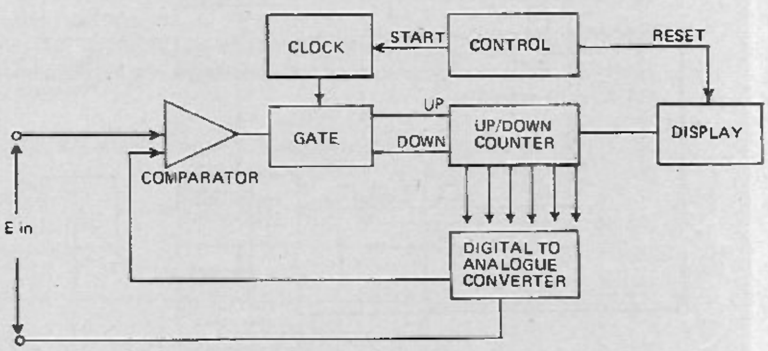


Fig. 5. Continuous balance A/D converter.

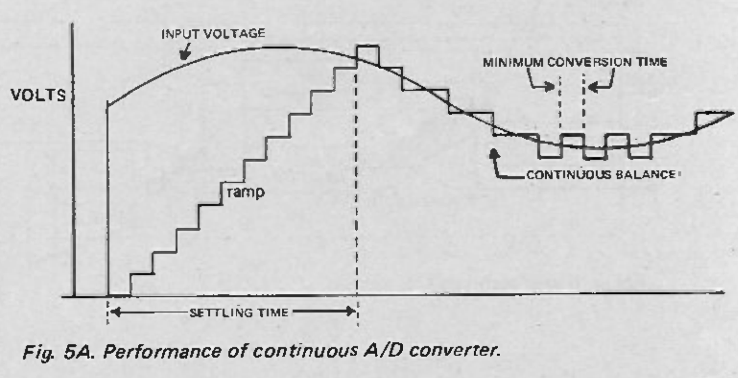


Fig. 5A. Performance of continuous A/D converter.

THE DIGITAL VOLTMETER

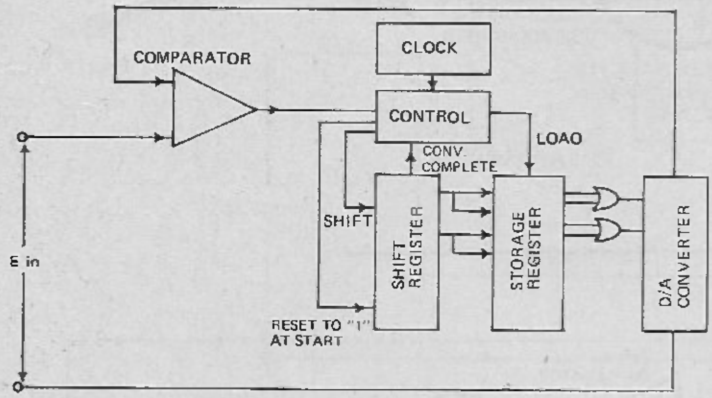


Fig. 6. Successive approximation converter.

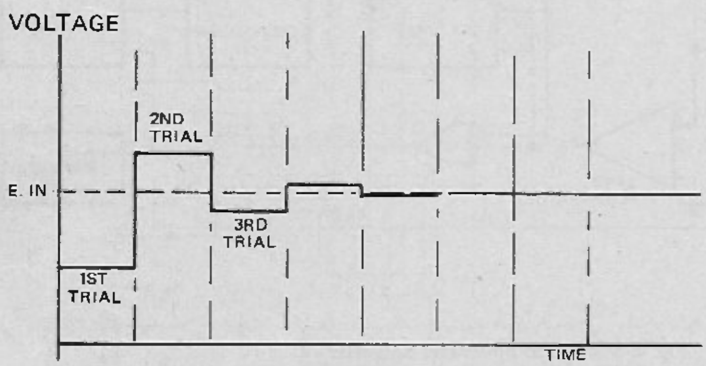


Fig. 6A. Successive approximation conversion.

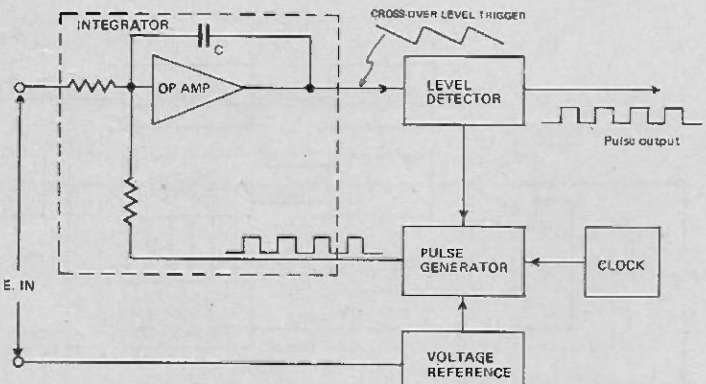


Fig. 7. V/F conversion employing integration.

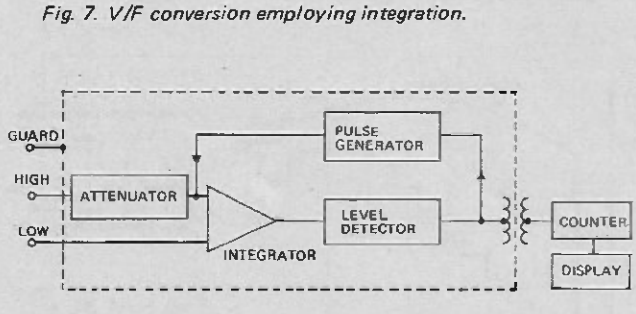


Fig. 8. Guard technique.

This is achieved by replacing the staircase counter with an up/down counter. Comparator logic determines whether the ramp voltage is higher or lower than the input voltage and directs the counter to count up or count down as necessary, to reach coincidence. (Fig. 5A).

If the input voltage varies rapidly due to superimposed noise at a frequency higher than the maximum tracking rate of the converter, the reading will 'hunt' around the mean voltage. Thus at times the presence of superimposed noise can render the instrument virtually useless. However this conversion method is ideal for rapid and continuous conversion of noise-free and slowly varying analogue voltages.

SUCCESSIVE APPROXIMATION

The successive approximation converter (Fig. 6) uses more advanced circuitry than the types previously described.

In this system the decision logic tries successive binary weighted voltages, starting from the highest voltage 'bit', and examines each approximation to see whether the result is higher or lower than the input voltage. If the 'bit' tried results in a comparison voltage lower than the input voltage, this bit is loaded into a storage register. The process continues until all 'bits' have been tried. The result is a binary 'word' which is then decoded and displayed. (Fig. 6a).

The accuracy of this technique is limited by the sensitivity of the comparator, the accuracy and stability of the reference supply, and the total number of 'conversion bits' used.

The advantages of the method include high speed, relative accuracy, and a fixed encoding time.

Digital voltmeters of this type are often used in computer based data logging systems and are capable of conversion rates of 50,000 per second with an accuracy of 0.01%.

The successive approximation method has sensitivity and noise problems. It cannot be used to make measurements in the presence of noise unless filters are used. But a filter slows the response to step input changes and detracts from the advantages offered by the otherwise high conversion rate.

In practice, conversion rates faster than four a second are not required in a dvm unless the instrument is specifically intended for systems use.

INTEGRATING (VOLTAGE to FREQUENCY) CONVERTER

This technique is widely used in good quality instruments because of its excellent noise rejection capability. (Fig. 7).

An integrating converter has the inherent capability to reject sinusoidal noise voltages of frequencies which are multiples of the integrating time of the converter. This is because the integration of integral numbers of sine wave noise pulses is zero.

Thus this method gives infinite rejection of normal-mode noise at frequencies which are multiples of the integrating time, and this is usually chosen as a multiple of 20 milliseconds in order to reject 50 Hz mains noise.

In operation the unknown input voltage is applied, via an attenuator/amplifier, to an operational-amplifier integrator, the output of which is a voltage ramp with slope directly proportional to the amplitude of the input voltage.

The output of the integrator is fed to a level sensitive detector which resets the integrator each time a reference level is reached.

As the slope of the integrator ramp is directly proportional to the amplitude of the input voltage, the reset will occur more frequently with higher voltages. The repetition rate of the reset pulses will therefore be directly proportional to the input voltage, and these pulses are counted for the sampling time, and displayed.

A further advantage of the integrating technique is that as

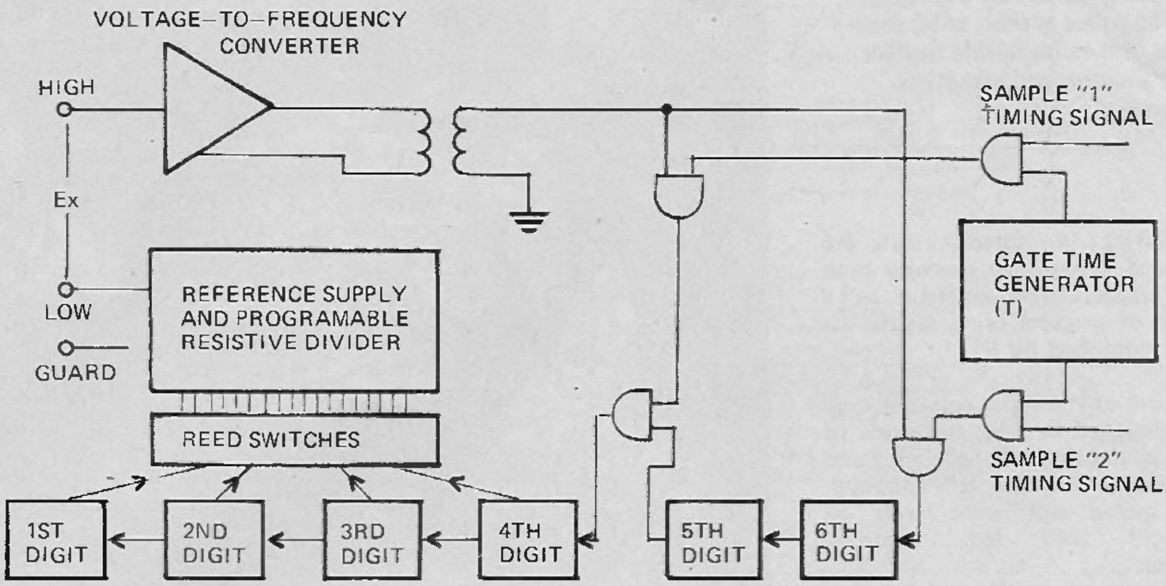


Fig. 9. Potentiometric/integrating digital voltmeter.

the converter produces a pulsed output this may be coupled out by a pulse transformer. Thus the entire converter may be enclosed in a shielded box insulated from earth. This technique which is known as guarding greatly increases the common mode noise rejection. (Fig. 8).

INTEGRATING POTENTIOMETRIC

A normal integrating dvm measures the average of the input voltage over a fixed sampling period; whilst a differential voltmeter compares the input voltage against a highly stable reference voltage.

These two methods are combined in the integrating-potentiometric converter and successfully improve both accuracy and resolution. (Fig. 9).

Instruments of this type consist of an integrating voltage to frequency converter, a counter with storage facility, and a digital to analogue converter which provides a reference voltage to an input comparator.

A reading is taken in two steps. Initially the voltage to frequency converter produces a frequency proportional to the input voltage. This is counted and stored in the first four decades of a six or seven decade counter. This count is then decoded by a highly accurate digital to analogue converter similar to the staircase ramp generator. A comparison is then made between this voltage and the input voltage, and the voltage to frequency converter produces a further frequency proportional to the difference voltage which is counted and added or subtracted to the count already stored. The initial integration is usually accurate to within 0.3% and the potentiometric comparison improves this to about 0.002%.

Following the comparison and subsequent correction, the total count is displayed on the full six or seven decades of the readout.

The advantages of this method include an increase in resolution and accuracy, but sampling speeds are lower than

(Continued on page 77)

Fig. 10. Recirculating remainder DVM.

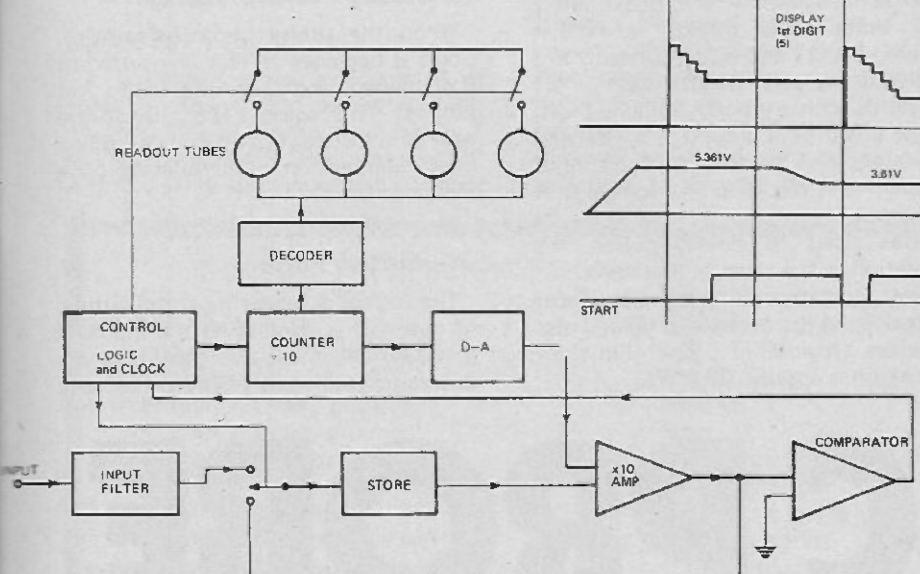
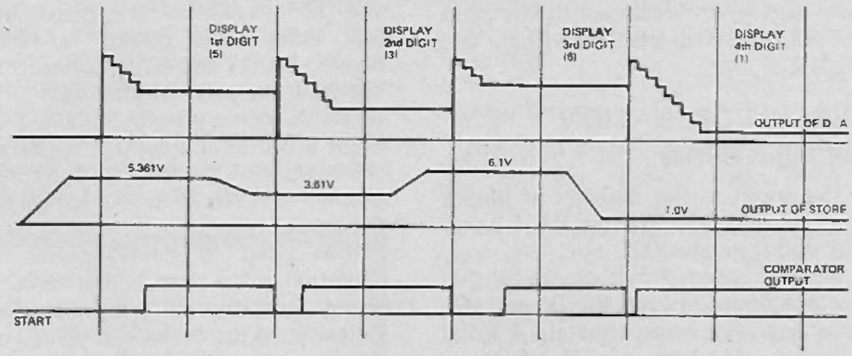
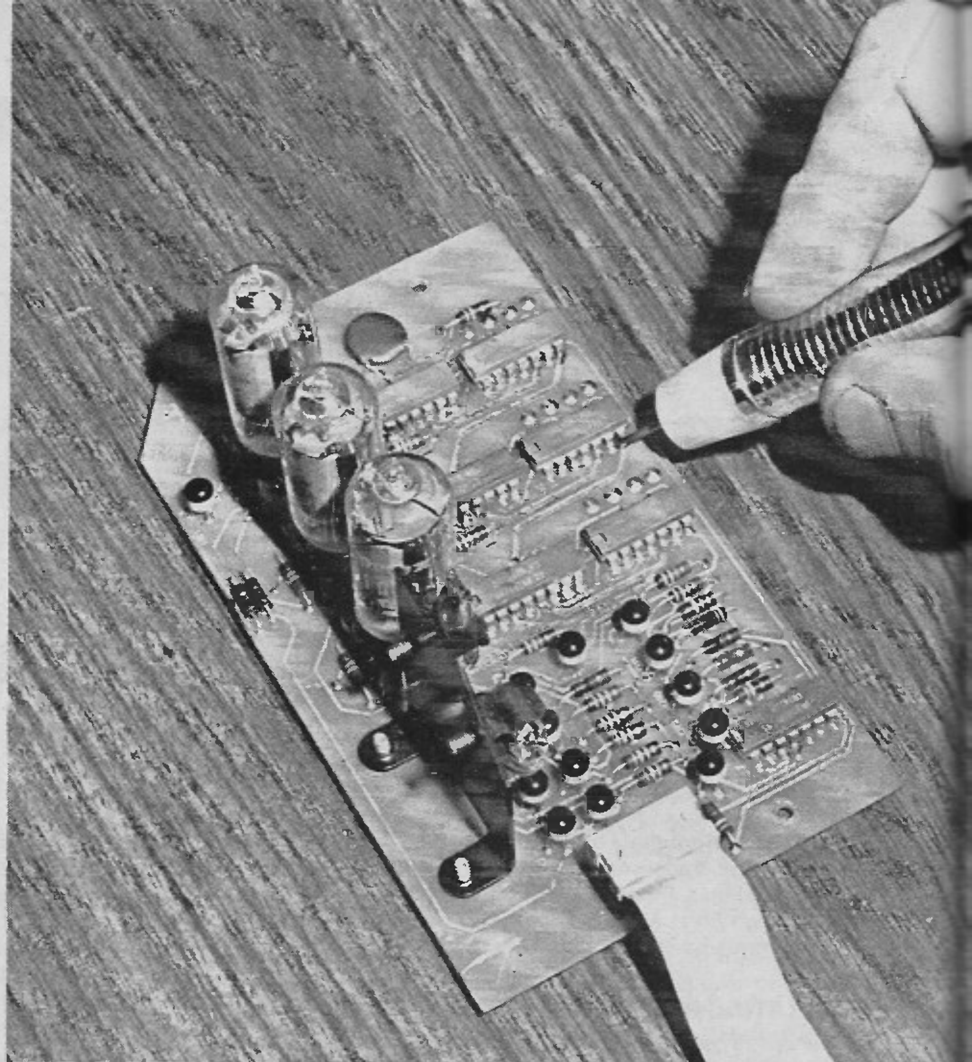


Fig. 9A. Waveforms of potentiometric/integrating DVM.



LOGIC PROBE

This probe provides visual indication of the logic state at any point in a circuit using digital ICs. Capable of detecting pulses as short as 50 nanoseconds, it is an invaluable tool for trouble-shooting and prototype development.



DIGITAL integrated circuits are being increasingly used by both professionals and amateurs, and a number of projects using digital ICs will be published by ETI.

The first of these projects is a logic probe designed to meet the needs of both professional engineers and amateur experimenters. It is not a toy.

The probe will work with all commonly used logic systems, including:

RTL (resistor-transistor logic).
DTL (diode-transistor logic).
TTL (transistor-transistor logic).

The logic probe may also be used with equipment using discrete components (such as pulse amplifiers and relay drivers).

The probe will indicate any of five conditions:

(1) Steady positive voltage.
(2) Steady ground potential.
(3) Single fast positive pulse.
(4) Single fast negative pulse.
(5) A pulse train with a frequency not exceeding 10 MHz.

As the probe must detect pulses as short as 50 nanoseconds, a monostable multivibrator is used as a pulse extender to provide indication times of 100 milliseconds. Separate monostables are used for positive and negative going pulses.

The necessary monostable and inverting functions required to meet conditions (1), (2), (3) and (4) are provided by interconnecting the gates of the quad two-input nand gate G1, 2, 3, 4.

CIRCUIT OPERATION

(a) Input Buffer

The input buffer consists of diodes D1, D2 and D3, resistors R1, R2 and R3, and transistor Q1.

With an open circuit on the probe, current flows through R1, D3 and R2, thus providing approximately 4 Volts bias on the base of Q1 which is switched into conduction. This results in a high level at point B (logical 1 at the 7400 gate input 2.

If, on the other hand, the probe is connected to a positive voltage greater than 2 Volts, diodes D1 and D2 block the flow of current to D3 and the subsequent operation is the same as for an open circuit on the probe.

If the probe is connected to ground potential, current flows through R1 whilst the forward voltage drops of D1 and D2 bias point A at approximately 1.2 Volts. This voltage is further divided by D3 and R2, and results in a negligible voltage on the base of Q1 which is consequently switched off. Point B is thus at ground potential and R3 'sinks' the current from the input gate of IC1, resulting in a logical 0 at the input.

When used to detect pulses, the operation is the same as that described above: a positive going pulse produces logical 1, whilst a negative going pulse provides logical 0. The limit of operation is approx. 20 MHz.

(b) Monostable/Inverter

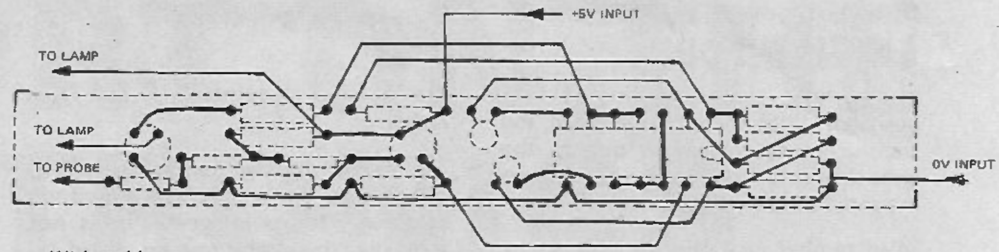
This stage is built around IC1, which is a quad two-input nand gate. As shown in Fig. 1, two gates are interconnected to form a monostable multivibrator. The remaining two gates are likewise interconnected, and the output of the first pair of gates becomes the input of the second pair.

(c) Steady Positive Voltage

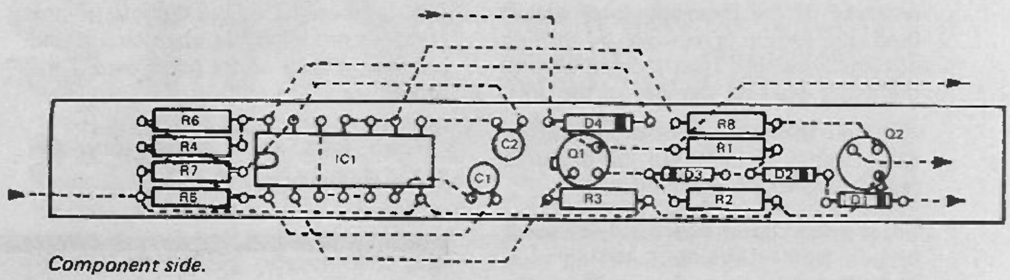
When the probe becomes positive, point B becomes 1. This is inverted to 0 at point C and again inverted to 1 at point D. This logical 1 is applied to the base of transistor Q2 which is switched into conduction, illuminating the indicator lamp.

(d) Positive Pulse

The logical 1 appearing at the output of gate G3 is applied to the input of gate G4, and these two gates now act as a monostable multivibrator because



Wiring side.



Component side.

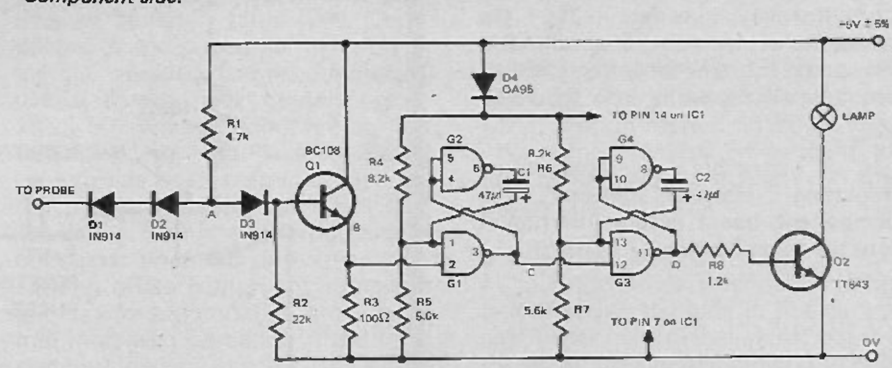


Fig. 1. Circuit diagram of complete unit.

the output G4 becomes 0 and capacitor C2 starts charging through R6/R7 potential divider.

During this charging period the second input of G1 is held at 0 and, even if output C changes to 1, the output of G3 will be 1. Thus a fast positive pulse at the probe input will be sensed and extended to illuminate the indicator lamp for 100 milliseconds.

(e) Steady Ground

A grounded probe produces 0 at point B. The 0 is inverted by G1, resulting in 1 at point C and, hence, 1 at the inputs of G2. The output of G2 is 0 and C1 is discharged. The output at point C is also fed through G3, which inverts it to produce 0 at point D, extinguishing the indicator lamp.

(f) Negative Pulse

When the probe is at positive potential and senses a negative going pulse, the operation is as follows:

Before the negative going pulse arrives, point B is at logical 1; this is inverted to 0 at point C and again inverted to logical 1 at point D, thus causing the indicator lamp to be illuminated. As soon as a negative pulse arrives, B goes to logical 0, resulting in 1 at C; this is again inverted by G3 and the output appears as logical 0 at point D, thus causing the lamp to be extinguished. At the same time the logical 1 is applied to the inputs of G2. G1 and G2 now form a monostable multivibrator ensuring that the lamp remains off for 100 milliseconds.

(g) Pulse Train

A pulse train will cause the monostable vibrators to cycle continuously, thus causing the indicator lamp to glow at reduced brightness.

Lamp Driver

The lamp driver stage consists of R8, Q2, and the indicator lamp. When a logical 1 appears at point D current flows through R8, causing Q2 to conduct and thus energizing the indicator lamp. A logical 0 appearing at point D will cause the transistor Q2 to be biased off and the lamp will be extinguished.

SPECIFICATIONS

Supply voltage	5 Volts dc ± 5%
Input voltage (high input)	> 2.4 Volts
Input voltage (low input)	< 0.8 Volts
Indication — steady positive	lamp on
Indication — steady ground	lamp off
Indication — fast positive pulse	lamp flashes on
Indication — fast negative pulse	lamp flashes off
Indication — pulse train	lamp glows less brightly
Minimum detectable pulse width	50 nanoseconds
Extended indication of lamp	100 milliseconds

CONSTRUCTIONAL DETAILS

A pen torch case makes an ideal housing for the probe. We used an Eveready unit that has a translucent lamp surround.

A small nail glued into the translucent end serves as the probe (remember to solder a wire to the end of the nail before glueing it into position). With the probe in place, the translucent tip will glow due to the light diffusing from the indicator lamp mounted directly behind it.

Pen torches vary in their methods of construction, but in most cases the switch mechanism will have to be removed. If the Eveready torch case is used, the switch is removed by drilling out the retaining rivet located behind the small label on the end of the unit.

For our prototype we mounted the components on a piece of phenolic resin board (0.1" hole centres).

A printed circuit board may be used, but point-to-point wiring is considerably easier. If the conventional components specified in the parts list are used, the finished product will fit easily into the torch case.

It is advisable to wrap some insulating material around the component board before inserting it into the torch body.

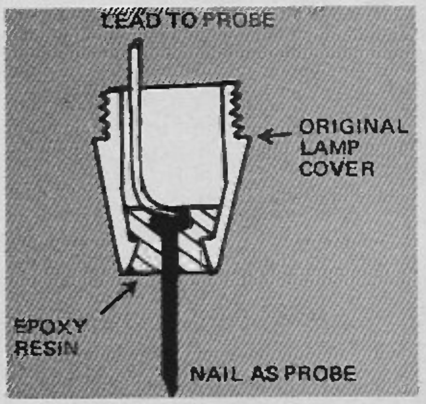
TESTING

Check the wiring carefully and connect the probe to a 5 Volt dc supply. The lamp should glow immediately. If it does not, recheck the wiring and measure the voltage at points B, C and D after referring to the circuit description.

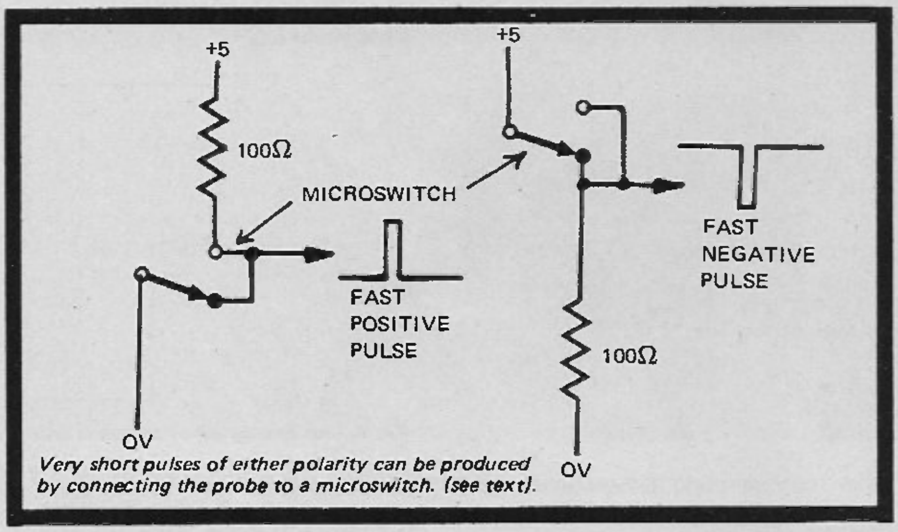
Next touch the probe onto a point that is at ground potential. The lamp should extinguish. If it does not, check the voltages at points B, C and D as above.

A source of fast pulses is required to check that the monostable stages are working. If a pulse generator is not available, the probe can be tested by connecting it to the common connection of a microswitch. When the microswitch is operated, the contacts momentarily open circuit and produce a very short pulse across the probe.

If all tests prove satisfactory, the probe is ready for use. ●



Probe tip, solder a lead to the nail before glueing into position.



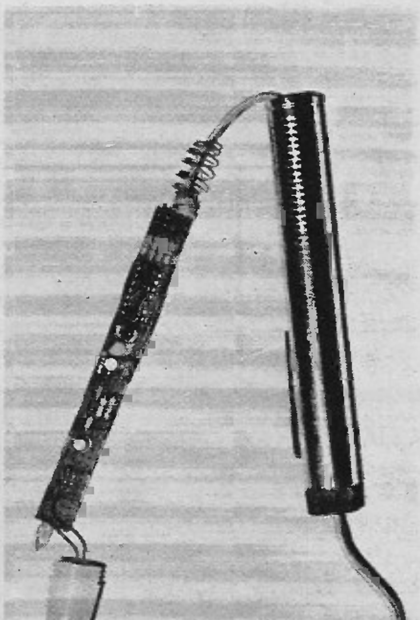
Very short pulses of either polarity can be produced by connecting the probe to a microswitch. (see text).

PARTS LIST

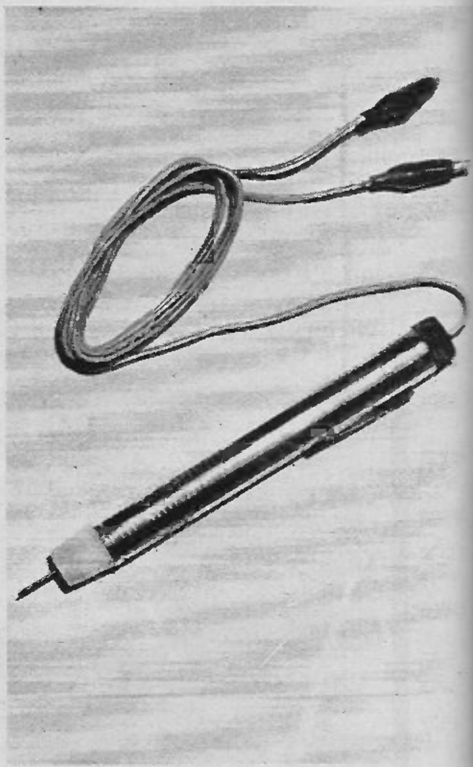
R1	–	resistor 4.7k ¼ watt 5%
R2	–	" 22k " " "
R3	–	" 100Ω " " "
R4, R6	–	" 8.2k " " "
R5, R7	–	" 5.6k " " "
R8	–	" 1.2k " " "
D1,2,3	–	diodes type 1N 914 (or equivalent)
D4	–	diode OA 95
C1, C2	–	tantalum tag capacitor (STC) 47μf, 6.3 volt
Q1	–	transistor, BC108
Q2	–	" 2N3643
IC1	–	integrated circuit 7400*
Lamp	–	6V 100MA

Matrix Board
Pen torch (see text)
*Note – the prefix for the 7400 series IC depends on the manufacturer i.e.:–

T7400	–	made by SGS
MC7400	–	" " Motorola
SN7400	–	" " Texas Inst.



How prototype unit was constructed; the circuit board should be insulated from the metal case.



Completed probe housed in a torch case.

REPORT ON THE ELECTRONICS INDUSTRY

Part 1: How the industry fared in 1971 and the short-term forecast for 1972/73.

A fat (424 pages) confidential and limited-circulation report prepared by a reputed firm of investment brokers and analysts for the benefit of investors in the electronics market has landed on our desk. It makes fascinating reading despite the fact that privately owned organisations in the industry are not covered by the extensive research which has obviously gone into the project.

It is obviously a difficult and perilous task to try and summarise the report. We believe that the three sections most likely to interest our readers are: Outlook for the industry in 1972/73, longer term outlook in 1973–76 and Implications of entry into the EEC. We deal with the short-term outlook in this Part 1 of a report on the Report; we emphasise that we are merely reporting and these are not our views.

RECAP ON 1971

International trading has always been a major feature of the electronics market. This is likely to become more pronounced in industrial and consumer products as foreign manufacturers strive to maintain growth rates by increasing their involvement in overseas market – with Western Europe as a major target.

For the UK electronics industry, the period since the autumn of 1970 underlined the disparities and contrasts between the activities of various organisations using electronics technology. Capital equipment manufacturers in the defence market and quasi-government purchasers generally fared well. Companies in the consumer electronics market enjoyed boom conditions similar to the peak demand years 1958/59 when monochrome TV appeared on the scene. Rapid growth has been seen in colour TV, unit audio, cassette recorders and car radios. Component producers to consumer-orientated industries – including office equipment, domestic appliances, automobiles, etc. – have met increased demand. In the telecommunications sector the Post Office, purchasing around 80% of the UK output, has shown no signs of reducing the growth in its ordering rate; sector deliveries have risen steadily in the last two years.

SHORT TERM OUTLOOK

Consumer durables are likely to witness the fastest expansion rate, with growth exceeding 1970 and 1971 rates; the expansion could be in excess of 20% in total demand. Our forecasts are for a rapid resurgence in business confidence by mid 1972 as demand growth accelerates. The buoyancy will be initially in the light engineering industries, with the heavier and industrial sectors sharing in the growth by the final quarter of 1972.

In the public sector, the Central Government and public Corporations can be expected to enter a very expansionary phase of investment as the authorities aim to stimulate resurgence of industrial confidence and capital expenditure. Local authority expenditures will also expand, though more modestly.

We expect capital investment to turn upwards quite markedly in the second half of 1972.

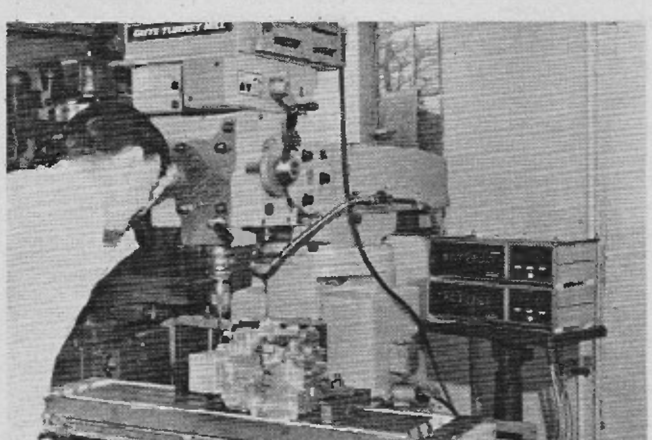
• COMPONENTS SECTOR

The principal factors determining and affecting demand in this sector are: scheduled deliveries of equipments by the capital, consumer and telecom areas; use of components in automobile, domestic appliance and associated industries; and demand for replacements from existing equipment users.

1972 is likely to see a reversal of 71's downward sales trend in discrete semiconductors and integrated circuits. With prices of many standard IC ranges and certain discrete items now steady or firming, indications are that far more stable overall prices in 1972/3 will help the improvement in domestic demand.

The valve and tube markets will generally continue to expand fairly steadily in 1972 with colour TV tubes as main growth feature. Import growth should curb itself now that recent expansions by Thorn and Mullard in domestic productions should be adequate to meet TV manufacture needs. A boost is expected in second half sales to the control and instrumentation markets.

Passive component demand should expand faster than in 1971 and could be quite sharp with any upturn in equipment orders. While the trend towards hybrid and monolithic IC use suggests narrowing of the scope for the discrete component market, miniaturisation of passive devices is expected, in the



Electronics in turret milling (Smith's Industries Ltd)

REPORT ON THE ELECTRONICS INDUSTRY

short term, to offset any decline in unit demand, mainly by virtue of the higher unit prices of miniaturised components. Miniature composition potentiometers, film capacitors, electronic (solid-state) relays and multi-layer printed-circuit boards are examples where growth could well exceed 25%.

• CAPITAL EQUIPMENT

Economic forecasts indicate a resumption of investment growth by the private sector in 1972 with a definite quickening in the fourth quarter. With the acceleration of public sector investment in the second quarter, the general economic outlook for capital equipment sector appears a lot healthier than a year ago.

The expansion in this sector's output is liable to be more modest in the long order-cycle products like computer or process-control systems; the bulk of recovery in output should occur in 1973.

(A) COMPUTER AND ASSOCIATED EQUIPMENT

Despite a small decline in system deliveries to the home market, total UK production in this category should show a small increase in 1972. With the first IBM 370 and Burrough's CPUs being completed in British factories for European markets and ICL also delivering several large systems for the East European and French markets, system exports should be significantly higher than in 1971.

Peripheral and data transmission equipment markets, with their shorter delivery cycles, should increase in deliveries in the second half of 1972. Demand for data transmission equipment is expected to show particularly rapid growth as several large multi-access systems are further expanded. In spite of intense competition in the display field with some 20 companies, sales of video units may achieve their long-awaited boom in 1972. Other input/output peripherals due for rapid sales growth are key-to-disk and tape-to-disk systems and optical character readers. Computer services should enjoy a better year in 1972 although the growth rate of late 60s is unlikely to be repeated. Introduction of VAT in April 1973 should generate substantial software business.

Factors influencing the long-term future of the UK computer industry remain virtually unresolved – the Government's future attitude towards the funding of British research and development, awarding of single tender contracts to ICL and the possibility of some viable cooperation with Europe in the computer field.

(B) CONTROL AND INSTRUMENTATION EQUIPMENT

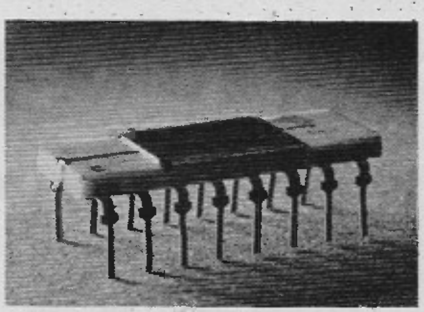
The rising trend engendered by the extension of electronic control and measuring techniques in a growing number of application areas as well as the anticipated growth from recent technical innovations is expected to augment domestic demand which so far has been largely determined by capital investment in the manufacturing (notably nationalised) industry, government and educational establishments.

The expected 3–5% expansion in demand for industrial control equipment owes much to orders from British Steel Corporation. Major plant developments at Scunthorpe, Newport and Ebbw Vale have led to substantial orders for GEC, George Kent and others, due for delivery in 1972. New control equipment requirements by CEGB are expected to expand in 1972, particularly in view of developments in thyristor controls replacing electromagnetic relays in many heavy plant applications.

The trend towards digital instrumentation will continue, boosting sales of digital meters. Demand for nucleonic instruments and controls is expected to remain close to the 1971 level.

(C) COMMUNICATIONS EQUIPMENT

Other parts of the capital equipment industry help directly with the means of production, e.g. industrial control equipment, computers etc. The products of the communications sector however, are concerned with providing services to the public – defence, air/sea transport, broadcasting etc. UK demand is thus a function of investment programmes of service organisations such as the various Ministries, BBC and ITV, the airlines etc; and the market is largely generated by replacement demand – with defence spending as the single major determinant.

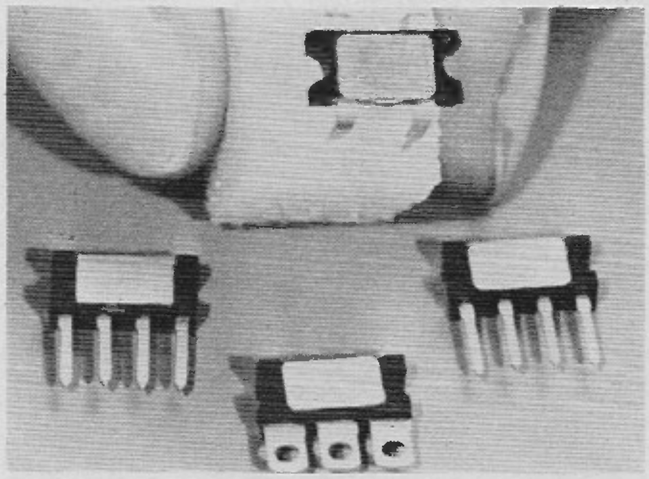


1024–bit shift register (General Instruments Micro–electronics Ltd)

Domestic demand for radio communications equipment is likely to accelerate in 1972 with increased "Clansmen" re-equipment deliveries, the replacement by the GPO of its double sideband HF coastal transmitters with SSB to meet the new International Telecommunications Union regulations and further expansion in land mobile sales. Marine equipment deliveries should also increase in 1972 due to Naval re-equipment and additional SSB conversion on merchant vessels.

Military avionic producers must rely, in the short term, upon established aircraft such as the Buccaneer and the Lightning (both with some export potential) or aeroplanes such as the Harrier VTOL and Anglo-French Jaguar (not due for full production till late 1972). Other demand sources are the Nimrod maritime patrol planes and some military helicopters.

Civil sales rest with established aircraft such as the Trident 3B and the 125 executive jet, with some extra work for pre-production Concorde. Development contracts for the multi-national MRCA project should help R & D avionics.



Subminiature solid-state switches

Total deliveries of radar and navaids to the UK market should increase modestly in 1972 due to Army and RN requirements and civil sales of small-boat radars and radar-based security systems. Foreign import's share of the home market should remain fairly small.

With renewed growth in closed-circuit TV, particularly for educational purposes, and larger re-equipment programmes by the BBC and ITA companies, domestic production of, and demand for, broadcasting equipment should manage an increase in 1971 figures.

• TELECOMMUNICATIONS EQUIPMENT

The principal demand continues to be from the PO capital investment programme – with a small contribution from industrial and commercial users.

In spite of well-documented PO investment policy for 1970–75, estimating UK market deliveries is made uncertain due to the chronic under-capacity on the telephone exchange equipment side, technical problems with the larger reed-relay exchanges and the industry's continuing inability to meet scheduled delivery dates.

Accelerating growth in exchange equipment deliveries to the PO will feature prominently in 1972 and, with no slackening of new orders, little overall decline in the increasing order backlog is expected. Much interest in the industry will be centred around the allocation of future TXE4 contracts and the new entrants, like Pye TMC, to the PO exchange market.

Continuing PO radio/microwave trunk transmission and further expansion of local lines should ensure a further steady rise. In the non-PO domestic market, demand for private-leased transmission lines for telex and Datel use is again expected to remain high. With several large orders for telephone apparatus from the PO and the telephone rental firms in the pipeline, and increased PO procurement of data modems and telex equipment for direct rental to subscribers, deliveries of subscribers' apparatus and parts should also be higher in 1972.

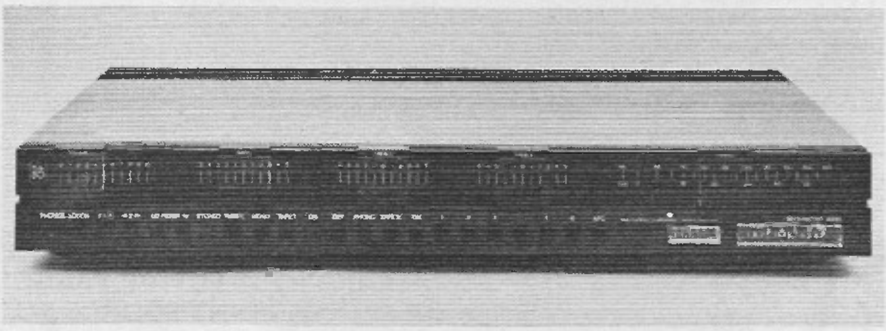
• CONSUMER GOODS

Some 22% (in constant prices) rise in consumer expenditure over 1971 levels is expected. As in 1970 and 1971, colour TV will continue to dominate the expansion. To counteract the stepped-up marketing effort by Hitachi, Sony, National, Sanyo etc., Thorn and other UK producers are expected to cut prices of their small-screen sets. In the larger screen markets, with the absence of significant overseas competition, prices are likely to remain more stable; the significance of this should not be over-rated since, in any event, the bulk of consumer acquisitions in this field is made through rental outlets. A real breakthrough for foreign firms, which 1972 may or may not witness, would be the winning of a substantial supply contract for a large nation-wide rental group, particularly jeopardising those manufacturers without tied rental outlets.

Likely major product developments are increased use of Varactor tuners (already common in Germany), an improved and cheaper glass delay line, possibly the introduction of "slim-line" sets based on a 110° tube and further incorporation of ICs in set design.

With much of consumer expenditure on electronic goods pre-empted by colour TV acquisition, any growth in radio set demand is likely to be confined to cheap portables and FM sets. With car radios, sales could prove another bright area.

In audio products, demand will continue to expand fast for unit audio and cassette recorders/players. With price falls in pre-recorded cartridges and cassettes, competing eventually with disc material, automobile tape players will become more commonplace.



Stereo FM Tuner (Bang & Olufsen)

• CONCLUSIONS

The outlook for the next 12 months, in nearly every sector of the electronics industry, is more favourable. Already industrial instrumentation and control equipment firms are experiencing an upturn in new orders. In the computer sector, from the evidence of higher component off-take, the order book levels are on the increase. Defence purchases are again on a strongly rising trend with the initial deliveries of the NATO "Clansmen" project under way, a RN refitment project recently announced and a build-up of work on the Jaguar and MRCA aircraft. In the capital equipment sector, as the upturn in the workload becomes more pronounced, there should be a significant improvement in profit margins. It is important, however, to distinguish between the long order-cycle products, like large computer systems or civil aviation equipment for new airframes, and short-cycle items such as test instruments or computer peripherals; in the latter field, a marked increase in deliveries should be apparent before the end of 1972.

Another year of rapid expansion is seen in the consumer electronics sector in spite of a probable slight slackening due to the introduction of VAT and its implications of a further 3–3½% reduction in retail prices in most consumer goods. A further import penetration – a feature in the last two years – is certain in 1972.

For component producers, a very rapid increase in order intake is imminent with any upturn in equipment orders, as the de-stocking of components by the capital sector in 1971 has been extensive.

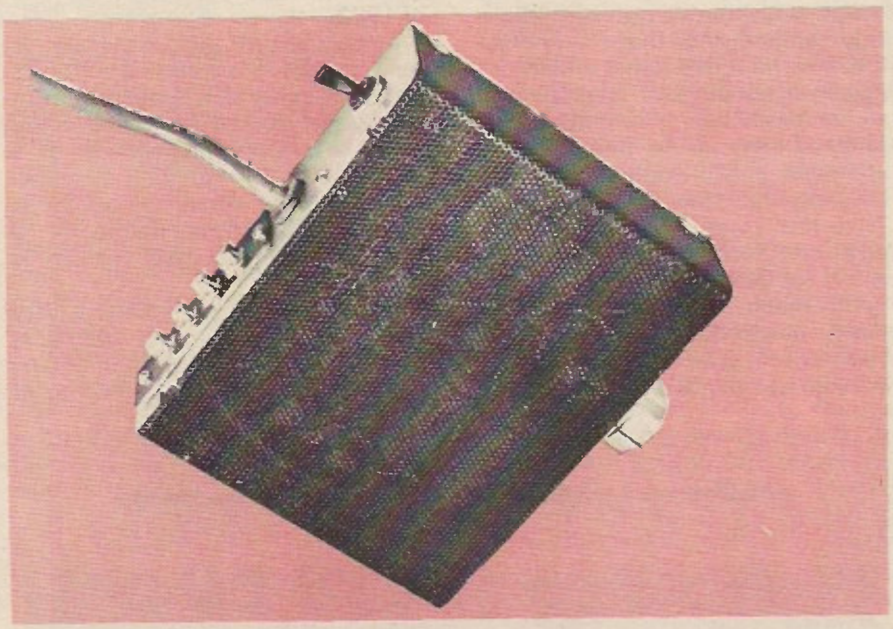
In the telecommunications sector, the main unresolved questions centre on the respective futures of the Crossbar backed by Plessey and GEC, and the TXE4 telephone exchange equipments and the industry's ability to meet PO delivery dates. This sector enters 1972 with record order books and net new orders.

The outlook for the industry as a whole for the remainder of 1972 and in 1973 is certainly more favourable than it has been in the immediate past.

In the longer term, if the pace of technical innovation slows and international competition intensifies, the downward de-rating of the investment rating for companies failing to out-perform the industrial sector as a whole could be substantial; however, within the sector, there are several stocks which merit further investment consideration

(Part 2 will deal with the long-term outlook and EEC implications.) •

SUPER-



ETI PROJECT 410

SELECT THE WIDTH OF YOUR STEREO'S EFFECTIVE IMAGE – FROM A POINT SOURCE TO A SPREAD MUCH GREATER THAN NORMAL.

When stereo reproduction was a novelty, many recordings were made with grossly exaggerated stereo 'image'. So much so that on some orchestral recordings the second violins appeared to be playing somewhere to the left of the gentlemen's toilet.

Now, some record companies have swung the other way, and music lovers complain that a number of recordings – especially of symphonic music – have *insufficient* spread, and the apparent stage is restricted to a small area either side of the centre line of the speaker enclosures.

To some extent this can be remedied by increasing the spacing between speakers – but only if room dimensions permit.

This is a problem that has attracted the attention of Mullard Ltd, and they have developed a 'sound-source width control' that enables the stereo 'image' to be adjusted so that at one extreme both stereo channels are spatially combined so that the sound apparently emanates from a point half way between the two speakers, whilst at the other extreme, the effective

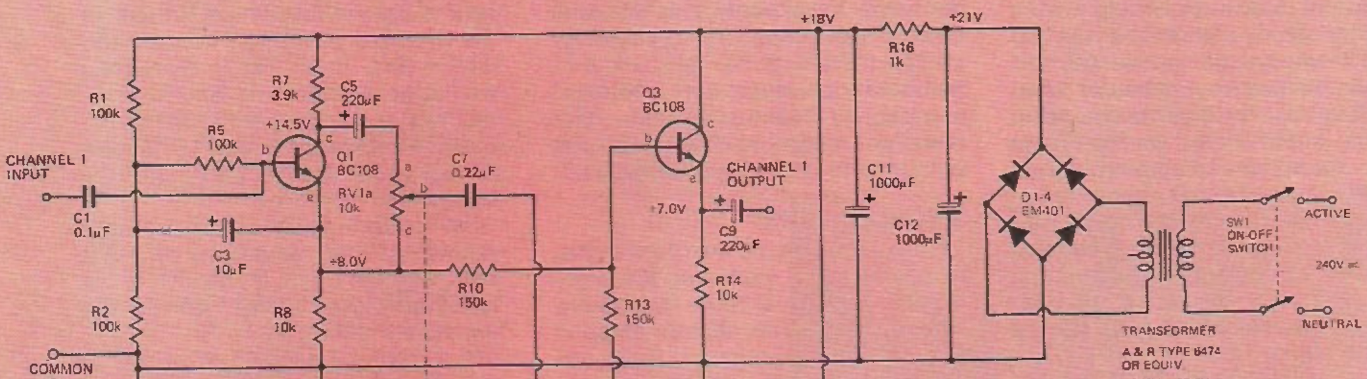


Fig. 1. Circuit diagram of complete unit.

STEREO

stereo image is increased quite considerably.

The circuit operates by adding part of the signal in one channel to the signal in the second channel. This is done with both signals in phase (to produce mono effects), or with the signals out of phase (to produce stereo-width enhancement).

Care has been taken to ensure that the unit does not introduce hum or distortion.

When we first assembled the unit we found that the range of adjustment provided by the width control was not really sufficient to cater for all programme material and the circuit described here has been modified to provide continuous adjustment, from mono, through the normal stereo image, to an apparent stereo spread approximately 40% greater than normal.

INTER-UNIT CONNECTIONS

This unit is designed to accept high level signals — exceeding 100 mV, and is intended for connection between a pre-amplifier and main amplifier.

It is not suitable for handling signals directly from a low level (less than 100 mV) magnetic pick-up. This is because internal noise generated by the unit will degrade the low level signals.

Crystal or ceramic pick-ups have sufficient output successfully to drive the unit and it may of course also be used between a pre-amplifier and tape recorder, tape recorder (reel-to-reel or cassette) and amplifier, or between two tape recorders.

Many modern amplifiers are of course built with the pre-amplifier and main amplifier combined. With these it is generally possible to connect the unit's input to the 'tape-out' connections and the unit's output to the 'tape-input' sockets on the stereo amplifier. (This approach is also used by the Bose company — their active equaliser is interconnected in the same way).

TESTING

At this stage connect input 1 and output 2 only, input 2 and output 1

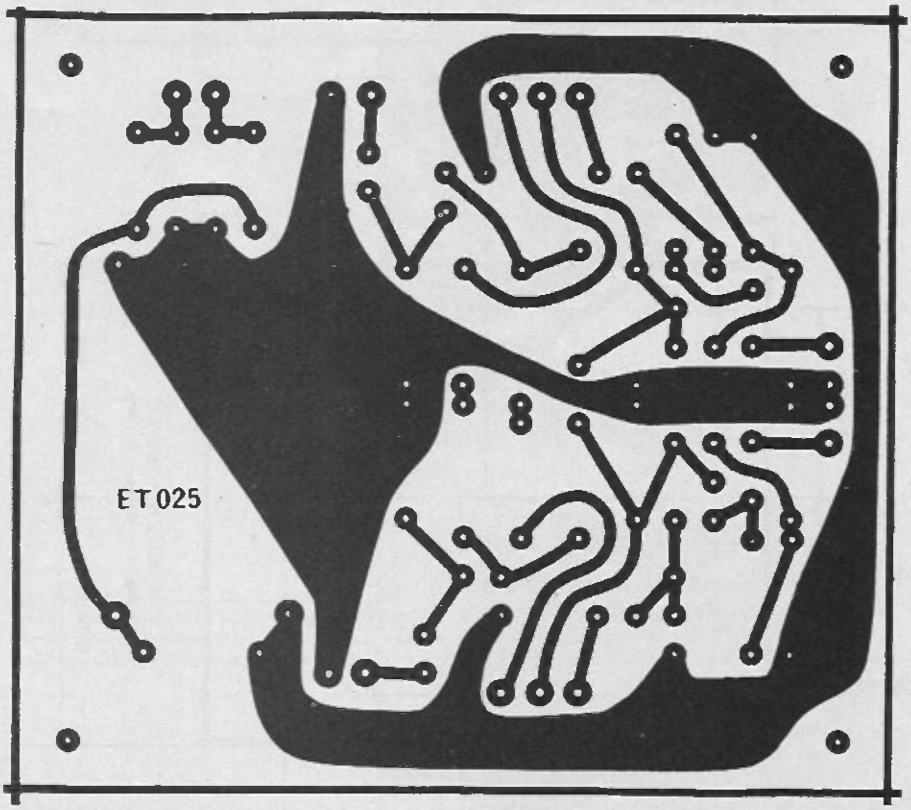


Fig. 2. Foil pattern of printed circuit board — full size.

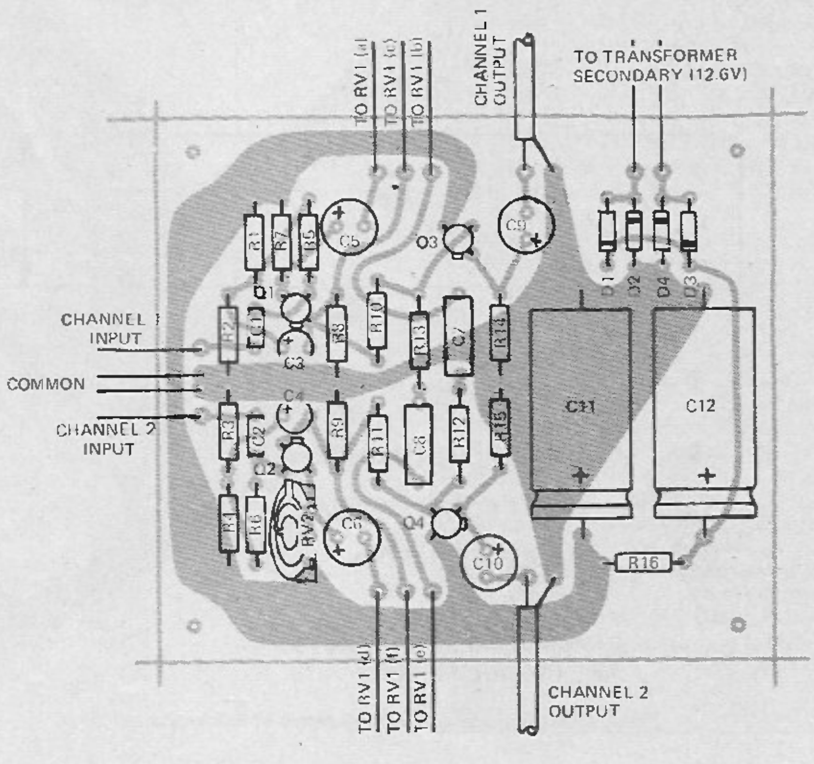


Fig. 3. How the components are located on the printed circuit board.

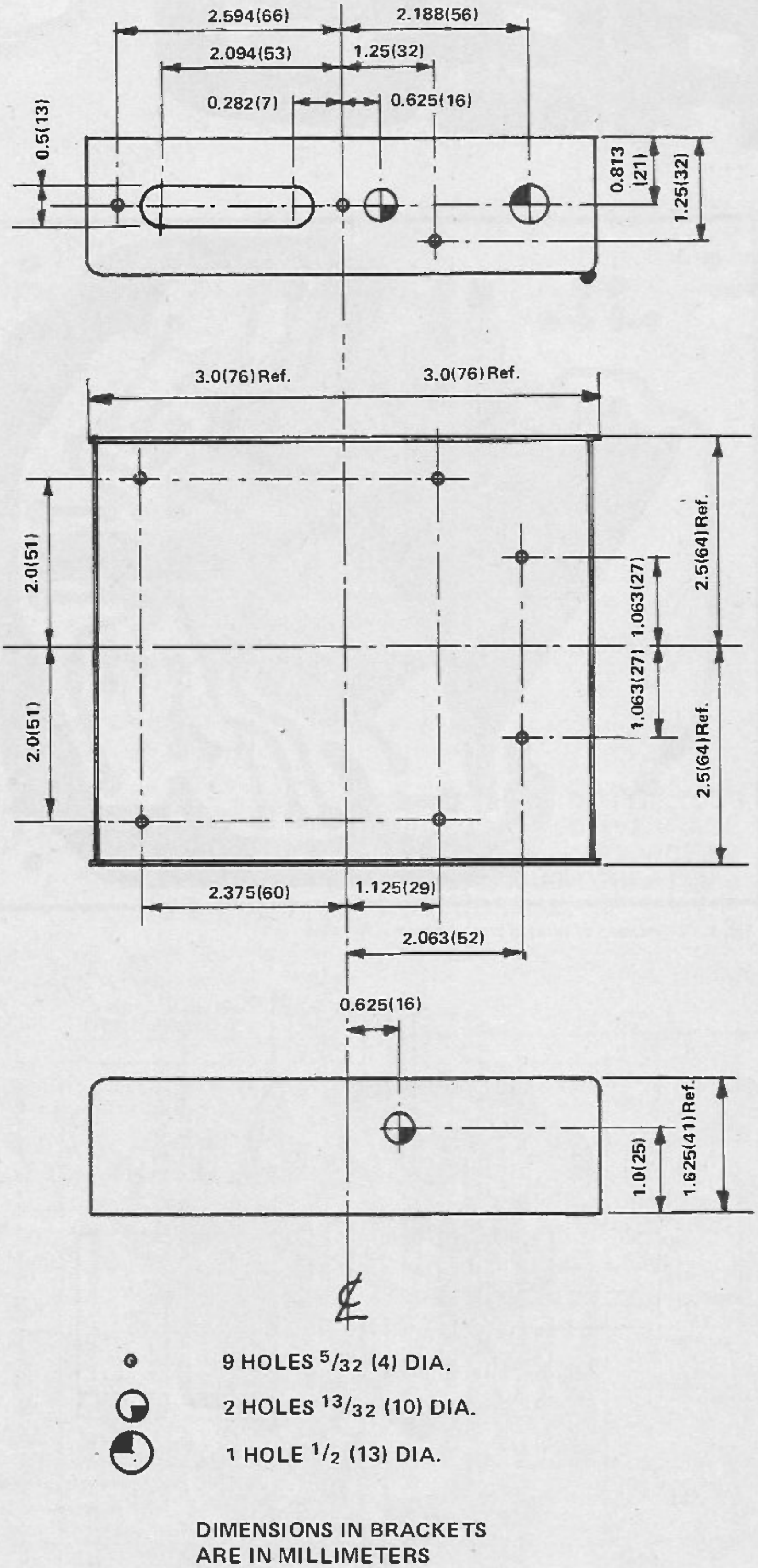


Fig. 4. Constructional and drilling details of metal case.

PARTS LIST ET410

R1	— resistor	100k	½ W	5%
R2	— "	100k	"	"
R3	— "	100k	"	"
R4	— "	100k	"	"
R5	— "	100k	"	"
R6	— "	100k	"	"
R7	— "	3.9k	"	"
R8	— "	10k	"	"
R9	— "	10k	"	"
R10	— "	150k	"	"
R11	— "	150k	"	"
R12	— "	150k	"	"
R13	— "	150k	"	"
R14	— "	10k	"	"
R15	— "	10k	"	"
R16	— "	1k	"	"

RV1 — 2 gang 10k Lin. Pot

RV2 — Trimpot 4.7k (Large Type)

C1 capacitor	0.1 uF 100V	
C2 "	0.1 uF 100V	
C3 "	10 uF 25V	electrolytic
C4 "	10 uF 25V	"
C5 "	220 uF 16V	"
C6 "	220 uF 16V	"
C7 "	0.22 uF 100V	
C8 "	0.22 uF 100V	
C9 "	220 uF 16V	electrolytic
C10 "	220 uF 16V	"
C11 "	1000 uF 25V	"
C12 "	1000 uF 25V	"

Q1 Transistor	BC108	or equivalent
Q2 "	BC108	"
Q3 "	BC108	"
Q4 "	BC108	"

D1-D4 Diode EM401 or equivalent
Transformer 240/12.6V 150mA

PC board ET025.
Metal box

4 way coaxial sockets.
Double pole 240V switch MSP 625 or similar.
Rubber grommets.
3 core flex and plug.
Cable clamp (for mains cord).
Knob for pot.
Nuts and bolts.
4 spacers ¼" long for PC board.
Coaxial cable wire etc.

must be left disconnected.

Switch on all units; and play a stereo recording through the system. Adjust RV1 (front panel control) for minimum putput in speaker channel 2. Leave RV1 in this position for the time being. Mark this position on the case — it represents the normal stereo setting.

Now connect input 2 and output 1, and disconnect input 1 and output 2. Again play the record through the system but this time adjust RV1 to give minimum output in speaker channel 1.

Reconnect input 1 and output 2. The unit is now ready for use.

It should be noted that the volume level will drop as RV1 is turned towards the 'super-stereo' position, this should be corrected by adjusting the volume control.

CONSTRUCTION

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

The simplest way to build the unit is to assemble the components on the printed circuit board – the foil pattern of which is shown full-size in Fig. 2.

Figure 3 shows how the components are assembled on the printed circuit board. Ensure that transistors, diodes and electrolytic capacitors are correctly orientated. Trimming potentiometer RV2 should be bent over slightly to allow ease of adjustment.

The assembled printed circuit board, together with the mains transformer and potentiometer RV1, should then be fitted into the metal case.

For our prototype unit, we used the chassis shown in Fig.4. This drawing shows sufficient details for those who wish to construct their own case.

Leads carrying audio signals must be screened if they are longer than an inch or so. However if the unit is assembled as shown in Fig. 5, only the output leads require screening. Co-axial cable or standard screened lead is suitable for this purpose.

When wiring up the power supply note that the transformer centre tap is not used.

It is of course perfectly feasible to build the circuit and controls within an existing stereo amplifier – in which case the power supply would not be required. (The unit draws only a few milliamps and within the range of 12 to 18 volts, voltage is not overly critical). ●

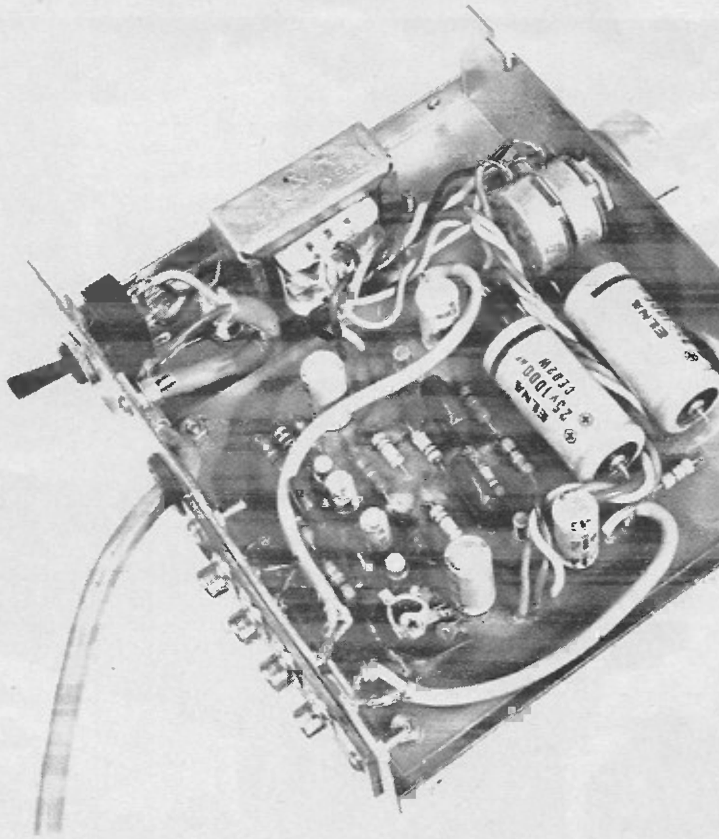
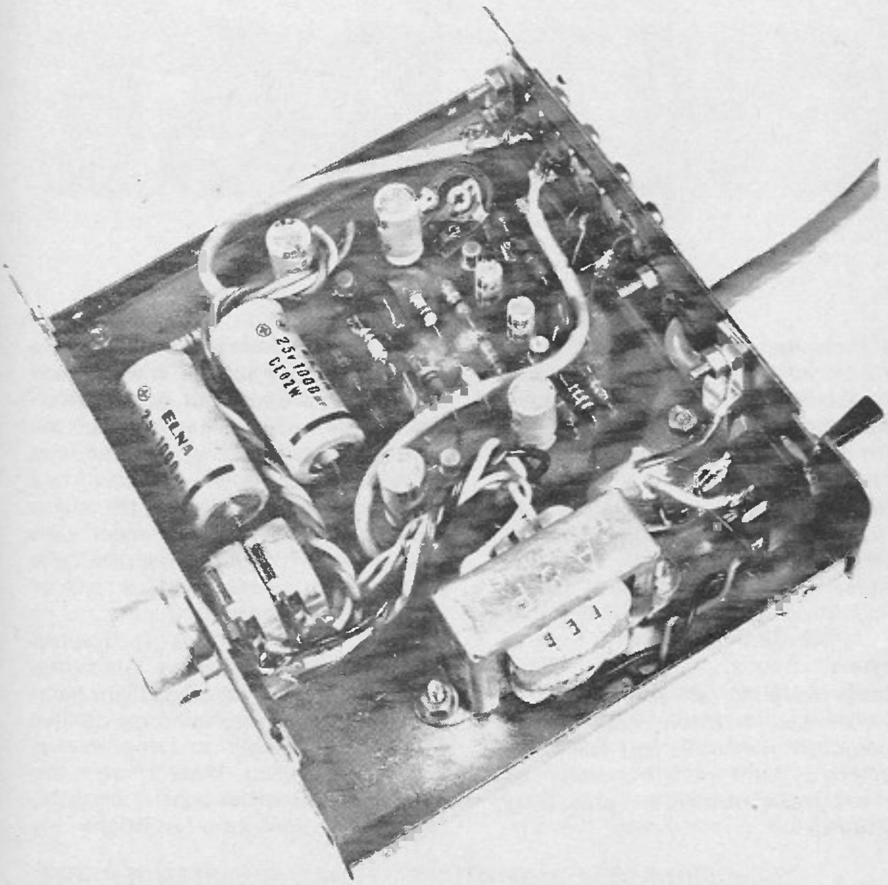


Fig. 5. Note how very short leads are used to connect the output sockets to the printed circuit board. Screened leads have been used only for the longer input connections.



HOW IT WORKS

Basically the circuit consists of two practically identical channels. This text describes the operation of channel 1.

The circuit consists of a buffer stage that provides both a unity gain 'in-phase' output, and an attenuated (39%) 'out-of-phase' output. Potentiometer RV1 enables the output of the buffer stage to be varied between either the 'in-phase' or 'out-of-phase' condition. This output is fed to mixer transistor Q3.

The output of Q3 consists of the channel 1 input plus a proportion of channel 2. The amount of channel 2 signal that is mixed with channel 1 depends upon the setting of RV1 and can vary from the full 'in-phase' channel 2 signal (mono) through zero input from channel 2 (normal stereo), through to 39% 'out-of-phase' (super-stereo).

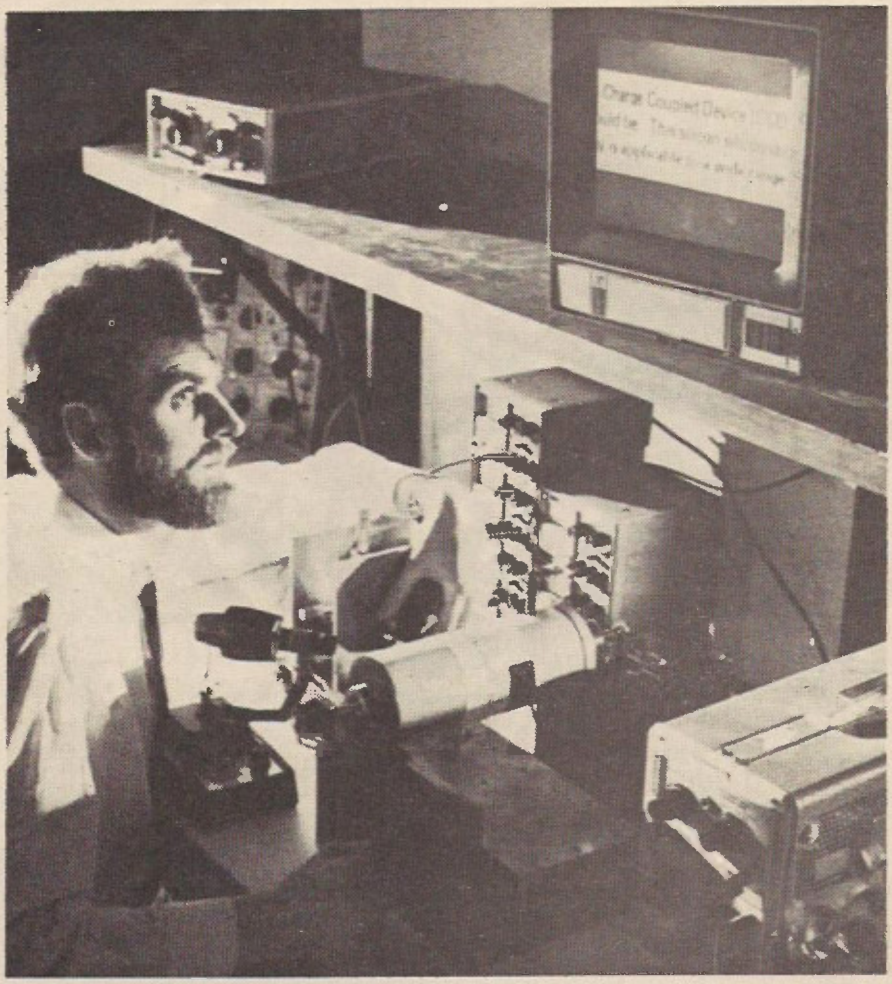
The operation of channel 2 is similar to that described above.

The mixing process either amplifies signals common to both channels – or attenuates the common signal (super stereo).

Buffer transistor Q1 is biased by R1, R2 and R5. Capacitor C3 provides some positive feedback to increase the input impedance (bootstrapping). Q1 has unity gain at the emitter (in-phase), and an inverted signal of 39% of the input voltage at its collector. RV1 provides the variable output. The bias for mixer Q3 is derived from the output of Q1 via R10.

The power supply consists of a 12.6V transformer, a bridge rectifier, and filter capacitor C12. Further filtering is provided by R16 and C11. Due to the large amount of filtering capacitance – and the low current drawn by the unit – the unit will continue to operate for about 45 seconds after it is switched off.

New semiconductor principle permits simpler construction of many electronic devices.



A scientist adjusts the lens of an imaging device using the charge-coupling principle.

CHARGE

A new solid-state device for electronically "reading" graphic material has been developed at Bell Telephone Laboratories (BTL) using charge coupling, a recently discovered semiconductor principle that permits simpler construction of electronic devices.

The device can be used to scan print or photographs line-by-line, and convert variations in light intensity into an electrical signal. Transmitted to a remote location, this signal can reproduce an image of the original with high resolution.

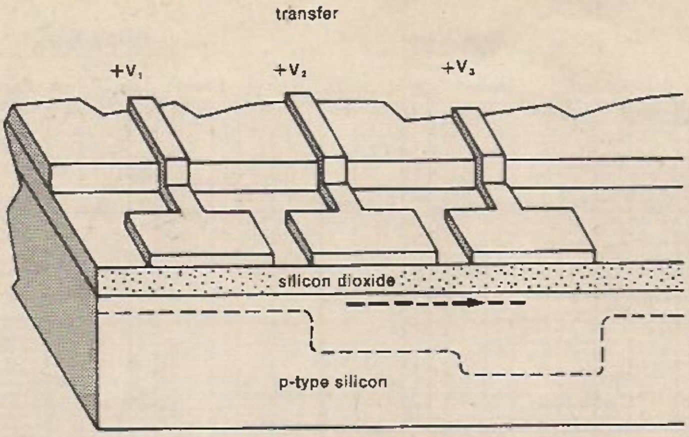
The imaging device, which represents an important practical application of the charge coupling technique announced by Bell Telephone Laboratories last March, ultimately could be used to transmit images of print, drawings or photographs over the telephone network.

The charge coupling principle makes possible simple devices that perform electronic functions usually requiring complex integrated circuitry. Fewer critical processing steps are required for fabrication than with many integrated circuits.

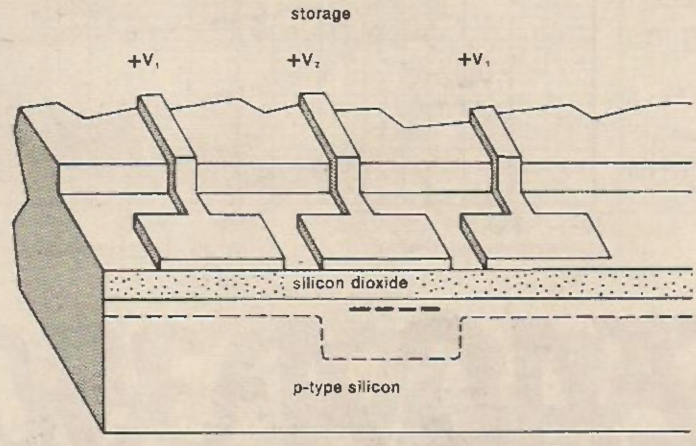
Charge coupling can also be used to make devices for information storage in computer memories and telephone switching systems as well as devices to perform information processing functions.

The imaging device is a silicon chip oxidized on one surface with a linear array of 288 electrodes deposited on top of the oxide. Electrodes on the device operate in groups of three, and every third electrode is connected to a common conductor running the length of the device. The region under each three-electrode group serves as one light-sensitive element, for a total of 96 elements.

In operation, the lens focuses an image of the document onto the surface of the silicon chip. Light from the document causes minority carriers or negative charges to be generated within the silicon. More charges are generated where the light is brighter; fewer where the light is less bright.



In a charge coupled imaging device, incident light causes free electrons to be generated within the silicon, more where the light is brighter and fewer where it is less bright. An array of electrodes overlays the silicon and the free electrons collect at the electrode with the highest positive potential in the area where they are generated. These charge packets are transferred along the surface of the silicon by applying a more positive voltage to the electrode next to the one holding the charge. The varying packets of charges collected at the end of the device are read out as an electrical current whose analogue variations represent variations in light intensity on the document being transmitted.



COUPLING

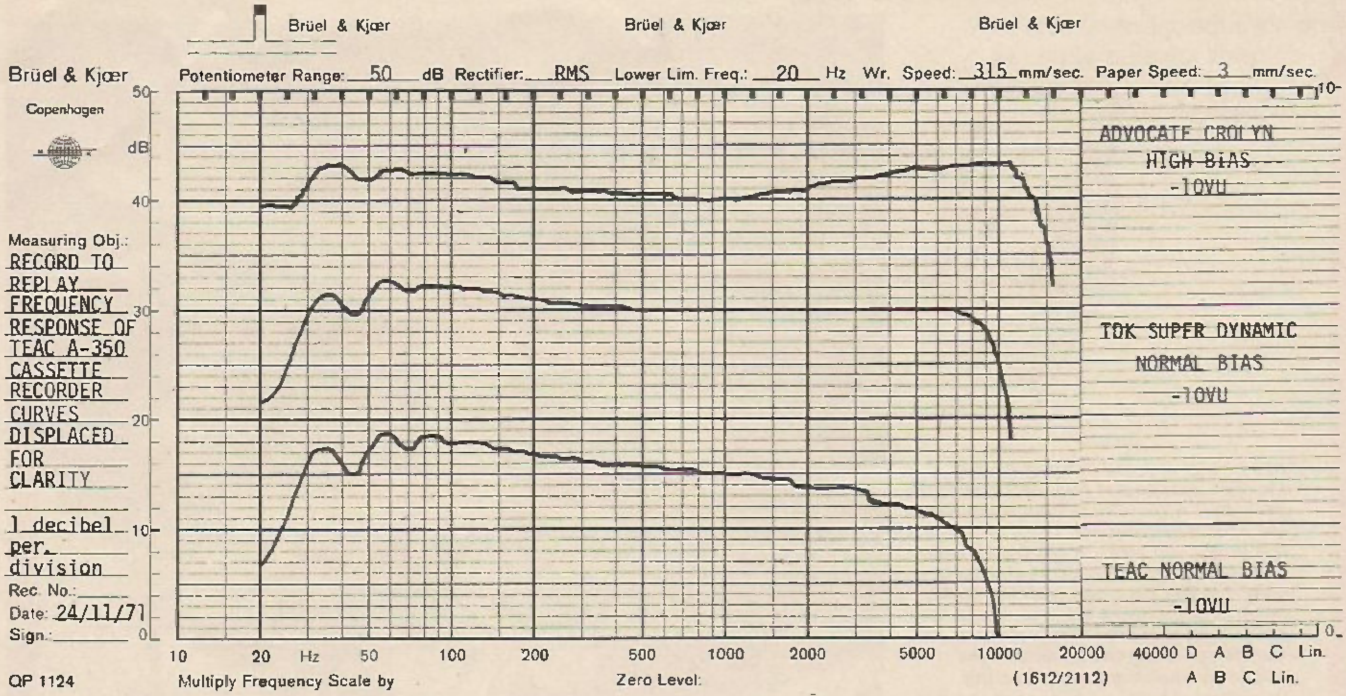
In each element, the centre electrode is connected to a more positive voltage with respect to the silicon than the other two. Charges, generated by the light near that element, collect at the surface of the silicon under this centre electrode. Since the number of collected charges at each element is proportional to the light flux falling on the silicon at that position during an accumulation period, the resulting concentration of charges is a linear measure of light and dark areas on the original document. In the experimental device, the charge pattern is accumulated in 2.5 ms.

At the end of the accumulation period, the groups of charges are transferred along the surface of the silicon by successively applying a more positive voltage to the electrode next to the one holding the charge, while decreasing the voltage on the electrode over the charge packet. This causes the packet to move from under one electrode to under the adjacent electrode. This transfer process, called charge coupling, is repeated until each charge packet has passed along the array of electrodes to the end of the device.

When they reach the last electrode, the packets of charge are collected by an output electrode, forming an electrical current whose analogue variations represent variations in reflected light intensity along a line of the original document. Read-out from the device requires about 96 μs.

The experimental line-imaging device scans the document to be transmitted along one dimension and converts light and dark areas into an electrical signal. The document being scanned must be moved relative to the device to generate a two-dimensional image.

In this experimental version, the scanning system containing the new device consists of a light source to illuminate the document, a lens to focus an image of the document onto the surface of the imaging device, a drive mechanism to move the document from line to line as it is scanned, and the silicon imaging device itself. ●



TEAC A-350 DOLBY C

electronics TODAY INTERNATIONAL product test

TEAC's new generation cassette recorder offers truly hi-fi performance.

THE TEAC A-350 is the second cassette recorder that we have reviewed which incorporates the Dolby noise reduction system as an integral part of the recorder. It is the first with high density ferrite heads. Many more will be marketed in the near future, for the recent advances with chromium dioxide and other new magnetic materials, greatly improve the frequency response obtainable.

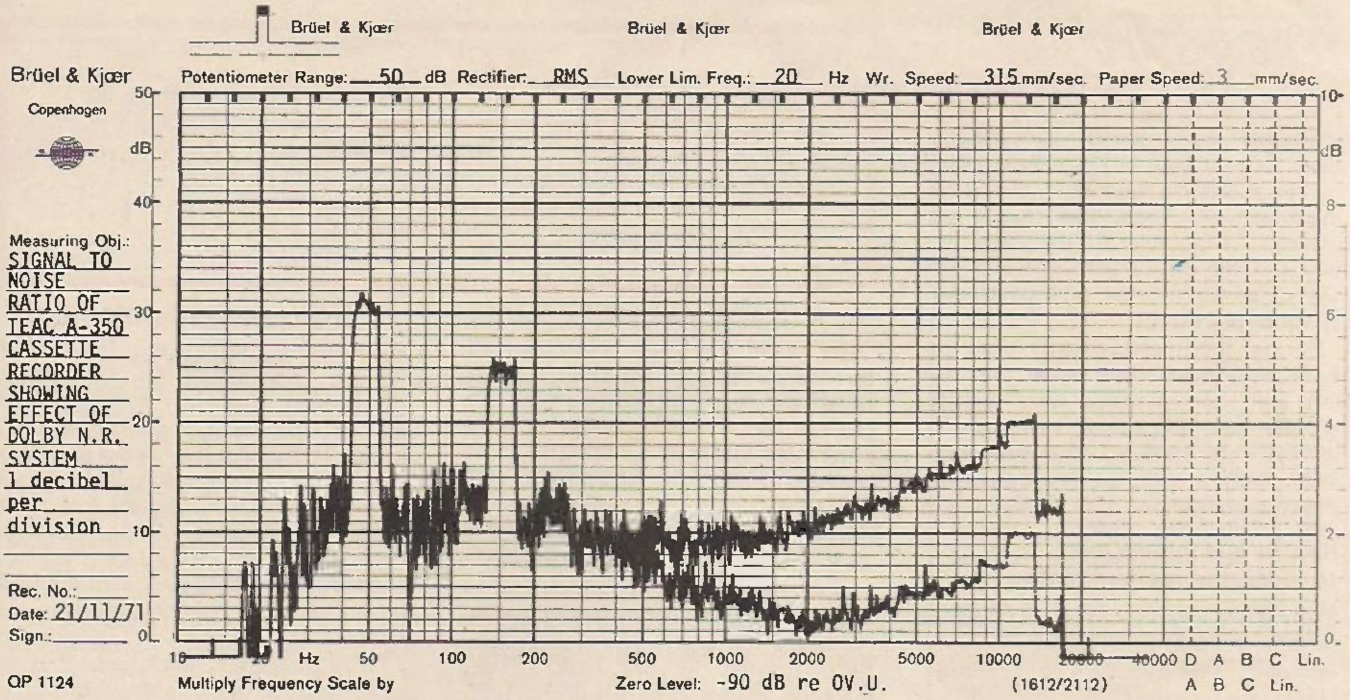
As with all TEAC equipment, the external appearance of the TEAC A-350 is pleasing to the eye. The control panel, which is moulded in a black plastic, is partially covered with brushed stainless steel panels and is fitted into an oiled timber base with high end panels. The left side of the deck contains the tape compartment, a set of six piano-type function keys, an index counter, a tape run indicator, a record mode indicator and a tape eject button.

The design of the cassette carrier used in this recorder is unusual. It is in two parts — comprising a metal carrier onto which the cassette is placed, and a large dust cover. Normally these two components are combined, making it virtually impossible to clean the heads and difficult to clear should the tape get caught up on the pinch roller. Another good feature of the dust cover is the large viewing window, measuring 1-3/8" x 2-3/4" providing a clear view of the cassette. A counter, with reset button, is located on the far left, just below the dust cover. An orange strobe-type indicator, showing that the tape is actually running, is located just below the tripmeter. Six piano keys provided the following functions; from left to right:—

a) Record, with an illuminated bezel strip above it.
b) Fast reverse.
c) Play.
d) Fast forward.
e) Stop.
f) Pause.

The sixth (pause) key is particularly useful. This can be depressed first so that there is no tape movement, particularly when selecting the record mode. All keys, with the exception of the pause key, are interlocked so that the stop key has to be operated each time before another function can be selected, thus minimizing the chance of pressing a wrong key.

The right hand side of the machine contains two medium sized VU meters; slide controls for input and output levels; microphone or line input, tape bias and Dolby mode switches and a peak level indicator.



CASSETTE RECORDER

The VU meters, which are mounted on a sloping panel to improve visibility, are well illuminated and graduated to within ±10% of actual level.

The addition of a peak level indicator provides an accurate indication of peak levels. These are more critical with chromium dioxide tapes, as stated in our previous issue. We found this indicator hard to see under normal lighting conditions, unless you are directly over it, because of its small size and relatively low light output. Depending on the type of music being recorded, it is possible to reach peak level with the VU meter reading -10 on low frequency transients. Four slide controls are mounted to the left and below the VU meters and provide level control of each chanel in the record and playback mode. These controls are very smooth in operation, and provide more than adequate level control. Three toggle switches and a power on/off rocker switch are located to the right of these controls. The toggle switches select normal or high bias, line or microphone input, and Dolby on/off.

A white indicator above the VU meters is illuminated when the Dolby system is selected.

Three large jack sockets are located on the front panel for left and right channel microphone inputs, and a stereo headphone output, (which is in parallel with the line output.) Standard R.C.A. type input and output sockets are located on a recessed panel at the back of the recorder, together with a DIN input/output socket.

Whilst most cassette recorders utilize tape tension comparators to stop the recorder at the end of a tape, the TEAC utilizes a new and superior system consisting of a rotary magnet and a reed switch with time delay circuit. Should the feed spool stop, due to a tape break or because the tape has finished, this mechanism will stop the recorder, after two to three seconds, and release the pinch roller as well as resetting the function switches.

MEASURED PERFORMANCE

In many respects the measured performance of the TEAC A-350 is extremely good, in others it is above average.

One exceptional characteristic is the very low wow and flutter. This was only 0.06% rms when checked using a standard TEAC cassette. We found

TEAC A-350 DOLBY CASSETTE RECORDER

that this figure varied considerably from tape to tape but rarely exceeded the 0.13% claimed by the manufacturer. These low figures are mainly attributable to the large fly-wheel in the drive mechanism and the use of an outer-rotor type hysteresis-synchronous motor.

During the measurements and the subjective tests it was noted that the left and right channels were slightly different. Further investigation showed that the bias settings for each channel were completely different, as shown below.

Relative bias settings prior to conducting measurements

Bias switch setting	Right Channel	Left channel
Normal	0dB (reference level)	+2.6dB
High	+1dB	+4dB

We have not been able positively to establish whether the bias settings were changed subsequent to manufacture. Correctly biased, we obtained good frequency responses, with both standard and chromium dioxide tapes.

The overall performance of the recorder was subjectively tested by playing specially pre-recorded cassettes and by recording excerpts from two records; Warner Brothers — JBL test record, and the CBS Simon and Garfunkel "Bridge Over Troubled Waters". The tapes were then compared with the record in an A-B type test. When chromium dioxide tapes were used, the difference between the original and the tape was particularly hard to detect, the only discernable loss being at very high frequencies. The loss was more apparent to the ear when conventional cassettes were used, as their frequency response rolls over before 10kHz on this recorder. In many homes, or where background music is required, the difference would not be noticeable.

For these tape comparisons the Dolby system was used and the marked reduction in tape noise provided by the Dolby Noise Reduction System was quite apparent, and certainly a necessary function to be used, if one desires to utilize the maximum frequency performance that chromium dioxide tapes can provide.

The frequency response obtainable from this machine is largely determined by the type of tape being used. Table I shows the extraordinarily wide range obtainable (at -10VU) with Advocate Crolyn and BASF C_rO_2 tapes compared with a number of the other top quality tape cassettes.

Tape	Measured Frequency Response
Advocate Crolyn Tape	20Hz to 14kHz ±3dB
BASF C_r02	20Hz to 12kHz ±3dB
TDK Super Dynamic C60	25Hz to 9kHz ±3dB
Scotch High Energy Cobalt C60	20Hz to 8kHz ±3dB
TEAC C60 cassette	25Hz to 5kHz ±3dB

The main circuitry is located on three separate printed circuit boards, which are clearly labelled so that each channel and its respective trimmer potentiometers can be identified. All the transistors are silicon and the microphone preamplifier has a frequency response of 20-20kHz +0 -2dB. The drive motor is fitted with a double grooved pulley, which can be inverted to provide the speed change necessary for 60Hz. The mains power fuse, located in the base of the machine, incorporates a multipin plug, which has five positions. These provide voltage settings 240V, 220V, 200V, 117V and 100V.

The high density ferrite heads fitted to the tape recorder carry a lifetime guarantee with respect to wear and performance. The recorder is supplied with a very basic, illustrated, eight page instruction manual complete with circuit diagram. TEAC also supply a quick reference card with operating instructions on the front and maintenance instructions on the back.

A full set of R.C.A. patching leads, and a cleaning kit consisting of a bottle of cleaning fluid and a packet of cotton swabs are also supplied.

The recorder was a delight to use and certainly should make anyone question the advantages of a conventional reel to reel recorder, with its attendant threading problems and relative inconvenience.

This "Dolbyised" deck helps to place cassette recorders in a new position in the High Fidelity field. They are no longer toys.

The inclusion of the Dolby system within the machine obviates the problems and inconvenience that occur with a separate Dolby unit which we personally dislike from a ergonomic point of view.

With a suggested retail selling price of £146.52 this unit is good value for money. ●

MEASURED PERFORMANCE TEAC A-350 STEREO CASSETTE DECK WITH DOLBY, MODEL A-350 SERIAL NO. 4346

Record to Replay Frequency Response

With TEAC C60	
0VU	-10VU
25Hz to 4kHz ±3dB	25Hz to 5kHz ±3dB
With Advocate Crolyn C_r02 C60	
0VU	-10VU
20Hz to 8kHz $^{+2}_{-3}$ dB	20Hz to 14kHz ±3dB
Wow and Flutter	
0.06% RMS	
Total Harmonic Distortion Re 1kHz Signal	
0VU	-10VU
1.4%	0.4%
Signal-to-Noise Ratio Unweighted	
55dB	
Cross Talk at 0VU	
1kHz	100Hz
41dB	43dB
Intermodulation Distortion	
With 1kHz and 970Hz Signal @ 0VU	
-41dB	
Line Input Sensitivity for 0VU	= 86mV
Microphone Input Sensitivity for 0VU	= 3.6mV
Line Output Sensitivity for 0VU Signal Level and Maximum Gain	=700mV
Dimensions: 4-3/8" (H) x 16-15/16" (W) x 9-7/8" (D)	
Weight: 11-3/4 lbs (5.3kg)	
Price: £146.52	

INPUT GATE

LETTERS FROM OUR READERS

FOUR–CHANNEL FALLACY

In your July issue you published a review of the article by myself and Dr. Sciama on Gravitational Radiation. It so happens that I have also been doing work in another aspect of wave-motion which is a major topic in the same issue, namely the attempt to extend stereo to giving the listener all-round directional information of a 360° sound stage.

Very briefly, my point of view is that the concept of 'four-channel' reproduction is quite fallacious in relation to existing discs, where evidently we have precisely two channels. Existing FM stereo broadcasts also give two channels, although there is sufficient bandwidth to provide a three-channel system, and this gives rise to some very interesting practical possibilities. Where we can have four channels, namely in special tape cassettes, it is by no means clear that this gives a practical advantage over an optimally coded three-channel system. In any case, pair-wise blended four channel 'discrete' emphatically does not represent the optimum way in which we could use four channels if we had them available.

These views are of course somewhat controversial, even heretical, but are strongly supported by the work of others, and there seems to be increasing recognition that the 'four-channel fallacy' is a barrier to progress in this subject. — Prof. P.B. Fellgett, Univ. of Reading.

LSI

Whose leg is being pulled in the large scale integration news item on page 8 of your July issue? — S. G. S., Hemel Hempstead.

ETI PROJECTS

We have been approached by one of your readers with a proposition to manufacture, and offer for sale to the public, some of your excellent Projects. Are your Projects covered by patents? — T. C., London.

 The same applies to constructional projects except that, where we have not taken out patent rights on any of our projects, we cannot guarantee that patents have not been taken out elsewhere. Any company wishing to manufacture equipment based on ETI projects should first discuss the matter with us — and also with a Patent attorney. — Ed.

ZERO TRACKING ERROR

The pickup arm referred to on page 58 of your July issue does *not* have zero tracking error. Indeed, if the head remains parallel to the fixed portion at the rear, then obviously it does not remain parelle! to the groove at all points. This arm is evidently operated as a parallelogram, i.e. with the twin booms of similar length. The secret of the Garrard Zero-100, and before that the BJ arm, is the use of *twin booms of unequal length.* I am completely baffled at the claim made by Garrard that they are the first! If Jim Davies will kindly use an alignment protractor on his tone-arm, he will find errors of up to five degrees in the tracking.

Congratulations on a really interesting new magazine. — I. Cosens, Avgarde Gallery Ltd., Manchester.

PHONE HANDSET

In your July News Digest you feature a telephone handset developed by the Bell Telephone Laboratories with a built-in volume control. The write-up gives the impression that this is something quite new. In fact, the British Post Office has offered such a handset, known as Handset 4, for some considerable time.

The British instrument would appear to differ from the American in providing a variable volume control which the user can adjust to suit his particular needs. — J. I. M., Shrewsbury.

READERS' LETTERS

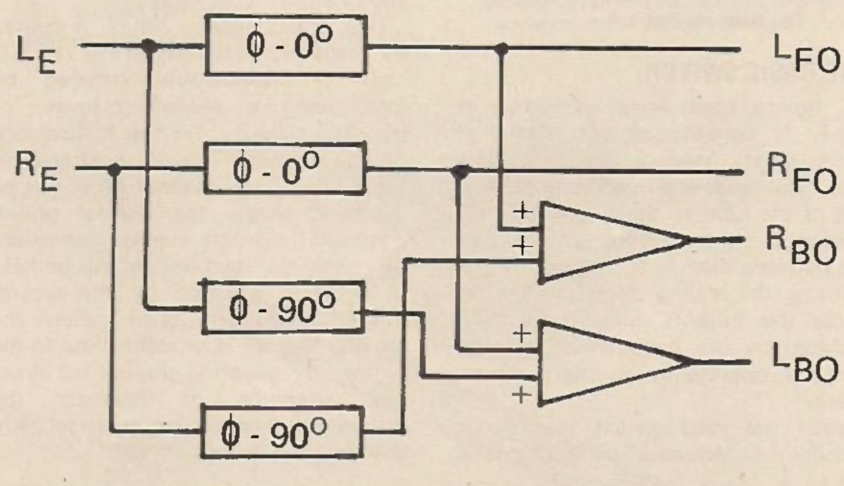
It is our policy to reply to all readers' letters — but not necessarily in these columns. Please give your name and full address in your letters. While we cannot, for obvious reasons, enter into correspondence on products not mentioned in ETI, we welcome informed and/or experienced opinions on all subjects of general, engineering and electronic interest.

We try to reply to letters as quickly as we can. However, if sometimes there is some delay, please bear with us and do not think that your letter has been ignored. — Ed.

CBS-SONY SQ

In the diagram on page 51 of your July issue, the equations for L_{FO} and R_{BO} should have 'j' multipliers for $0.707\ L_{BI}$. Also, to obtain the resultant signals quoted in this diagram, the SQ decoder diagram on page 49 should be as shown below :

— R.J.H. Brush, University of Dundee



PRACTICAL GUIDE TO REED SWITCHES

The dry reed is an almost perfect low-current switch.

It is fast — operating times of less than one millisecond are typical. It is reliable — as many as one billion operations can be achieved. And it is cheap — quantity price is well under 50 cents.

The dry reed switch is not by any means a new device for it was invented back in 1945 by Dr. W. B. Ellwood of the USA's Western Electric Corporation.

But it was ahead of its time. It remained practically unnoticed by the engineering world until only a few years ago when it was 'rediscovered' by the telephone industry.

And since then reed switches are receiving interest and acceptance at an ever increasing rate.

In its basic form, a reed switch is a magneto-mechanical relay. In other words it relies upon a magnetic force to initiate a mechanical switching action.

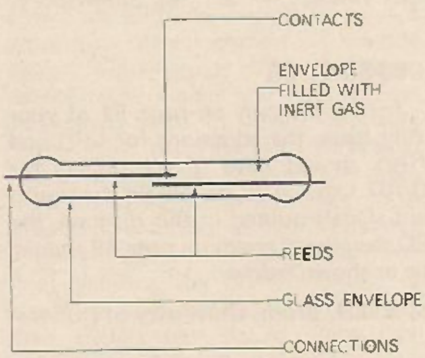


Fig. 1. The basic reed switch.

THE BASIC SWITCH

A typical reed switch is shown in Fig.1. It consists of two flattened ferromagnetic reeds sealed in a glass tube. The reeds are fixed, one at each end of the tube, so that their free ends overlap in the centre but with a 0.01" gap between them.

During the sealing operation the air inside the tube is pumped out and replaced by dry nitrogen so that the contacts operate in an inert atmosphere.

When the reed switch is brought within the influence of a magnetic field (either from a coil or a magnet) the reeds — being ferromagnetic — become a flux-carrying portion of the magnetic circuit. The extreme ends of the reeds will assume opposite magnetic polarity, and if sufficient flux is present, the attraction forces overcome the stiffness of the reeds and they flex towards each other and touch.

When the magnetic field is removed the reeds spring back to their original positions. There is however a difference between the value of field required to close the reeds, and the reduced value that will allow them to open again.

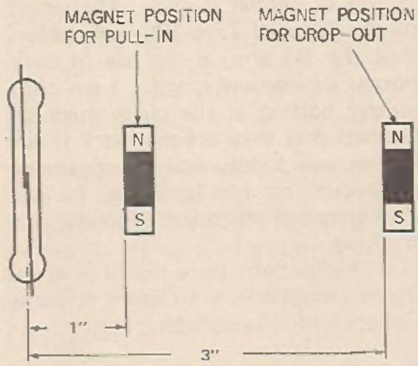


Fig. 2. The reeds close when the magnet is brought within one inch, and will remain closed until the magnet has been moved at least three inches away.

A typical example of this is shown in Fig.2. In this example the reeds close when the magnet is brought within one inch, but they will remain closed until the magnet has been moved about three inches away.

This phenomena — which is caused by magnetic hysteresis in the reeds — can be considerably reduced by introducing a second magnet, of opposite polarity, on the further side of the switch. This is illustrated in Fig.3. The fixed magnet must not be mounted within the normal pull-in position for single magnet operation, otherwise the reed switch will be held in a closed position by the second magnet and will open when the moving magnet is brought close to the switch. By selecting the correct types and strengths of magnets the differential can be set to practically any required value.

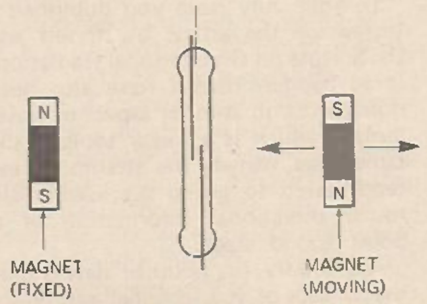


Fig. 3. A fixed magnet of opposite polarity to the moving magnet may be used to reduce pull-in, pull-out differential.

OPERATING MODES

As can clearly be seen in Fig.1, the reed switch is 'normally open'. The reeds close when a magnet is brought close to the switch enclosure.

However there are many applications where the switch is required to be 'normally closed' and to open when the magnet is introduced. This can be done either by biasing the switch with a second magnet (as shown in Fig.4), or by using a reed switch with change-over contacts (Fig.5).

In most applications where a reed switch is opened or closed by a permanent magnet, the magnet is fitted to a moving part, and the reed is fitted to a stationary part.

There are, however, a number of applications in which both the magnet and the reed must be located on a

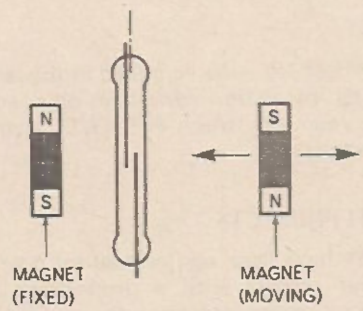


Fig. 4. 'Normally closed' operation can be obtained by biasing a 'normally open' reed switch with a fixed magnet. The moving magnet cancels out the fixed magnet and thus allows the switch to open.

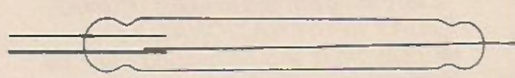
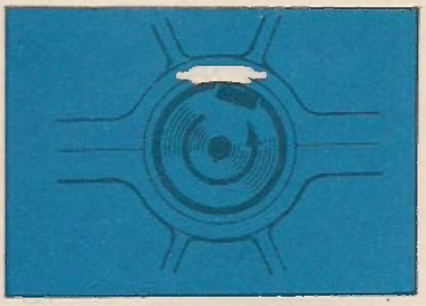


Fig. 5. This type of reed switch may be used for either change-over, or normally closed operation.



Tachometer applications, requiring the simplest addition to the moving part and offering ability to work in unfavourable conditions, plus high speed operation.

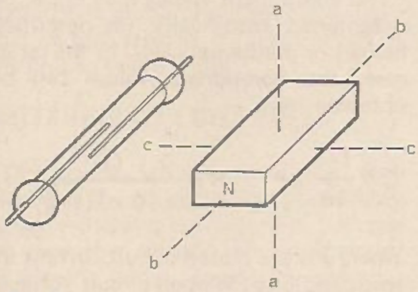


Fig. 6. Linear planes of operation; movement of the magnet in any of the planes indicated may be used to actuate the switch.

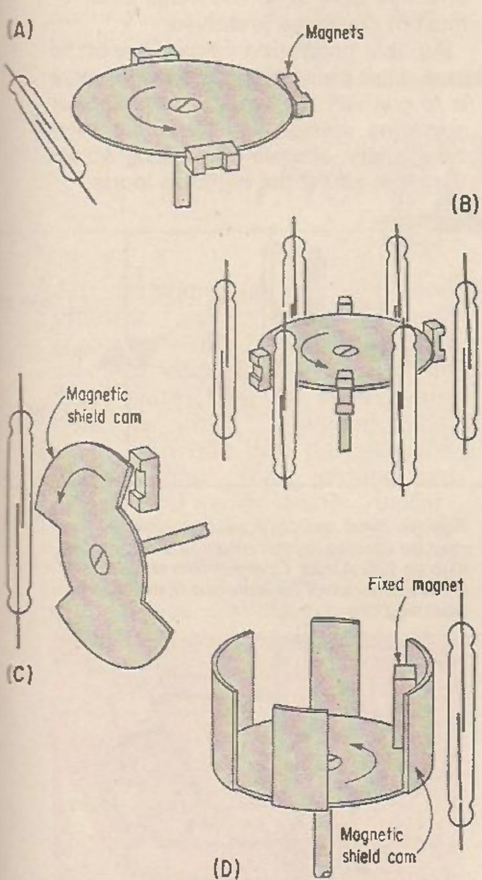


Fig. 7. Rotary motion may also be used to actuate a reed switch. In A and B the switches are stationary and the magnets rotate. In examples C and D both the switches and the magnets are stationary and the switch operates whenever the cutout portion of the magnetic shield is between magnet and switch.

stationary component. Operation may then be effected through distortion of the magnetic field by an external moving ferrous mass. If the magnet and the reed are sufficiently close, the reeds switch will be normally closed, but will be opened by the magnetic shunting effect of the external ferrous object. Alternatively, the magnet may be located so that the reeds are normally open and the external ferrous object used to 'reinforce' the field and thus close the reeds.

There are many different ways in which a moving magnet may be caused to operate a reed switch.

Linear planes of operation are shown in Fig. 6.; movement of the magnet in any of the planes a-a, b-b, and c-c will operate the switch. Magnet selection is fairly critical if the switch is operated in mode b-b, spurious operation may be caused by negative peaks on the magnet's field pattern curve. If these are large, the reeds will pull-in three times as the magnet is moved from one end of the switch to the other.

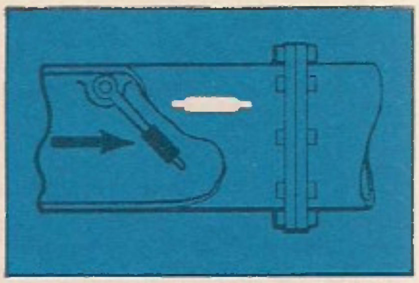
Rotary motion may also be used. Various ways of achieving this are shown in Fig.7. (A most versatile and simple impulse generator can be put together in a few minutes by placing one or more magnets on a gramophone turntable and fastening a reed switch to the motor base board. (Fig.8). Switching rates from approx one every two seconds to well over 2000 a minute can be selected merely by changing the turntable speed and/or using more magnets!)

Since the reed switch is truly a sealed device, it can be used in applications where conventional switches are not permitted, or where they have very limited life. Reed switches are frequently used in simple on/off push buttons, and outdoors, in dusty areas such as cement plants, especially in areas where explosive gases may be present.

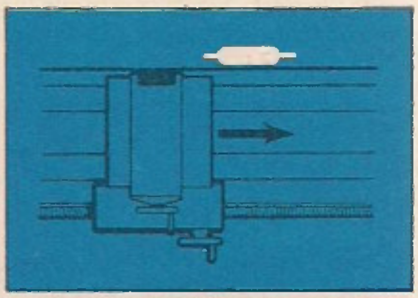
OPERATING LIFE

The operating life and load carrying characteristics of reed switches are interrelated. A switch may operate for 100 million or even 1000 million closures providing it is switching very

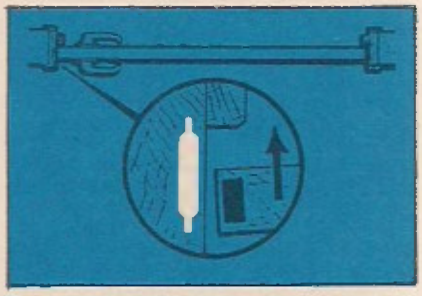
The reed switch is functional and versatile. It is almost the simplest elemental form of switch and has innumerable applications — from straightforward functions in which switch actuation is initiated by the proximity of a permanent magnet — to complex logic and computing functions, using hundreds of electromagnetically driven reeds. This practical three-part article, by Collyn Rivers, explains how and why they are used.



Flow control and indication, minimising restraint on the moving part and avoiding perforation of the container wall.



Position control and indication, obviating mechanical contact with its implications of wear, and simplifying mounting.



Door switches, obviating mounting and adjustment problems, and offering total concealment for security devices.

PRACTICAL GUIDE TO REED SWITCHES

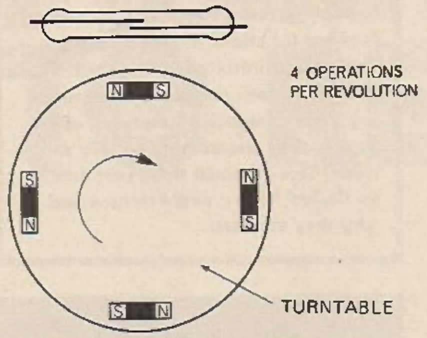
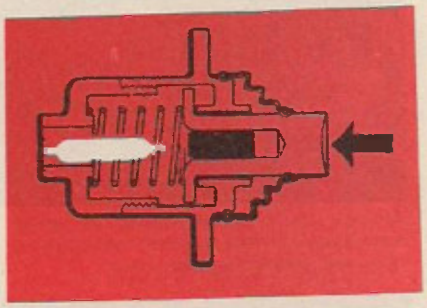


Fig. 8. Simple yet versatile impulse timer can be improvised by placing one or more magnets on a gramaphone turntable.

low currents. But the same type of switch may fail after half a dozen switching cycles if the load greatly exceeds the designed rating. The majority of reed switches are manufactured with contact ratings between 0.1A and 3.0A.

The current handling capacity of reed switches varies from type to type.



Switching in explosive atmospheres, obviating ignition risk; in dust filled atmospheres where conventional contacts would be unreliable; and in extremely cold conditions where ordinary switches would freeze up. In radioactive environments, magnetic operation can maintain integrity of shielding.

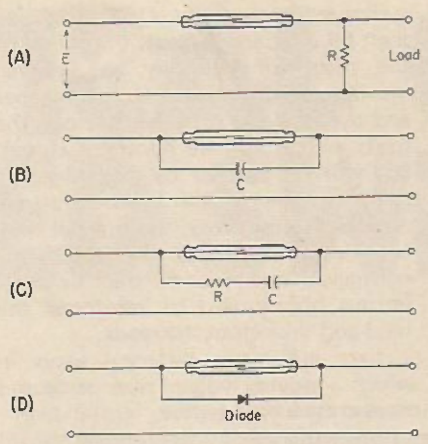


Fig. 9. Contact protection techniques: A – Resistor shunting load. B – Capacitor shunting contact. C – Resistor-capacitor series network for ac loads. D – Diode shunting.

In general the rating will be determined by the size and surface plating of the reeds, for the reed is an electrical conductor, and current rating will be a function of contact area.

The maximum rated contact loading is only applicable for purely resistive loads. If the load is capacitive or inductive the switch must either be drastically derated, or the switch contacts protected in a suitable fashion.

Four suitable methods of contact protection are shown in Fig.9.

In dc circuits all that may be required is a resistor shunted across the load (Fig.9A). Where the load is a relay coil or operating solenoid a resistor of approximately eight times the coil resistance is adequate to absorb a major portion of the induced energy when the circuit is interrupted. The addition of the resistor will of course increase the steady-state current flow but this extra load is negligible.

Another cheap and simple way to protect the reed switch is to wire a capacitor across the contacts. The required value depends upon load current, but something between 0.1 uf and 1.0 uf will be sufficient. (Fig.9B).

The most generally used method of protection is the resistor-capacitor series network shown in Fig. 9C. This circuit must be used if the switched load current is ac. The resistor should be approximately 160 ohms and the capacitor somewhere between 0.1 uf and 1.0 uf. That this is an extremely effective method was proven by a recent trial during which a motor starter was switched 50 million times without failure.

The component values may either be determined empirically (as described below) or mathematically. In the latter case, the component values can be obtained from –

$$C = \frac{I^2}{10}\,\mu F \quad , \quad R = \frac{E}{10 \times I\left(1+\frac{50}{E}\right)}\,\Omega$$

Where I is the closed circuit current in amps and E is the open circuit voltage in volts.

A fourth method of protection is to connect a diode across the switch contacts. (Fig.9D). This method is effective only with dc; diode polarity must of course be preserved.

Suitable protection circuits are often best determined empirically. One way is to connect the switch to the normal operating voltage and load, and then to actually observe the arcing across the reeds whilst the switch is in use.

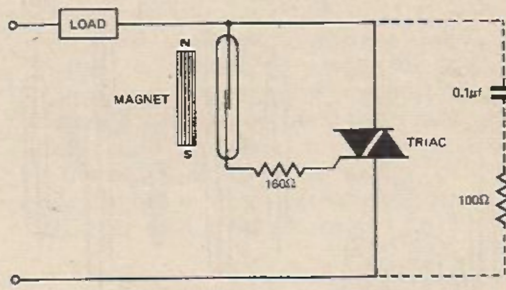
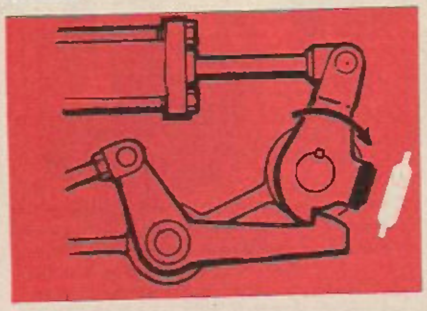


Fig. 10. Reed switch/Triac combination may be used to switch single phase loads as high as 125 Amps. Components shown in dotted lines must be included if the load is reactive.



Safety interlock switching, giving extreme reliability and simplicity of application to complex mechanical layouts. Reed insert completes circuit to illuminate warning lamp or permit further stage of operation.

SPECIFICATIONS	STANDARD	MINIATURE
Maximum voltage	150 Vdc 250 Vac	50 Vdc 150 Vac
Maximum current	2.0A	0.5A
Maximum power	25W	6W
Max. initial resistance	50 m.ohms	100 m.ohms
Max. end-of-life resistance	2 ohms	2 ohms
Peak breakdown voltage	500 V	300 V
Closure rate	400 Hz	2000 Hz
Insulation resistance	5000 M.ohms	1000 M.ohms
Temperature range	-55°C to +150°C	-55°C to +150°C
Contact capacitance	1.5 pF	0.5 pF
Vibration	10G at 10-55Hz	10G at 10-55 Hz
Shock	15G minimum	15G minimum
Life at rated load	5 x 10^6 operations	5 x 10^6 operations
Life at zero load	500 x 10^6 operations	500 x 10^6 operations

Table 1.Typical specifications for standard and miniature reed switches.

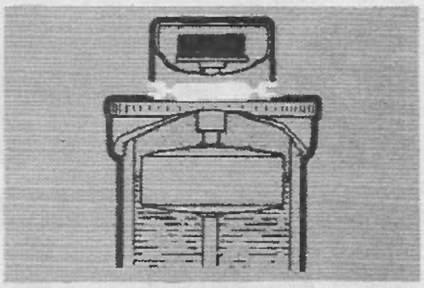
HEAVY CURRENT SWITCHING

There will be many applications in which a reed switch can usefully be used to switch very large currents. This can be done quite simply by combining a reed switch with a Triac. (Fig.10). Even miniature reed switches will safely carry the gate current required to trigger the largest Triacs, and by using this system it is possible to switch single phase loads of whatever Triac rating is used. Triacs can be readily obtained with ratings from 1 amp to 125 amps.

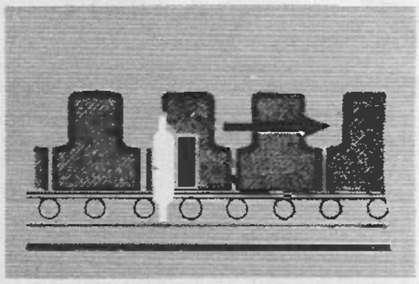
Three phase loads can also be switched by using the reed switch to energize a miniature three pole relay that in turn triggers a Triac in each of the phases of the supply.

SWITCHING AT LOW LEVELS

One great advantage of the reed switch is its ability to operate reliably when switching currents and voltages at very low levels. This is a major problem with standard switches because there is insufficient energy to break down non-conducting films on the switch contacts. But a reed switch — due largely to its gold-plated contact surfaces and inert atmosphere — will perform satisfactorily for at least a billion operations.



Hydraulic brake fluid level indicator, where feasibility depends on simplicity and ease of application.



Proximity counting, providing a very easy method of recording the passage of ferrous items past a point.

Some idea of the extraordinary reliability of reed switches was shown during a series of tests undertaken by the Bell Telephone Company in the USA. In one test four switches were operated at 120 closures a second carrying a load of 500 micro-volts, 100 microamps, dc. Each switch completed 50 million consecutive closures without a single instance of closed resistance exceeding 5 ohms.

FAILURES

A reed switch rarely fails completely. As load currents are increased the contacts suffer the same form of contact erosion experienced in conventional switches. The resultant particles are magnetic and collect in the air-gap. If these fragments become numerous enough they intermittently bridge the gap and cause a failure-to-open. It is also possible for these fragments to alter the closed contact resistance.

The most common cause of contact failure is the mechanical locking of a spike on one reed and a corresponding crater on the other. This type of failure is commonly called a 'weld' but it is not a weld in the true sense. The contacts are not joined by molten metal but are held by friction or interlocking between the spike and the crater.

NEXT MONTH

The second part of this article, which will be published next month, will describe applications in which reed switches are electrically energized. ●

DAMPING FACTOR

— just a sales gimmick?

This controversy began with a letter (see below) from Collyn Rivers to ELECTRONICS TODAY INTERNATIONAL's Acoustical Consultants.

Dear Louis,

I think that a whole lot of nonsense is being written about the effect of amplifier damping on loudspeakers.

Conventionally this term is taken to be the ratio of the nominal load impedance to the internal impedance of the associated amplifier.

Thus. with an 8 ohm speaker and an amplifier with 1 ohm internal impedance (due to negative feedback) the damping factor is said to be 8 (although as the loudspeaker impedance varies with frequency, then the damping factor must do likewise).

Recently. one has seen amplifiers for which their manufacturers claim damping factors of 100 or more. But this is a whole heap of b . . . . . because the argument totally ignores the fact that the dc resistance of the voice coil and the speaker leads is in series.

Thus, if the output impedance is 1 ohm and the speaker has a dc resistance of 6 ohms and ignoring the dc resistance of the leads then the damping factor for an 8 ohm speaker is not 8 but:—

$$\frac{Z_{vc}}{Z_{op} + R_{vc}} = \frac{8}{1 + 6} = 1.14$$

where Z_{vc} is the voice coil impedance — Z_{op} is amplifier output impedance and R_{vc} is dc resistance of voice coil.

If you half the amplifier output impedance to ½ ohm, then the damping factor is still only 1.23.

Even with zero output impedance, the damping factor is still only 1.33.

Admittedly the impedance of a speaker varies quite a bit with frequency and one might have a speaker impedance of say, four times the nominal value but even then, with 1 ohm output impedance the damping factor is 4.555 and with zero impedance it only rises to 5.333.

If you allow a realistic 0.2 ohm dc resistance for connecting leads etc. then the difference is very small.

Possibly I am overlooking something vital but I would like to see the result of stuffing a rheostat in series with a speaker and running a series of subjective experiments and then some objective ones using square wave inputs — or something — and photographing the resultant scope waveforms.

Would you care to have a go?

If you find that damping factors greater than '20' are significant, please see if you can find out why.

Collyn Rivers

This controversial article suggests that the effect of amplifier damping on loudspeakers is of far less importance than generally claimed.

THE Editor has asked, in positive terms, that we have a good look at the effect of *damping factor* on loudspeaker performance.

Damping factor has become an 'in' phrase, with quite unsupported claims that it is the panacea for good amplifier/loudspeaker performance.

Amplifiers are currently available with damping factors from 10 to over 1000 — it is one of the last of the big numbers.

Possibly the only specification that we have ever seen quoted for damping factor is in DIN 45,500, which specifies that "Damping Factor shall be at least 3 from 40 Hz to 12,500 Hz."

This, of course, falls far short of the specifications of even the poorest high-fidelity amplifiers currently available, and most probably below the limits of valve amplifiers which were available a decade ago.

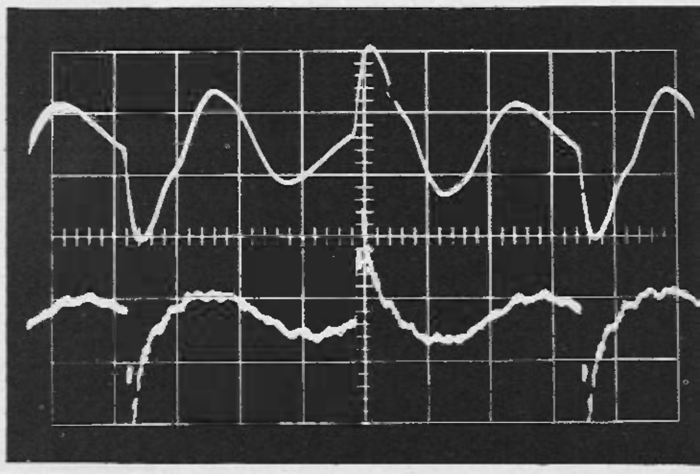
WHAT IS DAMPING FACTOR?

Damping factor is specified as the ratio of the load impedance of an amplifier to the output impedance of the amplifier. This simple definition has already introduced the first uncertainty — what is the load impedance when the load is a loudspeaker? For the time being we will insert the word "nominal" to enable us to quantify damping factor.

The damping factor of an amplifier — so far as the amplifier properties are concerned — is determined by the output impedance of the amplifer. In general, this is a result of an actual physical resistance of the output circuit, which may be about 10 ohms. together with the amount of negative feedback around the circuit. Twenty decibels of negative feedback will produce a reduction of 10. Our 10 ohm output impedance would, therefore, be reduced to one ohm, and if we had a *nominal* load impedance of 8 ohms, our damping factor would be 8. By providing 40 decibels of negative feedback the damping factor would be increased to 80 and so on.

The effects of negative feedback are extremely beneficial so far as the output amplifier characteristics are concerned. It improves the distortion

JBL Control Monitor driven by amplifier with output impedance 0.01 ohms. Top Trace Diaphragm Acceleration. Bottom Trace Sound Pressure Levels 6" from Diaphragm.



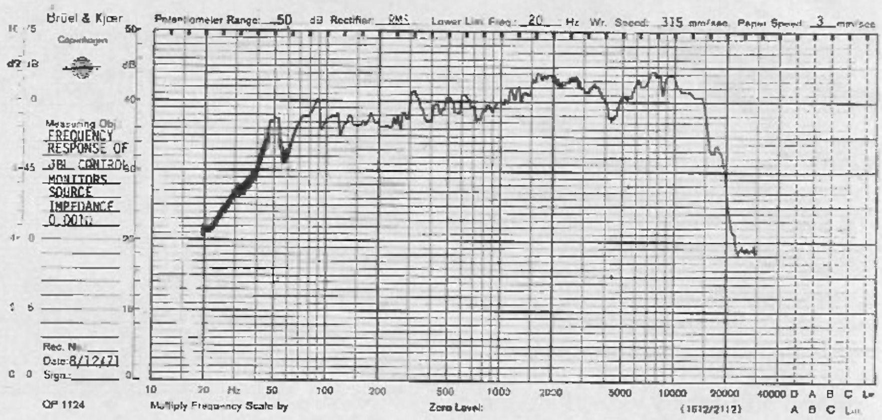
characteristics, the signal to noise ratio, and the frequency response. An amplifier design, without negative feedback would be totally unacceptable, but with it would have excellent characteristics. With careful design a very high level of negative feedback can be applied (at the expense of gain.)

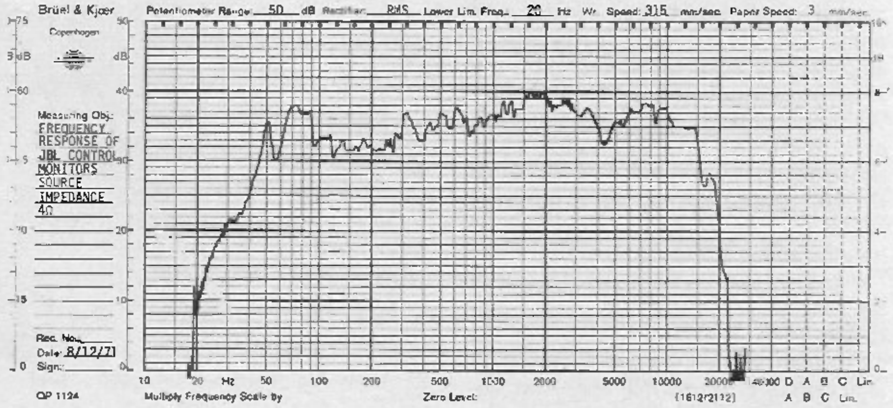
As the feedback is increased the damping factor increases. The purpose of this article is to investigate whether, in fact, a high value of damping factor is of any use in itself, or whether it is only a by-product of the improvement of other amplifier characteristics.

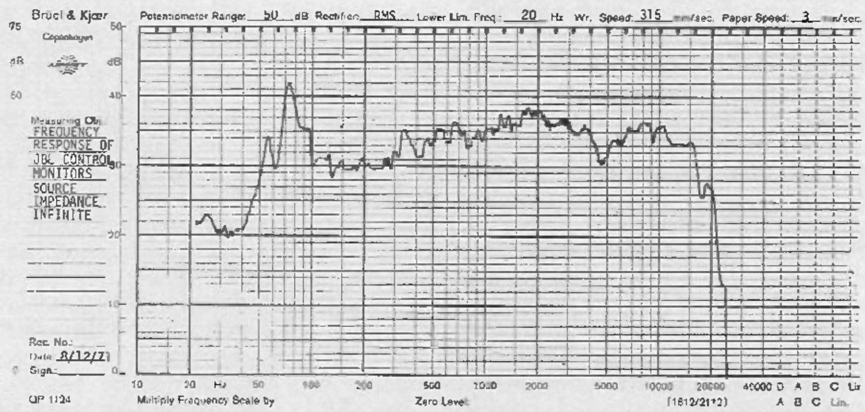
One of the problems in dealing with loudspeakers is that they are not particularly amenable to mathmatical computation, or even to simple physical measurement. Most papers dealing with loudspeakers limit their discussion to the piston range. This is the range of frequencies from the resonant frequency of the speaker to a frequency of the order of 400 Hz in the case of a 12" diameter loudspeaker. Outside this region the problems of analysis become extremely complex. In this article, for the purpose of simplicity, we are also considering only the piston range for a brief description of the parameters involved in a loudspeaker.

A practical loudspeaker in a vented enclosure has an equivalent electrical circuit, which may be approximated by the circuit shown in Figure 1. The two main components in this circuit that adversely affect the performance are the characteristics of the winding, its resistance and its self inductance. Because of these parameters the speaker cannot be completely externally controlled.

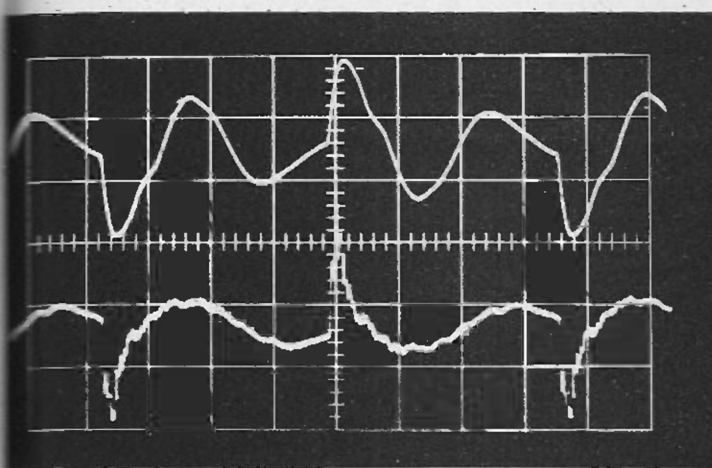
The winding resistance is a useful and necessary component to obtain the optimum low frequency response. If this resistance is too low, then the transient response of the system is



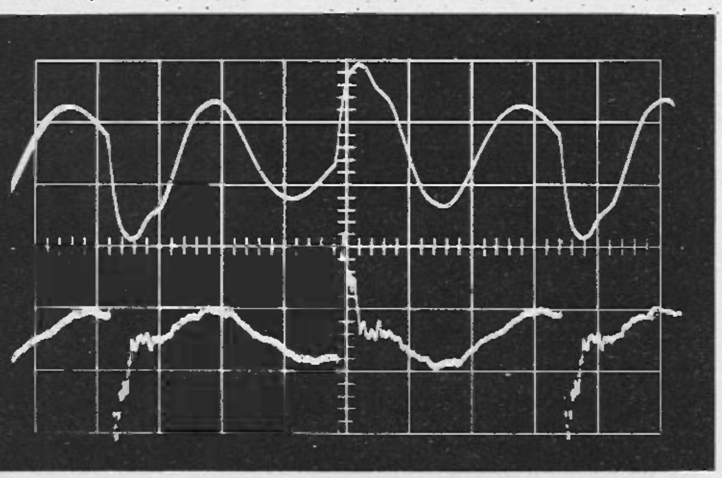




JBL Control Monitor driven by amplifier with output impedance 4 ohms. Top Trace Diaphragm Acceleration. Bottom Trace Sound Pressure Levels 6" from Diaphragm.



JBL Control Monitor driven by amplifier with output impedance of 100 ohms. Top Trace Diaphragm Acceleration. Bottom Trace Sound Pressure Levels 6" from Diaphragm.



DAMPING FACTOR

overdamped. If it is too high, the transient response is underdamped. The correct value provides critical damping. If the speaker is overdamped its frequency response will be poorer at the low frequency end of the specrum. If the speaker is underdamped its response will tend to be 'boomy.'

We will now take a look at a typical loudspeaker system with a nominal 8 ohm impedance. The dc resistance as measured with a bridge is about 7 ohms. Let the damping factor of the amplifier be a fairly modest '20', the amplifier output impedance therefore 0.4 ohms; (based upon a nominal 8 ohm load), the total equivalent series resistance is therefore 7.4 ohms. Even if the amplifier has zero internal resistance, *the series resistance would only be about 5% lower.*

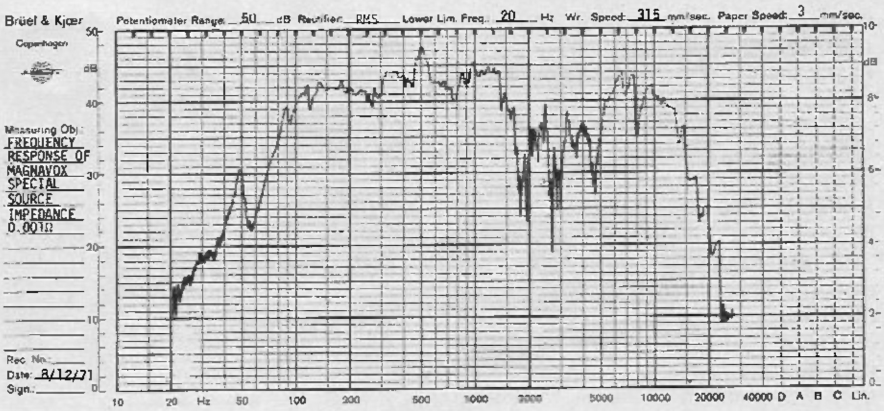
If the speaker system is such that a 5% change in the series resistance will result in a dramatic change in its performance, then the design would be unacceptable for normal use. And the normal method of connect speakers, using fairly fine figure "8" flex, could introduce a further 0.2 to 0.4 ohms of resistance.

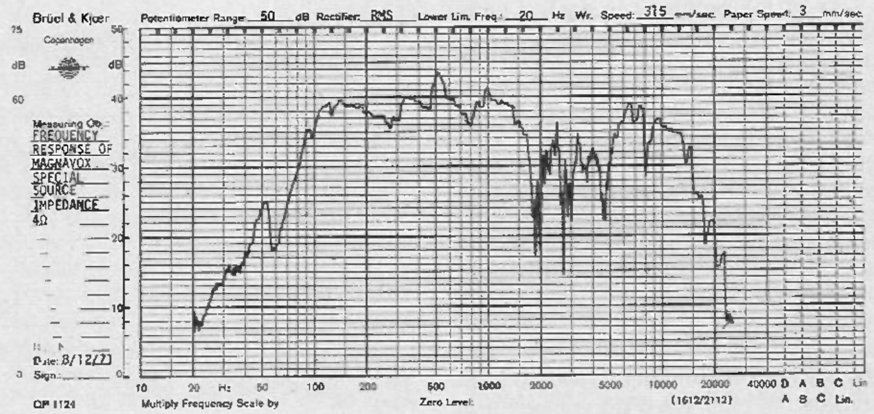
OUR TESTING METHOD

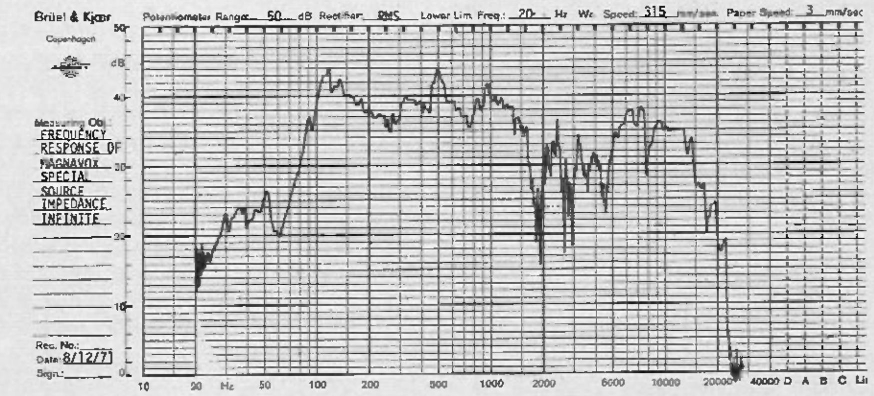
We decided to have a look at four differenct types of loudspeaker. We used the Bower and Wilkins DM1, an Acoustic Research Inc. AR-6, a special speaker system provided for the purpose by Magnavox Australia, (designed to give a distinct resonance at the bass end of the spectrum) and our J.B.L. control monitors which we use purely for comparison with other speakers in the laboratory. The B & W DM1 and the AR-6 were similar in that they are both small, fully sealed enclosures with two-way speaker systems. The special Magnavox enclosure was a simple two-way vented-enclosure system which consisted of two 8 inch low frequency speakers and one tweeter. We should emphasise that this speaker was not intended for high fidelity use, but was fabricated by Magnavox purely for this experiment. The measured impedance curves of the speakers showed that the impedance can vary between about 8 ohms and 30 onms, depending on frequency for a nominal 8 ohm speaker.

Having determined that speaker impedance varies between such wide limits it is obvious that the term "damping factor" has little relevance. Output impedance is, therefore, a more relevant quantity.

We tested the frequency response of the J.B.L. and Magnavox speakers under the same conditions, but using different amplifier output impedances. We first used essentially constant voltage drive. This provided an output impedance of approximately 0.001 ohms (obtained using feedback from the speaker terminals to eliminate the effect of wire resistance to the speaker). The second series of measurements was with an output impedance of 4 ohms, and the third was with infinite output' impedance; that is, constant current drive. As can be seen from the level recordings, the difference is not as marked as one might expect, except in the region of the resonant frequency of the speakers. Absolute levels were not recorded as accurately as our normal speaker tests, since we were not so interested in the *actual* frequency response but rather in the *relative* effects of the changes in the system parameters.







The conclusion to be drawn from this series of measurements is that, even with an effective output impedance of the order of 4 ohms, ie. a nominal damping factor of 2, the change in high frequency performance is not measurable, whilst the change in low frequency performance is just becoming significant.

These results tend to confirm the validity of the statement in DIN 45,500.

In order to examine the effectiveness of driving impedance on the resonant characteristics of the speaker we should, ideally, drive the speaker with either an impulse or a step response in order to evaluate the results. We chose to use a 20Hz square wave, to provide better characteristics for photography.

A number of different techniques

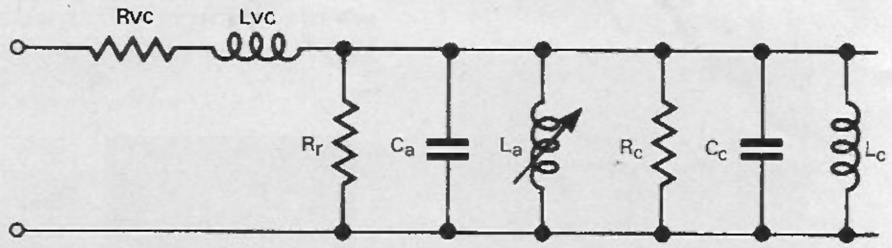
were utilised to measure the mechanical and acoustical characteristics of the speaker systems. For these tests we used amplifier output impedances of zero, 0.01 ohm and 100 ohms.

The first involved measuring the acoustical output from the speaker at a distance of one foot from the speaker diaphragm. The second method involved an examination of the mechanical motion of the speaker diaphragm using a miniature accelerometer suitably integrated to obtain the velocity, and later the displacement of the diaphragm.

The third method involved an examination of the sound pressure level inside the enclosures. Irrespective of which method of testing we used, the results were consistent. The effect of the 4 ohm amplifier impedance resulted in very little degradation of the speaker performance, compared with 0.01 ohms impedance. When we tried the 100 ohm impedance drive the result was a ringing, that was so pronounced that the original wave was hardly discernible. The main effect that showed up in this latter test was the generation of a fundamenta component at the resonant frequency of the speaker system, and very little evidence of the original driving signal. Similar effects were observed on the other speakers tested.

We tried subjective listening tests using the Simon and Garfunkel "Bridge Over Troubled Water" and the J.B.L. Warner Brothers Contemporary demonstration record. The first record has good clean bass while the second contains selections from the Warner Bros. catalogue specifically designed to show up weaknesses in loudspeakers particularly in the low frequency region.

Changing the amplifier output impedance from 0.01 ohms to 4 ohms did not result in a very significant difference in performance; a slight boominess was apparent on all of the loudspeakers with the exception of the J.B.L. control monitors and the AR-6. When the amplifier circuit was modified to the high impedance drive the boominess became marked.



RVC = Voice Coil Resistance
LVC = Voice Coil Self Inductance
R_r ~ Radiation Resistance
C_a ~ Acoustical Capacitance
L_a ~ Acoustical Inductance
R_c ~ Resistance of Suspension
C_c ~ Compliance of Suspension
L_c ~ Mass of Cone and Suspension

Fig. 1. Approximate equivalent circuit of speaker in an enclosure.

The principal difference between the speakers was the difference in the resonant frequency of each of the individual speaker systems. In the case of the J.B.L. control monitors, this was roughly 50Hz and consequently even with an effective amplifier output impedance of 4 ohms, the effects could not be readily detected.

The Magnavox 'Special' had a resonant frequency of about 110 Hz which resulted in an audible boominess with the 4 ohm amplifier output impedance. The AR-6s and the DM1s, being heavily damped by their enclosures, did not show nearly as much deterioration even though the resonant frequencies were higher.

The conclusion that must be drawn from this is that even the 'worst' loudspeaker has a fairly high tolerance to amplifier output impedance and that acoustical resistance type enclosures have an even greater tolerance. In our tests a damping factor of 2 did not result in a severe degradation of performance.

If the speaker system has a low resonant frequency the subjective effect is even less noticeable. It would, therefore, appear that there is only a very slight subjective improvement to be gained from a low output impedance with the more expensive speakers which have low resonant frequencies and a smooth frequency response.

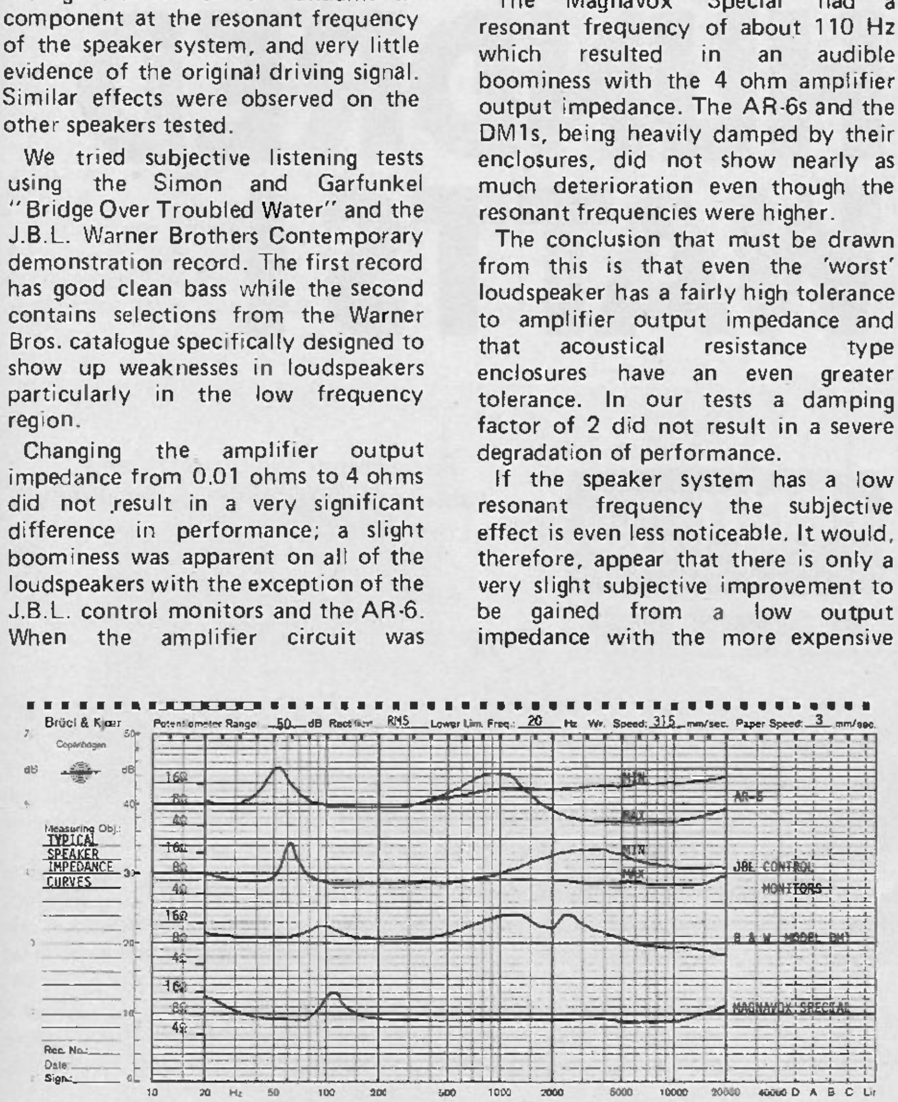
There will be a more significant improvement in speakers which have marked resonances at higher frequencies.

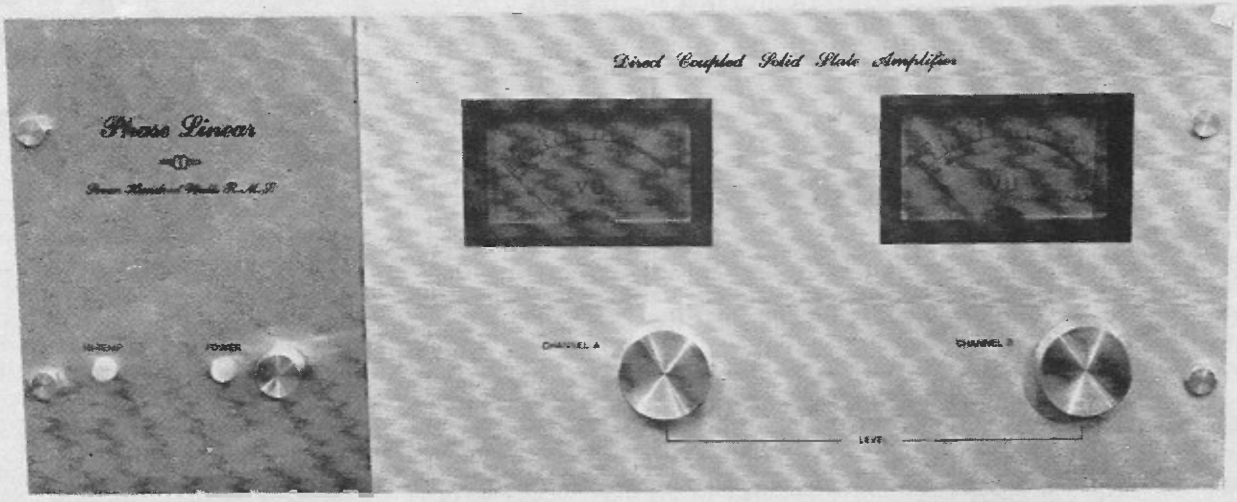
Subjective A-B testing using an amplifier with a damping factor of 1000 and then with a fairly modest amplifier with a damping factor of 20 did not reveal any significant difference as a result of subjective tests. In fact, this is what would be expected from our measurements with due consideration of the actual change in the equivalent series resistance of the loudspeakers.

When the speaker lead resistance is taken into account, even an amplifier with a nominal damping factor of 1000 will probably only have an effective damping factor of about 80 unless short copper bus-bars are used to connect the speakers to the amplifier!

We have only touched very briefly on some of the complex and difficult aspects of loudspeaker theory, but the results of the calculations, practical measurements, and subjective testing all come up with the same answer. That is, that an amplifier output impedance which corresponds to a nominal damping factor of 20 to 30 will result in a speaker performance which is not discernible from the performance of a speaker driven from the same amplifier with a nominal damping factor of, say, 1000, with lossless speaker leads.

It is apparent to us that a high fidelity audio amplifier with a "nominal" damping factor of between 10 and 30 (and all other things being equal) is adequate for most speaker systems, both good and bad, and that most of the statements made concerning the value of high damping factors are motivated by either lack of comprehension of the subject, or by manufacturers who are looking for a new sales pitch. ●





SEVEN HUNDRED WATTS!

"Power tends to corrupt — and absolute power corrupts absolutely". Lord Acton.

electronics TODAY INTERNATIONAL product test

The Phase Linear Corporation has set out to produce a high-powered amplifier with a flat frequency response from dc to beyond 20 kHz, and with phase performance to match. To a large extent these aims have been achieved.

The Phase Linear amplifier meets the most exacting specifications that could be realistically required for precision audio frequency equipment in scientific or industrial applications.

It is an unusual amplifier in that it is fully dc-coupled but has facilities in-built to allow ac coupling for audio work. It is as equally suited to a servo control system as it is in a theatre or auditorium.

It is in fact a precise instrument — and really too good for hi-fi applications.

Clearly this is a very fine unit indeed — so why on earth does the company's sales division promote it with claims and statements that are either grossly exaggerated or misleading.

We quote for example "... with today's low efficiency speaker systems, a power input of *several thousand watts* would be required (dissipation allowing) to produce the sound pressure peaks that occur in live musical performances. Clearly the larger the amplifier, other things being equal, the more faithful the sound."

(It can readily be shown that an average low efficiency speaker — with an electro-acoustic efficiency of 1% to 1½% can reproduce orchestral peaks at levels comparable to concert hall experience, i.e. half an acoustic Watt, with a speaker input power of less than 50 Watts. — Ed.)

Or, "A one hundred watt amplifier is not capable of producing the sound pressure levels often demanded on any but the most efficient speaker systems.", and, "most modern high fidelity speaker systems will be able to safely accommodate the reserve power of the Phase Linear".

At best this latter statement is a half truth. There are very many speaker systems that will handle neither peak nor average powers of the magnitude suggested. Seven hundred watts into the average horn loaded speaker, or small bass reflex unit, would project the voice coil practically into lunar orbit.

The statement also completely ignores the transient power capabilities of most amplifiers.

Even a pair of Bose speakers can get by very nicely indeed with a lot less than 700 watts.

But if Phase Linear say that you can use this much power — the least we felt we could do was to try — nevertheless 700 watts is 700 watts is 700 watts, so instead of using speakers of high electro-acoustic efficiency we chose four Bose units — two paralleled in each channel to absorb the power.

The testing equipment consisted of a Kudelski Nagra BH3 tape recorder with pre-recorded tapes, a Pioneer SC700 pre-amplifier together with the

We would like to make it completely clear that our criticisms of the Phase Linear promotional material applies to that material supplied with the amplifier and published in the USA.

Bose equaliser, the Phase Linear 700 amplifier and four Bose speakers — all set up in the open against our laboratory wall.

EXPLOSIVE

The results can only be described as explosive. Ten feet away, the *average* sound pressure level exceeded 108 dB, with peaks of over 116 dB. At one hundred and fifty feet, and at 90° to the axis of the speakers, the level exceeded 96 dB. The level was literally deafening, and in fact our ears were unable to evaluate the quality of reproduction. Only by using ear plugs could any degree of pleasure be obtained.

Even with very low efficiency speakers the sound levels that could be obtained were awe inspiring. (remember that peaks of 116 dB correspond to 100 times the sound level of a full symphony orchestra with all members playing flat out.)

We had intended to try this system in our reverberant chamber, but were spared the agony of music at 125 dB plus by the timely demise of our spare fuses. What it must be like in an enclosed room with medium or high efficiency speakers is difficult to imagine.

If the Phase Linear sales people are serious we must only assume that as far as amplifiers are concerned, some Americans have gone totally power mad; and this device is the latest manifestation of their mania.

And this is all a great pity because despite all their sales nonsense this really is a very fine amplifier indeed.

THE CONSTRUCTION

The construction of the amplifier is massive and could almost be described as a group of transistor heat sinks and a transformer attached to a 19" panel. Whilst this may seem an oversimplification, the remaining components make up less than 10% of the total weight and take up less than 30% of the total volume.

The frontal appearance is simple and business like. The brush-satin aluminium rack panel is divided into two sections. The lefthand end is engraved with the Phase Linear name and contains two bezel lights, one being the high temperature overload light, and the other the power light next to its rotary on/off power switch.

The main part of the panel is taken up by two large illuminated V.U. Meters with two large polished aluminium level controls cum attenuator knobs set below them.

A very large power transformer lies behind the left hand end of the front panel, whilst the main circuitry-mounted on a large printed circuit board — is located behind the V.U. meters in a well ventilated enclosure.

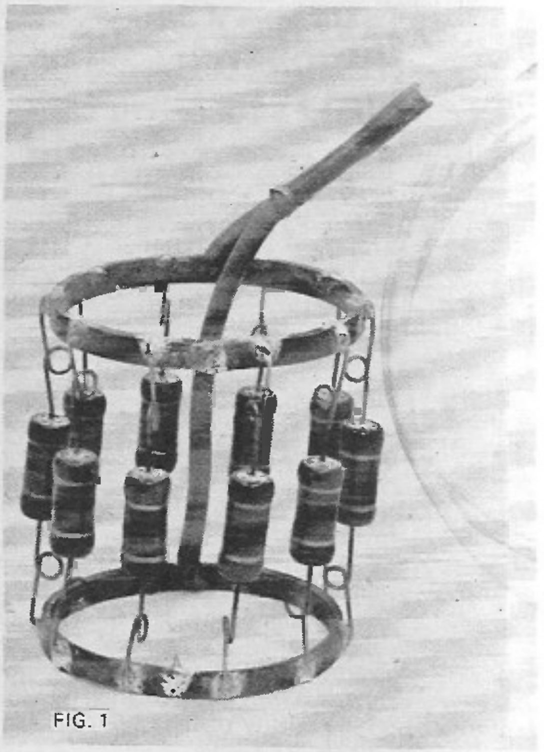
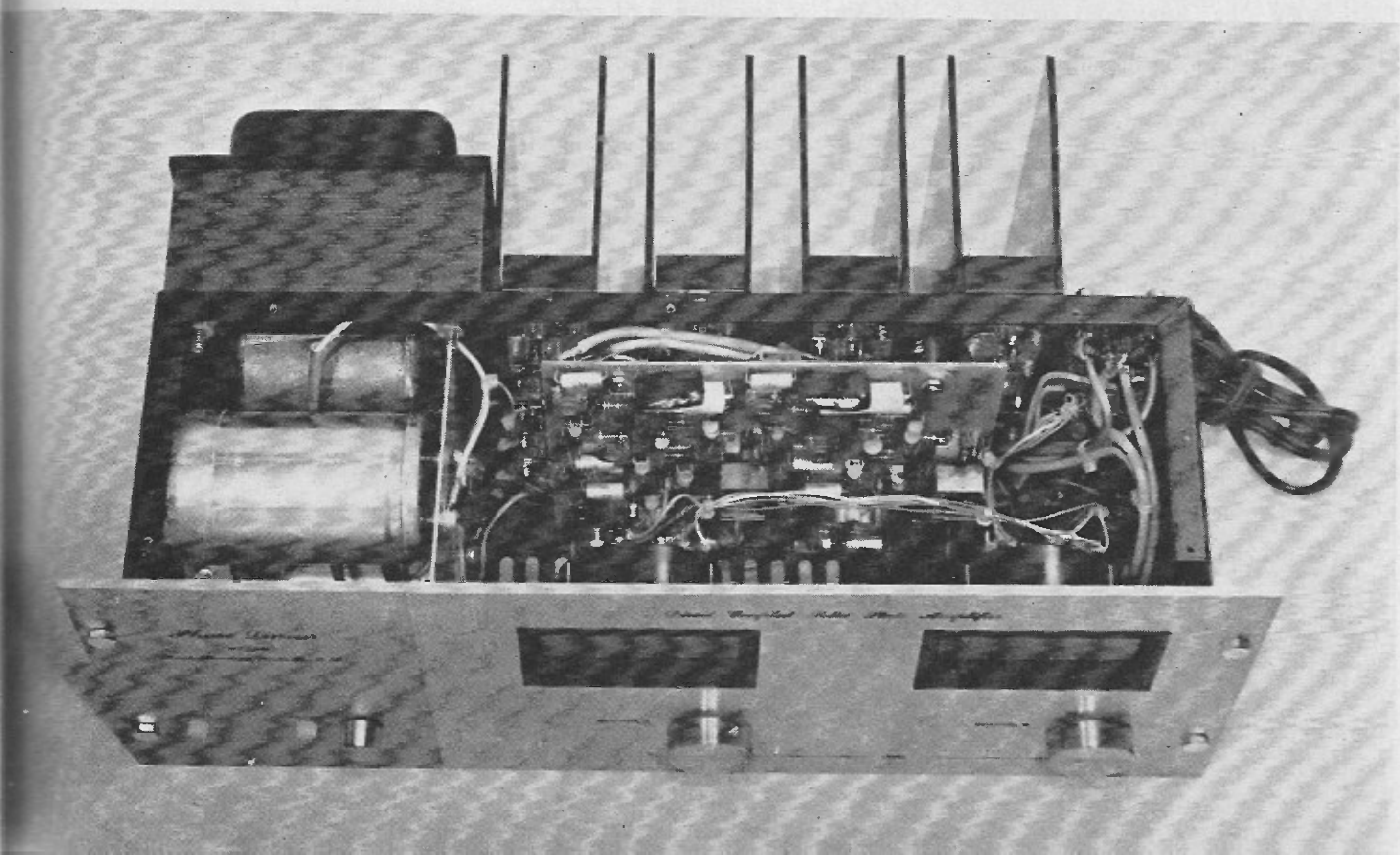


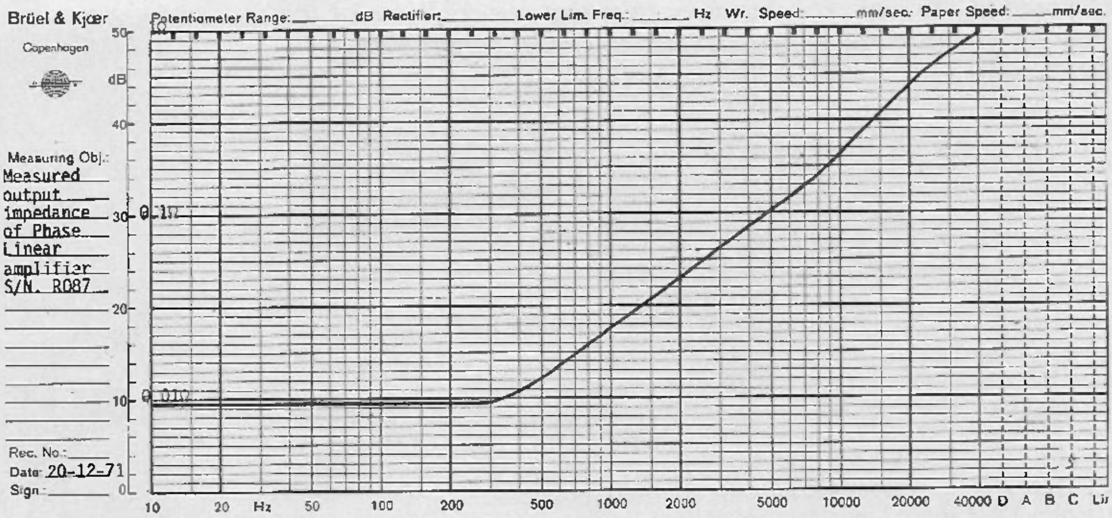
FIG. 1

The circuitry is fairly conventional and consists of a series of long-tail pairs used to drive a single-ended push-pull stage with five npn silicon power-transistors in parallel in each set of the positive and negative push-pull elements.

The designer has taken special care to protect the amplifier against thermal runaway and has interlocked the primary supply through a thermal relay of which the control circuitry is



SEVEN HUNDRED WATTS!



not shown on the circuit diagram supplied.

The components are all of professional quality and the construction is far better than one would expect from looking at the drafting quality of the circuit diagram in the service manual.

The back of the amplifier has all input and outputs on the extreme lefthand end (viewed from the rear) with the four large double fin heat sinks in the middle and flanked by the power transformer on the right.

Inputs consist of four RCA coaxial sockets at the top of the panel. Two of these inputs are for ac inputs and two are for dc inputs. A switch selects the inputs required.

The dc inputs must never be used for audio work, for low frequency transients would cause cone excursions that would drive the speaker diaphragms out of their frames. Fortunately the handbook clearly warns of this danger.

The outputs are located immediately below the inputs and consist of four colour-coded universal terminals suitable for wire terminations or banana plugs.

At the bottom of the panel are five fuse holders, one for the mains and four 5 amp fuses for the dc supply rails.

The heat sinks are ten gauge aluminium channels having fin dimensions of 6½" x 4¾". However despite this, the cooling area of each sink falls far short of that required for the dissipation of 700 watts of power. Because of this the manufacturers recommend the use of a cooling fan for extended high power operation. Without a fan we found the output power was limited to under 200 watts in an air-conditioned room with normal convection cooling.

With moderate volumes of air from a small fan placed under the amplifier, it was possible safely to dissipate the heat with an output of 700 watts of continuous power into a resistive load.

This sort of operation is of course, unusual and would not normally be expected except at a rock concert or under industrial use.

Although the manufacturer could be critized for not supplying a cooling fan this would be unfair as the type of fan and air flow capacity would be determined primarily by the amplifier's location and the air flow restrictions produced by its enclosure.

TESTING 700 WATTS

The task of performing instrumental measurements on an amplifier nominally three times more powerful than any we had measured before, presented a number of problems. Our first was that our precision dummy loads were not designed for more than 100 watts of continuous dissipation. These use, or should I say, used to use, 10 Corning Electrosil resistors (type TR8, 1 watt) in parallel (figure 1). And whilst these work quite happily in a bucket of water at 100 watts input, they complained at 350 watts, and at 400 watts they failed. It is a credit to their manufacturer that the resistors could stand 300 watts of continuous power for this is equal to 30 watts per resistor.

The load problem was eventually solved when we found that we could drive either a small radiator or a number of large light bulbs up to quite high frequency. A Variac interspersed between the amplifier and load enabled us to control power dissipation.

The remainder of the testing proved to be a simple task for the parameters of the Phase Linear amplifier are basically as stated by the manufacturer.

First of all the average continuous power with fan cooling into 8 ohm loads is 350 watts into each channel (making a total of 700 watts, and into 4 ohms, 600 watts into each channel). Under these conditions any transient occurring on either the supply or load side will cause the fuses to blow, and copious supplies of cooling air are required.

Whilst the manufacturer quotes power at clipping, as 450 watts/channel, this figure seems irrelevent for an amplifier that is intended for high quality work. Apart from this we were running out of precision load resistor banks!

Since this amplifier is very well suited to control applications, we decided to check out its phase response (the reason for the name Phase Linear). We found that because of its extremely flat frequency response in the dc mode, there is only a 10 degree lag at 20kHz. Between dc and 10kHz, its performance is extremely good, the phase shift going from zero degrees to approximately five degrees lag at 10kHz.

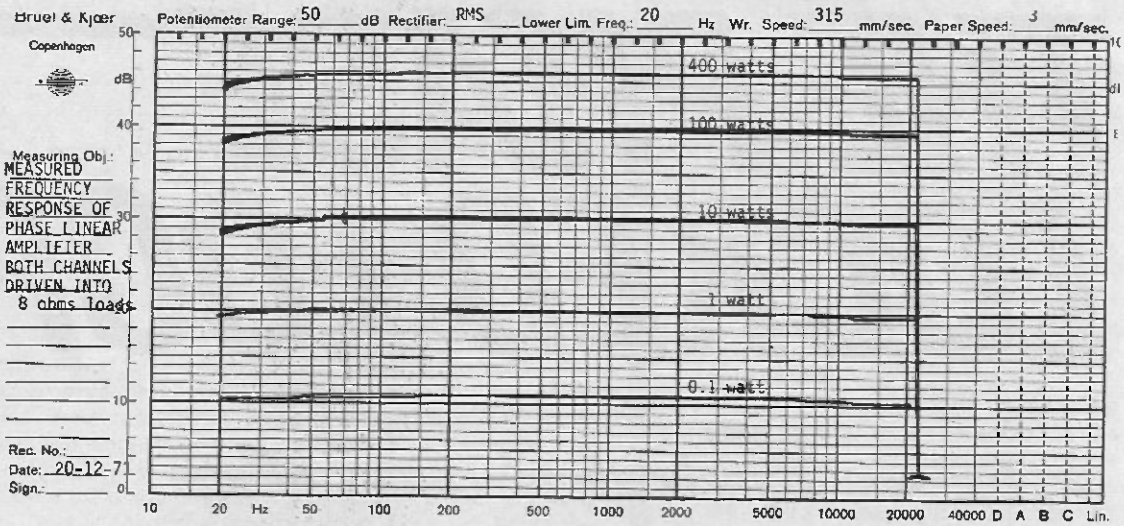
The manufacturers (or probably the sales division) of the Phase Linear amplifier, claim to have a patented 'computer' built in to maintain the output within specification. The description of how this works is very non-specific in the handbooks

MEASURED PERFORMANCE OF PHASE LINEAR AMPLIFIER SERIAL NO: R 087

Frequency Response
20Hz to 20kHz ± ½dB
Phase Shift
0° at 20Hz
5° lagging at 16kHz
10° lagging at 20kHz
Total Harmonic Distortion at rated continuous output of 350W (both channels loaded)

100Hz	0.20%
1kHz	0.15%
6.3kHz	0.15%

Input Sensitivity for rated output of 350W — 1.12V
Hum and Noise re rated output of 350W —96dB
Continuous Power Output (with cooling fan)
350 Watts into 8 ohms (both channels driven)
400 Watts into 8 ohms (one channel driven)
Dimensions
19" Wide x 7½" High x 10" Deep
Weight
45 lbs



provided. It would appear that the computer uses one transistor with information fed back from various parts of the circuit. It is intended, apparently to limit the maximum power output, any common mode operation of the two quasi – complimentary sections of the amplifier, and the maximum current output (dc or ac). Should any of these parameters be exceeded, the base of the first transistor in the driving stage is earthed.

As far as we were able to test, this circuit appears to work satisfactorily. The description of its operation is, however, grossly overstated and presumably not written by the design engineer.

Thermal cutouts are provided adjacent to the power transistors to protect them from excessive temperatures. Phase Linear recommend that if a thermal overload should cause the amplifier to trip out, the amplifier should be switched off for a few minutes to protect the thermal switches from the high transient currents which occur during switch-on. We had a look at the switches and could see why this was recommended. The switches were very small and would not withstand repeated operation for many thousands of switchings.

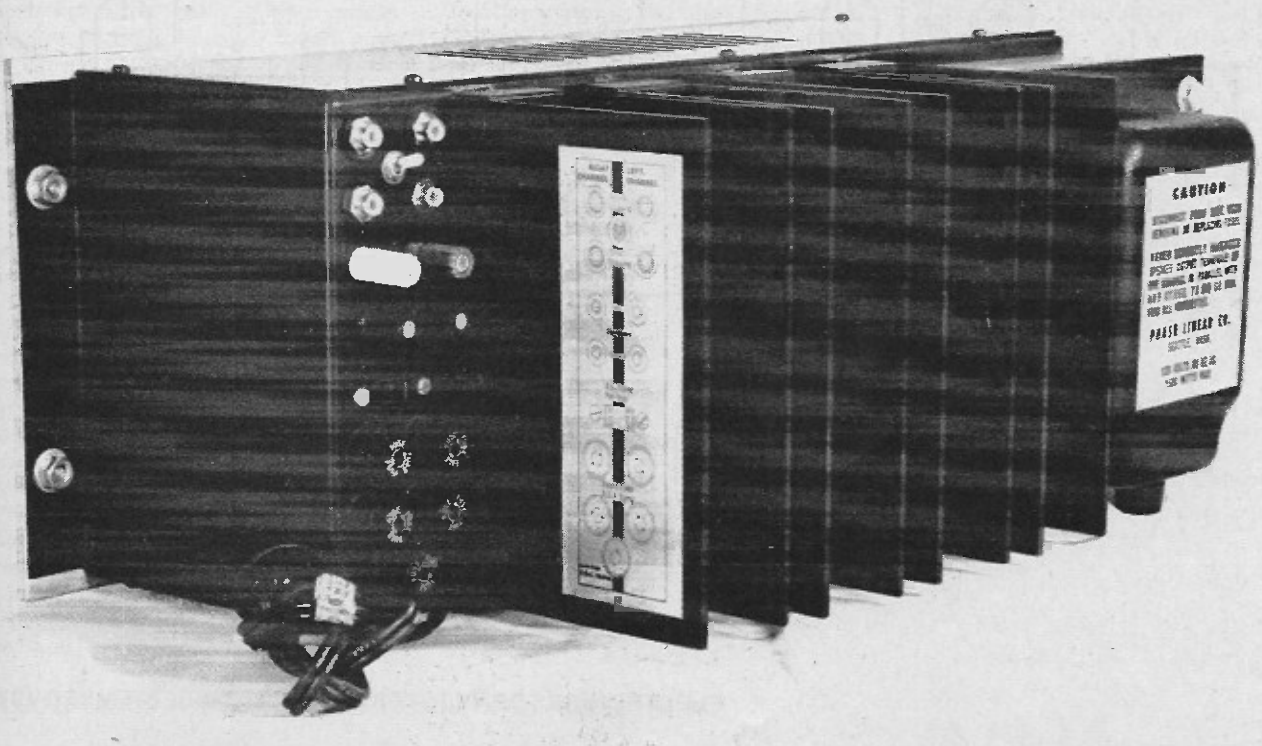
We did, however, decide to try them out over a period of several hours with the cooling fins covered and the amplifier running at about 50% of the rated output from each channel. The result was that after some 10 minutes, the amplifier switched off for a couple of minutes, turned on for about half a minute and then switched off again. After four hours of this abuse, the thermal switches were still operating correctly.

The power supply used in the Phase Linear 700 is very simple, and based on a nicely over-specified transformer that looks as if it could deliver about 1.5 kilowatts continously. This transformer feeds a bridge rectifier that supplies positive and negative 100 volt rails. The outputs are filtered by two 9800 mfd electrolytic capacitors.

At first sight such a simple power supply would seem inadequate, but since the voltage gain of the power amplifier stage is only unity, the degree of regulation required is not very critical.

Apart from the astonishingly bad sales literature, our only real criticism of the Phase Linear amplifier is the untidy and limited nature of the (preliminary) handbook supplied. It is to be hoped that when the production handbook is released, the information in it is presented in a more useful and lucid manner.

The best way to describe the Phase Linear 700 amplifier is that is is a precision instrument capable of many scientific and industrial uses, but promoted and priced so that a deaf audiophile with a pair of Bose speakers would consider it a bargain. ●



THE PHASE LOCKED LOOP

Dr. Tucker's 'Synchrodyne' comes of age

SYNCHRONOUS detection had something in common with Leonardo da Vinci's auto-gyro — both were brilliant ideas, and ahead of the level of technology required for their execution.

But unlike the 450 years required for da Vinci's auto-gyro, synchronous detection has taken only a relatively short time to become a practical concept. Recent development of phase locked loop ICs has made it all possible.

It all began in the 1930s as a quest for better audio frequency response than the (then) newfangled superheterodyne could provide. (For whilst the early crystal sets had their failings, distorted reproduction was not one of them).

Then in March 1947, Dr. Tucker, a research scientist with the British Post Office, published an article in 'Electronic Engineering' describing his 'Synchrodyne' receiver. (Fig. 1).

The basic 'Synchrodyne' principle was very simple — for AM reception a highly stable local oscillator produced a signal identical in frequency, and locked in a specific phase relationship with the incoming signal.

The incoming signal, and the locally produced signal, were then mixed together. The output from the mixer then consisted only of the modulation frequency that was superimposed on the original carrier, plus a number of unwanted components that were removed by a low-pass filter following the mixer.

The result? Recovery of the modulation frequency directly, and free of the distortion introduced by conventional superhet circuitry. There were no IF transformers to impose frequency limitations, and no detector to introduce distortion. The original modulation was recovered and separated from the carrier frequency in a form that was practically as pure as the modulating signal.

The locking of the local oscillator to the incoming carrier was, of course, the vital part of the system. In the

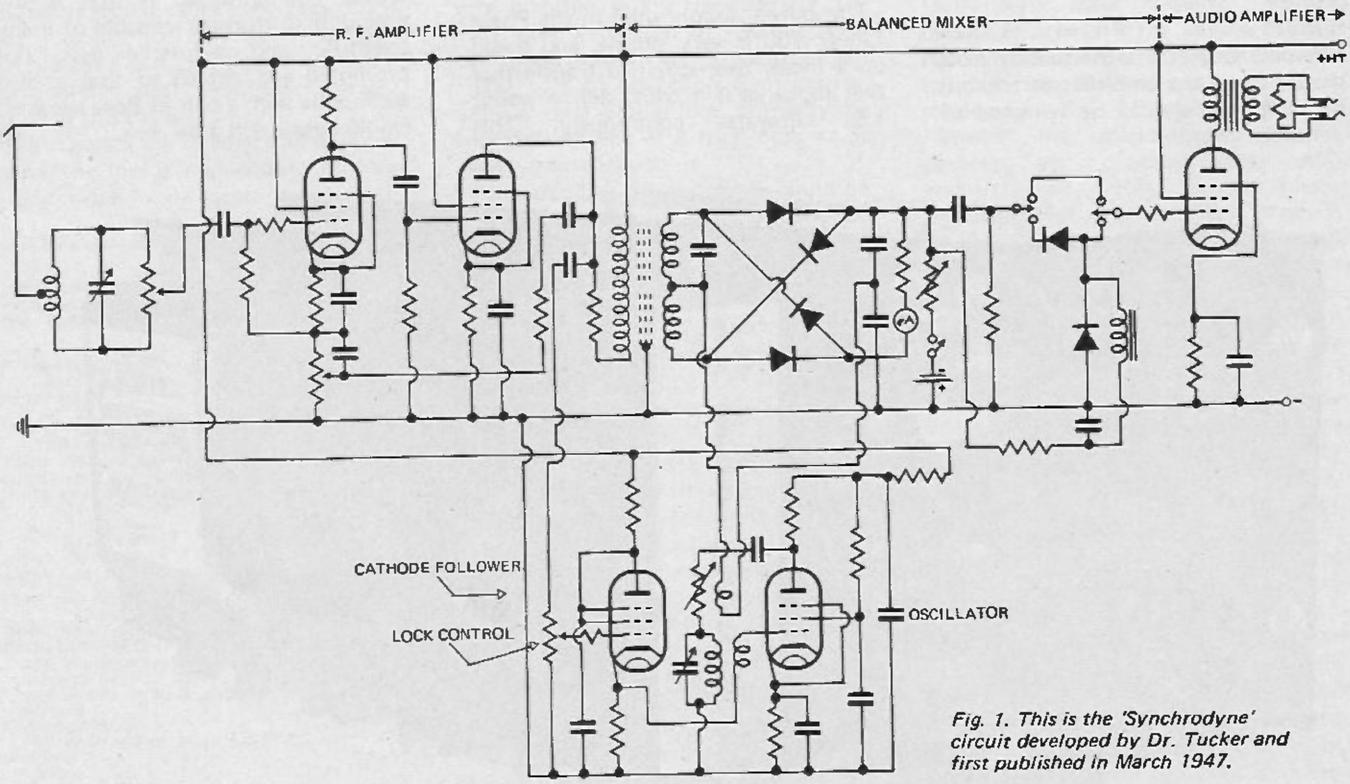


Fig. 1. This is the 'Synchrodyne' circuit developed by Dr. Tucker and first published in March 1947.

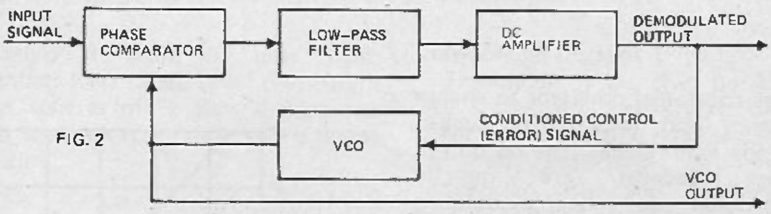


FIG. 2

A sinusoidal input signal is compared by the phase comparator with the VCO output to produce an error voltage representing the phase difference between these two signals. The phase comparator output is filtered, amplified, and applied as a control voltage to the VCO. The control (error) voltage is used to move the VCO frequency in the direction that reduces the phase difference between the input signal and the VCO output. Thus, a corrective feedback loop is formed. When the free-running frequency of the VCO is sufficiently close to the frequency of the incoming signal, the VCO synchronizes or "locks" with the input and tracks it over frequency deviations. When the PLL is "locked", it operates as a signal-tracking filter. For an FM input signal, the low-frequency VCO control voltage (dc amplifier output) is the demodulated output. Similarly, if the output is taken from the VCO, the PLL operates as a frequency-selective signal conditioner. This occurs since the VCO output duplicates the frequency of the input signal at a higher power level and at a greatly improved signal-to-noise ratio. In addition, the PLL can also function as a tuned frequency divider or multiplier by locking on multiples or submultiples of the input frequency.

original 'Synchrodyne' this locking was controlled by an adjustable injection of incoming signal to the local oscillator. Unfortunately, this 'brute force' method was a cause of instability, for with too little signal the lock was unstable, whilst with too much signal the local oscillator would lock on to the side bands rather than the carrier.

The real problem was that there was no feedback loop to control the local oscillator — rather the principle was one of 'feed-forward'.

Various modifications were proposed at the time to provide automatic gain control for the local oscillator, but their cost and complexity were too high, and so whilst the basic 'Synchrodyne' principle was simple enough, the methods of achieving it were not, and the 'Synchrodyne' went out of favour.

But now the development of the phase locked loop has brought it back again.

When used as an AM detector, the phase locked loop operates in a very similar manner to the 'Synchrodyne' except for one very important difference. And that is that the device generates a feedback signal which is used to control the frequency of the local oscillator.

If at any time the frequency of the locally produced signal attempts to drift away from the frequency of the incoming signal, the resultant difference frequency is fed back to the local oscillator in the form of a control voltage. This control voltage then acts at all times to maintain the local oscillator and the incoming signal, in synchronization.

The basic block schematic diagram of one type of phase locked loop is shown in Fig. 2. This is the Signetic Corporation's type NE 561B. This standard sized, 16 lead, dual-in-line IC contains a phase detector, a low pass filter, a dc amplifier and a voltage controlled oscillator. Given an output stage and a few capacitors and resistors, this IC contains all the requirements to build a complete AM or FM radio.

Figure 3 shows the Signetic NE 561B phase locked loop connected as a synchronous AM receiver. In this mode of operation, the PLL locks on the carrier, and produces, at the voltage controlled oscillator output, a reference signal at the same frequency as the input carrier, but without amplitude modulation. This reference is mixed with the modulated AM input. The output of the mixer is filtered to remove any remaining high frequency components, leaving the demodulated audio information. The external phase-shift network (normally two resistors and two capacitors) imparts a 90° phase shift to the input signal of the PLL section so that the voltage controlled oscillator output will be in phase (or 180° out of phase) with the incoming carrier.

This circuit may be tuned by either of two methods. The first, more 'conventional' way is to use a variable capacitor for C1. For broadcast band operation C1 should be variable from a minimum of 220 pF (1600 kHz) to a maximum of 650 pF (550 kHz).

Another, and perhaps more elegant way of tuning the receiver is to use a fixed capacitor for C1 (the value of which corresponds to the geometric mean of the required frequency range — probably about 450pF) and then to inject current, via a potentiometer, into pin 6 of the IC. (Fig. 4). Varying

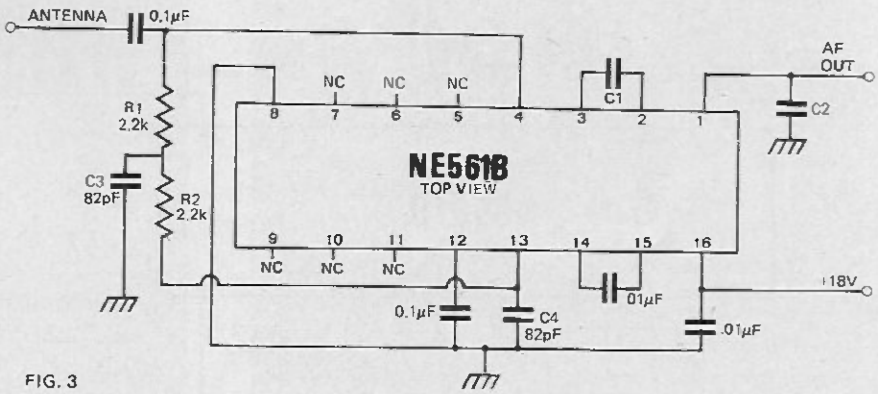


FIG. 3

THE PHASE LOCKED LOOP

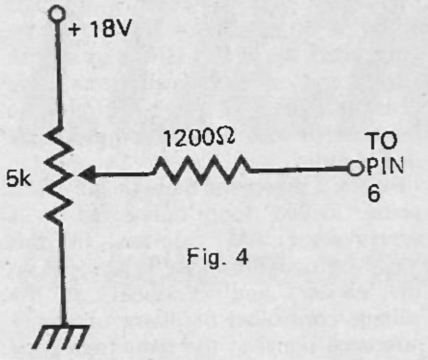


Fig. 4

the potentiometer will tune the receiver across the broadcast band over a range of approximately 3 : 1.

For satisfactory results, this receiver must have good input signal strength. It requires good antenna and earth systems. The signal strength, measured between pin 9 and earth must be at least 100 uV.

FM DETECTION

The phase locked loop is one of the simplest ways yet known, to make an FM receiver. When the phase locked loop is locked on to an incoming FM signal, the average dc level of the phase detector output is directly proportional to the frequency of the input signal. As the input frequency changes with modulation, this dc output changes and thus causes the voltage controlled oscillator to change frequency and thus remain locked onto the input signal. The dc output voltage changes are directly proportional to the modulating frequency, and hence the audio signal.

But there is one snag – the current generation of phase locked loop ICs run out of enthusiasm at 30 MHz.

The circuit of a simple FM detector is shown in Fig. 5.

The centre frequency of the voltage controlled oscillator is set by C1 – and the graph shown in Fig. 6 shows the correct value of C1 for frequencies between 100 Hz and 30 MHz. Fine adjustment of this frequency is achieved by injecting current into pin 6. Fig. 7 shows the percentage of frequency change for various values of current injection.

Input signal level should be at least 120 uV.

Despite its upper frequency limitations, the phase locked loop may be used at VHF frequencies by using a crystal controlled converter between the antenna and the rest of the circuit.

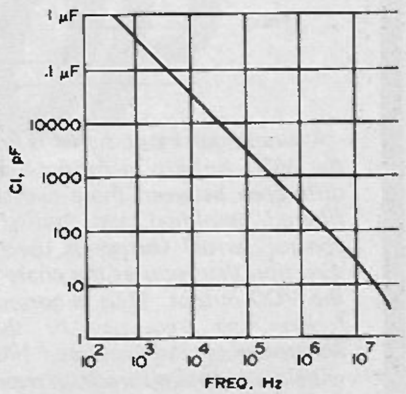


Fig. 6

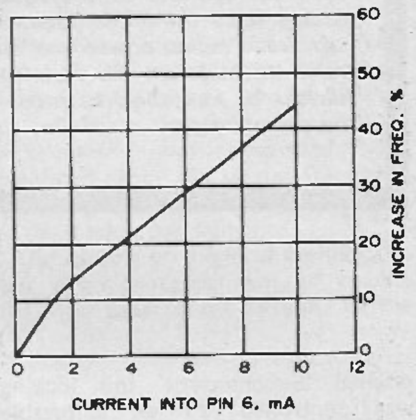


Fig. 7

FREQUENCY MULTIPLICATION

A phase locked loop may be used as an excellent multiplier or divider.

For use as a multiplier, the centre frequency of the voltage controlled oscillator is set to the required harmonic of the input signal. With a sinewave input the technique can be used to multiply by two, three, four or five times the input frequency. The output in all cases will be a square wave.

If a square wave input is used, any output up to 15 MHz can be produced from any multiple between twice and ten times the input frequency.

FREQUENCY DIVISION

The phase locked loop can also be used as a divider – but only for *odd* submultiples, i.e., 3, 5, 7 or 9. If you need to divide by 2, 4, 6 or 8 then the technique is not for you.

For most of us, what the phase locked loop has to offer is purer, less distorted reception of radio broadcasts, but it has many other applications in fields such as radio astronomy, space communications, telemetry, long range radar detection, frequency synthesizers and amateur radio operation. ●

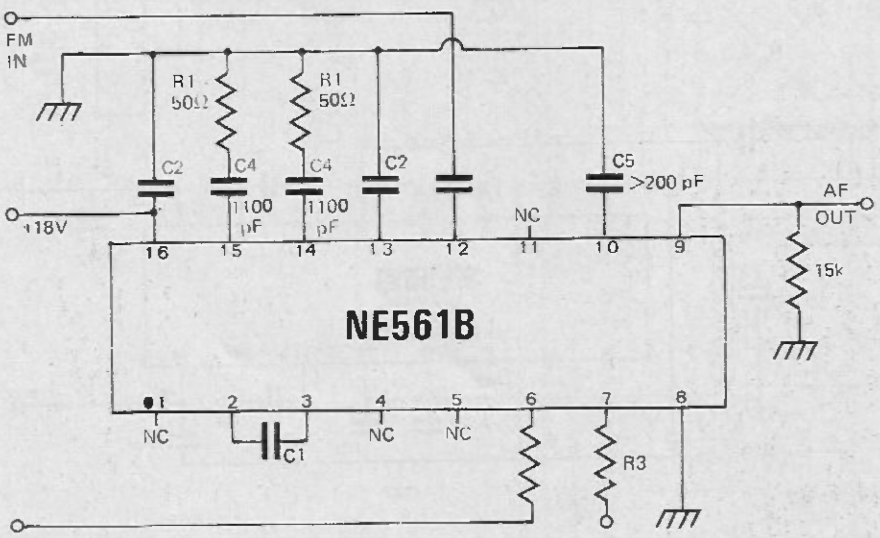
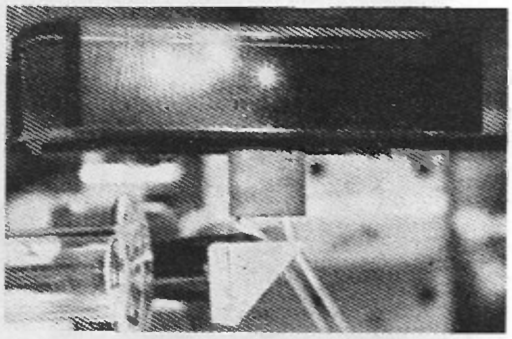


Fig. 5 This circuit shows how the NE 561B phase locked loop is used as an FM detector.

OPTICAL LEVITATION

Scientists suspend matter in space with laser light



USING a beam of laser light, scientists have raised small transparent glass spheres off a glass surface and held them aloft for hours in a stable position.

The experiments, which demonstrated optical levitation for the first time, were conducted by Arthur Ashkin and Joseph Dziedzic of Bell Laboratories, Holmdel, NJ.

In the experiment a laser beam is focused upward on a glass sphere about 20 microns in diameter (about one-thousandth of an inch). Radiation pressure from the light not only counteracts gravity and raises the particle, but also traps the sphere in the beam and prevents it from slipping sideways out of the beam.

In the experiment, which has been successfully demonstrated in air and in a partial vacuum, they generate a stable optical trap for holding particles which they term as an "optical bottle."

"Light photons have momentum as well as energy," Dr. Ashkin, head of Bell Labs physical optics and research department, says. "When we focus a quarter-watt laser on a small transparent particle, the extremely small force exerted by light is then sufficient to lift the sphere off the surface and suspend it."

The sphere is launched by lifting it off a transparent glass plate with the light beam. Initially, radiation pressure is not sufficient to overcome molecular attraction between the sphere and the glass plate.

This attraction, known as Van der Waals force, is about ten-thousand times gravity for a 20-micron sphere. For this experiment, the Van der Waals attraction is broken acoustically by vibrating a ceramic cylinder attached to the plate.

When the attraction is broken the sphere rises in the light beam and comes to rest where the upward pressure of the laser is balanced by the earth's gravity.

In this position, it can be held aloft as long as the light is focused on it. By changing the position of the focus, the trapped sphere can be moved up and down or sideways very precisely.

In the experiment, these trapping forces were also studied, using a second laser focused on the particle from the side. As the power of the second laser is increased, the particle is displaced within the first beam until it is finally driven out and falls.

"Any laser will produce the levitation effect," Dr. Ashkin says. "However, the particle is preferably transparent. If the beam were focused on objects that absorb light, most would melt. By remaining cool, the transparent sphere allows radiation pressure to be studied without any disturbing thermal effects."

The new technique is expected to provide simple, precise methods for manipulating small particles without mechanical support. It could be useful in communications research to measure scattering loss caused by particles, either in the atmosphere or in other transmission media. Such measurements may help in developing optical communications systems for the future.

When used in an evacuated environment, where damping effects on the particle are negligible, the techniques may also have applications in inertial devices such as gyroscopes and accelerometers. ●

INTERACTIVE DISPLAY

by D. O. Harris, B.Sc. (Eng), Ph.D., of Stabletron Ltd.

**Computers are not really electronic "brains" and have no intelligence as we understand it.
The development of interactive display has, however, revolutionised computer/man communication by enabling man-to-machine interaction in a way that is natural and beneficial to both.**

IT is worthwhile analysing the reasons why the computer is not yet such a powerful tool as the "electric brain" which was the progeny of the journalist's fertile imagination. The fundamental problem is, of course, communication. It is not, and will not be for some time, practical to stand before it and ask a question – the normal human method of soliciting information. In general it cannot understand speech because electro-mechanical devices cannot yet accommodate the variations in intonation and sentence structure which the simplest human being unconsciously copes with so easily – and sufficient software doesn't yet exist to allow the machine to interpret the sort of general question one is apt to want to ask.

In addition, there are no input channels comparable with the human senses by which the machine can assimilate experience from its everyday life. The computer thus has no data bank built from its own understanding of the questioner's environment to enable it to make a rational answer. It even requires instruction as to how to solve the problem or do an exercise presented to it.

In other words, the fundamental constraints in the efficient utilisation of computing power have been the difficulty of feeding data or instructions into the machine and the retrieval of information from it, coupled with the fact that, if you don't know specifically and intricately how to solve your own problem, it can't help anyway.

Although all this is obvious in the early '70s, the greatest danger in working closely with existing computer systems is, however, that one's mind can become narrowed by the limitations of the prevalent computer environment.

How far have we developed, then, from the situation where half a minute's run on the computer is the result of half a year's work from a team of expensive and error-prone systems analysts, programmers, and punch girls? These people constitute a very cumbersome and costly interface with the machine.

MAN/MACHINE INTERACTION

As with any industry in its adolescence, rapid advance has been made on all fronts simultaneously. For commercial reasons there has been a multiplication of effort in most fields. This, apart from squan-

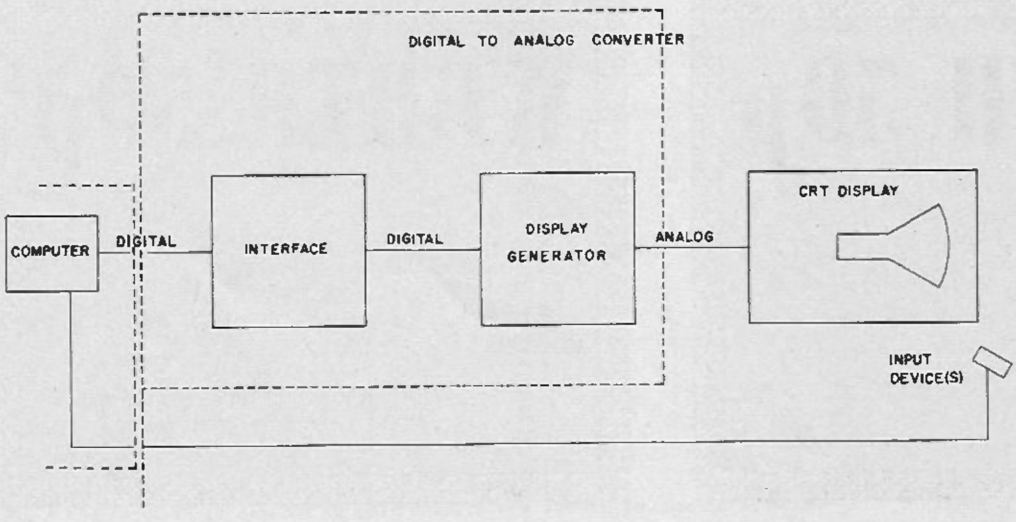


Fig. 1: CRT Graphics

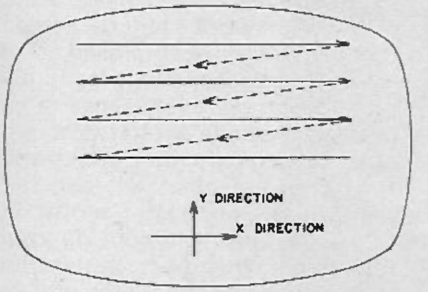


Fig. 2: Raster Scan

dering manpower, has resulted in some healthy competition from which it is hoped the strongest ideas will survive. On the software side, in order to simplify and shorten the programming task, higher level languages have been developed for specific applications, e.g., studies have been made on the division of labour between man and machine, so that man can utilise the computer for its speed at repetitive calculation, and his own intelligence in evaluating the result and supervising the calculation process.

On the hardware side, because of improvements which have come as a natural engineering development over the years, systems have grown more complex and cycle times have been progressively reduced. Response from the computer is, therefore, much quicker and the diferential between the time necessary to prepare the program and the time taken to calculate the answer has been highlighted. Input/output speeds via teletype, tape readers, card readers etc., are orders of magnitude slower than the cycle time of the slowest computer. Thus the communication link between man and the machine has once again become the major constraint to further progress.

The ability of third generation machines to cope rapidly with interrupts from peripheral devices has enabled the most exciting piece of hardware recently developed to be efficiently integrated into the computer installation – *the interactive visual display unit* based on the cathode ray tube. The basic elements of a CRT display system are electronic, not electromechanical, so that these input/output devices are capable of operating at computer speed. This makes true man/machine interaction possible for the first time, in such a way that creative talents of man are not frustrated by the slow response of the computer output device.

Man thinks in a basically visual form; the other senses are far less important in our memory system. In fact, the mind shows a preference for remembering things in a pictorial way. Heat or cold, noise or peace, are readily associated and conveyed pictorially – even a primarily aural stimulation such as orchestral music conveys mental pictures to the listener. It is, in fact, far easier to obtain a mental image of a pictorial situation than it is to recall a mental image of a word or number – something which has

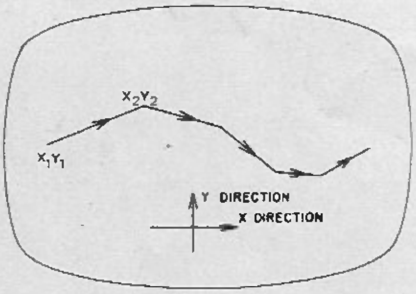


Fig. 3: Random Position Vector Generator

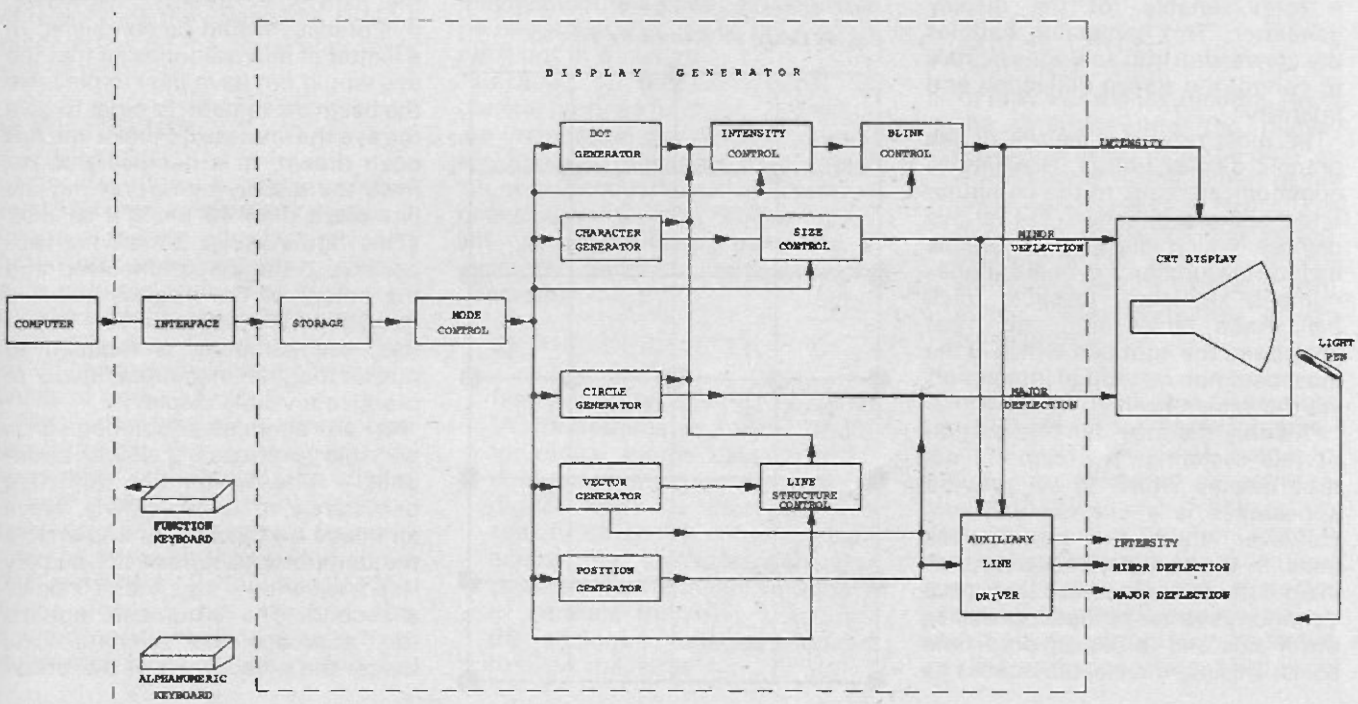
aural undertones – as anyone who knows exactly where the figure he needs is on a piece of paper, and yet can't recall that figure, will verify.

In dealing with picture form, both graphical and using symbols, one is therefore dealing with the idiom most easily manipulated in the mind of man. And using a CRT screen, one is employing the fastest output medium for the computer. What are then the facilities which enable these two to converse with one another across the interface of the CRT screen?

INTERACTIVE VISUAL DISPLAY

The CRT: In a visual display system, the CRT image is constructed by an electron beam, the deflection and intensity of which have to be controlled by analogue signals. The output of the computer driving this display, however, comprises a multidigital word. For this reason a complex digital to analogue (D/A) converter is required between the output of the

Fig. 4: Graphic Terminal



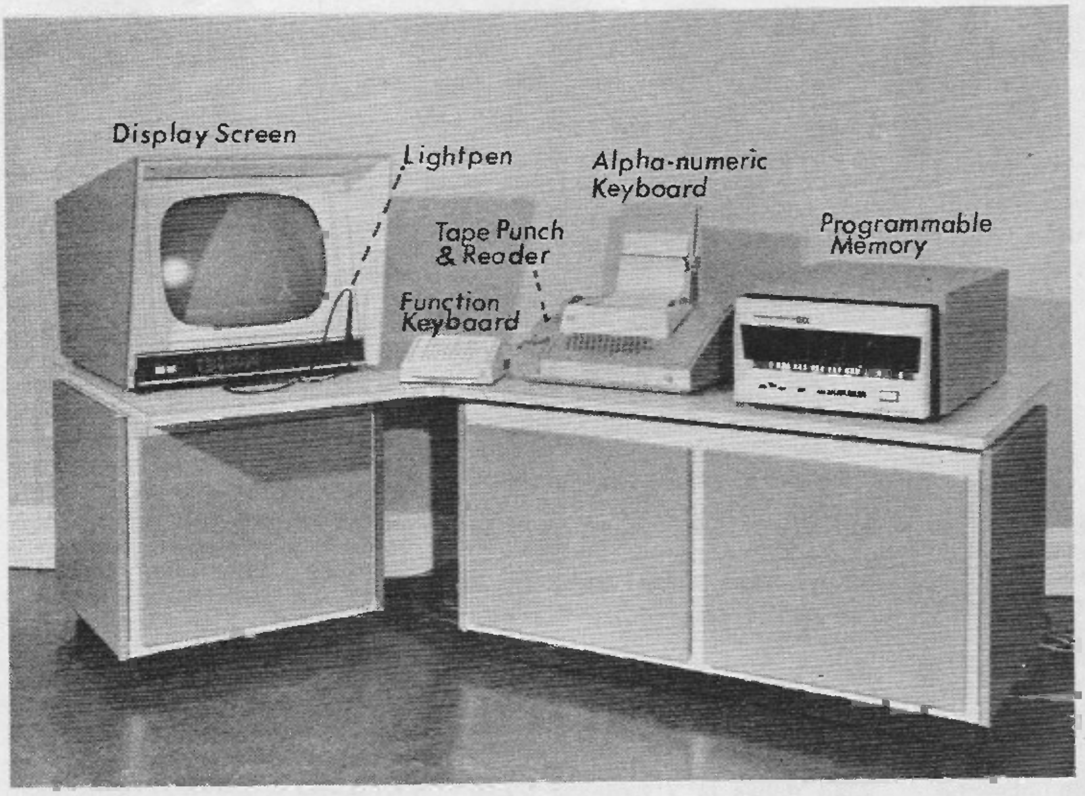


Fig. 5: IDIIOM Integrated Graphic Console

INTERACTIVE DISPLAY

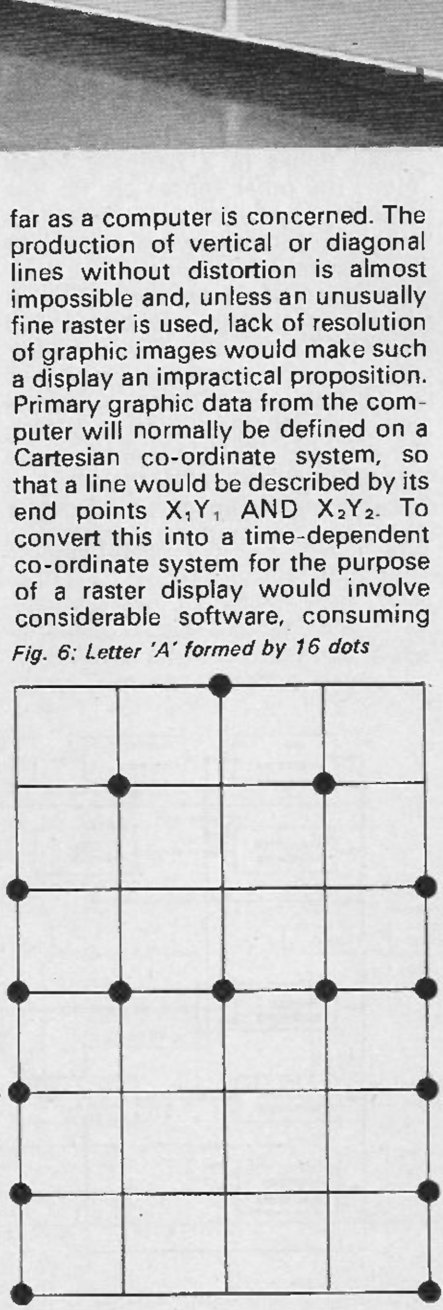
computer and the input to the cathode ray tube.

The D/A converter may be divided into two sections – the interface and the display generator. A digital word is input from the computer to the interface where it is reorganised into a form suitable for the display generator. This generator handles the conversion into analogue signals to control the screen deflection and intensity.

The most powerful feature of the graphic display unit is its ability to communicate back to the computer under operator direction. The various devices which make this possible include the function keyboard, alpha-numeric keyboard, joystick, track ball, Rand tablet etc., and most important, the light pen which is the most common method of interaction via the screen itself.

Probably the most familiar portion of this system is the cathode ray tube display which to all outward appearance is a television screen. However, there the resemblance ends. In the conventional television image, the beam is swept through a continuous raster process parallel to the X axis and is cut off on a time basis. This has several drawbacks as far as a computer is concerned. The production of vertical or diagonal lines without distortion is almost impossible and, unless an unusually fine raster is used, lack of resolution of graphic images would make such a display an impractical proposition. Primary graphic data from the computer will normally be defined on a Cartesian co-ordinate system, so that a line would be described by its end points X_1Y_1 AND X_2Y_2. To convert this into a time-dependent co-ordinate system for the purpose of a raster display would involve considerable software, consuming valuable core in the driving computer and wasting equally valuable time. Interactive control via the screen would also be complicated by this process.

Fig. 6: Letter 'A' formed by 16 dots



The visual display unit console is, therefore, organised on a random position basis. Thus the electron beam is left at rest until an analogue signal is presented to the deflection system. To draw the line from X_1Y_1 to X_2Y_2 the beam would be cut off by the grid voltage until position X_1Y_1 is reached, then turned on whilst it was being deflected along the path X_1Y_1 to X_2Y_2. However, this process would be completed in a matter of microseconds so that the eye would not have time to perceive the beam movement. In order to give the eye the impression that a line has been drawn, it is necessary to re-fresh the display by re-drawing the line more than 40 times a second. (This figure varies somewhat, according to the person involved and the colour of the display, but is a good general purpose value.) Therefore, the computer is required to output the line image repetitively to produce a visible display.

As an alternative solution it is possible to choose a slower phosphor – one which has sufficient persistence to decay slowly, leave an image on the screen, and enable the computer to refresh the display less frequently – say 5 or 10 times a second. The arguments against this approach are plentiful. The longer the persistence of the phosphor, the dimmer the display becomes, so that subdued lighting has to be used in the room in which the equipment is installed; the eye is most sensitive in the green region, the colour of the shorter persistence phosphors; the longer the persistence the more susceptible the phosphor becomes to damage through burning; the slower the refresh rate, the greater the difficulty of interactive control by light pen. The quality of the image presented to the observer is an all important factor, since he must perform tasks at the screen for lengthy periods.

As a result, modern display units are organised around high refresh rates. Modern computers are able to handle increasing quantities of information at fast speeds, and thus do not limit the screen performance under normal loading conditions. Should the computer be required to draw more lines than it can cope with in the time needed to refresh at the normal rate, some visible flicker will occur, this flicker increasing according to the overload. However, around 16000 line-inches can be drawn at a 30 cycles refresh rate on a 21" screen on a representative system, so that overloading and flicker is not a significant problem.

The physical size of the screen is generally made with as large a viewable area as possible within the limits of current CRT technology. This is obviously convenient from the user's point of view. It also enables the light pen to distinguish between lines displayed on adjacent co-ordinate positions, and a greater quantity of readable characters to be placed on each line. The overall quality of the picture displayed depends as much on the efficiency of the electronic system driving it as on the physical properties of the tube.

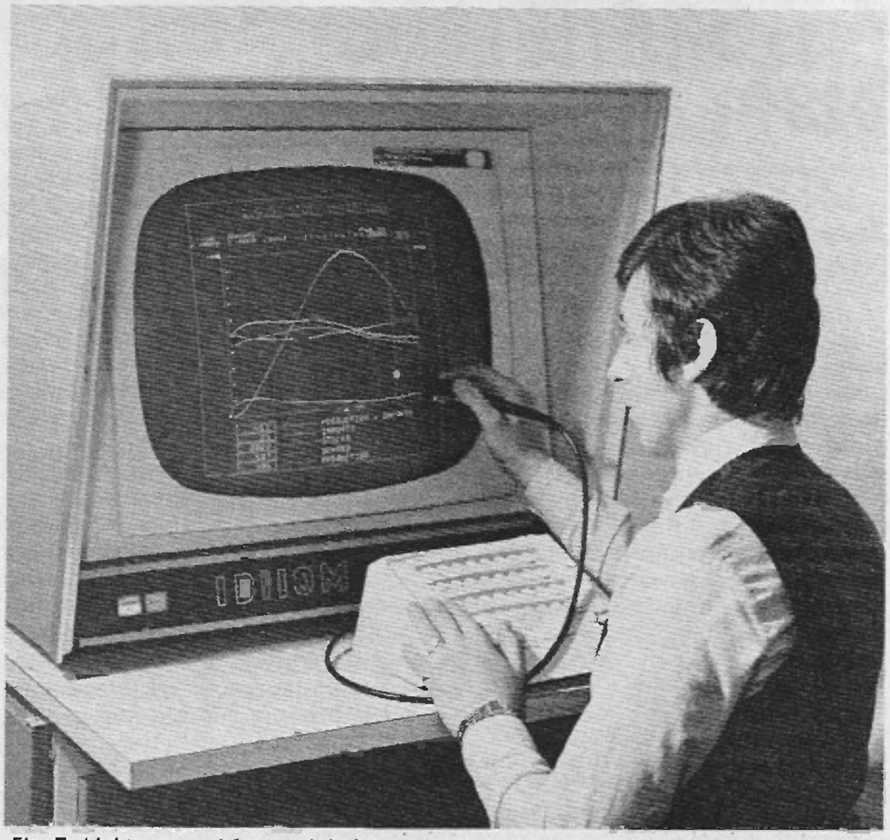


Fig. 7: Lightpen used for stock holding calculations

● THE DISPLAY GENERATOR

Consider how a digital signal might be used to construct a graphic image. Basically, all that is required is for the computer word to specify a co-ordinate position on the screen to which the beam could be moved and then illuminated. Any picture could then be constructed from a series of dots.

The primary elements of the display generator are thus a series of D/A converters (to change the digital X and Y designations into corresponding analogue signals to position the beam on the screen) and a dot generator (to illuminate the beam once it has reached the desired position). One would then need one separate instruction for each dot displayed. Owing to the limits of resolution and accuracy in the current state of CRT technology, it is not practical to designate more than 1024 addressable locations in both X and Y directions; parallel lines in adjacent co-ordinates will otherwise overlap. Thus 10 bits are needed to specify the X co-ordinate, and 10 to specify the Y co-ordinate. Therefore, with an elementary display generator, a 20-bit word would be needed to specify the position of each dot in a picture.

Because of this, a number of general purpose function generators are included in the display generator, allowing diagrams to be constructed without the use of excessive quantities of storage. These normally comprise a vector generator, a character generator and a circle generator.

● THE CHARACTER GENERATOR.

Instead of specifying the letter 'A', for example, as a series of 20-bit digital words describing 16 dots on a matrix, only a 6-bit digital code is necessary to specify up to 64 different characters. The character generator contains the hardware necessary to translate the 6-bit word into the analogue voltages required to draw the letter 'A'.

● THE VECTOR GENERATOR.

The vector generator relieves the computer programming problem of forming a line from a series of closely spaced dots. Instead by specifying the start and finish co-ordinates of the line required, the vector generator hardware deflects the beam along the desired path as described earlier.

● THE CIRCLE GENERATOR.

In this case the instructions (from the interface into the display generator used) describe only the co-ordinates of the centre of the circle and its required radius. The hardware generates the necessary analogue voltages in the same way as one normally generates Lissajous figures on an oscilloscope.

Once these hardware generators are included in the display generator, it is a relatively simple matter to add further elements to enhance their capabilities. For instance, an attenuator under program control can be added into the analogue output voltages of the character generator to provide size control; a line structure control can be added into the vector generator to provide

INTERACTIVE DISPLAY

dashed or dotted lines; and the outputs of all three basic generators can be routed through a digitally controlled intensity modifier to provide program controlled brightness levels and winking.

In the more sophisticated systems a mode control decodes the computer word and routes the information to the appropriate generators, and also carries out even further hardware functions such as automatic alphanumeric spacing, automatic carriage return line feed, character rotation, relative positioning, graph plotting, etc.

● THE INTERFACE.

The input to the display generator is a digital word. The number of bits this word will contain depends upon the design of the display generator, and may not be the same as the word length of the driving computer. In addition, the logic levels may vary. The interface therefore reorganises the computer word, converts the logic levels to display generator levels, and provides the necessary sequence signals to allow the computer to communicate with the display generator.

So far, our conversation between man and computer has been a monologue. We have seen how the computer can generate and maintain a picture on a CRT screen, and the most efficient way it can carry out this function. The next step on the path to full man-machine interaction lies in using this presentation to enable man to question, and reply to, the computer via the screen image.

COMMUNICATION DEVICES

Light Pen.

The communication device in most widespread use is the light pen – a light sensitive instrument which detects the passage of the electron beam. Once the beam has passed under the light pen, the computer process is interrupted. Registers in the display generator enable the computer software to identify which graphic element was being drawn at the time the process was interrupted, and the program user can decide what manipulation of this element he requires.

Normal methods of light pen usage can be divided into two basic categories – the pointing mode and the tracking mode. The former involves pointing the light pen at a list of alphanumeric options (or 'light pen menu') to add or delete parts of a diagram, or perhaps pointing to a graphic element to change its brightness or line structure.

The tracking mode enables parts of drawings or groups of characters to be moved about the face of the screen. As the light pen only reacts to the passage of the electron beam beneath it, a tracking symbol must be generated on the screen. This symbol consists of a search pattern which can detect movement of the pen by determining which part of the search pattern the pen was pointing at when the interrupt was generated. The computer then updates the position of the tracking symbol so that the centre of the search pattern is located immediately beneath the current light pen position. The movement of the tracking symbol can be used to generate lines or dots and thus draw shapes on the screen with the light pen.

Joy Stick and Track Ball.

These devices allow the operator to mechanically control two orthogonal A/D converters whose outputs enable a cursor to be drawn on the screen at the location specified. The software must then determine the part of the graphic image this cursor is intended to make reference to, and carry out any prescribed function of deletion, movement, rotation, etc.

Fig. 8: Joystick

The Graphic Tablet.

This is an electronic device consisting of a grid 1024×1024 lines, the same as the locations on the screen. A stylus is moved over the grid by the user, and its location is derived by the circuitry. A cursor may thus be positioned on the screen display. (A 2000 × 2000 line-pair digitiser is shown on page 75.)

The Function Keyboard.

This is normally a set of keys which can cause interrupts, their functions being determined by the software. The keys are illuminated by program control. Coded interchangeable overlays can be placed over the keys to change their meaning.

Alpha-numeric Keyboard.

This keyboard permits all the functions of the normal teletype terminal to be utilised; the operator can compose messages or make inquiries.

PART 2

We have seen how it is possible for the man or the machine to draw, on the screen, pictures composed of lines of various structures, characters of various sizes or circles – and how any or all graphic elements displayed on the screen can be made to wink or change in brightness. In Part 2 we will consider how these facilities can be utilised profitably in a commercial environment, how the ingenuity of man can be better combined with the fast calculating powers of the computer, and future trends and developments. ●

YOUR HELP, PLEASE!

The enthusiastic welcome given to ELECTRONICS TODAY INTERNATIONAL by a six-figure readership has justified our policy of filling the wide gap between professional specialist electronic journals and the hobby periodicals. Every month we get many readers' letters with comments and suggestions on the kind of editorial matter and level of treatment they would like to see. To ensure that development of magazine-content proceeds in the right direction, it is necessary for us to assess, as accurately as we can, a consensus of opinion from a wider cross-section of our readers.

This questionnaire should take very little time to complete. The items in Part 2 are intended solely to help our researchers get a good 'picture' of the readership now spread over a wide spectrum of professional and amateur engineering activities.

Help us – and yourself – by completing this Questionnaire and posting it to us. This is YOUR magazine, let us make sure it remains so.

– Editor.

1. **EDITORIAL CONTENT AND BALANCE.** (Place a √ in the appropriate box; M if you would like to see more space or higher technical treatment, S if you think present space treatment is about right, and L if less space or treatment is desired. Use the last three rows to add any other items to the list and tick appropriately).

	Space			Treatment		
	M	S	L	M	S	L
Features						
general interest						
technology						
audio/hi-fi						
practical guides						
Projects						
Product Tests						
News Digest						
Equipment News						
Component News						
Audio News						
Input Gate						
Tech Tips						
Solve a Problem						
Record Reviews – Jazz						
– Classical						
– Pop						
Book Reviews						
....						
....						
....						

2. **READER SPECTRUM.** (Delete *Yes* or *No* as appropriate. Be specific where you can.)

(a) Are you professionally employed in the electronics industry? *Yes/No.*

If 'yes', in what activity? ______________________

(b) Is your employment in an industry which utilises electronics? *Yes/No.*

If 'yes', what industry? ______________________

(c) Are you interested in electronics as a hobby? *Yes/No.*

(d) Are you interested in electronics as an aid to activities in or associated with your profession? *Yes/No.*

If 'yes', indicate how: ______________________

____

(e) Are you a regular reader of ETI? *Yes/No.*

(f) Do others share your copy of ETI? *Yes/No.*

If 'yes', how many on average? ______________________

(g) What sections do you read 'in depth'? ______________________

____

(h) What sections do you read 'for information only'? ______________________

____

(j) What sections do you skip intentionally? ______________________

____

(Please turn over)

FIRST FOLD

2. (continued)

(k) What items, features etc. you specially liked in the past issues? Please state:

(m) If you read any other publications in the electronics or other engineering field, please list them below and indicate whether regularly (R), frequently (F) or occasionally (O) in brackets after each publication:

SECOND FOLD

Stamp please

Electronics Today International
(Reader Questionnaire Dept.),
107 Fleet Street,
London E.C.4.

Additional copies of this questionnaire are available on request.

THIRD FOLD & TUCK IN

(n) Any further information or comments:

From

....

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....

....

(Information given in this form will be held confidential by our research panel. You may not care to include your name and address but, if you do, note that the five most informative forms received every week until this and the October issue are published will earn their senders a free one-year postal subscription to ETI.)

FIRST FOLD

COMPUTERISE - AND BE DAMNED?

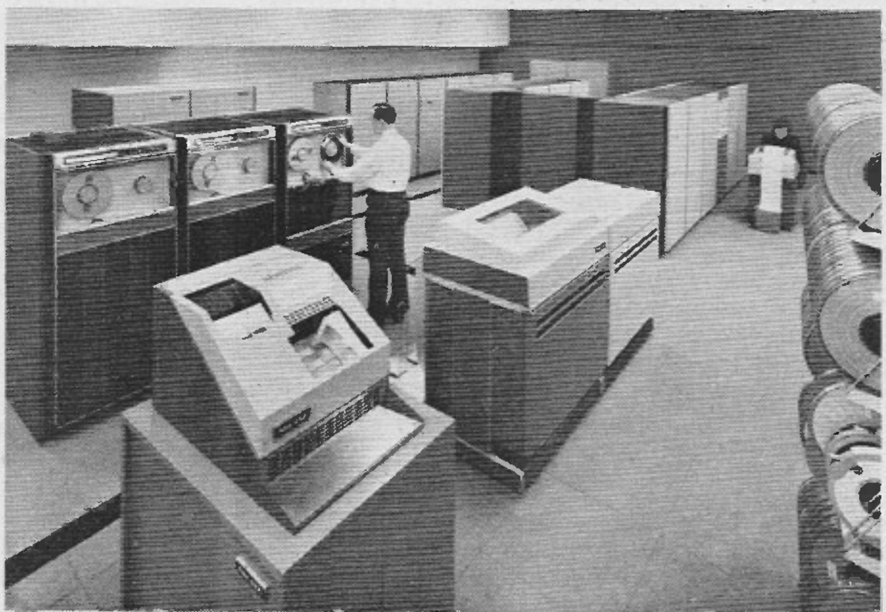
"If you were me, Oi wouldn't be dooin it" is the punch line to a well-known Emerald Island joke – and could also be the advice from management with some experience of computerising their company activities, when they choose to be honest with themselves and us.

CASE 1: Towards the end of 1971, a package holiday and travel firm with international operations sacked its computer, saved itself £90,000 a year and achieved more efficiency with half the staff. The most charitable comment from its managing director was "Perhaps using a computer could be profitable when we expand to double our present operations"; he had, then, 150,000 bookings a year!

Case 2: Early in 1970, a large firm in the UK domestic appliance sector computerised its extensive spare-parts inventory and despatch system. Two years later, after having spent nearly £100,000 on staff and equipment, they courageously hired two veteran O & M experts with only a nodding acquaintance with the mysteries of the computer. Their two months of intensive study resulted in suspension of all computerisation with almost over-night increase of productive work output and continuing cost savings.

Case 3: 'Management Practice' recently reported how a (US) company boosted its profits by taking a good hard look at its computerised inventory control.

What have all these three case histories in common with the laboratory engineer who was persuaded to buy a digital multimeter (measuring to 0.1% and with a number of other facilities) when all he really needed was an Avo Model 8 for continuity testing and simple voltage indications? Simply that, for a given function or set of functions to be carried out, there always exists a valid operational form which runs contrary to the oft-heard argument that complex-looking operations require complex-looking system or equipments. It is frightening to find that we are slowly but remorselessly being conditioned to using systems, procedures and equipments which are far too elaborate, involved and over-accurate for the problems we need to solve.



Sigma 9 System at Cybernet Time Sharing Ltd. (Rank Xerox).

REAL PROBLEMS

Returning to the computer case-histories, the tour operator found the system was cumbersome and slow, especially in dealing with clients' alterations to itineraries and bookings. A mass of information was potentially available, as the programmers and computer staff claimed, but nothing really worthwhile was readily available. Overheads, with staff, kept doubling every two years and eating into profits – while the promised 'golden day' seemed just as far away as ever, when all you had to do was press a button and get all the answers to a wide range of really important questions. A real hard look revealed that the staff were doing twice as much work as before the computer arrived, but 75% of their work was in feeding information to the seemingly bottomless funnel of the 'computer room'. With just one more assistant at certain key booking offices and a revised information-transfer system between the offices (using conventional phone, telex and postal services), the firm found that they could restore the sort of service they used to provide even allowing for the 100% increase in orders in the intervening 'computerised' period.

The appliance firm with spare-part inventory and order despatch difficulties had real problems which had nothing to do with computerising itself. The store-clerk, for example, was spending just as much (if not more) time in preparing information for the computer boys as he originally did in keeping a simple card index; the difference with computerisation was that, if he was asked how many IF strips he had in stock, he could no longer thumb a card index and give the answer but had to 'input' the computer which had the information in its invisible secret archives and whose current program could not be interrupted till who knows when. The firm's real problem was that the manual procedures for stock control, ordering and despatching had fundamental deficiencies which resulted in frequent and inevitable bottlenecks and which computerisation could not have taken care of. On the contrary, the computerisation (expectably, in hindsight) emphasised these administrative and procedural faults, for the simple reason that the programmes and data-processing experts (who knew nothing about the firm's commercial or engineering peculiarities) took their information from the day-to-day practices adopted in the company when they arrived on the scene. Once certain simple (and, as it proved, very effective) administrative and managerial 'base-rock' practices were introduced, bottlenecks vanished and, with it, the need for a computer white elephant.

The American company's real difficulty was that the computerised inventory control system was designed by data processing experts to whom the computer was the centre-piece on which to hang an inventory control system. They did not appreciate vital commercial aspects of inventory control such as EOQ (Economic Order Quantity) or ELS (Economic Lot Size). By including fixed-element costs to the variable elements in the cost of ordering inventories – instead of using just the variable factors – they created an unnecessary and wasteful excess of 20% or so in the overall inventory levels; far too much was being ordered and stocked. And, in their textbook approach to data processing, they did not allow for the familiar Pareto law that 80% of value is often accounted for by 20% of the items. By putting every one of the company's 12,000 and odd inventory items subject to computerised procedures, preparing the input to the monster involved far too much time and effort and cost. Just as much work was involved for a 3-cent nut and bolt as for a $5,000 item, and the scheduling of high-value items was literally lost in the mass of low-value item information.

SCEPTICISM

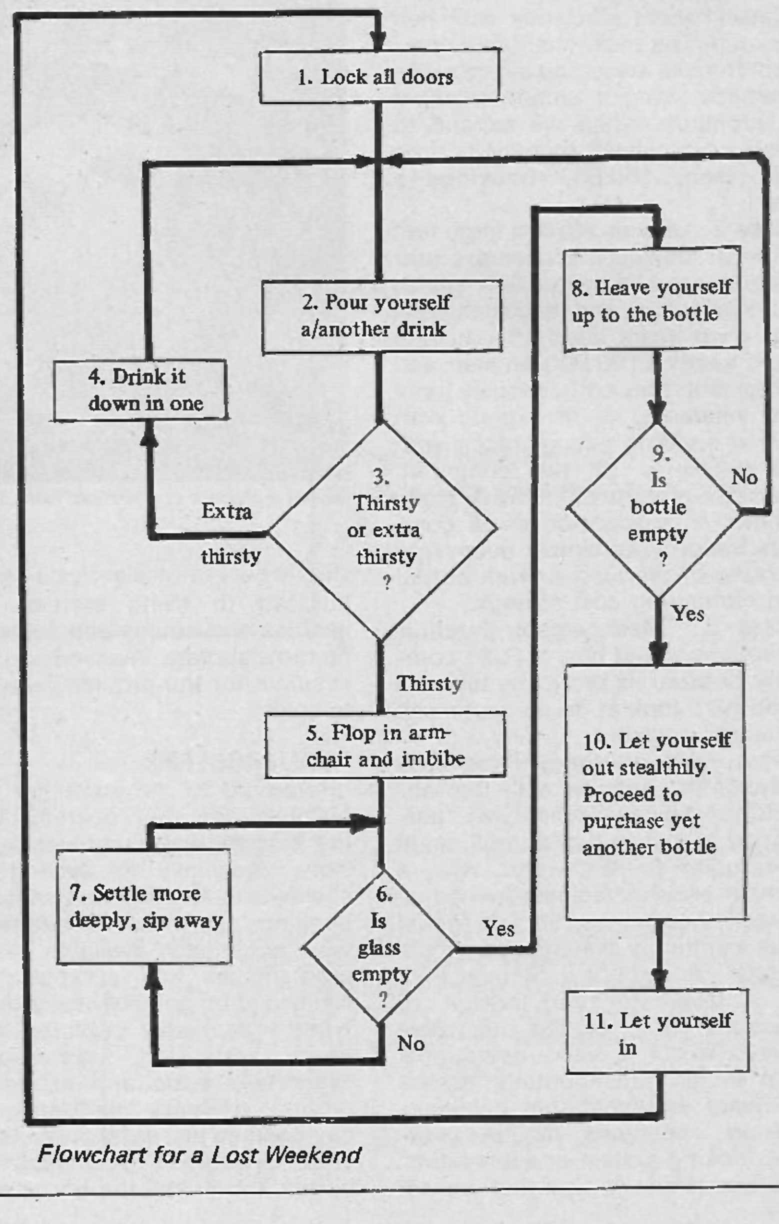
The 'Management' columnist in a national (UK) newspaper reports that, according to reliable management consultants, only one in five of computer installations are earning their keep. It is fast becoming accepted practice for board chairmen to insist "Yes, we think our £50 million in computerising was well spent" – and the scepticism with which such remarks are greeted in the profession also grows as tales of woe from users of EDP seem never ending. The real truth, if one digs into some cases, is that things are bad when the computer is installed (not surprising since, in the views of many managements ill-informed in computer applications, the computer was looked upon as the panacea to end all ills) and, when the computer is installed, things really get worse and the promised panacea recedes further and farther away.

When a computer expert like Brian Rothery writes a book called 'The Myth of the Computer' and (as journalists say) "reveals all", the time seems ripe for a second look at the situation by a by-stander not involved in selling or buying business computers.

SOME LESSONS

Some lessons have been painfully learned in the last decade of misguided over-selling by computer salesmen and equally misinformed acquiescence by ill-prepared managements.

Centralisation of corporate activities, especially in the accounting and similar data recording and retrieval sectors, does not always pay. For an organisation with subsidiary centres of activity scattered miles apart, centralisation of



Flowchart for a Lost Weekend

COMPUTERISE - AND BE DAMNED?

record-keeping at the head-office makes it virtually impossible for the centres' chief executives to assess, rapidly and continually, the profitability of their day-to-day operations and short-term plans; the records are elsewhere and, by the time they are collected, collated, processed and fed back to the centre in a form useful to the centre-manager, it is too late to do anything about falling profit curves or drain of cash-flow. The imminent collapse of a famous ship-yard in UK recently was evident to its operational managers six months before head-office tumbled to the inevitable conclusion that they have to cease operations; it took six months for the centralised accounting system to digest the inputs from various sources and spell out the result.

Before any mechanisation is installed, be it simple manual or computerised, the system of handling the work-load should first be examined thoroughly and the procedures clearly delineated. How much of a manager's or even a clerk's operation is based on intuition matured through experience or sheer man-made common-sense is perhaps not realised. Machines are fundamentally incapable of anything but systematic work and cannot cope with such aspects of the operation. Hence the frequent tales of computerised accounting sending household electricity or telephone bills for amounts astronomic even for a medium-sized business concern; in the old days of manual billing, a clerk would have spotted this discrepancy and queried it before it went farther into the system.

Computer consultants privately concede that most companies would find that, if they merely get their existing methods and systems better organised and made efficient before putting it all on computer, they would find that they can cancel the order for a computer – and be better off.

And the few who really still need a computer will be better advised to get their objectives clear, viz., what information, and to what detail, they want computerisation to provide. One management expert asserts that few computers provide real information, and almost all provide just a mass of meaningless and unusable data. As Brian Rothery indicates in his book, the result is that the only real benefit from the computer is payment of dividends to its manufacturers and programming bureaux.

Identification and clear understanding of what is expected from computerisation is not easy but is necessary. The same computer cannot be expected to process information for day-to-day operational activities and simultaneously act as a source of vital decision-making information for the management; the former involves systematic work, the latter operational research techniques with their own problems of modelling and forecasting. Handling of input data by the computer, its programming and problem-solving approaches for the two requirements are simply poles apart. In surveying just what various managements were trying to achieve from computerisation and how far they have succeeded, it is clear that working out wages for staff or providing information for management decision-making can often be done by cheaper and prompter means than with a computer; the sort of activities most suitable for a computer are the tedious repetitive tasks like sales statistics, stock control, order processing and mathematical calculations for scientific and research work.

In addition to pre-defining what work output is wanted from the computer, managements should also ask "Why?". Is it to save staff, reduce time lag between input and output of data, reduce errors or expand the scope of data coverage? This is probably the sort of area where insufficient analysis and inexact costing of existing methods and systems make it impossible to assess the saving which would result from computerisation.

BOAC's experience has another lesson, viz., never get a computer or EDP specialist to install the system for you. He may be an expert in information processing by electronic machines but he must be made to report to a manager who knows the business in which the company is engaged in, understands what the company's commercial objectives are and can direct EDP activities to the overall interests of the company. By applying to the computer staff the same controls of operational justification that any other productive worker in the company is subject to – and fighting to enforce it against the tide of EDP jargon sure to be bandied about – managements can virtually guarantee that, sooner or later, the computer staff will see themselves as managers serving to further the company's interests rather than EDP experts furthering computer technology.

Lastly, once the system is installed, it should be monitored frequently. Business conditions change – and, with it, the real results to be achieved by the computer. Many systems which started off with a specific job to do, have continued doing it when it is no longer an immediate need – merely because managers did not apply capability criteria to continually update job requirements. ●

EQUIPMENT NEWS

AIRFRAME LOADING

Load cell and mobile instrumentation

The manufacture of so precise and efficient a structure as the Concorde airframe demands special care to avoid distortion during assembly. GEC-Elliott electrical weighing equipment is now being used on the first production Concorde under construction at Filton to provide a safeguard as the major subassemblies of the airframe are fitted.

As the airframe is built up, the units are supported on hydraulic jacks, which provide alignment during assembly. Incorrect operation of any jack in this multisupport system could cause local damage to the structure. Load cells built into the jacks enable them to be finely adjusted to obtain the correct load distribution at various stages of construction. The weighing system has specially designed load cells compact enough to mount into the heads of BAC's existing jacks. These load cells measure only 108 mm high by 64 mm diameter, yet have working loads up to 9100 kg and can withstand excess loadings up to 36,400 kg without damage.

There are two sets of weighing equipment, one for the port side of the aircraft and one for the starboard. Each includes eight load cells, with quick release connections to a trolley-mounted instrumentation system incorporating channel selector switches and a 12" dial indicator. The instrument range is 0 to 10^4 deca-newtons and the reaction at each jack is measured with an overall system accuracy of better than 0.25%. Load-cell accuracy is said to be better than 0.1%.

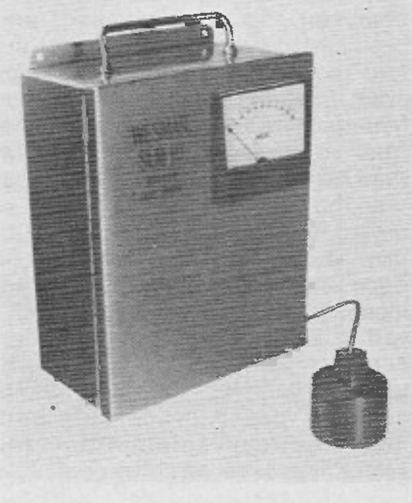
The instrumentation is built up from units of the GEC-Elliott modular weighing system, which provides all the basic weighing functions – such as indication, switching, automatic tare etc – from a range of off-the-shelf building bricks.

Weighing equipment supplied by GEC-Elliott Process Instruments has been used previously in the Concorde programme, for the Bristol Engine Division's static test bed for the Olympus 593. Here, the load cells measure the engine thrust, giving more accurate and repeatable results than the mechanical and hydraulic systems formerly employed.

Further information from GEC-Elliott Process Instruments Ltd., Century Works, London SE13 7LN. (35)

NO-CONTACT LEVEL CONTROL

Following the signing of a UK agency agreement with Western Marine Electronics of Seattle, USA, Fielden Electronics Ltd have announced the Wesmar SLM 10 level control and indicator using the principle of sonar-in-air, where an ultrasonic signal is reflected back from the material under surveillance; the time taken for the pulse to travel to the material and back to the sensor is proportional to the ullage and hence inversely proportional to level. Indication can be provided for both ullage and level.



The instrument includes circuits for the rejection of both acoustical and electrical noise, and fail-safe action.

Since the sensor need have no contact with the material in the container, the instrument is said to be ideally suited to many applications with liquids, slurries and solids such as aggregates, rock, coal, cement, etc.

In operation, an oscilloscope triggered by a repetition-rate generator sends a signal via a driver and power amplifier to the sensor which is mounted above the material. The sensor is a transducer which converts the electrical signals to ultrasonic pulses, and directs them on to the material. The reflected echoes are detected by the sensor, and the ultrasonic pulses converted to electrical pulses. This signal is then processed to convert the pulse transit time to an analogue signal proportional to the measured distance.

Both local and remote indication can be provided. Three adjustable alarm levels are available for overflow, high and low levels.

Further information from Fielden Electronics Ltd., P.O.Box 6, Paston Road, Manchester M22 4TX. (36)

COM-FICHE PROCESSOR

The Quantor 105 COM-fiche recorder/processor is claimed to be the first system which converts computer output tapes to microfiche in a single, rapid, automated operation.

The recorder, fiche cutter and fiche processor form three parts of a single unit system from which microfiche, fully processed, cut and dried, can be delivered ready for display, duplication and distribution.

Since the Quantor 105 is a self-contained unit, no photographic darkroom is necessary and there is no need for a separate fiche processor or for any external plumbing. Disposable, daylight-loading cassettes, each holding 100ft of 105mm film, clip into the unit, and the "Chem Pack" for the integral processor is easily renewed. The built-in fiche cutter ensures accurate cutting to NMA standards and film wastage is eliminated.

Standard computer magnetic tapes may be read and a choice of four magnetic tape drive options is available to accommodate format variations of input tapes. Character codes interpreted from tape are displayed on the CRT. Each page of information consists of a standard 64 lines of 132 characters per line, enabling the fiche to be read on a standard COM reader, e.g. the NCR 456-200. The standard character set contains 64 characters with a 128 character set as an optional extra. The Quantor 105 also has unique capabilities which allow considerable flexibility in page and fiche format.

Formatted tapes are created by supporting software and plastic job cards provide automatic job set up and running of the COM unit, minimising operator training requirement. The few manual controls are interlocked to ensure the correct sequence of operation and are backed up by a status display.

Further information from National Cash Register Co. Ltd., 206-216 Marylebone Road, London NW1 6LY. (37)

DATA DIGITISERS

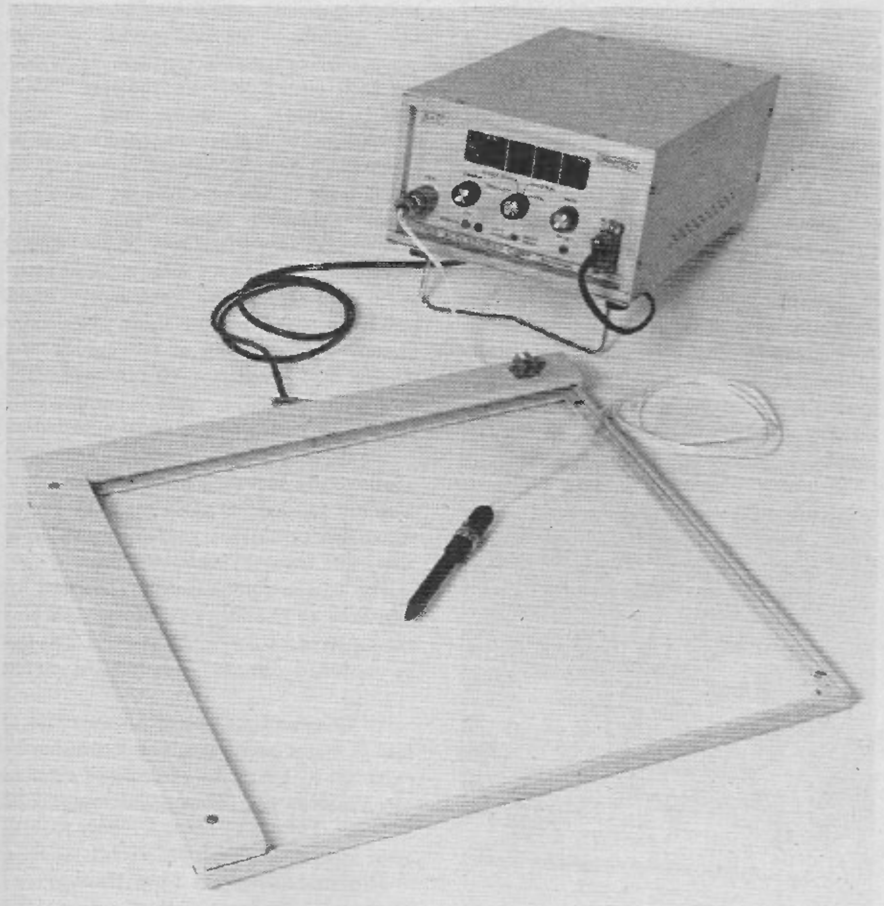
Information drawn, written or marked on the Graf/Pen ultra sonic data tablet with the stylus yields a permanent copy and is simultaneously digitised by hypersonic ranging, a new encoding principle, at rates up to 200 co-ordinate pairs per second and a resolution of 2000 x 2000 line pairs. The sensing rate is variable to match the user's speed and for efficient use of communications circuits and computer capacity. Output data, at TTL levels, are available in binary or BCD. A wide variety of interfaces can be supplied for various peripherals and computers.

The graf/pen comprises a Tablet, a Stylus, and a Control Unit. For display, a storage CRT or X-Y Recorder may be added. The Standard Tablet has an active area 14"x14" but any size and shape can be supplied. Frosted (for rear-protection) and transparent plates are available.

Strip Sensors on two sides of the Tablet receive signals from the Stylus which combines a ball-point pen with a tiny spark gap; the low-energy spark generates the sonicpulse with an extremely fast rise time used in the hypersonic ranging, and a small fraction of the energy provides the operator with a useful audible feedback. The control unit interprets information from the Sensors indicating the position of the Stylus on the X and Y axes of the Tablet, and discriminates against ambient noise. A variety of operating modes is selectable by panel switches. The sensitivity of the sonic system is said to be limited to the wavefront generated by the spark and prevents interference by even the highest ambient-noise level found in computer rooms.

Applications envisaged are: order transmission, inventory control, computer-aided drafting, numerical-control programmes, system analysis, etc.

Further information from Sintrom Electronics Ltd., 2 Arkwright Road, Reading, Berks RG2 0LS. (38)



DIGITAL THERMOMETER

The digital thermometer marketed by Ancom Ltd gives direct digital read-out of temperature from any specified thermocouple. It is a complete package incorporating a 'linearisor' to compensate for the non-linearity of the thermocouple, power supplies and the 'chopper' amplifier necessary to provide low drift with time, and the digital read-out.

In the process control field particularly, the unit should fill the demand for a complete,

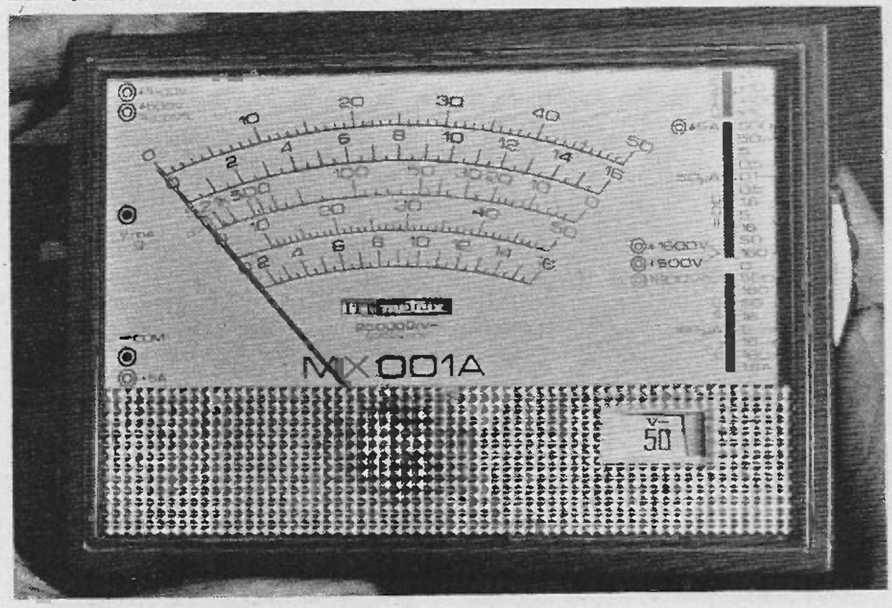
ready-to-use, packaged unit which simply links to a thermocouple probe, to give a direct temperature reading. Ancom can supply the unit matched to any of the most commonly used thermocouples such as Chromel/Alumel, Pt/Pt-Rh, Cu/Constantan, Fe/Constantan or Fe-Au/Chromel; special transducer requirements can also be catered for. The range covers automatic cold junction compensation or fixed cold junction as specified by the user.

An advantage of the packaged unit is that the individual components can be chosen, matched and factory-wired for optimum performance under extremes of operating conditions. The company states that the unit has an overall thermal stability of about 10 uV and long-term drift characteristics of the order of 0.05 uV per °C, with low input noise – typically 1 uV peak-to-peak. The feedback modules (function generator 'linearisor') straighten out the nominally non-linear output of typical thermocouples to an error bandwidth of about ± 1°C over the complete temperature range, depending on the particular thermocouple used.

The unit is supplied in a compact metal case (68.7 x 190 x 258 mm) complete with digital meter, suitable for fixed or portable use, but the basic linearisor, power supply and amplifier unit can be supplied separately for building into systems to drive conventional analogue meters or set-point meters or controllers.

Further information from Ancom Ltd., Denmark House, Devonshire Street, Cheltenham, Glos. (39)

LOW-COST POCKET MULTIMETER



The MX001A, introduced by ITT Metrix and priced at £12.75, is attractively styled with a bright red or royal blue shock-resistant plastic case, and can measure voltages up to 160V dc (and 500V and 1600V on separate sockets) with a sensitivity of 20,000 ohm/V; up to 500V ac with 1600V on a separate socket; and currents up to 500mA dc (5A on separate socket) and 1.6A ac; and resistance up to 5 megohm.

Range selection is by a thumbwheel switch, the range selected being shown at a window below the scale.

Weighing only 400g, the MX001A is fully protected against overload by both fuse and diodes, and uses a moving-coil movement with high-flux central magnet with minimal flux leakage.

A full range of accessories is available including a filter probe for TV line-voltage measurements, 15kV ac/dc probe, 30kV dc probe, range multiplier resistor box (3000 to 6000V ac/dc) and an adaptor for resistance measurements from 20 kilohm to 50 megohm. A carrying case and rubber shock protector are also available.

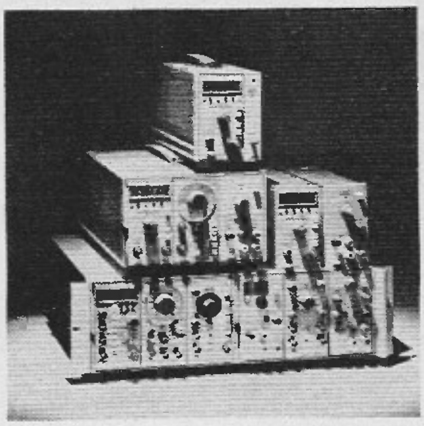
Further information from ITT Components Group Europe, Instrument Sales, Edinburgh Way, Harlow, Essex. (40)

PLUG-IN SYSTEM

A new compact plug-in test and measurement system, the TM500, offering a variety of measurement capabilities at very low cost, is announced by Tektronix. 14 plug-in units are available including digital counters, a digital multimeter, a ramp generator, a sinewave generator, pulse and function generators, and low-voltage power supplies.

Tektronix claim that the plug-in system enables, for instance, a counter, function generator and power supply to be used simultaneously with less bench space and at lower cost than three monolithic instruments. Up to six plug-in modules can be mounted in a standard 19-inch rack, and will occupy only 5¼" of rack height, enabling many of the common bench-gear functions to be combined in a compact, simple system.

The TM500 Series is designed so that connections between modules and external equipment can be made via the mainframe rear interface board and optional rear panel connectors. Each plug-in module has selected lines brought to its interfaces, some of which are parallel to front panel connectors, while others are present only at the interface. For example, digital counters have serial BCD outputs which can be brought out for data logging or processing. Typical examples of interface connections between modules are: to connect the output of the ramp generator to the voltage-controlled frequency input of the function generator for frequency sweep; or the output of the function generator to the input of the universal counter for frequency monitoring.



Further information from: Tektronix UK Ltd., Beaverton Road, Harpendon, Herts. (41)

SEQUENCE TIMER

Shennanton Electronics have announced their CTO2 all solid-state timer. The unit performs a sequence switching function basically similar to that of a mechanical cam-operated sequence timer, but without the many maintenance problems, size disadvantages, etc., of these. It is suitable for incorporation in modern solid-state process and other programme control equipment etc.

A number of independent outputs are switched for preselected periods in a repetitive timing sequence, the outputs maintaining constant relationship to each other and to the total sequence period. Each output consists of a fast rise-time voltage, translating '0' to '1' and vice-versa at predetermined switching points, which may be selected at 3½% intervals of the total period. Selection is made by connecting 'ON' and 'OFF' pins for each output with the required 'TIME' pins in a row of 31, representing 12° steps from 0° to 360°; this connection is made by short wired links or push-on connectors on flying leads or the pins may be taken to a selection switching system.

A number of outputs may be switched at one point. The output voltage can be interfaced with high or low level logic, TRIAC power switching etc. or made to operate directly a relay, lamp or counter up to a loading of 1.5 watts or 80 mA max. The total timed period, or cycle, is continuously variable in length and is easily adjusted by means of a screwdriver control, and may be continuously recycling or 'one-shot'; this function selection is again made by simple wired link or external switch. Provision is also made for applying 'inhibit' signals.

The unit is completely encapsulated for resistance to humidity, shock etc. All pins are on standard 0.1" grid, and the unit can be mounted directly onto printed circuit boards.

The specifications include a time cycle of 1 to 200 secs continuously variable (may be extended to 1 hour by addition of external capacitance), six independent outputs as standard, 18 to 36V 300mA supply requirement and approx 4½"x2½"x1" dimensions.

Further information from Shennanton Electronics, Kirkcowan, Scotland. (18)

THE DIGITAL VOLTMETER

(Continued from page 31)

would otherwise be possible with a straightforward integrating technique.

The integrating part of the method ensures a high level of rejection for normal and common mode noise, enabling measurements to be made with accuracy in the presence of high noise voltages.

The method combines the advantages of the two techniques, and the design requirements of the integrator are reduced in comparison to a straight integrating converter.

RECIRCULATING REMAINDER

This is a combination of the staircase ramp and the potentiometric type converters. (Fig. 10).

It is simple in that it has only one decade counter and only one decoder for the display, the readout being multiplexed (or time-shared).

Initially the input voltage is stored within the instrument – in analogue form. The single decade counter – the output of which goes to a staircase type of digital to analogue converter – is set to '9'. The decade counter then clocks down and is stopped when the output of the digital to analogue counter is equal or less than the stored input voltage.

The value now held in the decade counter becomes the integer part of the stored voltage, i.e. if the stored voltage was 5.361 volts the decade counter will stop at 5. This value is then displayed on the 1st digit readout tube.

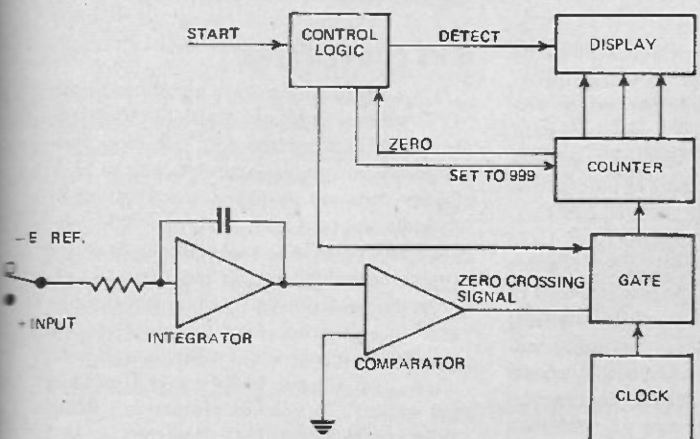


Fig. 11. Dual slope integrator.

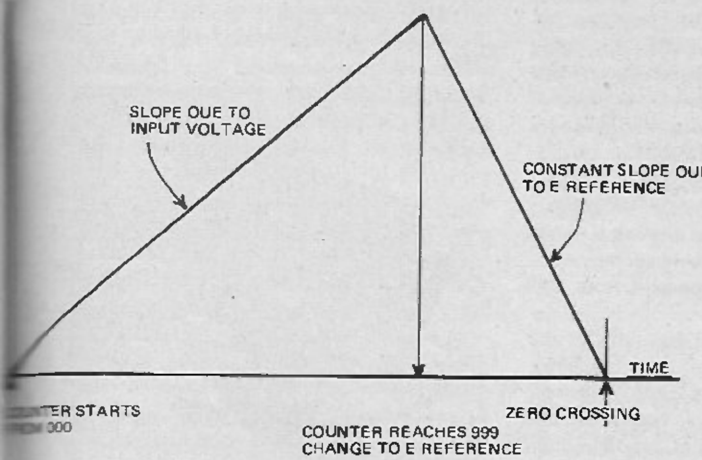
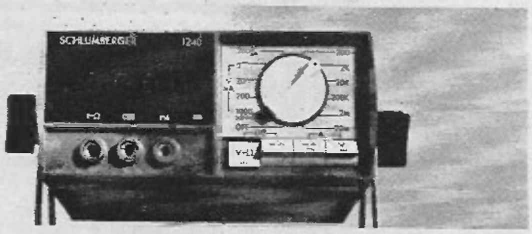


Fig. 11A. Dual slope integrator output.



The difference between the stored voltage and the digital to analogue converter is the remainder – in our example this would be 0.361 volts. This is amplified by ten and fed back into the store, as 3.61 volts. The decade counter is again set to '9' and the above sequence repeated except that the resultant decade counter value is now displayed on the 2nd digit readout.

The sequence is then repeated for the 3rd and successive digits.

DUAL SLOPE INTEGRATION

This is a fairly recent innovation and is commonly used in panel meters and other medium priced instruments. (Fig. 11).

Assume that a three digit display is used – initially when an unknown voltage is applied to the input a 'start conversion' pulse is generated, and simultaneously all the counters are set to '0'.

The integrator, which may be of simple design, begins to ramp up with a slope which is proportional to the input voltage. At the same time, clock pulses are gated to the counters which commence to count up.

Control logic detects when the count reaches 999, and then gates off the input voltage and gates on a reference voltage. The reference voltage is opposite in polarity to the input voltage and the integrator therefore instantaneously begins to ramp down with a slope proportional to the reference voltage. The process continues until zero voltage is reached.

At this point a zero crossing comparator closes the clock pulse gate, the counter stops and now holds a count which is proportional to input voltage. (Fig. 11A).

Design requirements for integrator and clock accuracies are much less stringent with this method because both input ramp and reference ramp use the same circuit path. Component inaccuracies cancel out, and accuracy becomes dependent mainly on the stability of the reference voltage and, if used, the input amplifier.

As with other integrating instruments the method provides good rejection of normal mode noise.

SUMMARY

These then are the basic types of digital voltmeters.

Each type of instrument has specific advantages and specific limitations. An instrument that is suitable for one application may be totally useless for another; especially if accurate measurements have to be made at high speed or with superimposed noise.

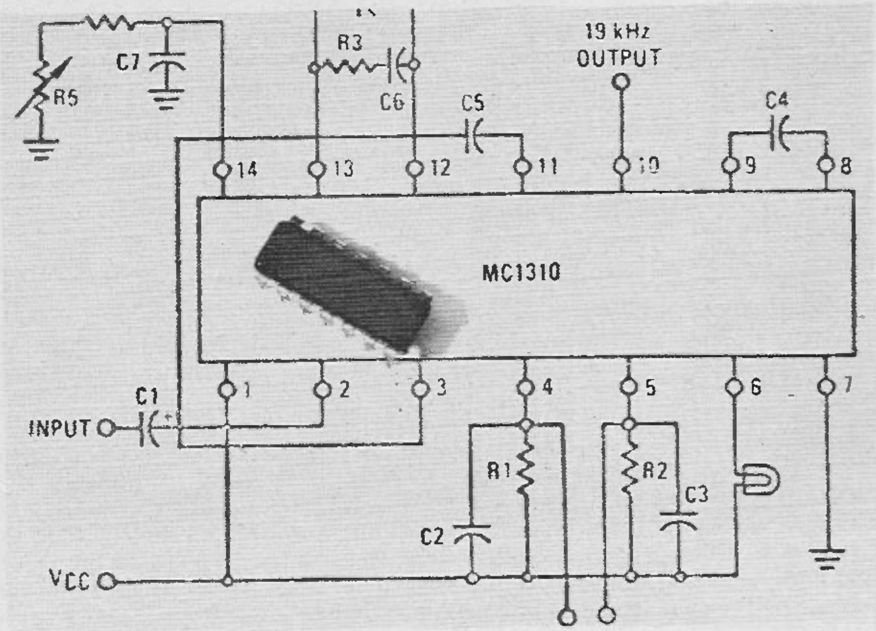
Generally speaking, price is a reasonably good (but by no means infallible) guide to quality.

Some digital voltmeters are better than others – and Electronics Today will be reviewing a number of different types during the next few months – but the dvm market is too competitive for really poor quality instruments to be sold.

Finally remember that accuracy is expensive. Very few measurements need to be made to accuracies closer than 1% – and even the cheapest of digital meters will do this with ease. ●

COMPONENT NEWS

STEREO DECODER



Jermyn announce off-the-shelf availability of the Motorola type MC1310P monolithic fm stereo demodulator which eliminates the need for tuning coils in a stereo decoder.

The unit uses a phase locked loop to lock on to the received 19 kHz pilot signal. This signal is frequency doubled, the resulting subcarrier signal being used to decode the fm stereo information, producing two audio outputs at an average level of 485 mV rms.

The only adjustment required is the setting of an internal 76 kHz oscillator. Acceptable performance is obtained with up to 2.5% oscillator detuning. Temperature variations cause detuning of only 0.5% over the range −30 to +85°C. Channel separation is 30 dB minimum and the total harmonic distortion, at the maximum composite input level of 560 mV, is 0.3%.

On stereo reception, a 75 mA signal for driving an indicator lamp is generated but this is automatically cut off during monaural or weak stereo reception. On monaural reception, the decoder is automatically switched off.

Further information from: Jermyn Distribution, Vestry Estate, Sevenoaks, Kent. (19)

PHASE LOCKED LOOPS

SDS Components have just announced off-the-shelf availability of Signetics' 560 Series of monolithic phase locked loops.

Each unit consists basically of a closed loop of a phase comparator feeding a low-pass filter and amplifier which controls a voltage controlled oscillator (vco),which in turn controls the phase comparator. External outputs are available from the amplifier and the vco.

The unit operates to maintain a constant output from the phase comparator regardless of variations of the frequency of the external input signal applied to the phase comparator, within limits set by the low-pass filter, i.e. it 'locks on' to the input frequency. In some units in the series, the vco signal is routed to the phase comparator externally, allowing external adjustable frequency multipliers and dividers to be used together with a crystal oscillator applied to the input. This enables synthesis of a wide range of stabilised frequencies with a single crystal.

Applications include FM demodulation without external tuned circuits (a de-emphasis control input is provided), synchronous AM detection, precision frequency multiplication and division, signal conditioning, side-band suppression and extraction of signals from high levels of noise, frequency shift keying and a variety of data communications facilities.

Operating frequency range claimed is 0.1 Hz to 30 MHz and the units are said to feature a high linearity which limits distortion to 1%. The input bandwidth or tracking range is adjustable by external components from ± 1% to ± 15%.

A companion function generator in the series produces square-wave and triangular wave outputs relative to an input frequency, for use in FM modulation, frequency shift keying and signal generation. Another companion unit is a tone and frequency decoder which drives an external load when a sustained frequency within a detection band is present; its applications include remote RF and ultrasonic control, radio paging, frequency monitoring and control, radio intercommunications and use as a precision oscillator.

Further information from: SDS Components Ltd, Gunstore Road, Portsmouth, Hants. (20)

H-P/CELDIS TIE-UP

Hewlett-Packard Ltd of Slough have signed an agreement appointing Celdis Ltd of Reading as the sole UK distributor for the Opto-electronic range of H–P components. The existing H–P marketing organisation will still be actively engaged in promoting the sales of the whole range of components but will concentrate on the big-order end of the spectrum. Celdis will be stocking light-emitting diode numeric and alpha-numeric displays, solid-state lamps, emitters of visible light, and isolators made up of emitter-detector pairs.

EHT CONVERTERS

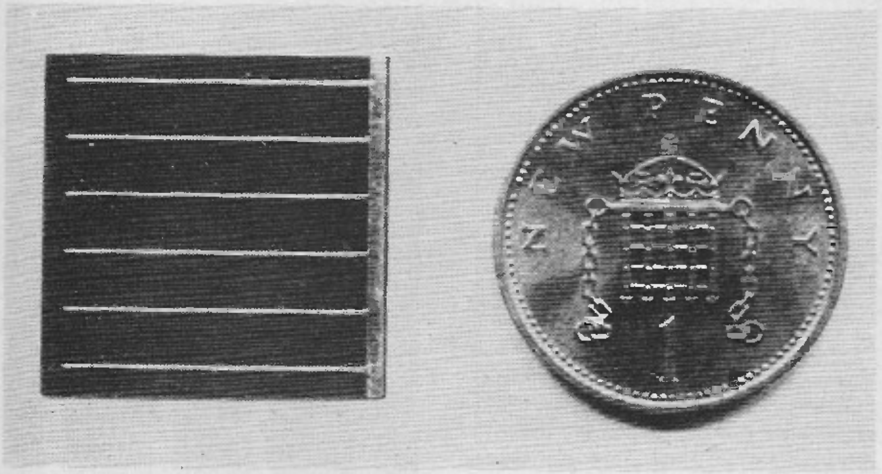
Coutant Electronics have announced their CPC Series of single and multi-output encapsulated EHT converters with stabilised, non-stabilised and adjustable outputs up to 5kV. These units are suitable for application in cathode-ray tube and photo-multiplier circuits as well as in special equipments of the type used in high voltage insulation testing.

On multi-output units, any output can be used in a feedback loop to provide highly stabilised outputs for any particular application. All versions feature current-limiting for output short-circuit protection. Being fully encapsulated, these converters are said to withstand severe environments and to be suitable for stringent industrial, avionic and other applications.

Further information from: Coutant Electronics Ltd., 3 Trafford Road, Reading RG1 8JR. (21)

COMPONENT NEWS

SOLAR CELL



Solar cell Model SS-2020G, originally developed for a satellite solar power plant, has conversion efficiency, radiation resistance, weight and reliability characteristics which, Photain allege, make it ideally suitable for a wide range of industrial control equipment. Its features include: 0.5V output at 130 mA (56mW optimum) when receiving light of intensity 140 mW/sq.cm., 0.3 g weight, −150°C to +150°C temperature range, more than 10.5% conversion efficiency and wide spectral response peaking at 800 mu.

Industrial applications of this cell include the charging of batteries in remote areas where a mains electrical supply is not available, for use in photo-electric equipment where a large output is required from a weak light source and for use with long-distance modulated infra-red beams operating as intruder detectors.

Further information from Photain Controls Ltd., Randalls Road, Leatherhead, Surrey. (22)

pH ELECTRODE

Electronic Instrument Ltd (George Kent Group) claim a unique advance in pH measurement with their 'new technology' industrial and laboratory pH electrodes.

The construction is designed around a moulded rubber plug inserted into the end of the electrode to separate the measuring element from the stem. This technique enables the cable terminations to be made at the bottom of the electrode stem and not, as on other electrodes, in the top cap, thus giving absolute protection at the union between the cable and the sensing elements and completely eliminating the problem of electrostatic interference and electrical failures due to moisture ingress. The technique also enables electrodes to withstand repeated steam sterilisation and allows for continuous operation at 100°C.

The electrodes utilise a recently introduced type of cable, featuring a polypropylene centre insulator and a continuous graphite loading, to give high temperature operation and to reduce noise generation.

The membrane glass is also of new formulation, covering the pH range between 0 and 14 and combining greater mechanical strength with faster response, lower electrical impedance and negligible sodium error. The sensors are available in two forms, one having a toughened bulb to resist breakage and the other designed for low temperature applications down to −5°C.

Both types use a gel form of electrolyte which allows the electrodes to be used in any position from the horizontal to the vertical, even under conditions of vibration.

Further information from: Electronic Instruments Ltd., Hanworth Lane, Chertsey, Surrey. (23)

COMPARATOR SUBSYSTEM

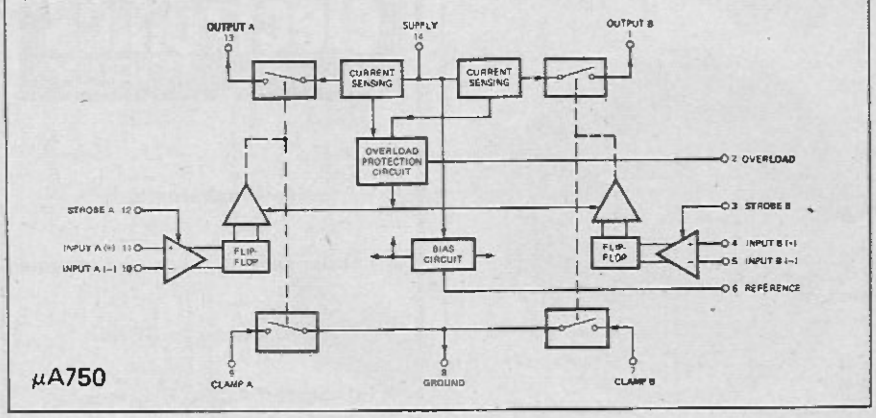
A new dual, high current comparator subsystem, known as the uA750 and released by Fairchild Semiconductor, consists of two completely independent comparators, except for common biasing and overload protection circuitry. Each comparator has a strobe inhibit facility, built-in hysteresis for positive switching, in-phase output current sinking, and high current sourcing capability, which allows operation in high noise environments.

The uA750 operates with a single power supply over the range +12V to +25V, and each comparator output is specified at

mHn is the unit quantity (approximately the amount required to launch one ship) of feminine pulchritude; also written in full as milli-Helen.

COMPONENT NEWS

BLOCK DIAGRAM



125 mA. Additional features include a separate voltage reference for external circuitry bias, thermal and short circuit protection.

Designed for a wide variety of applications including environment and process control systems, such as temperature controllers, lamp, relay and solenoid drivers, and other go/no-go systems, the uA750 functionally replaces a minimum of 7 active and 11 passive components, with the added advantage of increased system reliability and board space saving, and is available in 14 pin ceramic dual-in-line package.

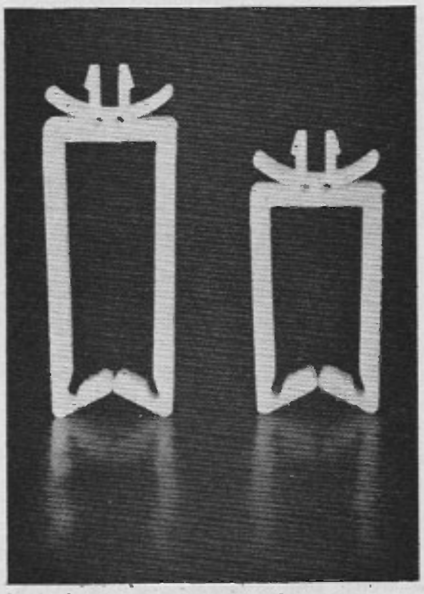
Further information from: Fairchild-Halbleiter GmbH, Hagenauer Strasse 38, 6202 Wiesbaden-Biebrich, West Germany. (24)

WIRING SADDLES

Wiring saddles manufactured by the RICHLOK Corporation are designed to minimise assembly time by use of a patent self-locking fixing device.

Made in high dielectric-strength nylon, and available in four sizes, the saddles provide a positive, spring-locking action on cable bundles up to 1" x ½" cross section. They are easily fixed by snapping into 0.187" diameter holes in the mounting surface and require no special tools.

Further information from: Peter Bowthorpe Raynor & Associates Ltd., Holmethorpe Avenue, Redhill, Surrey. (25)



BOOK REVIEWS

REVIEWER: Brian Chapman

110 INTEGRATED CIRCUITS PROJECTS – By R.M. Marston. Published 1971 by Iliffe Books. 128 pages 8½ x 5½.

Cased £1.80, Student edition £1.20

With integrated circuits now readily available at reasonable prices, more and more experimenters are building projects incorporating these devices. A book containing IC projects is therefore appropriate and timely.

This book forms a companion volume to "110 Semiconductor Projects" by the same author and is of the same very high standard. There are 30 projects incorporating the RCA CA3018 IC transistor array, 30 incorporating the CA3035 ultra-high-gain wide-band amplifier array, 15 power amplifier projects using the CA3020, PA237 and PA246 IC power amplifiers and 35 digital IC projects using the popular 914, 923 series ICs.

The variety and utility of the projects are excellent, and those in the companion volume mentioned above, are graded in order of complexity to facilitate instruction in the theory and technique of usage.

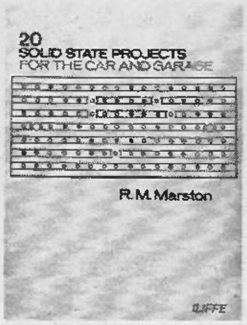
Most project books merely give circuit and constructional details without any real attempt to instruct the reader in the finer points of the theory. This is definitely not the case with Mr Marston's books – his primary aim is obviously to instruct the reader in the design of simple circuitry so that they can get the utmost enjoyment from their hobby whilst constructing useful devices.

This approach has been so successful that many US companies (including RCA) and technical colleges have sought permission to use these projects in their training courses. The book could have no better recommendation than that.

At the modest price how can you afford to be without it. – B.C.

20 SOLID STATE PROJECTS FOR THE CAR AND GARAGE – By R.M. Marston. Published 1970 by Butterworth, 115 pages 8½x5½.

Cased £1.80, Student edition £1.20



Electronic projects specifically designed for cars, such as tachometers, theft alarms, windscreen-wiper controls and battery chargers etc, are very popular indeed. This book by R.M. Marston should be scooped up by the auto-gadget hunters, for it contains just about every type of electronic auto project that has ever been thought of.

There are eighteen projects specifically designed for use in cars, and two for use in the garage. Quite a few of the designs have been previously published in the UK and the USA and have been extremely successful. In particular the first project – capacitor discharge ignition system, has been successfully built by many thousands of hobbyists. The theory of capacitor discharge ignition together with ignition theory in general is treated very completely, which gives the builder considerable insight into the reasons for the use of electronic systems.

Thus, as well as the obvious value of the projects themselves, there is the additional benefit of Mr Marston's teaching ability. In fact each project is accompanied by an excellent explanation of the theory of operation and the principles involved. In the very unlikely event that one did not want to build any of the projects, the book would still have value because of its enjoyable, commonsense treatment. – B.C.

LOGICAL DESIGN FOR COMPUTERS AND CONTROL – By K.N. Dodd. B.Sc., M.Sc., Ph.D. Published by the Butterworth Group 1972. 131 pages 8½ x 5½.

Cased £2.40, Limp £1.40

This book as stated in the preface is designed to introduce electronic control logic to high school students and engineers who need an understanding of the subject. The book commences with a development of two-state logic from first principles without reference to electronics. Circuitry for the implimentation of the logic functions is then treated and the electronic devices and integrated circuits typically used are discussed. Computers are then treated from two aspects: their construction from logical elements, and their use in control applications. Extensive knowledge of physics or mathematics is not required as the text is essentially conversational.

I must admit to being somewhat puzzled as to the choice of title from which one would assume that this book was meant for logic design engineers. A more suitable title would seem to be "An Introduction to Computer and Control Logic," for this is certainly what is intended by examination of the preface and the text.

As to the treatment of the subject, I doubt that *anyone* could progress at the rate implied by the brevity of the text, despite the author's warning that it needs taking in small stages. For example, on page 3 we are shown that a dot where two lines cross on a circuit diagram, indicates a join, and by page 14 we are up to the consideration of shift registers utilising JK flip-flops WOW!

After then progressing through binary arithmetic and Boolean algebra, we then dismiss electronic fundamentals in 10 pages and integrated circuits in eight. Control systems and computers are the subject of the last 50 pages.

High school students must certainly have much greater powers of assimilation than I thought possible. Although the book certainly contains much of interest, it is entirely too brief to be of interest to the technician or engineer – in fact it seems to be a complete miss – B.C. ●

RECORDINGS...

JAZZ

REVIEWER *John Clare*

JIMI HENDRIX – Hendrix in The West. Polydor Stereo 2302018 Johnny B. Goode, Lover Man, Blue Suede Shoes, Voodoo Chile, The Queen, Sergeant Pepper, Little Wing, Red House. Mitch Mitchell, drums; Noel Redding or Billy Cox, bass.

Some may wonder what this review is doing in the Jazz section. It is simply my belief that near the end Hendrix was developing an approach to guitar which was more appropriate to contemporary jazz than almost any jazz guitarist other than Sonny Sharrock or John McLaughlin. Listen to what he does about twelve bars into his solo on Lover Man. Those running phrases would not be at all amiss in an Ornette Coleman solo. His best effort, however, is on Red House, where he uses a traditional blues form to show just how far outside the blues basis of almost all rock guitarists he is able to go. Towards the end his solo is straight contemporary jazz, and he is not just imitating something he has heard, but really creating in the idiom. The tonal variety and the development of complex ideas are quite comparable to what contemporary jazzmen have been doing mainly on saxophones.

For all the complexity of musical thought, Hendirx has on this album pruned away many of the superfluous notes, the redundant ornamentation which made some of his earlier work sound a little gimmicky. Many rock guitarists have diahorrea of the fingers and I think this is partly due to their efforts to inject something new and original into the same old harmonic progression. Hendirx broke through not by adding extra notes at every opportunity, but by enlarging his harmonic sense, his knowledge of what notes, not how many notes, you can play at a given time.

I read somewhere that Hendrix had wanted to form a larger band of experimental musicians, and somebody told me that he was indeed listening to people like Albert Ayler and Archie Shepp. If only he'd lived. If you find it hard to believe that he was really heading in this direction, I suggest that you listen closely to the Red House solo, which is in fact divided into two distinct sections. In the first he does just about everything it's possible to do with blues conventions. There follows a reflective unaccompanied interlude, and then everything frees right up; he really breaks through into something else.

While Mitch Mitchell and Noel Redding are admirable, one wonders what Hendrix could have done with a drummer like Tony Williams or the king, Elvin Jones – the kind of drummer who could have actually fed him ideas as well as complementing everything Jimi could spring on them.

I think it will be a long time before the rock scene catches up with Jimi Hendrix, and it may be just as long before jazz guitarists wake up to what he had to offer them. In the meantime, I think that this is just about the best Hendrix I've heard. Let us not forget during these deliberations the marvellous revamps of old rockers like Blue Suede Shoes and Johnny B. Goode that are included on this album. Nor God Save The Queen, which is nearly as good as Jimi's version of The Star Spangled Banner. – J.C.

NEW LITERATURE

● General Instrument Microelectronics' new catalogue provides a condensed guide to their large range of standard MOS microcircuits.

Write to General Instrument Microelectronics, 57/61 Mortimer Street, London W1N 7TD.

● The wide range of Honeywell's fire and security devices are described and illustrated in a new brochure, 'Fire and Security Products', an eight-page publication (Ref No. SAB.54).

Another leaflet, 'Smoke doors in the way?' describes the S485B Electromagnetic doorholders which can conveniently hold smoke doors open – especially desirable in busy areas – but allow the door to close instantly upon alarm.

Both publications are available from Honeywell Ltd., Commercial Division, Charles Square, Bracknell, Berks RG12 1EB.

● A new 60 page Product Portfolio containing many line diagrams and tables of information covering the complete Newmarket product range is available from Newmarket Transistors Ltd., Exning Road, Newmarket, Suffolk. The book is divided into sections covering micro-circuits, germanium transistors, silicon transistors, packaged circuits and ancillary devices.

SOLVE A PROBLEM

Do you have a problem – in locating a device with special characteristics, in achieving a design or usage function, in applying electronic (and associated) techniques or merely as a challenge to ingenuity? Write and tell us – and, through this column, your fellow-readers in all engineering disciplines – about it. Here is a sample culled from readers' letters in the last few months:

Problem 001: We require to detect a direct current which could vary quite randomly between 0.1mA to about 10A under certain fault conditions. Below 0.1mA is the 'safe' condition. The device (or circuit) used to detect 'fault' must close a 220V 0.5A alarm circuit and must itself present less than 0.1 ohm resistance.

Problem 002: Is there a simple circuit to quieten or silence (but not switch off) the television, hi-fi and console radio at our home automatically when the telephone rings or when we answer the phone?

Problem 003: Having recently wired a conventional three-conductor* circuit to operate a 100W lamp in the garage (22 yards away) and a 60W lamp in the shed (a farther 10 yards away) individually from two SP on/off switches in the kitchen, I wonder if it could have been done using 35 yards of two-core* cable I had no use for. (* not counting the 'earth' conductor).

Problem 004: Very interested in the 'Car Distance Warning' item on page 6 of your August issue. However, is there no simpler gadgetry by which a driver can warn himself that he is too close to the vehicle ahead?

Problem 005: Perhaps this is not a purely electronic problem but, in our laboratories, we do need to draw on paper, sine-waves of differing amplitude and cycle-length. Is there a suitable drawing device? We envisage it as, for example, a hand-held device which is dragged on the paper to inscribe 3 or 4 sine-wave cycles of pre-set amplitude and period.

To readers with solutions: please help our mail department by writing the problem number prominently on the bottom left of the envelope. – Ed.

PS: Did you have a go at the cube problem in the August issue? – Ed.

READER ENQUIRY SERVICE

Both advertisement and editorial matter are allocated code numbers, in bold type in brackets, accompanying the item.

Enter the relevant numbers in the list provided on a card, cut it out and mail it to us. Your enquiries will be passed on to the manufacturers or companies concerned, and you can expect to hear from them directly.

If you did not see this copy first-hand or if you are way down on the circulation list, you may not be getting the best benefit from this enquiry service.

May we suggest that you have your own copy? Place an order with your newsagent at 20p per copy delivered to your door.

Subscription rates: UK, £3.60 a year. Overseas, £4.00 a year, postage by surface mail.

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ELECTRONICS TODAY INTERNATIONAL

ENQUIRY SERVICE

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OF UTMOST GRAVITY

(Continued from page 23)

meteorologist Alexander Friedman said that general relativity logically implies an expanding and contracting closed universe whose size is never constant: a universe that, in effect, breathes as the objects within it move apart and come together. Einstein admitted that he had made the "worst blunder of his life" in rejecting Friedman's predictions, after astronomer Edwin Hubble proved that the universe is expanding.

AN INFINITY OF FORMS

Further observations have confirmed that galaxies recede from each other at a decreasing rate because of their mutual gravitational attraction; eventually, they will reverse course and fall back together at an increasing rate. The present cycle of the universe will end when all galaxies reach the same point simultaneously, their complete gravitational collapse producing a singularity that will explode to begin another cycle; this indeterminable space curvature represents matters as it was and as it will be in an infinity of forms.

Quantum theory, the other giant of twentieth century physics, describes elementary particles as discrete quantities of energy, spin, charge and momentum occurring in multiples of basic units determined by probability waves. But quantum's laws do not allow for the destruction of most elementary particles – except by antiparticle annihilation – in relativistic black holes. The apparent contradictions of these pre-eminent theories may indicate that both are incomplete.

Many theoreticians have suggested that there is an elusive relationship between the worlds of the very large and the very small. The estimated radius of the universe at the phase of maximum extension exceeds the characteristic dimension of an elementary particle by a factor of 10^{40}; electric forces between two particles are 10^{40} times greater than gravitational forces; and the estimated number of particles in the universe is of the order of 10^{80}. There must be casual connections between these numbers, says Dr. Wheeler. Inside the black hole, quantum theory and general relativity may meet. A complete understanding of the extraordinary physics of these spacetime phenomena could lead to the quantization of relativity, or quantum geometrodynamics. Sought for more than 25 years, such a theory, with its comprehensive explanation of existence, would revolutionize the physical disciplines and perhaps challenge the precepts of western religion. – Mort La Brecque

RECORDINGS...

CLASSICAL

REVIEWER: John Araneta

PURCELL – THE FAIRY QUEEN (A New Concert Version) – Soloists. Ambrosian Opera Chorus – English Chamber Orchestra. Benjamin Britten (cond.) – DECCA SET 499-500.

Quite a number of critics have taken this new concert version of Fairy Queen to task, particularly for its only too numerous omissions. Listening to this set, however, I rather thought how marvellous, and even thank God, it's cut. On returning to the old complete Oiseau-Lyre recording under Lewis, I was appalled how tiresome Purcell's actually marvellous score could become with the music played in its purported original sequence without the play it originally went with. I am not exactly thinking of a recording which would approximate the original 1692 production of a bowdlerized "Midsummer Night's Dream." Certainly not. But a work like Indian Queen would surely be more enjoyable and sensible if numbers were rearranged, or perhaps even the text changed (!) to form some more wholesome structure than what sounds like bits and pieces rather arbitrarily strung together, as the Indian Queen is often performed and as it is recorded.

The Fairy Queen is, of course, a more extended work, and Purcell certainly built in some marvellous structures within the whole work, but who can see them in the older recording? The unities can be retained, surely, and the entire work made more sensible. I will concede then, that the pity of this new version is in its incompleteness. Perhaps Peter Pears or someone else can give us a new version employing all the music, but except for the sake of completeness, I would rather have this abridged version and not suffer the loss of what is wonderful in this music. Purcell's masques are not really operas, the sooner this is realized the better.

In Peter Pears, concert version, numbers are rearranged, and almost two-thirds of the score omitted to create a grand masque in four parts. His rearrangement is intelligible, tasteful, and at all times aware of an overall structure, something one does not get in the Lewis recording. The new four-part design serves to emphasize the subtleties of each number within each of the four sections. In this present devising, we have what seems like a complex, grand Nature festival, with a unity very reminiscent of Britten's own vocal and choral cycles. The Spring Symphony and Nocturne immediately come to mind, and indeed it is obvious the nocturnal qualities of Purcell's score especially appealed to the present arrangers.

The first part, entitled "Oberon's Birthday" sets the appropriate scene for the occasion of the Fairy King's birthday: a celebration of the end of Winter and its long nocturnal rule. The various seasons pass and pay tribute to Phoebus "great parent of us all," who gives "life, warmth, and vigour to all. E'vn love . . ."

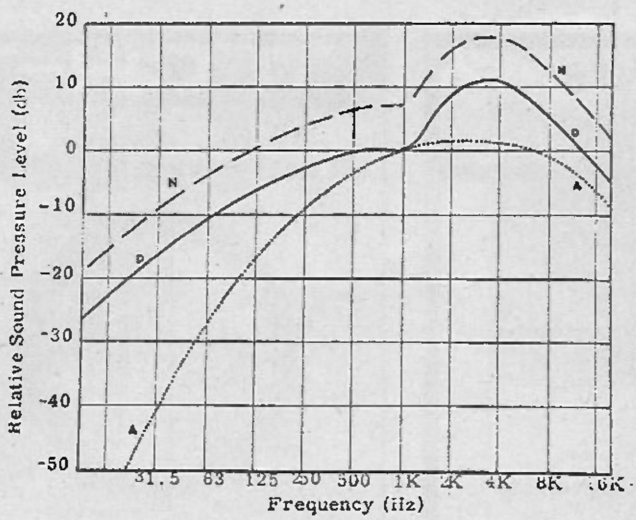
For once, as in this arrangement, the symbolic qualities of Purcell's use of the chaconne is wonderfully apparent. For once too, we see the text leads us to anticipate the ensuing sections: the calm of the midsummer night, the shepherd's passion, and the grand final Epithalamium.

The first part sets the tone for the various elements of the whole masque: in particular the pastoral and supernatural elements. In the next section "Night and Silence", the summer night's peace is for a while threatened by a poet "tripping it." Purcell's humanity and strangeness is wonderfully apparent here, but even more strange the entrance of Night, Secrecy, Mystery and there is more here that is reminiscent of Liszt's earlier masterwork, the Faust Symphony. The fine enough Cradle and Grave sections are also marred by an only too typical heroic middle section, and the heroic did tend to elicit from Liszt the empty gesture. This symphonic poem is not on par with either Orpheus or Hamlet, the latter one of those rare instances in Liszt where the heroic does not lapse into shallow rhetoric. I would have wanted more fury from Haitink in that middle heroic section but everything is otherwise well enough done, with Philharmonic playing beautifully.

Curiously, the engineers have provided a lower level of sound in this generally quiet work. Four more symphonic poems are due to be recorded by Haitink to complete this cycle, among them the rarely heard Heroide Dunebre (1849-50). None of the music in the remaining pieces are really even good but it remains to be seen whether Haitink's approach will stir them to some life, as he does Nos. 1 and 11 here. But once again one must be grateful that Haitink and PHILIPS have had the courage to let us hear this music. – J.A.A. ●

HOW NOISY IS THE CONCORDE?

(Continued from page 18)



Graph of response curve showing relationship between 'A' 'D' and 'N' weighting curves.

Thus, although we measured 125 EPNdB at 1 mile from the point of touchdown Professor Ffowcs Williams claims that this figure is 115 EPNdB for the prototype.

We measured 117 EPNdB for side line noise for the Concorde and 107 EPNdB for a Boeing 707 320c.

Whilst the side line noise figures are in general agreement with the available data, the landing noise figures measured for both one mile and two miles from the point of touch down are so far above the generally quoted figures that a number of questions need to be asked.

There are obviously two situations existing: the opponents who are quoting noise figures greater than those really existing, and the manufacturers, who are quoting few, possibly in the belief that this will quieten their opponents through lack of ammunition.

Regrettably, the data that is available from experts such as Professor Ffowcs Williams may well have been supplied by the aircraft's manufacturers. It certainly does not agree with the results of our field measurements.

It should be noted that the figures we measured do not take into account payload (or fuel retained in the tanks). The tolerances of system measurement errors have been taken into account, so that there is a 90% confidence limit in the actual figure lying above that stated.

Generally then, the Concorde noise level is much as we had expected. It is the loudest and noisiest civil aircraft in the world today (that is if 001 is not noisier).

If the Concorde's noise is reduced by the amount that the makers claim that they can, it is still very doubtful if it will be regarded as being "quiet" and even more doubtful that it will be, as the makers claim, as quiet as the "707" class of aircraft. ●

LOUIS A. CHALLIS

Louis A. Challis B.E., M.I.E. (Aust), M.A.C.E. (Aust), is a consulting, acoustical and vibration engineer.

Apart from his own consulting business, Mr. Challis is a lecturer in acoustics at the University of Sydney and also at the University of N.S.W.

He is a member of the Executive of Acoustics Committee of the Australian Standards Association, and a number of other committees including Hearing Conservation, Community Noise, Instrumentation, Aircraft Noise etc. Mr. Challis is also chairman of a working group currently producing Vehicle Noise Standards.

Louis A. Challis & Associates are retained by Electronics Today International as acoustical consultants.

ELECTRONICS TODAY INTERNATIONAL invited comments on Mr. Challis' findings from British Aircraft Corporation and the Anti-Concorde Project.

A spokesman from the British Aircraft Corporation has replied that BAC do not wish to comment on Mr Challis' findings at this stage.

We print below an extract from the Anti-Concorde project's comments.

– Editor.

FROM THE ANTI-CONCORDE PROJECT

Louis Challis's measurements of Concorde 002's noise on the approach to landing at Sydney agree with the measurements made at Fairford by Mr Geoffrey Holmes of the Federation Against Aircraft Nuisance.

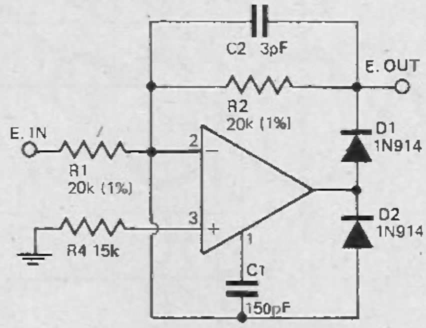
Mr Challis measured 132PNdB (see Fig. 6) and Mr Holmes 131PNdB on 23rd April 1972 and 135PNdB on 19th May 1972. All these were at the standard measuring point of one nautical mile from touchdown. Mr Challis's analysis gives him 125EPNdB and a comparison of this figure for the prototype with the figure of 115–116 EPNdB (the target noise level for the production version of the Concorde given in the British Airports Authority's Annual Report for 1971) shows what a long way the manufacturers have yet to go. Even the rather easier target that the manufacturers sometimes quote, viz., "Concorde will be no noisier than jets of the 707/VC10 generation", requires a reduction of at least 8dB to match the 117EPNdB of the Boeing 707/320C on approach to landing.

We will have to wait and see if these targets can be met. Anti-Concorde Project has its doubts because the "spade" type silencers being developed for the production Concorde are said to produce a reduction of only about 4½ to 5½dB on take off and the effectiveness of these is more limited during the approach to landing.

Even if these targets are met, Concorde will still be far noisier than the certification standard for subsonic jets of the same generation as Concorde. It is not as if the problem of aircraft noise has only just been recognised. For example, in 1962 one of the ten imperative design objectives for SST aircraft sent by the International Air Transport Association to manufacturers reads: "In fact engine noise from the SST must be lower than that of subsonic jets operating at present in order to permit round-the-clock operations." ●

TECH–TIPS

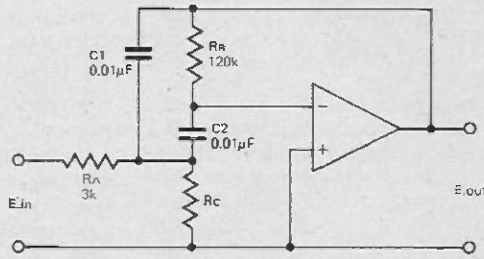
FAST HALF-WAVE RECTIFIER



A precision half wave rectifier using an operational amplifier may be constructed as shown. This will have a rectification accuracy of 1% from dc to 100 kHz.

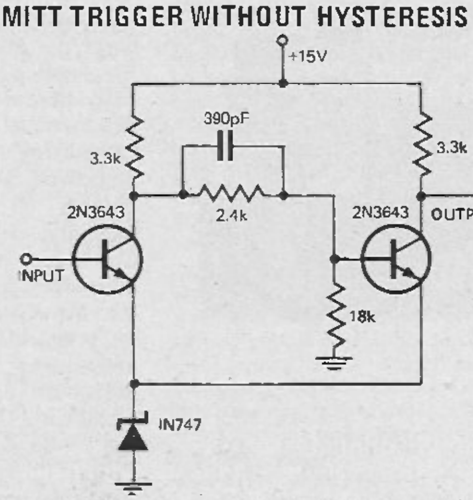
The input signal is applied through R1 to the summing node of an inverting operational amplifier. When the signal is negative, D1 is forward biased and develops an output signal across R2. As with any inverting amplifier the gain is R2/R1. When the signal goes positive, D1 is non-conducting and there is no output. The path through D2 reduces the negative output swing to –0.7V, and prevents the amplifier from saturating.

ACTIVE BANDPASS FILTER



A simple bandpass filter may be constructed using an op-amp and a few discrete components. The circuit shown has a constant gain and bandwidth, and the centre frequency may be adjusted from 1.6 kHz to 2.4 kHz by changing Rc from 1100 ohms to 400 ohms. Gain is 26dB at centre frequency and bandwidth is 775 Hz at 10dB down.

SCHMITT TRIGGER WITHOUT HYSTERESIS



By replacing the common-emitter resistor in a conventional Schmitt by a zener diode, the hysteresis normally associated with these circuits is eliminated.