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wireless world

NOVEMBER 1982 80p

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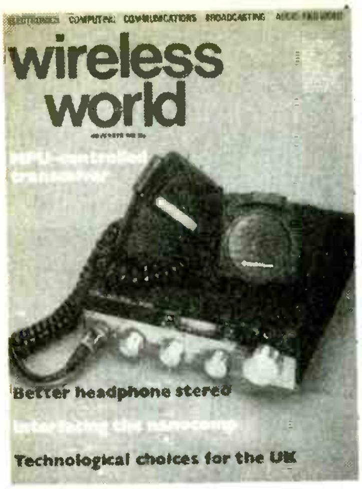

Front cover is the microprocessor-controlled amateur transceiver featured in this issue by T. D. Forrester, photographed by Alan McFaden with special effects by Lasercolor.

NEXT MONTH

Morse decoding by micro computer, by J. P. Sargent, uses a 567 tone decoding and seven-bit clock to time incoming signals Morse code is interfaced to a ZX81 via a p.i.o. chip. Machine code routines use this data to provide up to 9 lines of text.

Leading Japanese research engineer Y. Hirata, gives measurements of non-linearities in four p.c.m. processors and compares them with those from three analogue tape recorders.

Logic maps, by N. Darwood, gives the history of methods for showing logical truth – from 13th century Lull to present-day Karnaugh maps.

Picotutor-microprocessor assembly language trainer designed by Bob Coates of Nanocomp fame assumes no previous experience of microprocessors.

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By post, current issue £1.23, back issues (if available) £1.80, order and payments to EEP General Sales Dept., Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS.
Editorial & Advertising offices: Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS.
Telephones: Editorial 01-661 3500. Advertising 01-661 3130.
Telegrams/Telex: 892084 BISPRS G.
Subscription rates: 1 year £14 UK and £17 outside UK.
Student rates: 1 year £9.35 UK and £11.70 outside UK.
Distribution: Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS. Telephone 01-661 3500.
Subsciptions: Oakfield House, Perrymount Road, Haywards Heath, Sussex RH16 3DH. Telephone: 0444 59188. Please notify a change of address.
USA: $39 surface mail, $98.30 airmail. US subscriptions from IPC B.P., Subscriptions Office, 205 E.42nd Street, NY 10017.
USA mailing agents: Expediters of the Printed Word Ltd, 527 Madison Avenue, Suite 1217, New York, NY 10022. 2nd class postage paid at New York.
 ISSN 0043 6062.

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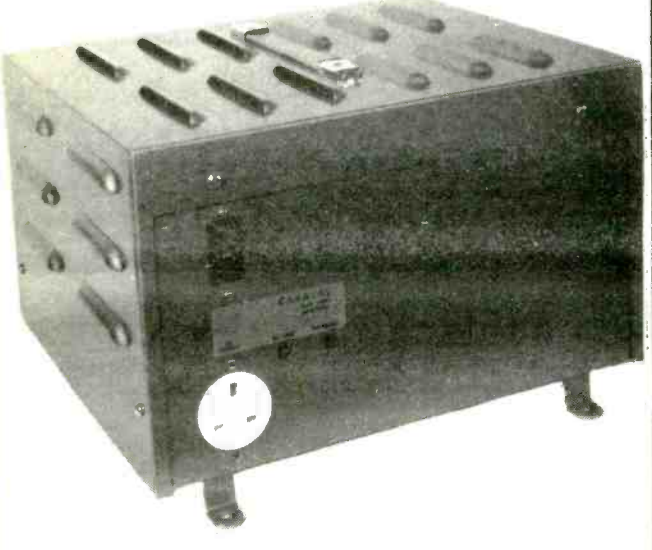

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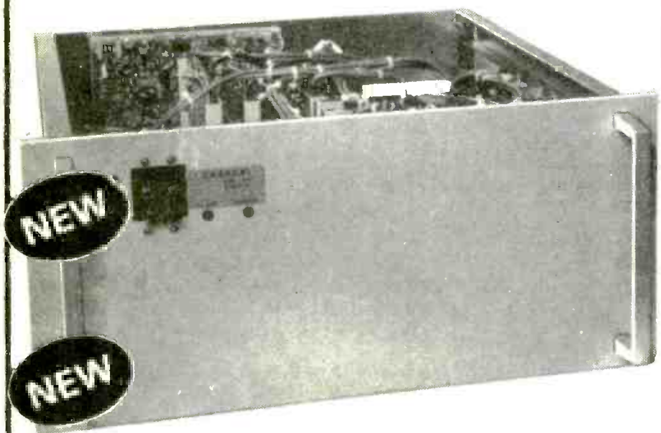

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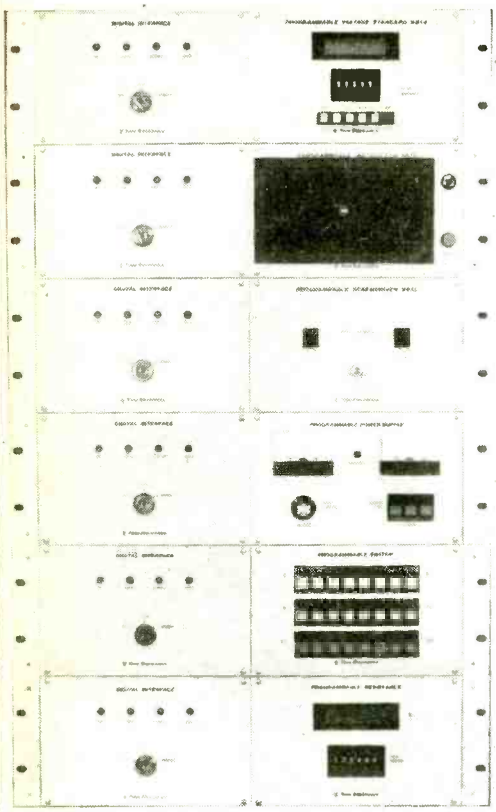

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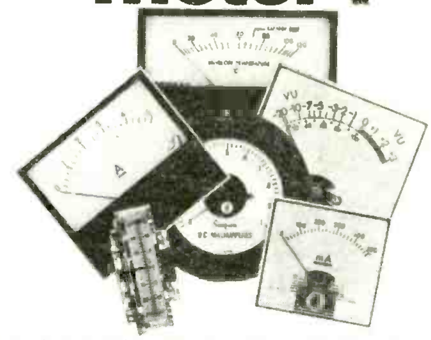

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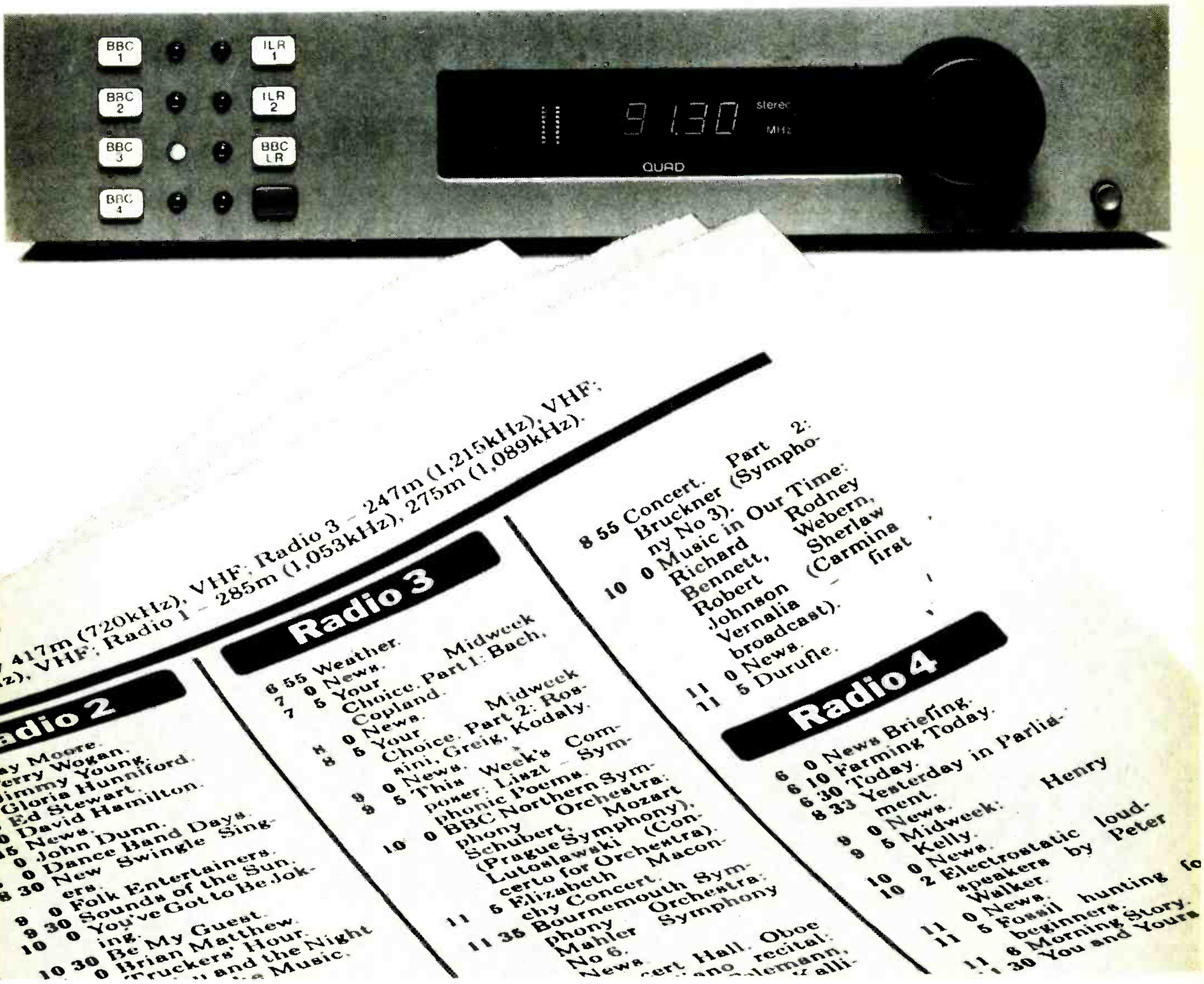

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TAG-END CAPACITORS: 64V: 2200 139p; 3300 198p; 4700 245p; 50V: 2200 110p; 3300 154p; 40V: 4700 160p; 25V: 2200 90p; 3300 98p; 4000, 4700 98p; 10,000 320p; 15,000 345p; 16V: 22,000 350p.

POLYESTER CAPACITORS: Axial Lead Type
400V: 1nF, 1n5, 2n2, 3n3, 4n7, 6n8 11p; 10n, 15n, 18n, 22n 12p; 33n, 47n, 68n 16p; 150n 20p; 220n 30p; 330n 42p; 470n 52p; 680n 1µF 68p; 2µ2 82p.
160V: 10nF, 12n, 39n, 100n 11p; 150n, 220n 17p; 330n, 470n 30p; 680n, 38p; 1µF 42p; 1µ5 46p; 2µ2 48p; 4µ7 58p.
1000V: 1nF 17p; 10nF 30p; 15n 40p; 22n 36p; 33n 42p; 47n, 100n 42p.

POLYESTER RADIAL LEAD CAPACITORS: 250V: 10n, 15n, 22n, 27n 6p; 33n, 47n, 68n, 100n 7p; 150n, 220n 10p; 330n, 470n 13p; 680n 19p; 1µ 23p; 1µ5 40p; 2µ2 46p.

FEED THROUGH CAPACITORS
1000pF/450V 8p

SIEMENS pcb
Type Miniature poly. Capacitors
250V:
1nF, 1n5, 2n2, 3n3, 4n7, 6n8, 10n, 12n, 15n 7p
18n, 22n, 27n, 33n 39n, 47n 8p
39n, 56n 12p
82n, 100n 11p
100V:
100n, 120n 10p
150n, 180n 12p
220n, 270n 15p
330n, 390n 20p
470n, 560n 28p
680n 30p
1µF 34p
2µΩ2 50p

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TANTALUM BEAD CAPACITORS
35V: 0.1µF, 0-22, 0-33 15p; 0-47, 0-68, 1-0, 1.5 16p; 2.2, 3-3 18p; 4.7, 6.8 22p; 10 28p; 16V: 2.2, 3.3 16p; 4.7, 6.8, 10 18p; 15, 36p; 22 30p; 33, 47 40p; 100 75p; 10V: 15, 22, 26p; 33, 47 35p; 100 55p; 6V: 100 42p.

POTENTIOMETERS: Rotary, Carbon, Track. 0.25W Log & Lin values.
500Ω, 1KΩ & 2KΩ (Linear only) Single Gang 30p
5KΩ-2MΩ Single Gang Log & Lin. 30p
5KΩ-2MΩ Single Gang D/P Switch 78p
5KΩ-2MΩ Double Gang 89p

MYLAR FILM CAPACITORS
100V: 1nF, 2, 4, 4nF, 10 6p; 15nF, 22n, 30n, 40n, 47n 7p; 56n, 100n, 200n 9p; 50V: 470nf 12p.

SLIDER POTENTIOMETERS
0-25W log and linear values 80mm
5KΩ-500KΩ single gang 70p
10KΩ-500KΩ dual gang 110p
Self Stick Graduated Bezel 40p

CERAMIC CAPACITORS 50V:
Range: 0-5pF to 10nF 4p. 15nF; 22nF; 33nF; 47nF 5p. 100nF/30V 7p. 200nF/6V 8p

PRESET POTENTIOMETERS
0.1W 50Ω–5MΩ Miniature Vertical & Horizontal 7p
0-25W 100Ω–3-3MΩ horiz. larger 10p
0-25W 200Ω–4-7MΩ vert. 10p

POLYSTYRENE CAPACITORS:
10pF to 1nF 8p; 1.5nF to 12nF 10p

SILVER MICA (Values in pF) 2, 3-3, 4.7, 6.8, 8.2, 10, 12, 15, 18, 22, 27, 33, 39, 47, 50, 56, 68, 75, 82, 85, 100, 120, 150, 180pF 15p each;
200, 220, 250, 270, 300, 330, 360, 390, 470, 600, 800, 820 21p each
1000, 1200, 1800, 2200 30p each
3300, 4700pF 60p each

RAM FOR BBC MICRO 4816AP 100ns 225p

MINIATURE TRIMMERS Capacitors
2-6pF, 2-10pF 22p; 2-25pF, 5-60pF 30p; 10-88pF 35p

RESISTORS – Carbon Film High Stability. 5% Miniature.

	RANGE	VAL	1-99	100+
¼W	2Ω2–4M7	E24	2p	1p
½W	2Ω2–4M7	E12	2p	1p
1W	2Ω2–4M7	E12	5p	4p
2% Metal Film		E24	6p	4p
1% Metal Film		E24	8p	6p

RESISTORS Network S.I.L.
7 Commoned: (8 pins) 100Ω, 680Ω, 1K 2k2, 4K7, 10K, 47K, 100K 25p.
8 Commoned: (9 pins) 150Ω, 180Ω, 270Ω, 330Ω, 1K, 2k2, 4K7, 10K, 22K, 47K, 100K 26p.

DIODES

AA119	15
AA129	20
AAY30	15
BA100	15
BAX13	20
BY100	24
BY126	12
BY127	12
CRO33	250
OA9	40
OA47	12
OA70	12
OA79	15
OA81	20
OA85	15
OA90	8
OA91	8
OA95	8
OA200	8
OA202	8
1N914	4
1N916	5
1N4001/2	5
1N4003	6
1N4004/5	6
1N4006/7	7
1N4148	4
1N5401	15
1N5404	16
1N5406	17
IN5408	19
1S44	9
1S921	9
6A/100V	40
6A/400V	50
6A/800V	65

NOISE Diode
Z5J 195p

VARICAPS

BA102	50
BB105B	40
BB106	40
BB109B	45
MVAM2	165

BRIDGE RECTIFIERS

1A/50V	18
1A/100V	20
1A/400V	25
1A/600V	34
2A/50V	30
2A/200V	40
2A/400V	48
2A/600V	65
6A/100V	83
6A/400V	95
6A/600V	125
10A/200V	215
10A/600V	298
25A/200V	240
25A/600V	395
BY164	55
VM18 DIL	50

ZENERS
Range: 2V7 to 39V 400mW 8p each
Range: 3V3 to 33V. 1.3W 15p each

TRIACS

3A200V	54
3A400V	56
8A100V	60
8A400V	69
8A800V	115
12A100V	78
12A400V	82
12A800V	135
16A100V	103
16A400V	105
16A800V	220
25A500V	220
25A800V	295
T2800D	120

75 SERIES

75107/8	95
75110	90
75114/5	150
75121/2	130
75150	125
75154	150
75182/3	99
75188/9	56
75322	140
75324	360
75361/3	150
75365	150
75450	86
75451/2	52
75454	85
75491/2	85

SCR Thyristors

5A/40V	32
5A400V	40
5A600V	48
8A300V	60
8A600V	90
12A100V	78
12A400V	96
12A800V	188
BT106	150
BT116	180
C106D	38
TIC44	24
TIC45	29
TIC47	35
2N5062	32
2N5064	38
2N4444	130

DIAC
ST2 26

TRANSISTORS

				BF179	36								
AC125	35	BC182L	10	BF180/2	38	MPF103	30	TIS90/91	30	2N3011	28	2N5879	190
AC126/7	35	BC183L	10	BF184/5	38	MPF104	30	UC734	85	2N3053	26	2N6027	32
AC128	30	BC184L	10	BF194/5	12	MPF105	30	VK101	80	2N3054	58	2SA671	250
AC141/2	30	BC186/7	28	BF196/7	12	MPF106	40	VN10KM	55	2N3055	48	2SA715	60
AC176	28	BC212	10	BF198/9	18	MPSA05	25	VN46AF	78	2N3108	46	2SC495	70
AC187	32	BC212L	10	BF200	300	MPSA08	25	VN66AF	80	2N3252	46	2SC496	70
AC188	32	BC213	10	BF224A	25	MPSA12	32	VN88AF	94	2N3302	30	2SC1061	250
ACY17/18	70	BC213L	10	BF224B	28	MPSA55	30	VN89AF	96	2N3441/2	140	2SC1096	85
ACY19/20	75	BC214	10	BF245	30	MPSA56	30	ZTX107/8	11	2N3614/5	199	2SC1162	30
ACY21/22	75	BC214L	10	BF256A	35	MPSU02	58	ZTX109	12	2N3663	15	2SC1173	125
ACY28	75	BC237/8	14	BF256B	45	MPSU05	55	ZTX212	28	2N3702/3	10	2SC1306	100
ACY39/41	85	BC307B	14	BF257/8	32	MPSU06	55	ZTX300	13	2N3704/5	10	2SC1307	150
AD142	120	BC308	16	BF259	35	MPSU52	65	ZTX301	16	2N3706/7	10	2SC1449	85
AD149	79	BC327/8	15	BF274	42	MPSU56	60	ZTX302	16	2N3708/9	10	2SC1678	140
AD161	42	BC337/8	15	BF336/7	40	MPU131	52	ZTX303	25	2N3710/11	10	2SC1679	180
AD162	42	BC441/61	34	BF451	35	OC26	170	ZTX304	17	2N3713	140	2SC1923	50
AF115/6	80	BC477	40	BF594/5	30	OC28/35	220	ZTX314	25	2N3771	179	2SC1945	225
AF117/8	90	BC516/7	40	BFR39/40	23	OC36/41	75	ZTX326	30	2N3772	195	2SC1953	90
AF124/26	70	BC547/8	12	BFR41/79	23	OC42/44	75	ZTX341	30	2N3773	210	2SC1957	90
AF139	40	BC549C	14	BFR80/81	25	OC45/70	40	ZTX451	23	2N3819	22	2SC1969	140
AF178	75	BC556/7	15	BFR98	105	OC71/72	40	ZTX500	14	2N3820	38	2SC2028	85
AF186	70	BC558/9	15	BFX29	28	OC74/75	50	ZTX501/2	15	2N3822/3	45	2SC2029	210
AF239	55	BCY30	68	BFX81	45	OC76/77	50	ZTX503	18	2N3824	65	2SC2078	170
ASZ21	125	BCY34	85	BFX84	28	OC81/82	50	ZTX504	25	2N3866	90	2SC2091	85
BC107	10	BCY35	60	BFX85/6	28	OC83/84	40	ZTX531	25	2N3870	150	2SC2314	85
BC107B	12	BCY39/40	85	BFY18	50	OC170/71	50	ZTX550	25	2N3903/4	15	2SC2166	165
BC108	10	BCY41/42	14	BFY50/51	23	OC200	50	2N697	23	2N3905/6	15	2SC2335	225
BC108B	12	BCY45	50	BFY52	23	TIP29A	32	2N698	40	2N3906	17	2SC2547	30
BC109	10	BCY58/59	35	BFY53	32	TIP29C	38	2N699	48	2N4037	48	2SC2612	225
BC109B	12	BCY70/71	16	BFY55/6	32	TIP30A	36	2N706A	19	2N4041	40	2SD234	74
BC109C	12	BCY72	20	BFY64	35	TIP30C	37	2N708	19	2N4058	10	2SK45	90
BC114/5	22	BCY78	24	BFY81	120	TIP31A	38	2N918	36	2N4061/2	10	2SK288	225
BC117/8	20	BD112	125	BFY90	80	TIP31B	39	2N1131/2	24	2N4064	115	2SJ83	225
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BC137/9	40	BD124	115	BSC20	20	TIP32A	38	2N1303	65	2N4220	78	3N128	112
BC140	30	BD131/32	48	BSX26/29	34	TIP32C	42	2N1304/5	60	2N4234/6	48	3N140	112
BC142/3	30	BD133	70	BSX78	45	TIP33A	65	2N1306/7	65	2N4264	24	40097	120
BC147	9	BD135	45	BSY26	30	TIP33C	78	2N1308	68	2N4286	15	40250	95
BC147B	10	BD136/37	40	BSY95A	25	TIP34A	74	2N1613	30	2N4289	18	40311	60
BC148	9	BD138/39	40	BU105	170	TIP34C	88	2N1670	150	2N4314	78	40313	130
BC148B	10	BD140	40	BU205	190	TIP35A	110	2N1671B	160	2N4400	18	40315	90
BC149	9	BD144/46	198	BU206	200	TIP35C	128	2N2160	295	2N4427	80	40316	95
BC149C	10	BD158	55	BU208	200	TIP36A	130	2N2217	46	2N4859	78	40317/20	80
BC153/4	27	BD205/6	110	BUY69C	225	TIP36C	140	2N2218A	25	2N4871	56	40323	60
BC157/8	10	BD222	85	E421	250	TIP41A	50	2N2219A	28	2N4898	135	40324	100
BC159	11	BD245	45	MD8001	250	TIP41B	52	2N2220A	28	2N4901	175	40328/7	70
BC160	45	BD378	70	MJ490	90	TIP42A	55	2N2221A	28	2N4921	55	40347	90
BC167A	10	BD434	55	MJ491	175	TIP42B	58	2N2222A	25	2N4922	70	40348	120
BC168C	10	BD517	75	MJ2955	70	TIP120	70	2N2297	25	2N5135/6	20	40360	60
BC169C	10	BD695A	125	MJE170	150	TIP121/2	73	2N2303	45	2N5138	18	40361/2	70
BC170	15	BD696A	125	MJE180	150	TIP141/2	105	2N2368	25	2N5172	18	40407/8	75
BC171/2	11	BDY56	180	MJE340	54	TIP147	120	2N2369A	18	2N5179	45	40411	285
BC173	11	BDY60	180	MJE370	100	TIP2955	80	2N2476	50	2N5180	45	40412	90
BC177/8	18	BF115	35	MJE371	100	TIP3055	60	2N2483/4	27	2N5190/1	75	40467A	130
BC179	20	BF154/8	25	MJE520	95	TIS43	32	2N2646	46	2N5194	80	40468	65
BC181	20	BF167	28	MJE521	95	TIS44/5	45	2N2846	60	2N5305/8	30	40594	105
BC182/3	10	BF173	27	MJE2955	99	TIS46	45	2N2904/5	28	2N5457/8	30	40603	110
BC184	10	BF177	25	MJE3055	70	TIS48	60	2N2906/7	28	2N5459	30	40636	175
		BF178	30	MPF102	40	TIS59/74	50	2N2907A	28	2N5485	36	40673	75
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6810	115	MC1489	55
6820	100	MC14411	690
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709 14 pin	40	ICM7216B	1950	MC1709G	90	TDA1008	310
709C 8 pin	35	ICM7216C	1950	MC3302	90	TDA1010	198
710	48	ICM7217A	790	MC3340P	120	TDA1022	499
741 8 pin	14	ICM7224	785	MC3360P	120	TDA1024	115
747C 14 pin	65	ICM7240	300	MC3401	65	TDA1034	350
748C 8 pin	36	ICM7555	80	MC3403	75	TDA1490	325
753 8 pin	185	ICM7556	150	MC3405	150	TDA2002	325
810	159	LA3350	250	MC3423	180	TDA2004	495
9400CJ	350	LA4031P	340	MC4016	00	TDA2020	320
AY-1-1320	225	LA4032	295	MFC6040	75	TDA2030	295
AY-1-5050	99	LA4400	440	MK50398	635	TDB0701	420
AY-1-5051	160	LC7120	300	ML924	275	TL170	50
AY-1-6720	210	LC7130	340	MSM5526	820	TLO61CP	40
AY-3-1270	730	LC7137	395	NE515	275	TLO62CP	60
AY-3-1350	350	LF347	150	NE529	225	TLO64CN	98
AY-3-8910	370	LF351	48	NE531	140	TLO71CP	24
Booklet for AY-3-890	150	LF353	95	NE534	150	TLO72CP	46
AY-3-8912	625	LF355	85	NE543K	225	TLO74CN	100
AY-5-1230	450	LF356	95	NE544	210	TLO81CP	24
AY-5-1317A	630	LF357	110	NE555	16	TLO82CP	46
AY-5-1350	388	LF398	475	NE556	45	TLO83CP	75
AY-5-3500	350	LM10	325	NE560	325	TLO84CN	90
AY-5-4007D	520	LM301AO	24	NE561	398	TLO91CP	56
AY-5-8100	775	LM307	5	NE562B	410	UA2240	120
CA3011	130	LM308T	95	NE564	420	UA78540	230
CA3012	175	LM311	70	NE565A	120	UAA170	170
CA3014	275	LM318N	150	NE566	155	UAA180	170
CA3018	86	LM319	215	NE567V	140	UAA1003/3	935
CA3019	80	LM324A	30	NE570	410	ULN2003	85
CA3020	210	LM334Z	90	NE571	400	ULN2004	90
CA3023	210	LM335Z	128	NE5534A	150	ULN2283	100
CA3028A	95	LM339	47	OM335	750	UPC575	350
CA3035	255	LM348	64	RC4136D	69	UPC1025H	375
CA3036	270	LM349	115	S566B	225	UPC1182	330
CA3043	275	LM358	60	SAB3209	425	UPC1156H	290
CA3045	385	LM377	175	SAB3210	325	UPC1366	195
CA3046	70	LM379	480	SAB3271	485	XR2206	300
CA3048	220	LM380	75	SAB4209	595	XR2207	375
CA3059	285	LM381N	145	SG3402	295	XR2211	575
CA3075	213	LM382	115	SL490	350	XR2216	675
CA3080E	70	LM384	140	SN76003N	350	XR2266	380
CA3081	190	LM386	90	SN76013	350	ZN414	80
CA3086	48	LM387	120	SN76018	148	ZN419E	190
CA3089E	215	LM389	95	SN76023N	350	ZN423E	135
CA3090AQ	375	LM393	100	SN76023ND	240	ZN424E	130
CA3123E	185	LM725CN	325	SN76033N	350	ZN425E	345
CA3130	90	LM733	70	SN76115N	215	ZN426E	300
CA3140	40	LM1458	45	SN76131	125	ZN427E	600
CA3160	96	LM1871	325	SN76227N	96	ZN428E	410
CA3161	160	LM2917	195	SN76477	420	ZN429E	210
CA3162E	450	LM301	24	SN76488	480	ZN459	570
CA3189	200	LM307	46	SN76660	120	ZN1034E	200
HA1336W	240	LM3302	75	SP8629	299	ZN1040E	875
HA1388	255	LM3900	50	TA7204	200	ZNA234E	850
ICL7106	750	LM3909N	80	TA7205	90		
ICL7107	975	LM3911	125	TA7205A	225		
ICL7611	99	LM3914	250	TA7210	150		
ICL7660	190	LM3915	250	TA7222	150		
ICL8038CC	300	LM3916	250	TA7310	160		
ICL8211A	150	LM13600	110	TAA621AX1	295		
ICM7205A	1150	LS7220	280	TAA661A	190		
ICM7207	475	M252AA	625	TAA700	275		
		M253AA	1150	TAA900	395		
		M51513L	230	TAD100	159		
		M51515L	320	TBA120S	70		
		M51516L	475	TBA540Q	275		
		MB3712	220	TBA550Q	330		
		MB3756	440	TBA641BX or BX11	290		
		MC1204	250	TBA651	190		
		MC1301	79	TBA800	80		
		MC1303	88	TBA810	95		
		MC1304P	260	TBA820	80		
		MC1310P	150	TBA920Q	200		
		MC1445	250	TBA950	300		
		MC145106	695	TBA990Q	350		
		MC1458	35	TBA540	275		
		MC1469	300	TCA220	350		
		MC1494	694	TCA270Q	350		
		MC1495	350	TCA280A	220		
		MC1496L	70	TCA940	175		

TTL 74

7400	11	7433	22	74174	54
7401	11	7437	25	74175	56
7402	11	7438	22	74176	40
7403	12	7440	17	74177	45
7404	13	7441	55	74178	80
7405	15	7442	32	74179	80
7406	20	7443	90	74180	40
7407	20	7444	90	74181	115
7408	14	7445	55	74182	60
7409	14	7446	60	74184	90
7410	14	7447	40	74185	95
7411	16	7448	45	74186	470
7412	18	7450	16	74188	250
7413	18	7451	16	74190	48
7414	24	7453	16	74191	48
7416	20	7454	16	74192	48
7417	20	7460	16	74193	45
7420	15	7470	35	74194	40
7421	20	7472	24	74195	40
7422	20	7473	26	74196	48
7423	20	7474	20	74197	40
7425	18	7475	25	74198	80
7426	18	7476	25	74199	84
7427	18	7480	48	74221	54
7428	26	7481	120	74246	120
7430	14	7482	85	74247	120
7432	22	7483	38	74248	120
		7484	70	74249	120
		7485	60	74251	65
		7486	20	74259	150
		7489	170	74265	55
		7490	20	74273	150
		7491	35	74276	120
		7492	25	74278	100
		7493	25	74279	50
		7494	35	74283	50
		7495	35	74284	155
		7496	35	74285	155
		7497	90	74290	105
		74100	80	74293	80
		74104	50	74297	235
		74105	55	74298	100
		74107	20	74351	195
		74109	25	74365	30
		74110	35	74366	30
		74111	55	74367	30
		74112	170	74368	30
		74116	88	74390	75
		74118	55	74393	90
		74119	60	74490	95
		74120	60		
		74121	25		
		74122	35		
		74123	35		
		74125	35		
		74126	35		
		74128	35		
		74132	30		
		74136	28		
		74141	55		
		74142	175		
		74143	210		
		74144	210		
		74145	50		
		74147	75		
		74148	60		
		74150	50		
		74151	40		
		74153	40		
		74154	55		
		74155	40		
		74156	40		
		74157	30		
		74159	80		
		74160	60		
		74161	60		
		74162	40		
		74163	40		
		74164	48		
		74165	48		
		74166	48		
		74167	150		
		74170	125		
		74172	250		
		74173	60		

74C

74C244	195
74C245	195
74C373	240
74C374	245
74C922	420

74L

74L00	68
74L04	85
74L30	50
74L47	380
74L75	145
74L85	349
74L121	165
74L123	325

74S

74S00	38
SO2	30
SO3	30
S04	40
SO5	60
SO8	60
S20	40
S32	70
S74	75
S86	85
S112	85
S114	85
S132	110
S133	60
S138	180
S157	250
S158	210
S188	210
S189	158
S194	320
S195	795
S201	320
S225	510
S241	390
S251	70
S257	250
S262	850
S287	300
S288	210
S289	195
S301	350
S412	380
S470	325
S471	620
S472	1150
S475	825
S571	820

74LS

LS00	11	LS63	120
LS01	11	LS73	18
LS02	11	LS74	18
LS03	12	LS75	20
LS04	12	LS76	18
LS05	13	LS78	18
LS08	12	LS83	36
LS09	12	LS85	42
LS10	13	LS86	16
LS11	13	LS90	28
LS12	13	LS91	60
LS13	20	LS92	32
LS14	26	LS93	26
LS15	13	LS95	40
LS20	13	LS96	95
LS21	13	LS107	40
LS22	13	LS109	28
LS26	14	LS112	26
LS27	13	LS113	22
LS28	14	LS114	22
LS30	13	LS122	36
LS32	13	LS123	38
LS33	15	LS124	90
LS37	15	LS125	24
LS38	15	LS126	25
LS40	13	LS132	35
LS42	28	LS133	30
LS47	35	LS136	24
LS48	45		
LS49	50		
LS51	14		
LS54	14		
LS55	14		

SWITCHES

TOGGLE 2A 250V
SPST 33p
DPDT 44p

SUB-MIN TOGGLE
SPST on/off 54p
SPDT c/over 60p
SPDT centre off 85p
SPDT biased both ways 105p
DPDT 6 tags 75p
DPDT centre off 88p
DPDT biased both ways 145p
DPDT 3 positions on/on/on 185p
3-pole 2 way 205p

SLIDE 250V
DPDT 1A 14p
DPDT 1A c/off 15p
DPDT ½A 13p

PUSHBUTTON 6A with 10mm Button
SPDT latching 99p
DPDT latching 145p
SPDT moment 99p
DPDT moment 145p

Mini Non Locking
Push to Make 15p
Push to Break 25p

DIL SWITCHES
(SPST) 4-way 70p; 6-way 85p; 8-way 90p; 10-way 145p.
(SPDT) 4-way 190p.

ROTARY SWITCHES (Adjustable Stop type)
1 pole/2 to 12 way; 2p/2 to 6 way; 3 pole/2 to 4 way; 4p/2 to 3 way 45p
ROTARY: Mains DP 250V 4 Amp on/off 58p
ROTARY: (Mak-a-switch) Make a multi-way switch. Shafting assembly has adjustable stop. Accommodates up to 6 wafers. (max 6 pole/12 way – DP switch) Mechanism only 90p
WAFERS: (make before break) to fit the above switch mechanism 1 pole/12 way; 2 pole/6 way; 3 pole/4 way; 4 pole/3 way; 6p/2 way 65p
Mains DP 4A Switch to fit 45p
Spacers 4p. Screen 6p.
ROCKER: 5A/250V SPST 28p
ROCKER: 10A/250V SPDT 38p
ROCKER: 10A/250V DPDT c/off 95p
ROCKER: 10A/250V DPST with neon 85p
THUMBWHEEL: Mini front mounting
Decade Switch Module 220p
B.C.D. Switch Module 275p
Mounting Cheeks (per pair) 75p

VEROBOARD 0.1in

	clad	plain
2½-3¼	80p	–
2½-5	91p	–
3¾-3¾	91p	–
3¾-5	105p	87p
3¾-17	360p	232p
4¾-17	470p	–

Pkt of 100 pins 50p
Spot face cuffer 135p
Pin insertion tool 178p
VQ Board 180p
DIP Board 350p
Vero Strip 374p

FERRIC CHLORIDE
1 lb bag Anhydrous 195p – 50p P&P

PROTO DECs
Veroblock 495p
S-Dec 350p
Eurobreadboard 520p
Bimboard 1 575p
Superstrip SS2 1350p

DALO ETCH RESIST PEN
Plus Spare Tip 90p

VERO WIRING
PEN – Spool 340p
Spare Spool 75p
Combs 6p

ULTRASONIC TRANSDUCER
40kHz 325 pr

IDC CONNECTORS

2 Rows	PCB Plugs with latch Pins Strt	PCB Plugs with latch Pins Angled	Female Header Plug	PCB Pins Angled
10 way	90p	99p	85p	65p
16 way	130p	150p	110p	78p
20 way	145p	166p	125p	90p
26 way	175p	200p	160p	110p
34 way	205p	230p	169p	135p
40 way	220p	250p	190p	150p
50 way	235p	270p	200p	175p
60 way	–	–	230p	220p

EURO CONNECTORS

	Female Socket Strt Pins	Female Socket Angle Pins	Male Plug Strt Pins	Male Plug Angle Pins
DIN41617 31 way	170p	–	–	175p
DIN41612 2×32 A+B	295p	325p	220p	295p
DIN41612 2×32 A+C	300p	340p	240p	300p
DIN16123×32 A+B+C	300p	385p	280p	400p

CRYSTALS

3.278M	150
3.5794M	98
3.6864M	300
4.0MHz	150
4.032MHz	290
4.80MHz	200
4.194304M	200
4.433619M	100
5.0MHz	160
5.185MHz	300
5.24288M	390
6.0MHz	140
6.144MHz	150
6.5536MHz	225
7.0MHz	150
7.168MHz	250
7.68MHz	200
8.0MHz	150
8.08333M	395
8.86723M	175
9.00MHz	150
10.0MHz	175
10.24MHz	200
10.7	150
12.0MHz	175
12.528M	300
14.31814M	170
16.0MHz	200
18.0MHz	180
18.432M	150
20.0MHz	200
19.968MHz	150
24.0MHz	170
24.930MHz	325
26.69M	150
27.648M	170
27.145M	190
38.66667M	175
48.0MHz	170
100.0MHz	295
116.0MHz	250

RELAYS

Miniature enclosed PCB mount
Our RL6 series
S.P.C.O.
RL6 91.170Ω coil 7V5 to 12V DC; 380V/6A AC; 1300VA/60W 210p
D.P.C.O.
43Ω coil 4V2/7V DC; 250V AC; 5A; 1100VA/150W 218p
RL6.111 170Ω coil 8V/14V; 250V AC 5A 220p
RL6 114 740Ω coil 17V5/29V; 250V 5A AC 222p

AMPHENOL PLUGS
IEEE 24 way 550p
Centronics Parallel 36 way solder 530p
Centronic Parallel 36 way IDC 550p

BUZZERS: miniature, solid-state 6V, 9V & 12V 70p

LOUDSPEAKERS
Miniature 0.3W 8Ω
2in, 3¼in, 2½in, 3in 80p
2½in 40Ω, 64Ω or 80Ω 80p

ASTEC UHF MODULATORS
Standard 6MHz 280p
Wideband 8MHz 425p

COPPER CLAD BOARDS

Fibre glass	Single sided	Double sided	S.R.B.P. 95-85
6-6	90p	110p	95p
6-12	150p	195p	

DIL SOCKETS

	Low Prof	Wire Wrap
8 pin	8p	25p
14 pin	10p	35p
16 pin	10p	42p
18 pin	16p	52p
20 pin	20p	80p
22 pin	22p	65p
24 pin	25p	70p
28 pin	28p	80p
40 pin	30p	99p

EDGE CONNECTORS

	.1	.156
2×15 way	–	140p
2×18 way	180p	145p
2×22 way	199p	200p
2×23 way	190p	–
2×25 way	225p	220p
2×28 way	210p	–
2×30 way	245p	–
2×36 way	295p	–
2×40 way	315p	–
2×43 way	395p	–
2×75 way	550p	–

DIL PLUGS (Headers)

	Solder	IDC
14 pin	40p	99p
16 pin	49p	105p
24 pin	88p	178p
40 pin	250p	255p

ZIF DIL SOCKETS
24 pin 575p
28 pin 820p
40 pin 975p

RIBBON CABLE price per foot

	Grey	Colour
10 way	12p	22p
16 way	18p	32p
20 way	25p	40p
24 way	33p	50p
34 way	48p	60p
40 way	56p	75p
50 way	65p	90p
54 way	85p	110p

D CONNECTORS: Miniature

	9 way	15 way	25 way	37 way
Plugs				
Solder lugs	80p	110p	160p	250p
Angle pins	160p	210p	250p	355p
W/wrap pins	120p	130p	195p	295p
Sockets				
Solder lugs	110p	160p	210p	360p
Angled pins	165p	215p	290p	440p
W/wrap pins	150p	180p	240p	420p
Covers	95p	95p	95p	110p

ETI PROJECTS
We stock most of the parts

JUMPER LEADS (Ribbon Cable Assembly)

Length	14 pin	16 pin	24 pin	40 pin
Single ended DIP (Header Plug) Jumper				
24 inches	145p	165p	240p	380p
Double ended DIP (Header Plug) Jumper				
6 inches	185p	205p	300p	465p
12 inches	198p	215p	315p	490p
24 inches	210p	235p	345p	540p
36 inches	230p	250p	375p	595p
IDC Header Socket Jumper Leads 24"	20 pin	26 pin	34 pin	40 pin
Single ended	160p	200p	280p	300p
Double ended	290p	370p	480p	525p

ANTEX SOLDERING IRON

C-15W 450p
CX17W 475p
CCN-15W 495p
CX25W 500p
Spare tips, assorted sizes 65p
Spare Elements 210p
Iron stand with sponge 165p

Soldercon Pins
100 pins 70p
500 pins 325p

PIEZO TRANSDUCERS
PB2720 55p

TRANSFORMERS: Prim. 240V

3-0-3V; 6-0-6V; 9-0-9V; 12-0-12V 100mA 98p
pcb mounting Miniature Split Bobbin
3VA: 2×6V-0.25A; 2×9V-0.15A; 2×12V-0.12A; 2×15V-0.1A 200p
6VA: 2×6V-0.5A; 2×9V-0.3A; 2×12V-0.25A; 2×15V-0.2A 270p
Standard Split Bobbin type
6VA: 2×6V-0.5A; 2×9V-0.4A; 2×12V-0.3A; 2×15V-0.25A 220p
12VA: 2×4.5V-1.3A; 2×6V-1A; 2×9V-0.6A; 2×12V-0.5A; 2×15V-0.4A; 2×20V-0.3A 295p (35p p&p)
24VA: 2×6V-1.5A; 2×9V-1.2A; 2×12V-1A; 2×15V-0.8A; 2×20V-0.6A 330p (60p p&p)
50VA: 2×6V-4A; 2×9V-2.5A; 2×12V-2A; 2×15V-1.5A; 2×20V-1.2A; 2×30V-0.8A 465p (60p p&p)
100VA: 2×12V-4A; 2×15V-3A; 2×20V-2.5A; 2×25V-2A; 2×30V-1.5A; 2×50V-1A 920p
(75p p&p charge to be added over and above our normal postal charge).

VOLTAGE REGULATORS

	+ve		-ve	
1A	T03	Metal case		
5V	7805	145p	7905	220p
12V	7812	145p	7912	220p
15V	7815	145p	7915	220p
18V	7818	145p		
1A	TO220	Plastic		
5V	7805	40p	7905	45p
12V	7812	40p	7908	60p
15V	7815	40p	7912	45p
18V	7818	40p	7915	45p
24V	7824	40p	7918	45p
			7924	45p
100mA	TO92	Plastic casing		
5V	78L05	30p	79L05	60p
6V	78L62	30p		–
8V	78L82	30p		–
12V	78L12	30p	79L12	60p
15V	78L15	30p	79L15	60p

CA3083 95p
LM300H 170p
LM304H 170p
LM305H 140p
LM309K 135p
LM317K 320p
LM317KP 99p
LM317H 280p
LM323K 500p
LM325N 240p
LM326N 240p
LM337 175p
LM723 35p
TAA550 50p
TBA625B 75p
TDA1412 150p
78HO5 +5V/5A 550p
78H12 +12V/5A 580p
78HG +5V to −25V/5A 599p
79HG 2.25V to 24V5A 685p

25 way 'D' CONNECTOR
Jumper Lead Cable Assembly
18" long, Single end, Male 495p
18" long, Single end, Female 525p
36" long, Double ended, M/M 1025p
36" long, Double ended, F/F 1050p
36" long, Double ended, M/F 995p

★ SPECIAL OFFER ★
TEX EPROM ERASER
Only £29.95

CRYSTALS

32.768kHz	100	1.28MHz	392
100kHz	235	1.6MHz	395
200kHz	266	1.8MHz	395
455kH	370	1.8432M	200
1MHz	275	2.0MHz	225
1.008M	275	2.4576M	200

PANEL METERS

FSD
60×46×35mm
0.50µA
0.100µA
0.500µA
0.1mA
0.5mA
0.10mA
0.50mA
0.100mA
0.500mA
0.1A
0.2A
0.25V
0.50V AC
0.300V AC
"S"
"VU"
496p each

'WEMON' New Version WATFORD'S Ultimate Monitor IC

A 4K Monitor chip specially designed to produce the best from your Super board Series I & II. Enhanced Super board & UK101. As reviewed by Dr A. A. Berk in Practical Electronics, June 1981.
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(Our BBC Micro Upgrade Kits will save you £s s s . . .)
16K Memory (8×4816AP) £18
Printer User I/O Port Kit £8.20
SK10 with 36" Cable £2
Complete Printer Cable 36" £12
SK9 with 36" Cable £3
Disc Interface Kit £41
Analogue I/O Kit £6.75
Serial I/O Kit £7.50
Expansion Bus Kit £8.50
SK11 with Cable 36" £3
SK12 with Cable 36" £3.75
Complete Upgrade Kit from Model A to Model B £45
Range of Connectors & Cables available. Send SAE for list.

LS138	25	LS327	240	4037	115	4500	675	40106	46
LS139	32	LS347	95	4038	110	4501	28	40107	60
LS145	70	LS348	90	4039	250	4502	60	40108	450
LS147	100	LS352	62	4040	40	4503	40	40109	100
LS148	70	LS353	62	4041	40	4504	75	40110	300
LS151	40	LS362	750	4042	40	4505	185	40114	240
LS153	40	LS363	150	4043	40	4506	35	40161	194
LS155	35	LS364	150	4044	40	4507	35	40163	65
LS156	38	LS365	30	4045	105	4508	130	40174	65
LS157	27	LS366	32	4046	46	4510	46	40175	75
LS158	30	LS367	30	4047	40	4511	45	40181	220
LS160	32	LS368	35	4048	40	4512	50	40182	90
LS161	35	LS373	65	4049	25	4513	199	40192	90
LS162	38	LS374	65	4050	25	4514	115	40193	68
LS163	35	LS375	50	4051	45	4515	115	40194	90
LS164	40	LS377	85	4052	60	4516	55	40195	72
LS165	50	LS378	80	4053	50	4517	275	40244	195
LS166	65	LS379	110	4054	85	4518	40	40245	195
LS168	84	LS384	395	4055	85	4519	30	40257	195
LS170	75	LS385	250	4056	85	4520	50	40373	240
LS173	65	LS390	50	4057	1915	4521	110	40374	245
LS174	60	LS393	45	4059	435	4522	125		
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LS181	90	LS399	150	4061	1195	4527	65	**OPTO**	
LS183	180	LS445	100	4062	995	4528	70	LS400C	255
LS190	45	LS471	620	4063	85	4529	150	OCP71	120
LS191	45	LS490	200	4066	24	4530	90	ORP12	86
LS192	45	LS541	120	4067	245	4531	130	ORP61	86
LS193	45	LS640	180	4068	14	4532	70	2N5777	45
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LS221	55	**CMOS**		4076	50	4544	150		
LS240	65			4077	13	4548	40		
LS241	65	4000	10	4078	15	4549	375		
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LS248	55	4009	24	4093	20	4558	120		
LS249	55	4010	24	4094	70	4559	395		
LS251	30	4011	10	4095	95	4560	160		
LS253	35	4012	16	4096	70	4561	104		
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LS259	58	4015	40	4099	110	4568	250		
LS260	22	4016	20	4160	95	4569	175		
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LS295	75	4027	20	4412	775	45106	598		
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LS299	150	4029	45	4419	280	40097	45		
LS300	175	4030	15	4422	770	40098	193		
LS302	175	4031	125	4433	770	40100	215		
LS320	200	4032	80	4435	850	40101	130		
LS323	195	4033	125	4440	999	40102	140		
LS324	168	4034	140	4450	350	40103	175		
LS325	295	4035	45	4451	350	40104	95		
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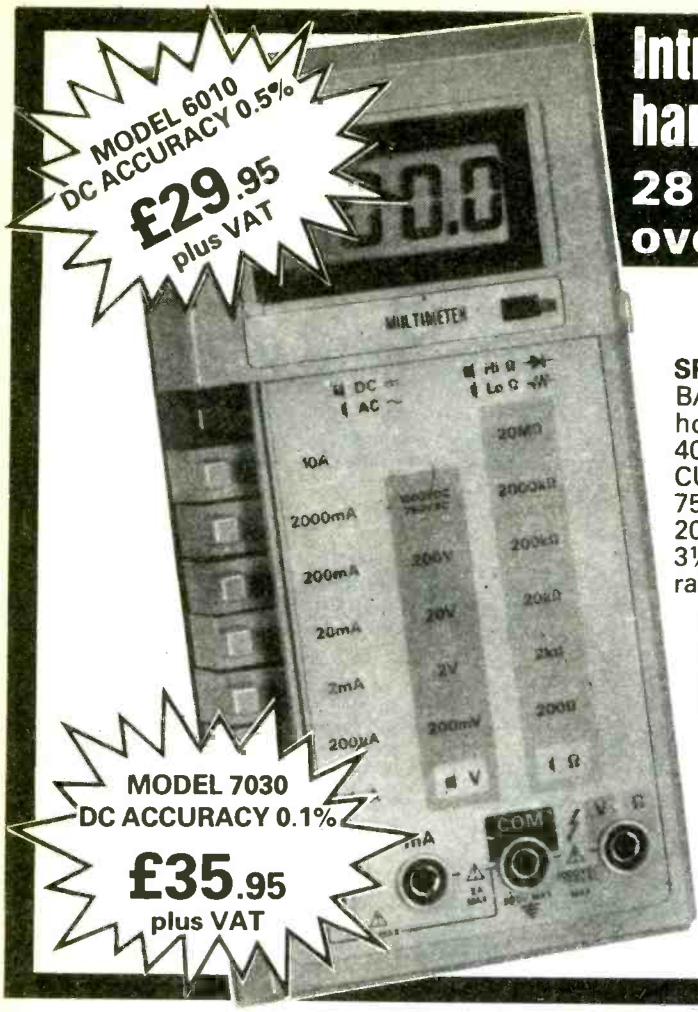

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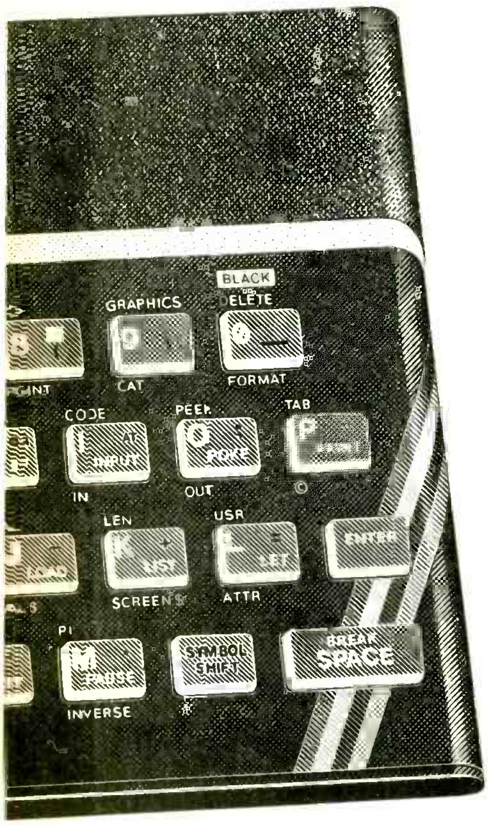

RS232/network interface board

This interface, available later this year, will enable you to connect your ZX Spectrum to a whole host of printers, terminals and other computers.

The potential is enormous. And the astonishingly low price of only £20 is possible only because the operating systems are already designed into the ROM.

ZX Spectrum

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The ZX Printer – available now

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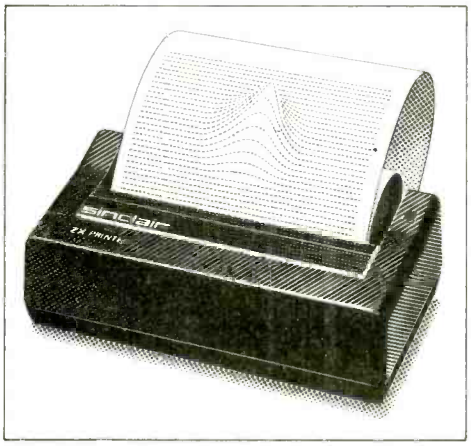
The ZX Printer connects to the rear of your ZX Spectrum. A roll of paper (65ft long and 4in wide) is supplied, along with full instructions. Further supplies of paper are available in packs of five rolls.



The ZX Microdrive – coming soon

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How to order your ZX Spectrum

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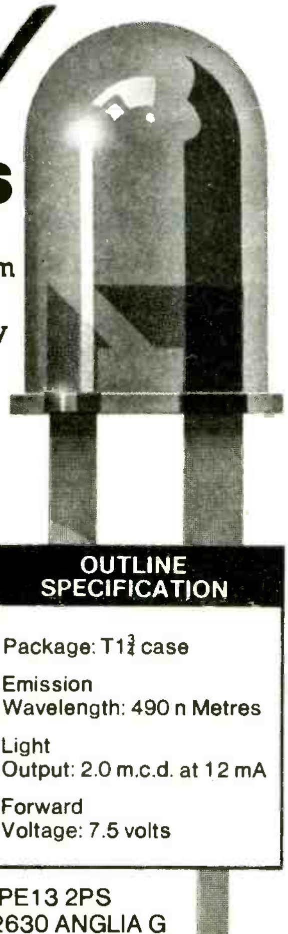

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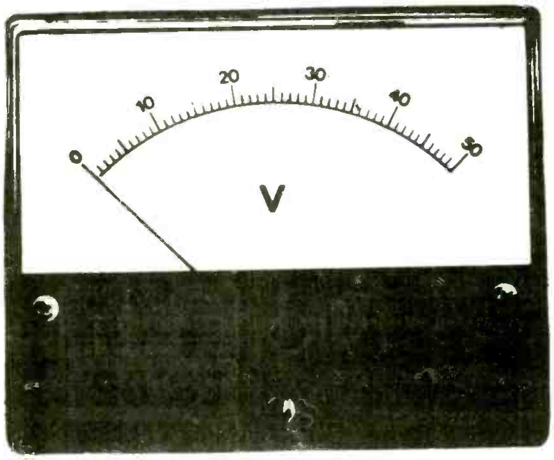

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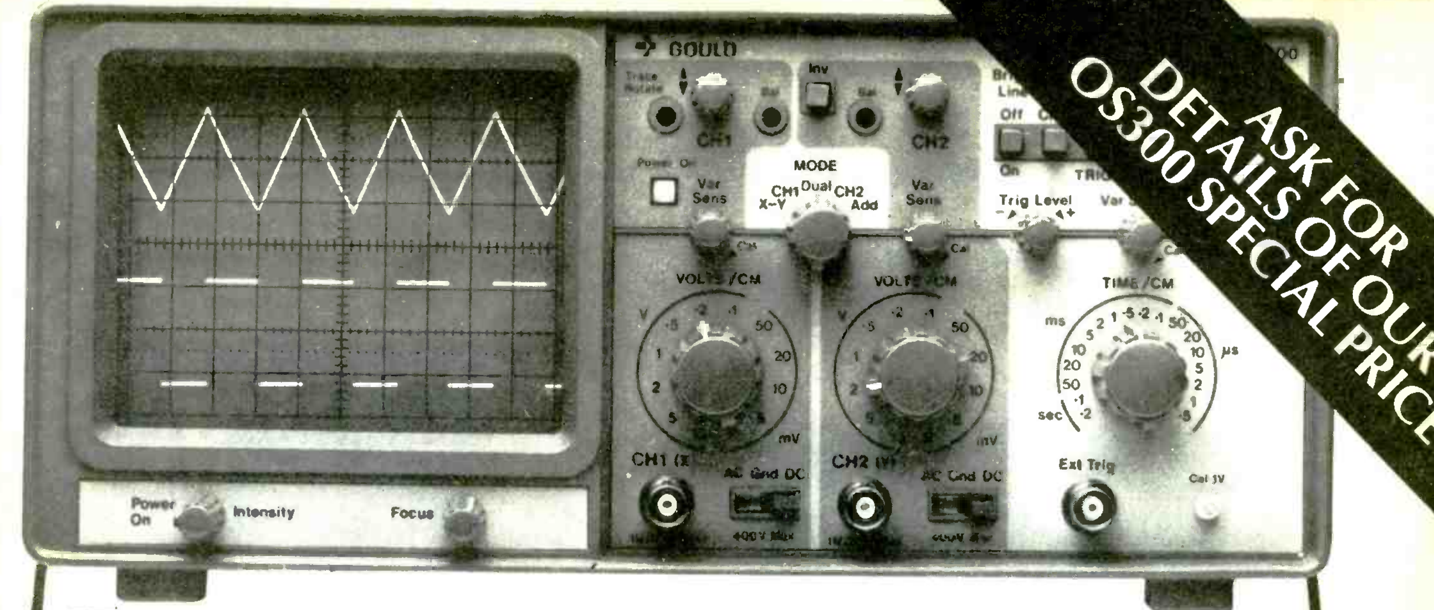

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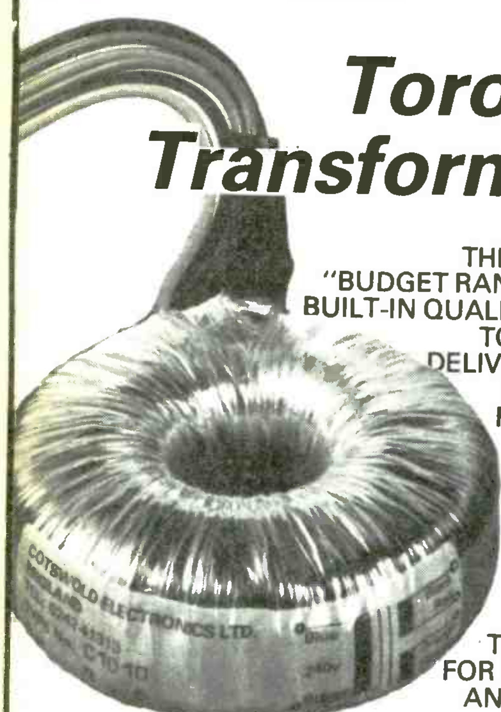

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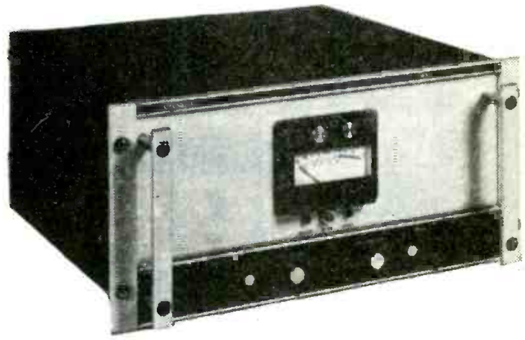

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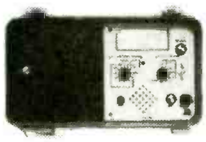

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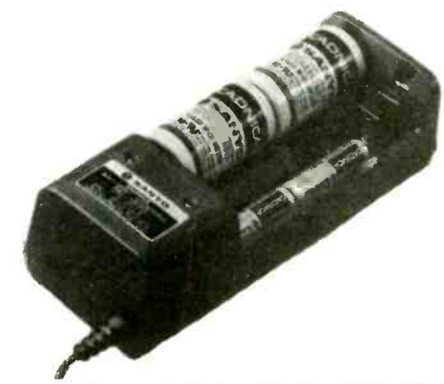

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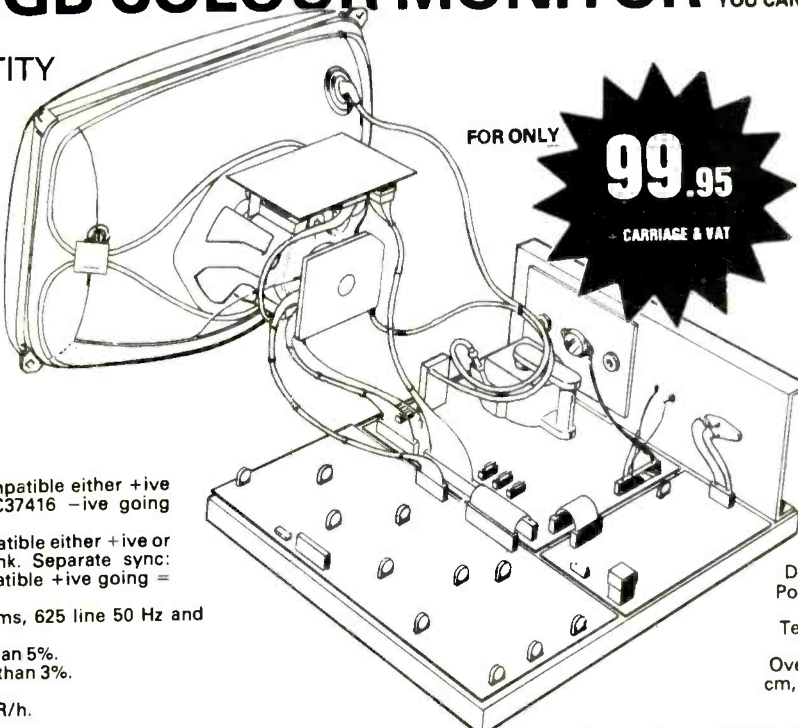

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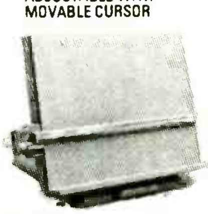

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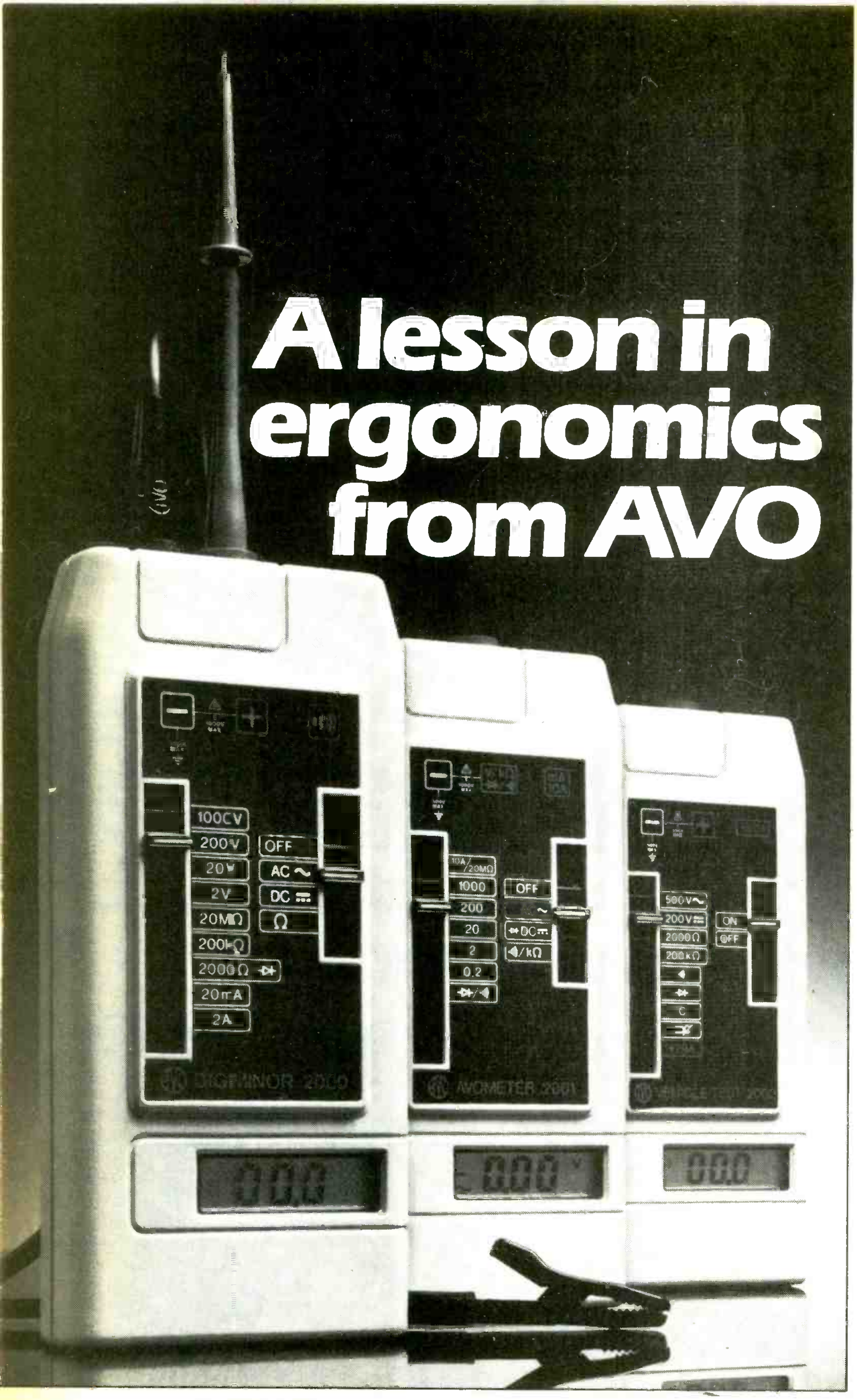

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Wiring technology of the past

In the aftermath of Hunt it will be important to keep the technical options open according to John Butcher MP, Under Secretary of State for industry, speaking to the Television and Radio Industries Club. He was referring to the choice of system architecture by potential cable system operators – tree or multi-star. Taken at face value, this may sound a flexible policy.

A tree structure is suited to broadcast distribution; it evolves outwards to feed additional customers by sub-division of its branches. Coaxial cables are the natural choice for tree structures where up to 30 channels per cable can be tapped off. But as a recently issued NEC report* points out in a 20-year look ahead, they have a very limited capability of providing two-way switched services involving wideband signals.

An alternative based on a multi-fibre tree structure would be very expensive in terms of optical switching and connectors. But a multi-star fibre arrangement – akin to the current telephone network – would allow an unlimited number of one-way channels to be accessed. And more importantly for the future the configuration readily provides full two-way capability; there is no need for encryption, and administration of charging for television channels is simpler.

If a network is required quickly, available technology and economics will favour coaxial cables rather than optical fibres. But a decision in favour of large-scale use of fibre would, says the NEC working party, in itself create a more economic fibre solution.

It would be a tragic waste of the opportunity offered by a two-way switched broadband system if we were to allow this cabling to be dictated by the needs of entertainment broadcasting or narrowcasting alone. The varied facilities of a combined telecommunication and broadcast network, preferably digital, with exciting possibilities of computer-based interactive services in business and in learning, could act as a lubricant for efficiency and national well-being, now and in the foreseeable future. The technology is advancing rapidly; development is still in hand on certain aspects, and many relevant standards have yet to be internationally agreed. There is thus a danger, says the NEC study, that by moving too fast, the UK could go it alone and lose out on export markets.

The opportunity both at home and abroad may not be realised. On the same occasion, John Butcher said BT and its competitors may have to adopt "an evolutionary approach rather than set off with a state-of-the-art switched interactive system, with the high initial costs involved and the risk that the technical breakthroughs may not take place in time to justify the confidence of investors." As the *Guardian* report of 30th September confirmed, this means reliance on coaxial cable feeds rather than optical fibres . . .

**Report of the Working Party on Technological Opportunities in Broadcasting, National Electronics Council 1982*

INTERFACING THE NANOCOMP

The popular Nanocomp microcomputer interface can be expanded by adding further p.i.a. devices and by connecting the interface board described in the October 1981 issue.

by R. Coates

For the Nanocomp microprocessor to pass information to and from additional devices it is necessary to bring out connections from its three buses. The eight data bus lines are of course needed as these are used in the transfer of data to and from the peripheral devices. Some address lines may also be required; for instance, the G821 needs A0 and A1 to select its internal registers. An address decoding signal will also be required to position the device at an appropriate place in the processor's memory map. On the Nanocomp, the 74LS138 decodes addresses; fortunately there are four outputs spare (five on the 6809) so these can be used to select this number of peripheral devices.

The addresses of the outputs of the 74LS138 are given in Fig. 1. The outputs are normally at logical 1, but go to 0 for the second half of the processor cycle if the microprocessor generates an address in the ranges indicated.

Although it's possible with these processors to address up to 65,536 different memory locations this is far more than can be used on a simple device like the Nanocomp; so some of the address lines are ignored in the decoding logic. Consequently the address range occupied by a particular device may be more than required. For instance, the on-board p.i.a. requires four consecutive memory locations given as 4000-4003. But because of the partial address decoding, it will respond to all addresses in the range 4000-4FFF, the four-byte sequence repeating itself 1024 times.

Similarly, the maximum address that can be used is 7FFF and not FFFF as would be expected, as the most significant address line (A15) is not used. So each of the outputs corresponds to a 4096 byte block in the memory map.

The spare outputs should be adequate for most purposes but if more are required a second or further 74LS138 can be added to split down one of the original outputs into eight, the connection details being given in Fig. 2.

A word of warning though: the processor cannot drive a limitless number of peripheral devices without buffering. Between seven and ten devices is the maximum, and there are four on the original board. If this figure is likely to be exceeded then all bus lines brought out should be buffered. Referring to Fig. 3, the data bus can be buffered with a single 74LS245, a bidirectional buffer, the direction being controlled by the read-write line. For the address and control lines, 74LS244s can be used as these bus lines are outputs only. Each device can buffer eight lines, but the precise number required depends on the application.

The easiest place to make the bus connections on the Nancomp is on the underside of the processor socket, with connecting leads as short as possible. Pin numbers of the relevent bus lines are given in Fig. 4.

Adding an additional p.i.a.

A further p.i.a. is the simplest expansion that can be made: a fairly useful one as well as being cheap. The original chip served a triple purpose of driving the display and reading the keyboard, as well as being available externally. This meant certain limitations in its use; if more than eight uncommitted lines were required for external use, the keyboard and display could not be used as part of the user program. Adding a second p.i.a. means that this one is completely free, leaving the original to cope with the keyboard and display.

Fig. 5 gives the connections associated with the 6821 p.i.a. One the bus side, all connections except 'chip select' input is taken to the equivalent pin on the 6802/9 chip; the 'chip select' input is taken to any one of the spare address decoding outputs of the 74LS138. And that is the p.i.a. connected. Addresses of the various internal registers are in the same sequence as the original, but the base address will depend on the 74LS138 output used.

6522 versatile interface adapter

An alternative to the 6812, more powerful but just as simple to connect, is the 6522 versatile interface adapter. Although an upgraded version of the 6821, it is not manufactured by Motorola, but is one of the 6500 microprocessor family from MOS Technology. Normally, mixing devices from one manufacturers processor family with another can lead to problems; bus structures and timing are usually quite different. Fortunately, the 6500 family are based on the 6800, the 6502 microprocessor being a scaled down version of the G800, and therefore peripheral devices in the two families are completely interchangeable.

Circuit connections to the 6522 are shown in Fig. 6; the only difference is that four address lines are required instead of two to access the 16 internal resisters. The peripheral side connections are identical to the 6821. Further details of the 6522 can be found in the Interfacing Microprocessors articles*; a copy of the manufacturers data sheet is also recommended.

Cuban interface board

Although analogue-to-digital converters for analogue input signals and digital-to-analogue converters for generating analogue outputs could be connected either to the p.i.a. or directly to the Nanocomp bus, a neater solution by way of the interface board described in the October 1981 issue. Designed for 6500-based systems, it is equally suitable for the Nanocomp. The facilities provided are a 6522 v.i.a, a 16-

* October 1981, pages 34-9, November, pages 59-62 and December, pages 71-5.

Table 1. A-D conversion, channel INO

	LDS #$1OFF	Initialize stack pointer
	STAA $6010	Start conversion, channel INO
	LDAA #$10	Wait for 100μs
LOOP	DEC A	
	BNE LOOP	
	LDAA $6010	Get conversion data
	SWI	Do software interrupt

Table 2. D-A Conversion

LDAA #$80	Load accumulator with desired value
STAA $6020	Store in D–A
JMP $7D97	Return to monitor

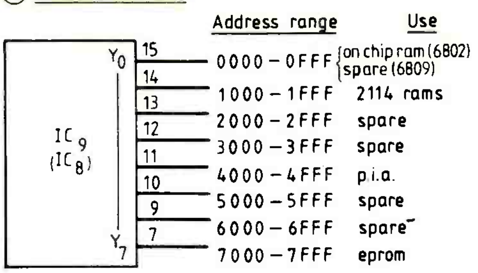
Table 3. Voltage tracker

START	STAA $6010	Start conversion, channel INO
	LDAA #$10	Wait for 100 μs
LOOP	DEC A	
	BNE LOOP	
	LDAA $6010	Read add
	STAA $6020	Store value in
	BRA START	And repeat

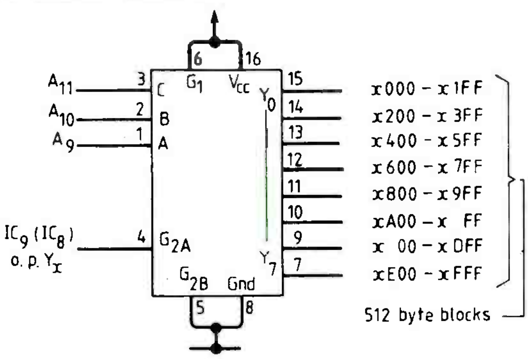
Table 4. VIA Test

	LDAA #0	Set port A as inputs
	STAA $6003	(all bits to 0)
	LDAA #$FF	Set port B as outputs
	STAA $6002	(all bits to 1)
LOOP	LDAA $6001	Read port A
	STAA $6000	Store in port B
	BRA LOOP	And repeat

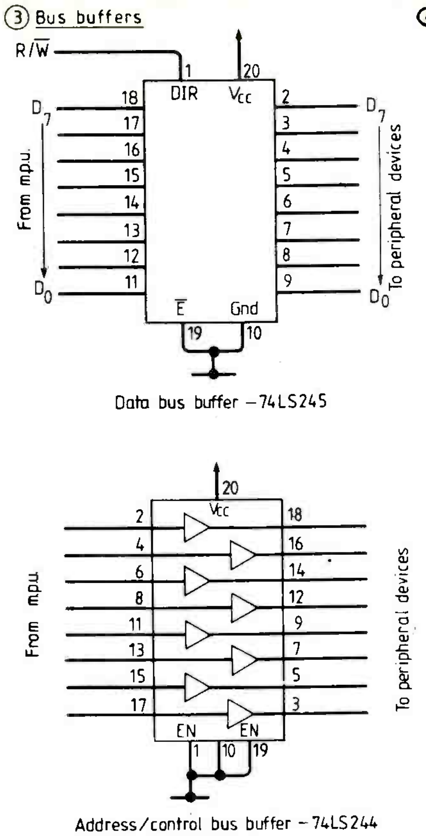
① 74LS138 OUTPUTS



② Connections for second 74LS138



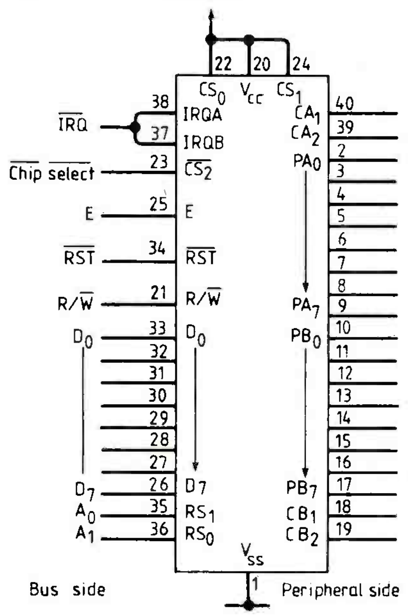
③ Bus buffers



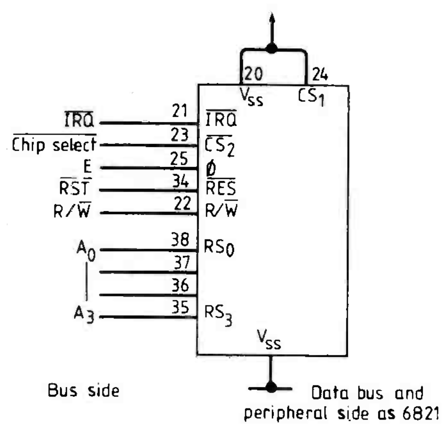
④ **MPU bus connections**

Name	6802	6809
D0	33	31
D1	32	30
D2	31	29
D3	30	28
D4	29	27
D5	28	26
D6	27	25
D7	26	24
A0	9	8
A1	10	9
A2	11	10
A3	12	11
A4	13	12
A5	14	13
A6	15	14
A7	16	15
A8	17	16
A9	18	17
A10	19	18
A11	20	19
A12	22	20
A13	23	21
A14	24	22
A15	25	23
E	37	34
VHA	5	–
R/W	34	32
RST	40	37
IRQ	4	3

⑤ PIA Connections (6821)



⑥ VIA Connections (6522)



channel analogue-to-digital converter and a single digital-to-analogue converter.

Connection is mainly a matter of taking the appropriate bus connections shown on the interface board circuit diagram to the appropriate pin on the Nanocomp processor chip; Fig. 4 shows the pin numbers. But note several points. Number 02 corresponds to E on the 6802/9, NRST is the reset line (RST), and NWDS, NRDS, BLK on the interface board are not used.

One modification is required to the interface board for use with the 6802, but not with the 6809. Addresses can occur on the address bus which are not valid memory addresses. For instance, when an INX instruction is executed, the index register's contents will appear on the address bus but this is obviously not a proper address. For devices on the bus to decide what is a memory address and what is irrelevant data, the valid-memory-address signal from the processor is used. This line will only be at a 1-level if the address bus contents are a valid memory address. This signal must therefore be gated into the address decoding circuitry to prevent spurious accesses to the interface board. This only requires a simple modification: the track to pin 1 of $1C_5$ on the interface board should be broken, and pin 1 connected to v.m.a. on the 6802, see Fig. 7. Later Motorola microprocessors such as the 6809 do not senerate these spurious addresses and so this modification is not required.

The interface board requires a section of the memory map 256 bytes long and this can be set anywhere in the memory by the block and page selector switches that is not already used by the Nanocomp. The block switch is the most significant digit in the four digit hex address, but remember, as A15 is not used in the Nanocomp, only positions 0-7 may be used. The page switch is the next most significant digit of the address.

In the examples given later, the board is assumed to be at 6000-60FF, which means block =6 and page =0.

As the address setting is unlikely to be changed, wire links could be used instead of the block and page switches, but note when working out which selector lines are 0 or 1 the 74LS136 is an exclusive -or gate, and not an exclusive nor-gate as shown in the circuit diagram.

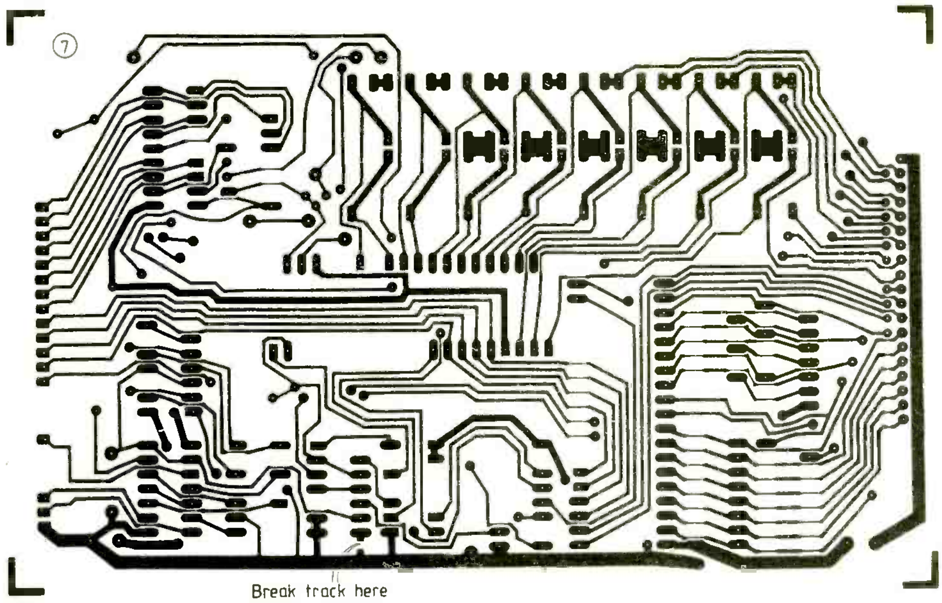
Power for the interface board can be taken from the original power supply but the extra load will cause an increase in heat dissipation and ventilation should be adequate. A larger heat-sink may be required for the regulator.

The interface board will clearly not fit inside the original Nanocomp case, but a deeper case, RS number 509-276, will accept both boards. As the front panel sizes are almost identical, the original front panel can be used with a little modification.

Driving the Cuban

Some sample source code programs are given to show how to read an anologue input signal, how to set an analogue output level, and how to read and drive the v.i.a. peripheral lines. Only the mnemonics are given, not the machine-code, as this differs in some cases between the 6802 and 6809.

First, the analogue to digital converter. The ADC0817 is a 16-channel 8-bit anal-



ogue-to-digital converter. That is, it has 16 analogue inputs, any one of which can be selected and the analogue voltage on it converted to an 8-bit value which can then be read and used by the microprocessor.

To measure a voltage, the converter must be told by the microprocessor to initiate a conversion on a specified channel. It takes about 100μs for this particular chip to perform the conversion, so there must be a wait of greater than this before reading the result. The conversion is initiated by the processor writing to one of the 16 a-d allocated memory locations (what data is written doesn't matter). The location written to determines the channel on which the conversion takes place; 6010 corresponds to channel IN0, 6011 to channel IN1, and so on up to channel IN15 at 601F.

A 100μs software delay loop should then be entered and then the conversion result obtained by the processor reading any one of the 16 a-d addresses.

Table 1 gives the listing of a simple program to read channel IN0.

After the software interrupt, accumulator A can be examined to determine the digital value proportional to the input voltage. This will be between 00 for zero input voltage and FF for a full scale (or greater) voltage. Full scale is defined as the voltage across the reference input pins of the ADC0817, and is set by the LM317 regulator and the 100 ohm potentiometer to between approximately 1.9 and 3.2 volts.

Digital-to-analogue converter

Digital to analogue conversion is the reverse of the above, and allows the microprocessor to generate an analogue voltage proportional to a binary value by simply writing a binary value to the d-a converter address.

The program in Table 2 gives a half full-scale output at the analogue output. Changing the contents of accumulator A changes the output voltage.

The program of Table 3 combines the two converters by reading the analogue input and setting the analogue output to the same value. The program then loops back and up-dates the output continuously, until "reset" is pressed. A variable voltage source on the input and a voltmeter on the output should confirm correct operation. When working correctly, adding an ASL A instruction after reading the a-d gives a voltage doubler!

Versatile interface adapter

The 6522 v.i.a. is similar in many respects to the 6821 p.i.a. but includes extra features such as two 16-bit timers and a shift register for serial communication. To access the greater number of internal registers therefore needed, the device occupies 16 consecutive memory locations, as opposed to the 6821's four. In this example the addresses are 6000-600F.

Consider the 16 peripheral data lines and their programming.

Each eight-bit peripheral port has a data direction register (DDRA, DDRB) for specifying whether the peripheral pins are to act as imputs or outputs. A logical 0 in a bit of the data direction register causes the corresponding peripheral pin to act as an input; a 1 causes the pin to act as an output.

Each peripheral pin is also controlled by a bit in the output register (ORA, ORB) and an input register (IRA, IRB). When programmed as an output, the voltage on the pin is controlled by the corresponding bit of the output, the voltage on the pin is controlled by the corresponding bit of the output register: a logical 1 causes the output to go high, and a zero causes the output to go low. Data may be written into the output register bits corresponding to pins which are programmed as inputs, but in this case the output signal is unaffected.

Reading a peripheral port causes the contents of the input register (IRA, IRB) to be transferred onto the data bus. The B register operates similarly to the A register; however, for pins programmed as outputs there is a difference. When reading IRA, the level on the pin determines whether a 0 or 1 is sensed. When reading IRB however, the bit stored in the output register ORB is the bit sensed. Thus for outputs which have large loading effects and which pull an output 1 down or which pull an output 0 up, reading IRA may result in reading a 0 when a 1 was actually programmed, and vice-versa. Reading IRB, on the other hand, will read the 1 or 0 level actually programmed, no matter what the loading on the pin.

To program the device, first set up the direction of each line with the data direction registers. DDRA is at address 6003 and DDRB at 6002. The outputs can now be programmed, or the inputs read at 6001 for port A and 6000 for port B. This is simpler than for the 6821 which requires the setting of a bit in the control register to determine whether access is to the direction or data registers, which are at the same address.

The listing in Fig. 4 shows a simple test program for the v.i.a. Port A lines are all inputs and port B outputs. The program continuously reads port A and stores the data in port B, so the outputs reflect the state of the inputs.

Connecting inputs to +5V or around while monitoring the equivalent output with a meter or oscilloscope should confirm correct operation. WW

TWO-METRE TRANSCEIVER

Design of a microprocessor-controlled transceiver with l.s.b., u.s.b. and f.m. simplex, repeater and reverse modes is described with which automatic scanning of the 144-to 146MHz band or up to nine memorized channels is possible. This first article covers specifications, operation and the front-end module.

by T. Forrester, G8GIW

It was my intention from the outset of this project about three years ago that the transceiver described here should be versatile yet uncomplicated and easy to duplicate. During the development stage components became available which simplified the design of the transceiver and the modular method of construction chosen made their inclusion a simple matter. There are currently commercially available modules which would further simplify the transmitter section even more, but as yet their cost is prohibitive. Should their price fall to a reasonable level they may easily be included.

The prototype was constructed using discrete-logic gates to control the synthesizer and displays, etc., but it soon became apparent that microprocessor control would be advantageous. Use of a microprocessor meant that many of the features found on commercial transceivers, and some additional ones, could be incorporated at the expense of time required to write the software, and that the number of i.cs used could be reduced from more than 30 to six, thus simplifying the construction.

Each module has its own p.c.b. and is housed in a screened rectangular box. Six of these modules form the transceiver, one is the microprocessor circuit and the remaining three are the display-driver, tone-burst and a.f.-preamplifier boards.

While the resulting design is not the ultimate by professional standards, it is good value for money and is certainly competitive with currently available amateur transceivers.

Operation

As the transceiver is primarily intended for mobile use, the number of controls are kept to a minimum while retaining flexibility, partly in the interests of road safety. The transceiver is turned on by the mode control and the appropriate mode selected at the same time; the microprocessor starts up immediately and sets the synthesizer and display with the last used frequency, after which it scans the controls.

With the transceiver in its 'normal' mode tuning carried out using up/down buttons on the microphone causes the synthesizer to step up or down in 100Hz or 25kHz steps. If the up or down button is kept pressed the synthesizer continues stepping at a gradually increasing rate until the button is released.

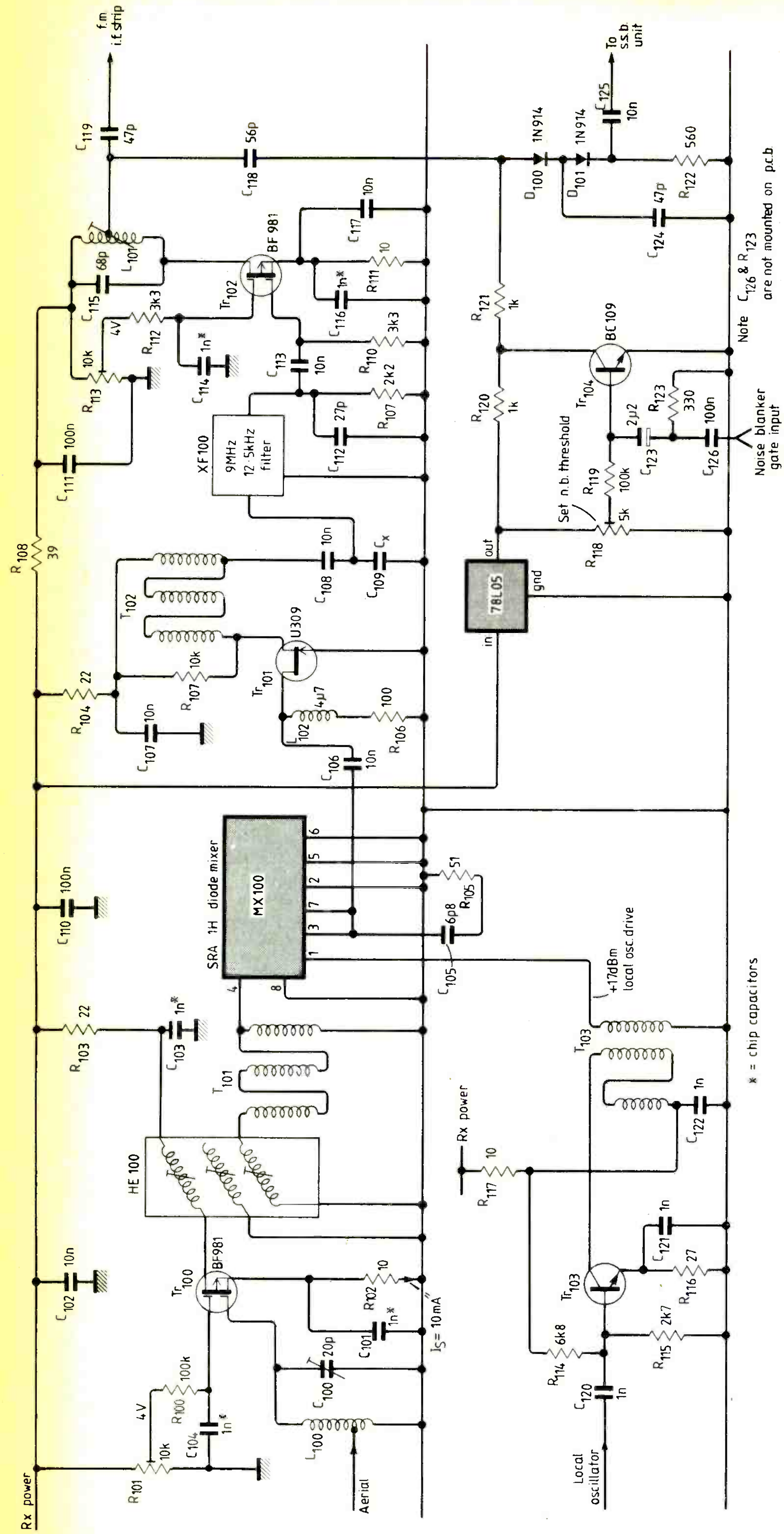
The volume control doubles as a frequency-step selector. Pulling the knob gives 100Hz steps and, if required, the s.s.b. noise-blanking facility. Steps of 25kHz are obtained when the volume-control switch is in its normal position.

When scan mode is entered with the receiver set for normal operation, i.e. not in memory mode, the transceiver scans the band and stops for six seconds on any channel whose signal lifts the squelch. If the transceiver is taken out of the scan mode during these six seconds it will remain on that frequency. Pressing the skip button at this point will result in the channel in question being passed over on the next scan of the band. The skip button does not work when the unit is in memory mode. To remove a channel from the list one sets the transceiver for normal operation, tunes to the channel concerned and presses the skip button.

This feature of being able to skip certain channels while scanning the band has been found to be particularly useful if one does

Specifications

Frequency coverage	144 to 146MHz
Frequency steps	100Hz or 25kHz
Frequency display	7-digit l.e.d. with 100Hz resolution
Tuning method	up/down buttons on microphone or channel switch (select memory channel)
Memory	9 memories programmed by push button – may be scanned with six second hold
Scanning	scan memory channels or scan band (144 to 146MHz) with provision to skip up to 40 channels
Modes	l.s.b., u.s.b., f.m. simplex, repeater and reverse repeater
Power	16.5W f.m. and 14.9W p.e.p. s.s.b. with 13.8V supply
Spurious outputs	better than -70dB at 16.5W
Harmonics	–45dB at 288MHz –50dB at 432MHz
Carrier suppression	50dB (s.s.b)
Squelch threshold	0.1µV (s.s.b. and f.m.)
Bandwidths	2.4kHz s.s.b. 12.5kHz f.m.
Sensitivity	0.26µV p.d. for 12dB quieting with f.m., 0.13µV p.d. for 12dB s/n ratio with s.s.b.
Receiver image response	<–76dB
Third-order intercept point (receiver)	–1dBm
Size	205 by 250 by 65mm
Antenna impedance	50Ω nominal



Components, module 1

Resistors

100, 119	100k
101, 113	10k sub-min. preset
102, 111, 117	10
103, 104	22
105	51
106	100
107	10k
108	39
109	2.2k
110, 112	3.3k
114	6.8k
115	2.7k
116	27
118	5k sub-min. preset
120, 121	1k
122	560
123	330

Capacitors

100	20p sub-min. preset
101, 103, 104, 114, 116	1n chip
102, 106, 107, 108, 110, 111, 113	10n disc
105	6.8p
109	s.o.t. for filter, typ. 22p
112	s.o.t. for filter, typ. 27p
115	68p
117, 125	10n
118	56p
119, 124	47p
120, 121, 122	1nF disc
123	2.2µ tantalum
126	100n disc

Semiconductor devices

$Tr_{100, 102}$	BF981
Tr_{101}	U309
Tr_{103}	2N918
Tr_{104}	BC109
$D_{100, 101}$	1N914
VR_{100}	78L05*
Mx_{100}	SRAH1*

Inductors

L_{100}	5 turns of 20s.w.g., 12.5mm long, 7.5mm i.d., tapped at 1¼ turns
L_{101}	25 turns of 30s.w.g. on 4mm dia. former tapped 4 turns from earthy end, slug tuned
HE_{100}	3-stage helical filter, part number 17-10063*
$T_{101, 102, 103}$	4 turns per winding, trifilar wound with 30s.w.g.

The 9MHz crystal filter with 12kHz bandwidth is available from IQD, 29 Market Street, Crewkerne, Somerset. Components marked with an asterisk are available from Ambit International, 200 North Service Road, Brentwood, Essex CM14 4SG. All the resistors are 1/4W with 5% tolerance. Teko screened boxes are available from West Hyde Developments Ltd, Unit 9, Park Street Industrial Estate, Aylesbury, Bucks HP20 1ET.

not wish to listen to repeaters or similar stations.

If certain favourite channels are to be memorized, it is only necessary to tune them in using the up-down buttons, enter memory mode, select a suitable position in the memory using the memory switch and then press memory-write button. The channel previously tuned to will then be displayed and sent to the synthesizer. Up to 9 channels can be memorized and, if required, scanned.

When repeater mode is selected the 1750Hz tone burst is automatically turned on, and when the unit is set to transmit the shifted transmit frequency is automatically displayed and the tone burst operated. Likewise for reverse repeater, the appropriate frequencies are displayed and no retuning is required.

While the operating frequency is being changed by means of the up-down buttons on the microphone, a 'peep' is emitted from a transducer mounted inside the transceiver. This feature is useful when driving since the frequency change can be judged by counting the peeps.

When the transceiver is in scan mode the peep generator is disabled, as its continual peeping as the synthesizer changes channel would be annoying, if not distracting while driving a vehicle.

Modules

Each module is numbered as follows and any components referred to in the circuit descriptions will be preceded by the number of the module in which they are used.

1 receiver converter, 144 to 9MHz
2 transmit converter, 9 to 144MHz
3 transmit power amplifier and power regulators
4 t.m.-i.f. discriminator, squelch, noise blanking and a.f. power amplifier
5 synthesizer logic
6 synthesizer v.c.o. and power switching
7 s.s.b. 9MHz transceiver and exciter
8 microprocessor control and interfaces
9 frequency-display driver
10 1750Hz tone-burst generator and receive a.f. preamplifier

Units one to seven are housed in separate screened boxes measuring 160 by 50 by 26mm. Modules five and six share the same box while modules 8, 9 and 10 are attached directly to the transceiver chassis and are not in screened cases. The modules are described in the above order.

Receive converter – 1

The front end of any high performance receiver is perhaps the most critical component, with the possible exception of the frequency synthesizer, so these two elements justify extra care in design. This receive converter is the end result of six months' work, and gives excellent results.

Criteria for a good receiver, besides the obvious low noise figure and frequency stability are good dynamic range, i.e. reluctance to overload and cross-modulate in the presence of strong signals, and secondly good adjacent-channel rejection. Unfortunately most mass-produced amateur transceivers are built to a price, with one or two exceptions, and their performance when subjected to strong signals can leave a lot to be desired.

To overcome these problems, a different approach to the usual configuration comprising mosfet preamplifier, mosfet mixer, ceramic i.f. filter, etc., is used which gives excellent performance for a modest outlay. Most of the cost is tied up in the mixer and i.f. filters.

The receive converter comprises the usual modules, but individual parts are tailored to ensure good performance.

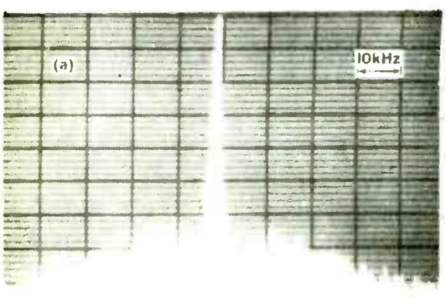
The antenna it matched to the r.f. preamplifier, Tr_{100}, to obtain the best noise figure for a conventional tuned circuit. The r.f.-preamplifier drain load is a readily available three-stage helical filter which has an ideal bandwidth for the 2-metre band. This filter is transformed from its nominal impedance of 500Ω to 50Ω by T_{101} (trifilar wound) to match the mixer impedance.

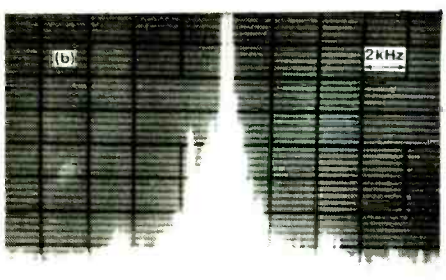
The mixer in this receive converter is the SRA 1H type which requires +17 dBm (approximately 45mW) of local-oscillator drive. This mixer has a typical third-order intercept point of +17dBm and a conversion loss of 7-8dB. To overcome this loss and maintain a good overall noise figure an i.f. amplifier is used directly after the mixer, Tr_{101}. To ensure that this i.f. amplifier does not overload a power f.e.t. is used (third order output intercept point +30dBm). An added benefit of using this type of f.e.t. (U309) is that its input impedance is 50Ω. It is important for the proper operation of a switching mixer such as the SRA1H, that the i.f. port is kept terminated with 50Ω. A 6.8pF capacitor, C_{105}, and 51Ω, R_{105}, resistor maintain 50Ω at high frequencies.

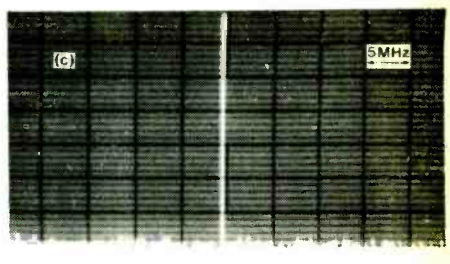
This i.f. amplifier gives 10dB gain, which is just enough to overcome the mixer loss, and its output is matched to the 9MHz 12½kHz crystal filter by another trifilar transformer, T_{102}. All three transformers in this module are identical. Use of a high-quality crystal filter at this point is important as it provides all the f.m. receive selectivity and aids the ultimate rejection on s.s.b. Ceramic filters are usually not good enough.

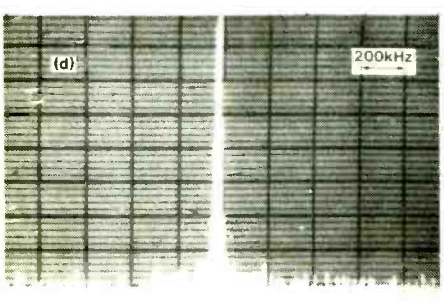
After the first i.f. filter comes a low-noise i.f. amplifier using another BF981, Tr_{102}, with a tuned-drain load. Its output splits two ways; one goes directly to the f.m. i.f. strip and the other goes to the s.s.b. receiver unit through the noise-blanking circuit shown at the bottom right-hand side of the diagram.

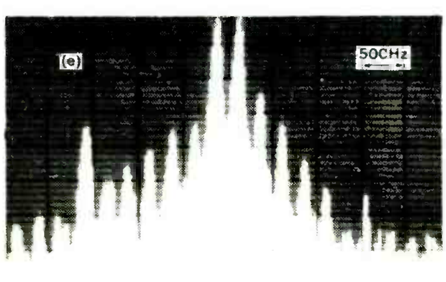
The noise-blanking circuit is placed between the f.m. and s.s.b. filters to restrict its sampling bandwidth to 12½kHz thus preventing i.f. cross modulation from strong signals on nearby frequencies. Local-oscillator drive for the mixer is amplified by a class-A amplifier using a



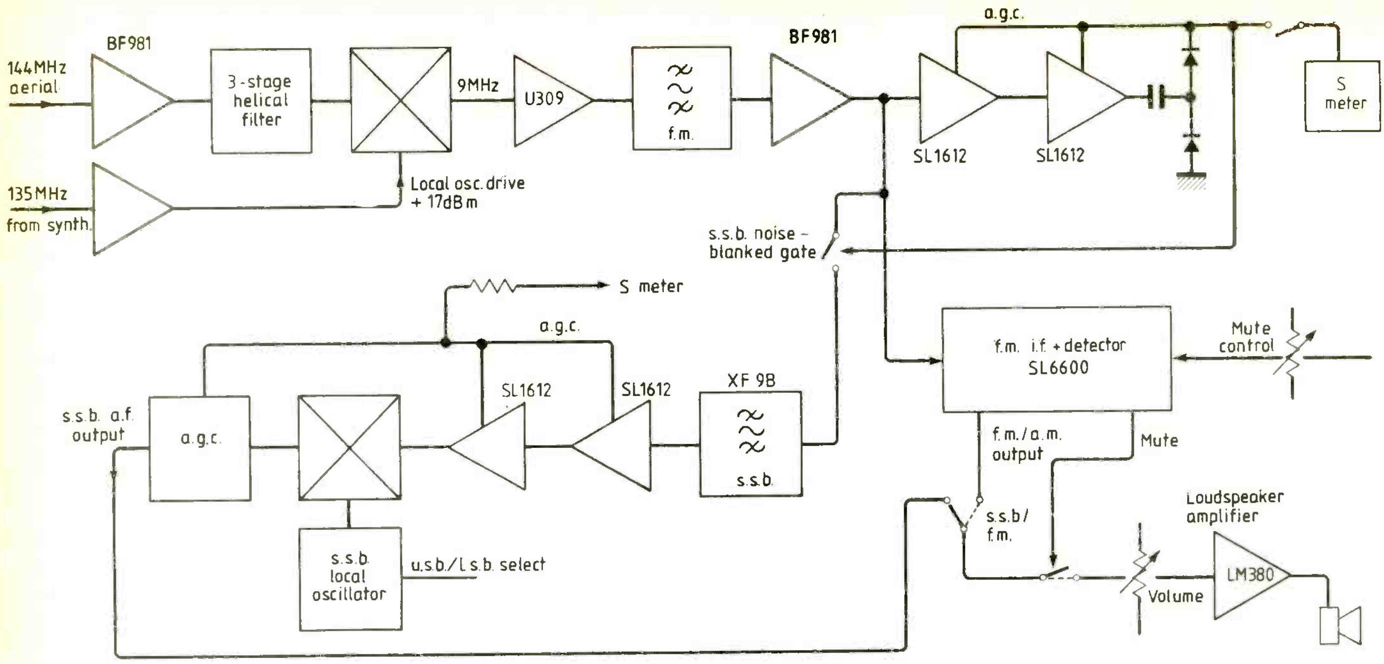








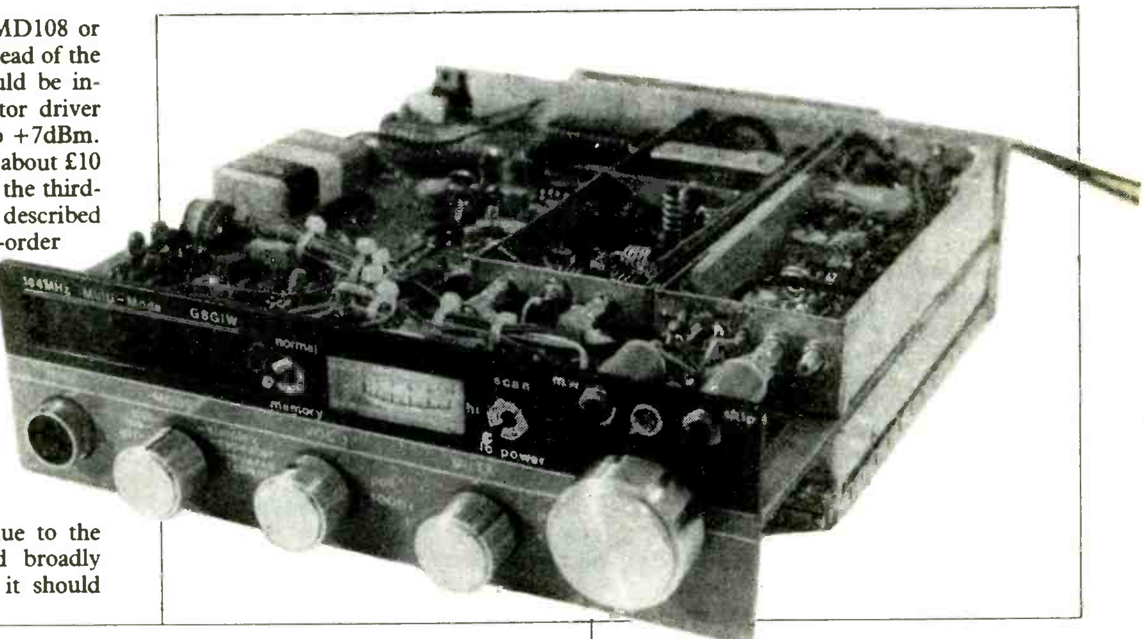
Analyses of transceiver performance all use 10dB/div vertical sensitivity and 145 MHz centre frequency, except (a) which has 136.5MHz centre frequency. Synthesizer output shows noise floor at approximately −70dB (a), two-tone s.s.b. intermodulation with wide sweep at 10W p.e.p. (b), extra-band spurious signals at full power (c), inter-band spurious signals at full power (d), and two-tone intermodulation distortion with narrow sweep at 10W p.e.p. (e).

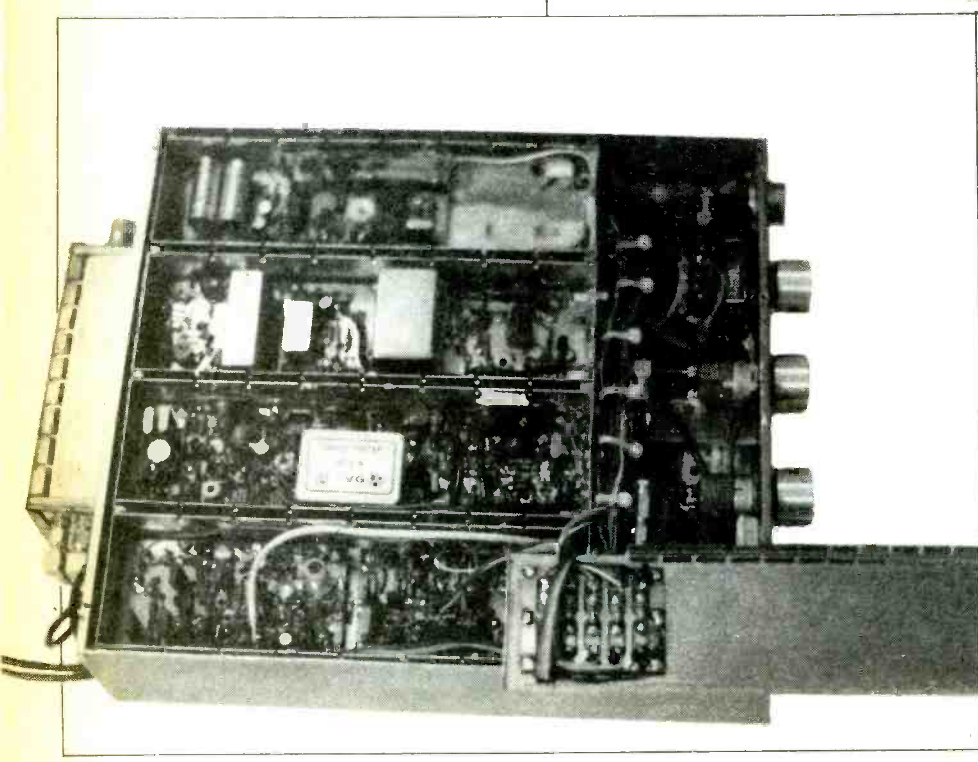


2N918 transistor, Tr_{103}. If an MD108 or similar type of mixer is used instead of the SRA1H, then a 10dB pad should be inserted between the local-oscillator driver and mixer to reduce the drive to +7dBm. Using a MD108 mixer will save about £10 but at the cost of 10dB or so on the third-order intercept point. As it is described here, the circuit gives a third-order intercept point of −1dBm and a noise figure of between approximately 1.8 and 2dB.

Failure to use 1nF chip-type bypass capacitors or to mount them directly on the leads of the BF981 fets may lead to instability and in consequence a poor noise figure.

Receiver alignment is easy due to the ready-aligned helical filter and broadly tuned 9MHz i.f. amplifier, so it should only be necessary to peak the tuned circuits for maximum signal (including the helical) and trim the f.m. discriminator.





An overall block diagram of the receiver is shown and details the individual component parts, and the signal flow paths for both s.s.b. and f.m.

The 5kΩ potentiometer, R_{118}, sets the noise blanking threshold and initially should be set to the minimum voltage required to turn Tr_{104} off, so providing minimum noise blanking action and maximum signal to the s.s.b. i.f. This p.c.b. is fastened into the screened box by means of four tapped stand-off bushes fitted one in each corner.

All power and low-frequency signals to all modules in the design are filtered by means of 1nF lead-through capacitors, although they may not be shown on the circuit diagrams. These lessen the possibility of spurious r.f. feedback paths and so increase the repeatability of the design.

To be continued

BINAURAL RECORDINGS AND LOUDSPEAKERS

Analysing reproduction of binaural recordings through loudspeakers leads to the development of circuitry for their correct reproduction, and which also gives out-of-head localization for stereo headphone reproduction.

by J. H. Buijs

Binaural recordings are made with two microphones situated in the ears of a dummy head. As a consequence of this recording technique, reproduction should take place through headphones. One of the drawbacks of this system is that it is restricted to personal reproduction. To make the improvement in sound location over conventional stereo enjoyable by more than one person at a time without having to use several headphones, reproduction through loudspeakers has to be possible.

The standard recording and reproduction procedure is depicted in Fig. 1, where the microphones of the dummy head feed signals of the appropriate magnitude and phase position to the headphones. When the binaural recording is reproduced over loudspeakers, the situation as is drawn in Fig. 2 arises. The microphones send the same signals as before to the loudspeakers, but now each loudspeaker produces its own pressure pattern at the ears of the listener. The left loudspeaker generates the sound pressures L_l and R_l at the left and right ear respectively. The right loudspeaker generates the sound pressures L_r and R_r. Adding up the corresponding pressure phasors, the left phasor L leads the right phasor by a small angle γ, which is not equivalent to the original phase angle ϕ. This shows that when loudspeakers are used for the reproduction of a binaural recording, much of the directional information is lost.

The cause of this loss of information is the existance of a double cross-feed, one at the microphones of the dummy head and the other at the loudspeakers. The situation can be improved by introducing a signal R'_l in the right loudspeaker. This signal R'_l should be equal to $-R_l$, so that R_l is cancelled. In the left loudspeaker a signal $L'_r(=-L_r)$ should be introduced for the same reason.

The result of such an operation can be gathered from Fig. 3, in which a similar analysis is given as in Figs 1 and 2. Signal L consists of the addition of the phasors L_l and $L(R'_l)$, and the signal R is formed by the phasors R_r and $R(L'_r)$.

A more detailed analysis reveals that the angle between L_l and $L(R'_l)$ is equal to $180-2\delta°$, where δ is the phase angle between the phasors of the sound pressure at the left and the right ear caused by one of the two loudspeakers. This situation is drawn in Fig. 4, where $\alpha=180-2\delta°$ and one can see that

$$\tan\zeta=\frac{L(R'_l)\sin\alpha}{L_l+L(R'_l)\cos\alpha}$$

As $L(R'_l)$ is the same signal as L_l but adapted twice by the cross-feed function H(f), one can also write

$$\zeta=\text{arc}\tan\frac{|H(f)|^2\sin 2\delta}{1-|H(f)|^2\cos 2\delta}$$

Because the same applies for the stimulus for the right ear R, the phase angle between L and R is equal to the phase angle between L_l and R_l, and is therefore correct. The amplitude of signal L is

$$\sqrt{(L_l+L(R'_l)\cos\alpha)^2+(L(R'_l)\sin\alpha)^2}$$
$$=\sqrt{L_l^2(1-|H(f)|\cos^2 2\delta)^2+(L_l|H(f)|\sin 2\delta)^2}$$
$$=L_l\sqrt{1+|H(f)|^2\cos^2 2\delta-2|H(f)|\cos 2\delta+|H(f)|^2\sin^2 2\delta}$$
$$=L_l\sqrt{1-2|H(f)|\cos 2\delta+|H(f)|^2}.$$

From this one can conclude that correct reproduction of binaural recordings through loudspeakers is possible provided that the cross-feed function between the two ears of the observer is known, and can be reproduced electronically. Also, an amplitude-correcting circuit will have to be designed in view of the equation for the amplitude of the stimulus, as derived above. If one assumes that the loudspeakers are placed along lines which make an angle of 45° with the perpendicular to

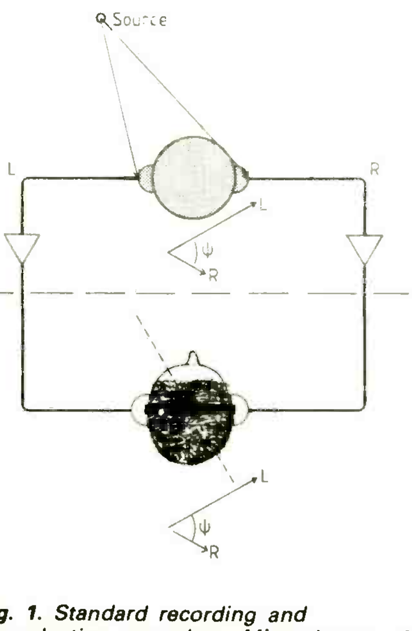


Fig. 1. Standard recording and reproduction procedure. Microphones of dummy head feed signals of appropriate magnitude to the headphones.

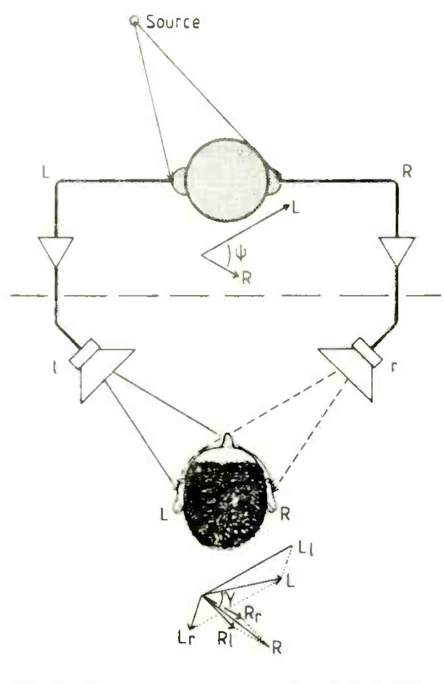


Fig. 2. When binaural recording is used for binaural recording reproduction, much of the directional information is lost.

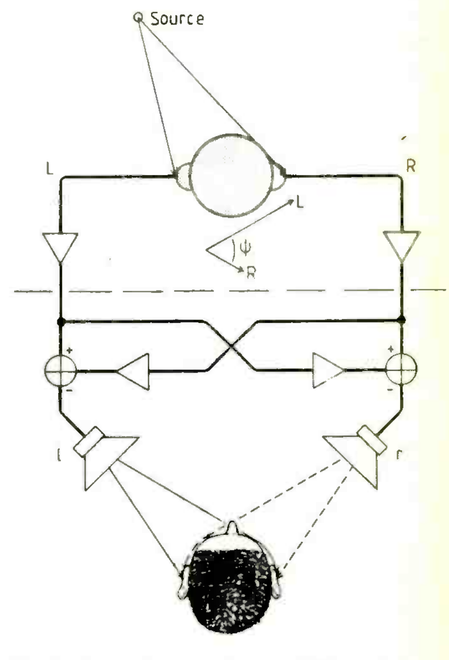


Fig. 3. Signal L consists of addition of phasors L_l and $L(R'_l)$ and the signal R is formed by phasors R_r and $R(L'_r)$.

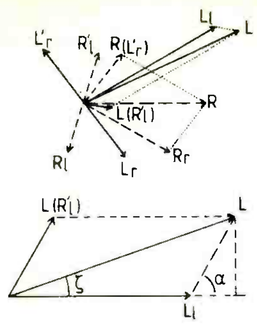


Fig. 4. Angle between L_1 and $L(R'_1)$ is equal to 180-2δ°, where δ is phase angle between phasors of sound pressure at left and right ear caused by one of two loudspeakers.

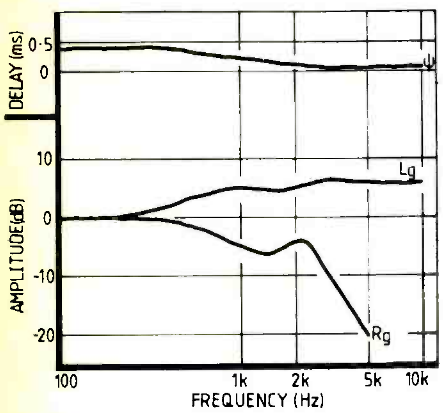


Fig. 8. Cross-feed function of Fig. 7, itself derived from the work of Wiener and Shaw.

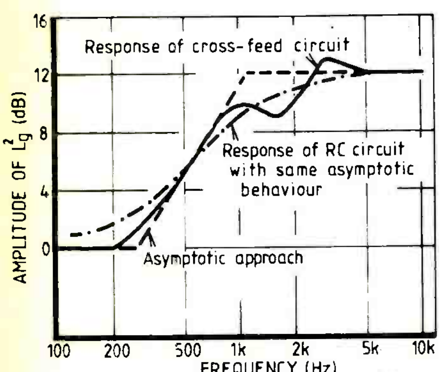


Fig. 9. Because transfer function L_g^2 enhances frequencies over 200Hz by 12dB a correction circuit gives approximate compensation, as above.

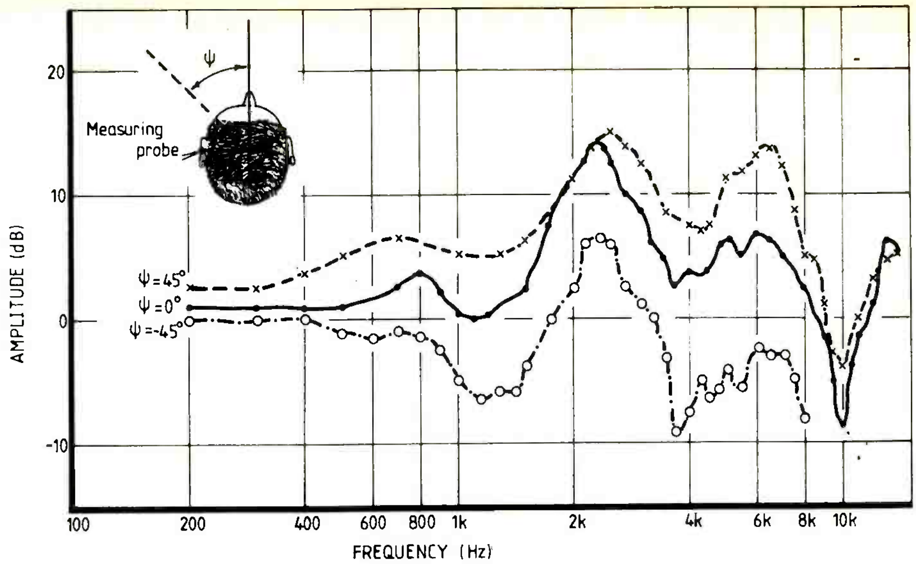


Fig. 5. Results obtained by Shaw for determination of cross-feed function assuming loudspeakers placed along lines making 45° with perpendicular between left and right ear.

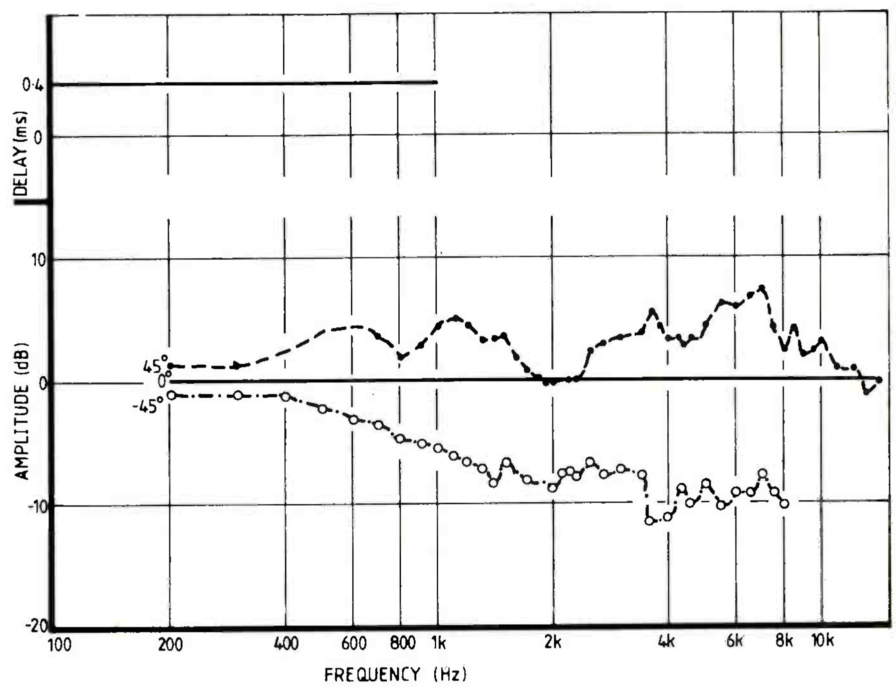


Fig. 6. When data of Fig. 5 are normalized to ear-canal pressure at 0° angle this results. Value for time delay between left and right ear originating from same loudspeaker is from Bauer.

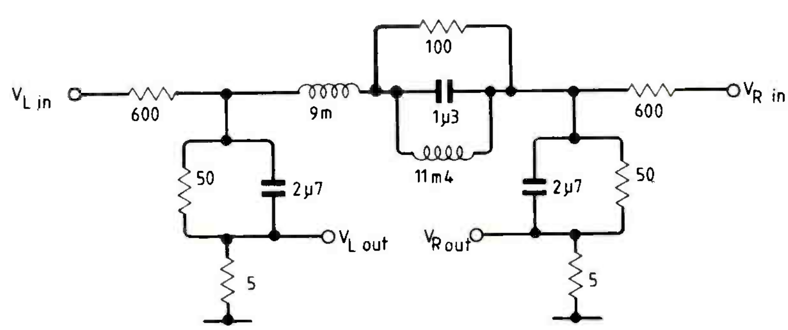


Fig. 7. Bauer designed this circuit to simulate cross feed from Wiener's data.

the line between the left and right ear, one can turn to research by Wiener[1] and Shaw [2] for the determination of the cross-feed function. The results obtained by Shaw are reproduced in Fig. 5, which form an extension in frequency range of the measurements performed by Wiener.

When these data are normalized to the ear canal pressure at 0° angle, Fig. 6 results. The value for the time delay between the signal for the left and right ear originating from the same loudspeaker is from Bauer [3].

From similar data originating from Wiener, Bauer designed a circuit drawn in Fig. 7 to simulate the cross feed. In this circuit

$$V_{Lout}=L_gV_{Lin}+V_{Rin}R_ge^{j\phi}$$

and

$$V_{Rout}=L_gV_{Rin}+V_{Lin}R_ge^{j\phi}$$

where L_g and R_g and ϕ are the transfer functions, as displayed in Fig. 8.

The input signals for the cross-feed generator to arrive at the loudspeaker signals for reproduction of binaural recordings are

$$V_{Lin}=L$$

and

$$V_{Rin}=-R$$

which leads to

$$V_{Lout}=L_gL-RR_ge^{j\phi}$$

and

$$V_{Rout}=-L_gR+LR_ge^{j\phi}.$$

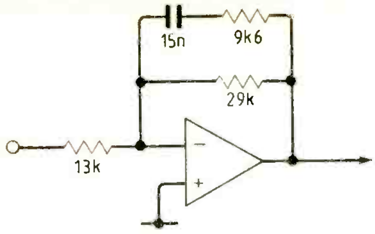


Fig. 10. Correction circuits give approximate compensation to L_g^2 transfer function of Fig. 9.

After inversion of V_{Lout} and reproduction of these signals by loudspeakers, the sound pressure at the ears is

$$V_L = L_g(-L_gL + R_gRe^{j\Phi}) + R_ge^{j\Phi}(-L_gR + R_gL.e^{j\Phi}) = -L_g^2L + R_g^2Le^{2j\Phi}$$

and $V_R = -L_g^2R + R_g^2Re^{2j\Phi}$.

Further corrections

From the previous section the general form of the sound pressure at the ears is

$$V_{ear} = (-L_g^2 + R_g^2e^{2j\Phi})V_{in},$$

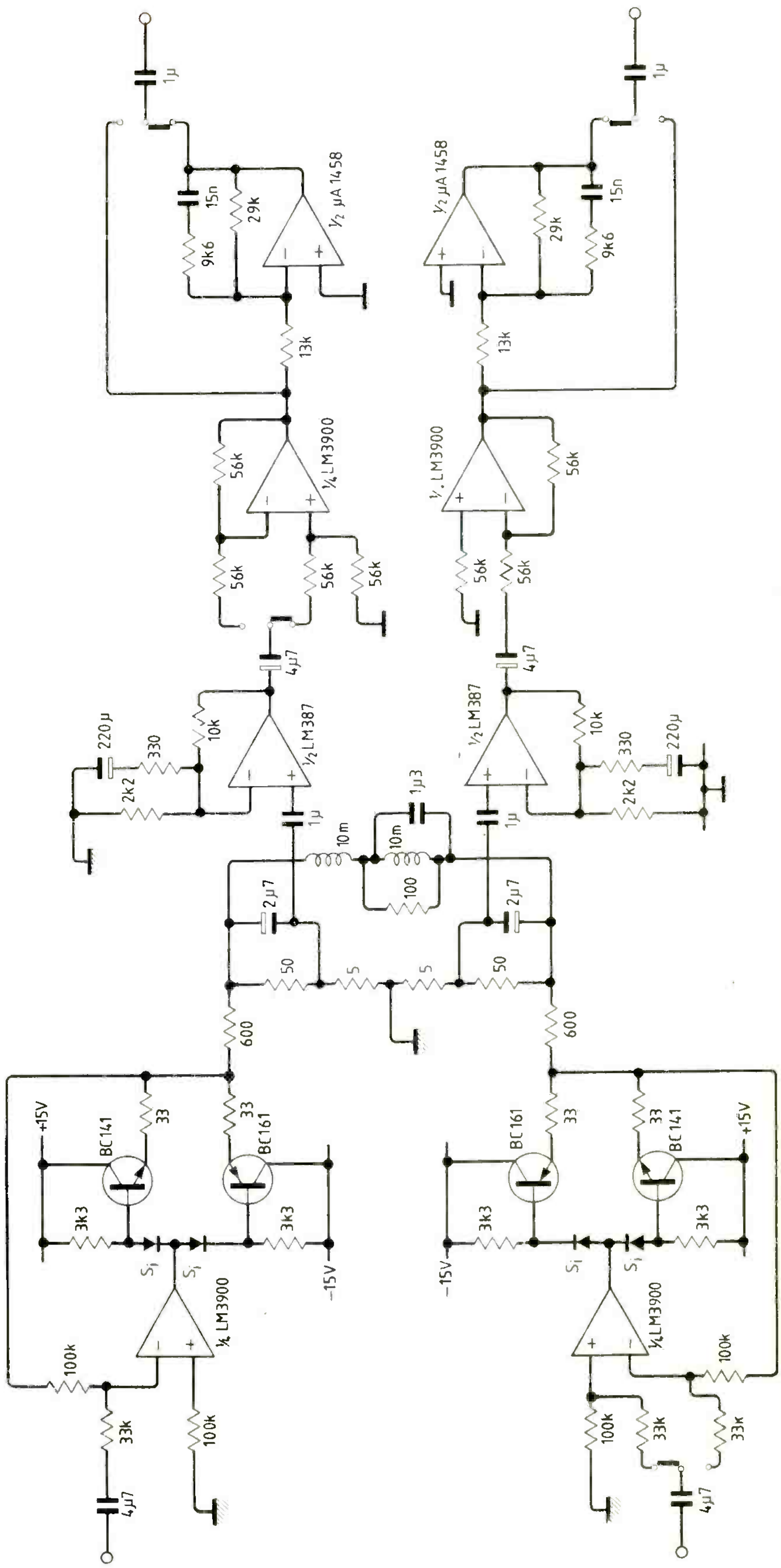
which can also be written as $V_{ear} = (-L_g^2 + R_g^2 \cos 2\omega T + jR_g^2 \sin 2\omega T)V_{in}$ where ω is frequency in radian /s and T is time delay between left and right ear as given in Fig. 8. This signal consists of V_{in} and the 2T-delayed signal, V_{in}. One can compare this with the effect of reproduction of monophonic recordings via two loudspeakers, since the sound pressure at the ears now consists of the signal L_g V_{in} and the T-delayed signal R_g V_{in}. Now a signal consisting of V_{in} and a delayed version of V_{in} with a delay smaller than 30ms is perceivd as a single signal only consisting of V_{in} (Haas phenomenon[4]). This indicates that L_g determines the sound quality.

As the transfer function L_g^2 enhances the frequencies above 200Hz by up to

In practice...

The use of the circuit for "stereophonic headphones" results in an astonishing improvement in reproduction of stereophonic programs via headphones, since the sound seems to originate outside instead of inside the head. The use of the circuit for "binaural loudspeakers" leads to life-like positioning of the sound. Recordings of aircraft passing overhead sound so realistic that one is tempted to look up in search for the airplane. One person I demonstrated the circuitry to said, on reproducing the sound of waves at a beach: "It sounds as if I'm standing in the water," which indeed it did. It's difficult to describe the acoustic results of reproduction of binaural recordings via loudspeakers; one should try it to be convinced that this is a way toward better sound reproduction.—JHB

Fig. 11. For headphone reproduction of stereophonic recordings, circuit includes compensation for rise in L_g^2 transfer function above 200Hz. Switch is in headphone position.



COMMUNICATIONS

Piccolo players

The wartime rush to adapt for radio communication the teleprinter or Teletype system originally developed for line operation remains an example of the danger of making use of technology standards for a different purpose without a fundamental rethink. Compared with alternative forms of machine telegraphy, including high-speed Morse and the Hellschreiber system, conventional r.t.t.y. with five-unit code and frequency-shift keying has always demanded, if error rates are to be kept low, a very good signal-to-noise ratio, freedom from interference and multipath effects, and preferably diversity reception. To minimize these problems, the seven-unit code and other error-correcting techniques, including automatic repetition, have come into widespread use, though clearly these are palliatives rather than cures.

Many years ago it was recognized that under difficult radio conditions an improvement was possible by the use of multi-tone signalling. J. V. Beard and A. J. Wheeldon (*Point-to-Point Telecommunications* June 1960, pp.20-48) showed that two-tone a.m. transmission could offer substantial improvement over f.s.k. in conditions of selective fading, weak signals and interference. However, a series of counter-attacks on two-tone transmission, based on results over high-power point-to-point circuits, appeared soon afterwards, since when binary f.s.k. has remained the dominant system for h.f. – though with at least one notable exception.

Since October 1962, the Communications Engineering Department of the Foreign & Commonwealth Office (formerly Diplomatic Wireless Service) has been using the Piccolo system based on multiple frequency-shift keying as the basis of its main h.f. network that links more than 50 British embassies to Hanslope Park, near Newport Pagnell. The original Piccolo system, with no less than 32 tones, imposed stringent requirements on frequency stability but, due to signal integration techniques using resonant LC filters, it could produce clean copy from signals almost buried in noise. It was thus far more suitable than conventional f.s.k. for use with relatively low-power transmitters located in residential areas, often with a flag-pole-type aerial. Harold Robin, Don Bayley and J. D. Ralphs made many attempts to interest British firms and organizations in the system and for a time Marconi undertook to market equipments built by D.W.S. More recently, manufacture and marketing has been by Racal, although clearly it has never been an easy task to introduce a relatively costly, non-compatible system. By 1968, by which time the Mark III unit was being introduced, I was lamenting in print on the reasons why Piccolo went flat and on the general lack of interest in this technically elegant British system.

Recently a new Mark VI system has been developed that reduces the number of tones from 32 to 6 for ITA-2 and 12 for ITA-5 (*Radio and Electronic Engineer* Vol. 52, no. 7, pp.321-330, July 1982). Although this clearly loses a little in basic performance, it halves the bandwidth requirements and reduces the formerly extremely stringent frequency stability requirements. It also makes for rather lower capital costs and permits the use of either forward error correction or automatic request for repeats. Combined with the Piccabell selective calling system that summons an off-duty operator for urgent traffic, it remains one of the few technically successful attempts to match r.t.t.y. to simple low-power h.f. circuits. But it remains to be seen whether the Mark VI system (to be marketed by Racal as the LA1117 modem) will at last achieve the wider commercial acceptance that the Foreign Office engineers have always felt it deserved, but which has so far always eluded the earlier models.

Project Raven

Much though some engineers may regret it, the British communications industry has become increasingly coupled to meeting military or "defence" requirements; a market that has (so far) not been under pressure from Japan and one in which a good deal of expertise has been acquired by British design teams. A major Australian project, born in 1976 and due in service in 1986, "Project Raven," covering e.c.m.-resistant h.f. and v.h.f. vehicle and manpack tactical systems for ranges up to 2000 miles, looks like bringing major contracts to Plessey Australia (with Plessey UK participation). In 1981 "project definition" contracts were awarded to both Plessey and Racal Milcom but the latest A$7-million contract for design and establishment of production facilities has been won by Plessey who hope it will lead to production contracts worth A$150M to A$200M.

Technically an interesting feature of the Plessey proposals is the use of electronic null steering of simple twin aerials to provide some 40dB rejection of a single jammer as an electronic-counter-counter-measure. Null steering as an antijam protection system is considered now feasible even for manpack v.h.f. sets and may be extended to h.f. In general Plessey engineers argue that while simple frequency hopping systems are of considerable value against an unsophisticated opponent they are particularly vulnerable to d/f-assisted attack. They list priorities for e.c.c.m. in the following order: imperceptibility; inscrutability; physical invulnerability; and electromagnetic invulnerability. A simple null-steering technique for h.f. communications was described at the recent IEE conference "H.F. communication systems and techniques" by J. K. Webb (Mitre Corporation) using a quadrature phase-shift channel with an auxiliary aerial.

Secrets of Hut 6

In the decade since the disclosure of the breaking of the German Enigma cipher machine (as well as the Abwehr and police hand ciphers and the Italian machine cipher) in the books by Gustave Bertrand "Enigma" and Frederick Wintherbotham "The Ultra Secret", there have been a spate of further books and memoirs of the fascinating Bletchley Park operation. But most of the insider books have reflected the views of the Intelligence analysts and distribution people of Hut 3 rather than those of the actual cryptanalysts of Hut 6, who were responsible for codebreaking, or the signals people and radio operators who intercepted the traffic. Few of the many authors, with the exception of Bertrand whose teams were in France and not at B.P., have been in any position to draw conclusions of permanent value to the black arts of codebreaking and Sigint.

For this reason it seems a pity that a new book "The Hut Six Story" by Gordon Welchman (published in the USA by McGraw Hill and in the UK by Allen Lane) has attracted less public interest and fewer reviews than the earlier books. For Welchman joined the B.P. team of cryptanalysts in 1939, worked in Hut 6 and later became Assistant Director of Mechanization. After the war, his plans for the peacetime GCHQ were largely rejected but instead of returning to the academic field he entered industry, joined the brain drain in 1947, and for many years worked in the field of communications systems planning for The Mitre Corporation, the US Federal Research Centre, etc. concerned with battlefield communication systems etc.

The earlier accounts, while differing in the credit given to the Polish and French cryptographic organizations, have largely supported the idea that Enigma could always be cracked by rigorous mathematical attack when backed up by some prior knowledge of the machines. Most (Bertrand's excepted) played down the role of Hans-Thilo Schmidt, the German who provided the French with a mass of information on Enigma ciphering procedures. Few have shown any clear understanding of why the German cryptographers had every reason to believe their system was totally secure in those pre-computer days.

Gordon Welchman shows that while indeed Enigma had fatal flaws, it would nevertheless have been impregnable against a purely mathematical attack. Unfortunately for the Germans they introduced a number of strengthening elements progressively with the result that Hut Six was normally in possession of, or could deduce, plaintext "cribs" and could "guess" likely key letters from their knowledge of the short-cuts of "lazy" operating procedures of the German cipher operators. Even so, Welchman maintains, the whole operation might have come to a sudden stop had the Germans taken more steps to ensure that the Enigma machines were used in accordance with the basic rules of cryptography (for example, never re-encode the same plaintext in different keys, never use standard long addresses, etc). It is worth recalling that B.P. never succeeded in breaking the Gestapo (SD) Enigma. He also emphasises the importance of good liaison between Hut 6 and the main Y intercept stations as well as the role of traffic analysis when the messages remained unread.

He believes that the Ultra secret was kept too long with the result that many lessons that could have been learned from B.P. have been lost.

He also reflects the view that engineers and administrators have too readily accepted the view that cryptosystems can be made secure by increasing the number of key permutations to a total beyond that which could be examined by computer in a reasonable time, pointing out that many system contained short-cuts.

Not every communications man would agree with all of his outspoken and often provocative comments but his revelations of the tight-rope on which Bletchley Park walked, and the conclusions he draws from this, make this a book of current as well as historic interest, with a high technical content.

AMATEUR RADIO

435MHz digital stereo

First experimental transmissions from an amateur station of digital stereo audio signals in the UK (and possibly in Europe) were made on August 8 by Angus McKenzie, G30SS in Finchley, North London with the help of G8UQX and G6BYH. The co-operating station, that of A. G. Goddard, G3NQR, in Harrow, first monitored the incoming signals to assist in setting the pulse levels and then recorded them on video tape. Subsequently the tape was replayed through G3NQR's amateur tv transmitter back to G3OSS where the incoming signals were decoded back to high-quality stereo and also recorded for a second time. The recovered speech and tone signals included long passages that were virtually perfect though with rather more errors on the second generation tape.

The experiment highlighted several critical factors including the vulnerability of digital transmissions to multipath smearing of the pulses. Adjustments to the transmitter were also critical, though it was demonstrated that the digital audio could be well received at signal strengths below those required for good tv reception. Tests over longer distances at higher power are planned and later it is hoped to use the 1296MHz band.

Equipment used included AKG condenser microphone, Sony PCMF-1 digital processor with the digital bit stream superimposed on a PAL-compatible video waveform, Microwave Modules ATV transmitter with average power of about 1.5 watts and two 21-element Tonna aerial arrays at 68ft above ground level. Receiver comprised GaAs fed mast-head pre-amplifier, Microwave Modules up-converter feeding a Panasonic NV7000B VHS video recorder. Output from the VCR goes to a domestic colour tv set for waveform examination and analogue audio outputs go to KEF 105 series II loudspeakers from a stereo amplifier. Stereo audio is sampled at 44.056 kHz with 16-bit coding and a potential 90dB s.n.r. from 10Hz to 20kHz. The bandwidth is about 3MHz with the 435MHz transmission compatible with 625-line tv standards. G30SS is equipped for PAL colour tv transmission and has been received at distances up to 50 miles.

While such digital audio is aimed at high-quality reproduction, it seems relevant to point out that intelligible speech can be transmitted digitally at much lower bit rates since amplitude variations contribute remarkably little to basic intelligibility. 3-bit or 4-bit coding of speech at about 8kHz sampling rate could provide an effective weak-signal communications system on the amateur microwave bands.

Bands released

Since October 1, UK amateurs have been permitted limited access to the WARC-1979 bands at 18 and 24MHz (18.068 to 18.168MHz and 24.89 to 24.99MHz) on a strictly non-interference basis. Restrictions include A1A (c.w.) mode only, maximum carrier power 10 watts, horizontally-polarized aerials only with zero gain relative to a half-wave dipole (i.e. no verticals or beam arrays). At the same time the new microwave bands at 47, 75.5, 142 and 250GHz became available to UK amateurs. It has also been announced that a limited number of Class A amateurs will be authorized to operate between 50 and 52MHz outside of television broadcasting hours. There is also to be an experimental relaxation, initially applying to special event (GB) stations only, on the sending of greetings by non-licensed persons over amateur stations.

On the other hand, British amateurs within 100km of London are being requested not to use the sub-band 431 to 432MHz, which is being made available to the private mobile radio service in the London area, and in future amateurs may find themselves sharing 10.25 to 10.4GHz with a commercial data network which becomes the primary user.

Here and there

The City & Guilds of London Institute will in future hold three instead of only two Radio Amateurs' Examinations each year. Next examinations will be in December 1982 and March and May 1983. There is however little sign yet of any reforms to the examination syllabus or paper.

Winner of the 1981 RSGB National Field Day trophy was the Racal Amateur Radio Group (B section). Leading single-entry station ("Bristol Trophy") was the Great Western Contest Group. Other leading clubs were Gravesend Amateur Radio Society ("Gravesend Trophy"), Glenrothes and District Radio Club (leading Scottish entry) and the Maidenhead club ("Frank Hoosen Trophy").

The Ipswich Radio Club announces that arrangements have been made for students to sit the RAE at Kesgrave and Claydon Adult Centre, the High School, Kesgrave, Ipswich IP5 7PB. Enrolments by mid-October for the December examination.

Reg Cole, G6RC

An old-time but apparently ever-young radio amateur, Reg Cole G6RC, an active operator on the bands for well over 50 years, has died, aged 81 years. Until his retirement, Reg Cole was company secretary of George Newnes Ltd, now part of the IPC Group of companies. During World War I he trained as a radio officer in the merchant marine and during World War II was first a Voluntary Interceptor for the Radio Security Service, then served at Hanslope Park until he became one of Lord Sandhurst's group of operators on the Secret Service clandestine links with France and the Low Countries. He put this experience to good use on the amateur bands in the post-war period, becoming one of the UK's leading DX operators.

PAT HAWKER, G3VA

ENGINEERING AND SOCIETY

The responsibility of engineers to society is often discussed in the abstract: here, Robin Howes deals with the subject in a more tangible manner. In this, the first of two articles, he relates the question of responsibility to the current industrial and political state of the UK.

by R. W. Howes,
M.Sc., M.Ed., M.I.E.E.

You have probably heard of the nuclear engineer who, when asked about the social implications of nuclear power, said: "I'm here to stop you freezing in the dark, not to talk about it". His attitude is often thought commendable, and it is also thought, perhaps unjustly, that unless an engineer is competent at his job his views on social responsibility are irrelevant anyhow.

Let us pass from the individual engineer to one view of industrial society as a whole: "We are all in a car and the car is in motion. Nobody has found out how to steer it, but some groups have, for a long time, been making detailed studies of the steering linkage. It has been found that small changes in direction are a bit easier to understand and to influence, and the ride seems to be smoother, when a foot is kept hard on the accelerator. Hitherto this has never proved catastrophic because the car has been moving about a wide plateau. Someone looking out of the dirty windscreen thinks he can see the edge of a precipice ahead and suggests they slow down. The others criticize his knowledge of the steering mechanism; they are affronted by his suggestion. Looking out of the window is a waste of time and talking like that alarms the passengers. A majority would prefer that there aren't any edges."[1] Should the engineer get on with his job on the steering linkage or should he look through the window as well?

To avoid debating definitions the following should suffice for the purpose of this article. Science is about finding things out and technology is about making things. Technology predates the rise of experimental science in the 17th century, as the building of Stonehenge and the feats of Roman architecture show. Technology today involves both applied science and traditional know-how, and in common usage the term technology is often synonymous with engineering. Both approach problems via systems analysis, design and modelling. Engineering, like medical practice, can also be regarded as an art in which an almost intuitive feel for the material world which has been developed by practice may be more important than systematic knowledge provided by scientific research. A recent textbook[2] speaks of electronics as a simple art, a combination of some basic laws, rules of thumb, and a large bag of tricks. As these authors would probably be the first to point out, you cannot learn electronics just by reading books. For a more philosophical approach there is the remarkable book by Robert Pirsig[3]: "There is no manual that deals with the real business of motor cycle maintenance, the most important aspect of all. Caring about what you are doing is considered either unimportant or is taken for granted . . . In that strange separation of what man is from what man does we may have some clues as to what the hell has gone wrong in this twentieth century."

Three options for the UK

If one looks at possible futures for the UK or similar industrial country, there are, broadly speaking, three options. The first is the high-technology future, which was first promoted in the 1960s although envisaged by science fiction years before. Apart from actual advances in military and space technology, including the moon landing in 1969, there was the hope of an automated, leisured society, dependent on the use of computers, the hope of electricity 'too cheap to be worth metering' provided by nuclear power, and the hope of using new cereal crops as a 'green revolution' to save the Third World from famine. From a purely technical point of view, such projects were usually outstanding successes; from a social and often economical point of view they were frequently outstanding failures. To take an example directly familiar to most people in Britain, one of the planners' dreams which came to fruition in the 1960s was a solution to the housing problem – the building of multimillion-pound complexes of high rise flats. These are now being blown up because they are too expensive to run and too vandalized to use. This is a classical example of the tunnel vision of experts who are blind to the social and even economic effects of their work, and is the result of trying to find a purely technical solution, a 'technical fix', to a systems-type problem.

In retrospect, such experts seem to have acted as if deficient in common sense and even in common humanity. The economic growth of the 1960s was fuelled by cheap, imported oil, which encouraged a profligate use of energy and which promoted technologies for the production of goods that were far more wasteful of energy and resources than ever before.

The second option rejects the first one as technocratic fantasy and disengages itself completely from the industrial concept of economic growth. It promotes a society that is sustainable in the long term because its energy and resource inputs are renewable. Its technology is variously described as low, soft, alternative, intermediate or appropriate. The rather different meanings of these terms have been discussed by David Dickson[4] and others. Perhaps the best term is 'appropriate technology' as it immediately raises the key issue – appropriate for whom? It is important to realise that alternative technology (AT) can be just a technical fix for the affluent in a consumer society, e.g. solar panels for the suburban householder and tidal power for the CEGB, but that its true realisation involves an alternative society. AT used to be the prerogative of commune dwellers, 'a bunch of middle-class misfits playing at being farmers', as one critic said, and the 'brown-bread-and-sandals brigade'. Today many professional engineers are working in the AT field, but its large-scale adoption in our present industrial society is clearly politically inadmissible, and most people would not want it.

The third option is a compromise between the other two and involves a gradual transition towards a more sustainable society, meanwhile trying to ameliorate the effects of present high technology. It still has made very little headway politically in the UK, where politicians still seem hooked on the 1960s mirage of unending economic growth, and see the current recession as U-shaped rather than L-shaped. An essentially middle-of-the-road report by Gerald Leach[5] considered the energy inputs required for low to modest growth scenarios and concluded that waste reduction, recycling and conservation measures would enable modest growth to occur without the high energy inputs forecast by the Department of Energy and the CEGB. This removes the need for a major nuclear power programme, which in any case is now becoming increasingly suspect on purely economic grounds. On thermodynamic grounds alone it is wiser to save a kilowatt than to supply an extra one, and as energy consultant Amory Lovins has said, 'Instead of opening the bath taps even wider, it's better to put the plug in'.

In an important article which promoted the Engineering Responsibility Forum, John Endersby[6] discusses the ills of contemporary industrial society and makes some proposals for their improvement. He quotes from an earlier book by Meredith

Thring[7]: "Very many thoughtful people in positions of responsibility, including British MPs, senior civil servants, teachers and business executives are well aware that society is heading for disaster, but are forced to stifle their subversive thoughts since their job is to uphold the status quo". Professor Thring has proposed a Hippocratic Oath for engineers in which they vow to use their professional skills only on projects which will better mankind. This immediately involves a value judgement by the engineer on what constitutes betterment and which sectors of mankind are to be bettered, since conflicting interests between the sectors involved is usual. Professor Thring has also considered the long-term implication of energy policy [8]: "One is inevitably forced to the conclusion that an essential condition for our grandchildren's life is that the rich countries bring their energy consumption per capita down to about the present world average figure over the next 30 years". This means a reduction from about 5 kW per head towards 500 W per head. As Thring says, "What is right for our grandchildren is always uneconomic and almost always impolitic".

In their pursuit of the chimera of economic growth, politicians of both left and right maintain a 'conspiracy of silence' about these issues. Their short-term efforts to relieve the symptoms have been described as an obsessive re-arrangement of the deck chairs of the Titanic.

British industry

When we look at British industry it is apparent that business as usual in the 1960s sense will not come again. By 1980 the industrial sector produced only 40% of the total goods and services. But the growing service sector cannot make good the loss of industrial export markets and the rise in imports, especially since we still import nearly half our food. Nor is a transition to a 'post-industrial society' likely to be the panacea for our ills.

Although the recession has produced massive unemployment among unskilled workers, the UK policy of capital-intensive energy growth has continued. The alternative would be a switch to a policy of energy and resource conservation which would be labour-intensive, and which could involve repair of goods which were made to last. An EEC study in 1977 on the potential for substituting manpower for energy showed that this change would provide more than enough jobs to compensate for those lost in the manufacturing industries.

Small firms are known to be a source of new jobs but the recession has meant that many small businesses have gone bankrupt. The now discredited dogma of the 1960s was that the merging of smaller firms into industrial giants was the way to produce goods efficiently. The age-old wisdom that about 500 people was the appropriate number for any corporate enterprise such as a school, an army battalion or a factory was ignored. In many large businesses it was found that what was saved in economies of scale was more than lost socially by poor industrial relations. In contrast to the poor record of large firms is the fine innovative record of small technology-based firms. These have had the double benefit of small size and a high proportion of engineers among their managers.

The rest of British industry does not share this happy state. The editorial in *Electronics and Power* (journal of the IEE) of July 1978 pointed out: "One of the more enduring myths about British industry is that British goods are best, and that it is only their high prices, caused by low productivity, which makes them hard to sell. In fact there is growing amount of evidence that the reverse is true, and that, compared with the products of the other industrial nations, British goods are poor value and sell only because the depressed state of the British economy makes them cheap". This attempt to compete by low price instead of by quality may reflect the low esteem which the British establishment has for engineering skills as opposed to financial acumen. The engineer is still seen as the man with grease under his fingernails. The Finniston Report[9] commented: "Although Britain is a nation rich in creative talent, it has been weak in the commercial realisation of its own engineering-based innovations or in the adoption of innovations originating elsewhere". The Report also criticized UK engineering education. The prestigious engineering schools of the Continent, such as the German Technische Hochschule, are based on the 'Technik' philosophy which involves the practical application of knowledge and the synthesis of technical, human and commercial factors. By contrast, in the UK engineering is treated as a branch of applied science. "This militates against an effective marriage between the theory and application and fails to give students a sufficiently wide outlook. In consequence, employers have often taken the attitude that few engineers are properly equipped to take on broader managerial responsibilities and have employed them instead as providers of technical services, thereby closing the vicious circle".

British politics

It must be admitted that the regeneration of industry and indeed the regeneration of national life is not helped by the British political establishment. The editorial in *Electronics and Power* of July 1979 stated: "The idea that increased energy consumption is a necessary condition of any increase in overall wellbeing, seems, in spite of all the evidence against it, to be an unchallengeable assumption as far as many of our policy makers are concerned. Indeed, there is a strong tendency to regard as politically suspect all those, no matter how respectable, who promote the opposite view". This can go to ridiculous extremes, as when the relatively respectable and certainly for from subversive conservation group Friends of the Earth are called Friends of the Kremlin. This is not to deny the fact that since the environmental movement cuts right across the political spectrum its fringes include some neo-Marxists, who, like homeless fleas, leapt into environmentalism when the corpse of sociology grew cold.

Politicians like a single solution to their problems, such as the current enthusiasm for nuclear power to solve the energy problem and for the Trident missile to solve the defence problem. Engineers know that there is never a single solution to a problem, only an optimal solution that may change with time and circumstance. Since the political decision-making process is secret, there are no checks and balances operating to help arrive at an optimal solution and to monitor the process afterwards. The British tradition of governmental secrecy, which Lord Croham, until recently Britain's top civil servant, describes as "The most secretive administrative system in the Western World", must be a major reason for the persistent backing of losers in high technology. Two notorious examples are Concorde and the AGR, which will produce a net loss of £2000 million each, according to Professor David Henderson. Part of the blame must lie with the engineers concerned who have been able to ride their hobbyhorses at the taxpayers' expense and did not have to defend their case in open debate with their peers, as occurs in 'advocacy planning' in the USA.

A recent report from the National Consumer Council [10] points out that official secrecy in Britain conceals far more than that small sector of government concerned with national security. The operation of central government and nationalized industry is hidden from those whom the official view seems to consider the most subversive group of all – the citizens of this country. Secrecy, combined with the lobbying of vested interests, tends to produce faulty decisions, especially in high-technology projects with long lead times. This is not because the politicians and their senior civil servants are venal or incompetent; they may well be talented and dedicated. Part of the problem is that the whole system is too big, and so remedies must perforce be political in nature. Among those which have been suggested are regional devolution to overcome the 'diseconomies' of scale, proportional representation to break the stranglehold of a two-party system where the two sides of the House of Commons echo the two conflicting sides of industry, and, thirdly, a freedom of information act on the lines of that in Sweden or the USA to promote genuine as opposed to purported open government. Industrial deadlock could be broken by some genuine form of worker participation. Both the CBI and the TUC are opposed to industrial democracy of the type which works so well in West Germany, and which ironically was forced on the Germans by the British occupying power.

These political remedies are not so far removed from the proposals of Endersby and Thring. In case these two engineers should be thought of as crying in a wilderness otherwise only inhabited by middle class self-sufficiency freaks, the work of the Council for Science and Society should be mentioned. The members of the Council, founded in 1973, include engineers such as Sir Monty Finniston, Sir Bernard Lovell and, prior to his death in 1979, Professor Dennis Gabor, in company with other distinguished individuals from the universities, management and the trade unions. The Council has produced several reports, including one on the problem of monitoring large scale technologies[11], such as nuclear power, aerospace and the chemical industry, which mention the need to protect 'whistle blowers'. At present in the UK these tend to be people already at the top of their professions or who have retired; engineers like Sir Martin Ryle and Sir Kevin Spencer, scientists like Professor Joseph Rotblat and Professor Patricia Lindop. More recently, the Council has produced a report which tackles the issues involved in questions like 'Are we on the brink of the post-industrial society, a world of leisure and information technology?'[12] Such questions tend to mask the real issues which are inevitably political:

Who is going to control the new technology, for what purposes will it be used, and who will benefit?

The essentially middle-of-the-road conclusions of the Report reject three possible scenarios, these being only slight change from the present situation, or a shift of 90% of the work force into service industries, or total breakdown of society (as a result of high unemployment, and leading to a dictatorship of left or right). The Report recommends further study of four areas of changing concepts to work, these being the producer co-operatives of Mondragon in Northern Spain, trade union participation in planning in Scandinavia, the Lucas Aerospace shop stewards 'Alternative Corporate Plan', and full employment for life provided by certain large Japanese companies. The Japanese experience is often thought to be inappropriate to the UK due to racial and cultural differences. But Japanese subsidiaries in the West, including the UK, which use local line managers and labour do as well as the parent companies in Japan. Their industrial relations are far superior to most UK companies.

Significantly, the Report also concludes that until we fully reject the exploitation and inhumanity of the Industrial Revolution and root out the philosophical principles to which it gave birth, we will not recover our energy and confidence. WW

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BBC ENGINEERING, 1922 ONWARD

November 14th 1982 sees the 60th anniversary of the BBC's first broadcast Although there is only a psychological magic about round-number anniversaries, there is perhaps justification for a look back over the past decades and a look forward to those in store.

by Pat Leggatt

The essence of broadcasting is, of course, the programmes. But, as in any industry, production and distribution is founded on engineering; and the past 60 years have seen a very fruitful relationship between engineering and programme developments, each offering challenges and opportunities to the other.

The history of BBC engineering can fairly be called a success story. In case this sounds immodest, coming from a BBC pen, I would say that the ingredients of success were there from the beginning and that failure to exploit these would have been a surprising waste of opportunities. Let us examine what these initial ingredients were.

Broadcasting was one of the first major users of the brand new technology of electronics. It was a technology which clearly had great potential for development and it was therefore attractive to resourceful and inventive engineers.

Broadcasting in the UK was founded on public service ideals and with the philosophy of aiming for the highest achievable standards, both in programme and engineering terms. This philosophy meets with general public approval, so that engineers and others in broadcasting feel that their best efforts are appreciated and fulfil a worthwhile social need.

The product (that is the programmes) can be of such variety as to suit all tastes for much of the time and is therefore in continuing and increasing demand. Engineering developments contribute directly to more and better programmes, and hence receive general support.

The benefits of good engineering have always been recognized within the BBC and financial investment has been adequate to secure continuing expansion and improvement. The required scale of investment, in terms of cost per head of the audience, is not very large and it has been possible, therefore, to direct engineering developments towards high quality rather than the lowest cost. So BBC engineering started healthily, has grown healthily and seems set for healthy maturity.

Mr Leggatt is Head of Engineering Information

Wireless before broadcasting

Wireless communication originated in the 1880's with the experiments of Hughes and Hertz, based on the earlier theoretical studies of Clerk Maxwell. Before the close of the nineteenth century, Marconi had established himself in England and was doing imaginative work to increase the reliability and range of the new medium; he succeeded in transmitting signals across the Atlantic in 1901.

For this early work, spark transmitters were the norm and the detector usually employed was the coherer, in which metal filings were induced to 'cohere' under the influence of incoming radiation and hence provide a low-resistance current path for a bell or relay. Being an on-off device, the coherer could be used only for digital signals, such as Morse code.

In the early 1900s attention was turned to wireless transmission of telephony. For this a continuous carrier wave was required and the first systems employed modulated high-frequency alternators and electric arcs. Recognizable speech was transmitted by these means, but the quality must have fallen well short of today's standards.

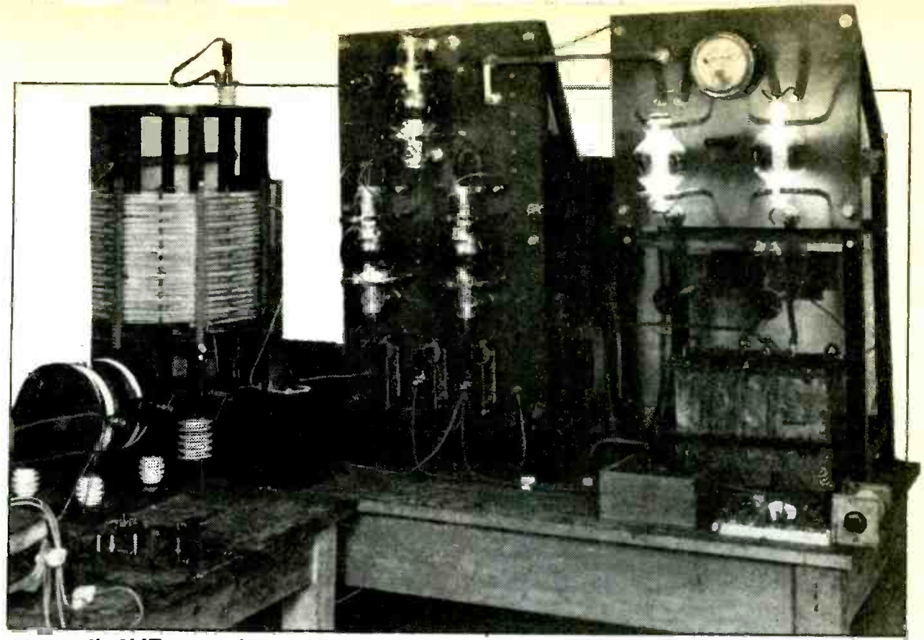
Shortly before World War 1, the triode valve, developed from Lee de Forest's Audion, began to be used for generation of continuous carrier waves. The relatively pure waveform produced, and the comparative ease of modulating such a source with speech signals, opened the way to wireless speech transmissions of reasonable quality. Receivers during this period employed crystal detectors, or Marconi's magnetic detector, in which the changing magnetic state of an endless loop of soft-iron wire served to demodulate incoming signals. Wireless was, of course, very largely used as a means of communicating with ships at sea and the magnetic detector proved far more mechanically stable than the more sensitive crystal detectors, whose cat's whiskers were easily jolted out of adjustment by the rolling and pitching of a ship.

The military necessities of the 1914-18 war gave a considerable boost to wireless development. Engineers fully appreciated the virtues of the valve and the French 'R' valve in particular was an outstanding development in terms of performance and stability, together with the Marconi 'Q' valve. The widespread use of valves in transmitters and receivers, and the development of tuned-circuit arrangements of reasonably good sensitivity, made usable wireless equipment available on a mass production basis.

Start of broadcasting

After the war, a lot of military wireless equipment and components came on the general surplus market and was eagerly bought up by amateur enthusiasts keen to try the intriguing new technology for themselves. Many people built crystal or valve receivers, but of course there was not much of interest for them to receive. The regular time signals (in Morse) from the Eiffel Tower had been transmitted since 1909, and were a useful facility for checking that a receiver was actually working: but they were of limited entertainment value.

Realising that there was a gap to be filled, an enterprising Dutchman commenced in 1919 a regular schedule of Sunday evening transmissions of music and speech which became known as the 'Hague Concerts'. These were much welcomed by listeners in the UK, as well as in Europe, and indeed were financed for a time by British listeners, following an appeal by *Wireless World*, and by contributions from the *Daily Mail*. The entertainment potential of broadcasting was appreciated also by UK industry: 1920 saw the Dame Nellie Melba recital from the Marconi transmitter at Chelmsford, followed in 1922 by the Marconi stations 2MT at Writtle, near Chelmsford, and 2LO in London. Also in 1922, two other industrial companies set up broadcasting facilities – Metropolitan Vickers in Manchester and the Western Electric Company in Birmingham.



Marconi's 2MT transmitter at Writtle in 1922.

Thus it came about by 1922 that a number of organizations had seen and acted on the potentialities of entertainment broadcasting, primarily as a necessary aid to establishing a market for receivers. Many of these were eager to jump on the band-wagon and the time had come for some co-ordination and regulation.

Formation of the BBC

To bring order out of threatening chaos, the Postmaster General, who had refused to license any more independent stations, told those manufacturers wishing to be involved to get together to form a single company for broadcasting. Agreement was reached at a meeting at the Institution of Electrical Engineers at Savoy Hill, London and the British Broadcasting Company was formed. Six large manufacturers combined in this venture, Marconi's, Metrovick, Western Electric, GEC, BTH and the Radio Communication Company, with John Reith as the General Manager.

The new BBC took over existing studios and transmitters, hitherto operated by the individual manufacturers. Its first broadcast was from the 2LO station in London on 14 November, 1922, with 5IT in Birmingham and 2ZY in Manchester on the following day.

The BBC remained a commercial company until 1 January 1927 when it was reconstituted with a Royal charter as the British Broadcasting Corporation.

Early engineering

Apart from operating the existing studios and transmitters, the first task of the Engineering Department was to spread coverage over the country. By 1924 there were nine main stations and eleven relay stations. Public interest and demand was very buoyant, and in 1925 there were nearly a million licence payers and no doubt many unlicensed listeners.

Although the main engineering efforts after the start of broadcasting were directed to such basic necessities as providing acceptable quality from the studios and distributing programmes as widely as possible throughout the country, there was time too for more innovative work. In 1925, for example, transmitters in London and Daventry were paired for an experimental transmission of stereo sound from an operatic performance, although it was to be forty years before these efforts bore final fruit in the form of regular stereo programme transmissions.

Expansion of radio. At the beginning, the various stations in different parts of the country transmitted their own individual programmes from their own studios. This was indeed local radio, one more thing in broadcasting that is not as new as we may think today. It was not long before a 'simultaneous broadcast' system of lines was established, enabling all transmitters to radiate a common programme as a network when required. Soon after this, a high-power, long-wave station, 5XX, was built at Daventry, giving coverage of much of the country and giving listeners a national alternative to the regional programmes from the existing stations.

Another important step forward was taken with the opening, in 1932, of the Empire Service, broadcasting to the world on short waves. One of the first broadcasts in this service was the Christmas message from King George V on 25th December 1932.

The higher-power main transmitters were obtained from commercial suppliers, but no manufacturer could offer low-power equipment for the relay stations. Accordingly, these were designed in the newly-formed Development Section of the BBC Engineering Department. Later, they designed high-power, 50 kW transmitters, again because none were available from commercial sources.

Testing for the 1937 Coronation television transmissions from Apsley Gate.

The first broadcasting engineers had to be resourceful men. Not only were they continually breaking fresh ground on the technical front, but those operating the transmitters and studios were often called upon to fulfil announcer duties and even to act as 'uncles' in the children's programmes. What with this, and the fact that the first chief engineer Peter Eckersley had himself provided much of the entertainment on the original 2MT programmes, one wonders why it has since become necessary to have an army of producers, writers and performers to put the programmes across: perhaps they should have left it to the engineers!

The other important task for engineers in early days was to improve the quality of sound from the studios. Microphones needed much attention and a lot of co-operation between the BBC and industry was devoted to improvements over the original carbon granule types. One of the better new developments was the Magnetophone from the Marconi company. This gave a considerable improvement in quality, although requiring very skilled personal attention in that the voice coil was attached by pieces of cotton wool impregnated with vaseline. If the studios became too warm, the vaseline melted and more had to be applied: perhaps this was what gave rise to a skilled operator becoming known as 'dab hand'.

Studio acoustic plays a vital part in determining transmitted sound quality. Virtually nothing was known of these techniques when broadcasting began, and much early research effort was devoted to the subject. Many of the fundamental principles were established at this time, and BBC Research Department maintains a strong and continuing effort in this field at the present day.

For the first eight years of the BBC's existence, all programmes were broadcast live. Although some programmes were recorded on disc by commercial recording companies for special purposes, programme production and scheduling suffered from the very severe handicap that no operational recording apparatus was available. Although the magnetic tape recording seems now to be the modern successor to disc, it was a magnetic system which was first used within the BBC. This was the Blattnerphone, using steel tape as a medium, which was introduced in 1930. It was five years later, in 1935, that disc recording was first employed, supplemented in 1936 by the Philips-Miller mechanical (not photographic) sound-on-film system.

From the early 1930's, then, all the fundamental ingredients for broadcasting were there: studio and outside broadcast origination equipment of acceptable quality; recording systems; and increasingly country-wide and world-wide transmitter networks. From then on, the story of radio up to the present day is one of improvement, expansion and sophistication. One should mention highlights such as the enormous improvements in audio quality in all parts of the chain, from studio acoustics to loudspeakers; the introduction of v.h.f. and stereo; the expansion of programme networks at home and overseas and the start of local radio; the use of digital programme links between studio and transmitter; and the start of digital sound recording. All these things represent 'very much more' and 'very much better', but all rest on the foundations completed by 1930.

Television

The first BBC transmissions of television took place in 1926, when experimental broadcasts of pictures from Baird's 30-line apparatus were carried by the 2LO transmitter. There were further tests in succeeding years and in 1932 the BBC set up a 30-line television studio in the newly built Broadcasting House.

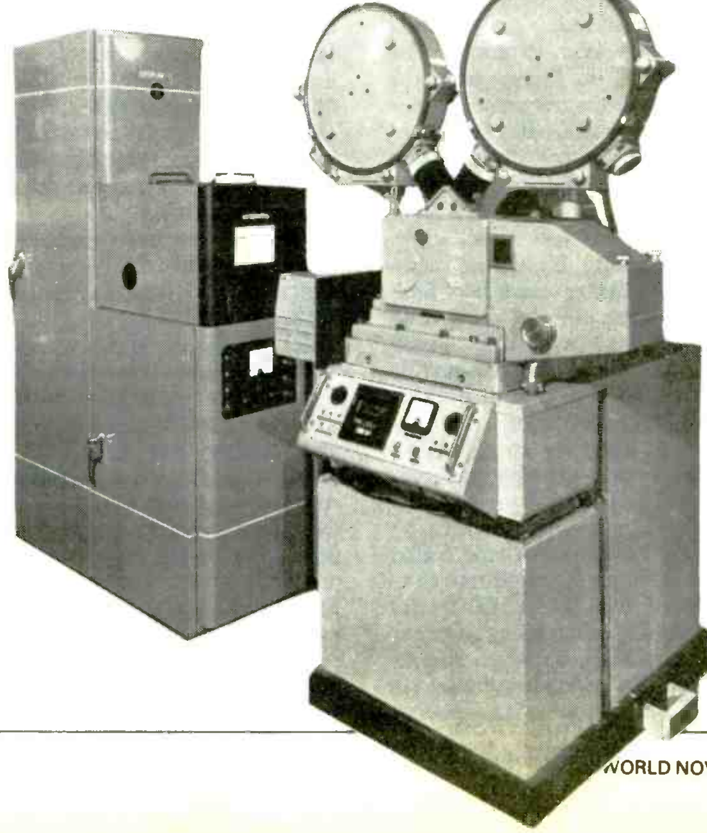
A rather different form of 'television' was experimentally transmitted in 1928. This was the Fultograph slow-scan, still-picture system, wherein radio signals from a medium wave transmitter actuated a facsimile paper printer. Recognizable pictures could be reproduced at the rate of about one every five minutes, but the system created little public enthusiasm.

During the 1930's, Baird up-graded his system to 90, 120 and 180 lines. In 1938 the BBC set up a purpose-built television studio and transmitter at Alexandra Palace, including Baird equipment, now operating on 240 lines. Also installed at Alexandra Palace was 405-line equipment from the Marconi-EMI company. This was an entirely electronic system, as opposed to Baird's electro-mechanical devices, and side-by-side trials revealed it to be much superior. Accordingly, after a few weeks of alternate transmissions by the Baird and EMI systems, the former was abandoned and transmissions from January 1937 continued on the EMI system alone.

The engineers and the programme makers quickly learnt the potentialities and limitations of the equipment; and quickly built up a body of increasingly sophisticated production techniques. In May 1937 quite comprehensive outside broadcast coverage was given to the Coronation of King George VI, a very ambitious venture at that early stage in television history.

Expansion of television. During the 1939-45 war, the frequency requirements of radar had to override those of television, and the service was closed down for the duration. It opened again in June 1946, in time to cover the Victory Parade on 8 June: the BBC television service was the first in

35mm Moy-Cintel rapid-pull-down teleciné equipment in 1958.



Europe to re-open after the war. In 1946 the television service had only the two studios at Alexandra Palace and two o.b. units. The one transmitter covered only the London and Home Counties area and there were little more than 20,000 viewers.

As had earlier been the case with radio, television suffered very much from the lack of any recording systems. Much research and development effort was applied to the problem and a workable system of recording television pictures on film was in use tentatively by the end of 1947, with an improved version being in regular service in 1949.

The scene was then set for the big expansion of television which the public wanted. Television transmitter coverage was extended to the major regional population centres and increasingly into more remote areas of the country. New studios were established, first at Lime Grove in West London, later in the purpose-built Television Centre and in numerous regional cities. Outside broadcast equipment and operations multiplied, taking events from anywhere in the country and eventually from overseas. Great improvements were made in the quality and sophistication of programme origination equipment, including of course the introduction of magnetic video tape recording which freed programme makers from so many shackles of location and time scheduling. Ever-extending links, including satellites, gave comprehensive national and international programme distribution and exchange, with standards convertors of continually-improving quality.

Particularly notable were the start of the competitive commercial television service in 1955; and the second BBC programme in 1964, coincident with the start of 625-line television in the u.h.f. band. The introduction of colour on BBC2 in 1967, the first colour service in Europe, was perhaps the biggest single engineering change since television began.

Teletext, offering an entirely new information service riding on the back of the television signal, started in 1974 and heralded the first real public availability of the information technology which is so much in the news today.

Broadcast engineering today

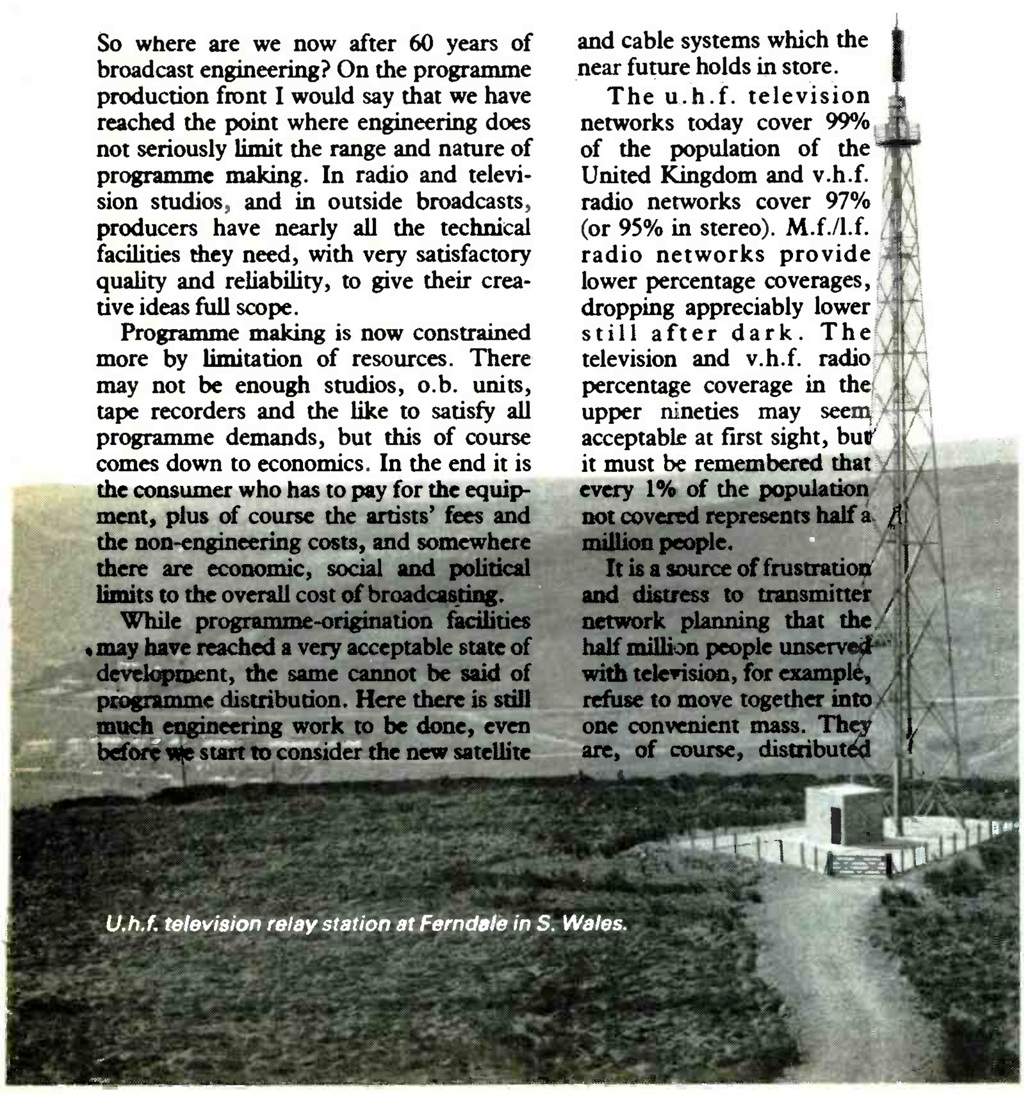
So where are we now after 60 years of broadcast engineering? On the programme production front I would say that we have reached the point where engineering does not seriously limit the range and nature of programme making. In radio and television studios, and in outside broadcasts, producers have nearly all the technical facilities they need, with very satisfactory quality and reliability, to give their creative ideas full scope.

Programme making is now constrained more by limitation of resources. There may not be enough studios, o.b. units, tape recorders and the like to satisfy all programme demands, but this of course comes down to economics. In the end it is the consumer who has to pay for the equipment, plus of course the artists' fees and the non-engineering costs, and somewhere there are economic, social and political limits to the overall cost of broadcasting.

While programme-origination facilities may have reached a very acceptable state of development, the same cannot be said of programme distribution. Here there is still much engineering work to be done, even before we start to consider the new satellite and cable systems which the near future holds in store.

The u.h.f. television networks today cover 99% of the population of the United Kingdom and v.h.f. radio networks cover 97% (or 95% in stereo). M.f./l.f. radio networks provide lower percentage coverages, dropping appreciably lower still after dark. The television and v.h.f. radio percentage coverage in the upper nineties may seem acceptable at first sight, but it must be remembered that every 1% of the population not covered represents half a million people.

It is a source of frustration and distress to transmitter network planning that the half million people unserved with television, for example, refuse to move together into one convenient mass. They are, of course, distributed throughout the country, often in very small communities, and it has so far taken about 600 television transmitters to achieve 99% coverage. Further relay stations are being provided for communities down to 500 people, and in the mid-1980's groups as small as 200 will be catered for. This television transmitter development programme is handled by the BBC and the IBA as a joint project and represents a major continuing effort over many years. Only eleven groups of four channels are available in the u.h.f. broadcasting bands and very elaborate planning is needed to enable the hundreds of stations to be operated without mutual interference. BBC Research Department have built up a computer-based frequency-planning system, taking account of geographical and topographical features, which enables maximum use to be made of these scarce frequency resources.



U.h.f. television relay station at Ferndale in S. Wales.

In sound radio, the m.f./l.f. bands are increasingly overcrowded and subject to foreign interference. The BBC is effecting marginal improvements here and there, but in general it is not possible to do anything very significant and it is to v.h.f. radio that major development efforts are directed. Current work includes the addition of a vertically-polarized signal to the existing horizontally-polarized transmissions, offering considerable benefit to users of portable and car radios with vertical rod aerials. Another important project is the continuing spread of stereo transmission throughout the country, progress on this being determined primarily by availability of digital audio p.c.m. links to the appropriate transmitters.

But the prime requirement for development of v.h.f. radio is availability of more frequency channels in the v.h.f. Band II. Without these it is not possible to provide the additional networks to avoid the current necessity for sharing of a v.h.f. channel by Radio 1 and Radio 2, by Radio 4 and educational programmes, and to provide Radio 4 v.h.f. coverage in the national regions of Scotland, Wales and Northern Ireland. Furthermore, we need additional frequencies to accommodate about 100 relay transmitters, which are needed to fill the gaps in existing v.h.f. coverage.

The v.h.f. Band II is, by international agreement, to be extended up to 108 MHz for broadcasting use, but the Home Office timetable for re-locating the emergency and mobile services using the upper part of the band at present is disappointingly slow. It appears that real progress on v.h.f. coverage is going to have to wait until 1990 or thereabouts.

So our 60 years have brought us to a very satisfactory state of studio and o.b. origination quality and facilities, although improvements and refinements will, of course, continue; but availability of television and radio services to all the public is by no means complete and much work remains to be done to improve this.

The first priority of BBC engineering in 1922 was to extend coverage and, while enormous progress has been made, it remains a priority today.

The future

It is fashionable nowadays to talk of 'the technological revolution'. The term has become a cliché which all decent men now avoid, but it cannot be denied that it is in some senses a true one.

Certainly, there are technological developments now in progress which will profoundly change the broadcasting scene. There will not be dramatic technological revolution – there never has been one – but in the next few years we shall all become increasingly aware of major changes and new opportunities.

Prototype dish for satellite television broadcasts.

Wider choice

The first and the most publicly obvious area of development will be the provision of additional programme channels. In television, the start of the 4th channel (ITV's second programme) is upon us and this will complete the exploitation of terrestrial broadcasting in the u.h.f. Bands IV and V. The obsolete 405-line television services in the v.h.f. Bands I and III are in process of being closed down and it is possible, although not yet decided*, for Band III to be re-engineered to provide a fifth 625-line television network, perhaps on a regional basis. No other v.h.f. or u.h.f. spectrum is allocated for television broadcasting, so that four television programme networks with the possibility of a fifth will be the long-term limit of terrestrial transmission. Provision of these additional channels represents 'more of the same' rather than any technological innovation.

On a different level (literally!) is the introduction of direct broadcasting by satellite (d.b.s.). Satellite reception on a domestic basis has indeed been made feasible by recent technological advances, although these are refinements of techniques already used in the communications field rather than a current new development. With most other European countries, the UK has been allocated five d.b.s. channels in the 12 GHz band and the first two of these will be made available for two new BBC programme services from 1986. The remaining three UK d.b.s. channels will no doubt be allotted in future years. The year 1986 will therefore see six broadcasting television programme channels in the UK, with the possibility of the total rising to ten in future years.

*But see interim report of Merriman Inquiry, News

The number of television programmes available could increase even further as the proposed wide-band cable systems come into operation. In theory at least, a wide-band cable system could carry thirty or forty television channels and to this can be added the choice of programmes available in the homes of people equipped with video-cassette or disc players. As one final tit-bit, it will be possible for some satellite receiver owners who are willing to spend a bit more money to receive programmes from foreign satellites in addition to those of the UK.

Quality improvements

Improvement of the technical quality of vision and sound has been a continuing process since broadcasting began. But there are now more opportunities for particular advances stemming from the "technical (r)evolution".

Satellite broadcasting, for example, offers such advancement opportunities. The effective video bandwidth which can be modulated onto a 27MHz satellite channel is, at about 10MHz, appreciably wider than the 5.5MHz offered by existing terrestrial transmissions; and this wider bandwidth can readily be exploited to remove some of the defects of the present PAL signals. Conventional PAL employs ingenious interleaving of the brightness (luminance) and the colour (chrominance) components of the signal, but exhibits some degree of mutual interference between luminance and chrominance, resulting in the flashes of false colour on finely detailed patterns (cross chrominance) and moving dot patterns on sharp edges (cross luminance). Both these cross effects are minimized by restricting the luminance bandwidth of the PAL signals in the receiver, but this results in limited picture definition and leaves some of the cross effects still apparent.

The wider satellite bandwidth will enable us to transmit luminance and chrominance signals separately, so that cross effects are eliminated without the need to restrict luminance bandwidth. The Research Department has evolved a system known as Extended PAL to achieve this, offering satellite pictures of full 5.5 MHz resolution with no cross colour or cross luminance distortions. With Extended PAL transmissions, existing receivers could still be used and would enjoy freedom from cross colour and cross luminance; while a new receiver, designed to exploit Extended PAL to the full and embodying a high-resolution cathode-ray tube display, would give the additional benefit of appreciably sharper pictures.

The IBA has also devised a system to exploit video satellite bandwidths. Known as Multiplexed Analogue Components

BBC satellite up-link terminal coupled to standard radio-link van.

(MAC), the IBA system also offers freedom from cross colour and cross luminance, although in the form proposed there would be no significant improvement in picture definition.

Both Extended PAL and MAC provide separate transmission and reception of luminance and chrominance components. Given this, modern digital storage and signal-processing techniques offer the possibility of standards conversion within the receiver at a cost which would be acceptable in a domestic product. The implication of this is that picture signals, although still transmitted in 625 line 50 field/s form, could be converted in the receiver and displayed on a higher standard with, say, 1250 lines or 100 field/s or both. Although there would be no more information transmitted, a display with much less visible line structure and free from flicker could be subjectively far more pleasing. Considerable research effort has gone into these possibilities, with the hope that a large, bright, high resolution display device will appear in due course to do justice to such advances.

The longer-term goal is, of course, true high-definition television (h.d.t.v.) whose picture would be actually generated and transmitted on high line and field rates and would thus genuinely carry more information. The difficulty is that real h.d.t.v. would require a bandwidth of some 30 MHz and is thus beyond the capacity of currently-planned satellite channels in the 12 GHz band, unless it could be accepted that two or three 12 GHz channels could be employed for a single h.d.t.v. signal: but this seems an uneconomically lavish use of the available spectrum.

Progress towards broadcast h.d.t.v. must be either in considerable advances in bandwidth-comparison techniques, or in the use of a higher-frequency (say 40 GHz) satellite broadcasting band where more spectrum space could be available. But such high frequencies are very susceptible to absorption by rain or snow storms, so the viability of this approach must be in doubt. The ingenuity of BBC engineers, and others, will certainly be focused on these problems in the years to come. Not only are there intriguing possibilities for improvements in picture quality, but sound signals also can be expected to show dramatic advances. A satellite broadcasting channel will accommodate, in addition to wider-bandwidth picture signals, a number of high-quality digital sound channels. BBC proposals, for which it is hoped soon to receive international agreement, envisage six such sound signals with each of the two satellite channels, of which two would form a pair for stereo sound accompanying the television picture, with the remainder affording a vehicle for high-quality stereo radio programmes.

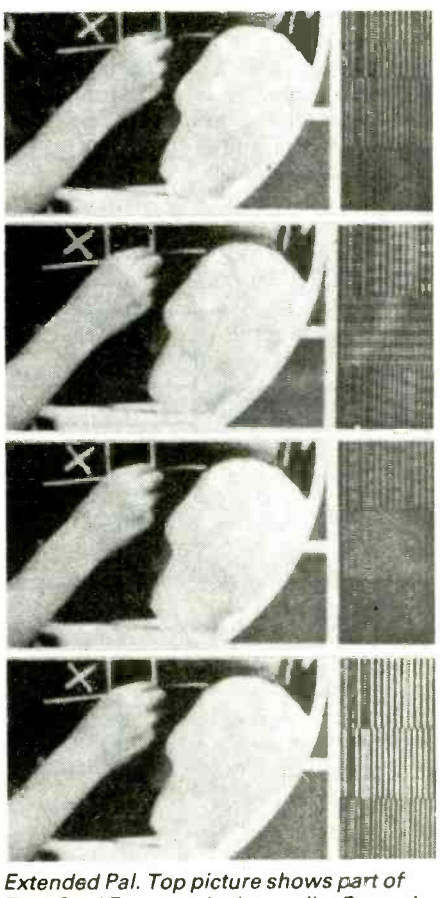
The advent of the BBC satellite broadcasting channels in 1986, therefore, will see the first direct transmission of digital sound and the first opportunity for broadcast stereo television sound in the UK.

The BBC, some years ago, conducted experiments in the terrestrial transmission of digital sound signals. These were not very successful due to digit corruption by multipath (reflected signal) effects and it is difficult to see how this problem could be overcome. Satellite signals are not, of course, subject to multipath distortion.

BBC investigations into the possibilities for stereophonic sound on terrestrially-transmitted television are accordingly based at present on analogue methods. On-air experiments with a dual sub-carrier analogue system are currently in hand, the critical factor to be assessed being the absence of interference to existing, monophonic, television receivers. The addition of stereo sound to terrestrial television will surely come, but is likely to be some years in development. Even when a satisfactory transmission system is agreed, a long and expensive programme of work will be needed to provide a stereo sound distribution system from the studio centres to the country-wide transmitter network.

Other forms of distribution

Distribution by wideband cable (optical fibre or co-axial) and by video disc could be free from the bandwidth restrictions which limit the capabilities of terrestrial and, to a lesser extent, satellite broadcasting. The extent and the time scale of implementation of these new media cannot at present be forecast with any certainty, but the potential is there for exploitation of many of the ideas which are being generated by engineers with broadcast applications in mind.



Extended Pal. Top picture shows part of Test-Card F as seen in the studio. Second frame is picture as normally seen with existing equipment-distortions in the frequency bars are evident. Third picture is picture transmitted by Extended Pal but received on conventional equipment. Final frame shows result of E.Pal transmissions and E.Pal decoder.

Development of cable systems, in particular, leads some people to forecast the eventual demise of broadcasting. But from an engineering standpoint, cable is simply another means of programme distribution and there is no fundamental reason why broadcasting (and the BBC in particular) should depend for its existence on distribution by radiated signals. BBC engineering will adapt in the future, as in the past, to whatever technological advances are appropriate to the time and will no doubt be ready to exploit the potentialities of cable or any other distribution methods. This is not to say that the BBC is now considering setting up or operating a cable system on its own account, any more than it plans to build and launch its own satellite, but it can be expected to continue to play a significant role in the technological development of distribution systems of the future.

Programme origination

Extension and refinement of digital techniques will surely be the dominant theme in the development of studio origination equipment. BBC engineering research and development has been in the forefront of many advances in this area and will certainly continue to be so, both nationally in collaboration with British Industry and in the international sphere, where co-operation and standardization are so important.

The main advantages of digital signals and equipment are reliability and resistance to distortion. These virtues are of great importance to a large broadcasting organization, where breakdowns or signal impairment are expensive hindrances to the tightly-knit flow of programme production: but, like many virtues, they are perhaps a little unglamorous. More obviously exciting are the opportunities offered, not so much by digitization as such, but rather by the ease and economy with which digital signals can be stored and manipulated. Once a picture signal can be held in store and made available for manipulation, all sorts of possibilities present themselves in the way of special effects, graphics, standards conversion, noise reduction, removal of blemishes and programme editing. Digital storage is also fundamental to the development of information systems such as teletext and the radio-data system for identification of radio programme signals.

* * *

In the early 1920s, BBC engineering seized on the new technology of electronics and carried it forward in the broadcasting field with enthusiasm and innovation. In the early 1980s, we are once again in the fairly early stages of what is virtually a new technology, that of microelectronics and digital processing. Once again, a broad vista of new opportunities opens up before us and the next 60 years of BBC engineering promises to be as exciting as the first.

WW

MEMORY SYSTEMS

An introduction to the common types of memory cell and array, with their characteristics, and the application of memory to microprocessors

by L. Macari

In a computer both instructions and data are stored in various kinds of memory, whose design depends on the type of storage needed, whether it is permanent, semi-permanent or temporary, and on whether the stored information can be examined at random or in some kind of sequence. This two-part article outlines the memories most often used with microprocessors.

To illustrate the structure of a simple memory, Fig. 1(b) shows eight storage locations, each capable of storing one bit, i.e. an 8 bit memory or an 8 × 1 bit memory. If each cell in the memory (Fig. 1(a)) is a simple Nor gate memory, it is possible to arrange control and data lines so that the state of the data line is latched on to the memory when the $\overline{W}$ line is low as shown in the diagram.

When eight cells are combined in a single memory circuit, some means of selecting the cell required for writing or reading must be available. A 3-line-to-8-line decoder is the simplest way to provide the necessary address lines internally from the three external address lines, each output line from the decoder selecting a single cell of the memory. The $\overline{W}$ (write enable) and $\overline{S}$ (device select) lines determine whether the data is being written or read and whether the circuit is selected or not.

Although there are no commercial memories with as few cells, the same principles apply to larger configurations. When the number of words stored is large, more than one decoder will be used and a row/column matrix will be used to select a particular word in the memory. As an example, the 4096 × 1 bit memory has 12 address lines. These are split into two 6-line-to-64-line decoders. The outputs from the two decoders will then be combined so that any two together will allow one word (in this case one cell) to be accessed.

Timing diagrams

Although it may appear to be the wrong order to look at timing diagrams for the read cycle before those of the write cycle, it is more convenient to do so because the diagram is simpler than that for the write operation. It must, therefore, be assumed that the memory has been loaded with data.

Read cycle. To access one item of data the address of the location in memory must be present as a binary pattern on the address lines, and must remain stable during the time the data is being read, as in Fig. 2. If the memory device has not previously been selected by pulling $\overline{S}$ low, this must now be done. If the data lines have tristate outputs they will remain at high impedance for a time t_s – the select time, after which valid data will appear on the data lines. The time between valid address and valid data is known as the access time t_a for the memory and is specified as a maximum value.

If the address is now changed, the data lines will remain steady for a time t_{HA} – the 'data-hold' time after an address change. Taking $\overline{S}$ high causes the new and possibly changing data to remain on the data lines for a time t_d – the disable time, after which the lines will return to a high-impedance state.

Write cycle. It is usual for the 'write enable' control on a memory to be an active-low signal, so when data is to be placed in the memory at a given address the address must be given time to settle and locate the required word in the memory. The time allowed for in Fig. 3 is known as $t_{SU(A)}$ – the address set-up time, which can be zero for some devices. After $t_{SU(A)}$, the write-enable line can be made active and must remain active for at least t_w – the smallest write-pulse width. If the memory device is not selected, SEL must go low for at least $t_{SU(S)}$ before the write-enable goes off again. The time $t_{SU(S)}$ is the set-up time for select.

If the correct data is to be placed in the chosen memory location then input data must be valid for a time $t_{SU(D)}$ before $\overline{\text{WRITE}}$ goes high again. The data must also be held valid for a time $t_{H(D)}$ – the data-hold time, after the $\overline{\text{WRITE}}$ signal is made inactive. (This time can also be zero.) The address must also remain valid for a time

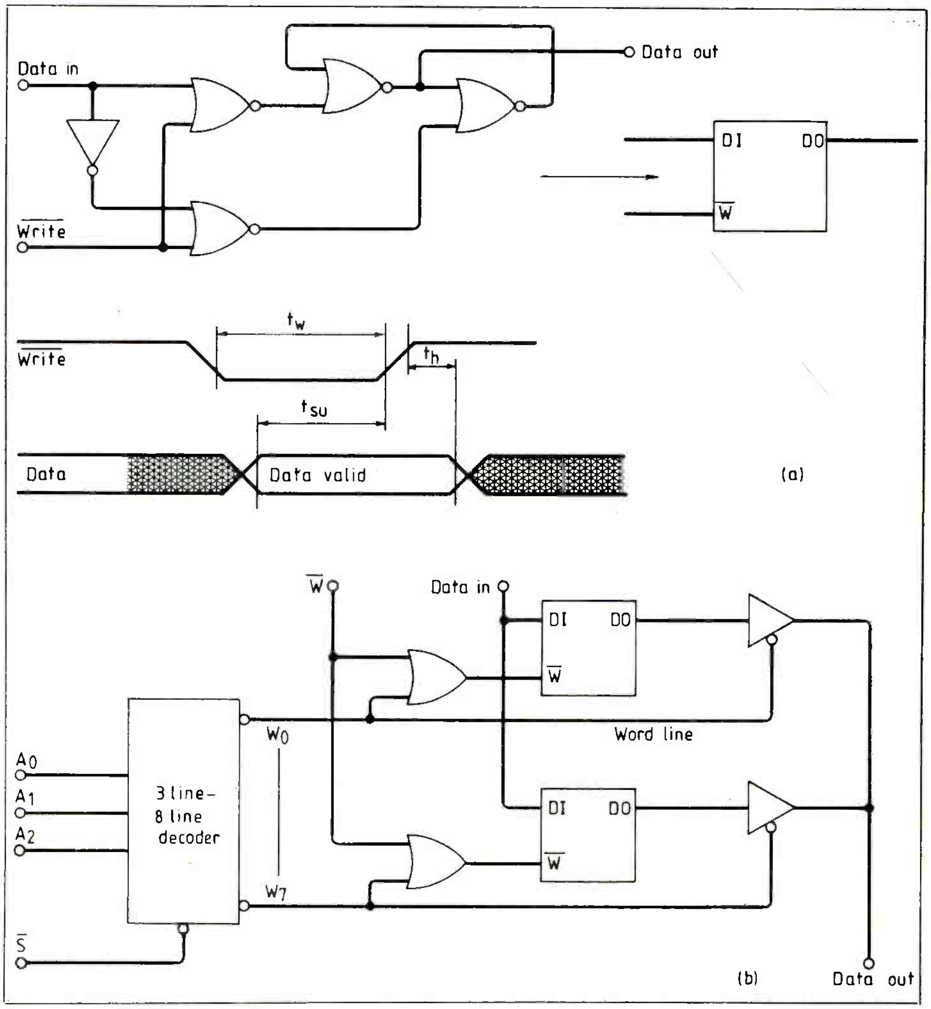


Fig. 1. A simple memory. At (a), a single cell of the memory, using Nor gates: when Write is low, data is latched in. Eight such cells are used in the 8 bit memory at (b), which is provided with a decoder, deriving eight cell addresses from three input lines. Data is always at the output. In a real memory, input and output data lines are multiplexed to give a single data line.

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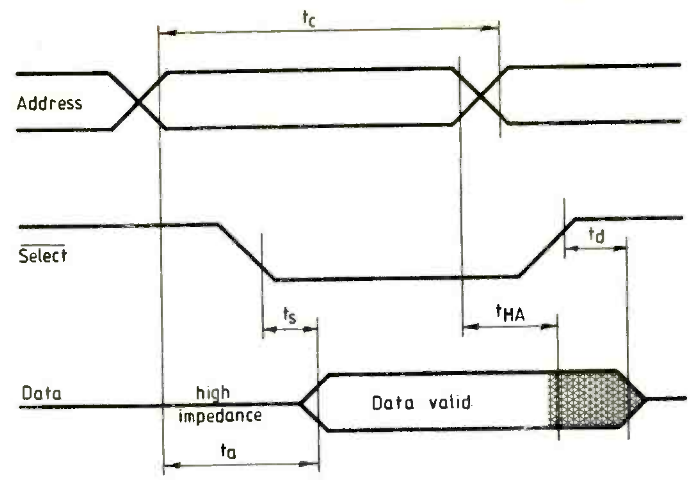


***Fig. 2.** Timing of a 'read' cycle of operations.*

$t_{H(A)}$ – the address-hold time, after the $\overline{\text{WRITE}}$ is made inactive.

Some memory devices have more than one select line. In such cases, all the select lines must be in their active states for the memory read or write functions to be performed.

The terminology used here for the various time delays of the read and write cycles is not standardized, each manufacturer using different terms. What is important is that the diagrams and the significance of the various propagation times be taken account of when a memory system is to be matched to a given processor running at a particular clock frequency.

To choose a speed to suit the microprocessor and the clock rate at which it runs, it is necessary to examine the manufacturer's data to see how many clock cycles are involved in read or write operations and to choose the speed of the memory to be faster than this time.

As an example, the 8085 A-2 micropro-

Glossary

Microcomputer memories fall into a number of different categories, semiconductor and magnetic being the most common types: large computers use the same technologies for data storage. These are some of the terms used to describe memories and their operation.

Cell
A device within a memory which can store a single bit of information, e.g. a flip-flop. A memory consists of an array of cells.

Storage capacity
The total number of cells contained in the memory device, i.e. the total capacity in terms of bits.

Word
One or more cells within the memory which contain one item of data. The memory consists of a number of these units of data (usually a power of 2). Some data sheets quote the number of words and the size of the words instead of the capacity. Some memories have as few as one bit per word. Four-bit and eight-bit words are the other most common sizes of memory words.

Byte
The term used for an eight-bit word. Examples are: 4096 × 1 bit memory, which can store 4096 words of 1 bit length, and which has, therefore, capacity of 4096 bits; 1024 × 8 bit memory, storing 1024 words of 8 bit length, i.e. 1024 bytes, with a capacity of 8192; 32 × 8 bit memory, with 32 bytes of storage, i.e. 256 bits.

Address
The unique number which identifies a particular word in memory is known as the address of that word. If the memory can store 2^N words of data, there are N address lines to the device, so that each of the 2^N possible binary patterns applied to the address lines will locate a data word.

A 4096 × 1 bit memory has 12 address lines.

A 1024 × 4 bit memory has 10 address lines.

A 32 × 8 bit memory has 5 address lines.

If a memory is to be of any value, it must be possible to place data in it and at some other time examine the data. Some memories are designed so that these operations can be performed with equal ease, while others are designed for more permanent storage and the placing of data is only performed once, or at most a few times, in the memory's life.

Write operation
This is the term used to describe the placing of data in a memory and is also known as a store operation.

Read operation
This is the means whereby the information stored in the memory is obtained at the data terminals of the device. In memories where read and write operations are performed with equal ease, it is usual to have a control line to determine what operation is being performed. This signal line is usually active-low for a write operation and is labelled $\overline{W}$ or sometimes R/$\overline{W}$.

Read and write cycle times
The cycle time is the minimum time which can be taken between successive operations of the same kind.

Random access
A memory for which the location of the data does not affect the time taken to write or read the data is known as a random-access memory.

Sequential access
If the data is stored in some sequential device, such as a shift register or magnetic tape, then access time to a particular data position depends on the position.

Read/write memory
Memory for which read and write operations are performed with equal ease. Memory known as ram is really read/write memory.

Read-only memory
The data in this type of memory is stored using techniques which are usually different from those used to read the data back from the memory.

- Mask programming is done at the manufacturing stage and the data storage is permanent.
- Fusible-link roms are constructed of arrays of transistors with links, which can be 'blown' by the application of suitable voltages. The blown and non-blown links constitute the 1s and 0s in the memory.
- Ultra-violet-erasable roms. This type of memory has a transparent window over the semiconductor in the i.c. package. Application of suitable voltage levels program the 1s and 0s which are then retained even when the supply is removed. When it is required to replace the data in the rom it is irradiated with u.v. light, which erases the data stored and makes it possible to write new data to the memory.
  When data is erased frequently it becomes progressively more difficult to store data in the memory.
- In electrically-erasable roms, the write operation is still a different operation, but it can be performed without removing the i.c. from the system and requires only the application of the correct voltage levels.

Core-store memory
Memory which makes use of a ferrite ring for each data cell, the direction of magnetization of the cell determining the binary state of the data stored.

Non-volatile memory
Memory which retains its data when the supply is removed (or fails) is known as non-volatile memory. Rom and core, and all magnetic memory is non-volatile. Ram can be made non-volatile by placing back-up batteries on the memory boards to provide for the event of supply failure.

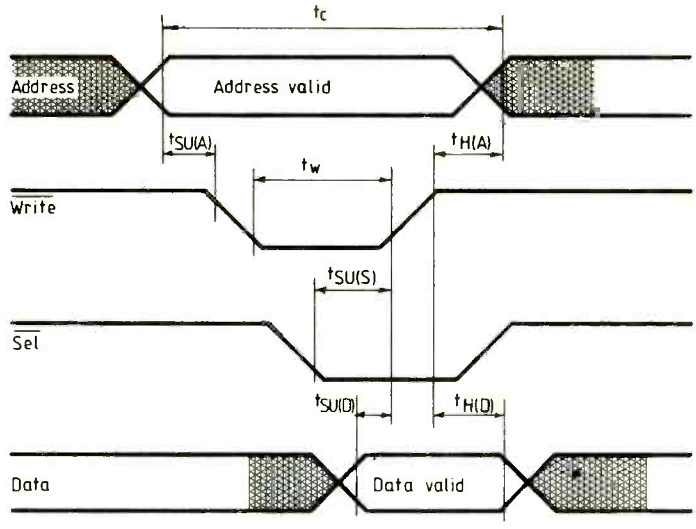


Fig. 3. *'Write' cycle timing. Terminology varies with manufacturers.*

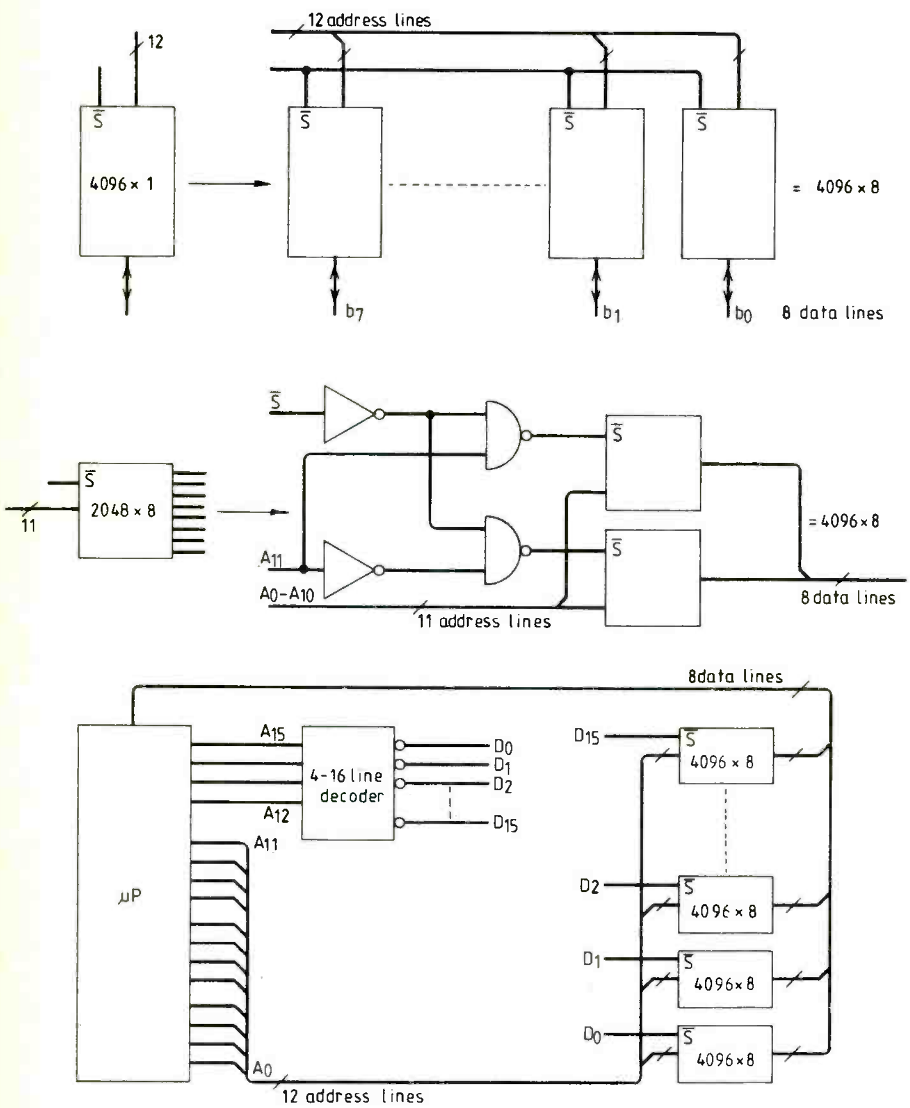


Fig. 4. *Using both ram and rom with a micro. 4K x 1 bit ram blocks at (a) are made into a 4K x 8 bit memory and 2K x 8 bit roms are similarly arranged as in (b). All these 4K blocks are then connected as in (c).*

cessor can use a 5 MHz internal clock. The processor expects valid data two clock cycles after the address has been set up. This is a time of 400ns, so the access time of the memory devices used with this processor must be shorter than this, 350 ns being a satisfactory figure.

Connecting to a processor

Figure 4 (a) shows, as an example, a system requiring a monitor program in rom, which is 4096 words in length and written into two 2K × 8 bit roms. If the rest of the 64K memory space is to be fully utilized with read/write memory, using 4K × 1 bit memories, how can such a system be arranged, assuming that the rom is to use the bottom 4K of memory space?

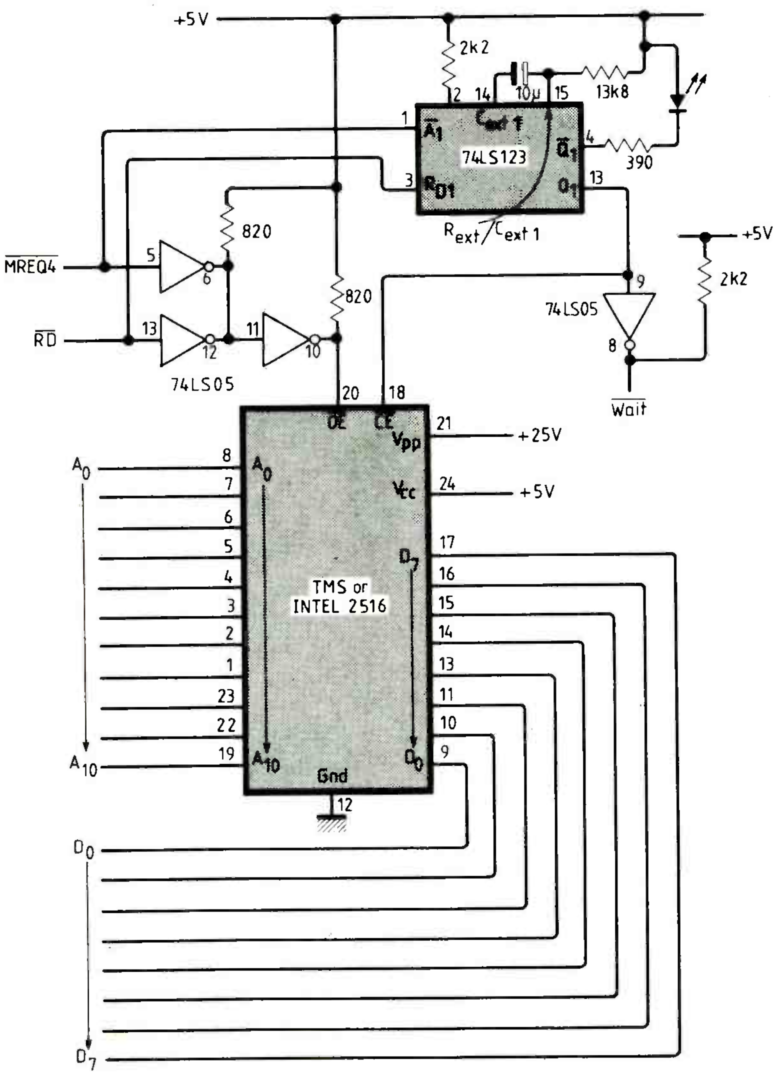
The ram chips have 12 address lines and a single data line, while the roms have 11 address lines and eight data lines. 4K × 8 blocks of ram can be made up by connecting the address lines of eight 4K × 1 bit rams in parallel and using one chip for each of the eight data positions. The 2K × 8 bit roms can be made into a 4K × 8 bit block, requiring 12 address lines, by taking the address line A11 to the two $\overline{S}$ lines on the rom devices using the gating circuit shown. This can now be drawn as a 4K × 8 block of rom, with an active-low select line.

How are all the 4K × 8 blocks to be connected to the 16 address lines to use up the full amount of the memory space? First of all, parallel all the address lines on the 4K memory blocks in Fig. 4 (b) and connect these to the least significant 12 bits of the address bus on the processor. The four remaining address bits can now be taken to a 4-line-to-16-line decoder whose outputs are active low. Each of these outputs can be used to select a 4K block of memory, D0 being used for the rom and D1 – D15 for the ram devices. The relevant control lines for reading and writing would then be connected to the sections of memory as required. WW

To be continued

Meteosat high-resolution images

Table 2 on page 62 of Mike Christieson's August article, describing add-on circuits for his weather-satellite receiver, consists of three eight-bit words. The circuit of Fig. 5 on page 83 of the October issue should sense these three words but is actually shown wired to sense three different words. Readers who find it difficult to work out what the correct wiring should be may obtain a photocopy of the correct diagram by sending an s.a.e. to Wireless World Meteosat, Room L303, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS. The original weather-satellite receiver, designed for Tiros N high-resolution images, was described in the November/December 1981 and January 1982 issues.




```
         11 00 10   LD DE,1000      ;Start of ram
         21 00 60   LD HL,6000      ;Start of eprom
         1A         LD A,(DE)       ;Get byte
NEXT     77         LD(HL),A        ;Program it
         BE         CP(HL)          ;Verify
         28 04      JRZ,SUCCESS
         CD 80 03   CALL 0380       ;New-line & print HL
         C7         RST 0           ;Return to monitor
SUCCESS  13         INC DE          ;Next byte
         23         INC HL          ;Next eprom address
         7C         LD A,H
         FE 68      CP 68           ;Finished?
         20 F0      JRNZ,NEXT       ;No – continue
         C7         RST 0           ;Return to monitor
```

Logic table for 2516

CE	OE	V_{pp}	Output	Mode
L	L	+5	D_{out}	read
H	H or L	+5	high Z	standby
pulsed L-to-H	H	+25	D_{in}	program
L	L	+25	D_{out}	program verify
L	H	+25	high Z	program inhibit

Z80-based 2516 programmer

This simple programmer has few components, is easy to operate, and can be used to verify 2516 eproms. Originally designed for the *Wireless World* scientific computer, it can easily be modified to suit other Z80-based systems.

$\overline{MREQ4}$ is an 8K page-select signal for address area 6000-7FFF though any other unused select signal covering at least 2K of memory can be used. When this line goes low, read line $\overline{RD}$ remains high and the monostable is triggered, resulting in a positive 50ms pulse on the chip-enable input and forcing latching of the processor data and address lines through a low wait signal.

Verification of the byte is possible since decoding and propagation delays result in the read signal going low before the memory-request signal so the monostable is inhibited. Now, the eprom output enable is active and data is gated onto the bus.

As the write signal arrives too late to produce the processor wait signal, wait is not carried out until the next cycle, i.e. an op-code fetch. Also wait inhibits the processor's dynamic ram refresh signals. To avoid spurious programming, the 25V supply to pin 21 should be applied after, and removed before, the 5V supply to pin 24 of the eprom.

Specifically for the scientific computer, bus request and wait signals should be separated, with the last-mentioned connected to +5V through a 2.2kΩ resistor and linked to a spare pin on the expansion socket. Bus request is tied to +5V using the 47kΩ resistor already on the board.

Single-byte programming is carried out using the ALT command. The routine for all 2048 locations shown takes about 100 seconds and uses the Mk III monitor.

Vincent M. Grayson
Haywards Heath

Gray-to-binary converter

Whilst the Gray to binary converter proposed by J. J. Mouton (Circuit Ideas, October 1981 issue) undoubtedly produces the correct conversion, it is inefficient in terms of component count. This is a direct result of the generation of a wealth of redundant terms, a problem which increases with the number of bits being used in the system. A ten-bit converter, for example, would require 45 exclusive-Or gates.

An alternative circuit is given in Fig. 1, which merely requires one gate fewer than the number of bits in the code. This drastic reduction in parts is possible because, as with And and Or gates, a combinational network using several exclusive-Or gates in cascade to increase the number of inputs also allows these inputs to be interchangeable. Considering part of J. J. Mouton's circuit, Fig. 2, a term D has been generated from input A being exclusive Ored with input B, which has further been exclusive Ored with input C. The Boolean expression for this is

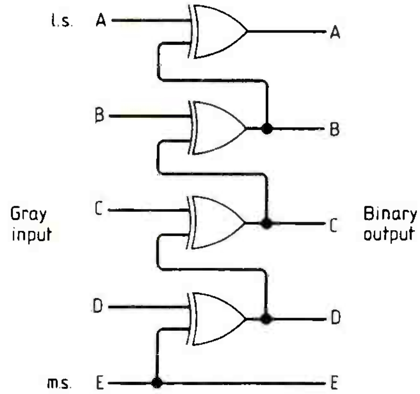
$$A_{out}=\bar{A}.B.\bar{C}+A.\bar{B}.\bar{C}+\bar{A}.\bar{B}.C+A.B.C.$$

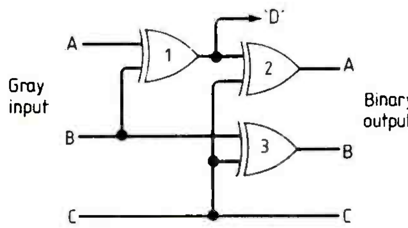
Exclusive-Or gate 1 may be eliminated by exclusive-Oring the already derived output B with the input A. The only difference is that to produce the A output, input terms A and C have been exchanged yielding the term

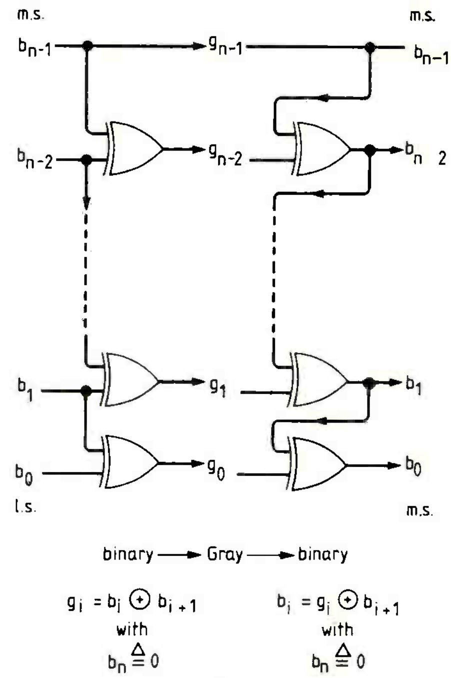
$$A_{out}=\bar{A}.B.\bar{C}+\bar{A}.\bar{B}.C+A.\bar{B}.\bar{C}+A.B.C$$

which is equivalent to the previous expression. This principle can be propagated through each successive bit, eliminating the redundant gates and producing the circuit of Fig. 1 which may be expanded to any number of terms.

P. Gladdish
Holbrook
Derbyshire







Here is a more elegant solution to the binary-Gray interconversion logic; if the original idea had interest, this smaller implementation presumably has greater interest. I cannot claim any originality in the design (e.g. "Switching theory in space technology", pp. 75-76, 1963). The improved circuit, Fig. 3, is in the same form as the original, although this is not intended as parody.

A number in binary with n bits has a corresponding Gray code with n bits. The number zero is represented by all bits zero in both codes. When any number is incremented the binary code changes one or more bits in a connected sequence, including the l.s.b. The corresponding Gray code changes only one bit, the one corresponding to the highest changed bit in the binary sequence. Code interconversion may be achieved as shown.

P. Kirkby
Ipswich

Automatic intensity control for leds

To save power and reduce glare at low ambient-light levels this simple circuit keeps luminance roughly proportional to incident illumination over more than two decades. Operation of the circuit is unnoticeable even with rapid changes of illumination and the circuit consumes no current when the display is blanked; thermal effects are imperceptible.

The original circuit running from a 10V supply produced sufficient brightness to be easily readable in bright daylight, except with direct sunlight on the display, using a high-brightness orange two-digit display. Resistor R_1 was chosen to suit the l.d.r., used behind a mask with a $1mm^2$ aperture. Lowering R_3 reduces the minimum led current. Due to the necessity to monitor the current through at least one led, segment c must be used in conjunction with any other except f.

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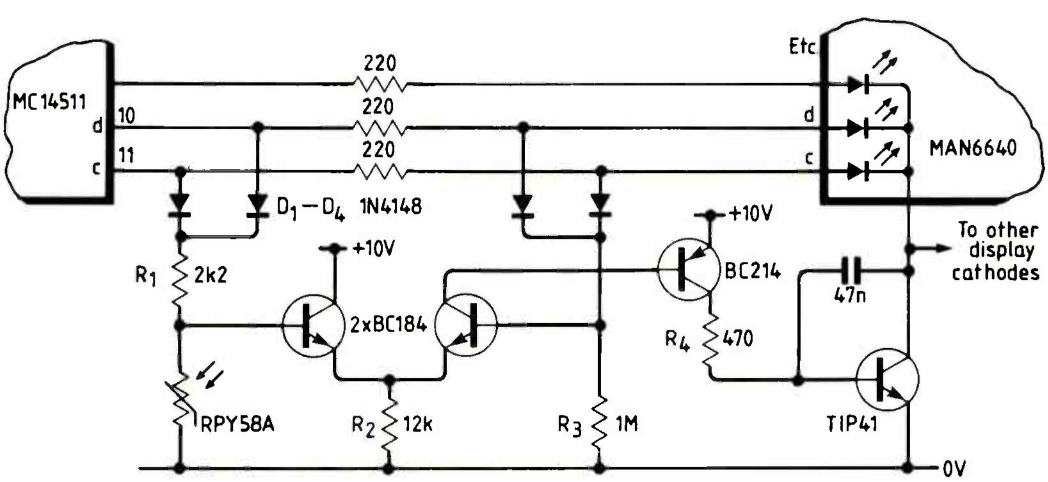
Cambridgeshire

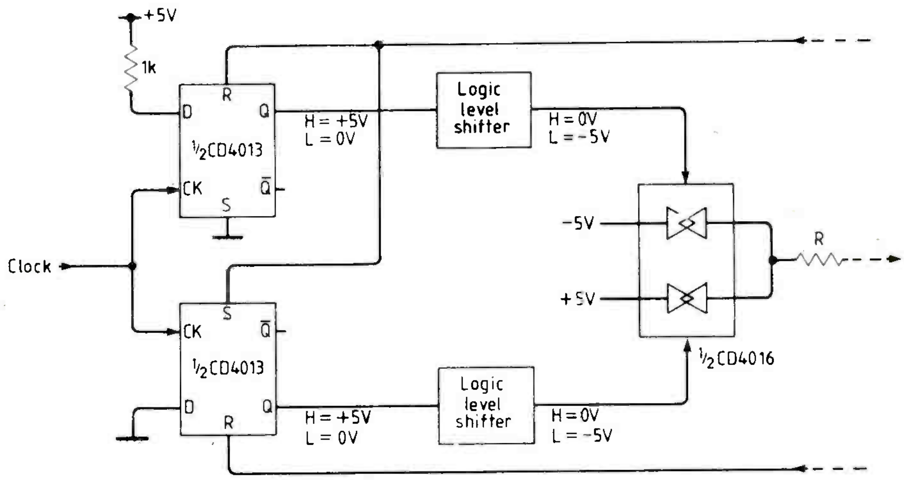


Clock-triggered triangular generator

In the circuit of G. Tombras (June 1982, page 60) output signals of the two CD4013 act as control signals to the analogue switches. From his circuit diagram +5v and 0V represent high and low signal-states respectively. But c.m.o.s. analogue switches permit peak input-signal voltage swings within the full supply voltage range; peak input-signal voltage swings outside this range cannot be transmitted.

The circuit is easily adapted by logic level shifters which can be simply inserted between the 0 output of the D-flip flops (CD4013) and the control inputs of the analogue switches (CD4016) to act as interfaces between the different logic levels, H ≡ +5V and L ≡ 0V of the output signals of the CD4013 on one hand and that of the valid control input signals (H ≡ 0V and L ≡ −5V) of the CD4016 on the other.

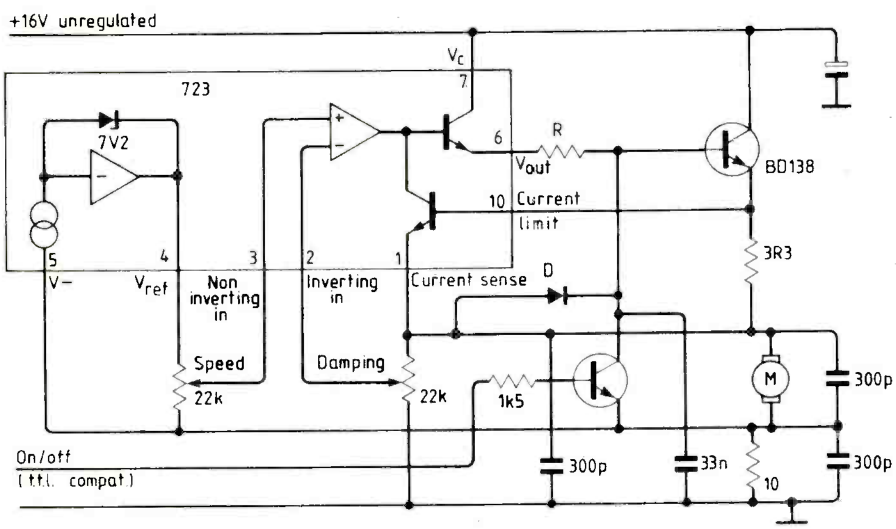
C. C. Odukwe
Gelsenkirchen-Buer
Germany



Speed control for small motors

Designed initially for use in a floppy-tape transport mechanism, this circuit senses back-e.m.f. for speed control. Unlike similar circuits, this one also detects current and can differentiate between motor voltage due to back-e.m.f. and that due to resistive loading. In addition, a t.t.l.-compatible on/off input with active braking and independent speed and damping controls are provided. The on/off transistor is a 2N1893 and the braking diode D is a 1N4148. The value of R depends on the supply voltage.

P. H. Pazov
London



In our next issue

Morse decoding by microcomputer, by J. P. Sargent, uses a 567 tone decoding i.c. and seven-bit clock to time incoming signals. Morse code is interfaced to a ZX81 via a p.i.o. chip. Machine code routines use this data to provide up to 9 lines of text.

A leading Japanese research engineer, Y. Hirata, discussed the distortions in analogue and digital recordings, gives measurements of non-linearities in four **p.c.m. processors,** and compares them with results from three analogue tape recorders.

Logic maps, by N. Darwood, gives the history of methods for showing logical truths – from 13th century Lull to present-day Karnaugh maps.

To introduce **computer networks,** Philip Barker describes some of the current approaches used to link together two or more computer systems.

Picotutor is a microprocessor assembly language trainer, described by Bob Coates, the Nanocomp designer, and assumes no previous experience of microprocessors.

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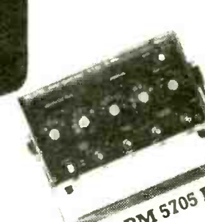

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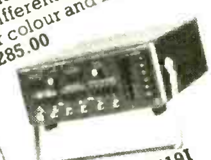

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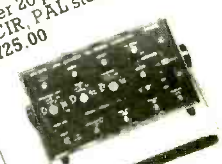

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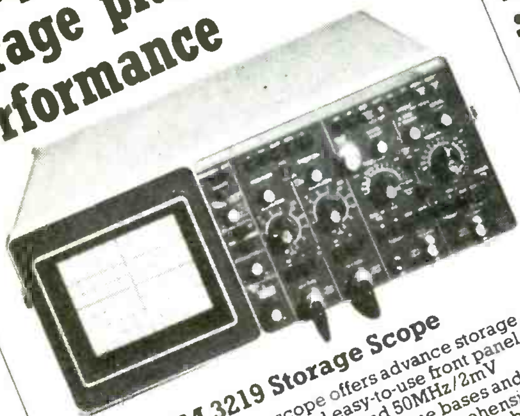

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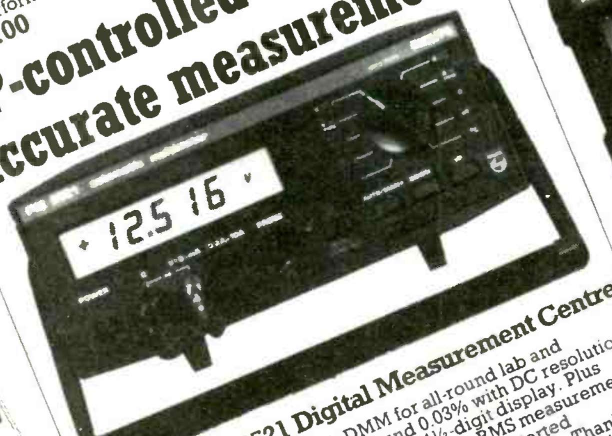

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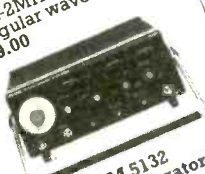

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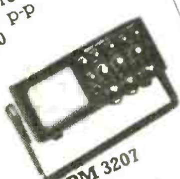

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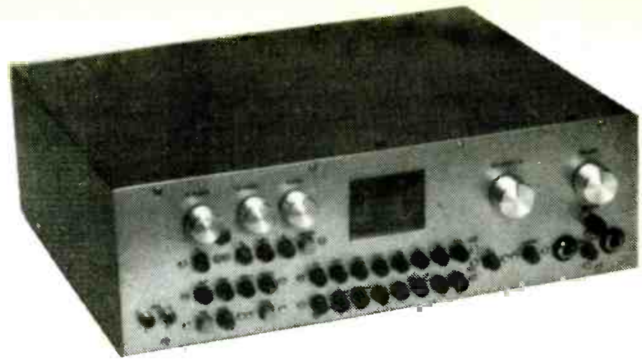


The basic system described in the first article is developed by the addition of further modules – tone control, bass and treble filters and a headphone amplifier. Part one dealt with power supply, pickup amplifier, mixer and impedance converter.

by J. L. Linsley Hood

Although the system described in the first part of this article will work very well when the programme sources, the loudspeakers, and the listening conditions are all as good as one would wish, it is, unfortunately, in the nature of things that for part of the time in some circumstances, and all of the time in others, it will be desirable to modify the signal in its route from source to listener. I am, therefore, going to describe some of the more conventional of these signal-modification modules in this part of the series: these are the tone control, the treble filter, and the rumble filter. Since it may be useful at this stage, I am also giving details of the headphone amplifier. These circuits are all based on dual, low-noise, low-distortion operational amplifiers wherever the signal level allowed, and are all, with the necessary exclusion of the headphone amplifier, unity-gain, non-inverting stages, so that they may be included, or omitted, as desired – either in the constructional stage, or by subsequent switching.

Tone control

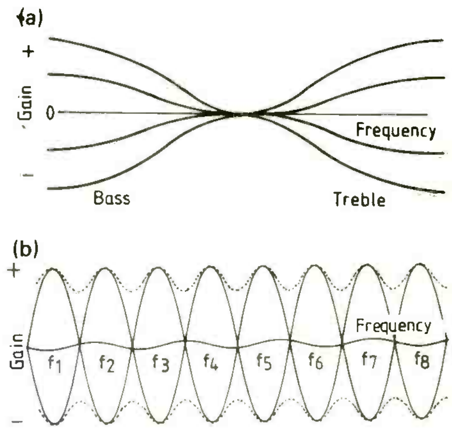
Tone-controls have been the source of some debate among the 'hi-fi' fraternity over the past decade, with the purists insisting that the signal should be accepted, or rejected, as it stands. However, for those of us who are a little less pure, the nature of our tinkering with the frequency response is still an interesting question, and there are a number of options from which to choose. Figure 9 shows the types of frequency response adjustment offered by these.

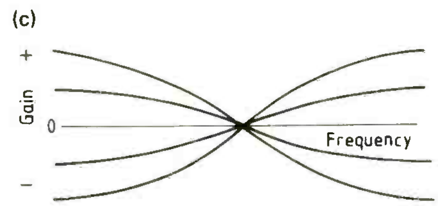
Baxandall. This circuit, originally described in these pages by P. J. Baxandall, over thirty years ago[1] is still the most popular circuit of this type and is used in the majority of audio amplifiers, the world over, in one or other of its contemporary forms. The practical shortcomings of the circuit (a) are mainly that it does not allow any scope for selective adjustment of the frequency response, except for raising or lowering the signal level at bass or treble, though the frequencies at which the lift or cut can be made may be adjusted by switching the capacitor values, as I had done in an earlier amplifier[2]. Also, with standard dual-gang potentiometers, it may not be possible to achieve a level frequency response, simultaneously, in both channels, by any setting of the pots. Finally, although the continuously variable quality of the adjustment is valuable, it does make it more difficult to return to a previously found combination of control positions.

Graphic equalizer. The basic intention of the arrangement at (b) is a good one – that the received frequency spectrum should be divided up into eight or nine octave bands, within which the gain of the system can be individually adjusted, as required, by individual, calibrated-slider potentiometers. Alas, in the way in which it is normally implemented, with each octave band being selected by one or other of a group of LC tuned circuits, the transient response of the arrangement, to a square-wave or step-function input, is both complex and unnatural. Moreover, the frequency response, with all of the sliders set 'level' at any point other than the precise mid-position, is likely to be exceedingly ragged. These major limitations, in the bulk of units of this type, have earned the arrangement the reputation of being more for the lover of sound than the lover of music.

Slope or tilt control. This concept (c) has recently been proposed, as a means of giving a small but continuous skew to the frequency response, to correct for the sound appearing over-'toppy' or bass heavy, and it does offer some unobtrusive benefits in use. However, like the Baxandall, it does not offer any opportunity to make an adjustment, perhaps quite small, to a particular part of the frequency response where some improvement is required.

Step frequency adjustment. Having contemplated this point for some years, the conviction has grown on me that it





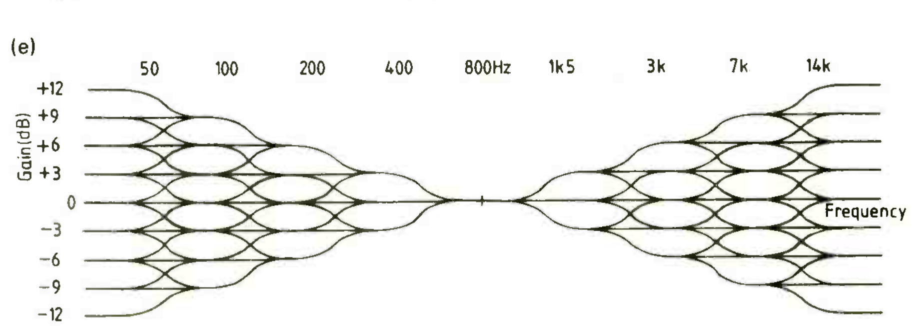
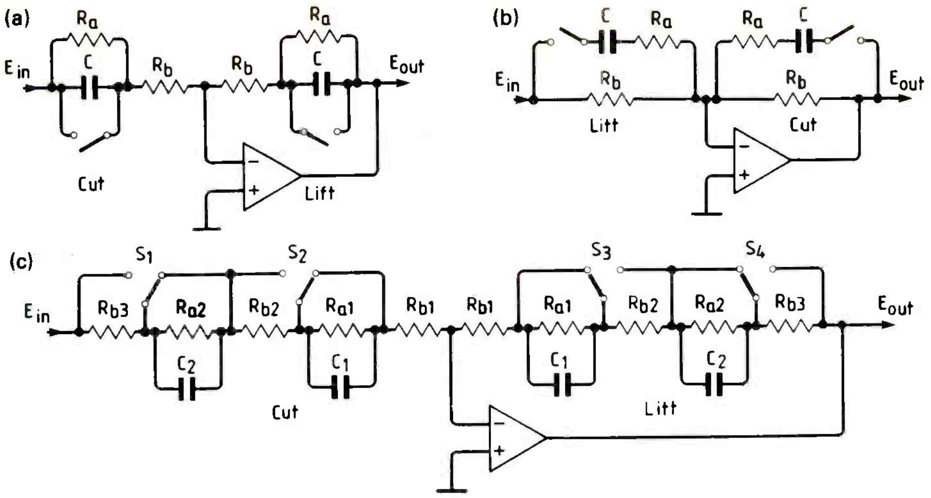


Fig. 9. Adjustments of frequency response offered by various types of tone-control circuit. Baxandall – still the best known – is at (a): no selective adjustment of any band is possible. Graphic equalizer at (b) adjusts frequency bands, but can distort waveforms. Slope control, shown at (c) broadly similar to Baxandall, but whole response is varied. At (d) is the step frequency adjustment, which would be useful, but additional steps would not be of equal size. Response (e) is 'Clapham Junction' which is a development of (d) in which steps are additive.



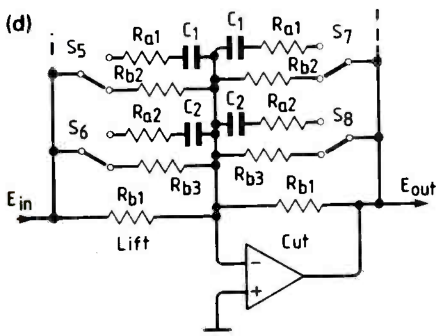


Fig. 10. Bass (a) and treble (b) lift and cut circuit elements, to give response at Fig. 9 (d). Circuits at (c) and (d) provide additive steps to give 'C J' type of response.

would be most useful to be able to switch into circuit some arrangement which would give a small, say 3dB, platform-type lift or cut operating downwards or upwards from some specified frequency, in the manner shown in (d). If such lifts or cuts were truly additive, it might be possible both to correct an overall programme balance, if it seemed bass or treble dominant, but also to achieve a measure of selective equalization.

A single-frequency bass or treble lift or cut can be obtained with the switched-feedback network arrangements shown in Fig. 10(a) and (b), though these circuits would only be appropriate for a single step up or down. If the values of R_a and R_b were chosen to give a lift or cut of, say, 3dB it would be found that a subsequent RC block switched into circuit would give only, say, a further 2dB of adjustment, and so on, with progressively diminishing effect.

'Clapham Junction'-type tone control. If it were possible tc make a multiple frequency step tone-control circuit, in which each of the steps was identical in amplitude, and in which the results were truly additive, the result could be a family of options of the type shown in 9(e), giving a whole range of possible frequency response paths down which the user could steer his ultimate frequency response curve, in the manner of a train negotiating a railway junction. This would allow a certain measure of discreet doctoring of the frequency response curve, in a predictable and reproducible fashion and, since it could be implemented in a feedback path having a limited phase excursion, the transient response would be free of ringing, and a level gain/frequency characteristic could be assured when all the lifts and cuts were removed, or where every cut was matched by an equal lift – or vice versa.

I have shown one of the possible network arrangements by which these step bass and treble lifts and cuts could be obtained, in an additive manner, in Fig. 10(c) and (d). In this arrangement, the switches are arranged so that each time an RC element, such as $R_{a1}C_1$, is switched into circuit, an element of R_b is switched out of circuit, restoring the potential subsequent gain increment. As shown, any number of switched steps could be adopted, and any required degree of lift or cut. However, there are practical limits, and I have chosen to employ two banks of eight push-switches, one for lift, one for cut, which give four possible frequencies each for treble and bass, centred on 800Hz. The centre frequency itself can effectively be raised or lowered by generating a symmetrical shelf on either side, leaving it either on a pedestal or in a trench. Similar trenches or pedestals may be implemented elsewhere in the spectrum.

In its simplest usage, with a one or two stage successive lift in bass or treble, the results are similar to that given by the familiar and well-known Baxandall arrangement, except that the steps are fixed rather than continuously variable, though there is scope for doing very much more than this, if required.

I have shown the circuit which I have used for this multiple step tone control, made by combining the separate elements of Figs 10(c) and (d), in its composite form in Fig. 12. This relatively simple implementation of the basic intention of 9(e) does have one, not unacceptable, characteristic which is that the lift is partly achieved by a depression of the remainder of the spectrum, such that a +3dB shelf centred on, say, 400Hz would raise the part of the frequency spectrum below this frequency by 2.5dB, while lowering that above it by 0.5dB, and so on, in the manner in which I have shown in Fig. 11.

If need be, the gain control can be used to restore the status quo, or it can simply be accepted as a combination of shelf and slope. A small elaboration of the switching network to remove an equal element of resistance from both arms each time an RC element was introduced into circuit would correct for this, but by this time, I felt that the circuit and its associated switching had grown complex enough. The small capacitor (C_{28}) across the bass circuit op-amp is to avoid possible troubles due to unpredictable inter-wiring stray coupling capacitances.

Putting the two successive phase-inverting stages in series fulfils the original stipulation that each module in the preamplifier should have unity gain, and be non-inverting. In the prototype, I have used non-interlocking, push-button, double-pole change-over switches, which can be operated without clicks; indeed, the whole tone control may be switched in and out of circuit noiselessly, to compare 'with' and 'without'. Also, the wish that a flat response should be given with all switches out, and with corresponding pairs in, both singly and in multiples, has been met in practice. My only major regret was that, in designing the p.c.b., I had not gone to the extra trouble of designing the wiring to the switches so that all I had to do was to plug them into the board. However, this regret faded once I had completed the task of wiring it up, and had put right the three or four erroneous connexions to the switches shown up by square-wave testing, in which certain pairs did not cancel!

Variable-slope treble filter

While some form of tone control stage can be useful in trimming the overall characteristics of the unit, the maximum slopes possible will not exceed 6dB/octave, and there may be occasions when some more drastic modification is desired. The circuit of Fig. 13 is a three-element active filter, in which the slope can be varied from −6dB/octave up to a maximum −20dB/octave optimally flat response. The circuit I have used is based on a 'bootstrap' filter design, though a three-element Sallen and Key filter could equally well be used with a unity-gain, non-inverting amplifier element. I have chosen to use a 'bootstrap'

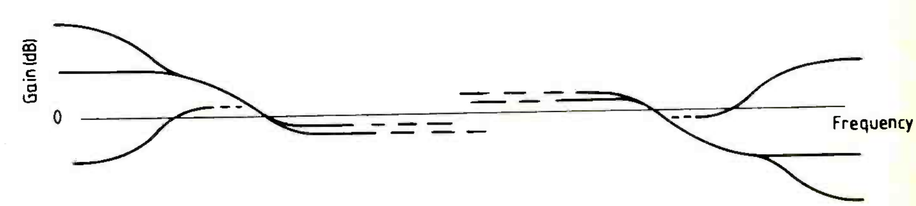


Fig 11. Amplitude-frequency response given by circuits of Fig 10 (c) and (d).

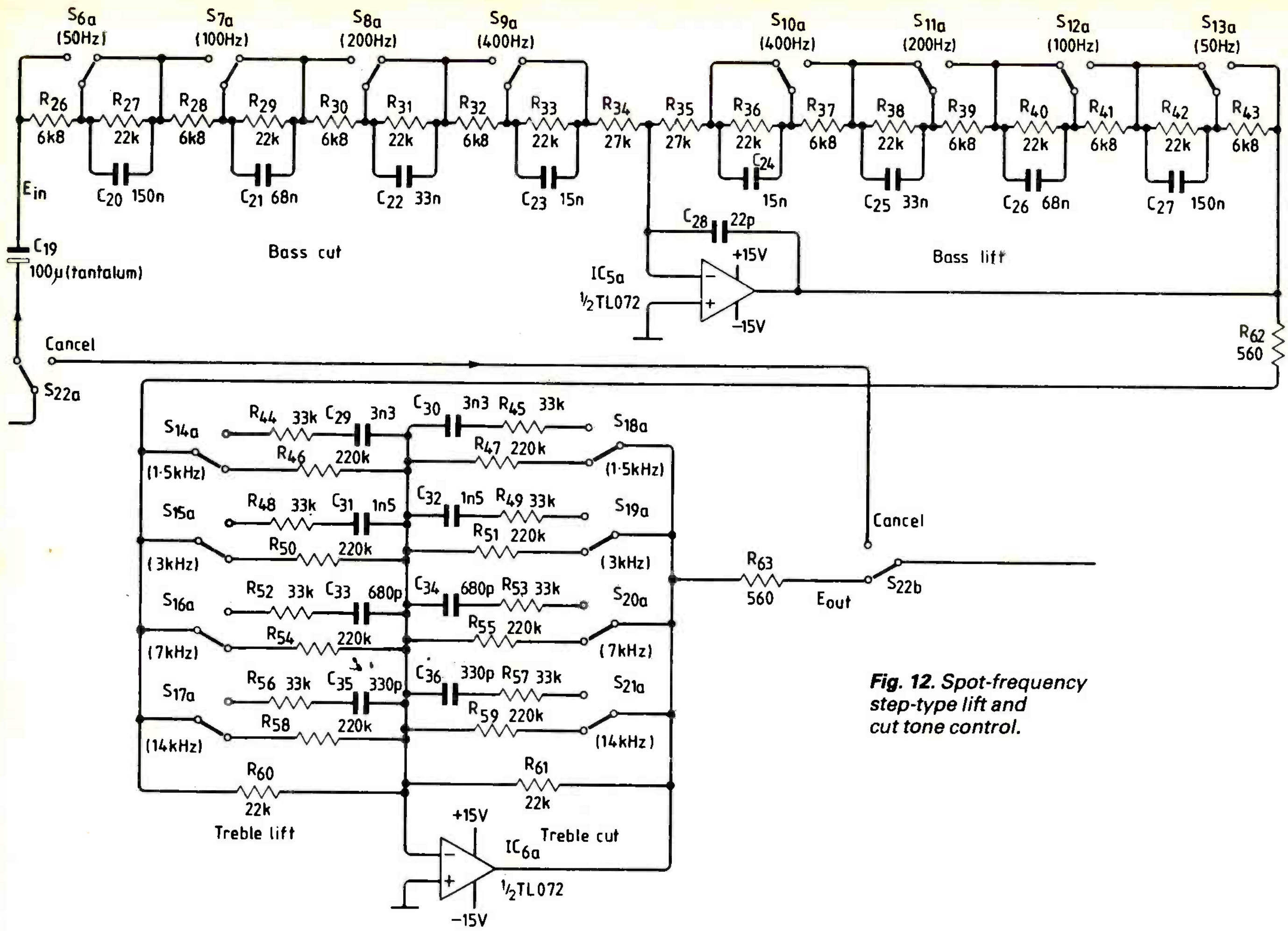
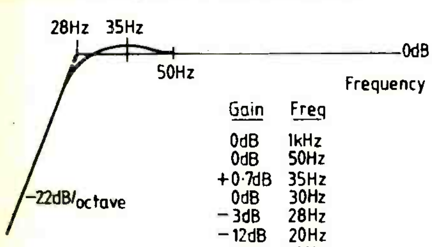


Fig. 12. Spot-frequency step-type lift and cut tone control.

filter circuit because I invented it and, in consequence, have a large amount of design calculations in a form which are intelligible (to me).

For the convenience of those who may wish to employ the circuit arrangement to give different cut-off frequencies, I have appended the design details at the end of the article. These also cover the circuit component values for the rumble filter which uses the same circuit configuration. A variable-slope circuit at which the pivot frequency (by which I mean the turn-over point) is constant, can be obtained by returning the third-stage integration capacitors (C_{41} and C_{42}) to the top of the slope pot. Unfortunately, this arrangement does not give quite such a good transient response, at all settings of the slope control, as the circuit shown. IC_8 is used as a unity-gain buffer stage to preserve the constant line impedance required by following stages. The input resistor R_{64} is necessary to prevent the input seeing an open-circuit when the cancel switch (S_{23}) is open.

Attenuation role of rumble filter.



Gain	Freq
0dB	1kHz
0dB	50Hz
+0·7dB	35Hz
0dB	30Hz
−3dB	28Hz
−12dB	20Hz
−20dB	15Hz
−30dB	10Hz
−32dB	9Hz

Rumble filter

This uses a similar three-element bootstrap filter circuit to that of the treble filter, and is shown in Fig. 14.

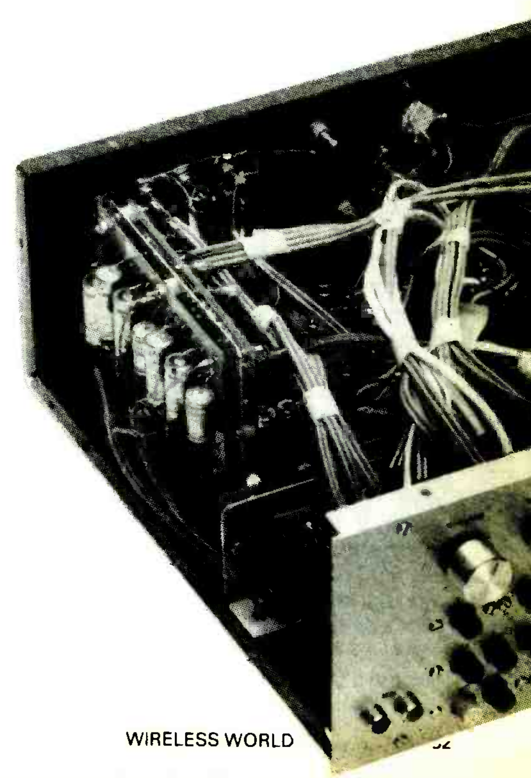
Since the presence of a small hump in the bass response curve is less significant audibly than the same peak in the treble response, I have calculated the circuit values for a slightly higher 'Q', to give a steeper attenuation rate below the nominal 28Hz transition frequency. I have shown the measured gain/frequency characteristics of the prototype, over the range 9Hz (the lowest frequency from my signal generator) to 1KHz in the Table. Calculations show a value of −43dB at 6Hz, and −49dB at 5hz, which should give an adequate rejection of turntable v.l.f. components.

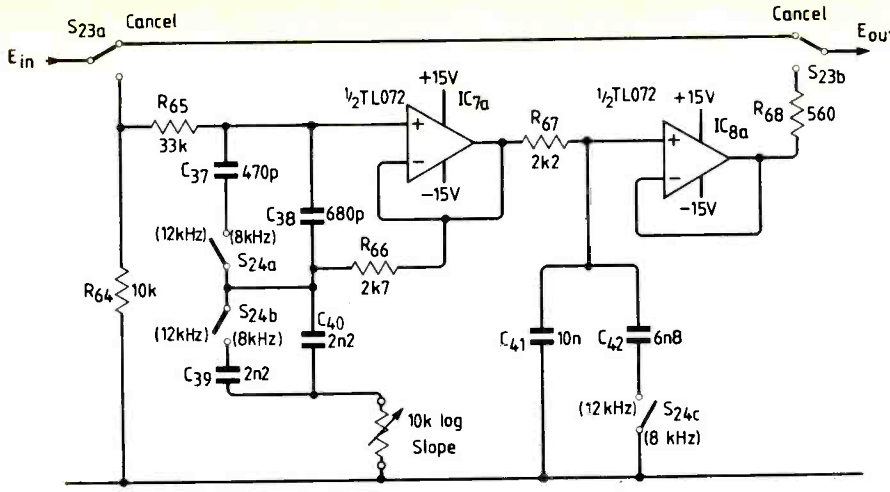
In use, the circuit shows very little detectable l.f. coloration, but does remove, very effectively, occasional rumbles from poor discs.

There is no particular preferred position in the post-mixer signal chain for either the treble or rumble filters. They can be inserted wherever it is mechanically or electrically convenient.

Headphone amplifier

My views on headphone listening underwent a change, some few years ago, when I built for a friend a high-quality class A headphone amplifier, in which I had done the very best job that I then knew how, in order to preserve the greatest amount of information obtainable from the groove. Listening to some records through this amplifier was a delightful, and occasionally revealing experience, and showed – perhaps because I was tempted to listen at a somewhat greater sound level than I would have chosen (or would have





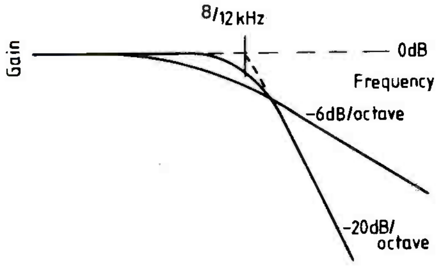


Fig. 13. Variable-slope treble filter using bootstrap circuit (see appendix).

been permitted!) on loudspeakers – things which I had not previously heard on the discs in question.

It also, and I suppose there must be a fly in every ointment, showed that some records, which I had previously thought to be very good, had substantial unobserved faults – such as the most irritating (once heard) background breathing of a noise reduction circuit, where the increase in hiss once the music increased in volume reminded me strongly of listening to a string quartet playing on a shingle sea shore, where the waves came in as soon as the instruments began to play, and receded again when they stopped.

However, on balance, I think a good headphone amplifier is a 'good thing', and preferably should be placed ahead of the power amplifier, to shorten the audio chain. The snag, for me, was that I already had a very good, though complex, headphone amplifier, and I wanted one which was equally good but simpler to

build. Fortunately, the low-distortion i.c. allows a simplification in this area too, and allows a smooth transient response on resistive and reactive loads, and a distortion below 0.01% on all loads down to 8 ohms, up to 3V r.m.s. output. The amplifier will operate in class A under almost all headphone load conditions, especially since the lower-impedance 'phones will generally require a smaller output voltage swing.

To avoid the possible injection of asymmetrical signal components into the smoothed and regulated 15V supply lines used to feed the remainder of the preamplifier, I have drawn the large current (40-50mA/channel) supply to the output transistors from the unregulated ±25V line in the power supply unit. This does not contribute any measurable 50 or 100Hz component to the output, though I confess that I was tempted to put in an extra pair of 7815/7915 regulators just to feed the headphone amplifiers. The gain of four seems about the right value to give a similar level on 'phones or on speakers through the power amplifier.

I have shown the circuit diagram for this unit in Fig. 15. The output transistors (four in all, since only one channel is shown) are mounted, with insulating washers, on a piece of aluminium sheet, some 6×2in overall, bent into a U-shape to take two transistors on either side. No further mounting fixtures are then required for this plate, which can be painted black, with advantage. The voltage regular i.cs in the power supply can employ a similar heat sink.

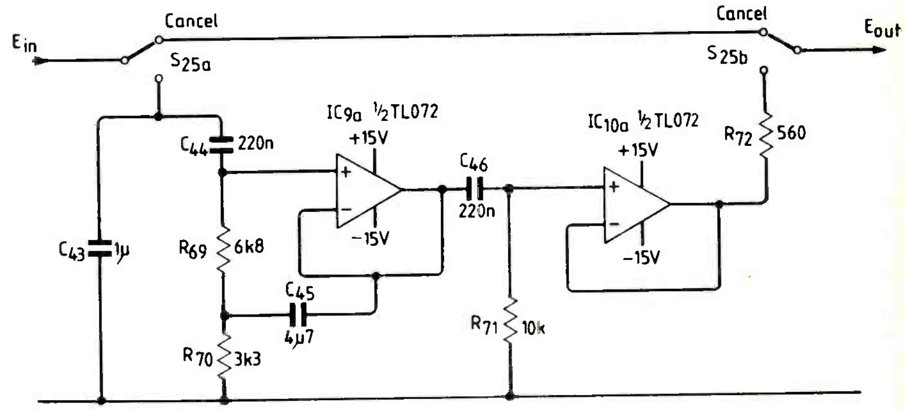


Fig. 14. Rumble filter for different cut-off frequencies – see appendix.

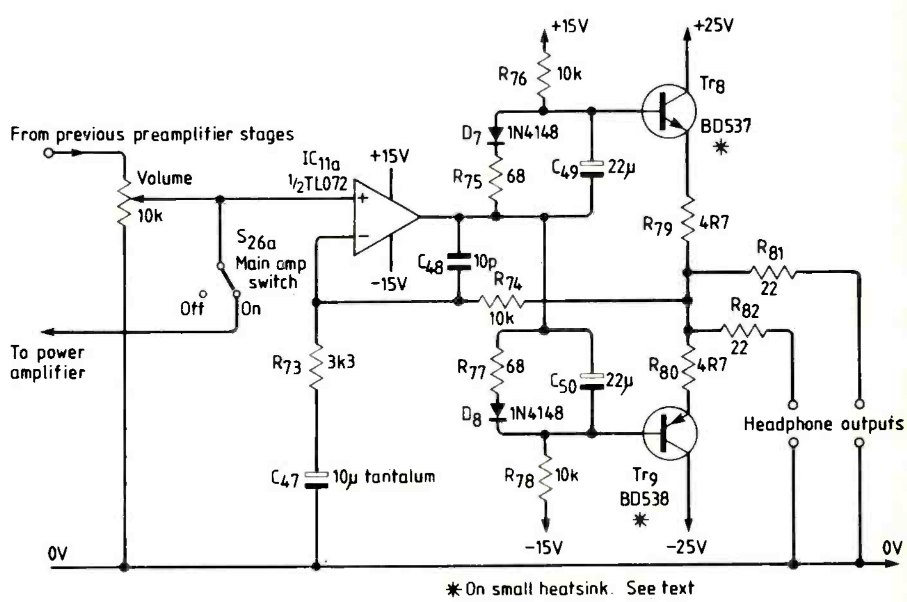


Fig. 15. Class A headphone amplifier – one channel shown.

In the next part of this article, I will describe the head amplifier for use with moving-coil pick-up cartridges, the microphone amplifier, the stereo image-width control – which will allow an increase in channel separation as well as a blend facility, the impulse noise-blanker circuit, which allows a useful reduction in the intensity of the annoying clicks and bangs which occur repetitively on a scratched gramophone record, and the signal-strength metering circuit.

References

1. Baxandall, P. J. *Wireless World*, October 1952, pp402-405.

2. Linsley Hood, J. L. *Hi-Fi News and Record Review*, January 1973, pp60-63.

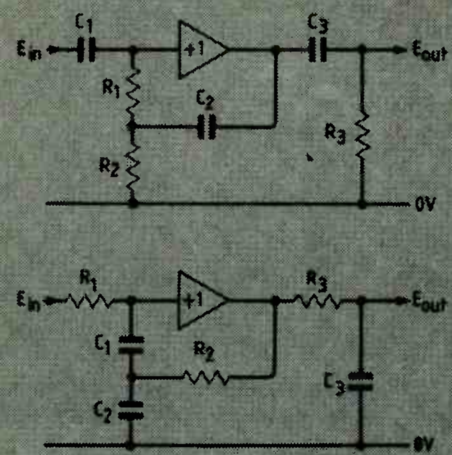
Appendix

The calculations below refer to the diagrams in Fig. 16, and are calculated to give a unity-gain system with a 0dB point at f_0

Any second-order active filter with a Q value greater than 0.707 will have a frequency response peak at the value I have defined as f_0. If a third RC leg is added to restore the gain at this point to unity, the ultimate slope above or below this point can be increased. The optimally flat Butterworth characteristic is given by a third-order filter of this type with a Q of $\sqrt{2}$, which will give an ultimate attenuation slope of −18dB/octave. The Q can, however, be pushed a bit higher than this without the excursions above and below the datum line becoming too great. For example, a Q of 2.0 in this circuit will give a final slope of about −20dB/octave, with only about a 0.4dB ripple.

The practical calculations from these formulae can best be done by deciding the desired Q and the ratio y, and then seeing whether the required frequency of turnover can be given with preferred R and C values. If this is not the case, a different value of y can be used as the basis for a further attempt. Because the original calculations were made with the mathematically convenient assumption that the amplifier was an ideal, unity-gain, non-inverting stage, with high input impedance and low output impedance, and because many of the recent operational amplifier i.cs approximate quite closely to this ideal over the audio passband, these formulae allow the implementation of a whole range of steep-cut filters which can be based on these op-amp i.cs.

A minor word of warning should be added. This type of filter may act as an oscillator if it is installed with its input circuit open, because of the positive feedback path through C_2R_1 or R_2C_1. A small value of capacitor or an appropriate resistor connected across the input will prevent this, if the circuit calls for input switching, as in Fig. 14, where C_{43} is added.



High pass

$$C_1(\mu F)=\frac{10^6}{2\pi f_0 R_2(1+y)Q}$$

$$y=\frac{R_1}{R_2}$$

$$C_2=C_1\frac{Q^2(1+y)^2}{y}$$

$$C_3(\mu F)=\frac{10^6}{2\pi f_0 R_3 Q}$$

Low pass

$$C_1(\mu F)=\frac{10^6}{2\pi f_0 R_2(1+y)Q}$$

$$y=\frac{C_2}{C_1}$$

$$R_1=R_2\frac{Q^2(1+y)^2}{y}$$

$$C_3(\mu F)=\frac{10^6 Q}{2\pi f_0 \cdot R_3}$$

Fig. 16. Bootstrap filter for third order flat response.

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continued from page 41

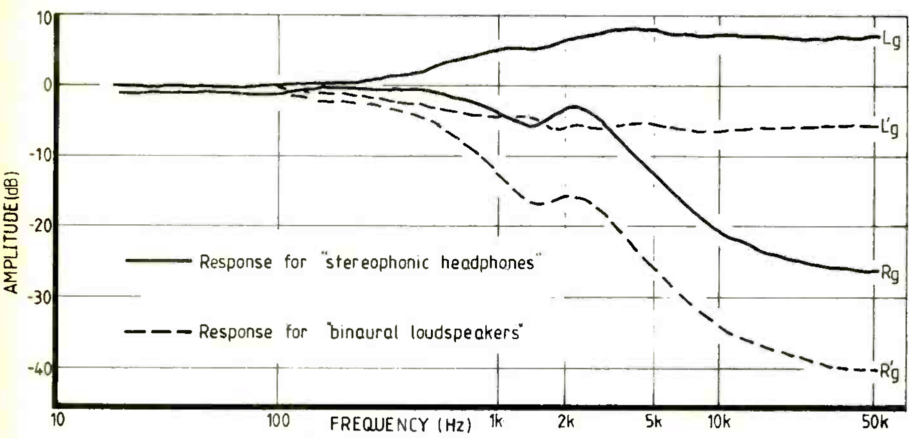


Fig. 12. Aplitude responses of Fig. 11 circuit for both headphone and loudspeaker switch positions.

12dB, a correction circuit has to be constructed to obtain a "flat" amplitude response. In Fig. 9 the turnover frequencies are determined graphically. The resulting frequency response is given as well and shows that deviations from the design objective are smaller than 2dB, which is considered sufficient. A circuit which realises the desired frequency response is given in Fig. 10. The total circuitry is given without further comment in Fig. 11, except that a switch is included for use of the circuitry for "stereophonic headphones" as well as "binaural loudspeakers" (ref. 3). The frequency responses are given in Fig. 12.

For those who want to enjoy life-like sound reproduction, a description of a home-construction binaural microphone can be found in reference 5.

References

1. F. M. Wiener, Diffraction of a progressive sound wave by the human head. *Journal of the Acoustical Society of America*, vol. 19 1947, pp 143-6.

2. E. A. G. Shaw, Ear canal pressure generated by a free sound field. *Journal of the Acoustical Society of America*, vol. 39 1966, pp. 465-70.

3. B. B. Bauer, Stereophonic earphones and binaural loudspeakers. *Journal of the Audio Engineering Society*, vol. 9 1961, pp. 148-51.

4. N. V. Franssen, Stereofonica (Philips Technical Library). Dutch edition: Centrax, 1962; also available in English.

5. G. A. Nelson, Build a binaural mike set. *Audio* May 1976, pp. 34-8.

See also Towards true stereophony, by "Toneburst". *Wireless World*, Sept 1969, pp. 423-4.

DIGITAL POLYPHASE SINEWAVES

Arithmetical generation by computer program of any number of sinewave phases

by N. Darwood

The digital generation of a two-phase sine and cosine waveform was described in an earlier article*. In summary, the method, proposed by Pierre Diederich, was to assign initial values to the sine and cosine waveforms. Then for each step to compute the next values by adding a proportion of the cosine to the current value of the sine and subtracting the same proportion of the sine from the current value of the cosine. Supposing the proportion chosen was a half (0.5) this could be expressed in a computer program as:

```
10 S = n: C = m
20 Output S, C
30 S = S + 0.5* C
40 C = C − 0.5* S
50 GOTO 20
```

When run, this procedure produces the amplitude of a sine wave. It can be shown to be an approximation of the sum to two angle formulae thus:

$$\sin(A + f) = \sin A.\cos f + \sin f.\cos A$$

If f is small, cos f = 1 and (sin f)/f = 1 or sin f = f (in radians). Substituting,

$$\sin(A + f) = \sin A + f.\cos A.$$

Returning to the program, the wave form may be inverted, seeming to run backwards by interchanging the + and − signs. The output gives a stepped version of the waveform and a D-to-A converter may be used to give an analogue signal. The step size is 0.5 radians, giving 12.5 steps for a cycle. other step sizes may be chosen by altering the value of f (see Appendix). For example a value of 0.1 could be chosen to give a program:

```
10 S = 0: C = 1: f = 0.1
20 Output S, C
30 S = S + f* C
40 C = C − f* S
50 GOTO 20
```

This step size of 0.1 radians gives 62.8 steps per cycle in the output wave form. The amplitude of the waveform can be specified by altering line 30 to read S = S + f (C + A) where A is the required peak amplitude. As each step takes the same amount of computer time, altering the step size (f) changes the frequency of the output wave. The frequency will depend on the speed of the computer used.

*N. Darwood, "Accurate sine-wave oscillator", *Wireless World*, June 1981.

Table 1. Three-phase software

```
10 A = 0: B = 0.866: C = −0.866
20 Output A, B, C
30 A = A + f*(B − C)
40 B = B + f*(C − A)
50 C = C + f*(A − B)
60 GOTO 20
```

In the program for generating three phases, A, B and C are the phases, each 2π/3 apart. The initial conditions set are A = 0, B = sin2π/3 and C = sin4π/3. The step size was chosen as √3.f where f is the fraction used in the program. The presence of √3 is coincidental as will be seen later.

Table 2. 7-phase software

```
A = 0          (= sin (0* 2π/7))
B = 0.78       (= sin (1* 2π/7))
C = 0.97       (= sin (2* 2π/7))
D = 0.43       (= sin (3* 2π/7))
E = −0.43      (= sin (4* 2π/7))
F = −0.97      (= sin (5* 2π/7))
G = −0.78      (= sin (6* 2π/7))

10 A = A + f* (B − C + D − E + F − G)
   B = B + f* (C − D + E − F + G − A)
   C = C + f* (D − E + F − G + A − B)
   D = D + f* (E − F + G − A + B − C)
   E = E + f* (F − G + A − B + C − D)
   F = F + f* (G − A + B − C + D − E)
   G = G + f* (A − B + C − D + E − F)
80 Output A, B, C, D, E, F, G
90 GOTO 10
```

The seven-phase generator shown above is in its longer version and computing time can be saved by reducing it. To explain the short form, consider the coefficient of f for phase A. From Table 2 this is B − C + D − E + F − G. We can call this I (for initial value) and then look at the coefficient for B, which is C − D + E − F + G − A which is equal to B − (A + I) and which becomes the new I. Similarly the coefficient for C is D − E + F − G + A − B which is equal to C − (B + I). Thus we can generate all the coefficients for the short form of the program. The initial value of I may be found from I = B − C + D − E + F − G. In trigonometrical terms this is

$$I = \sin\omega - \sin 2\omega + \sin 3\omega - \ldots$$

where ω is 2π divided by the number of phases (N).

Surprisingly, considering it came from an approximation, I is found to be sinω/(1 + cosω) where ω = 2π/N. This has the golden property that the inverse of I is sinω/(1 − cosω), which may be shown as follows:

$$\sin^2\omega = 1 - \cos^2\omega$$
$$= (1 + \cos\omega)(1 - \cos\omega)$$

$$\therefore \frac{\sin\omega}{1+\cos\omega} = \frac{1-\cos\omega}{\sin\omega}$$

Table 3. 7-phase software, short form program

```
    A to G have the same initial values as
    in Table 2.
    I = B − C + D − E + F − G
      ≈ 0.48
10  A = A + I* f
    I = B − (A + I)
    B = B + I* f
    I = C − (B + I)
    C = C + I* f
    I = D − (C + I)
    D = D + I* f
    I = E − (D + I)
    E = E + I* f
    I = F − (E + I)
    F = F + I* f
    I = G − (F + I)
    G = G + I* f
    I = A − (G + I)
150 Output A, B, C, D, E, F, G
160 GOTO 10
```

For a 5-phase program, N = 5, and ω = 2π/5. This would make I = sin 2π/5 − sin 2.2Ω/5 + 5in 3.2Ω/5 − 5in 4.2Ω/5 = 0.73, f may be found by selecting a step size. As the step size is I.f., suppose that we wpould like to make this 1°, i.e. 360 steps per cycle. I.f. is then0.075 rasdians and we have established that I is 0.73 so f is 0.024.

Appendix

Let sin(n) be the value of the sine wave at step n and assume the following procedure.

S(0) = 0
C(0) = 1

S(1) = S(0) + f.C(0) = f
C(1) = C(0) − f.S(0) = 1

S(2) = S(1) + f.C(1) = f + f = 2f
C(2) = C(1) − f.S(1) = 1 − f^2

. . . and so on. It is found that the coefficients of f at step n are the values in row n of Pascal's Triangle. This is shown in Table 4.

Table 4. Analysis

Step						
0	1					
1	1	1				
2	1	2	1			
3	1	3	3	1		
4	1	4	6	4	1	
5	1	5	10	10	5	1
sin		f	$-f^3$		$+f^5$	
cos	1		$-f^2$		$+f^4$	. . .

WW

LETTERS

TELETEXT DECODER

Readers may be interested in two further modifications to the *Wireless World* teletext decoder, following those given in the October issue.

(V) Addition of board IV involved the removal of IC1 which, upon inspection, supplied 0V to R_4 via pin 10. While the decoder will still operate without this connection being made, it is preferable to restore the connection to 0V, thus giving the correct time constant and greater noise margin at this point of the circuit. Readjustment of VR_2 will then be necessary.

(VI) In the original decoder design, the memory-address converter functions correctly only for row addresses within the text display area, i.e. rows in the range 0-23. If the detected five-bit row address corresponds to n, one of the remaining rows in the range 24-31, this 'row' will appear in columns 33-40 of rows n-24, n-16 and n-8 due to the operation of the code converter during the display period (*WW* Feb. 1976 p.50). A simple modification to prevent such information being written into the memory is as follows: isolate 70(11), feed 20(12) and 20(2) to the inputs of a 2 input Nand gate whose output is connected to 70(11). This disables write pulses at 70(8) during the detected illegal rows.

Ken Drew
Nottingham

THE RIGHT FORMULA

Mr K. Wood cites an example in Letters, September 1982, which was not the one I had in mind. The one that intrigued me was a throwaway remark by Patrick Moore that an American observatory (I failed to catch the name) had observed the products of a supernova expanding at *ten* times the speed of light. I do not believe any valid explanation has as yet been put forward for the phenomena.

Mr O. B. Balean has figures closely paralling my own. What is not clear to me is why it is a mathematical 'figment'! It seems an awful lot of mass to 'lose', yet plainly it does not exist. Perhaps it is 'relativistic mass' which is the figment.

Mr Ivor Catt seemed rather tetchy! I suppose it must be rather frustrating when adjudicators demand 'proof' and he simply doesn't have any! Why is he so bitter about 'instrumentalists'? Is there any way of working with electronics without using instruments? He implies he uses a sampling oscilloscope and certainly uses a computer. His remark that 'today, hardly anyone can successfully assemble 1ns logic' is highly suspect, since pulse circuitry is peculiarly adaptable to analysis by computers and checking by multiple-beam oscilloscopes. Is it really true that Mr Catt's theory came *before* he had found out how to do the job?

What *is* a 'theory', anyway? I read his letter and find he uses the word to mean (a) an equation, (b) an aid to understanding, (c) an extension of electromagnetic concepts and (d) a new way to view the phenomena. All in one letter! Surely the engineering comes *first*. Later on, the academics follow along, as always a few years behind! After all, isn't the whole fun of electronics the fact that we don't know how anything really works, we just know that if we do so'n'so, such'n'such happens and on such slender bases huge industries grow.

I would merely ask Mr Catt two questions. What is the use of a theory if it doesn't predict what a circuit will do?

The second question is an equation:

$$\frac{E}{R} = ?$$

Ronald G. Young
Peacehaven
Sussex

NIKOLA TESLA

Martin Berner is, perhaps, right to chide me gently for seeking a second centennial for the famous N. Tesla (*WW*, Letters, Sept., 1982, p.41). However, I do feel that Tesla is more to be respected for his work than for the accident of birth. Meanwhile we have about ten years in which to debate this point in regard to his radio-frequency spark generator of 1892. Martin Berner also reflects the hope that many historians must cherish – that somebody else will tackle the more difficult subjects! Tesla's writing makes excellent reading, but it *is* terribly short of vital technical information. I am sure it would be much easier to write about the less-known and certainly deserving Elihu Thomson, simply because Thomson wrote more clearly and more factually. And Thomson also had the grace to cite[1] the earlier work of Rowland in 1889, who used a Ruhmkorff coil as high voltage source. Classen seemed to be doing much the same in Germany in 1890[2], but more effectively by using an air-blast on the high-voltage spark. Classen acknowledges Rijke[3] (1862) for this idea, one of the most fruitful contributions to the technology of spark transmitters, as far apart as Australia and the Eiffel Tower. Its widespread application may actually have been helped by the difficulty of establishing patent rights on a blast of air! Tesla's patent agents neatly avoid this kind of problem in his patent 645,576 of 1900; for they were wise enough to include a disclaimer on the actual apparatus itself. I suspect that this may well have helped the Supreme Court to find in his favour, even if his claim seems to have little technical merit to support it.

Desmond Thackeray
University of Surrey
Guildford

Rerefences

1. *Electrician*, *44*, (1899, Nov. 3), 40, Elihu Thomson
2. *Annalen*, *39*, (1890), 647, H. Classen (reference supplied by Alan Douglas)
3. *Pogg. Annalen*, *117*, (1862), 276, Rijke

IT'LL DO, PERHAPS

I was very interested in the August letters headed "It'll do – or will it?": so much that I have felt impelled to join in the argument.

Mr Feeney complains, quite rightly, about two faults which he feels should not have happened. The replies are jewels of their kind and should be framed and hung in every sales manager's office.

Mr Bennett carefully evades the main issue in the design he is defending. Surely he can see that if a fuse goes high resistance, for any reason, and by doing so causes damage to the components it is supposed to be protecting, then the design is at fault. The bit about this being the only case that they know about is a refrain heard so often by purchasers of electronic equipment in this country that the majority of us can join in after the third or fourth note. His last line is worthy of further study. Why was production stopped? Perhaps the product got a bad name for some reason or other and didn't sell too well.

Mr Topping's reply is a much more upmarket version. Here again there is not the slightest intention of accepting the criticism and doing something about it. Instead we are treated to a short advertising blurb, followed by praises for the designer of the self-destructing amplifier (again the main point is evaded. A fuse should protect by its absence, not destroy), and we discover that the design in question had a market life of only four years. All interesting stuff to an industrial archaeologist no doubt, but it doesn't make the product any better.

Following this excursion Mr Topping finally gets down to his own product. In the first paragraph on this subject he appears to accept full responsibility for the equipment, in spite of it being of Japanese manufacture. This is as it should be. If you sell a product, it is your responsibility. Full marks here. But what follows? An argument based on what is known as the absent authority. The authority in this case is the specification referred to and it is absent because Mr Topping keeps it so (presumably with good reason). Again the main point is evaded. The switch failed, Mr. Topping, and any number of closely typed bits of paper won't change that fact. The moral of all this is plain to see. Complain to a British manufacturer and if you get a reply at all it will be one of the above. I worked with electronic instruments for nine years at one factory and felt that the society of psychical research would have been interested in the number of unique events which happened to us. At no time can I recall a single manufacturer offering to do something about it.

I suggest that the manufacturers take note and listen to their customers while they still have some, or they will go the same way as the cotton mills and motor bikes.

H. E. Hicks
Nether Kollett
Lancs

AMATEURS AND CB

Contrary to Mr Clayton's assertion (Letters, *Wireless World*, August, 1982) illegal broadcasting stations *are* traced and those involved *are*, where possible, prosecuted.

Mr Clayton was certainly misinformed if he was told – not by Home Office officials incidentally – that the Home Office would not authorise prosecutions. We do. A pity that you did not check this allegation with us.

In 1981, nine such stations were involved in successful prosecutions and 14 people were convicted; further prosecutions are being undertaken this year.

A. Wood
Chief Press Officer
Home Office

DIGITAL CONTROL OF THYRISTORS

I read with some interest the article by Dr Pardoe on digital phase control of thyristors (*WW*, Sept. 1982, p. 45). The system has some similarity with that described in the article by myself and N. M. Allinson (Microprocessor Controlled Lighting System – *WW*, April 1982, p. 36). Since our article was concerned with lighting control desks rather than lighting dimmers, I would like to take this opportunity to expand on the principles of phase-control dimmer design.

Our first article described the complex non-linear relationship between conduction angle and the perceived light output. Since the function is very difficult to synthesize using analogue methods, most analogue dimmers I have come across use a linear ramp. This allows the ramp generator circuitry to be kept quite simple and easy to align. Since the mains voltage and frequency is subject to variation a simple open-loop generator is not adequate. To overcome these problems the ramp generators are enclosed in a negative feedback arrangement which allows stabilization of both ramp height and linearity. Using components of reasonable tolerance and a reasonable circuit design, analogue dimmers can be built which require no adjustments.

The major problem in designing lighting dimmers is arranging for all channels to track each other; this is readily achieved by using one ramp generator (or its digital equivalent) to drive many comparators. The ramp generator can then be made quite sophisticated without increasing significantly the cost of the system. The article by Dr Pardoe uses a separate oscillator and counter arrangement for each channel. This oscillator frequency is not locked to the mains frequency and is dependent upon the tolerance of two passive components. Assuming that the oscillator is running at 50 Hz, a 2% variation in mains frequency will result in the loss of 2-3 bits at the maximum power end of the control range. Given a 5% tolerance in the components used in the oscillator circuit will give to a rough approximation a 5% tolerance in oscillator frequency which is well outside frequency limits permitted on the mains supply. The most marked effect on the oscillation frequency tolerance will be poor tracking between separate channels on the mid power control range when $dL/d\phi$ is at its greatest where L is luminous intensity and ϕ conduction angle (See *WW* April 1982, p. 37, Fig. 4).

As Dr Pardoe points out, in order to eliminate motor creep and light flicker the ramp generator (analogue or digital) must be synchronized to the zero volt crossing points of the mains. The trial trigger circuit shown by Dr Pardoe does, in fact, produce one pulse per half mains cycle; whilst this trigger method is entirely satisfactory for essentially resistive loads (lamps, heaters) it is inadequate for inductive loads. When switching inductive loads, current will still be flowing through the switching devices at zero voltage crossing points of the mains. Since a simple pulse may occur during the 'reverse' current period incorrect operation would result. This problem may be overcome by using a train of gate pulses and, to prevent spurious triggering, no gate pulses should occur between the zero crossing point of the mains and the desired trigger point.

The equation given for the current in the primary of the pulse transformer is correct; however, the energy stored in the pulse transformer is dissipated in the diode across the primary. Assuming a suitably rated transistor, removal of the diode will allow the stored energy to produce additional gate drive.

While Dr Pardoe's circuit does provide a simple and cheap means of digitally controlling conduction angle in phase control, I would not recommend its use in a multi-channel system because of the tracking problems already mentioned. Additionally in a multi-channel system I believe that a solution based on our article would produce a cheaper system, since only one oscillator and counter are used for many channels and there will be no possibility of resolution loss.

J. D. H. White
University of Keele
Staffordshire

CITIZENS' BAND

I would like to reply to Mr Briggs and Mr Hewlett in July Letters: I will deal with the main points only.

When Mr Briggs says that there is nothing political about the CB pirates, what he means is that there is nothing *consciously* political about them. Nevertheless, whether they know it or not they are engaged in a political act; which is a revolt against an arbitrary power which had wrongly denied them a CB service.

I agree that not all CB users are young and that the f.m. service does have some technical merit. I did not mean to imply otherwise and I am sure Mr Steedman didn't either.

I am accused of being petulant, which means complaining and impatient; but if more people were impatient and complained abour problems a lot more fiercely then the problems would be solved a lot more quickly.

Mr Hewlett says that he can "get enough of the other thing" from the rest of the media, but as far as CB is concerned this does not appear to be true. I am not aware that any other part of the media has discussed the true causes of illegal CB interference, so if *WW* did not discuss them they would not be discussed at all; and the chance to learn from the experience would be lost.

In my letter in the March issue I was trying to make a very serious point, which is that the interference caused by illegal CB has a political cause; and that part of that cause is the tyranny of an unelected, unaccountable, unscrupulous higher-civil-service, which is immune to rational argument. Jo Grimond, MP, has described the civil service in the following way; "Rigid, non-elective, hierarchical, cautious, secretive, conformist, narrow, furthering the interests of an apparatus and the careers of those within it."[1]

Now let us see how this is relevant to the CB issue, and let us begin with a principle laid down by Burke 200 years ago;

> "Those who give and those who receive arbitrary power are alike criminal, and there is no man but is bound to resist it to the best of his power . . . It is a crime to bear it when it can be rationally shaken off. Law and arbitrary power are in dreadful enimity."[3]

The public service exists for the public; not the public for the public service. This means that if a citizen asks a public servant to do something the public servant must do it or show cause why not or resign. If he does none of these things he neglects his duty and should be disciplined or sacked.

A CB service was first requested in the mid-1970s, but the Minister and Parliament were too busy to look into the matter and so it was left to civil servants to decide.

The officials concerned neither gave permission for CB nor gave a good reason why not nor resigned. They therefore neglected their duty and exercised abitrary power. The people who wanted to use CB then had no choice but to take direct action, and in so doing they were merely obeying Burke's dictum. They were resisting the arbitary power of the Home Office to the best of their ability; and it would have been a crime to have borne it when it could be rationally shaken off.

S. Frost
Edinburgh

References

1 Community Politics, 1976, p. 138
2 "Rule of Law," Conservative Political Centre, pp 19 & 39.
3 "Rule of Law," frontspiece.

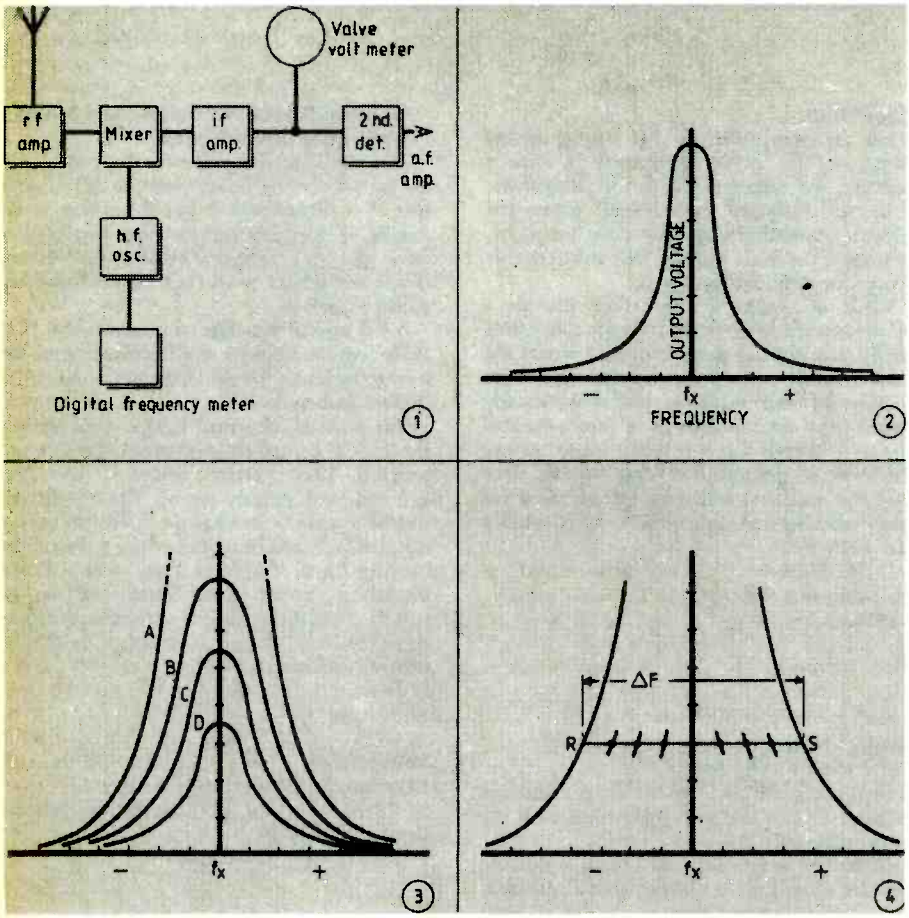
SPREADING

My letter in the October 1981 issue on the above subject has provoked some comment in subsequent issues, and that is a good thing.

Some correspondents have made the mistake of confusing the subject of "splatter" with the subject of "spreading". Until the amateur radio movement recognises that the two phenomena are separate and distinct, and learns to study each phenomenon separately and in isolation, they will not come to a proper understanding of either. My letter in the Oct. '81 issue, acting on the principle of "one thing at a time", referred to spreading – just that – and it would be desirable to confine discussion for the present to that subject.

Now, so far as spreading is concerned, I am saying that a single-sideband transmitter properly and correctly operated and occupying no more than 3 kHz of spectrum space, may nevertheless *appear* on a receiver, if assessment is made by S-meter readings in conjunction with dial frequency calibration, to be occupying *more* than that space, possibly much more; I am saying that this is *not* because the transmitter is radiating energy over the wider band, but is due to an effect in the receiver itself due to a combination of the effects of selectivity and a.g.c. There can be no doubt about the truth of that statement. It can be demonstrated by mathematical analysis and verified by experiment; there is also a fair bit of secondary evidence which backs it up.

Once the truth of this proposition is accepted it must necessarily follow as a corollary that it is impossible to tell from S-meter readings and dial calibration (with no other evidence) *how much* spectrum space a transmitter is actually occupying.



Consider the following simple exercise as an aid to thought. Refer to Fig. 1 which shows an elementary receiver to which has been added a digital frequency meter connected to the h.f. oscillator, the S-meter having been replaced with a vacuum-tube voltmeter or similar instrument as shown. Assume further that there is a crystal oscillator on the bench some short distance away putting out a signal of comfortable strength. The receiver is operated in the first instance without the benefit of agc, that is to say, under manual r.f. gain control.

Tune the receiver across the crystal frequency and plot output voltage (read from the v.t.v.m.) versus frequency, maintaining the receiver at a constant level of sensitivity. You will obtain a curve rather like Fig. 2. This is a selectivity curve for the receiver under this set of conditions. There is a whole family of such curves, and the parameter of the set of curves is the r.f. gain of the receiver, howsoever it be defined quantitatively. To emphasize this point I have shown (Fig. 3) four such curves A, B, C and D, extracted from the family, in descending order of receiver sensitivity.

Switch on the a.g.c. and tune across the crystal frequency f_x as before, commencing well below f_x and proceeding to well above f_x. Coming along the curve of Fig.2 (re-drawn in Fig. 4) you proceed to the point R. Here the a.g.c. takes control, the point R being determined by the voltage-delay of the a.g.c. system. Tuning higher in frequency the a.g.c. maintains the output constant, until finally we exit from the control of the a.g.c. at point S and continue along the original selectivity curve. Someone, expert in the Red Herring Department, will want to argue with me about the practical niceties of a.g.c.; some other time, please!

The output meter shows substantial output across a band of frequencies Δf. This does *not* mean that the transmitter under scrutiny is actually radiating energy across the whole of the band Δf. The transmitter (in this case a crystal oscillator) is radiating energy on *one* single frequency only, viz. f_x. Only a very stupid person would attempt to argue that, because the output meter shows a substantial reading across a band of frequencies, this is proof that the transmitter is transmitting over the whole of that band of frequencies.

What has all this to do with a single-sideband transmitter? If you can understand the above reasoning, then you can understand why a single-sideband transmitter radiating over a 3 kHz bandwidth can provoke your S-meter to a substantial reading over a band of 8 or 10 kHz, or even more: the principle is the same in both cases.

One further point – I should have said earlier that when you traverse the section RS in Fig. 4 as described above you are in effect hopping from one selectivity curve to another. This is indicated in the sketch. There is, of course, an infinite number of such curves, so that it is a smooth transition.

And finally – you will note that if you turn *up* the r.f. gain and allow the a.g.c. to control the receiver, the impression of broadness is enhanced, because you are working across a curve such as A (Fig. 3). But if you turn *down* the r.f. gain control the *apparent* broadness is reduced, because you now work across a curve such as C or D. A single-sideband transmitter will exhibit the same effect – naturally – and the effect may easily be observed by a competent operator.

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N.S.W.

WIDE-RANGE NOISE GENERATOR

With reference to Mr Ian Hickman's article in the July 1982 issue of *Wireless World*, I should like to suggest that if the 28-stage digital noise generator really works with a shift register pattern of $2^{28}-1$ different states (the maximum length), this can only be the case because theoretical limitations are compensated by electronic anomalies. Obviously, these "shortcomings" may go completely unnoticed in practice and therefore the object of my letter is not to imply that the design is incapable of producing a wide range of very useful and interesting noise effects. Nevertheless theory and implementation (however elaborate) of this shift-register application show several doubtful points worth mentioning. In this respect it is, for instance, revealing that the practical implementation as given in Fig. 3 does not indicate where the second Ex-Or-input comes from. A correct feedback configuration is far more difficult to find than is suggested in the mathematical "explanation".

The first incorrect statement is that in the general case a maximum-length sequence can always be obtained by using an Ex-Or gate with two inputs only: one from the last register stage, the second from "the correct earlier stage". This applies only to shift registers with up to seven stages, but the 8-stage case already invalidates the above "theorem". When an 8-stage implementation is used, eight different feedback configurations can be envisaged. In each case let us examine the sequence starting with the 11111111-state, the Ex-Or output determining the first bit (most left).

With both inputs coming from the 8th stage (most right), the Ex-Or will always turn out a zero and the sequence will never come back to the 11111111-state again; with the second Ex-Or input connected either to the 7th or to the 1st stage output, the sequence will have a length of 53; using either the 6th or the 2nd stage output, the sequence will have a length of 217 (which is still far less than the maximum $2^8-1=255$); finally using the 4th stage output, the pattern will have a length of only 12. As a matter of fact, maximum length shift register sequences can always be obtained, but the feedback function should generally apply to more than just two stages.

The second erroneous statement is that the maximum-length pattern will establish itself, provided at least one of the shift register stages comes on with a 1-output. Let us once again consider the relatively easier case of an 8-stage shift register and let the feedback function be taken from the 8th stage and the 5th stage. It can now easily be discovered that four different sequences are possible: one is 217 long and contains 1111111, the second is 31 steps long and contains the 11111011-state, the third is seven steps long and contains 10011101, the last one is the indefinitely repeating 00000000-state. When the shift register operating conditions are normal, one sequence (e.g. the one which contains the 11111011-state) will never jump to a different sequence (e.g. the one which contains the 11111111-state).

This clearly demonstrates that much more careful analysis is needed in order to establish whether in the particular case of a 28-stage shift register the maximum-length sequence of $2^{28}-1$ can be obtained with an Ex-Or gate having only two inputs! By the way, a full 2^N sequence can also be obtained, but this requires a feedback function a little bit more elaborate than just an Ex-Or array connected in a parity check configuration!

The two misinterpretations should immediately have come to the mind of the author when he observed the (unexplainable?) peculiar circuit behaviour (long start-up effect, periods of silence alternating with hiss, apparent jumps from one sequence to another etc. . . .). May I suggest this could probably be explained by shortcomings in the circuit design (e.g. power supply rating too low, or decoupling near the i.cs insufficient, or spike pick-up by the unconnected gate inputs supposed to be at the high level, or wrong time constants giving long lasting amplifier saturation effects after power turn-on, . . .)?

More detailed information on the actual circuit layout might have been helpful, together with photographs and oscillograms. I doubt very much whether this circuit is easily reproducible! Faulty operation may arrange matters!

Maybe Mr Hickman could reveal the actual feedback function, as it should have been indicated in his Fig. 3, in order to obtain really the longest sequence (starting with the all-zero condition when an Ex-Or invert gate is used) . . . It would also be fruitful to analyse how much this longest sequence is actually off the maximum length of $2^{28}-1$. Even if the difference between projected and actual length turns out to be small, it should still be emphasised that the electronic implementation wouldn't fully exploit the lower frequency range, the values of the coupling capacitors in the filter, attenuator and output circuits as shown in Fig. 4 are too small, except for exclusive audio use: when the filter is set to 10Hz low-pass, the result is actually rather a band-pass! In applications other than audio this might limit the circuits effectiveness.

One might ask the question whether, for audio purposes, a shorter shift register wouldn't have given comparable results when designed correctly! Apart from these remarks, fundamental from a theoretical point of view, it goes without saying that Mr Hickman's circuit can be very instructive for musical applications.

G. J. Naaijer
Louviers
France

The author replies:

Before dealing with the points raised by Mr Naaijer I should like to correct one or two minor graphical errors which crept into the article as published.

In Fig. 1(a) the second input to the exclusive Or gate should be labelled "From m^{th} stage Q output", where m is of course less than n.

In Fig. 3, the input to pin 12 of IC_{10} should come from pin 13 of IC_8.

In Fig. 4, R_{35} and R_{36} are the two sections of 22kΩ twin-gang potentiometer, and references to R_{35} or R_{36} in Fig. 5 and throughout the text should read "R_{35}/R_{36}".

The references to "R_{34}" in the 25th line of the third column of page 40 and in the last two paragraphs of the article should read "R_{35}/R_{36}".

The negative end of C_3 in Fig. 6 should go to 0V chassis.

The author should have made it clear that following normal practice, all unused gate inputs in Fig. 3 are returned to +5V via a 1kΩ resistor.

Turning now to Mr Naaijer's letter, he questions whether a shorter shift register would be adequate. A 28-stage register was arrived at from the following considerations.

It was desired to have white noise with a Gaussian amplitude distribution available to as high a frequency as conveniently possible, say 100kHz. It was clear that the necessary number of stages would be of the order of 25, and a modest clock frequency of around 5MHz is convenient when using a simple And gate oscillator employing standard t.t.l. gates. As stated in the article, Gaussian noise is obtained if the sequence is filtered with a cut-off frequency lower than f_{clock}/n, i.e. lower than 5MHz/25 or 200kHz. Thus Gaussian noise is available up to about 100kHz as required. At the low-frequency end of the range, the frequency of the lowest spectral line in the output is of little interest in itself: the important consideration is the spacing *between* spectral lines at the lowest frequency of interest. This was taken as 10Hz, and the possibility of external bandpass filtering with a Q of 100 was catered for. The 3dB bandwidth would then be 0.1Hz. Now using SN7495s, six devices would provide a 24 stage register and the maximal length pattern would repeat at approx. 0.3Hz. Thus the spacing between the spectral lines would be greater than the filter bandwidth and the noise would not (in this admittedly extreme case) appear white.

Adding a seventh 7495 provides a 28 stage register, giving a spacing between spectral lines of 0.02Hz, which is quite adequate. It is interesting to note that Beastall, in his white-noise generator design, published in *Wireless World* in March 1972, used a 31 stage register (although 32 stages were available in the i.c.).

The purpose of the article being to describe the design and use of a white noise generator, the subject of maximal length shift registers was touched on only very briefly. The article did not, or was not intended to, imply that for any length shift register, two suitable tappings can be found to give a maximal length sequence with a single Ex-Or gate. This is not always the case. I admire Mr Naaijer's industry in working through all the possibilities for an eight stage register, but a correct feedback configuration is not, as he suggests, difficult to find. It is simply derived from any of the tables of irreducible polynomials published in the literature. These do not bear out Mr Naaijer's statement that "the feedback function should generally apply to more than just two stages" except in the sense that there are numerous possible feedback arrangements for most register lengths, all giving maximal length sequences. However for register lengths of 2 to 34 stages inclusive, there is a single Ex-Or configuration giving the maximal length sequence in 20 cases, including 28 and 31 stage registers. The remaining 13 cases require three or more taps, including lengths 8 (as noted by Mr Naaijer), 24 and 32. For length 28 the correct taps are stages 28 and 3 or stages 28 and 25; the one arrangement provides the same maximal length sequence as the other but with the bit sequence in the reverse order.

It is not always realized that the maximal length sequence is not unique. Even a register as short as five stages can (with the appropriate feedback arrangements) produce six different maximal length sequences, though only one of these (plus its time reverse) can be obtained with a single Ex-Or gate feedback arrangement.

Mr Naaijer has pointed out that there is a problem with the circuit as published, and perceptive readers will have noted the cause. On rereading the article it was immediately apparent to me that if the arrangement produced the intended maximal length sequence, then the sequence would commence immediately. For, ignoring the degenerate 'all-zeros' case, any other possible combination of register contents at switch-on is by definition a valid member of the maximal length sequence, which will therefore continue from that point. The problem was the tendency of the register contents to come up as all-zeros at switch-on. A section of IC_{10} was therefore included as an inverter with the intention of making all 1s the degenerate case, but unfortunately this does not have the desired effect. One could alternatively use the correct Ex-Or gating instead of the Ex-Or arrangement shewn, and arrange to load a 1 into at least one register stage at switch-on. But a simpler modification which I have tested and incorporated is to invert the *inputs* to the Ex-Or gate as well as its output. With this arrangement, the all zeros case in the register looks like the all 1s case to the Ex-Or gate, and the circuit commences the maximal length sequence immediately as expected. By connecting R_2 directly to pin 10 of IC_8 instead of pin 6 of IC_{10}, two spare Ex-Or gates are available and these were used to invert the outputs of stages 25 and 28 of the register, i.e. pins 13 and 10 of IC_8.

I do not know how long the non-maximal length sequence produced by the circuit as published is, but it must be said that none of the brief tests I was able to conduct in the frequency domain could distinguish between the noise produced and that produced using the correct maximal length sequence. Nevertheless I am grateful to Mr Naaijer for pointing out the snag, to which there is, as I have indicated, a convenient and simple solution.

OPTO-ELECTRONIC CONTACT BREAKER

In your Letters column of September 1982 Stevenson complains that he was unable to obtain the i.c. specified for my opto-electronic contact breaker, and transformer for Rod Cooper's c.d. unit.

I can assure him that in the case of the i.c. that component is crucial to the reliability of the circuit. I have written before in *WW* that the environment in which automotive electronics have to work is far from ideal, and it is not unreasonable to specify a 54-series device in an engine-mounted application. Like Rod Cooper, I am conscious of the need to specify obtainable parts, but there is a converse argument which suggests that sticking to parts from the corner shop stultifies design. This notwithstanding, I wrote on p.67 of the February 1982 issue the name of a Texas Instruments supplier (Quarndon Electronics) and many more spring to mind. Quarndon were kind enough to confirm today by telephone that the SN5401N is in stock and available to anyone.

If one assumes that Stevenson missed the February issue, I would still question whether he had exhausted all possibilities until Rod and-/or myself had been consulted. Criticism for failing to provide that for which one has not been asked is hard to accept. Mr Stevenson should be aware that, as authors, we cannot hope to satisfy everyone all the time, but we do feel responsible for our designs, and can usually help.

J. R. Watkinson
Reading

DISC-DRIVE CONTROLLERS

Control logic, the penultimate subject in the disc-drive series, divides into data-handling and drive-coordination sections. These sections, and how they are controlled by sequencing logic, are discussed here.

by J. R. Watkinson

Essentially, disc-drive control logic does not vary much from one drive design to another, but because of the wide price/performance range and changes in technology, one cannot assume that all the features mentioned here will be found in all disc-drive units.

Control logic can be thought of as having two main sections – one for controlling the disc subsystem, including circuits for obtaining subsystem status information, and the other for handling data to be stored or retreived. These sections are coordinated by sequencing logic.

Execution of a function by the disc-control logic requires a complex series of steps determined by logical decisions made between each step. Sequencing logic resembles a processor with subsystem functions as instructions and the steps as states.

As with central processors, sequencers can be implemented either with combinational logic or with rom-controlled microsequencers, but unlike c.p.us, sequencers have to work in real time and keep in step with the disc's rotation. Figure 1 shows the essentials of a rom-controlled sequencer.

Control and status. Excluding operator controls, disc drives are controlled entirely by functions and parameters loaded into registers in the subsystem. How the registers are loaded is not unique to disc drives and is therefore not discussed here.

Table 1 shows a list of functions performed by a typical disc subsystem and Fig. 2 depicts the most common functions, read, write and write verify. In Fig. 2(a), the disc is altered by data being read from memory and written into it, and changes in memory occur when data are read from the disc, Fig. 2(b). Neither memory nor disc is altered when written data are being verified. In this operation, data are read from the disc and compared word-for-word with data in memory.

Not all disc subsystems have the verify function; in some computer systems data verification is carried out by the main processor at the expense of some processing time.

Figure 2 also illustrates parameters necessary for a data transfer, namely the starting address in memory, the starting address on the disc, and the amount of data to be transferred.

Figure 3 shows a typical register set for a disc subsystem. Most units use direct-memory access (d.m.a.) techniques to transfer data to and from memory without involving the processor. To do this, the d.m.a. logic needs to know the physical starting address of the memory area to be affected by the transfer. This address is loaded into the memory-address register which increments automatically every d.m.a. cycle so that sequential memory locations are accessed. A word-count register controls the amount of data to be transferred. As it is relatively easy to detect when a register contains zero using hardware, it is often arranged to load the two's complement of the desired word count into the register, which increments every d.m.a. cycle. When the register overflows to zero the transfer is complete.

The starting address of a selected disc must be specified in three dimensions, namely desired sector, desired head and desired cylinder. One disc transfer may consist of many contiguous disc blocks, and the desired disc address registers can be arranged to increment as each block is completed. As the disc turns, the desired sector address increments first, until the highest numbered sector is reached. When this block is completed, the sector address is reset and the desired head register incremented. The next track is now in use. This process may continue until the highest numbered head reaches the highest numbered sector. In this case both desired head and sector registers reset and the desired cylinder address increments.

Not all units have this feature. The change in cylinder address causes a cylinder difference signal and implies a seek (explained in the May issue of *Wireless World*). Before the transfer can continue

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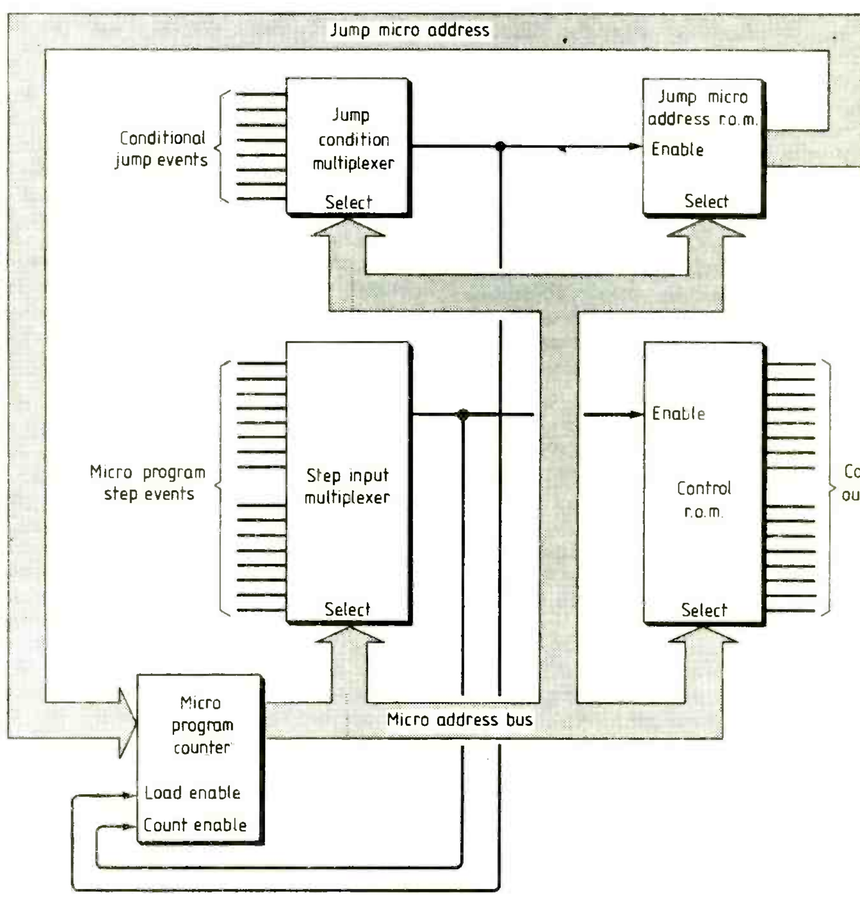
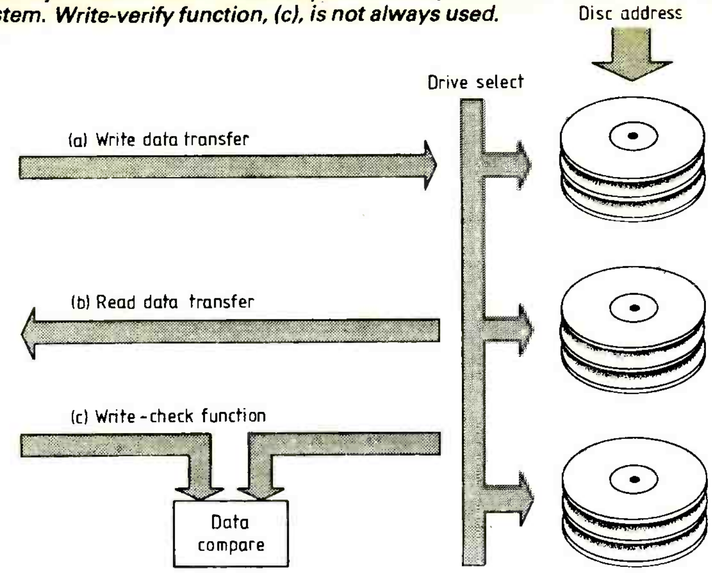


Fig. 1. Disc-control sequencer using rom control. Each address generated by the program counter results in one or more control signals being sent to the system. At the same time the event which causes the program to advance to the next step is selected by the input multiplexer. Certain addresses cause a conditional jump and if the conditions are satisfied, a new non-sequential address is loaded into the program counter from the jump-address rom. More advanced units have stack registers enabling them to call subroutines and return afterward.

Fig. 2. Three major data transfer functions performed by a disc subsystem. Write-verify function, (c), is not always used.



the positioner has to move on to the next cylinder. The process is only terminated by a word-count or disc-address overflow.

Disc drives work with blocks of data, and hardware is necessary to prevent malfunction if a specified word count is not a multiple of the block size. When reading, if the word count overflows before the end of a block, the transfer to memory stops but the drive continues to the end of the block to read the error-checking character there. When writing, the disc-control logic pads a partially written block with zeros to retain the standard disc format before the check character. The purpose and operation of check characters will be discussed in the next article. Figure 4 shows the flow-chart for the automatic disc-address incrementing algorithm.

Status circuits give the operating system information about the operation of the drives. The boundary between control and status is difficult to define, since the status path can be thought of as a feedback mechanism for the control process.

On completion of a data transfer function, the status circuits inform the operating system that the disc subsystem is no longer busy by way of an interrupt; as with d.m.a. techniques, the c.p.u. is not involved with the data transfer and will be performing useful processing. Following the interrupt, the operating system will read the disc subsystem's status register. If all is well, a ready bit is set, but in the event of a malfunction, an error bit will also be set. There are many conditions which could cause such an error signal. The error bit in the status register is an OR function of all of them, referred to as the composite-error bit.

In a 16-bit system, the ready and error bits are often bits 7 and 15, since these are the sign bits of the low byte and the word respectively. Using 'test' or 'test-byte' instructions, the processor status word will become negative if the sign bit is set. A conditional branch instruction whose outcome is determined by the processor status is then used to determine the program flow. When an error occurs, the system branches to a routine to read the subsystem error register to find out what has gone wrong.

In the case of a non-data-transfer function, such as a seek or search, the drive will become ready when the operation is complete. Non-data functions can take place simultaneously with a data transfer in a multi drive subsystem, and upon their completion it is necessary to know which drive has become ready. This could be achieved by selecting each drive in turn using the unit-select register in a process

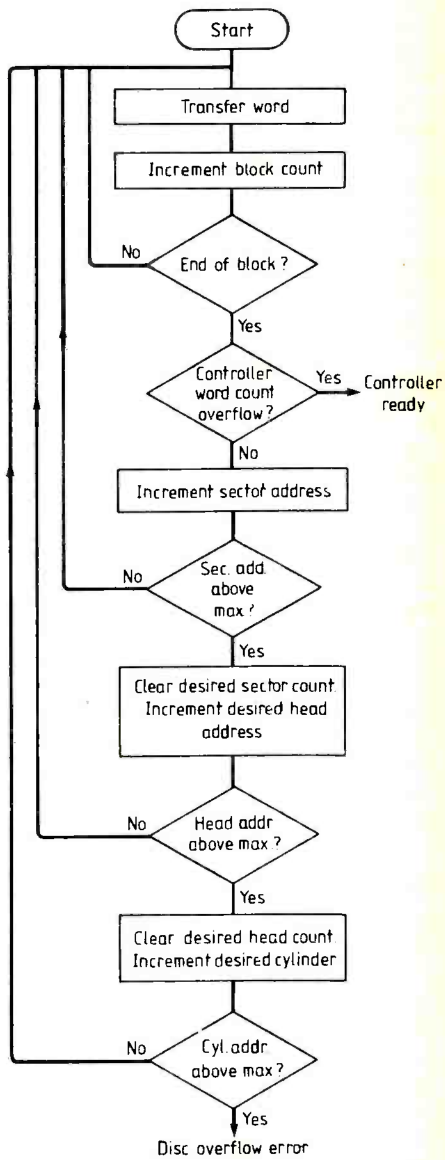


Fig. 4. Disc transfers may extend over several disc blocks without the need for each one to be addressed individually. The disc address increments automatically as long as there are words left to transfer.

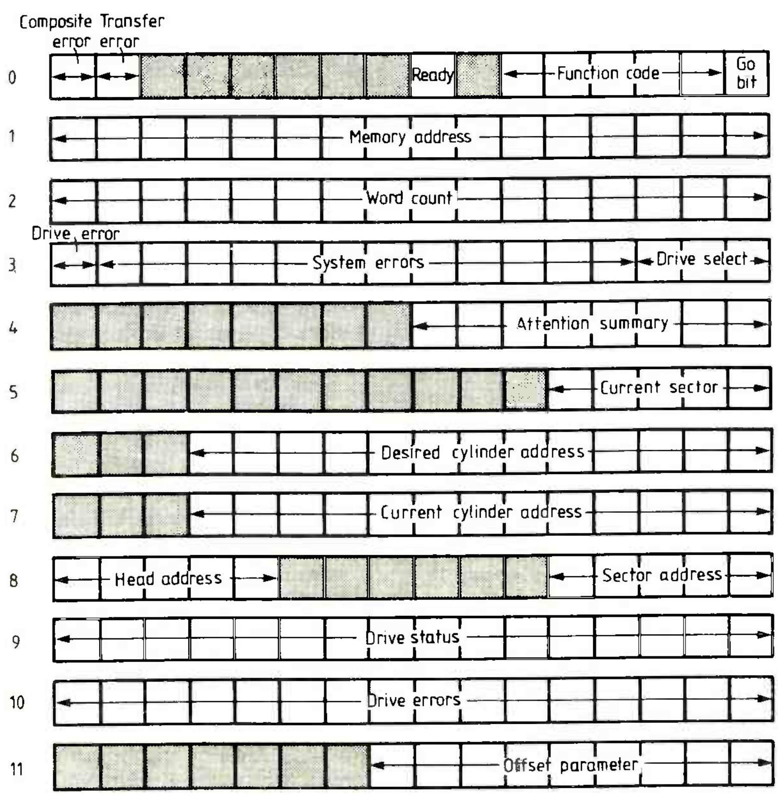


Fig. 3. Register set of a typical disc drive. Composite error is set by the change of state of an OR gate with inputs representing many possible error conditions.

known as polling, but this is wasteful of processing time. A better alternative is to use the summary register, which contains one bit position for each drive in the subsystem.

When a change of status occurrs in one or more drives, a bit pattern is present in the summary register. Any bit present here will cause an interrupt, and the system has only to read the summary register to find out which drive requires attention. When one of the drives has a fault, the composite error bit will be set, as will a bit called drive error in the subsystem error register. If so, the unit number specified in the summary register has to be loaded into the drive select register. If the c.p.u. now reads the drive-error register, it will obtain the status of the affected drive. Figure 5 shows a typical service-routine flow-chart. Action taken as a result of an error varies from one operating system to another, but typically the error conditions would be recorded in the operating-system error log, and then attempts would be made to clear the error condition by issuing drive-clear or controller-clear commands. Positioning errors normally result in a recalibrate function prior to repeating the failed function.

Hardware failures, such as power-supply faults, cause the system to discontinue use of the drive concerned and send appropriate messages to the operator. Such a failure in the swapping disc will usually cripple the whole computer, as the time-sharing process cannot proceed. Action taken to recover from data errors will be detailed later.

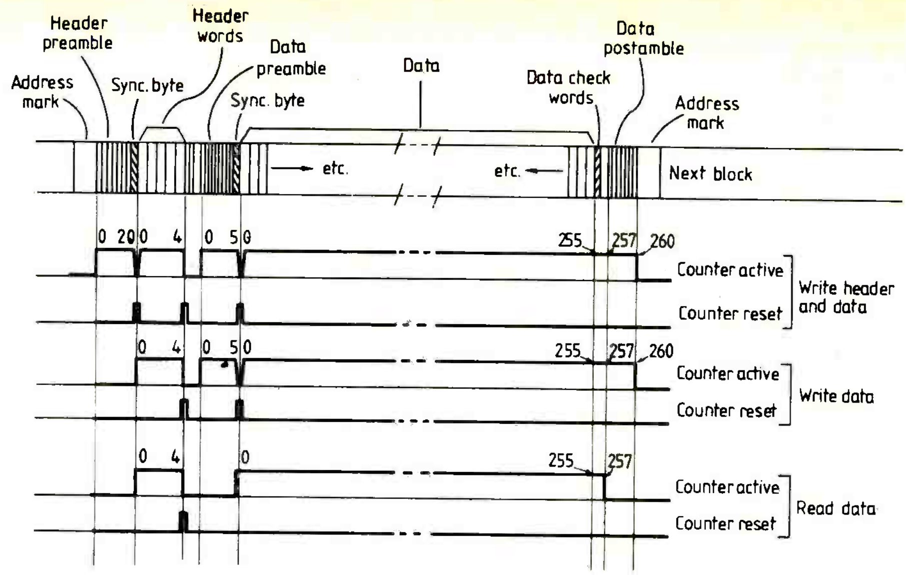


Fig. 6. *Format of a typical disc block in relation to the count process used to establish the head's position in the block at any time. During reading the count is derived from data read but during writing the count is derived from the write clock.*

Position verification. Before a data transfer can take place, the selected drive must physically access the desired disc block and confirm its position by reading the header. At the end of an implied seek, should one be required, the positioner circuits declare that the heads are on track and settled. The desired head will have been selected by the head matrix, and the next step is to perform a search along the track by comparing the contents of the current-sector, or 'look-ahead' register with the contents of the desired sector register. When the two are equal, the head is about to enter the desired block. Figure 6, the format of a typical disc track, shows that between blocks are placed address marks, which are areas of steady magnetization that generate no read pulses and can be detected by the read circuits.

Following address-mark detection, the data separator starts to synchronize to the header preamble. Any a.g.c. in the read channel will stabilize at this time. Toward the end of the preamble the data separator will be locked to the read signal and will generate zeros (assuming modified f.m.) and the separate bit clock.

Serial data is converted to parallel form by the serializer, Fig. 7, which is based on a shift register. The serializer also has the ability to convert parallel data to serial form for writing operations. Preamble zeros are clocked down the shift register in the serializer by the bit clock, and in due course the sync-byte's pattern shifts through and is recognized by the sync-byte decoder. When this takes place a divider is enabled, which divides the bit clock by the word-length to give a word count, or in some cases a byte count. The word count is decoded by part of the sequencing logic to enable the various steps which take place synchronously with the disc.

Figure 8 shows decoding necessary for the disc format shown in Fig. 6. The first

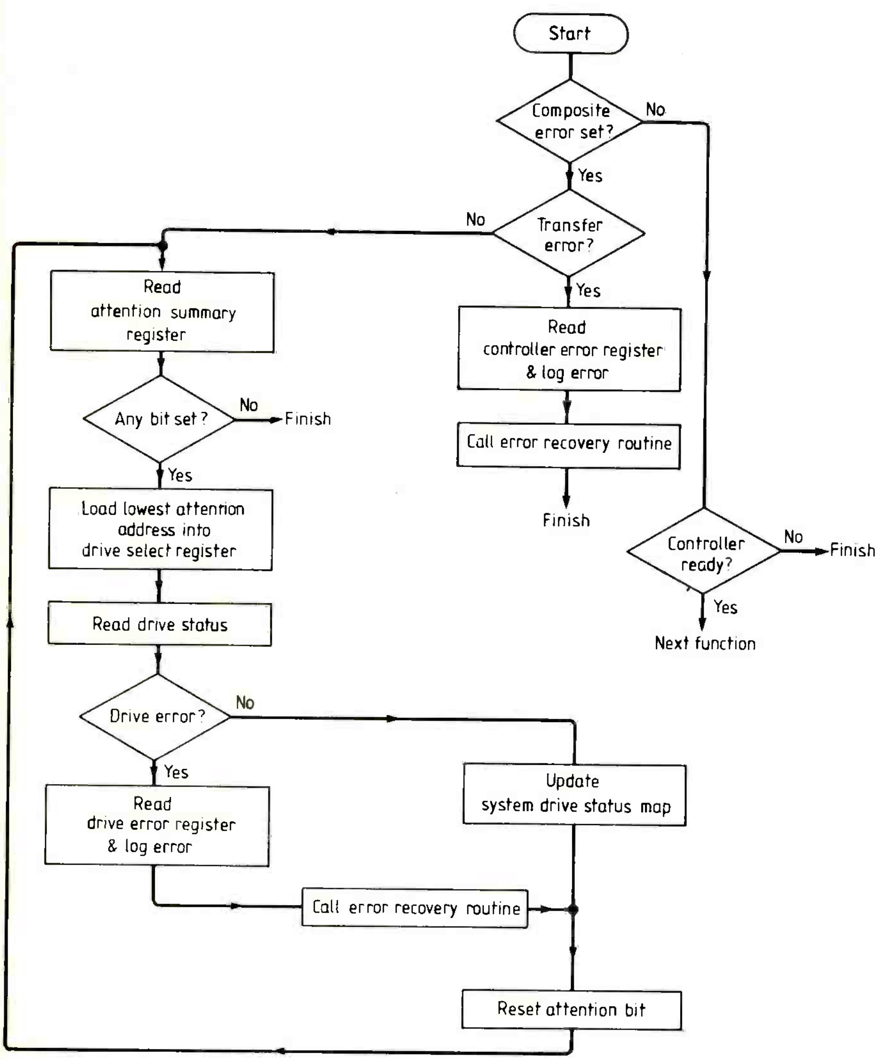


Fig. 5. *Flow-chart describing the handling of disc subsystem status registers following an interrupt. Interrupt may have resulted from the controller on data-transfer completion, from a drive completing a function not involving data transfer or from an error condition. More than one drive may have an attention condition at once.*

Table 1. Abbreviated list of functions performed by a disc drive. Only one data-transfer function can take place at a time, but other functions can be performed by different drives in the subsystem at the same time.

Function	Type
1 Read	Data-transfer function (see Fig. 2)
2 Write	
3 Write verify	
4 Read header (and data)	
5 Write header (and data)	
6 Seek – move positioner to new cylinder	Non-data transfer functions which may be issued to another drive at the same time as a data transfer
7 Search – interrupt when current sector is same as desired sector	
8 Recalibrate – move positioner to cylinder zero	
9 Offset – move positioner off track centre	
10 Return to centre line – cancel offset	
11 Port release – permit other port access to drive	
12 Standby – unload heads and stop spindle	

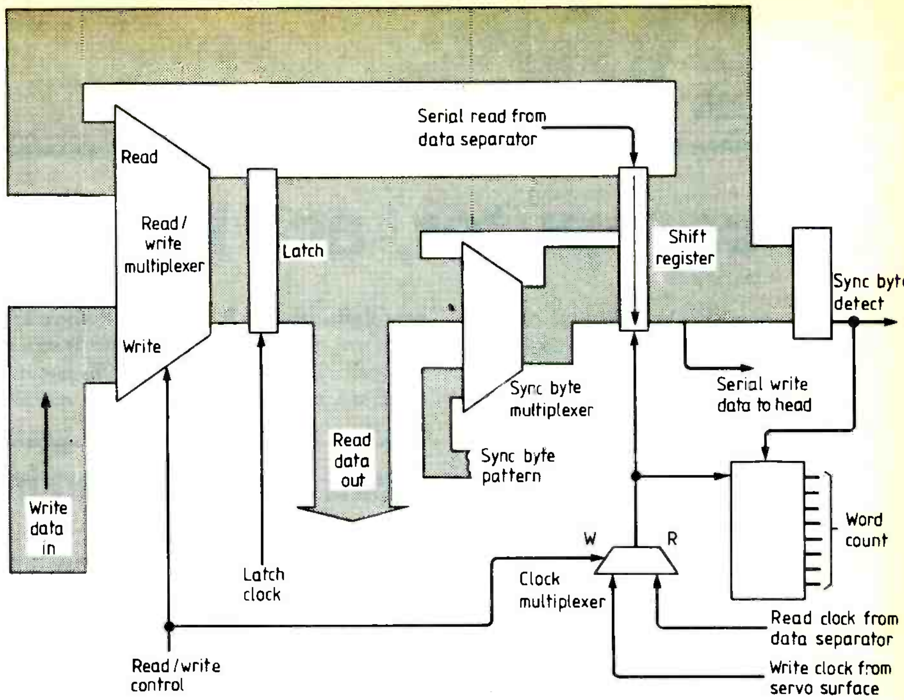


Fig. 7. Conversion between parallel data used by the computer and serial data used by the disc takes place in the serializer which reconfigures itself for either reading or writing.

header word is the cylinder address, and this is compared with the contents of the desired-cylinder register. The second header word contains both the sector and head addresses of the block, which are also compared with the desired addresses.

Some header formats contain extra information such as bits which specify the density of data in the following block, passwords which are used in high security systems and information about media defects in the data area. Each header finishes with a cyclic-redundancy check character which confirms its validity. Only if the header contained the right addresses and was read correctly will the data transfer take place.

Figure 9 will show a flow-chart for the process of position verification. Automatic reading of the header by the sequencer should not be confused with the read-header command used to place the contents of the selected header in the memory. This is usually only used after a write-header command, to verify that the disc has been formatted properly.

Data transfer. During a data block read, the serializer and sequencer are employed again. As with the header, zeros from the data preamble are clocked into the shift register until the sync. byte is detected, when the next bit will be the first data bit in the block. On every word, the output of the shift register goes around the loop in the serializer and is loaded into the latches. The d.m.a. logic now has finite time to send the word to memory before the next word arrives from the disc. When the word-count decoder decides that the last word in the block has been transferred, check words are sent to the error-checking logic. A description of this operation will be given.

During a write function, header checking is repeated as it is important not to write in the wrong place on a disc. A write process is a little more complex than the read because preambles, sync. bytes and postambles have to be written together with the actual data. To write the preamble, again assuming modified f.m., the serializer is held clear by the sequencer.

At the end of the preamble, the sync.-byte pattern is loaded into the shift register. Data words are then loaded into the shift register from memory in order to write the block.

To be continued

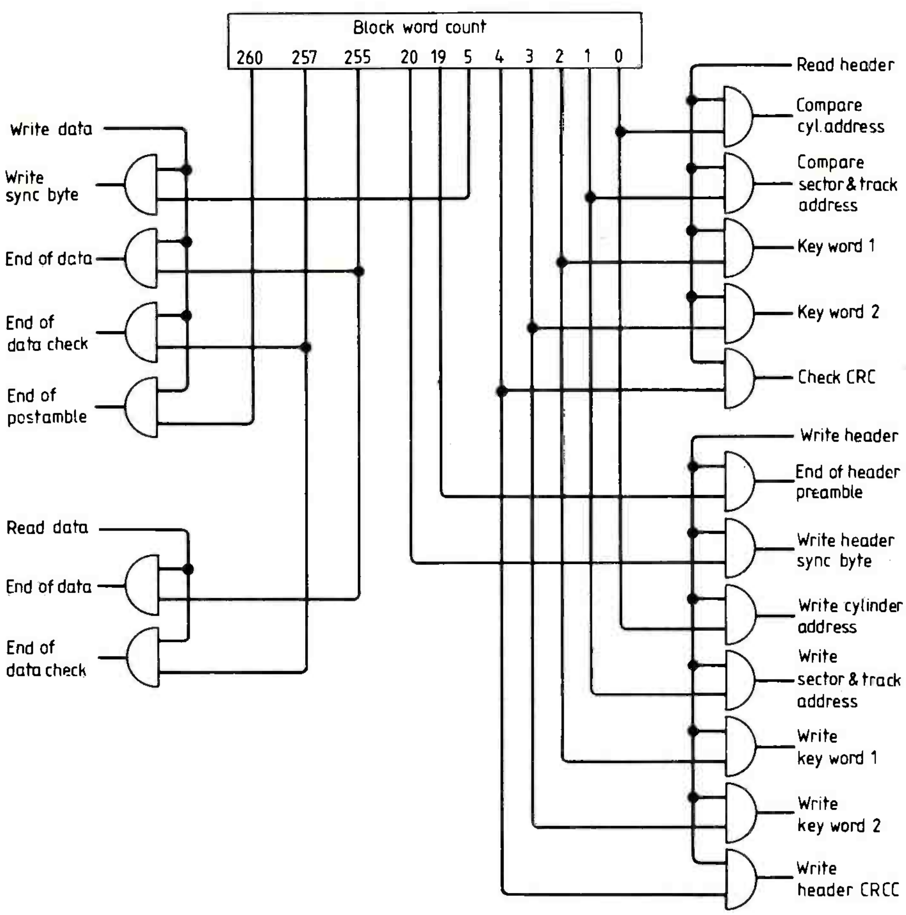


Fig. 8. Decoding for the disc format shown in Fig. 6. As the count is reset several times during a block, the same decoder can be used for a number of purposes. During writing, preambles and sync. bytes must be included but this is not necessary during reading.

Ace computer, ace language?

The most important characteristic of the programming language Forth is that it is a "threaded interpretive language", and not that it uses reverse Polish notation, as frequently reported elsewhere. But in terms of how a Forth computer is received it is interesting to look at Forth and how reverse Polish notation is used. The following analysis is based on experience with a pre-production prototype of the Jupiter Ace computer (News, October issue), and was sent to us by Boris Allan. "I hope the Ace succeeds," he tells us, "it is a very brave initiative, but I do not know whether it will; what I do know is that Ace Forth is the best implementation on small computer I have seen".

Reverse Polish notation seems to imply that it is in some way back-to-front – the accompanying description uses reverse Polish in the definition of F and so on, and the order does not seem unreasonable. It only becomes "unreasonable" when thinking purely numerically. To have to use 2 3 + to perform the calculation 2 + 3 may seem odd, though if it is introduced as "take 2 then 3 and then add them together" then it is much more reasonable. Though Forth is very useful for the numerical, its strengths become more apparent at a higher level of abstraction; yet the Jupiter Ace is aimed at the cheap end of the market. So to what extent is the strange mode of approach a problem?

It is only strange if it is approached in a way which makes it *seem* strange – the definition of the Forth word "F" (see panel) does not seem strange. The operation 2 3 + only becomes strange when we say that it is equivalent to 2 + 3, and not when we say that it is equivalent to take 2 and then 3 and add them together. This strangeness is not long-lasting.

A far more important problem with Forth is the ways in which restrictions are placed upon defining and redefining words, and it is the complexity of these manipulations that are far more telling for Forth as an introductory language. To make it easily usable, the defining, redefining, and editing of Forth words needs conceptual simplification. This is where the Ace scores over most other systems.

Ace Forth introduces new words EDIT, LIST, and REDEFINE, which make the changing of Forth words simple for the user. LIST F would produce BAR BLIP BAR BLIP BLIP CR and EDIT F would produce a similar listing, and allow one to edit the listing. After editing there would be an extra version of F on the VLIST (the new version), and if we then entered RE-DEFINE then Forth would search through the words in the dictionary (ie those on the VLIST) and substitute the new definition of F for the old definition (as if we changed a page in our loose-leaf manual). If a word is defined by use of a word not yet defined, there is no way this illegal definition can appear on the VLIST.

It is easy to crash most Forth systems because the checks on what the pro-

Forth: a threaded interpretive language

If the instructions in a repair manual are "unscrew the nut holding the wurble plate to the ding box, but only after disconnecting the mains supply to the ding box, otherwise you will be electrocuted" there will be a fair number of fatalities. In a t.i.l. the manual has to be written in a sensible order. "First, disconnect the mains supply to the ding box; second, unscrew the nut holding the wurble to the ding box" so that there are no nasty surprises. It is safe to read ahead in the manual because it makes the whole operation that much slower, and how far forward is it possible or necessary to read?

Forth and other t.i.l.s take the sensible approach to reading the manual because it is simpler, and you always know where you are. Any computer program is no more than a set of instructions, and sometimes the same set of instructions are repeated – a truly ignorant person might have to be told, on each occassion, how to unscrew a nut. The manual might then read "First, disconnect the mains supply (see page 1) to the ding box; second, unscrew the nut (see page 2) holding the wurble to the ding box", where the "(see page . . .)" instructions are pointers to other places in the book. That is, we have the name of the operation, and then the location of the instructions with that name (if there was only one operation per page, the page number alone would be sufficient).

The manual itself is an operation – repair a Thing – and is composed of smaller operations, which can then be seen to be composed of even smaller operations, until one reaches certain primitive operations, those which have to be left undefined, eg "pick up a screw-driver". As one goes through the manual new operations are defined before one uses them in terms of the operations which are included in the latest, more complicated, operation. This again is what happens to a t.i.l. (For more details consult Threaded Interpretive Language, by R. G. Loeliger. Byte Books, 1981.) It is now possible to understand any Forth program. Here is a line of program taken from "Starting Forth," by Leo Brodie (Forth Inc, 1981):

F

We know that this is an instruction to do something and so we also know that somewhere the instructions to accompany F will be found. They are

BAR BLIP BAR BLIP BLIP CR

thus whenever we come across F, the computer will think BAR BLIP BAR BLIP BLIP CR. There are three new named instructions here, and BAR means

MARGIN 5 STARS

whereas BLIP means

MARGIN STAR

and CR is a *primitive* which means "carriage return". MARGIN is defined as

CR 30 SPACES

(on an 80 column printer or vdu), so BLIP misses 30 spaces and prints out one star, and BAR misses 30 spaces and prints out five stars, so that F (which is BAR BLIP BAR BLIP BLIP CR) will print out.

```
*****
*
*****
*
*
```

a trivial application but one which is totally transparent. To print out a large F, one types F – – could it be easier?

It is possible to program in this manner in Basic especially one which allows the user to use meaningful names for functions and procedures (though the applications in Forth – what are called "words" – are closest to *functions* in other languages). In Forth, however, the process of defining words is done there and then, and is done in what might be called, in Basic, "instant mode". Most forms of Basic will not allow you to enter (say) function definitions instantly, though it is possible to PRINT in immediate mode. In Forth, to define the meaning of F one enters

: F BAR BLIP BAR BLIP BLIP CR ;

where the colon means a word is to be defined (the next word in line) and semi-colon means that is the end of the definition. Try that in Basic; it is possible, but more complicated, using subroutines.

In most versions of Forth if one enters VLIST, an index is produced of all words so far defined and in the order in which they were defined. The order is important because the user of the manual (ie the Forth system) is incapable of looking forward in the manual to find a definition (one can only look back). If in the word F, one of the defining words (eg BLIP) had not already been defined the definition would be invalid. In terms of the output from a VLIST, a word can only be defined in terms of words which are lower down the list. What happens then when a manual is updated, and an improved method of unscrewing nuts is given?

Depending on the manual, various things could happen. If the manual was a loose-leaf manual, the old set of operations could be taken out to be replaced by the new set, and if each new set of instructions started on a new page, the insertion would be that much easier. An alternative method would be to mark the old instructions with a note, "see amendment sheet 14", so that on going to page 2 you would be redirected to the new set of instructions. Once done, the first is less work to use than is the second.

In conventional Forth systems, neither of these methods (or their equivalents) can apply. To change the definition of F so that it will be put closer to the left-hand-side of the screen, all that appears to be necessary is to alter the definition of MARGIN (as BAR and BLIP, and thus grammer can do are few; it is simple to over-write the words in the dictionary, and for the system to disappear in a puff of smoke. Such things on the Ace didn't succeed. Steve Vickers (the language designer) explains that there were two modes of running programs in Forth on the Ace, FAST and (the default) SLOW. SLOW mode means that everything that can be checked, is checked (eg the stack over-writing), and FAST means that all checks are off (useful when you know it works) and the program runs 25% more quickly.

Forth is an inherently compact efficient language and is not far short of the speed of machine code for some applications, and twice as slow at worst. The standard Ace comes with 3K bytes of ram, which may not seem a great deal but as Forth programs are so compact it is worth far more in terms of equivalent storage for a Basic program. The Ace will be able to use the Sinclair 16K ram pack in any case, so storage of programs presents no problem, and the cassette system is simplicity itself to use. The Z80A chip used is not the best for Forth – the 6809 is better suited – but Altwasser and Vickers say they knew the Z80A inside out and back to front – and it worked.

Forth is excellently suited for control applications, and so the Ace might be bought for that. Success might partly depend on how many interfaces to the outside world are produced; though as many of the ZX81 (etc) devices seem to be already compatible perhaps this has been partly solved already.

A possible further demerit is the claim that Forth as a language can promote the datk syndrome ("design at the keyboard") in that, because one has to get the basics right first, the overall structure gets lost. I think that datk is valid and though it may not be "structured" in the sense of top-down programming, it does lead to efficiency of coding – top-down programming inherently leads to verbosity in programs.

F, both depend upon MARGIN in their own definitions), eg

:MARGIN CR 5 SPACES:

which is simplicity itself. However, this doesn't work.

If MARGIN is redefined and you ask for a VLIST, MARGIN will be at the top of and further down (lower than BLIP, BAR, or F) another occurence of MARGIN. If you type at the console

MARGIN 10 STARS

You will find a space of 5 blanks and then 10 stars. If you now key F, the output will be exactly the same as the original version. When the computer comes across F within the body of coding for F there are pointers to the places at which the code for BLIP and BAR can be found. BLIP and BAR still point to the *original* coding for MARGIN – ie with 30 spaces. The introduction of a new definition for MARGIN has not affected anything earlier, and so all the old pointers are unaltered – they can only point backwards, never forwards. Without doubt this is a major problem.

Another problem concerns program development and the editing of source material. Suppose that we define MARGIN with 5 spaces, try it out, and then decide that perhaps it would be better with 10 spaces (then 8 spaces, then . . .), what happens? Under VLIST (unless one is careful) a large number of competing and conflicting definitions of MARGIN will appear. It is possible to FORGET MARGIN (ie erase the last definition) but often it is the kind of action which is easily forgotten. The way in which a source record is kept of the definitions (on what are termed "screens") can in itself lead to problems.

Consider this word, and its definition,

: LOOP-TO-12 13 0 DO I . CR LOOP ;

which prints out numbers from 0 to 12 (the point means print out the last number mentioned, in this case the loop counter I). If that is stored on a screen, and the EDITOR used, the EDITOR redefines I to an edit command, and so every time LOOP-TO-12 is used the word will use the redefined version of I (as per its use in the EDITOR). Unless one is careful more complex interactions can occur.

For a t.i.l. to work most effectively what is needed is a processor which is able to efficiently point to locations which point to locations which point to locations which . . . More technically what is needed is a processor with sophisticated addressing modes. The common Z80 or Z80A micro-processor is not known for its sophisticated addressing – the opposite in fact – and though the also popular 6502 is slightly better, there is little to choose between them. The recent Motorola 6809, as used in the Tandy Color Computer and the Dragon, seems to be a chip which would fit the t.i.l. philosophy well.

BORIS ALLAN

Advice to dbs panel

The advisory panel considering technical transmission standards for direct broadcast satellites is accepting advice until early November. The panel, headed by Sir Antony Part once permanent secretary at the Department of Trade and Industry and now chairman of Orion Insurance, includes Roger Griffiths, professor of electronics at Loughborough University, and Alan Day, professor of economics at LSE, with consultant Bernard Rogers as an assessor. Secretary is P. R. Birch, DoI, 29 Bressenden Place, London SW1E 5DT, tel. 01-213 5810. The short notice, according to the Home Secretary in a parliamentary answer, is to enable "the necessary receiving equipment to be ready in time for the projected start of d.b.s. in 1986."

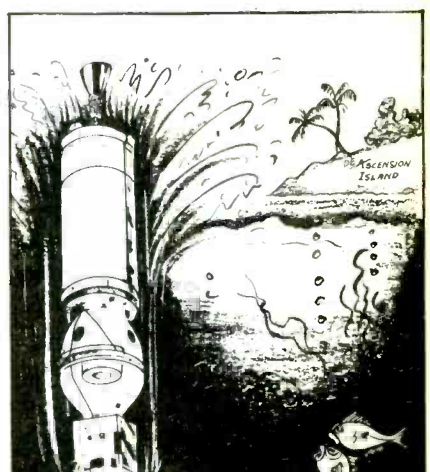
Uosat back in operation

The amateur radio satellite Uosat has been given an "off" command through the large radio telescope dish of the Standord Research Institute, California. Uosat became uncommandable in April this year when both its 145 and 435MHz transmitting beacons were switched on together. This swamped the command receiver and no further commands could be passed.

Now, the University of Surrey is in full command. All telemetry has been tested and found to be correct as it was originally left in April. Test and analysis programs are being dumped on to the F100 spacecraft computer for future use in the Phase 3 programmes. The 1800 on-board computer is having its software checked to ensure that no false command will be accepted and thus cause the same fault.

The system transmits at various rates during weekday passes but for the next few weeks, at weekends, transmissions will be at 300 baud. Amsat-UK and the University of Surrey invite suggestions from readers on what the data rate should be at weekends to stimulate maximum interest. They would also be grateful for hard copies to be sent to the University for evaluation.

Information on Uosat and Amsat-UK can be obtained from Amsat-UK, London E12 5EQ, by sending a stamped addressed envelope. There is also a guide to operating Oscar available for £1 and the latest satellite information will be included.



After a "perfect countdown" to the launch of Marecs B on 10 September, announced ESA said "an anomaly led to a lower tragetory than required".

HDTV-on-Sea

Visitors to the International Broadcasting Convention at Brighton had a good opportunity to assess the high definition colour television system which NHK, the Japanese Broadcasting Corporation, has been developing over the past few years. Sony were demonstrating a camera, monitors, a v.t.r. and a large-screen projector, all working on the 1125-line, 60 field/s standard proposed by NHK. The pictures are said to contain five to six times the amount of information provided by current NTSC, PAL and SECAM services, but although the images were undoubtedly superior they did not seem as impressive as one might expect from doubling the number of lines and sextupling the video bandwidth to 30MHz. Of course, the relationship between subjective picture quality and objective definition parameters is not a linear one and probably there is a law of diminishing returns here.

Sony's camera uses three 1-inch Saticon tubes with an optical beam-splitter, giving R, G, B signals with a resolution of 1200 television lines. The 17 and 24in colour monitors are based on Trinitron display tubes with a fine-pitch vertical grille (300, and 400μm respectively); while the projector, using red, green and blue 9-inch tubes, throws a picture on a 2000 by 1200mm screen. Recording on the 1-inch v.t.r. is by the f.m. method using Y, U, V signal components with a luminance bandwidth of 22 MHz and chrominance bandwidth of 10MHz.

Of course all this was closed-circuit television, as there does not seem much likelihood of transmitting a 30MHz video bandwidth until direct broadcasting satellites get going. In the meantime it seems more likely that HDTV will have useful applications in the production, distribution and projection of motion pictures. Sony claim that the picture quality "fully matches that of 35mm motion picture film." (But this is not a new idea: older readers in the UK will remember Norman Collins's film production company High Definition Films of some 30 years ago.)

Nevertheless there is no reason why high definition equipment of this kind should not "be used in the studio well before the capacity to transmit such signals becomes established", in the words of Charles Sandbank, head of the BBC's research department. Indeed if signal processing electronics become cheap enough, it might also be possible to use high definition techniques with advantage in the receiver (the transmission system remaining unchanged and compatible with existing standards). As Mr Sandbank remarked, in his paper on future broadcasting developments, for signals "derived from a high definition studio standard and pre-filtered for compatible 625-line transmission, up-conversion to a higher line standard, e.g. 1250, with adaptive interpolation may also be worthwhile."

However, the same speaker very sensibly pointed out that high definition television broadcasting in the full sense really awaits the time when large-area domestic displays capable of doing justice to a standard with more than 1000 lines" become commonplace components."

Wireless telephones legal – at a price

Rumours that the Government were about to licence sale of wireless telephones were confirmed recently by the Department of Industry. The previous "liberalization" schemes of November last year covering extension telephones and modems, and of last May covering callmakers/repeating diallers with integral modems, are now extended to include "cordless" telephones, as the DoI call the wireless extensions to distinguish them from radio telephones.

The devices have to be tested for conformity with technical guide 47, which for a "small charge" is available from J. Jeans, BTHQ, ICS214, 45 Moorfields, London EC2Y 9U, tel: 01-432 9347 (the small charge turns out to be £10). There is a hefty charge for testing; probably between £3,000 and £5,000 will be required before testing begins. In defence of such amounts BT say that ordinary telephone testing already costs around £2,000 (three samples are assessed) and additionally there are r.f. and security aspects to take into account.

Interim frequency allocations up until 1986 are 1632 to 1792kHz for transmitting and 47.45 to 47.55MHz for receiving.

"Some manufacturers have the u.l.a. made for them to the specification of the computer," says Oric computer designer P. T. Johnson of Tangerine Computer Systems, "rather than designing the u.l.a. around it". Like many popular computers Oric 1 is based on a 6502 microprocessor and a u.l.a., but unlike others it provides an eight-colour facility together with 16K of user ram for £100. A printer and disc drive are promised for the near furure, as is a £60 modem to interface with videotex systems.

Interim Merriman

The Merriman spectrum review committee recommends that the 405-line tv service should be closed by the end of 1984, years earlier than planned. They suggest that the best use of these v.h.f. bands would be for mobile services – radio-telephones and internal and operational communication for the broadcast authorities. The mobile radio allocation plan should be developed in consultation with manufacturers and users by the end of 1983, as should plans for the broadcast ancillary services, to be implemented progressively, starting in 1985. Having considered some of the alternatives, such as community tv and a full channel of teletext, the review committee considered that all tv services would be best served by existing and proposed schemes such as satellite and multi-channel cable services.

Tapping their own drum

After just a month of production in their new factory, the inventors of an electronic drum synthesizer had orders worth over £250,000, secured by the new company's New York distributor. Developed two years ago the drum kit, as it is called, has touch-sensitive pads that trigger production of sounds: rhythms are not programmed in as with conventional rhythm generators. Its four main touch pads trigger bass drum, snare, high and low tom-toms and secondary pads operate high-hat, closed high-hat and variable crash/ride cymbals. It also incorporates a rhythm unit which can be set to trigger the high-hats with variable tempo and time signature modes. Sound levels of each effect is adjustable and outputs allow direct interface with multitrack mixing desks. Associated instruments can be used individually or triggered by the device, for instance the Clap gives a wide range of clap effects, gun shots, explosive and other white noise effects, while another gives tympani effects.

The electronics design aspects were the work of Clive Button who teamed up with Mike Coxhead, who otherwise runs a building renovation firm, "Its a bit of a

departure from my own business" says Coxhead "but I'm glad we got it on the market before anyone else got the idea". His inital investment of £30,000 for the prototype has paid off and he's now after £1 million orders by the end of year.

Micro arithmetic leaves UK in cold

Floating-point arithmetic for new microprocessor systems, the subject of IEC publication 559, defines ways to perform binary floating-point arithmetic, whether realized entirely in hardware, software or a combination. The need for this world standard comes from booming international trade in microprocessor systems say the IEC, and a divergence of national practices could act as a brake. In defining a family of commercially feasible ways for new microprocessor systems to perform floating-point arithmetic, the IEC say the benefits will be "enhanced portability and capability programs; direct support for execution-time diagnosis of anomalies, smoother handling of exceptions, and interval arithmetic at a reasonable cost; and development of standard elementary functions, high precision arithmetic and coupling of numerical and symbolic algebraic computation".

It specifies 32 and 64 bit formats, results for arithmetic operations, conversions between integers or decimal strings and floating-point numbers and between different formats, as well as exceptions and their handling, including non-numbers. The standard is based on an IEEE 754 draft and was prepared in just over a year by the microprocessor sub-committee of the IEC semiconductor devices committee. The UK did not vote explicitly in favour of publication of this standard, though the USA, USSR, Japan and most of Europe did. And we haven't been able to contact anyone from the sub-committee yet – there were no UK members.

Basicode by radio

In an attempt to find a universal version of the computer language Basic which would allow different computers to 'talk' to each other and to be able to load the same programs from a single source, Dutch radio has developed Basicode, a list of reserved words common to nearly all versions of Basic. A large number of the more popular home and hobby computers may be easily adapted to load programs written in Basicode. Earlier this year Radio-Nederland started broadcasting computer programs on the English-language programme *Media Network*, as did NOS on the domestic *Hobbyscoop* programme. They found that for shortwave 300 baud was the maximum rate for reliable reception but they also transmit locally on medium wave at 1200 baud and have had reports of successful recording of data from neighbouring Germany. Use of Basicode on amateur v.h.f. bands has now been approved by the Dutch telecommunications authority.

Radio Nederland has published a book listing the Basicode reserved words and protocol and giving hardware and software adaptations which may be needed to use the system with a number of popular computers. The book and a cassette of programs written in Basicode are available at cost price (from Europe this is 25 guilders, about £5) from Basicode, Administrative Algemeen Secretariat, NOS, PO Box 10, 1200 JB Hilversum, Netherlands.

The Hunt is up

The findings of the Committee of Inquiry into cable television suggest that there should be few controls and that cable and programme providers can provide as many channels as they like. The report recommends the setting up of a supervisory, franchising authority. There would be no restriction on the quantity of advertising. Each franchise should cover an area of not more than half a million homes. Present providers of cable services would no longer be obliged to carry BBC and ITV programmes though any new service would.

These recommendations do not seem to provide the 'licence to print money' that many potential cable providers were looking for. It does not suggest a national standard for cable services (the Eden Inquiry is looking into cable standards). The main, and most controversial, point is that there is no distinction between the cable providers and the programme providers. If they were separated, there could be a national plan to give interactive services over the whole country. With the current plan, there will be no cable service in the less populated areas for a long time.

Fast a-2-d converter

Research into high-definition television at NHK laboratories has produced an 8-bit analogue-to-digital converter with a maximum sampling rate of almost one gigabit per second.

Corrections

Circuit modelling by microcomputer by R. I. Harcourt, August 1982. The graphs published were inadvertently printed in place of some more recent ones. In the examples used, the 'phase degree' axes should be shifted by 180° to correct the graphs.

Simple, low-frequency oscilloscope. There are one or two changes to the circuit diagram of this instrument, which was described in the September issue. The top contact of the sweep-speed selector switch should be removed, and the 10kΩ and 3.3kΩ resistors on the base of the tail transistor in the Y amplifier should be interchanged. The author also asks us to point out that the 470nF capacitor in the −2kV line (not +2kV) should be of 1200V working and the 1μF should be 600V, not 6000V.

PROGRAMMABLE GPIB-TO-SERIAL INTERFACE

Remote programmable facilities dispense with some of the switch packs used in the earlier talker/listener interface design.

by Chris Jay

> This second part completes the description of a programmable modification to the 488 parallel-to-serial interface. Featured in the July issue of WW, it was conceived as a low-cost interface solution for instruments with a serial data link such as an RS232C port. When configured to a keyboard and addressed as a talker, characters typed on the keys are converted by the interface from serial to parallel data and transmitted over the bus data lines. A printer interfaced to the bus is addressed as a listener; data bytes received are serially encoded and fed to the serial input port of the printer. The interface used 13 i.cs including a 96LS488 to perform interface functions and message decoding, an IM6402 uart for the serial/parallel encoding of data, and an MC14411 as a frequency reference for serial transmission and reception at four link-selectable rates. During the talker-active state the interface could automatically recognize an end-of-text character, and assert the EOI line concurrent with the transmission of the final data byte in the character string.

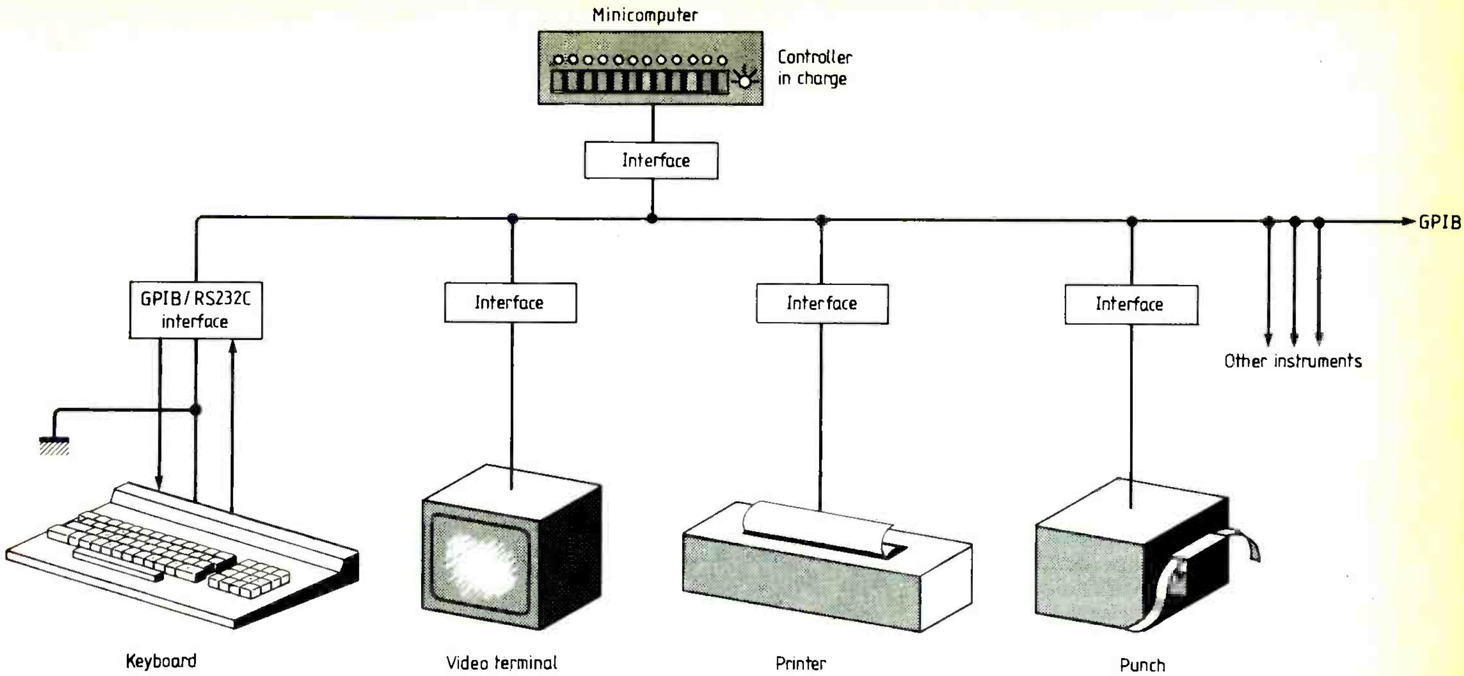
A data byte on the internal instrument bus may be loaded into the octal latches of the comparator chip. In the acceptor-data state, the byte corresponding to the end-of-text character is clocked into the F524 by the rising edge of $\overline{STB3}$, applied to the CP input. This signal is derived from the RXST 96LS488 output in the same way as $\overline{STB1}$ and $\overline{STB2}$. The RXST and RXRDY handshake is completed through and-gate 4 and multiplexer IC_{12}. When the instrument receives an unlisten command, and provided one of the other three functions is addressed, $\overline{ENBL3}$ returns high, so I_{11} drives the S0, S1 inputs low, putting the 74F524 into the compare mode. Appendix 1 gives a more detailed description of the 74F524 operation. In this mode the 74F524 compares the eight-bit data input with that data latched internally. If the bytes do not match the equals (=) output will stay low. But if there is a true comparison the internal open-collector driver turns off and the output floats passive high through the 10kΩ pull-up resistor. During talker active the three state condition on inverter I_{13} is removed, and a passive high on the 74F524 output results in an active low on the end-or-identify line. The assertion of $\overline{EOI}$ concurrent with the transmission of the final data byte in a character string can be treated by the controller, and listeners active on the bus as an end-of-text terminating message.

Interface as an active listener. After initialization, the interface may then be addressed as an active talker or listener for the serial/parallel or parallel/serial conversion of data. The interface becomes listener addressed after receipt of the following remote messages: UNL, MLA and MSA 0. When MSA 0 is received a falling edge at the 96LS488 $\overline{LAD}$ output inverts through the nand-gate 1, producing a rising edge at the CP inputs of the dual D-type latch IC_7. The CP pulse clocks the low outputs from I_1 and I_2 to the Q outputs of the D-type latches. The A0 & 1 address inputs of the 74LS139 select the O0 outputs of IC_8. The $\overline{ENBL0}$ output of IC_{8b} provides a low select input to IC_{12}. This establishes a TBRE/RXRDY handshake signal between the u.a.r.t. and the 96LS488. The 96LS488 RXST output drives the uarts $\overline{TBRL}$ input through I_5, the selected O0 output of IC_{8a} and the nand-gate 5. The TBRE output from the uart is used as an enabling input to gate 5, whichensures that $\overline{TBRL}$ will not go low until the transmit register has serially encoded and transmitted the data byte present at the TB1-8 inputs. This completes the RXST/$\overline{TBRL}$ handshake for the asynchronous transfer of data bytes to the uart transmit buffer register. Data bytes present on the GPIB data lines are inverted onto the internal instrument bus by IC_3 which is enabled by the active low signal $\overline{LACSENBF}$.

Interface as an active talker. To program the interface as an active talker the sequence of UNL, MTA and MSA 0 is sent. The $\overline{TAD}$ 96LS488 output goes low and latches the code 00 into the dual D-type latch IC_7. The $\overline{ENBL0}$ output of IC_{8b} goes low, and when inverted by I_8 produces a high enable signal for nand-gate NG2, so the inversion of TXST may drive the $\overline{DRR}$ uart input. Also, the output of I_8 enables and-gate seven establishing a DR/TXRDY handshake between the uart and 96LS488. When the interface enters the talker active state the $\overline{TACSENBF}$ signal goes low. The 74F240 enable inputs and the uart receive register disable input goes low. Parallel data serially encoded from the RS232C input is inverted to drive the bus data lines by IC_4. The uarts data ready output drives the 96LS488 TXRDY input high, via and-gate seven, to inform listeners active on the bus that a data byte is valid. When this data byte has been taken the 96LS488 decodes the bus handshake lines to set TXST high. This assertion is inverted by gate 6 to drive the uarts $\overline{DRR}$ input low. When low the uart permits the next serial data input to be received without overrun error. Transmission of data bytes continues until the end-of-text character is sent. Transmission of the final data byte results in a data match with the contents of the 74F524. The EQU (=) will be pulled passive high by the 10kΩ pull-up resistor. Inverter I_{13}, which has been enabled drives the $\overline{EOI}$ line low, concurrent with the transmission of the final data byte in the character string. The controller-in-charge may recognize this end-of-text message, regain control of the bus and un-address the instrument until it is required to talk again.

Serial poll capability

The instrument interface has the capability to generate a service request and respond to a serial poll. If, during the serial encoding or decoding of data bytes, a framing, parity, or overrun error occurs, the output of nor-gate 8 goes low. The cross-coupled latch of gates 9 & 10, set during a power on master reset, will drive the 96LS488 $\overline{RSV}$ (request for service) input low. The 96LS488 responds by asserting the service request line. The controller-in-charge may regain control of the bus to conduct a serial poll, and hence determine the source and cause of the service request. To perform a serial poll, the controller asserts the $\overline{ATN}$ bus line and issues an UNL message to prevent active listeners responding to status bytes as though they were data bytes. The serial poll enable message is sent over the data lines and each instrument capable of responding to a serial poll will sequentially receive its talk address. The controller removes the assertion on line $\overline{ATN}$ and listens to the bus for the instrument, to issue a status byte. When the interface is in the serial poll active state, the $\overline{SPASENBF}$ output from or-gate 3 goes low. The 74F240 half of IC_{10} drives the data lines 1-3 with the inverted IM6402 outputs of PE,OE and FE. Note to relieve the three-state on these outputs the 6402 status flag disable input must be disabled low. The output of the SPAS-enabled $\overline{EOI}$ inverter drives the $\overline{EOI}$ bus line inactive high. This signal is not asserted by the instrument during serial poll active state. The requested service output $\overline{RQS}$ from the 96LS488, wire-or'ed to data line 7, will go active low, indicating that the interface originated the service request. When the



status byte is read by the controller the STST 96LS488 output goes high then low, pulsing the STRDY input low then high through inverter I_{10}. So as the status byte is read the local handshake STST to STRDY is automatically driven. From the format of the status byte the controller program may determine the error that occured during encoding and transmission or reception. If an error resulted in one of the error flags going active high then it will be necessary to issue a clear message to the interface before normal operation can be resumed.

Clearing the system

There are two ways of clearing the instrument interface. On the application of power the RC network of 10kΩ and 10μF reset the 96LS488 and the uart. The uart may be cleared remotely on the receipt of a device clear or selected device clear message. If a request for service had arisen due to an error (framing parity or overrun) generated during the transmission or reception of data, it will be necessary to clear the uart and set the RSV latch. After the serial poll the controller may respond by addressing the interface as a listener and sending a selected device clear. The CLR 96LS488 output pulses low, producing a high at the output of gate 11. This resets the uart through the master reset input. Also, the $\overline{CLR}$ low output sets the cross-coupled nand-gate configuration of gates 9 & 10, resulting in $\overline{RSV}$ being driven inactive.

RS232C transmission and reception

The t.t.l. level signal at the uart TRO output and RRI inputs are converted to RS232C ±12 volt levels by the μA1488 transmitter and from the ±12 volt levels that by the μA1489 receiver. Pin 2 of the μA1489 is left open-circuit.

Clock frequency for the 96LS488 CP input is generated by a CR network of 470pF and 220Ω. The "power-on" reset consists of a 10μF and 10kΩ network, the diode 1N4148 configured to provide a rapid discharge path when power is removed from the circuit. The $\overline{TAD}$ and $\overline{LAD}$ 96LS488 outputs are wired to l.e.ds and resistor pull-ups. Red and green l.e.ds are configured to the $\overline{TAD}$ and $\overline{LAD}$ outputs of the 96LS488 and may be mounted so

Table 5a. UART control register, MSA 1

DAB 1	DIO1	DIO2	DIO3	DIO4	DIO5	DIO6	DIO7	DIO8
	SBS	EPE	PI	CLS1	CLS2	x	x	x

Control register — The following inputs are used to set the control register status when the CRL input goes high.

CLS1, CLS2 — Character length select – these two inputs select the character length according to

Character length	5	6	7	8 bits
CLS1	L	H	L	H
CLS2	L	L	H	H

PI — Parity inhibit. A high level inhibits parity generation, parity checking and forces the PE status flag output low. This input overrides the EPE input.

EPE — Even parity enable. When the PI is set low a high level on the EPE input generates and checks even parity conversely a low level selects odd parity.

SBS — Stop bit select. This input selects the number of stop bits. The number of stop bits added to the transmitted character also depends on the character length selected by the CLS1 and CLS2 inputs. The following table lists the number of stop bits selected versus the character length and state of the SBS input.

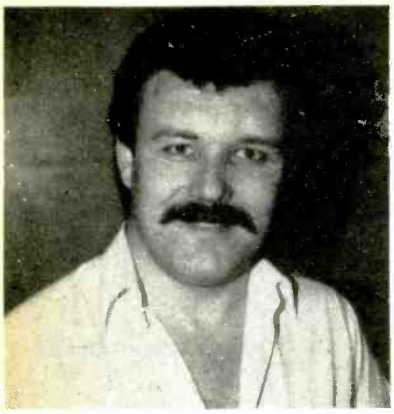
Table 5b. Data speed generator latch, MSA 2

DAB 2	DIO1	DIO2	DIO3	DIO4	DIO5	DIO6	DIO7	DIO8	Data Rate
	0	0	0	x	x	x	x	x	75
	1	0	0						300
	0	1	0						600
	1	1	0						2400
	0	0	1						1200
	1	0	1						4800
	0	1	1						4800
	1	1	1						19200

Table 5c. MC14411 clock outputs

Outputs (Hz)	×64	×16	×8	×1
F3	307.2k	76.8k	38.4k	4800
F7	76.8k	19.2k	9600	1200

Clock rate outputs are 16 × data speed of the uart serialized data. Using A & B control inputs, 00 gives ×1, 10 ×8, 01 ×16 and 11 ×64.



Chris Jay is senior design engineer at Marian Electronics, Stroud, Gloucestershire. Joining GCHQ in Cheltenham as a trainee technician straight from school, he obtained City and Guilds (Telecommunications) and HNC qualifications at day release and evening classes. These qualifications helped him qualify as a mature student for a full-time degree course at Essex University. On graduation in 1977 he joined Texas Instruments as part of the engineering design effort on the 9911 DMA controller chip. Preferring to be involved with device applications he joined Linotype paul in Cheltenham where he designed computerized file storage equipment for the newspaper and printing industries. He left to join Fairchild's Bristol design centre in 1980, where he wrote this article.

that the user may clearly see the current addressed state of the instrument. The return-to-local 96LS488 input is permanently wired to V_{cc} through a 10kΩ resistor.

Ideas for further development

Although the interface circuit was designed to have a number of useful features this design could be developed for increased functional capability. With the addition of a 74150 multiplexer circuit and

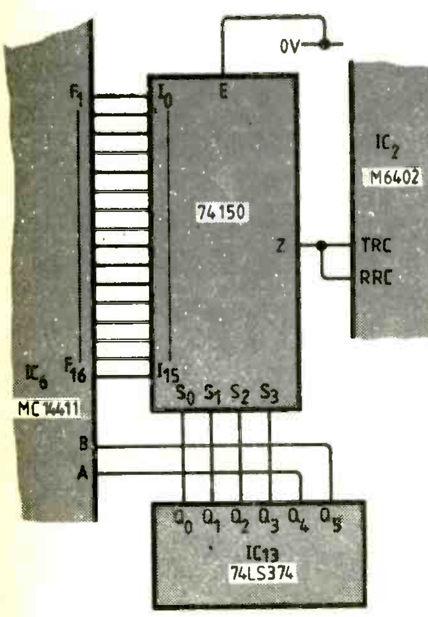


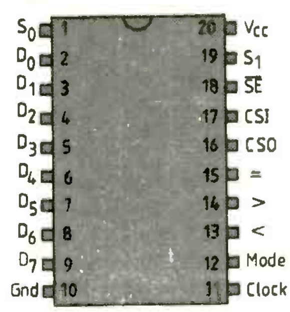
Table 6

S0	S1	Operation
0	0	Hold – retains data in shift register
0	1	Read – read contents in register onto data bus
1	0	Shift – Allows serial shifting on next rising clock edge
1	1	Load – load data on bus into register

use of three of the unused outputs of IC_{13}, a significant increase in the number of rates available may be achieved, see Fig. 3. Four address inputs S0, S1, S2 and S3 of the 74150 may be driven from the Q0-3 74LS374 latch outputs. Address inputs may select any one of the clock outputs F1-16 of the MC14411. If the E input is permanently low and the Z output is connected to the TRC and RRC inputs of the IM6402, the outputs F1-16 wired to multiplexer inputs I0-15 may be individually selected to provide a clock input to the uart. The A and B inputs to IC_6 can be wired to the Q4 & 5 outputs of IC13, 74LS374. The two-to-one multiplexer of OG3, OG4 and AG2, shown in Fig. 2 may be dispensed with. A full description of the MC14411, including a table of the clock frequencies at the outputs F1-16, may be obtained from the Motorola publication "European cmos selection".

Appendix 1

The 74F524 is a new addition to Fairchild's Fast family. It is a registered (latched) comparator with bidirectional eight-bit I/O and an independant serial data I/O. When data is stored internally the device may compare a byte offered to its parallel eight-bit data input, and generate an equivalence, greater than or less than output, for a programmed mode input of magnitude, or two's complement



compare. The three comparison outputs are all open-collector, and designed to be pulled passive high when asserted. This makes it convenient for cascading with other 74F524 devices. These outputs are enabled by a logic low on the $\overline{SE}$ input. The S0 and S1 address inputs permit register loading, reading, data holding and shifting. Format of S0 and S1 is shown in Table 6. The mode input may be set high or low depending on whether the design requires magnitude or two's complement comparison. There is a single clock pulse input; the rising edge on this pin can load data into the register, or shift the contents by one bit from the CSI input to the CSO output. Pin configuration is shown in Fig. 4.

Appendix 2

Serial poll: The serial poll is a mechanism by which instruments capable of talking may individually send information pertaining to their current status over the data lines. The controller may interrupt events on the bus to invoke a serial poll either in response to a service request initiated by the instrument or as an autonomic process initiated by the controller's command program. The service request line may be used by the instruments to request attention from the controller and may be likened to the use of an interrupt line to generate an interrupt and divert processing during the execution of the computer program when attention is required by a peripheral component.

Parallel poll: The parallel poll can have a distinct speed advantage over the serial poll because a single status bit from eight individual instruments may be read by the controller simultaneously. The end-or-identify line is used by the controller as the identify line (this line is also used by talkers active on the bus for end-message, so it has a a dual purpose). Any instrument capable of listening will be assigned a data line by the controller onto which it will declare its status bit during the parallel poll active state. Notice that two or more instruments may use a single line as a wired-or function. The controller will configure the instruments to respond to a parallel poll in the following way.

The instrument will be addressed to listen. The controller will send the parallel poll configure message which conditions the instrument to expect the following parallel poll enable message, and its format determines how the instrument responds during the active state. Data bits on lines 5, 6 & 7 of the PPE message are set to 110. Data line 4 will contain a parity bit. A true comparison with the device-dependant individual status message will produce an affirmative parallel poll response during the active state. A false comparison between the line 4 bit received in the enable message, and the i.s. message results in no response to the identify message. The remaining bits of the enable message on lines 1, 2 & 3 will contain a one-of-eight code which will assign one line for transmission of the compare bit during a poll response. If the bit pattern were 000, the response would occur on data line 1, 001 would yield a response on 2, and so on. WW

Single i.c. for f.s.k. modem

Data transmission by telephone line remains the most convenient and cheap method of conveying digital information over medium and long distances despite its slowness, hence interest in modems. Advanced Micro Devices are to manufacture an i.c. that requires only a handful of non-critical components, some switching and level conversion logic, and an acoustic coupler or direct-coupling arrangement to form a modem that can be switched to suit one of four standards.

The Am7910, whose application is outlined in the diagram below, has built-in a-to-d and d-to-a converters and all processing, including filtering, is done digitally under the control of a crystal, so drift problems due to ageing and temperature change are not inherent and adjustments not required. Five mode-select inputs set the maximum data rate at 300, 600, or 1200 bit/s and select one of nine modes shown in the table.

When set to operate to either Bell 202 or CCITT V23 standards, and say, acknowledgement and control signals may be returned to the sender on remaining bandwidth while the sender continues to transmit at 1200 bit/s.

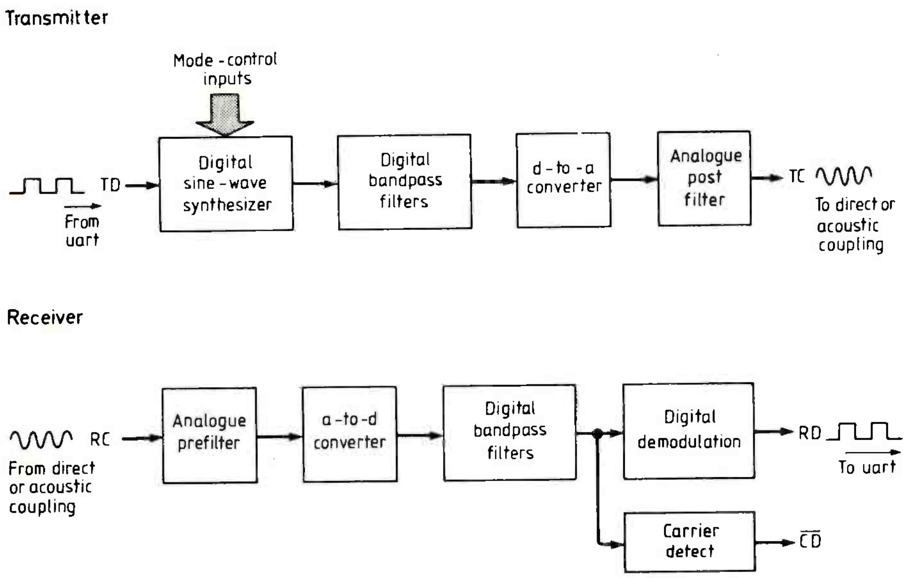
An auto-answer facility meeting Bell and V25 specifications is also built in. Upon receipt of a signal at its ring input, a silence interval is followed by an answer tone at the transmit-carrier output. T.t.l.-compatible terminal-control signals such as data-terminal ready, request to send, clear to send and carrier detect are provided, with appropriate delays.

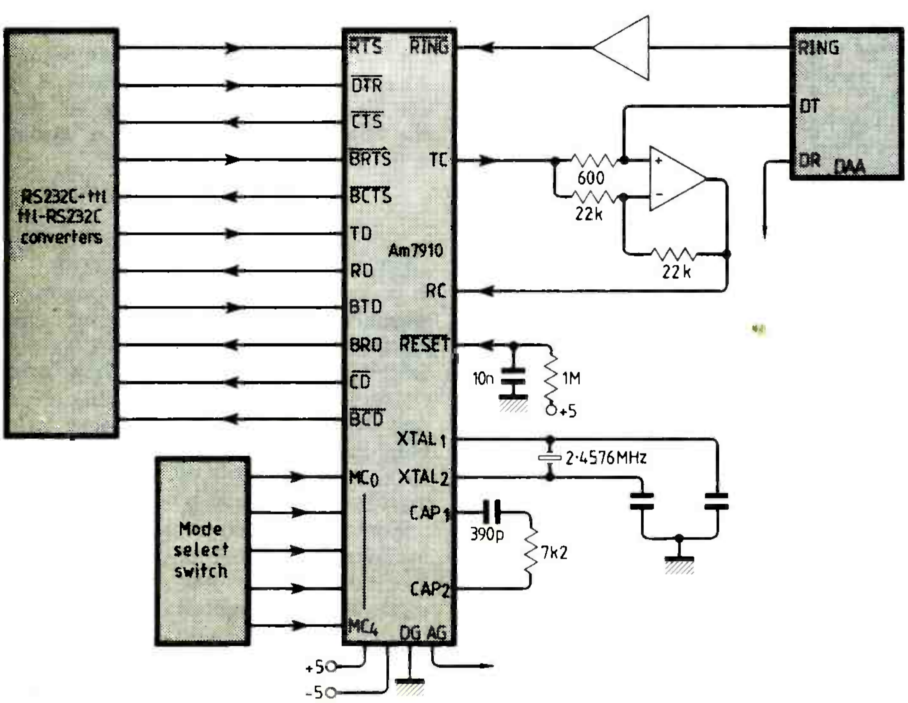
To aid testing, the device can be set to operate in one of ten loop-back modes, in which transmitter and receiver sections are set to operate on the same channel or frequency and either the analogue output and input connected together for local testing or the digital data lines connected externally to allow testing of the local modem using a remote one.

Although this 28-pin n-mos device will not be in full production until the beginning of next year, samples of out-of-specification i.c.s should be available now.
WW500 for further details.

Modem configurations

Standard	Bit/s	Duplex	Features
Bell 103	300	full	originate
Bell 103	300	full	answer
Bell 202	1200	half	
Bell 202	1200	half	line equalizer
CCITT V 21	300	full	originate
CCITT V 21	300	full	answer
CCITT V 23 mode 2	1200	half	
CCITT V 23 mode 2	1200	half	line equalizer
CCITT V 23 mode 1	600	half	





EVENTS

October 27
Application of viewdata to transaction processing; one day seminar in central London. Details from Modcomp, Molly Millars Lane, Wokingham, Berks.

October 28
Modern tv chassis – philosophy and circuits: Royal Television Society meeting, 7pm at IBA, 70 Brompton Road, London SW3.

November 2
Commencement of programme broadcasting on Channel 4

November 9
Comex 82, Radio communications exhibition, Saxon Inn, Northampton. Organised by the Federation of Communication Services, 70 Church Road, London SE19.

November 10
Industrial robotics; IEEIE lecture, White Horse Hotel, Dorking, Surrey. IEEIE 2 Savoy Hill, London WC2R 0BS.

November 11
Newspeed – news without paper. Royal Television Society meeting on TVS news gathering system. 7pm, IBA, 70 Brompton Road, London SW3.

November 18-19
Industrial applications for distributed computing: conference at National Computing Centre, Manchester and sponsored by SERC. Details from F. Chambers, Logica, 64 Newman Street, London W1A 4SE.

November 20
Electronics for Peace Network: Inaugural meeting in Bracknell, Berks. Further details from Tim Williams, Telephone: 0732 864882.

November 23-25
2nd International Conference on Semi-custom ICs. The West Centre, London SW6. Organised by Prodex (Seminars) Ltd, 79 High Street, Tunbridge Wells.

November 25
Hi-Fi TV – Bigger, Better Pictures: Royal Television Society lecture at IBA, 70 Brompton Road, London SW3 at 7pm.

November 26 - December 5
11th International exhibition of inventions combined with the first **International exhibition of special techniques.** New Exhibition and Conference Centre, Geneva. Details from the Secretariat, International Exhibition of Inventions, 8 rue du 31-Decembre, CH-1207 Geneva, Switzerland.

EPROM EMULATOR

This board programs a 2716 eprom with software developed on the emulator described in the September and October issues. A small printer provides hard copy of the software under development. Only two i.cs are required for the programming board, one for conversion from 5 to 25V and the other to determine the programming-pulse length.

by Peter Nicholls, M.A.

Only a relatively simple circuit is required to transfer software evolved using the emulator into an eprom since the programming-control software and key are included in the main-board design already published.

To program a 2176 or any of its close relatives, addresses and corresponding data are presented to the 'empty' device and each byte is held for 50ms. This programmer addresses the eprom sequentially, as is usual. A 50ms pulse coinciding with the 'data-hold' period is applied to the eprom's program input, pin 18, while pin 21 of the i.c., V_{pp}, is held at 25V. The 25V supply, present at pin 21 while the eprom is being programmed, must not be applied to the i.c. in the absence of a 5V supply, otherwise the eprom will be damaged.

Operation

Referring to Fig. 1, control software on the emulator board first switches flag 1 high when the 'e' key is pressed. Transistors $Tr_{2,4}$ switch the 25V program voltage to the 2716 socket. The software continues, doing nothing more than reading all the 6116 ram's data onto the bus in sequence.

A few nanoseconds after the point in the read cycle where the 6116's chip-select input goes low, IC_{10} is triggered to provide two opposite pulses. Negative pulses, at pin 9, are applied to the processor's NHOLD input and, while low, cause the system buses to become static. When IC_{10} reverts, the processor goes into the next read cycle, and so on until the eprom is full. Positive pulses are fed to the eprom's program-pulse input.

Transistor Tr_3 only allows pulses to pass to the processor's hold input after the e key has been pressed and until programming is completed. Without this blocking transistor, transmit and receive functions of the emulator will not work while the programming board is connected and display problems will be encountered with some functions.

Power supply. Figure one also shows the switching-regulator circuit used to provide a 25V programming voltage from a 5V supply. The inductor shown may be made using 56 turns of 32 s.w.g. wire on an RM6/250 pot core. Both regulator and pot core are available from RS Components.

Before the programmer is used the programming voltage should be set to within half a volt of 25V at pin 21 of the eprom socket. This is done with a temporary 10kΩ load resistor connected between pin 21 of the programming socket and ground (pin 12). The programming board should be connected to the emulator, the 'e' control key pressed, and the potentiometer adjusted to give the required voltage at pin 21. Under the same conditions but with the flag input low, the voltage reading at pin 21 should be close to 4.3V.

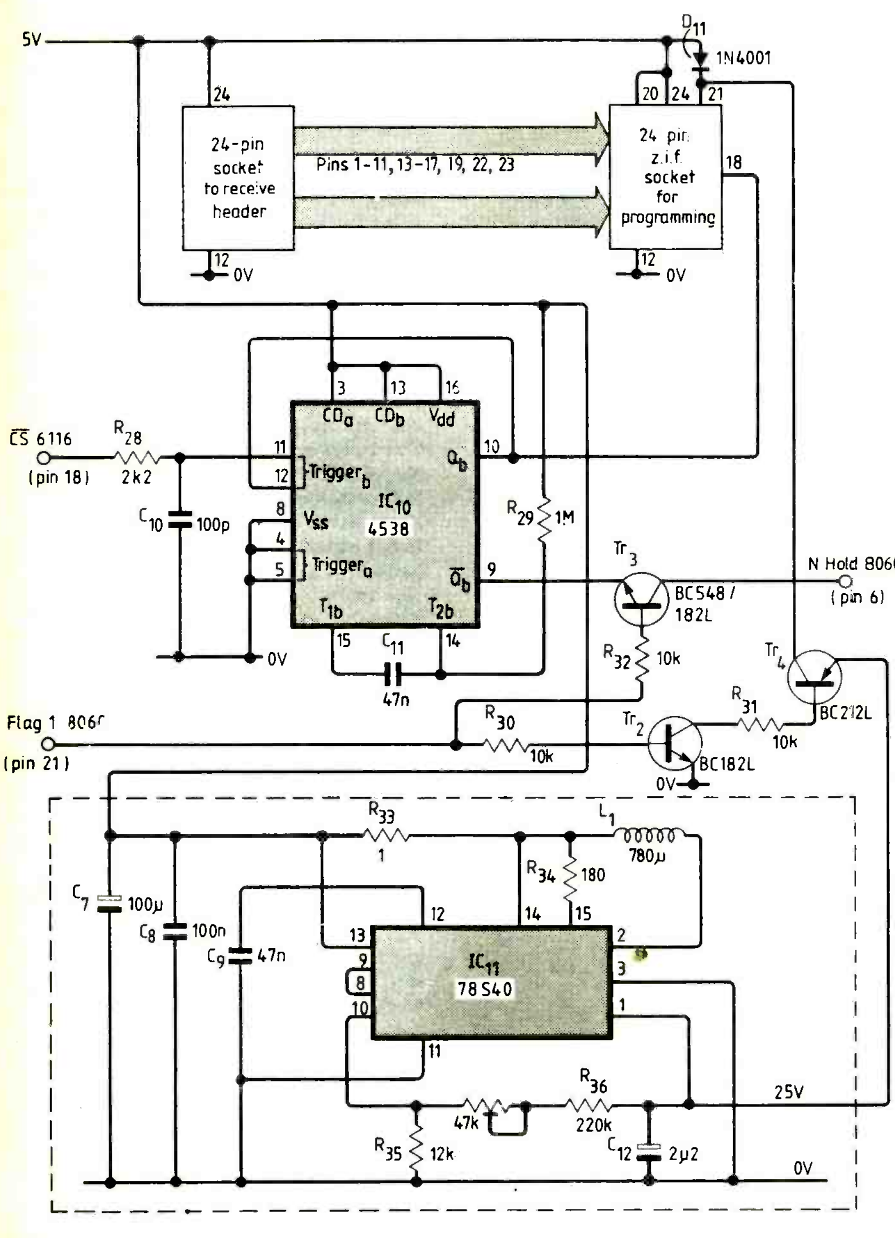


***Fig. 1.** 2716/2516-eprom programming board shown connects directly to emulator board and requires only 5V supply. A 25V supply is generated on the board by IC_{11}. Monostable IC_{10} generates 50ms programming pulses.*

Connection to the main board

A 24-pin dil socket, which may be either a standard or zero-insertion-force type, mates with the header plug on the lead from the emulator board. Three other connections to the programming board may be made through a four-way cable, plug and socket. I used an RS467 611 socket shell, with 467 589 terminals, and a 468 080 right-angle plug in my version.

Boards produced using the available overlays (and those boards from PKG Electronics) have four holes for this connector to the right of IC_1. From top to bottom, the connections are flag 1, no connection, $\overline{CS}$ and NHOLD. Removal of the unused plug pin and fitting of

Table 1. Modification to the programming software. With the original software*, the e prompt did not occur until one second after e had been keyed. Uninitiated operators pressing the e key again within 1s to try and get some response on the display would find their software overwritten with FF bytes. The e prompt appears as soon as the key is pressed with the software modifications shown. Blank spaces in lines 36 and 45 should be ignored since the original software at their locations remains unaltered.

36				75										C4	00	C9
37	C0	C4	07	C9	C1	C1	C1	E4	9F	9C	40	C4	04	C9	C0	C4
38	00	C9	C1	B9	30	9C	E4	C4	08	36	C4	00	32	C6	01	36
39	D4	0F	98	05	36	8F	02	90	F4	C4	00	07	C4	03	C9	2A
40	C4	63	C9	2B	C4	2F	C9	2C	C4	2B	C9	2E	C4	07	C9	2F
41	C4	7F	C9	28	C4	05	37	C4	D2	33	3F	C4	0E	C9	C0	C4
42	00	C9	C1	36	C9	30	36	32	C9	31	32	C4	FF	CE	01	36
43	D4	0F	98	07	36	8F	02	90	F4	90	1D	C4	08	36	C6	01
44	8F	02	32	01	C1	31	60	98	04	01	32	90	F1	36	01	C1
45	30	60	98	A5	01	36	90	E6								

** The author asks us to point out that the tenth byte along line 21 of the main program shown last month read 69 but should have read B9.*

a blanking plug in the socket will ensure that the connector cannot be fitted the wrong way round.

Before the eprom to be programmed is inserted, the 5V supply should be switched on and the emulator and programming boards connected together. Now, with a blank eprom in the socket and a developed program in the emulator's memory, the e key is pressed. This initiates the programming sequence, consisting of 2048 cycles of about 50ms each. When programming is complete, the display will show 'burnt'.

If the software written into the emulator is not intended to fill the eprom, set the display to show the first unused address and press the e key twice within one second. The prompt will amend to F and each unused byte of ram will be loaded with FF immediately before the byte concerned is programmed into the eprom; otherwise, the programming sequence remains the same.

Should software in the emulator have to be programmed into the remaining space of a partially full eprom, the emulator ram should be filled with FF before the eprom is inserted ready for programming. When the procedure is finished, the display will show 'burnt'. Removing the three-pole connector carrying flag 1, chip-select and hold will speed up the FF-filling process by eliminating the 50ms delay at each address. Now, the required program can be typed into the emulator from a specified address, the connector replaced, the eprom inserted and the e key pressed once. This transfers the new program, leaving data already in the eprom unaltered.

It is not possible to read back the contents of an eprom with this basic tool so it is wise to keep copies of programs on tape if future software expansions or modifications are envisaged.

Printer-mechanism control

Minor software modifications and a little additional hardware allow a small printer mechanism to be driven by the emulator to produce whole or partial listings of the emulator's memory contents. Discounting the printer and its 24V power supply, it is estimated that additional electronic components will cost about £2.

Printing is initiated by a spare control key marked p mentioned in the first article. Referring to Fig. 2, transistors five and six switch the 24V supply to control the paper when the p key is pressed. Transistors seven to ten drive and brake the motor.

The i.c. used for display driving on the emulator board, IC_3, consists of seven Darlington transistors. When the printer is operational, this i.c. is used to drive the heads so prompt characters are not shown on the display. In this case, the printer in action provides sufficient prompting.

Character generation and synchronization with the print-head traverse are carried out by software for which there is ample space in the 2K monitor eprom. Using software in this way keeps costs to a minimum.

Operation

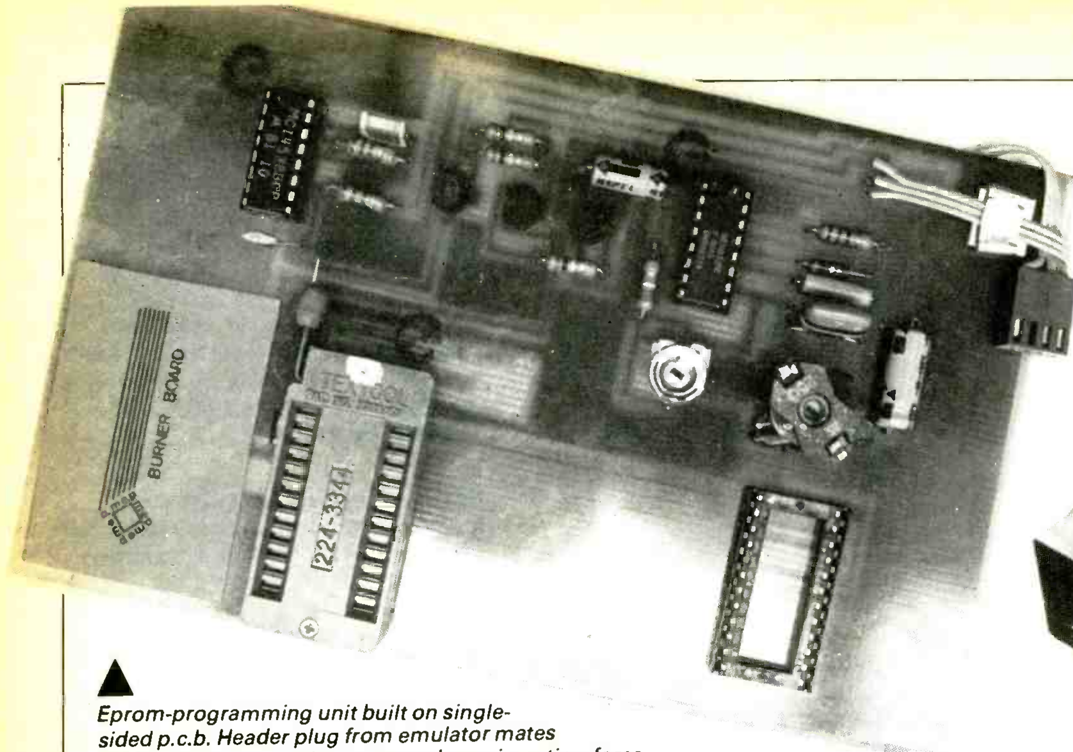
Before the printer is used, the 24V supply should be set by adjusting the potentiometer in the 12V regulator's ground lead. When the printer is connected, the a key is used to set the displayed address to the beginning of the program to be printed and the p key is then pressed. Printing continues until address 7FF is reached unless the p key is redepressed for around a half of a second. When printing is completed, the print head positions itself at the left-hand side of the carriage and out of contact with the paper so that the software record can be fed through and torn off.

It is important to note that the metallized paper used is at 24V with respect to the 0V line of the emulator so damage is likely to result if the paper touches any conducting element of the system while still in the printer. Covers will be needed not only to prevent access to mains voltages but also to prevent the paper touching any conducting part of the system.

The PU245-L20 printer mechanism used with the original system prints twenty columns of 5-by-7-dot characters on 60mm-wide electrosensitive paper in roll form and is available from Farnell

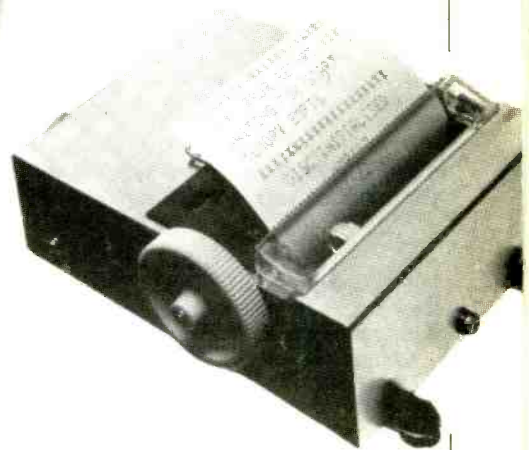
Table 2. Control and character-generator software for driving a small printer mechanism to provide listings of the emulator's ram. As shown, the relocatable printer routine between lines 45 and 60 follows on at the end of the modified programming routine shown in this article. If the programming software shown in the October issue is to be used, line 45(a) at the end of this listing should be used instead of line 45. If the modified programming routine is to be used without the printer, line 45(b) should be used. This leaves the eighth control key without a function and the program jumps back to the start of the monitor if it is pressed. Blank spaces should be ignored and decimal line numbers shown correspond with those given in the original listing. Lines 98 to 102 are character generator tables.

45									C4	06	37	C4	10	33	C4	00
46	C9	35	C9	36	C9	3C	C9	3D	C9	3E	C9	3F	C9	C0	C4	04
47	07	C4	00	C9	41	C4	08	C9	40	06	D4	10	98	FB	06	D4
48	10	9C	FB	C2	00	1C	1C	1C	1C	01	02	40	70	70	70	70
49	01	C3	80	C9	30	C4	01	70	01	C3	80	C9	31	C4	01	70
50	01	C3	80	C9	32	C4	01	70	01	C3	80	C9	33	C4	01	70
51	01	C3	80	C9	34	C6	01	D4	0F	01	40	70	70	70	70	01
52	C3	80	C9	37	C4	01	70	01	C3	80	C9	38	C4	01	70	01
53	C3	80	C9	39	C4	01	70	01	C3	80	C9	3A	90	04	90	95
54	90	A1	C4	01	70	01	C3	80	C9	3B	C4	30	01	06	D4	20
55	9C	FB	06	D4	20	98	FB	C1	80	C9	C0	C4	AE	8F	00	C4
56	00	C9	C0	06	D4	20	9C	FB	06	D4	20	98	FB	40	E4	3F
57	98	06	C4	01	70	01	90	D5	C1	C1	E4	9E	98	04	C4	01
58	C9	41	B9	40	98	02	90	B8	36	D4	0F	98	05	36	C1	41
59	98	AC	06	D4	10	98	FB	8F	B8	C4	00	07	C1	C1	E4	9E
60	9C	FA	C4	00	37	C4	00	33	3F							
98	3E	45	49	51	3E	00	21	7F	01	00	21	43	45	49	31	42
99	41	51	69	46	0C	14	24	7F	04	72	51	51	51	4E	1E	29
100	49	49	06	40	47	48	50	60	36	49	49	49	36	30	49	49
101	4A	3C	3F	48	48	48	3F	7F	49	49	49	36	3E	41	41	41
102	22	7F	41	41	22	1C	7F	49	49	49	41	7F	48	48	48	40
45(a)	08	08	08	08	08	08	08	08	C4	06	37	C4	10	33	C4	00
45(b)	30	60	98	A5	01	36	90	E6	C4	00	37	C4	00	33	3F	FF



Eprom-programming unit built on single-sided p.c.b. Header plug from emulator mates with standard i.c. socket; a second zero-insertion-force socket is more convenient here but far more expensive.

Electrosensitive printer mechanism used to provide hexadecimal listings of the emulator ram contents. It has a vertical row of seven dots and the character dot width is determined by software.



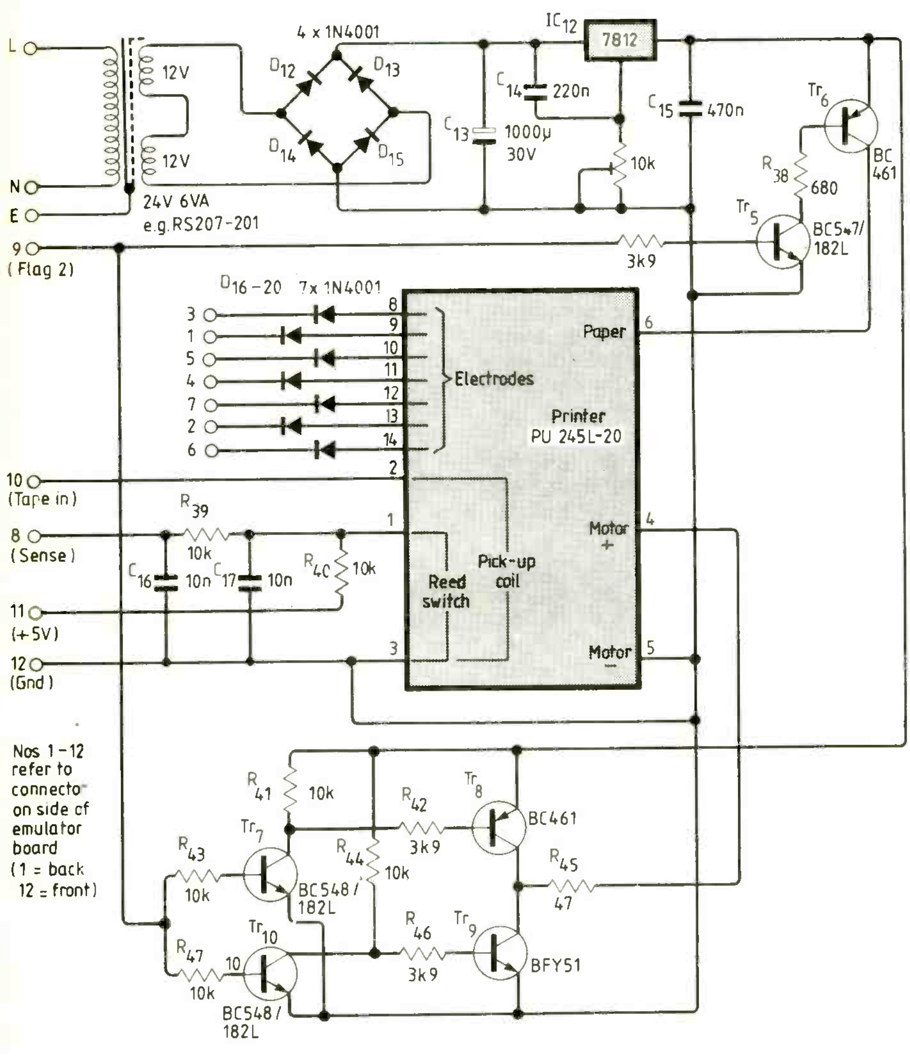


Fig. 2. *Hard copy of the emulator ram's contents was obtained using a small, cheap printer mechanism connected as shown. The display-driver i.c. consisting of seven Darlington drives the print head so display prompts are not given during printing. Numbers 1 to 12 refer to connector pins on the single-sided boards available.*

Sample of the PU245 printer's font which is under software control.

Electronic Components Ltd, Canal Road, Leeds LS12 2TU, or from GMT Electronics, Newport House, 22 Hartfield Road, London SW19 3TD under the code name 10E 012 LE. The print head has seven vertical dots and software is used to determine the character dot width.

Etched but undrilled boards for the programmer and printer electronics are available from PKG Electronics, Oak Lodge, Tansley, Derbyshire for £4 each including postage. Undrilled boards for the emulator are also available at £8 each inclusive, as are programmed eproms at £5 inclusive, from the same source. These eproms contain the printer routine.

Photocopies of the track layouts and component positions can be obtained by sending a large s.a.e. to Wireless World Emulator, Room L303, Quadrant House, Sutton, Surrey SM2 5AS.

Wireless World Index

The index for last year's volume of *Wireless World* is available for 75pence, postage included, from General Sales Department, IPC Electrical-Electronic Press Ltd, Quadrant House, Sutton, Surrey. Indices back to 1973 are available for the same price, except that for 1977 which costs £1.20.

NEW PRODUCTS

PERSONAL COMPUTER

Basic language in Hewlett-Packard's portable computer is part of a 48K operating system supplemented by 16K of ram, expandable up to 24K, and up to three plug-in rom modules of 8 or 16K. As the unit is battery powered, memory contents are retained when the computer is switched off and the real-time clock can be used as an alarm clock or to turn on the computer and run a program at a set time. The 32-character sections of 96-character lines shown on a dot-matrix l.c.d. may be scrolled from side to side. Programs and data stored on magnetic strips capable of holding 1.3K bytes are read by a transducer in the computer, or alternatively peripherals with much larger magnetic memories may be used. Of the 169 instructions in the operating system, 147 are Basic commands, statements or functions; program, data and appointment files can be named, saved and made to interact with each other. Every key on the 254 by 127 by 32mm unit is redefinable and may be given a new label using snap-on overlays. Peripherals include printers and plotters. Hewlett-Packard Ltd, Nine Mile Ride, East Hampstead, Wokingham, Berks.
WW301

WW301

LOW-COST 1MBYTE DISC DRIVES

Up to 1.2Mbyte of formatted data can be stored on a half-height 5¼ in disc drive costing under £400 excluding vat. Called the YD380T, this double-sided, double-density drive comes from the Japanese company Ye-Data who also manufacture a standard-height 5¼in drive capable of holding 800Kbyte of formatted data and costing £325, the YD280. An eight-inch version, the YD180, with a capacity similar to the 380T costs under £400 and uses IBM or equivalent diskettes. When used as double-density drives, the two 1.6Mbyte drives, the 180 and 380T, transfer data at 500Kbits/s and have average access times of 91ms and average latency times of 83ms. These drives are intended for original-equipment manufacturers are are thus uncased and without power supply.

Systems consisting of one 8in drive and one high-density 5¼ drive, or two of the latter, are also available. A CP/M compatible disc-operating system for either size of drive may be used to transfer existing software from one size of drive to the other, or existing software on 8in disc can be converted by the importer if two 5¼in high-density drives are to be used. Vincelord Ltd, Suite 2, 26 Charing Cross Road, London WC2.
WW302

CMOS A-TO-D CONVERTER

An 8-bit microprocessor-compatible analogue-to-digital converter called the ADC830 is manufactured by Datel-Intersil (Intersil Datel in the UK). Conversion time is 100μs and the device, with external adjustment, gives a maximum error of ±½ l.s.b. Outputs may be switched to a high-impedance state. Intersil Datel (UK) Ltd, Snamprogetti House, Basing View, Basingstoke, Hants RG21 2YS.
WW303

WW304

STORAGE SCOPE FOR LESS THAN £1,000

According to Gould, the OS1400 20MHz digital-storage oscilloscope is the first of its kind for under £1000 since their first one in the early seventies. This dual-channel instrument has pre-triggering from 0 to 100% and post-storage trace expansion facilities and may be used as a real-time oscilloscope. Its storage capacity is 1K by 8-bits, giving vertical and horizontal resolutions of 1 in 256 and 1 in 1024 respectively; a dot-joining facility giving linear interpolation between samples is incorporated. Display modes allow freezing of the display at the end of a triggered sweep, immediate freezing of the display, data and display refresh on triggering and a rolling-display mode in which the pre-trigger storage facility may be used. A version with X, Y and pen-lift outputs for use with a plotter is also available. Gould Instruments Ltd, Roebuck Road, Hainault, Ilford, Essex IG6 3EU.
WW304

EIGHT-CHANNEL MULTIPLEXER

Eight analogue and/or digital time-related signals may be viewed at once on a single-channel oscilloscope using the 8001 from Global Specialities. Multiplex rate and overall gain are variable as is the trigger level between ±5V, triggering being taken from the first channel and available as a t.t.l. compatible signal at the output. Each channel has an input impedance of 1MΩ, will accept levels of ±5V, and has a flat response to 12MHz down 3dB at 20MHz. Channels may be viewed individually by stepping manually, viewed all at once, or one of two groups of four may be displayed. Its price is £225 excluding vat. Global Specialities Corp., Shire Hill Industrial Estate, Saffron Waldon, Essex CB11 3AQ.
WW305

WW305

NEW PRODUCTS

ZX INTERFACE

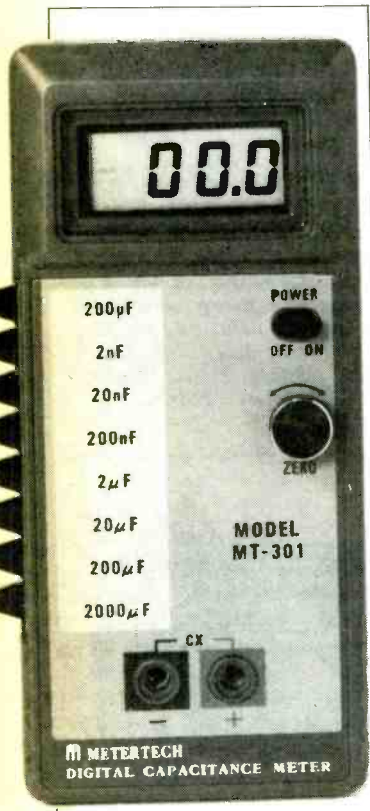
Digital and analogue i/o modules for control and sensing applications using the ZX80 and 81 computers are made by RD laboratories. These modules connect to the computer through one of two main interfaces, one at £15 for carrying two modules and one at £40 for carrying up to eight modules. Five modules ranging in price from £27.50 to £34.49 are available for digital i/o, analogue input, output and multiplexing, and light-pen connection. RD Laboratories, 5 Kennedy Road, Dane End, Ware, Herts SG12 0LU.

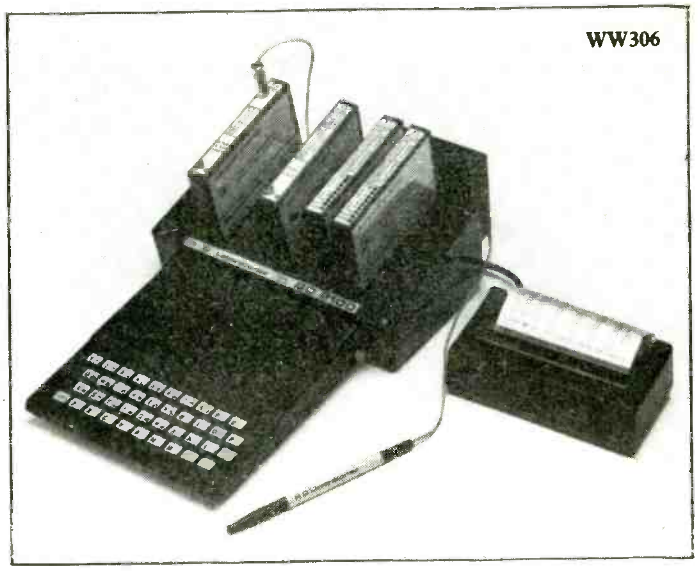
WW306

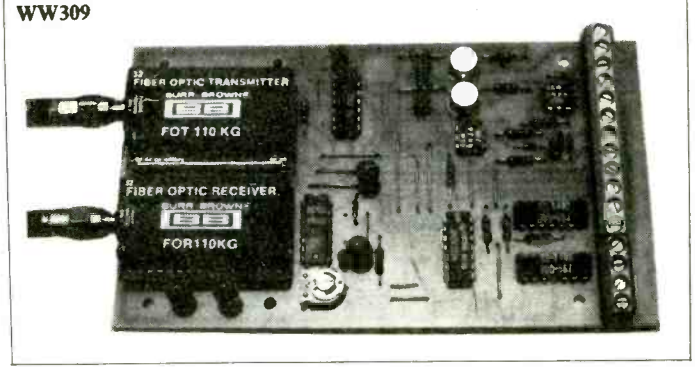
DIGITAL CAPACITANCE METER

Highest and lowest of eight ranges on Metertech's MT301 hand-held capacitance meter are 2000µF and 200pF respectively. The meter's readings are given on a half-inch high 31/2 digit l.c.d. with 0.5%, ±1 digit error on the lowest range with 0.1pF resolution. At £69, the instrument includes test clips and batteries; a case is available for £6. Centemp Instruments Co., 62 Curtis Road, Hounslow, Middlesex TW4 5PT.

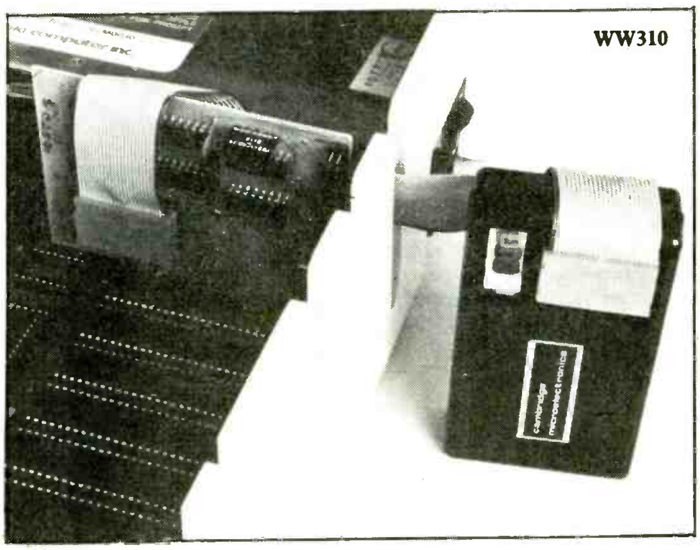
WW307




WW306



WW309


WW310

P.W.M. I.C. FOR REGULATORS

Two i.cs designed for driving power mosfets in switched-mode power supply applications are manufactured by Siliconix and available through Semiconductor Specialists. The PWM25 and PWM27 are 16-pin devices containing an error amplifier, flip-flop, oscillator, pulse-width modulator and voltage regulator for controlling drive-signal frequency and pulse width. The PWM25 has two outputs which are low in the off state; in the PWM27, the outputs are high in the off state. A shut-down function is included. The same distributors have recently introduced a range of low-noise op-amps from Raytheon, the RC714 series, that require an input bias current of typically 1nA. Semiconductor Specialists (UK) Ltd, Carroll House, 159 High Street, Yiewsley, West Drayton, Middlesex UB7 7XB.

WW308

FIBRE-OPTIC DATA LINK

Designers wanting to evaluate the many advantages of fibre-optic data-communication links over their electrically-conducting counterparts can do so with a kit from Burr Brown. Two RS232/20mA-compatible transmitter/receiver boards and two 33-metre lengths of fibre-optic cable are main elements of the £299 kit. Burr Brown International Ltd, Cassiobury House, 11-19 Station Road, Watford, Herts WD1 1EA.

WW309

ROM USING RAM

Lithium batteries are used to retain data in 2Kbyte of data in cmos ram for around 10 years in a product called Memic-L from Camel. Connection of the 102 by 61 by 25.4mm device to the computer is through a 30cm long 24-way cable so more than one unit may be used on boards with sockets that are close together such as used in the Apple. Function switches are used to select the upper or lower half of memory or the whole 2K, depending on the type of system, and access time is said to be better than 200ns. Each device is supplied with instructions for £29.95. Cambridge Microelectronics Ltd, 1 Milton Rd, Cambridge CB4 1UY.

WW310

AMBISONIC DECODER

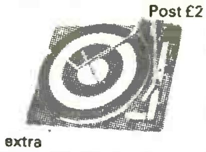
Besides decoding UHJ ambisonic recordings, such as used on records from Unicorn and Nimbus, the AD2 also enhances standard stereo. It consists of a board measuring 100 by 100 by 25mm intended to fit into existing hi-fi equipment and includes a control for compensating for different speaker layouts. Currently available recordings are two channel but the decoder will also be suitable for three-channel UHJ recordings. (See, for example, NRDC surround-sound system by M. A. Gerzon, WW April 1977 page 36.) The AD2 costs £49.45 including vat. Minim Audio Ltd, Lent Rise Road, Burnham, Slough SL1 7NY.

WW311

Professional readers are invited to request further details on items featured here by entering the appropriate WW reference number(s) on the mauve reply-paid card.

U.K. RETURN OF POST MAIL ORDER SERVICE, ALSO WORLDWIDE EXPORT SERVICE

BSR DE LUXE AUTOCHANGER £18



Post £2

Plays 12", 10" or 7" records, Auto or Manual. A high quality unit backed by BSR reliability. Stereo Ceramic Cartridge. AC 200/250V. Size 13½×11¼in. 3 speeds. Above motor board 3¾in. Below motor board 2½in. Cut out Mounting Board £1 extra

HEAVY METAL PLINTHS

Post £2

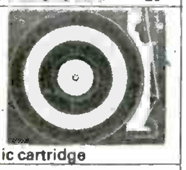
Cut out for most BSR or Garrard decks. Silver grey finish, black trim. Size 16x13¾in. **£4**

DECCA TEAK VENEERED PLINTH. Post £1.50
Superior finish with space and panel for small amplifier. Board is cut for B.S.R. 18¾in.×14¼in×4in. Black/chrome facia trim. Also with boards cut out for Garrard £3. **Tinted plastic cover £5** **£5**

TINTED PLASTIC COVERS Post £2

17⅞×13⅛×3¼in.	£5	18¼×12½×3in.	£5
17¼×9⅜×3½in.	£3	14⅜×12½×2⅞in.	£5
16½×15×4½in.	£5	16⅝×13×4in.	£5
17×12⅞×3½in.	£5	14½×13⅛×2¾in.	£5
22⅝×13⅞×3in.	£5	17¼×13¾×4⅛in.	£5
21½×14¼×2½in.	£5	21×13⅞×4⅛in.	£5
23¾×14×3⅞in.	£5	30¾×13⅝×3¼in.	£5

BSR SINGLE PLAYER DECKS



BSR P170 RIM DRIVE QUALITY DECK **£20** Post £2

Manual or automatic play. Precision ultra slim arm. Black with silver trim, stereo ceramic cartridge

BSR P204 SINGLE PLAYERS SPECIAL OFFERS
Two speed 33/45 r.p.m. hi-fi decks with stereo cartridges, cueing device and snake arm.
Ceramic – 240V AC **£15** or 9V DC **£18**
Magnetic – 240V AC **£20** or 12V DC **£24** **Post £2**

THE "INSTANT" BULK TAPE ERASER **£9.50** Post 95p

Suitable for cassettes and all sizes of tape reels. AC mains 200/250V. Hand held size with switch and lead (120 volt to order). Will also demagnetise small tools and computer tapes.
Head Demagnetiser only £5.

BATTERY ELIMINATOR MAINS to 9 VOLT D.C.
Stabilised output, 9 volt 400 m.a. U.K. made in plastic case with screw terminals. Safety overload cut out. Size 5x3¼x2½in. Transformer Rectifier Unit. Suitable Radios, Cassettes, models, **£4.50**. Post 50p.

DE LUXE SWITCHED MODEL STABILISED. £7.50. PP £1. 3-6-7½-9 volt 400ma DC max. Universal output plug and lead. Pilot light, mains switch, polarity switch.

DRILL SPEED CONTROLLER/LIGHT DIMMER KIT. Easy build kit. Controls up to 480 watts AC mains, **£3.** PP 65p.
DE LUXE MODEL READY-BUILT 800 watts. Front plate fits standard box, £5. Post 65p.

EMI 13½x8in. LOUDSPEAKERS

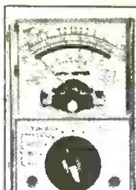
Model 450, 10 watts R.M.S. with moving coil tweeter and two-way crossover; 3 ohm or 8 ohm.
"Final Clearance". **Sale Price** **£8**
SUITABLE BOOKSHELF CABINET £6.50. Size 18×11×6in. Post £1.50. Post £1.50

RELAYS. 6V DC **95p.** 12V DC **£1.25.** 18V **£1.25.** 24V **£1.30**
BLANK ALUMINIUM CHASSIS. 6×4–**£1.45;** 8×6–**£1.80;** 10×7–**£2.30;** 12×8–**£2.60;** 14×9–**£3;** 16×6–**£2.90;** 16×10–**£3.20.** 14×3 **£1.80.** All 2½in. deep. 18 swg.
ANGLE ALI. 6×¾×¾in. 18 swg. **30p.**
ALUMINIUM PANELS, 18swg. 6×4–**45p;** 8×6–**75p;** 14×3–**75p;** 10×7–**95p;** 12×8–**£1.10;** 12×5–**75p;** 16×6–**£1.10;** 14×9–**£1.45;** 12×12–**£1.50;** 16×10–**£1.75.**
ALUMINIUM BOXES. 4×4×1½ **£1.** 4×2½×2 **£1.** 3×2×1 **£1.** 6×4×2 **£1.60.** 7×5×3 **£2.40.** 8×6×3 **£2.50.** 10×7×3 **£3.** 12×5×3 **£2.75.** 12×8×3 **£3.60.** All with lids, (inch sizes).
BRIDGE RECTIFIER 200V PIV 2a **£1.** 4a **£1.50.** 6a **£2.50.**
TOGGLE SWITCHES SP **40p.** DPST **50p.** DPDT **60p.**
MINIATURE TOGGLES SP **40p.** DPDT **60p.**
RESISTORS. 10Ω to 10M. ¼W, ½W, 1W, **2p**: 2W **10p.**
HIGH STABILITY. ½w 2% 10 ohms to 1 meg. **10p.**
WIRE-WOUND RESISTORS 5 watt, **10** watt, 15 watt **20p.**
PICK-UP CARTRIDGES SONOTONE 9TA **£2.50.**
BSR Stereo Ceramic SC7 Medium Output **£2.** SC12 **£3.**
PHILIPS PLUG-IN HEAD. Stereo Ceramic. AU1020 (G306 GP310 - GP233 -AG3306, **£2.** A.D.C., **QLM 30/3 Magnetic £5.**
GOLDRING G850 **£6.50,** G800 **£8.50. STYLUS** most popular Acos, Sonatone, BSR, Diamond £1.20ea.
LOCKTITE SEALING KIT DECCA 118 . Complete **£1.**
VALVE OUTPUT Transformers (small) **90p.**
SUB-MIN MICROSWITCH, 50p, Single pole changeover.
ANTEX SOLDERING IRON 240V 15W **£4.60.** 25W **£4.70.**
JACK PLUGS Mono Plastic **25p;** Metal **30p.**
JACK PLUGS Stereo Plastic **30p;** Metal **35p.**
JACK SOCKETS Mono **25p.** Stereo **30p.**
FREE SOCKETS – Cable end **30p.** Metal **45p.**
2.5mm and 3.5mm **JACK SOCKETS 25p. Plugs 25p.**
DIN TYPE CONNECTORS
Sockets 3-pin, 5-pin **15p.** Free Sockets 3-pin, 5-pin **25p.** Plugs 3-pin **20p;** 5-pin **25p;** Speaker plugs **25p;** Sockets **15p.**
PHONO PLUGS and SOCKETS ea. 20p.
Free Socket for cable end **20p.** Screened Phono Plugs **25p.**
300 ohm TWIN RIBBON FEEDER 10p yd.
300 ohm to 75 ohm AERIAL MATCHING TRANSFORMER £1.
U.H.F. COAXIAL CABLE SUPER LOW LOSS, 25p yd.
COAX PLUGS 30p. COAX SOCKETS 20p. Lead Sockets 65p.
NEON INDICATORS 250V, round **30p.** Rectangular **45p.**

POTENTIOMETERS Carbon Track

5kΩ to 2MΩ. LOG or LIN. L/S **50p.** DP **90p.** Stereo L/S **£1.10.** DP **£1.30.** Edge Pot 5K. SP **45p.**

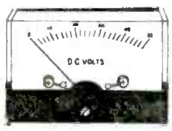
MINI-MULTI TESTER NEW



De luxe pocket size precision moving coil instrument. Impedance + Capacity – 4000 o.p.v. Battery included.
11 instant ranges measure:
DC volts 5.25, 250, 500.
AC volts 10, 50, 500, 1000. **£6.50**
DC amps 0-250μA, 0-250mA. Post 50p
Resistance 0 to 600K ohms.

De Luxe Range Doubler Model, 50,000 o.p.v. £18.50. 7×5×2in. Post £1

NEW PANEL METERS £4.50



50μa, 100μa, 500μa, 1ma, 5ma, 50ma, 100ma, 500ma, 1 amp, 2 amp
25 volt, VU Meter.
2¼×2×1¼ Post 50p
Stereo VU meter
3¼×1⅝×1in. **£3**

RCS SOUND TO LIGHT CONTROL BOX **£27**

Complete ready to use with cabinet size 9×3×5in. 3 channel, 1000 watt each. For home or disco Input 200mV to 100 watt. AC 200/250V. Post £1.
OR KIT OF PARTS £19.50, LESS CABINET £15
Disco bulbs 100 watt, blue, green, yellow, red, amber, screw or bayonet **£1.85** each. Post **£1.50** per six.
Rope lights, 4 channel, 11ft with controller 240V **£33.** PP £1.
"Fuzz" lights, red, blue, green, amber, 240V AC. **£23.**
200 Watt Rear Reflecting White Light Bulbs. Ideal for Disco Lights, Edison Screw. 6 for **£4,** or 12 for **£7.50.** Post 65p. Suitable panel mounting holders **85p.**

RCS "MINOR" 10 watt AMPLIFIER KIT £14

This kit is suitable for record players, guitars, tape playback, electronic instruments or small PA systems. Two versions available: Mono, **£14;** Stereo, **£20.** Specification 10W per channel; size 9½×3×2in. SAE details. Full instructions supplied. 240V AC mains. Post £1.

RCS STEREO PRE-AMP KIT. All parts to build this pre-amp. Inputs for high, medium or low imp per channel, with volume control and PC Board **£2.95**
Can be ganged to make multi-way stereo mixers Post 65p

MAINS TRANSFORMERS

	Price	Post
250-0-250V 80mA, 6.3V 3.5A, 6.3V 1A	£5.00	£2
350-0-350V 250mA, 6.3V 6A CT	£12.00	£2
220V 25ma 6V lamp £2. 220V 45ma 6V 2 Amp	£3.00	£1
250V 60mA, 6V 2A	£3.75	£1
AUTO 115V to 240V 150W £9. 250W £10. 400W £11. 500W	£12.00	£2

GENERAL PURPOSE LOW VOLTAGE

Tapped outputs available	Price	Post
2 amp. 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 25 and 30V	£6.00	£2
1 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£6.00	£2
2 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£10.50	£2
3 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£12.50	£2
5 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£16.00	£2

5-8-10-16V. ½ amp.	£2.50	80p	15-0-15V. 2 amps	£3.75	£1
6V. ½ amp.	£2.00	£1	20V 1 amp	£3.00	£1
6-0-6V. 1½ amp.	£3.50	£1	20-0-20V 1 amp	£3.50	£1
9V. 250ma.	£1.50	80p	20-40-60V 1 amp	£4.00	£2
9V. 3 amp	£3.50	£1	25-0-25V 2 amps	£4.50	£1
9-0-9V. 50ma	£1.50	80p	28V 1 amp Twice	£5.00	£2
10-0-10V. 2 amps	£3.00	£1	30V 1½ amp	£3.50	£1
10-30-40V. 2 amps	£3.50	£1	30V 5 amp and 17-0-17 2a	£4.50	£2
12V. 100ma	£1.50	80p	35V 2 amps	£4.00	£1
12V. 750 ma	£2.00	80p			
12V 3 amps	£3.50	£1	TOROIDAL 30-0-30V 4a and 20-0 20V ½a	£10.00	£2
12-0-12V. 2 amps	£3.50	£1			

CHARGER TRANS	Post	RECTIFIERS	Post
6-12 volt 3a	£4.00+£2	6-12 volt 2a	£1.10+80p
6-12 volt 4a	£6.50+£2	6-12 volt 4a	£2.00+80p

OPUS COMPACT SPEAKERS £22 pair Post £2

TEAK VENEERED CABINET
11×8½×7in, 15 watts
50 to 14,000 cps. 4 ohm or 8 ohm
OPUS TWO 15×10½×7¾in 25 watt 2-way system **£39 pair.** Post £3

LOW VOLTAGE ELECTROLYTICS Wire ends 10p
1 mf, 2 mf, 4 mf, 8 mf, 10 mf, 16 mf, 25 mf, 30 mf, 50 mf, 100 mf, 250 mf. All 15 volts. 22 mf/6v/10v; 25 mf/6v/10v; 47 mf/10v; 50 mf/6v; 68 mf/6v/10v/16v/25v; 100 mf/10v; 150 mf/6v/10v; 200 mf/10v/16v; 220 mf/4v/10v/16v; 330 mf/4v/10v; 500 mf/6v; 680 mf/6v/10v/16v; 1000 mf/2.5v/4v/10v; 1500 mf/6v/10v/16v; 2200 mf/6v/10v; 3300 mf/6v; 4700 mf/4v.
500mF 12V 15p; 25V 20p; 50V 30p. 1200mF 76V **80p.**
1000mF 12V **20p;** 25V **35p;** 50V **50p;** 100V **70p.**
2000mF 6V **25p;** 25V **42p;** 40V **60p;** 1200mF 100V **£1.20.**
2200mF 63V **90p.** 2500mF 50V **70p;** 3000mF 50V **65p;**
4500mF 64V **£2.** 4700mF 63V **£1.20.** 4700mF/40V **85p.**

HIGH VOLTAGE ELECTROLYTICS

2/500V	45p	8+8/450V	75p	32+32+16/350V	90p
8/450V	45p	8+8/500V	£1	100+100/275V	65p
16/350V	45p	8+16/450V	75p	150+200/275V	70p
32/500V	75p	32+32/350V	50p	220/450V	95p
32/350V	50p	32+32/500V	£1.80	32+32+32/325V	75p
50/450V	95p	50+50/300V	50p	50+50+50/350V	95p

CAPACITORS WIRE END High Voltage
.001, .002, .003, .005, .01, .02, .03, .05 mfd 400V **5p.**
.1MF 200V **5p.** 400V **10p.** 600V **15p.** 1000V **25p.**
.22MF 350V **12p.** 300V **20p.** 1000V **30p.** 1750V **50p.**
.47MF 1500V **10p.** 400V **20p.** 630V **30p.** 1000V **60p.**
TRIMMERS 30pF **50pF, 10p.** 100pF, 150pF **20p.** 500pF **30p.**
MICROSWITCH SINGLE POLE CHANGEOVER 40p.
TWIN GANG, 12CpF **£1.** 500+200pF **£1.**
GEARED TWIN GANGS 25pF **95p.**
GEARED 365+365+25+25pF **£1.**
TRANSISTOR TWIN GANG. Japanese Replacement **£1**
SOLID DIELECTRIC 100pF £1.50, 500pF £1.50

HEATING ELEMENTS, WAFER THIN (Semi Flexible)
Size 11×9×⅛in. Operating voltage 240V, 250W approx. Suitable for Heating Pads, Food Warmers, Convector Heaters, Propagation, etc. Must be clamped between two sheets of metal or ceramic, etc.
ONLY 60p EACH (FOUR FOR £2) ALL POST PAID.

NEW baker Star sound

high power full range quality loudspeakers British made exceptional reproduction. Ideal for Hi-Fi, music P.A. or discotheques. These loudspeakers are recommended where high power handling is required with quality results. The high flux ceramic magnet ensures clear response.

MODEL	INCHES	OHMS	WATTS	TYPE	PRICE	POST
MAJOR	12	4-8-16	30	HI-FI	£14	£2
DELUXE MK II	12	8	15	HI-FI	£14	£2
SUPERB	12	8-16	30	HI-FI	£24	£2
AUDITORIUM	12	8-16	45	HI-FI	£22	£2
AUDITORIUM	15	8-16	60	HI-FI	£34	£2
GROUP 45	12	4-8-16	45	PA	£14	£2
GROUP 75	12	4-8-16	75	PA	£18	£2
GROUP 100	12	8-16	100	Guitar	£24	£2
DISCO 100	12	8-16	100	Disco	£24	£2
GROUP 100	15	8-16	100	Guitar	£32	£2
DISCO 100	15	8-16	100	Disco	£32	£2

BAKER AMPLIFIERS BRITISH MADE

NEW PA150 MICROPHONE PA AMPLIFIER £129
4 channel 8 inputs, dual impedance, 50K-600 ohm 4 channel mixing, volume, treble, bass. Presence controls, Master volume control, echo/send/return socket. Slave sockets. Post £3.

BAKER 150 Watt AMPLIFIER 4 Inputs £89
For Discotheque, Vocal, Public Address. Three speaker outlets for 4, 8 or 16 ohms. Four high gain inputs, 20 mv, 50K ohm. Individual volume controls "Four channel" mixing. 150 watts 8 ohms R.M.S. Music Power. Slave output 500 M.V. 25K.ohm. Response 25 Hz – 20kHz ± 3dB. Integral Hi-Fi preamp separate Bass & Treble. Size – 16"×8"×5½". Wt – 14lb: Master volume control. British made. 12 months' guarantee. 240v A.C. mains or 120V to order. All transistor and solid state. Post £2.
MONO SLAVE VERSION £75. 100 Volt Line Model £104. Post £2.
New Stereo Slave Model 150 + 150 watt £125. Post £4.

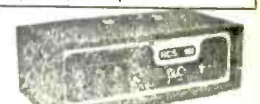
BAKER £69 Post £2 50 WATT AMPLIFIER

Ideal for PA systems, Discos and Groups. Two inputs, Mixer, Volume, Controls, Master Bass, Treble Gain.

RCS offers MOBILE PA AMPLIFIERS. Outputs 4-8-16 ohms
20-watt RMS 12v DC, AC 240v, 3 inputs. 50K **£46 PP £2.**
40-watt RMS 12v DC, AC 240v, 4 inputs. 50K **£75 PP £2**
Mic 1; Mic 2; Phono; **aux. outputs 4 or 8 or 16 and 100v line**
60-watt RMS, Mobile 24 volt DC & 240-volt AC mains. inputs 50K.
3 mics + 1 music. Outputs 4-8-16 ohm + 100 volts line **£95 PP £2**

Battery only Portable PA Amplifier 10w max. Includes mike and speaker, OK for meetings, crowd control, stalls, fetes, traders, parties, etc. Batteries included (6 of U2) **£27.50** post £2.

R.C.S. 100 watt Robust VALVE AMPLIFIER



4 Channel mixing. Master treble, bass and volume controls. 5 Speaker outlets, suits 4, 8, 16 ohm. Disco group. £125. Carr. & ins. £15.

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MAKE	MODEL	SIZE	WATTS	OHMS	PRICE	POST
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GOODMANS	TWEETER	3½in	25	8	£4	£1
AUDAX	TWEETER	4in	30	8	£6.50	£1
SEAS	MID-RANGE	4in	50	8	£7.50	£1
SEAS	MID-RANGE	5in	80	8	£12	£1
SEAS	MID-RANGE	4½in	100	8	£12.50	£1
GOODMANS	HIFAX	7½×4¼	100	4/8/16	£22	£2
GOODMANS	WOOFER	8in	25	4/8	£6.50	£1
GOODMANS	HB	8in	60	8	£12.50	£1
RIGONDA	GENERAL	10in	15	8	£5	£2
SEAS	WOOFER	10in	50	8	£16	£2
GOODMANS	HPG	12in	120	8/15	£29.50	£2
GOODMANS	GR12	12in	90	8/15	£27.50	£2
GOODMANS	HPD	12in	120	8/15	£29.50	£2
GOODMANS	HPD	18in	230	8	£80	£4

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LOUDSPEAKER BARGAINS
3 ohm, 5in, 7×4in, **£2.50;** 6½in, 8×5in, **£3;** 8in, **£3.50.** 10in, **£5.**
8 ohm, 2¾in, 3in, **£2;** 5×3in, 7×4in, 5in, **£2.50;** 6½in, 8×5in, **£3;** 8in, **£4.50;** 10in, **£5;** 12in, **£6.**
15 ohm, 3½in, 5×3in, 6×4in, **£2.50.**
25 ohm, 3in, **£2;** 5×3in, 7×4in, **£2.50.** 120 ohm, 3¼in dia. **£1.**
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R.C.S. LOW VOLTAGE STABILISED POWER PACK KITS **£3.95.** Post 65p
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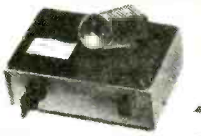
SOLDERING EQUIPMENT



PSU 24 VAC soldering station **£16.56**

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Both cut wire flush with surface, length 115mm
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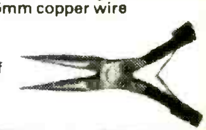
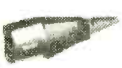
LONG NOSE PLIERS
2411 Slim narrow jaws, half round section
Total length 130mm **£4.48**



BULGIN MOULDED CONNECTORS



6 amp 250 VAC BS4491
P589 Length matching P580 **£0.91**
P589 Length side entry matching P580 **£0.91**
P589 2.5m P700 moulded cord set. BS1363A mains plug and CEE22 appliance connector with 2.5m of black cable **£2.25**

Mains inlet mates with P587 and P589 6 amp 250 VAC re-wirable P580/110/POT **£0.28**
P587 Screw terminals **£0.52**
P588 Side entry **£0.72**
P590 Mains inlet mates with P597 only 10 amp 250 VAC hot condition **£0.31**
P597 Mains connector **£0.56**
11328 Terminal cover **£0.15**
PF1/110 Fused appliance coupler **£0.57**

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Handheld Sabtronics complete with leads. Model 2035A **£49**

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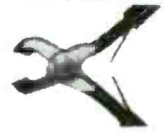

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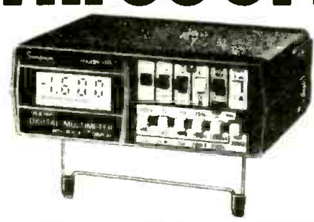

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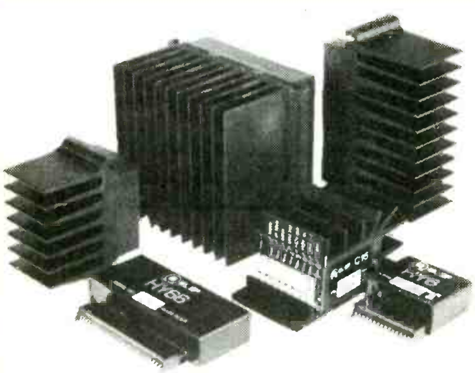
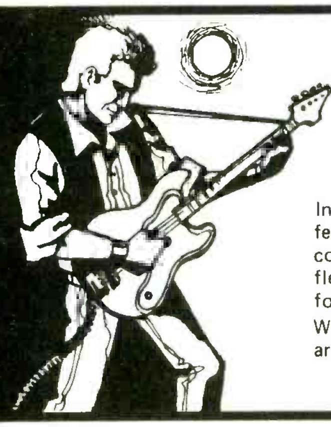


ILP Modular Amplifiers

the third generation

Due to continous improvements in components and design ILP now launch the largest and most advanced generation of modules ever.



WE'RE INSTRUMENTAL IN MAKING A LOT OF POWER

In keeping with ILP's tradition of entirely self-contained modules featuring, integral heatsinks, no external components and only 5 connections required, the range has been optimized for efficiency, flexibility, reliability, easy usage, outstanding performance, value for money.

With over 10 years experience in audio amplifier technology ILP are recognised as world leaders.

BIPOLAR MODULES

Module Number	Output Power Watts rms	Load Impedance Ω	DISTORTION T.H.D. Typ at 1KHz	DISTORTION I.M.D. 60Hz/7KHz 4:1	Supply Voltage Typ	Size mm	WT gms	Price inc VAT
HY30	15	4-8	0.015%	<0.006%	± 18	76 x 68 x 40	240	£8.40
HY60	30	4-8	0.015%	<0.006%	± 25	76 x 68 x 40	240	£9.55
HY6060	30 + 30	4-8	0.015%	<0.006%	± 25	120 x 78 x 40	420	£18.69
HY124	60	4	0.01%	<0.006%	± 26	120 x 78 x 40	410	£20.75
HY128	60	8	0.01%	<0.006%	± 35	120 x 78 x 40	410	£20.75
HY244	120	4	0.01%	<0.006%	± 35	120 x 78 x 50	520	£25.47
HY248	120	8	0.01%	<0.006%	± 50	120 x 78 x 50	520	£25.47
HY364	180	4	0.01%	<0.006%	± 45	120 x 78 x 100	1030	£38.41
HY368	180	8	0.01%	<0.006%	± 60	120 x 78 x 100	1030	£38.41

Protection Full load line. Slew Rate 15v/µs. Risetime 5µs. S/N ratio 100db
Frequency response (−3dB) 15Hz − 50KHz. Input sensitivity 500mV rms.
Input Impedance 100K Ω. Damping factor 100Hz >400.

PRE-AMP SYSTEMS

Module Number	Module	Functions	Current Required	Price inc. VAT
HY6	Mono pre amp	Mic/Mag. Cartridge Tuner/Tape/Aux + Vol/Bass/Treble	10mA	£7.60
HY66	Stereo pre amp	Mic/Mag. Cartridge/Tuner/Tape/Aux + Vol/Bass/Treble/Balance	20mA	£14.32
HY73	Guitar pre amp	Two Guitar (Bass Lead) and Mic + separate Volume Bass Treble + Mix	20mA	£15.36
HY78	Stereo pre amp	As HY66 less tone controls	20mA	£14.20

Most pre-amp modules can be driven by the PSU driving the main power amp. A separate PSU 30 is available purely for pre amp modules if required for £5.47 (inc. VAT). Pre-amp and mixing modules in 18 different variations. Please send for details.

Mounting Boards
For ease of construction we recommend the **B6** for modules HY6—HY13 £1.05 (inc. VAT) and the **B66** for modules HY66—HY78 £1.29 (inc. VAT).

MOSFET MODULES

Module Number	Output Power Watts rms	Load Impedance Ω	DISTORTION T.H.D. Typ at 1KHz	DISTORTION I.M.D. 60Hz/7KHz 4:1	Supply Voltage Typ	Size mm	WT gms	Price inc. VAT
MOS 128	60	4-8	<0.005%	<0.006%	± 45	120 x 78 x 40	420	£30.41
MOS 248	120	4-8	<0.005%	<0.006%	± 55	120 x 78 x 80	850	£39.86
MOS 364	180	4	<0.005%	<0.006%	± 55	120 x 78 x 100	1025	£45.54

Protection: Able to cope with complex loads without the need for very special protection circuitry (fuses will suffice).
Slew rate 20v/µs Rise time 3µs. S/N ratio 100db
Frequency response (−3dB) 15Hz − 100KHz. Input sensitivity 500mV rms
Input impedance 100K Ω Damping factor 100Hz >400.

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C15
Mono Power Booster Amplifier to increase the output of your existing car radio or cassette player to a nominal 15 watts rms.

Very easy to use.

Robust construction. **£9.14 (inc. VAT)**

Mounts anywhere in car.

Automatic switch on.

Output power maximum 22w peak into 4Ω
Frequency response (−3dB) 15Hz to 30KHz, T.H.D. 0.1% at 10w 1KHz
S/N ratio (DIN AUDIO) 80dB, Load Impedance 3Ω
Input Sensitivity and impedance (selectable) 700mV rms into 15KΩ 3V rms into 8Ω
Size 95 x 48 x 50mm, Weight 256 gms.

C1515
Stereo version of C15. **£17.19 (inc. VAT)**

Size 95 x 40 x 80. Weight 410 gms.

POWER SUPPLY UNITS (Incorporating our own toroidal transformers)

Model Number	For Use With	Price inc. VAT
PSU 21X	1 or 2 HY30	£11.93
PSU 41X	1 or 2 HY60, 1 x HY6060, 1 x HY124	£13.83
PSU 42X	1 x HY128	£15.90
PSU 43X	1 x MOS128	£16.70
PSU 51X	2 x HY128, 1 x HY244	£17.07

Model Number	For Use With	Price inc. VAT
PSU 52X	2 x HY124	£17.07
PSU 53X	2 x MOS128	£17.86
PSU 54X	1 x HY248	£17.86
PSU 55X	1 x MOS248	£19.52
PSU 71X	2 x HY244	£21.75

Model Number	For Use With	Price inc. VAT
PSU 72X	2 x HY248	£22.54
PSU 73X	1 x HY364	£22.54
PSU 74X	1 x HY368	£24.20
PSU 75X	2 x MOS248, 1 x MOS368	£24.20

Please note: X in part no. indicates primary voltage. Please insert "O" in place of X for 110V, "1" in place of X for 220V, and "2" in place of X for 240V.

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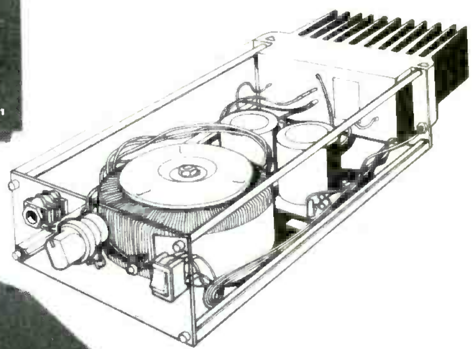
Because of ILP's modular approach, "open plan" construction is used and final assembly of the unit parts forms a compact aesthetic unit. By this method construction can be achieved in under two hours with little experience of electronic wiring and mechanical assembly.



Hi Fi Separates

UC1 PRE AMP UNIT: Incorporates the HY78 to provide a "no frills", low distortion, (<0.01%), stereo control unit, providing inputs for magnetic cartridge, tuner, and tape/monitor facilities. This unit provides the heart of the hi fi system and can be used in conjunction with any of the UP Unicase series of power amps. For ultimate hum rejection the UC1 draws its power from the power amp unit.

POWER AMPS: The UP series feature a clean line front panel incorporating on/off switch and concealed indicator. They are designed to compliment the style of the UC1 pre-amp. Performance for each unit which includes the appropriate power supply, is as specified on the facing page.

Power Slaves

Our power slaves, which have numerous uses i.e. instrument, discotheque, sound reinforcement, feature in addition to the hi fi series, front panel input jack, level control, and a carrying handle. Providing the smallest, lowest cost, slave on the market in this format.

UNICASES

HIFI Separates					Price inc. VAT
UC1	Preamp				£29.95
UP1X	30 + 30W/4–8Ω	Bipolar	Stereo	HiFi	£54.95
UP2X	60W/4Ω	Bipolar	Mono	HiFi	£54.95
UP3X	60W/8Ω	Bipolar	Mono	HiFi	£54.95
UP4X	120W/4Ω	Bipolar	Mono	HiFi	£74.95
UP5X	120W/8Ω	Bipolar	Mono	HiFi	£74.95
UP6X	60W/4–8Ω	MOS	Mono	HiFi	£64.95
UP7X	120W/4–8Ω	MOS	Mono	HiFi	£84.95
Power Slaves					
US1X	60W/4Ω	Bipolar	Power	Slave	£59.95
US2X	120W/4Ω	Bipolar	Power	Slave	£79.95
US3X	60W/4–8Ω	MOS	Power	Slave	£69.96
US4X	120W/4–8Ω	MOS	Power	Slave	£89.95

Please note X in part number denotes mains voltage. Please insert '0' in place of X for 110V, '1' in place of X for 220V (Europe), and '2' in place of X for 240V (U.K.) All units except UC1 incorporate our own toroidal transformers.

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Small business systems

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The brains we're talking about are the printed circuit, silicon-chip variety and you'll find them (thinking hard) in the vast range of exhibits at The Northern Computer Fair. The show covers the fields of personal computing, home computing, small business systems and associated software, through computer books to video games, with a special attraction being the ZX 81 Sinclair Village. So whether you're a businessman (or woman) who needs to keep up to date with the latest developments in this fascinating field, a die-hard computer enthusiast, or simply interested in the subject, you'll find what you're looking for at the Northern Computer Fair.

Ticket prices at the door are £2.00 for adults and £1.00 for children under 16, but special party rates are available for 20 people or more with the organiser admitted free. For more information contact IPC Exhibitions, Surrey House, 1 Throwley Way, Sutton, Surrey SM1 4QQ. Tel: 01-643 8040.

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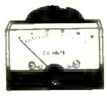

T Range
60 x 45mm
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NEW – 20KΩ/V: AC/DC/-RES./dB in 23 ranges: 130 x 88 x 37mm
£11.20N

YN 360TR
20KΩ/V: AC/DC/R/dB/Transistor Test: in 21 ranges: 145 x 96 x 45mm
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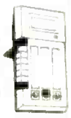
DMM DD601
LCD 3½ digit (1999) Push button 26 ranges 170 x 80 x 38mm
£32.00N



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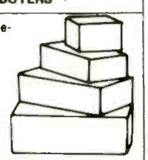

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50	50	25	–		5001P	90p	5001	123p
100	60	25	2002	96p	5002P	117p	5002	154p
113	63	31	2003	109p	5003P	143p	5003	184p
121	66	40	2004	115p	5004P	162p	5004	210p
152	82	50	2005	134p	5005P	216p	5005	268p
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120	50	35	21390	83p
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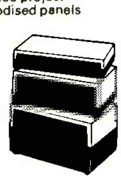

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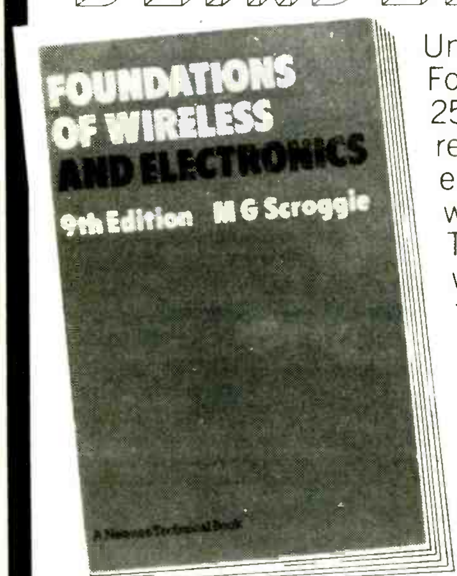

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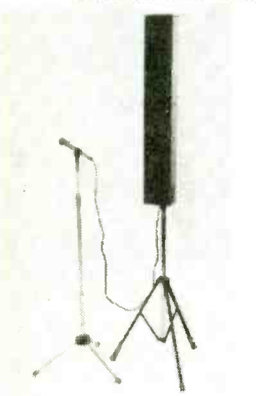

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214	300, 300	0-20, 0-20	3.39	1.20
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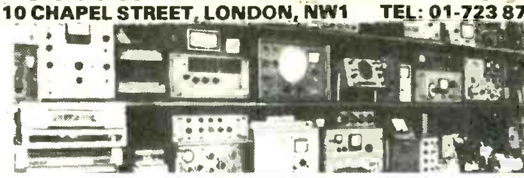

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TEKTRONIX 565. Twin Timebase c/w two 2A63 Y-Amps (DC-300KHz. 1mV).
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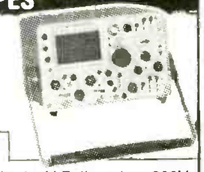
COSSOR CDU150. DC-35MHz **£200**
TELEQUIPMENT D53 £150
TEKTRONIX 454. DC-150MHz **£750**

SPECIAL PURCHASE OF TEKTRONIX 454 PORTABLE OSCILLOSCOPES



Tektronix 454 DC-150MHz dual-beam oscilloscopes in stock now. 5mV/cm Y-amplifier (1mV cascaded). 2.4ns risetime. Calibrated sweep delay. We can offer these units in first-class operational condition complete with three months' guarantee, for a once only price of **£750.**

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WAYNE KERR AF Signal Generator Type S121 **£75**
AIRMEC Wave Analysers Models 853 and 248A.
CENTRONICS P1 Printer, one only. AND Type 663 Printer.
ROHDE & SCHWARZ SDR Signal Generator. 300MHz-1GHz.
HEWLETT PACKARD 608C Signal Generator. 10-480MHz AM.

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PLEASE NOTE. All the pre-owned equipment shown has been carefully tested in our workshop and reconditioned where necessary. It is sold in first-class operational condition and most items carry a three months guarantee. For our mail order customers we have a money-back scheme. Repairs and servicing to all equipment at very reasonable rates. PLEASE ADD 15% VAT TO ALL PRICES.

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NOVEMBER ISSUE

TELEVISION

SERVICING · VIDEO · CONSTRUCTION · DEVELOPMENTS

FOCUS ON PORTABLES
looking at circuit techniques used in B & W small screen TVs, starting with the i.f. strip and a.g.c. arrangements.

SERVICING THYRISTOR LINE TIMEBASES
Advances in colour c.r.t. scan coil design have made thyristor LOP stages obsolete: however, large numbers of sets are still in use, so we've published a practical guide to fault-finding and servicing.

VCR SERVICING
Tape path faults and adjustments

PLUS!
* Quick checks on PYE Hybrid CTVs
* The Spirit of '51 – for VINTAGE TV enthusiasts.

ON SALE NOW...WELL WORTH A CLOSER LOOK

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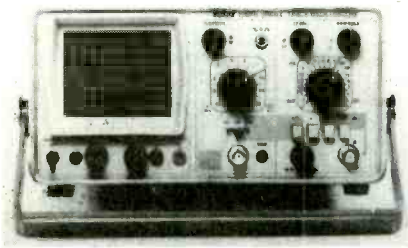
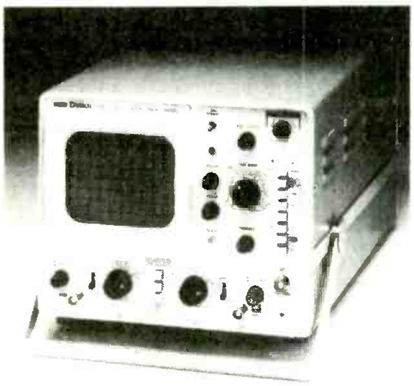


TYPE 3030

- DC–15MHz Bandwidth
- 5mV/div sensitivity
- 200ns – 200ms/div sweep speeds
- Rectangular CRT
- Compact and lightweight
- Triggered and automatic sweep
- Triggering to 20MHz
- Fully regulated high and low voltage supplies
- 200mV Calibration signal

BUILT–IN COMPONENT TESTER **£150***



TYPE 3131

- DC–15MHz Bandwidth
- 5mV/div sensitivity on both channels
- Algebraic addition and subtraction
- X–Y Operation
- 200ns/div to 0.2s/div timebase
- 5" CRT
- Triggering to 35MHz
- Z Modulation
- 10 x 8 div display
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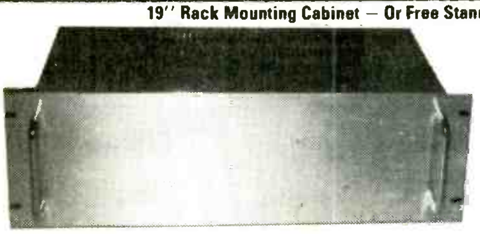
19" Rack Mounting Cabinet – Or Free Standing



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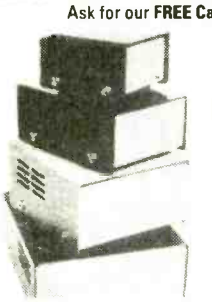

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a	£1.70
b	£2.55
c	£3.04
d	£4.08

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4019	0.38	4529	0.70	74LS27	0.12	74LS158	0.30
4020	0.55	4531	0.65	74LS28	0.15	74LS160	0.37
4021	0.55	4532	0.80	74LS30	0.12	74LS161	0.37
4022	0.55	4534	4.00	74LS32	0.12	74LS162	0.37
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4025	0.15	4539	0.80	74LS40	0.13	74LS165	0.60
4027	0.26	4543	0.80	74LS42	0.30	74LS168	0.70
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4043	0.50	4553	2.70	74LS48	0.45	74LS170	0.90
4044	0.60	4554	1.20	74LS49	0.55	74LS173	0.60
4046	0.60	4555	0.35	74LS51	0.13	74LS174	0.40
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4050	0.24	4557	2.30	74LS55	0.14	74LS181	1.05
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4060	0.75	4559	3.50	74LS74	0.16	74LS191	0.60
4066	0.30	4560	2.50	74LS75	0.22	74LS192	0.45
4068	0.16	4561	1.00	74LS76	0.20	74LS193	0.42
4069UB	0.14	4562	2.50	74LS78	0.19	74LS194	0.35
4070	0.16	4566	1.20	74LS83	0.40	74LS195	0.35
4071	0.16	4568	1.45	74LS85	0.60	74LS196	0.55
4072	0.16	4569	1.70	74LS86	0.14	74LS221	0.50
4073	0.16	4581	0.18	74LS90	0.28	74LS240	0.80
4075	0.16	4572UB	0.22	74LS92	0.31	74LS241	0.80
4076	0.55	4580	3.25	74LS93	0.31	74LS242	0.70
4077	0.18	4581	1.40	74LS95	0.40	74LS243	0.70
4078	0.18	4582	0.70	74LS96	1.20	74LS244	0.60
4081	0.12	4583	0.80	74LS107	0.25	74LS245	0.80
4093	0.30	4584	0.27	74LS109	0.20	74LS257	0.40
4175	0.80	4585	0.45	74LS112	0.20	74LS258	0.37
4502	0.60	40174	1.05	74LS113	0.20	74LS260	0.50
4503	0.50	40195	1.08	74LS114	0.19	74LS266	0.22
4506	0.70	74LS00	0.10	74LS122	0.35	74LS273	0.70
4507	0.37	74LS01	0.10	74LS124	1.80	74LS279	0.35
4508	1.50	74LS02	0.11	74LS123	0.35	74LS365	0.32
4510	0.55	74LS03	0.11	74LS125	0.24	74LS366	0.34
4511	0.45	74LS04	0.12	74LS126	0.24	74LS367	0.32
4512	0.55	74LS05	0.13	74LS132	0.42	74LS368	0.35
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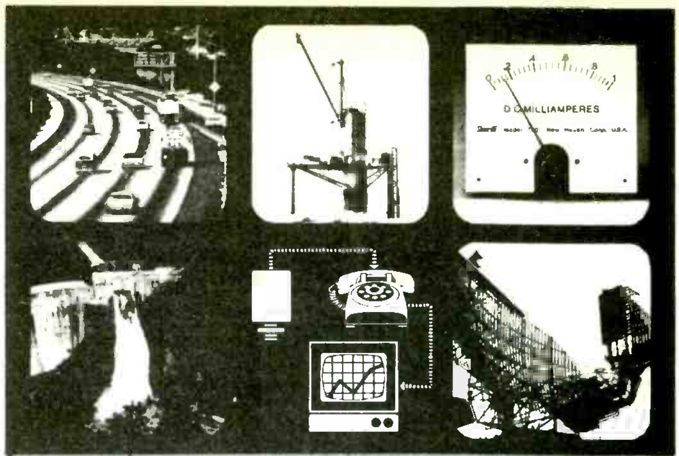

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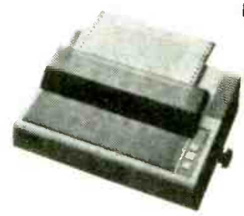

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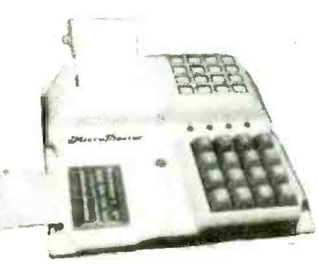
Microdoctor complete with psu, printer probe cable and two configuration board



CONNECTOR SYSTEMS

ID CONNECTORS
(Speedblock type)

No of ways	Header Plug	Receptacle	Edge Conn.
10	90p	90p	200p
20	145p	125p	240p
26	175p	150p	300p
34	200p	160p	380p
49	220p	190p	550p
50	235p	200p	600p

JUMPER LEADS
24'' Ribbon Cable with Headers

	14pin	16pin	24pin	40pin
1 end	145p	165p	240p	380p
2 ends	210p	230p	345p	540p

24'' Ribbon Cable with Sockets

	20pin	26pin	34pin	40pin
1 end	160p	210p	270p	300p
2 ends	290p	385p	490p	540p

24'' Ribbon Cable with D. Conn.
25-way Male 500p. Female 550p

DIL HEADER PLUGS

	Solder Type	IDC Type
14pin	40p	100p
16pin	50p	110p
24pin	100p	150p
40pin	200p	225p

RIBBON CABLE
(Grey)

10 way	60p
14 way	80p
16 way	90p
20 way	105p
26 way	140p
34 way	220p
40 way	265p
50 way	330p
64 way	370p

D CONNECTORS
No. of ways

	9	15	25	37
MALE				
Solder	90p	130p	160p	250p
Angled	160p	230p	265p	425p
FEMALE				
Solder	110p	160p	210p	350p
Angled	175p	240p	310p	500p
Hood	95p	95p	95p	125p

36-way Centronix Type Conn. £5.50
25-way 1EEE Type Conn. £5.50

EURO CONNECTORS
(Indirect Edge Conn.)

DIN STD	Plug	Skt.
41617 21 way	170p	170p
41617 31 way	180p	180p
41612 2×32 way	250p	320p
Angled 2×32 way	325p	375p
41612 3×32 way	275p	380p
Angled 3×32 way	–	400p
2×32 way IDC a+c	–	525p

(for 2×32 way specify a+b or a+c

EDGE CONNECTORS

	0.1''	0.156''
2 x 18 way	–	140p
2 x 22 way	200p	170p
2 x 23 way	210p	–
2 x 25 way	225p	220p
1 x 43 way	260p	–
2 x 43 way	395p	–
2 x 50 way	–	–
1 x 77 way	700p	–
S100 Conn.	–	600p

MICROTIMER

6502 Based Programmable clock timer with
★ 224 switching times/week cycle
★ 24-hour 7-day timer
★ 4 independent switch outputs directly interfacing to thyristor/triacs
★ 4 digit 7 seg. display to indicate real time, ON/OFF and Reset times
★ Output to drive day of week switch and status LEDs.
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The complete microprocessor development system for Engineers and Hobbyists. You can develop programs, debug, verify and commit to EPROMS or use in host computer by using softy as a romulator. Powerful editing facilities permit bytes, blocks of bytes changed, deleted or inserted and memory contents can be observed on ordinary TV.
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6802 Nancomp I **£80**
6809 Nancomp II **£80**
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Full details on request

RUGBY ATOMIC CLOCK

This Z80 micro controlled clock/calendar receives coded time data from NPL Rugby. The clock never needs to be reset. The facilities include 8 independent alarms and for each alarm there is a choice of melody or alternatively these can be used for electrical switching. A separate timer allows recording of up to 240 lap times without interrupting the count. Expansion facilities provided.
See July/August ETI for details. Complete Kit **£120** + £2 p&p

BOOKS
(No VAT p&p £1)

CMOS Cook Book **£7.75**
CRT Controller H/Book **£5.95**
Programming the Z80 .... **£11.50**
Z80 Microcomp handbook **£6.95**
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7412	14p
7413	16p
7414	18p
7416	18p
7417	18p
7420	14p
7421	18p
7422	20p
7423	18p
7425	18p
7426	18p
7427	18p
7428	18p
7430	14p
7432	18p
7433	22p
7437	22p
7438	22p
7439	25p
7440	15p
7441	55p
7442A	30p
7443	70p
7444	70p
7445	50p
7446A	50p
7447A	38p
7448	45p
7450	15p
7451	15p
7453	15p
7454	15p
7460	15p
7470	30p
7472	25p
7473	25p
7474	18p
7475	22p
7476	25p
7480	48p
7481	120p
7482	65p
7483A	38p
7484A	60p
7485	60p
7486	18p
7489	170p
7490A	20p
7491	35p
7492A	25p
7493A	24p
7494	35p
7495A	35p
7496	35p
7497	90p
74100	80p
74104	50p
74105	55p
74107	22p
74109	25p
74110	30p
74111	55p
74112	170p
74116	50p
74118	55p
74119	60p
74120	80p
74121	25p
74122	30p
74123	36p
74125	30p
74126	30p
74128	36p
74132	30p
74136	30p
74141	55p
74142	175p
74143	200p
74144	200p
74145	40p
74147	75p
74148	60p
74150	50p
74151A	36p
74153	38p
74154	50p
74155	38p
74156	40p
74157	30p
74159	75p
74160	40p
74161	40p
74162	40p
74163	45p
74164	45p
74165	45p
74166	48p
74167	150p
74170	120p
74172	250p
74173	50p
74174	55p
74175	50p
74176	40p
74177	45p
74178	70p
74179	70p
74180	40p
74181	115p
74182	40p
74184	90p
74185A	90p
74186	470p
74188	250p
74190	45p
74191	45p
74192	45p
74193	45p
74194	40p
74195	40p
74196	40p
74197	40p
74198	80p
74199	80p
74221	55p
74251	45p
74259	100p
74265	45p
74273	120p
74276	90p
74278	100p
74279	40p
74283	50p
74284	160p
74285	160p
74290	75p
74293	80p
74298	100p
74351	150p
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74366A	30p
74367A	30p
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74376	100p
74390	75p
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74490	95p

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Type	Price
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74LS14	25p
74LS15	12p
74LS20	12p
74LS21	12p
74LS22	12p
74LS26	12p
74LS27	13p
74LS28	14p
74LS30	12p
74LS32	13p
74LS33	14p
74LS37	14p
74LS38	15p
74LS40	12p
74LS42	30p
74LS47	36p
74LS48	45p
74LS51	14p
74LS54	14p
74LS55	14p
74LS63	120p
74LS73	18p
74LS74	16p
74LS75	18p
74LS76	17p
74LS83	36p
74LS85	48p
74LS86	16p
74LS90	22p
74LS91	66p
74LS92	32p
74LS93	22p
74LS95	40p
74LS96	50p
74LS107	20p
74LS109	27p
74LS112	20p
74LS113	20p
74LS114	22p
74LS122	28p
74LS123	34p
74LS124	90p
74LS125	24p
74LS126	25p
74LS132	34p
74LS133	25p
74LS136	25p
74LS138	27p
74LS139	27p
74LS145	70p
74LS147	120p
74LS148	75p
74LS151	40p
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74LS190	38p
74LS191	36p
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74LS221	50p
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74LS244	55p
74LS245	70p
74LS247	50p
74LS248	55p
74LS249	55p
74LS251	30p
74LS253	30p
74LS257	30p
74LS258	35p
74LS259	55p
74LS261	138p
74LS260	20p
74LS266	20p
74LS273	60p
74LS275	225p
74LS279	30p
74LS280	100p
74LS283	40p
74LS290	45p
74LS293	40p
74LS295	90p
74LS297	900p
74LS298	90p
74LS299	180p
74LS323	180p
74LS324	150p
74LS348	90p
74LS352	60p
74LS353	60p
74LS356	250p
74LS363	140p
74LS364	140p
74LS365	27p
74LS366	27p
74LS367	27p
74LS368	27p
74LS373	55p
74LS374	55p
74LS375	45p
74LS377	60p
74LS378	60p
74LS390	45p
74LS393	45p
74LS395	90p
74LS399	160p
74LS445	100p
74LS490	200p
74LS467	90p
74LS540	90p
74LS541	80p
74LS624	90p
74LS629	90p
74LS640	100p
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74LS643	100p
74LS644	100p
74LS645	100p
74LS668	120p
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74LS670	140p
74LS678	550p
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74S11	50p
74S20	40p
74S22	50p
74S30	40p
74S32	70p
74S37	60p
74S74	75p
74S85	450p
74S86	90p
74S112	90p
74S113	90p
74S114	90p
74S124	300p
74S132	110p
74S133	60p
74S138	120p
74S139	120p
74S157	250p
74S158	195p
74S163	300p
74S174	250p
74S175	320p
74S194	320p
74S195	500p
74S225	510p
74S241	300p
74S244	300p
74S251	250p
74S257	250p
74S258	250p
74S260	70p
74S261	300p
74S262	850p
74S373	400p
74S374	400p

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Type	Price
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4002	12p
4006	50p
4007	14p
4008	36p
4009	24p
4010	24p
4011	11p
4012	16p
4013	20p
4014	48p
4015	40p
4016	20p
4017	32p
4018	45p
4019	25p
4020	48p
4021	40p
4022	45p
4023	13p
4024	32p
4025	13p
4026	80p
4027	20p
4028	40p
4029	45p
4030	15p
4031	125p
4032	80p
4033	125p
4034	140p
4035	45p
4036	275p
4037	110p
4038	110p
4039	290p
4040	40p
4041	40p
4042	40p
4043	40p
4044	40p
4045	105p
4046	50p
4047	45p
4048	50p
4049	24p
4050	24p
4051	45p
4052	60p
4053	50p
4054	90p
4055	90p
4056	90p
4059	450p
4060	55p
4063	90p
4066	27p
4067	225p
4068	14p
4069	14p
4070	14p
4071	14p
4072	14p
4073	14p
4075	14p
4076	48p
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4078	16p
4081	14p
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4095	75p
4096	70p
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4516	55p
4518	40p
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4522	120p
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4527	60p
4528	50p
4532	70p
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4556	35p
4557	300p
4560	120p
4566	160p
4568	250p
4569	170p
4572	30p
4583	90p
4584	40p
4585	75p
40014	40p
40085	90p
40097	45p
40102	140p
40103	170p
40105	110p
40106	40p
40109	100p
40110	275p
40163	60p
40174	50p
40175	75p
40193	75p
40244	195p
40245	195p
40373	160p
40374	180p
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Type	Price
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AY3-1270	750p
AY3-1350	400p
AY3-8910	440p
AY3-8912	625p
AY5-3600	600p
AY5-4007D	520p
CA3028A	120p
CA3019	80p
CA3046	70p
CA3048	220p
CA3059	285p
CA3060	250p
CA3080E	70p
CA3086	48p
CA3089E	200p
CA3090AQ	375p
CA3130E	90p
CA3130T	110p
CA3140E	50p
CA3140T	90p
CA3160E	100p
CA3161E	150p
CA3162E	450p
CA3189E	300p
CA3240E	110p
CA3280G	200p
D7002	480p
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HA1366	195p
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ICL7611	95p
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ICM7555	80p
ICL7611	90p
LC7120	300p
LC7130	325p
LF347	150p
LF351	60p
LF353	95p
LF356P	95p
LF357	110p
LF13331	100p
LM10C	325p
LM301A	25p
LM310	120p
LM311	70p
LM318	75p
LM319	215p
LM324	30p
LM334Z	90p
LM335Z	140p
LM339	50p
LM348	65p
LM358P	60p
LM377	175p
LM380	75p
LM381AN	180p
LM382	120p
LM386	90p
LM387	120p
LM389	95p
LM391	150p
LM392N	60p
LM393	100p
LM394CH	300p
LM709	36p
LM710	50p
LM711	70p
LM725	300p
LM733	60p
LM741	18p
LM747	70p
LM748	35p
LM1014	150p
LM1801	300p
LM1830	250p
LM1871	450p
LM1872	450p
LM1886	700p
LM1889	350p
LM2917	200p
LM3302	75p
LM3900	50p
LM3909	85p
LM3911	125p
LM3914	200p
LM3915	200p
LM3916	225p
LM13600	110p
M51513L	230p
M51516L	500p
MB3712	200p
MB3730	400p
MC1310P	150p
MC1413	75p
MC1445	250p
MC1458	38p
MC1493	100p
MC1495L	350p
MC1496	70p
MC3340P	120p
MC3401	50p
MC3403	75p
MC3480	600p
MK50938	635p
ML920	800p
MM57160	620p
MN6221A	600p
NE531	140p
NE544	150p
NE555	18p
NE556	45p
NE564	420p
NE565	120p
NE566	155p
NE567	140p
NE570	410p
NE571	400p
NE592	60p
NE5534P	110p
NE5534AP	120p
PLL02A	500p
RC4136	60p
RC4151	200p
S566B	225p
SAA1900	1600p
SAD1024A	850p
SFF96364	800p
SL490	350p
SN76115N	215p
SN76131	125p
SN76477	450p
SN76488	450p
SN76660	120p
SN87489	400p
SN76495	400p
SP8515	750p
TA7120	150p
TA7130	160p
TA7204	200p
TA7205	90p
TA7222	150p
TA7310	150p
TBA641AX1	275p
TBA641BX1	300p
TBA800	80p
TBA810	100p
TBA820	80p
TBA920	200p
TBA950	225p
TC9109	900p
TCA210	350p
TCA220	350p
TCA270	350p
TCA940	175p
TCA965	120p
TDA1004A	300p
TDA1008	320p
TDA1010	220p
TDA1022	500p
TDA1024	120p
TDA1170	300p
TDA2002V	325p
TDA2003	325p
TDA2020	320p
TL064	100p
TL071/81	25p
TL072/82	45p
TL074	100p
TL083	75p
TL084	90p
TL094	200p
TL170	50p
TL430C	70p
UA1003-3	935p
UA2240	150p
UAA170	170p
ULN2003A	75p
ULN2004	75p
ULN2068	250p
ULN2802	200p
ULN2804	150p
UPC575	275p
UPC592H	200p
UPC1156H	275p
UPC1185HZ	550p
XR2206	300p
XR2207	375p
XR2211	575p
XR2216	675p
XR2240	120p
ZN414	80p
ZN419C	180p
ZN423E	130p
ZN424E	130p
ZN425E	350p
ZN426E	300p
ZN427E	590p
ZN428E	410p
ZN1034E	200p
ZN1040E	670p
ZNA234	850p

VOLTAGE REGULATORS

FIXED PLASTIC

1A	+ve		-ve	
5V	7805	40p	7905	45p
6V	7806	40p	7906	45p
8V	7808	40p	7908	45p
12V	7812	40p	7912	45p
15V	7815	40p	7915	45p
18V	7818	40p	7918	45p
24V	7824	40p	7924	45p
5V 100mA	78L05	30p	79L05	45p
6V 100mA	78L06	30p		
8V 100mA	78L08	30p		
12V 100mA	78L12	30p	79L12	60p
15V 100mA	78L15	30p	79L15	60p

OTHER REGULATORS

Type	Price
LM309K 1A 5V	140p
LM317K T03	325p
LM317T	200p
LM337T	225p
LM323K 3A 5V	450p
LM723 150mA Adj	37p
TL494	400p
78S40	225p
78P05	900p
78HGKC	600p
78H05KC	550p
78GUIC	200p
79GUIC	225p
79HGKC	700p
ICL7660	200p
TL497	300p
LM305AH	250p
78H12	600p
SG3524	300p

OPTO-ELECTRONICS

Type	Price
2N5777	45p
OCP71	180p
ORP12	120p
ORP60	120p
ORP61	120p
TIL32	55p
TIL78	55p
TIL31A	120p
TIL81	90p
TIL100	75p

OPTO-ISOLATORS

Type	Price
ILD74	130p
MCT26	100p
MCS2400	190p
ILQ74	240p
TIL111	70p
TIL112	70p
TIL113	70p
TIL116	70p

LEDS

Type	Price
0.125" TIL209 Red	10p
TIL211 Gr	12p
TIL212 Ye	15p
0.2" TIL220 Red	10p
TIL222 Gr	12p
TIL228 Ye	15p
Rectangular LEDs(R,G,Y)	30p

DISPLAYS

Type	Price
NSB5881	570p
TIL311	600p
TIL312/3	110p
TIL321/3	130p
TIL330	140p
7750/60	200p
DL704	140p
DL707 Red	140p
FND357	120p
FND500	90p
FND507	90p
MAN3640	
MAN4640	200p

DRIVERS

Type	Price
9368	250p
9370	300p

COMPUTER COMPONENTS

CPUs

Type	Price
1802CE	650p
2650A	£12
6502	350p
6502A	500p
6800	225p
6802	250p
68B02	700p
6809	650p
68B09	£12
6809E	£12
8035	350p
8039	300p
8080A	250p
8085A	350p
INS8060	£11
TMS995	£12
TMS9980	£20
Z8	£24
Z80	250p
Z80A	320p
Z80B	£15
Z8088	£12
9902A	£3
TMS4500	£14
TMS9918	£60
Z80P10	250p
Z80AP10	280p
Z80CTC	250p
Z80ACTC	280p
Z80ADART	700p
Z80ADMA	£10
Z80S10/1/2	£9

SUPPORT DEVICES

Type	Price
3242	800p
3245	450p
6520	280p
6522	310p
6522A	550p
6532	550p
6551	650p
6821	100p
68B21	220p
6829	£12.50
6840	375p
68B40	600p
6850	110p
68B50	220p
6852	250p
6854	700p
68B54	800p
6875	570p
8154	950p
8155	350p
8156	350p
8205	225p
8212	110p
8216	100p
8224	110p
8226	250p
8228	220p
8243	280p
8250	850p
8251	250p
8253	390p
8255	250p
8256	£36
8257	400p
8259	400p
8271	£36
8279	440p
8284	350p
8288	£11
8755	£16

MEMORIES

Type	Price
2101-4A	400p
2102-3L	120p
2107B	500p
2111A	300p
2112-A	300p
2114-2L	100p
2147	450p
4027-3	300p
4044-45	450p
4116-15	100p
4116-20	90p
4118-3	450p
4164-2	500p
4816AP-3	270p
5101	300p
5516	550p
6116-3	420p
6116LP-3	750p
6514-45	300p
6810	120p
7489	210p
74S189	225p
74S201	350p
74S289	175p
93415	600p
93425	600p

ROMs/PROMs

Type	Price
74S188	325p
74S287	350p
74S288	225p
74S387	325p
74S471	650p
74S473	850p
74S474	650p
74S570	650p
74S571	650p
74S573	950p

EPROMs

Type	Price
2516(+5v)	250p
2532	375p
2564	£15
2708	250p
2716(+5v)	250p
2732	450p
2716(350ns)	500p
2732(350ns)	750p
TMS2716	750p

CRT CONTROLLER

Type	Price
CRT6545	900p
CRT5027	£18
CRT5037	£18
EF9365	£48
EF9366	£48
MC6845	650p
MC6847	650p
SFF96364	£8
TMS9918	£80
TMS9927	£18
TMS9928/9	£35
TMS9928	£31

INTERFACE ICs

Type	Price
AD558CJ	775p
AD561J	£14
AM25S10	350p
AM25LS2521	£2
AM26LS31	125p
AM26LS32	125p
COM8116	800p
D7002	480p
DAC80	£28
DM8131	275p
DP8304	250p
DS3691	400p
DS8830	140p
DS8831	140p
DS8832	250p
DS8833	225p
DS8836	150p
DS8838	225p
FL13201	450p
MC1488	55p
MC1489	55p
MC3418	950p
MC3446	300p
MC3480	850p
MC3486	500p
MC3487	300p
MC4024	325p
MC4044	325p
MC14411	675p
MC14412	750p
75107	90p
75110/12	160p
75114/15	160p
75121/22	140p
75150P	120p
75154	140p
75182	90p
75324	375p
75361	150p
75363	150p
75365	150p
75451/2	72p
75453/4	72p
75491/2	65p
81LS95/96	80p
81LS97/98	80p
8T26	120p
8T28	120p
8T95/96	90p
8T97/98	90p
9602	220p
9637AP	160p
ZN425E-8	350p
ZN426E-8	350p
ZN427E-8	650p
ZN428E-8	500p

DISC CONTROL ICs

Type	Price
FD1771	£20
FD1791	£22
FD1793	£23
FD1795	£28
FD1797	£28
FD8271	£36
WD1691	£15
WD2143	550p

CHARACTER GENERATORS

Type	Price
RO3-2513 U.C.	750p
L.C.	700p
DM86564	£12
MC66760	750p
SN74S262AN	£10

KEYBOARD ENCODER

Type	Price
AY5-2376	700p
74C922	500p
74C923N	500p

BAUD RATE GENERATORS

Type	Price
MC14411	700p
COM8116	800p
4702B	750p

UARTs

Type	Price
AY-3-1015P	300p
AY-5-1013P	300p
COM8017	300p
IM6402	450p
TR1602	300p

ZIF SKTS (TEX TOOL)

Type	Price
24 pin	800p
28 pin	800p
40 pin	£10

MODULATORS

Type	Price
6MHz UHF	375p
8MHz UHF	450p

CRYSTALS

32.768KHz	100p
100KHz	250p
200KHz	280p
Freq in MHz	
1.0	290p
1.008	275p
1.5	450p
1.8432	210p
2.00	225p
2.45760	210p
2.5	250p
2.662	250p
3.276	150p
3.5795	100p
3.686	300p
4.00	150p
4.194	200p
4.43	110p
4.608	250p
4.915	250p
5.0	175p
6.0	150p
6.144	150p
7.0	150p
7.168	175p
8.00	175p
8.86	175p
10.00	175p
10.5	250p
10.7	150p
12.00	150p
14.318	175p
14.756	250p
15.00	200p
16.00	200p
18.00	200p
18.432	150p
19.968	150p
20.00	200p
26.690	150p
27.145	200p
38.6667	175p
48.0	175p
55.5	400p
116	300p
145.80	250p

REAL TIME CLOCK

Type	Price
MM58174	700p
MSM5832	700p

TELETEXT DECODER

Type	Price
SAA5020	600p
SAA5030	900p
SAA5041	£16
SAA5050	900p

LOW PROFILE SOCKETS BY TI

Type	Price
8 pin	9p
14 pin	10p
16 pin	11p
18 pin	16p
20 pin	18p
22 pin	22p
24 pin	24p
28 pin	26p
40 pin	30p

WIRE WRAP SOCKETS BY TI

Type	Price
8 pin	25p
14 pin	36p
16 pin	40p
18 pin	50p
20 pin	60p
22 pin	65p
24 pin	70p
28 pin	80p
40 pin	100p

TRANSISTORS

Type	Price
AD161/2	85p
BC107/8	13p
BC109C	16p
BC117	20p
BC147/8	9p
BC149	10p
BC157/8	10p
BC159	11p
BC169C	12p
BC172	12p
BC177/8	17p
BC179	18p
BC182/3	10p
BC184	11p
BC187	30p
BC212/3	11p
BC214	12p
BC237	15p
BC327	16p
BC337	16p
BC338	16p
BC461	25p
BC477/8	30p
BC516/7	40p
BC547B	14p
BC548C	12p
BC549C	16p
BC557B	14p
BC559C	16p
BCY70	18p
BCY71	22p
BD131	75p
BD132	50p
BD135/6	40p
BD139	40p
BD140	40p
BD189	60p
BD232	60p
BD233	75p
BD235	85p
BD241	60p
BD242	60p
BD379	60p
BD380	60p
BD677	40p
BF244B	35p
BF256B	50p
BF257/8	32p
BF337	30p
BFR39	25p
BFR40/1	25p
BFR79	25p
BFR80/1	25p
BFR96	180p
BFX29	40p
BFX30	27p
BFX84/5	40p
BFX86/7	27p
BFX88	27p
BFX89	180p
BFY50	24p
BFY51/2	24p
BFY56	33p
BFY90	80p
BRY39	45p
BSX19/20	24p
BU104	225p
BU105	190p
BU108	250p
BU109	225p
BU126	150p
BU180A	120p
BU205	200p
BU208	200p
BU406	145p
BUX80	600p
BUY69C	350p
E310	50p
MJ802	400p
MJ2501	225p
MJ2955	90p
MJ3001	225p
MJ4502	400p
MJE340	60p
MJE2955	100p
MJE3055	70p
MPF102	40p
MPF103/4	30p
MPF105	30p
MPSA06	30p
MPSA12	50p
MPSA13	50p
MPSA20	50p
MPSA42	50p
MPSA43	50p
MPSA56	32p
MPSA70	50p
MPSA93	40p
MPSU06	63p
MPSU07	60p
MPSU45	90p
MPSU65	78p
TIP29A	35p
TIP29C	40p
TIP30A	35p
TIP30C	40p
TIP31A	40p
TIP31C	45p
TIP32A	45p
TIP32C	40p
TIP33A	70p
TIP33C	80p
TIP34A	90p
TIP34C	120p
TIP35A	120p
TIP35C	140p
TIP36A	140p
TIP36C	150p
TIP41A	50p
TIP41C	55p
TIP42A	60p
TIP42C	65p
TIP54	160p
TIP120	75p
TIP121	75p
TIP122	80p
TIP142	120p
TIP147	120p
TIP2955	78p
TIP4055	70p
TIS93	30p
ZTX108	12p
ZTX300	13p
ZTX452	45p
ZTX500	15p
ZTX502	16p
ZTX504	18p
ZTX552	55p
ZTX652	60p
ZTX752	70p
VN66AF	72p
VN10KM	60p
VN66	80p
2N697	25p
2N698	45p
2N706A	30p
2N708	30p
2N918	45p
2N930	18p
2N1131/2	38p
2N1613	25p
2N1711	25p
2N2102	70p
2N2160	350p
2N2219A	25p
2N2222A	25p
2N2369A	25p
2N2484	30p
2N2646	45p
2N2904/5	25p
2N2906A	25p
2N2907A	25p
2N2926	9p
2N3053	30p
2N3054	65p
2N3055	48p
2N3442	140p
2N3553	240p
2N3584	250p
2N3643/4	48p
2N3702/3	12p
2N3704/5	12p
2N3706/7	14p
2N3708/9	12p
2N3773	225p
2N3819	25p
2N3820	40p
2N3823	50p
2N3866	90p
2N3902	700p
2N3903/4	16p
2N3905/6	16p
2N4037	25p
2N4123/4	27p
2N4125/6	27p
2N4401/3	27p
2N4427	90p
2N4871	60p
2N5087	27p
2N5089	27p
2N5172	27p
2N5191	90p
2N5194	90p
2N5245	40p
2N5296	65p
2N5401	60p
2N5457/8	40p
2N5459	40p
2N5460	60p
2N5485	44p
2N5875	250p
2N6027	48p
2N6052	300p
2N6059	325p
2N6107	65p
2N6247	190p
2N6254	130p
2N6290	65p
2SC1172	150p
2SC1306	100p
2SC1307	150p
2SC1957	90p
2SC1969	225p
2SC2028	95p
2SC2029	250p
2SC2078	200p
2SC2335	250p
2SC2612	250p
3N128	120p
3N140	120p
3N141	110p
3N201	110p
3N204	200p
40290	260p
40361/2	75p
40408	90p
40409	100p
40410	100p
40411	300p
40594	120p
40595	120p
40673	75p
40871/2	100p

DIODES

Type	Price
BY127	12p
BYX36300	20p
OA47	8p
OA90/91	9p
OA95	9p
OA200	9p
OA202	10p
1N914	4p
1N916	7p
1N4148	4p
1N4001/2	5p
1N4003/4	6p
1N4005	6p
1N4006/7	7p
1N5404/5	14p
1N5404/7	19p
IS920	9p

BRIDGE RECTIFIERS

Type	Price
1A 50V	19p
1A 100V	20p
1A 400V	25p
1A 600V	30p
2A 50V	30p
2A 100V	35p
2A 400V	45p
3A 200V	60p
3A 600V	72p
4A 100V	95p
4A 400V	100p
6A 50V	80p
6A 100V	100p
6A 400V	120p
10A 400V	200p
25A 400V	400p

TRIACS PLASTIC

Type	Price
3A 400V	60p
6A 400V	70p
6A 500V	88p
8A 400V	75p
8A 500V	95p
12A 400V	85p
12A 500V	105p
16A 400V	110p
16A 500V	130p
T2800D	130p

THYRISTORS

Type	Price
3A 400V	100p
8A 600V	140p
12A 400V	160p
16A 100V	180p
16A 400V	180p
C106D	45p
MCR101	38p
TIC44	27p
2N3525	130p
2N4444	180p
2N5060	30p
2N5064	35p

PCB MOUNTING RELAYS

Type	Price
6 or 12V DC Coil SPDT 2A 24V DC	160p
6 or 12V DC Coil DPDT 5A 24V DC 240V AC	200p
6 or 12V DC Coil SPDT 10A 24V DC 240V AC	225p

ZENERS

Type	Price
2.7V-33V 400mW	9p
1W	15p

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SHOPS AT: 17 BURNLEY ROAD, LONDON NW10
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PLEASE ADD 40p p&p & 15% VAT
(Export: no VAT, p&p at Cost)

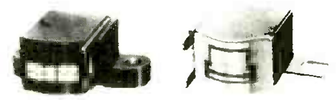
Orders from Government Depts. & Colleges etc. welcome.

Detailed Price List on request.
Stock items are normally by return of post.

LINSLEY-HOOD PEAK DRIVE INDICATOR

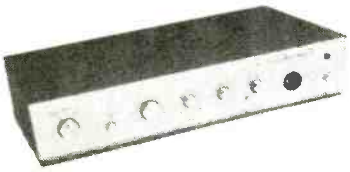
A very useful device, connected to loudspeakers giving a 4 light readouts of peak power delivered for the protection of both the loudspeaker and the perceived quality of sound. Gives instant indication even for peaks of only five microseconds' duration. Unit uses CMOS technology, is self-contained and battery powered. Complete Kit except batteries.
Only £17.40 plus VAT.
Reprint of Article 25p. No VAT. Post free.

HIGH QUALITY REPLACEMENT CASSETTE HEADS



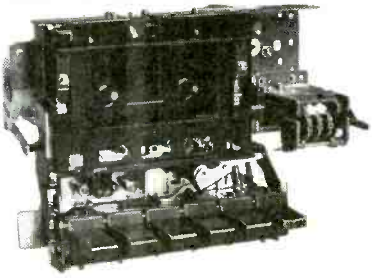
Do your tapes lack treble? A worn head could be the problem. Fitting one of our replacement heads could restore performance to better than new! Standard mountings make fitting easy and our TC1 Test Cassette helps you set the azimuth spot-on. We are the actual importers which means you get the benefit of lower prices for prime parts. Compare us with other suppliers and see! The following is a list of our most popular heads, all are suitable for use on Dolby machines and are ex-stock.
HC20 Permalloy Stereo Head. This is the standard head fitted as original equipment on most decks £4.25
HM90 High Beta Permalloy Head. A hard-wearing, higher performance head with metal capability £6.20
HS16 Sendust Alloy Super Head. The best head we can find. Longer life than Permalloy, higher output than Ferrite, fantastic frequency response £8.20
HQ551 4-Track Head for auto-reverse or quadrophonic use. Full specification record and playback head £7.40
Please consult our list for technical data on these and other Special Purpose Heads.

LINSLEY-HOOD 300 SERIES AMPLIFIERS



These latest designs from the drawing board of John Linsley-Hood, engineered to the very highest standard, represent the very best that is available on the kit market today. The delicacy and transparency of the tone quality enable these amplifiers to outperform on a side-by-side comparison, the bulk of amplifiers in the commercial market-place and even exceed the high standard set by his earlier 75-watt design.
Three versions are offered, a 30-watt with Darlington output transistors, and a 35- and 45-watt, both with Mosfet output devices. All are of identical outside appearance which is designed to match and stack with our Linsley-Hood cassette recorder 2.
As with all Hart kits the constructor's interests have been looked after in a unique way by reducing the conventional (and boring) wiring almost to the point of extinction.
Any of these kits represents a most cost-effective route to the very highest sound quality with the extra bonus of the enjoyment of building a sophisticated piece of equipment.
30-watt Darlington amplifier, fully integrated with tone controls and magnetic pick-up facility. Total cost of all parts is **£81.12**. Special offer price for complete kits is **£72**.
35-watt Mosfet amplifier. Total cost of parts **£98.41**. Special offer for complete kits **£87.40**.
45-watt Mosfet amplifier. Total cost of parts **£104.95**. Special offer price for complete kits **£94.80**.
(Reprints of original Articles from Hi-Fi News 50p. Post free. No VAT.
Reprints of MOSFET article 25p. No V.A.T. Post free.

VERTICAL FRONT LOADING CASSETTE DECK VFL910



This deck is used in our Linsley-Hood Cassette Recorder 2 and has every possible feature to ensure top notch performance. Recently featured in this magazine in a "Digital Multi-Track Tape Recorder" by A. J. Ewins.
12v DC Servo Feedback Motor.

VFL910 Deck. Fitted with HS16 Sendust Alloy Super Head **£31.99**

SPECIAL OFFER

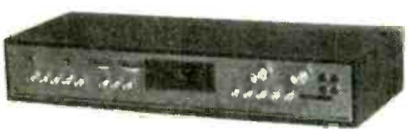
Replacement heads for SONY machines.
First Quality Stereo head with special base to fit Sony decks.
These are only available while stocks last, so buy now to keep in. Only £5.95.
Trade price available on 10 or more.

HART TRIPLE-PURPOSE TEST CASSETTE TC1

One inexpensive test cassette enables you to set up VU level, head azimuth and tape speed. Invaluable when fitting new heads. Only **£3.80** plus VAT and 50p postage.

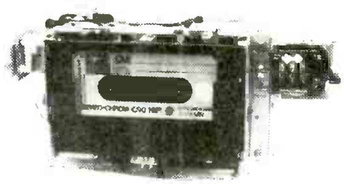
Tape Head De-magnetiser. Handy cassette size mains operated unit prevents build up of residual head magnetisation causing noise on playback **£3.68**

'P. W. WINTON' TUNER AND AMPLIFIER



Snazzy matching slimline tuner and amplifier in beautiful wooden cabinets. These Ted Rule designs are for the enthusiast. Tuner covers LW, MW, SW, FM and TV sound! Digital frequency readout with clock and timer features. FM has 6 section front end and switchable bandwidth for exceptional fringe area performance. Amplifier has Toroidal transformer, Mosfet output stages, 50 watts per channel and got a cracking review in Practical Wireless.
Tuner. Complete Kit £163.00
Amplifier. Complete Kit £109.00

FEED YOUR MICRO BYTES WITH OUR SOLENOID CONTROLLED CASSETTE DECK



Front loading deck with full solenoid control of all functions including optional read in fast wind modes. 12 volt operation. Fitted 3-digit memory counter and Hall IC Motion Sensor. Standard erase and stereo R/P Heads. Cheapest price ever for all these features. Only £38.90 plus VAT. Full technical specification included.

CASSETTE MOTORS

Brand New Governed 12v DC Tape Drive Motor Type MMI-6A2LK.
As used in SF925 and many other decks. 40mm Dia x 35mm Long, Shaft 10.5mm long x 2mm Dia. 6 x 2.5mm Mounting Holes on 26mm PCD on shaft end face. Anti-clockwise rotation at rated speed of 2200 RPM. Free run current 25mA. **£4.85 each.**

Lenco CRV/FFR
We have a small quantity of spare motors for these decks at £6 each complete with drive pulley. Spare belts for FFR or CRV **90p (Large), 30p (Small).**

LINSLEY-HOOD CASSETTE RECORDERS

We have done two kits to this design, one using the original car cassette mechanism and the newer version using a very high quality front loading deck. This new deck has an excellent W & F performance and fitted with our latest Sendust Alloy Super Head gives an incredible frequency range (with good tape you can see 23KHz on ours!).

Linsley-Hood Cassette Recorder 1 .... £75.00
Linsley-Hood Cassette Recorder 2 .... £94.90
Reprints of "WW" Articles .... 70p. No VAT

HIGH-QUALITY HEAVY DUTY CASSETTE DECK

This will appeal to all lovers of elegant design combining a basic simplicity with sound construction. No less than three direct drive motors are integral with the die-cast structure which gives unparalleled stability to the whole unit. Dual capstans allow the use of a three head system for off-tape monitoring. Function control is by solenoid with a half-way position to read tape in the fast mode. Price fitted with 3 Heads **£120.65.**

LINSLEY-HOOD 100 WATT POWER AMPLIFIER

Our complete kit for this brilliant new design is the same size as our Linsley-Hood Cassette Recorder 2. Kit includes all parts for two power amplifiers with large heatsink area, huge power supply and speaker protection circuit. Total cost of all parts is **£114.48** but our special introductory price for all parts bought together is only **£105.50.**

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EBC90	0.75
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PCC89	0.70
PCC189	0.70
PCC805	0.70
PCC806	0.80
PCE82	0.80
PCF80	0.65
PCF82	0.60
PCF84	0.65
PCF86	1.20
PCF87	0.40
PCF200	1.35
PCF201	1.35
PCF800	0.40
PCF801	1.35
PCF802	0.60
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U25	0.68
U26	0.90
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U41	0.70
U50	2.00
U54	4.50
U82	3.00
U191	0.70
U192	1.00
U193	0.65
U251	1.00
U291	0.60
U301	0.55
U801	0.75
UABC80	0.65
UAF42	1.00
UBF80	0.60
UBC41	1.25
UBC81	1.00
UBF89	0.60
UBL21	1.25
UC92	0.95
UCC84	0.70
UCC85	0.60
UCF80	1.00
UCH21	1.20
UCH41	1.20
UCH42	1.35
UCH81	0.60
UCL82	0.75
UF41	1.25
UF42	1.25
UF80	0.60
UF89	1.10
UL41	2.25
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YL1060	15.00
YL1070	115.00
YL1071	109.00
YL1370	5.50
YL1371	8.50
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Z300T	5.00
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Z759	24.00
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ZA1002	1.50
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1B24	10.00
1C1	1.20
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1D5	1.00
1FD1	0.90
1G3GT	1.00
1L4	0.60
1L6	1.50
1LA6	1.00
1N5GT	2.50
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1T4	0.45
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1X2B	1.15
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2C39WA	24.00
2C40	37.00
2C40A	55.00
2C42	17.00
2C43	17.00
2C51	0.75
2C53	32.00
2B7	1.50
2D21	0.95
2D21W	2.50
2E26	12.00
2J42	93.00
2K25	17.50
3A/147J	7.50
3A/167M	10.00
3A2	3.00
3A3A	3.00
3A4	1.10
3AL5	0.95
3AT2	1.75
3AW2	3.35
3B2	3.00
3B7	4.50
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3B28	12.00
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3C45	12.50
3CN3A	2.50
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6AJ4	2.00
6AJ7	2.00
6AK5	0.60
6AK6	2.00
6AL5	0.52
6AM4	2.50
6AM5	6.00
6AM6	1.20
6AN5	2.00
6AN8A	2.15
6AQ5	0.82
6AR5	2.00
6AR8	2.00
6AS5	1.50
6AS7G	6.00
6AT6	0.75
6AU4	2.00
6AU6	0.55
6AV6	0.72
6AW8A	2.50
6B8G	0.75
6BA6	0.50
6BA6W	2.50
6BA7	3.75
6BA8A	3.50
6BC8	1.00
6BD4	1.50
6BD6	1.00
6BE6	0.72
6BF5	1.10
6BG6G	1.25
6BF5	1.60
6BH6	1.60
6BH8	1.00
6BJ6	1.05
6BK4	2.75
6BK7A	1.50
6BM8	0.58
6BN4	1.25
6BN6	1.30
6BN7	3.50
6BN8	2.00
6BQ5	0.60
6BQ7A	0.72
6BL8	0.65
6BR5	0.70
6BR7	3.75
6BR8	1.20
6BR8A	1.20
6BS7	3.75
6BS8	1.88
6BW4	1.30
6BW6	4.50
6BW7	0.75
6BW8	4.00
6BX6	0.48
6BX7GT	3.00
6BZ6	2.00
6BZ7	2.50
6BZ8	0.95
6C4	0.80
6C6	0.50
6C8G	1.25
6C11	2.50
6C15	2.50
6C18	2.50
6CA4	0.60
6CA7	4.50
6CB6	1.50
6CD6GA	4.00
6CF6	1.50
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6CL8A	2.00
6CM5	1.60
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6EA8	1.80
6EB8	1.10
6EU8	1.10
6EW6	1.80
6F1	2.00
6F6G	2.00
6F12	1.50
6F13	3.00
6F14	1.00
6F17	3.00
6F18	1.50
6F19	0.48
6F21	2.50
6F22	0.70
6F23	0.48
6F24	1.25
6F25	1.25
6F28	1.25
6F33	11.00
6FG5	1.50
6GH8A	0.80
6GK5	1.00
6GK6	2.00
6GV7	2.50
6H3N	0.70
6H6	1.35
6H6GT	1.20
6J4	1.10
6J5	3.00
6J5GT	0.75
6J6	0.55
6J7	1.05
6J7GT	1.25
6JB6A	3.95
6JE6C	3.50
6JS6A	3.50
6JS6C	3.50
6K4N	1.00
6K7G	0.70
6KD6	4.50
6L1	2.50
6L6GC	2.50
6L6GT	1.00
6L7	0.55
6LD20	0.60
6LF6	2.95
6LQ6	2.95
6N7GT	1.50
6P15	0.80
6P25	4.00
6P28	2.00
6Q7	1.20
6S7	1.10
6SA7GT	1.00
6SC7	1.20
6SG7	1.20
6SH7	1.20
6SJ7GT	1.20
6SK7	0.80
6SK7GT	1.20
6SL7GT	0.72
6SN7GT	0.69
6SQ7	0.80
6SS7	1.50
6U4GT	1.75
6U5G	2.50
6U8	0.60
6U8A	1.00
6V6GT	0.80
6X2N	1.00
6X4	0.96
6X5GT	0.60
6X8A	2.25
7A7	2.00
7AD7	1.75
7B7	1.40
7C5	2.50
7C6	2.50
7H7	1.50
7Q7	2.00
7S7	3.00
7Y4	1.00
10C1	5.50
10C2	0.70
10D2	1.25
10F1	0.75
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10P14	2.50
10P18	0.78
10LD11	1.00
10LD12	0.65
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11E3	55.00
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12AG8	1.50
12AL5	1.00
12AT6	0.59
12AT7	0.55
12AT7WA	2.50
2AU6	1.50
12AU7	0.55
12AV6	0.80
12AX4GT	1.00
12AX7	0.60
12AX7WA	2.50
12AYZ	4.00
12AZ7A	1.50
12BA6	0.75
12BE6	1.05
12BH7	0.95
12BH7A	0.95
12BL6	0.70
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12CX6	1.20
12E1	16.50
12E14	28.00
12GN7	3.95
12HG7A	3.95
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12K5	1.00
12K7GT	0.60
12K8	1.10
12Q7GT	0.50
12SA7GT	1.00
12SH7	0.50
12SK7	1.00
12SJ7	0.60
12SN7GT	1.85
12U7	1.50
13D3	3.20
13D7	3.20
13E1	115.00
14S7	1.00
15E	1.00
17DW4A	1.75
17JZ8	1.80
18D3	1.60
19AQ5	0.70
19Q6	9.00
20A2	10.50
20D1	0.70
20D4	1.75
20LF6	3.50
20L1	0.95
20P1	0.55
20P3	0.60
20P4	1.05
20P5	1.15
25L6GT	1.75
25BQ6	1.75
29C1	19.50
30	2.85
30C1	0.70
30C15	0.40
30C17	0.40
30C18	2.00
30F5	0.95
30FL1	0.95
30FL2	0.95
30FL12	1.10
30FL13	1.10
30FL14	1.85
30L1	0.45
30L15	0.60
30L17	0.60
30P4MR	1.00
30P12	1.00
30P18	0.60
30P19	1.00
30PL1	2.50
30PL13	0.60
30PL14	2.25
31JS6A	2.95
35A5	4.50
35L6GT	2.00
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35Z3	1.85
38HE7	4.50
47	6.00
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50C5	0.95
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52KU	2.00
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61SPT	4.50
75B1	1.50
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76	1.50
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90C1	2.50
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92AG	10.00
92AV	10.00
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150C4	1.50
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307	5.00
329	5.00
388A	17.50
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813 USA	59.50
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782A	16.00
873	60.00
884	5.50
954	0.50
955	0.90
958A	0.90
1299A	0.60
2050	9.00
3545	4.00
4212E	170.00
4313C	4.00
5642	5.50
5651	1.75
5654	1.95
5670	3.50
5675	15.00
5687	3.50
5692	3.50
5696	2.55
5718	5.50
5725	2.50
5726	1.50
5727	2.00
5749	2.50
5750	2.00
5751	1.50
5763	3.50
5814A	2.75
5840	3.50
5842	6.50
5876	6.25
5879	3.90
5894	39.50
5899	4.50
5963	1.50
5965	2.25
5993	8.00
6005	3.50
6012	6.00
6057	1.85
6059	3.75
6060	1.50
6062	2.50
6063	2.00
6064	1.85
6067	1.50
6072	4.20
6080	4.50
6080WA	8.50
6096	2.85
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	2K2-6K8	0.18
	10K	0.24
7 Watt	R47-4K7	0.18
	5K6-12K	0.19
	15K-22K	0.20
11 Watt	1R-10K	0.20
	15K-22K	0.24
17 Watt	1R-10K	0.26
	15K-22K	0.28

WW-2

BASES ETC.

B7G	0.15
B7G Skirted	0.30
B8G	0.70
B9A	0.20
B9A Skirted	0.30
B10B	0.16
B13B	0.50
8 Pin DIL	0.10
14 Pin DIL	0.12
14 Pin DIL/Q	0.30
16 Pin DIL	0.15
OCTAL	0.35
CANS	0.27
B9A PCB	0.15
B5	0.75
B9G	0.38

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15V 16V 18V 20V 22V 24V 27V 30V
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2V7 3V 3V3 3V6 3V9 4V3 4V7 5V1
5V6 6V2 6V8 7V5 8V2 9V1 10V 11V
12V 13V 15V 18V 20V 24V 27V 30V

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VA1056S	0.23
VA1104	0.70
VA8650	0.45
VA1097	0.25

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Ticket prices at the door are £2 for adults, £1 for children but party rates are available for 20 people or more. To find out more, contact the Exhibition Manager, Electronic Hobbies Fair, IPC Exhibitions, Surrey House, 1 Throwley Way, Sutton, Surrey SM1 4QQ. Tel: 01-643 8040.

Electronic Hobbies Fair is sponsored by Practical Electronics, Everday Electronics and Practical Wireless and is organised by IPC Exhibitions Ltd.

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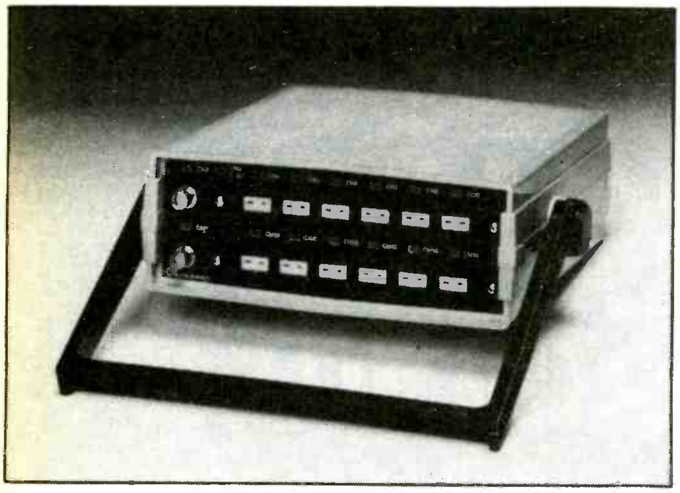
Friday 19 Nov. – 10.00-18.00
Saturday 20 Nov. – 10.00-18.00
Sunday 21 Nov. – 10.00-17.00

PCI 1002 IEEE THERMOCOUPLE CONVERTER



The PCI 1002 is a 12 Channel IEEE compatible thermocouple converter having two input ranges of ± 10mV or ±100mV F.S.D. selected by an internal switch. It has 12 Bit resolution of the A to D converter giving a resolution of 0.06 deg.C on 10mV range and covers all common thermocouple types.

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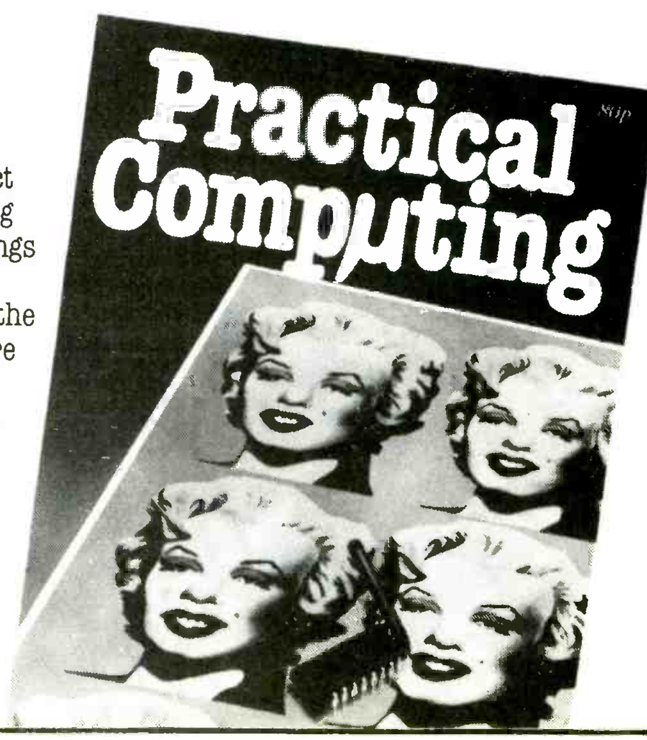

This month, we home in on the picture-making aspect of computers – and report on four exciting and intriguing developments: "Bit-stick", the joystick device which brings out the artistic streak in Apple II; Apple II graphics for chemists – a package that draws molecular structures; the BBC micro as a colour graphics terminal, and how to store screen designs as graphic pages within a memory.

Also this month, we report on the Commodore 64 – a powerful computer with graphics facilities – and a new letter-addressing capability of Wordpro...

And that's just a sample of Practical Computing – together with advice for users of Pet, Apple, Tandy and Sinclair ZX 80/81 Computers. Buy Britain's leading personal computer magazine.

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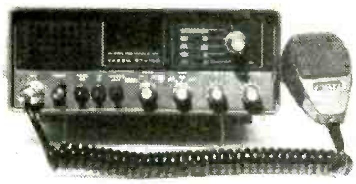

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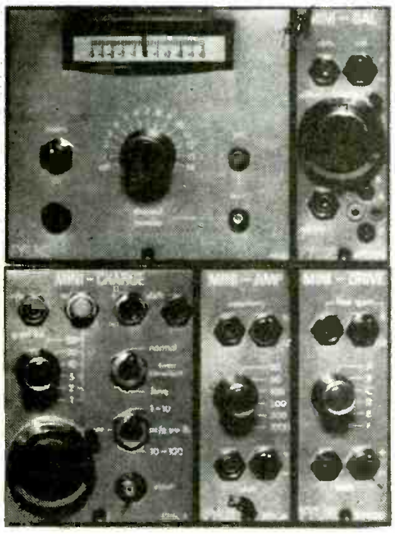

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TYPE	SERIES No	SECONDARY Volts	RMS Current	PRICE
30 VA 70×30mm 0.45Kg Regulation 18%	1x010	6+6	2 50	£5.12 +p/p £1 04 +VAT £0 92 TOTAL £7 08
	1x011	9+9	1 66	
	1x012	12+12	1.25	
	1x013	15+15	1.00	
	1x014	18+18	0.83	
	1x015	22+22	0.68	
	1x016	25+25	0.60	
	1x017	30+30	0 50	
50 VA 80×35mm 0.9 Kg Regulation 13%	2x010	6+6	4 16	£5.70 +p/p £1 30 +VAT £1 05 TOTAL £8 05
	2x011	9+9	2 77	
	2x012	12+12	2.08	
	2x013	15+15	1 66	
	2x014	18+18	1.38	
	2x015	22+22	1.13	
	2x016	25+25	1.00	
	2x017	30+30	0.83	
	2x028	110	0.45	
	2x029	220	0.22	
	2x030	240	0.20	
80 VA 90×30mm 1 Kg Regulation 12%	3x010	6+6	6 64	£6.08 +p/p £1 67 +VAT £1 16 TOTAL £8 91
	3x011	9+9	4.44	
	3x012	12+12	3 33	
	3x013	15+15	2 66	
	3x014	18+18	2 22	
	3x015	22+22	1 81	
	3x016	25+25	1 60	
	3x017	30+30	1.33	
	3x028	110	0 72	
	3x029	220	0 36	
	3x030	240	0.33	
120 VA 90×40mm 1.2 Kg Regulation 11%	4x010	6+6	10.00	£6.90 +p/p £1 57 +VAT £1 29 TOTAL £9 86
	4x011	9+9	6 66	
	4x012	12+12	5.00	
	4x013	15+15	4 00	
	4x014	18+18	3 33	
	4x015	22+22	2.72	
	4x016	25+25	2 40	
	4x017	30+30	2.00	
	4x018	35+35	1.71	
	4x028	110	1 09	
	4x029	220	0.54	
	4x030	240	0.50	
160 VA 110×40mm 1 8 Kg Regulation 8%	5x011	9+9	8 89	£7.91 +p/p £1 57 +VAT £1 44 TOTAL £11 02
	5x012	12+12	6 66	
	5x013	15+15	5.33	
	5x014	18+18	4 44	
	5x015	22+22	3 63	
	5x016	25+25	3 20	
	5x017	30+30	2 66	
	5x018	35+35	2 28	
	5x026	40+40	2 00	
	5x028	110	1 45	
	5x029	220	0.72	
	5x030	240	0 66	

TYPE	SERIES No	SECONDARY Volts	RMS Current	PRICE
225 VA 110×45mm 2.2 Kg Regulation 7%	6x012	12+12	9 38	£9.20 +p/p £2 00 +VAT £1 68 TOTAL £12 88
	6x013	15+15	7.50	
	6x014	18+18	6 25	
	6x015	22+22	5 11	
	6x016	25+25	4.50	
	6x017	30+30	3.75	
	6x018	35+35	3.21	
	6x026	40+40	2.81	
	6x025	45+45	2 50	
	6x033	50+50	2 25	
	6x028	110	2.04	
	6x029	220	1 02	
	6x030	240	0.93	
300 VA 110×50mm 2.6 Kg Regulation 6%	7x013	15+15	10.00	£10.17 +p/p £2 00 +VAT £1 83 TOTAL £14 00
	7x014	18+18	8.33	
	7x015	22+22	6.82	
	7x016	25+25	6.00	
	7x017	30+30	5.00	
	7x018	35+35	4.28	
	7x026	40+40	3.75	
	7x025	45+45	3 33	
	7x033	50+50	3.00	
	7x028	110	2.72	
	7x029	220	1 36	
	7x030	240	1 25	
500 VA 140×60mm 4 Kg Regulation 4%	8x016	25+25	10 00	£13.53 +p/p £2 35 +VAT £2 38 TOTAL £18 26
	8x017	30+30	8 33	
	8x018	35+35	7 14	
	8x026	40+40	6 25	
	8x025	45+45	5.55	
	8x033	50+50	5 00	
	8x042	55+55	4 54	
	8x028	110	4 54	
	8x029	220	2 27	
	8x030	240	2 08	
625 VA 140×75mm 5 Kg Regulation 4%	9x017	30+30	10.41	£16.13 +p/p £2 50 +VAT £2.79 TOTAL £21 42
	9x018	35+35	8.92	
	9x026	40+40	7.81	
	9x025	45+45	6.94	
	9x033	50+50	6.25	
	9x042	55+55	5.68	
	9x028	110	5.68	
	9x029	220	2 84	
	9x030	240	2 60	

IMPORTANT: Regulation – All voltages quoted are FULL LOAD. Please add regulation figure to secondary voltage to obtain off load voltage.

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Signature ______

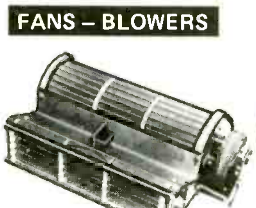
Post to: ILP Electronics Ltd., Freepost 5, Graham Bell House, Roper Close
Canterbury CT2 7EP. Kent, England
Telephone Sales (0227) 54778: Technical (0227) 64723: Telex 965780.

ILP TRANSFORMERS (a division of ILP Electronics Ltd)

WW – 057 FOR FURTHER DETAILS

Bargains BULK BUYERS LIST
That will save you money...

FANS – BLOWERS



Snail type blower with inset mains motor. Smiths £2.50
Extractor fan. 5" Woods, ex computer £3.75
Tangential blower. 10 x 3" air outlet. Dual speed, £ 2.90
Ducting blower — Large 1/8 H.P. £12.50
Medium 1/10 H.P. £10.00

LIGHTING & POWER CABLES

Copper Clad. PVC sheathed. Made by Volex to BSS.

1.5mm single	per 100 metres	£2.00
1.5mm flat twin	per 100 metres	£3.50
1.5mm flat 3 core & E	per 100 metres	£5 50
6 mm single	per 100 metres	£3.00
6mm flat 3 core	per 100 metres	£27.50
16mm flat twin & E	per 100 metres	£47.50

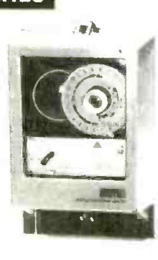
Telephone and multiway cables. Reliance as used by GPO
15 core per 200 metres £60.00
10 core per 200 metres £40.00

3 core and screened power flex cable:
3 cores each 50.025 (equiv. 2.5mm) per metre .40
3 cores each 30.025 (equiv. 1.5mm) per metre .30
3 cores each 24.02 (equiv. .1mm) per metre .20
Armoured Cable 1,5mm, 3 core .40
Extension lead. 3 cores .5mm pvc covered /100 M £9.50
Ext. lead. twin .5mm rubber covered /1000 metres £60.00
Iron Flex. Woven cotton covered, rubber insulated
2 core 100 metre £12.50
FIGURE 8 FLEX Heavy Duty .75mm. 600 metre £19.00
Figure 8 Flex per 100 metres £3.00

THERMOSTATS & HEAT SWITCHES

Thermostat: 3 level contact type .30
10 amp appliance type thermostst. Spindle adjust .40
Contact type with changeover, 10 amp switches,
0 – 100°C .58
Wall mounting, metal case, c/o contacts low valtage £2.30

TIMERS & CLOCKSWITCHES

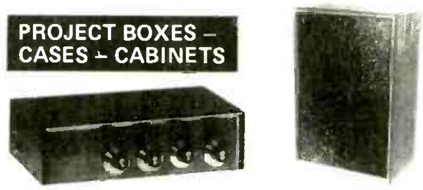


Time and Set Switches. Smiths, Glass fronted 25 Amp, 230 volts £2.30
24 Hour time switch. 100 amp Smiths with clockwork reserve. Ex-Electricity Company. £5.50
Cooker clock switch. Smiths, 12 hour £1.00
Clockwork operated switches:
15 amp, 230 volt. On time up to:
10 minutes £1.37
30 minutes £1.37
120 minutes £1.37
360 minutes £1.37
OMRON mini timer, ref STP NH £3.50

BLEEPERS – SIRENS – BELLS – ALARMS – BUZZERS

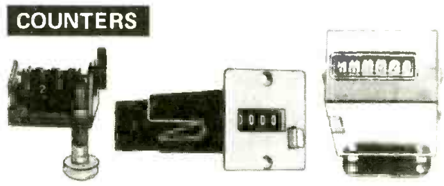
Siren/Hooter – Delta 6 or 12v DC or 24v AC .37
Open type buzzer, ex GPO, 10 - 20v .30
Fire alarm bell, 12" gong, heavy cast iron const. £12.00

PROJECT BOXES – CASES – CABINETS



Black plastic boxes, 2 7/8 x 4 1/8 x 3 deep .50
Ditto 3 5/8 x 2 3/4 x 1 3/4 deep .40
Ditto 3 7/8 x 3 3/8 x 1 deep .30
Plated metal box, 7½ x 4½ x 1½ deep £1.00
Dark grey half boxes. May be joined to make three different depth boxes, 4 5/8 x 2 5/8 x 3/4 deep .20
4 5/8 x 2 5/8 x1 deep .25
White plastic box ideal for touch switch, transmetter, etc. Through top is square hole, 3½ x 3½ x 3½ .50
Loudspeaker cabinet for 6½" speaker .95
PORTABLE RADIO CASE — 5" speaker, size approx 6¼" x 3¾" x 2" deep £1.00

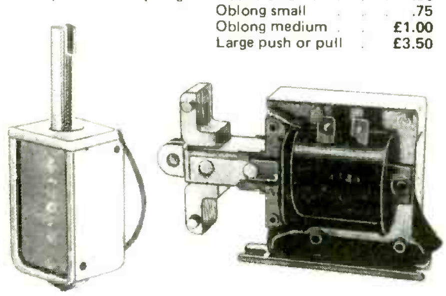
COUNTERS



6 digit counter. Mains operated. Not resettable .60
Ditto, But even numbers only .50
6 digit counter. 48v DC, 115v AC. Resettable £1.00
Tape counter resettable 30p.

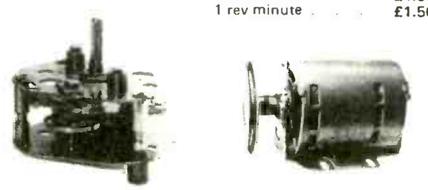
SOLENOIDS – BATTERY & MAINS

Mains operated with plunger. Round small .60
Oblong small .75
Oblong medium £1.00
Large push or pull £3.50



MOTORS – MAINS & BATTERY

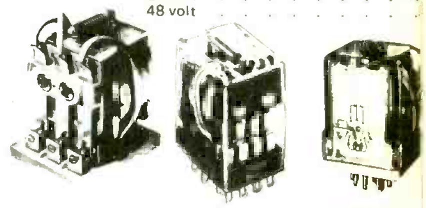
3 – 6 volt battery motor, very small .15
3 – 12 volt battery motor, very low current .20
Mains motor with gear box: 5 rev minute £2.25
80 rev minute £3.00
110 rev minute £2.00
200 rev minute £1.50
Mains motor, double ended fan motor £1.20
Ditto single ended fan motor £1.00
Fan blade for the above .50
Mains motor, double ended, very powerful 1½" stack £1.50
Mains instrument motors with gear box: 1 rev 24 hours £1.50
1 rev 1 hour £1.50
16 rev minute £1.50
4 rev minute £1.50
2 rev minute £1.50
1 rev minute £1.50



Motor, clockwork, set up to 1 hour .38
Motor, clockwork, set up to 1 hour with ringer .75
Mains motor ¼ h.p. 1425 revs, ex computer £4.25
Vent opening motor with end stop switches £12.50
12 volt motors, Smiths. single ended ¼" spindle £1.50
12 volt motors, Smiths. double ended ¼" spindle £2.00
12 volt motors, P Magnet type, single ended £1.75
1½ h.p. motor 3450 rpm 100 volt. 50Hz. New £5.00

RELAYS & RELAY BASES

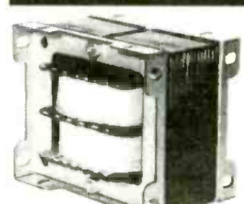
Standard open relays 3 x 8 amp c/o contacts
6 volt dc coil .90 110 volt ac coil
24 volt dc coil .50 230 volt ac coil
1 x 8 amp changeover, 230 volt AC coil
Enclosed plug in round base relays — 3 changeover contacts
50 volt coil (ex fruit machine)
110 volt coil 2 changeover
12 volt coil 3 changeover
8 pin bases. Basses for 2 changeover relay
11 pin basses. Basses for 3 changeover relay
Miniature Relays: 12 volt 2 changeover
12 volt 4 changeover
24 volt
48 volt



SWITCHES – ROCKER, TOGGLE, ETC.

Rocker switches: white push into hole 1" x 7/16". All rate
10 amp, AC 250 volt. on/off
changeover centre off
on/off with neon
push to make spring return
push to break spring return
Larger two circuit one on one off with mounting plate
13 amp rocker switch. Car Fastener (DoT)
Pistol Grip Switch: with lock-on as in electric drills
Interlocking Switch: blow heater, 3 rockers, 10 amp
Micro switches. V3 types, mains button operated: 10 amp c/o contacts
15 amp c/o contacts
10 amp off/on
15 amp off/on
Lever operated add
Lever with roller operation add.
Miniature types: Burgess V4T6 c/o
Two mounted with roller operator
Glass reed switches: 60 watt 10p. 40 watt 5p.
flat multi stackable 60 watt
Operating coils for reed switch multi voltage 3, 6, 9 or 12
Ceramic magnets Mullard.
Mini magnet

MAINS TRANSFORMERS



6 volt 1 amp
6.3 volt 2 amp £1.
12 volt ½ amp
12 volt 4 amp £2.
12 volt 1 amp £1.
8.5 - 0 - 8.5 1 amp £1.
18 volt 1 amp £1.
35 volt 2 amp £2.
38 volt 2½ amp £2.
26 volt 10 amp £4.
50 volt 2 amp £2.
12 - 0 - 12 2 amp £2.
12 - 0 - 12 1 amp £2.
100W auto 115v o/p £2.

FLUORESCENT LIGHTING

12 volt inverter for 21", 13w tube with lamp leads £1.
Chokes for: 8' 125 watt tube £3.
6' 85 watt tube £1.
5' 65 watt tube £1.
4' 40 watt tube £1.
2' 15/20 watt tube £1.
12" 8 watt
Capacitor for 8' 125 watt choke
ditto for 6' 85 watt choke
12" 8 watt miniature tube
2' 40 watt bi pin end tube 1½" diameter
3' 30 watt bi pin end tube 1" diameter
1m 40 watt bi pin ends tube 1½" diameter
1m 25 watt bi pin ends tube 1½" diameter
5' 80 watt bc ends tube 1½" diameter £1.
6' 85 watt bi pin ends tube 1½" diameter
8' 120 watt bc ends tube 1½" diameter £1.
8' 120 watt bi pin ends tube 1½" diameter £1.
Sign tube Philips 25 watt. "W" shape £1.

AMPLIFIERS

½ watt, Japanese made with v.c. £1.
1 watt, Mullard module 1172 £1.
4 watt, Mini-amp with v.c. £1.
Pre-amp, Mullard Ref. 9001 module .8

Approximately 100 tons of stock has to be cleared right away from our big store, hence these very low price offers. Prices quoted are for bulk orders, minimum order £100, minimum any item £12. VAT and carriage are extra, although large orders not too far away will be delivered free. Contact us on this point.

Should you want a small quantity of any of the items as samples, for instance, then send the listed price x 2, which will cover the VAT and postage on letter post items. For heavy items, add the amount you think, bearing in mind that the smallest parcel now costs £1.35 and a 10 kilo parcel £3.25.

We have listed most of the items in our stores. All goods are offered subject to being unsold and conditions of sale are as stated, but should you want more information contact Mr. Bull or Mr. Stepney between 12 - 4pm on (0444) 454563.

J. BULL (Electrical) Ltd.

(DEPT. WW), 34 — 36 AMERICA LANE,
HAYWARDS HEATH, SUSEX RH16 3QU.

Established 30 YEARS

ELECTRICAL ACCESSORIES

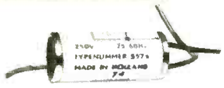
IEM WHITE ACCESSORIES

ingle 1 way 5 amp switch	.40
wo-way & intermediate 5 amp switch	.50
win 2 way 5 amp switch	.80
riple 2 way 5 amp switch	£1.20
ouble pole 20 amp switch	.75
ouble pole 20 amp with neon	.60
attress shallow	.20
itto — double deep	.40
letal Box	.30
ee Junction box	.15
3 amp spur with switch	.50
3 amp spur	.20
3 amp fuses 10 for	.50
urface Switches brown 1 way 5 amp	.15
brown 2 way 5 amp	.20
white 2 way 5 amp	.25
ocket 3 pin 5 amp brown	.20
ocket 3 pin 5 amp brown switched	.30
witch push/push table lamp	.20
lanket switch with neon	.55
ampholder, porcelain	.30
ampholder, screwed ½ brass thread	.20
lexible conduits, plastic egotube 20mm - 50 metres	£4.00
25mm - 50 metres	£5.00

TOROIDAL COIL

transformer lamination alloy, two sizes; 100mm outside dia meter 50mm internal diameter 25mm wide - 75p each; 58mm outside diameter 30mm internal dia. 20mm wide - 45p each.

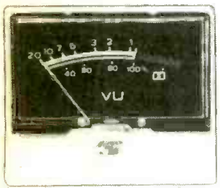
INTERFERENCE SUPPRESSORS



Suppressor .1 mfd 250v 50Hz side tag metal cased 10p
Condensers .1mfd +2 x .0005 mfd side tag metal cased 10p
.2mfd + 2 x .0005 mfd metal cased . . . . .10p.
Choke/condensor combination, stops mains interference from or to equipment. up to 15 amps, stud or clip mount. . .95p.

PANEL METERS & INSTRUMENTS

Volt meter 0 — 200 volts 2½" round	£1.50
— amp meter, hot wire scaled 0 — 9 amps	£1.20
Micro ammeter 2½", round, centre zero 1ma f.s.d.	£1.00
Hot wire meter 6" panel mounting	**£4.50**



Charger panel meters, 1¾" dia. scaled 3 amp . . .35p
Panel meter 1 5/8" square, scaled VU . . .60p
Panel meter, Amstrad, 40mm sq. centre zero, scaled 1,2,3, . . .50p
Edgeways panel, 3"0 - 25 ma, ex GPO . . £1.00.

FERRITE RODS FOR AERIALS, ETC.

Dia ¼" — 4" long 15p	5" long 20p	8" long 30p
Dia 5/16" — 5" long 20p	6" long 25p	8" long 30p
Dia 3/8" — 4" long 20p	5" long 25p	8" long 30p
Dia ½" — 6" long 35p		

Ferrite slab — 3" long x 3/4' x 1/8" 20
L & M coils for above, per set 20

TELESCOPIC AERIAL

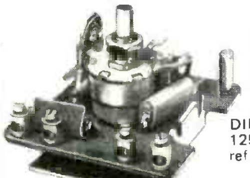
Nickel plated: Collapsed 8½" extended 4' 50
Collapsed 4½" extended 2' 40

BULBS & LAMPS

Torch bulbs, 3.5v MES Box of 25		.35
Pilot light bulbs 6.2v .3A	11mm Box of 50	£1.00
6.2v .3A	14mm Box of 10	.30
12v .5A	16mm Box of 10	.50
Car Bulbs: 18 watt SBC		.12
SBC Lamp holders		.15

MISCELLANEOUS ITEMS

Neon Mains indicators. Standard	.15
Extra small	.25
Bench isolation mains in 230/240v output. 250W	£4.50
Mains input. Porcelain removable fuse	.20
Light operated switch 12 volt. Encapsulated	£1.25
Insulating board. srbp etc. Approx 10 tons. Sheet size 4' x 4' or larger. Various thicknesses, price per lb.	.50
Ditto, Tufnol, price per lb.	£2.00
Aerosol can ICI Fluon lubricant	.35
Varicap P.B. TV tuner	.50
Battery Holder takes 6 U2 batteries, snap connector	.25
Car Battery clips, as for charger, + and — per pair	.10



BUY TIME SLOT METER, 10p gives 1 hour, boxed with lock and coin tray . . . £2.00.

DIMMERS & CONTROLLERS
1250W dimmer, Ultra ref. SF20/5 . . . £2.00.

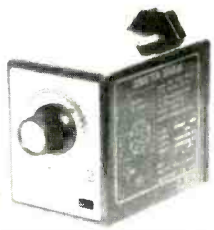
TOOLS:

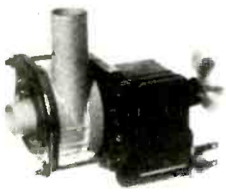
8 ba button dies	.15
Screw driver, miniature for grub screw	.10
Small size, general purpose	.08
Solenoid mains operated AIR VALVE	
200/230 volt model	£2.30
100 volt model	£1.15
ULTRA SONIC Transmitters and receivers	.25
VALVE HOLDERS: B9A with skirt ceramic	.15
B7G PTFE	.25
INSERT speaker/mike, balanced armature, 600 ohm	.30
Rewireable fuse and carrier MEM 20 amp 250 volt	.28
Magnetic Clutch. Zerox 1215494 PN 866 - 10	.90

POWER SUPPLY UNITS

In car, 12 volt for using 6 volt equipment	£1.25
Mains to 24 volt Mullard. Stereo	£1.90
Mains to 12v — 600 mA	£1.50
200 ohm ear piece, screen lead	.35

INDUSTRIAL TIMER
Omron reference STP NH, for 0 - 60 seconds . Price £3.50.





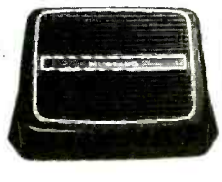
WASHING MACHINE PUMP
Fan cooled, mains driven, Price £3.50.

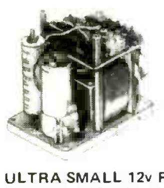
RESISTORS
1/4 — 1/3 watt: carbon film, 5% tolerance normal ends
Price per 100 . . . . £1.00

CATHODE RAY TUBES
Short neck, 9 x 7 screen. Brimar, two models — F28 130 LD and F21 130 SR . . . £7.50 each.

14 KV RECTIFIED EHT UNITS
By Advance. .5mA mains input. . . . Price . £7.50

STEREO CAR SPEAKERS
In plastic cases, 8ohms — 5 watt. £1.50.



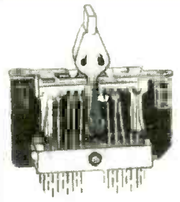


TELEPHONE RINGING MAINS UNIT
Reduces mains to 50 volts and 20Hz. Price . . . **£2.00**

ULTRA SMALL 12v RELAYS
Single pole 12 volt coil. Size 17mm long 10mm diameter, price . . . . £1.00.

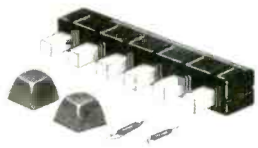
LOCKING MECHANISM One fixing, with 2 keys . . . 60p.

SWITCHES



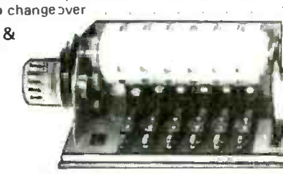
Miniature Make before break Wafer Switch:

1 pole 12 way/ 2 pole 6 way	20p
3 pole 4 way/ 4 pole 3 way	20p
6 pole 2 way/4 pole 2 way	20p
2 pole 2 way/ 1 pole 2 way	20p
2 pole 12 way/4 pole 6 way	45p
6 pole 4 way/ 8 pole 3 way	45p
12 pole 2 way	45p
6 pole 5 way/6 pole 6 way	70p
9 pole 4 way/12 pole 2 way	70p
18 pole 2 way	70p



Push/push table lamp type, better than average quality	.15
10 digit switch pad for telephone	£1.00
Computer key switches, bank of 6 with knobs	£1.25
Lever type, as used by Post Office	.60
Push button switch bank, 9 push (6 interlocking,	
3 independent locking)	.40
3 push switches, with integral knobs	.40
PCB Mounting 2cm diameter 1 pole 4 watt	
Low pressure switch, sensitive could be mouth operated:	
Single 10 amp changeover	£1.15
Ditto, with spindle for adjustment	£1.50
Ditto, 3 10 amp changeover	£1.64

MOTORISED & AUTOMATIC SWITCHES



Uniselectors: 3 pole 25 watt 50 volt coil	£4.75
4 pole 25 watt 50 volt coil	£6.00
2 pole miniature 25 watt	£2.30
Motorised c/o Micro switches. Adjustable sw cams mains capacitor run motor: 4 switch	£2.00
6 switch	£2.50
8 switch	£3.00
12 switch	£3.50

HUMIDITY SWITCH, spindle adjustable 50
DELAY SWITCH, A delay switch which can give delays of a few seconds to a few minutes, depending upon the voltage applied to its heater coil

WIRE WOUND POT, 25 watt 1K	.50
and 8 ohm	.50
100K Multi turn pots	.15
Wire wound pot, with integral knob, available in values — 15 ohms, 33 ohms, 50 ohms, 100 ohms	.15
Miniature PRE-SETS, each	.05

CAPACITORS

AC 50 HZ Working or for DC voltages up to three times AC.

.1uf	250v	.18	3.5uf	275v	.41
.1 +2x .005	250v	.23	4uf	375v	.58
.2uf	440v	.23	5uf	300v	.58
.2uf	1500v	.38	5uf	370v	.70
.2uf	275v	.20	5uf	440v	.76
1uf	440v	.23	5uf	570v	.82
1.25uf	360v	.25	6uf	440v	.80
1.5uf	440v	.33	6uf	660v	.90
1.5 +1.5uf	440v	.58	6.25uf	260v	.58
1.5 +1.5uf	450v	.58	6.3uf	400v	.85
1.7uf	440v	.35	7.4uf	275v	.63
1.7uf	550v	.47	8uf	250v	.68
2uf	440v	.44	8uf	400v	.95
2uf	660v	£2.00	8uf	600v	£1.00
2 + 05uf	350v	.44	7MFD	440v	.80
2.2uf	250v	.37	8.4uf	250v	.70
2.5uf	250v	.38	11uf	275v	.83
2.5uf	440v	.46	12uf	250v	.80
2.7uf	250v	.40	13uf	275v	.85
3MF	100v	.29	15uf	250v	.93
3MF	400v	.50	15uf	325v	£1.20
3.4uf	440v	.58	20uf	275v	.93
3.5uf	250v	.38	32uf	250v	£1.44
120uf	275v	£2.38	62.5uf	260v	£2.38

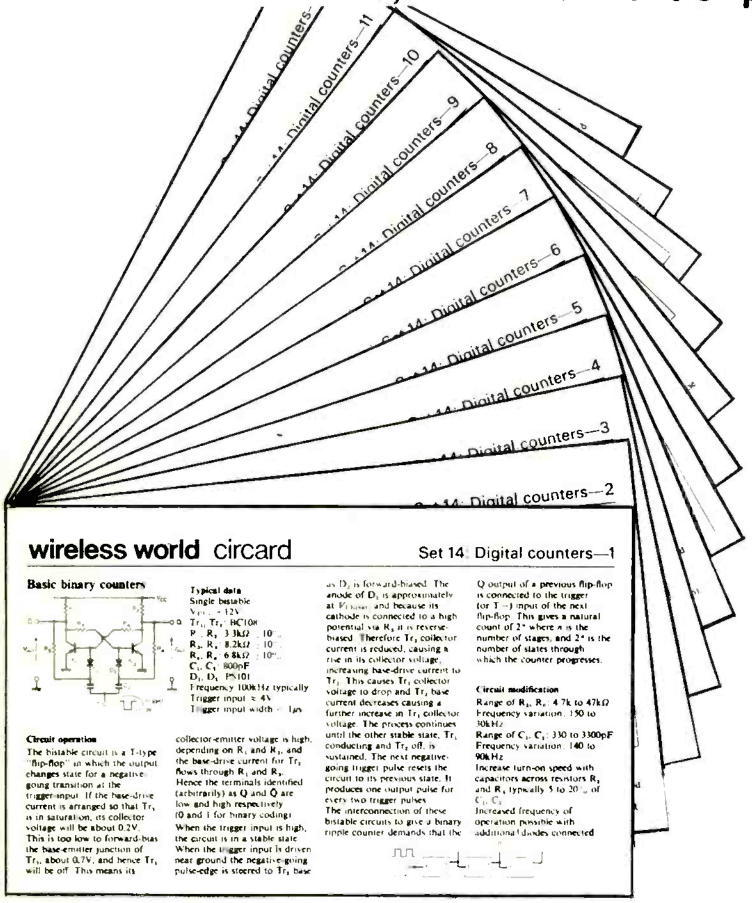
TRANSISTORS

Photo transistors. Mullards seconds 75% working, 100 for	£5
Full wave rectifier, 440v 2 amp	.20
g.p. 50v Silicon diodes	.02
Silicon transistor 107, 109, etc.	.03
Germanium transistors	.05
Surface Barrier transistors	.25

WW — 083 FOR FURTHER DETAILS

BRITAIN'S BETTER BARGAIN STILL IN WORLD-WIDE DEMAND

WIRELESS WORLD CIRCARDS at 1976 prices 10% discount for 10 sets! Most sets are still available even though the companion volumes CIRCUIT DESIGNS 1, 2 and 3 are out of print. (CIRCARDS SETS 1 to 30).



Fill gaps in your circuit files with these sets of 127 x 204 mm cards in plastic wallets. These unique circuit cards normally contain descriptions and performance data of 10 tested circuits, together with ideas for modifying them to suit special needs.

1 Basic Active filters 2 Switching Circuits, comparators and Schmitts (But these gaps cannot be filled)
6 Constant current circuits 7 Power amplifiers 8 Astable circuits 9 Optoelectronics 10 Micro power circuits 11 Basic logic gates 12 Wideband amplifiers 13 Alarm circuits 14 Digital Counters 15 Pulse modulators 16 Current differencing amplifiers – signal processing 17 Current differencing amplifiers – signal generation 18 Current differencing amplifiers – measurement and detection 19 Monostable circuits 20 Transistor pairs 21 Voltage-to-frequency converters 22 Amplitude modulation and detection 23 Reference circuits 24 Voltage regulators 25 RC oscillators – 1 26 RC oscillators – 2 27 Linear cmos – 1 28 Linear cmos – 2 29 Analogue multipliers 30 Rms/log/power laws 31 Digital multipliers 32 Transistor arrays 33 Differential and bridge amplifiers 34 Analogue gate applications – 1 35 Analogue gate applications – 2.

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General Sales Department,
Room 205,
Quadrant House,
Sutton,
Surrey SM2 5AS**

Company registration in England
Quadrant House, The Quadrant,
Sutton, Surrey SM2 5AS
Reg. No 677128

**Please send me the following sets of Circards:........................£2 each, £18 for 10 post free.
Remittance enclosed...............payable to IPC BUSINESS PRESS LTD.**

Name (Please print)......................

Address (Please print)....................

....

LANGREX SUPPLIES LTD

Climax House, Fallsbrook Rd., Streatham, London SW16 6ED

RST **Tel: 01-677 2424 Telex: 946708** **RST**

SEMICONDUCTORS

AA119	0.10
AAY30	0.17
AAY30	0.17
AAZ13	0.15
AAZ15	0.15
AAZ17	0.15
AC107	0.55
AC125	0.25
AC126	0.25
AC127	0.25
AC128	0.30
AC141	0.28
AC141K	0.35
AC142	0.28
AC142K	0.35
AC176	0.30
AC187	0.28
AC188	0.28
ACY17	1.30
ACY18	1.15
ACY19	1.10
ACY20	1.10
ACY21	1.15
ACY39	2.50
AD149	0.75
AD161	0.35
AD162	0.35
AF106	0.35
AF114	0.75
AF115	0.75
AF116	0.75
AF117	0.75
AF139	0.33
AF186	1.00
AF239	0.39
AFZ11	4.00
AFZ12	4.00
ASY26	1.40
ASY27	0.90

ASZ15	1.20
ASZ16	1.10
ASZ17	1.00
ASZ20	2.30
ASZ21	2.50
AU113	2.50
AUY10	3.00
AUY10	3.00
BA145	0.13
BA148	0.15
BA154	0.10
BA155	0.11
BA156	0.10
BAW62	0.05
BAX13	0.06
BAX16	0.06
BC107	0.16
BC108	0.16
BC109	0.16
BC113	0.15
BC114	0.15
BC115	0.18
BC116	0.19
BC117	0.23
BC118	0.18
BC125	0.18
BC126	0.18
BC135	0.15
BC136	0.19
BC137	0.19
BC147	0.12
BC148	0.12
BC149	0.13
BC157	0.13
BC158	0.13
BC159	0.13
BC167	0.11
BC170	0.11
BC171	0.11

BC172	0.11
BC173	0.11
BC177	0.28
BC178	0.28
BC179	0.28
BC182	0.11
BC183	0.11
BC184	0.11
BC212	0.11
BC213	0.11
BC214	0.11
BC237	0.11
BC238	0.11
BC301	0.33
BC303	0.34
BC307	0.11
BC308	0.11
BC327	0.12
BC328	0.12
BC337	0.12
BC338	0.12
BCY30	1.25
BCY31	1.50
BCY32	1.50
BCY33	1.10
BCY34	1.00
BCY39	3.40
BCY40	2.80
BCY42	0.30
BCY43	0.30
BCY58	0.19
BCY70	0.17
BCY71	0.18
BCY72	0.17
BCZ11	1.75
BD115	0.42
BD121	1.70
BD123	2.80
BD124	2.00

BD131	0.44
BD132	0.48
BD135	0.40
BD136	0.40
BD137	0.40
BD138	0.48
BD139	0.48
BD140	0.50
BD144	2.00
BD181	1.20
BD183	0.80
BD2137	0.54
BD238	0.54
BDX10	0.91
BDX32	2.00
BDY20	1.50
BDY60	2.75
BF115	0.35
BF152	0.16
BF153	0.16
BF154	0.17
BF159	0.17
BF160	0.17
BF167	0.24
BF173	0.30
BF177	0.35
BF178	0.35
BF179	0.35
BF180	0.28
BF181	0.28
BF182	0.30
BF183	0.28
BF184	0.28
BF185	0.30
BF194	0.14
BF195	0.12
BF196	0.13
BF197	0.14
BF200	0.40
BF224	0.25
BF244	0.28

BF257	0.27
BF258	0.27
BF259	0.28
BF336	0.34
BF337	0.33
BF338	0.36
BFS21	4.00
BFS28	2.25
BFS61	0.20
BFS98	0.20
BFW10	0.97
BFW11	0.96
BFX84	0.30
BFX85	0.30
BFX87	0.30
BFX88	0.30
BFY50	0.25
BFY51	0.25
BFY52	0.25
BFY64	0.30
BFY90	0.95
BSX19	0.27
BSX20	0.27
BSX21	0.29
BT106	1.20
BTY79/400R	2.00
BU205	1.30
BU206	1.50
BU208	2.00
BY100	0.40
BY126	0.13
BY127	0.14
BZX61 Series	0.17
BZY88 Series	0.10
CRS1/40	0.60
CRS3/40	0.75
CRS3/60	0.90
GEX66	3.00

GEX541	5.00
GJ3M	1.75
GM0378A	1.75
KS100A	0.45
MJE340	0.60
MJE370	0.73
MJE371	0.71
MJE520	0.47
MJE521	0.73
MJE2955	1.30
MJE3055	1.10
MPF102	0.35
MPF103	0.35
MPF104	0.35
MPF105	0.35
MPSA06	0.26
MPSA56	0.28
MPSU01	0.53
MPSU06	0.65
MPSU56	0.69
NE555	0.45
NKT401	3.50
NKT403	2.50
NKT404	2.20
OA5	1.20
OA7	0.60
OA10	0.55
OA47	0.12
OA70	0.25
OA79	0.12
OA81	0.17
OA85	0.17
OA90	0.08
OA91	0.08
OA95	0.08
OA200	0.15
OA202	0.15
OA211	1.50
OAZ200	1.50
OAZ201	1.50
OAZ206	1.50

OAZ207	1.50
OC16	2.50
OC20	2.50
OC22	2.50
OC23	4.00
OC24	3.00
OC25	1.00
OC26	1.50
OC28	2.00
OC29	2.00
OC35	1.50
OC36	1.50
OC41	0.90
OC42	0.90
OC43	1.50
OC44	0.85
OC45	0.65
OC71	0.55
OC72	1.00
OC73	1.00
OC74	0.70
OC75	0.65
OC76	1.00
OC77	1.00
OC81	0.65
OC81Z	1.20
OC82	0.90
OC83	0.80
OC84	0.80
OC122	2.75
OC123	2.00
OC139	3.00
OC140	4.00
OC141	4.25
OC170	1.25
OC171	1.25
OC200	1.50
OC201	2.50
OC202	2.75
OC203	3.00
OC204	3.00

OC205	2.75
OC206	2.75
OC207	2.50
OCP71	2.00
ORP12	1.00
R2008B	2.00
R2009	2.25
R2010B	2.00
T1C44	0.27
T1C226D	1.20
T1L209	0.16
T1P29A	0.43
T1P30A	0.45
T1P31A	0.33
T1P32A	0.36
T1P33A	0.54
T1P34A	0.67
T1P41A	0.44
T1P42A	0.42
T1P2955	0.70
T1P3055	0.56
T1S43	0.43
ZS140	0.25
ZS170	0.21
ZS178	0.54
ZS271	0.23
ZS278	0.57
ZTX107	0.12
ZTX108	0.12
ZTX109	0.12
ZTX300	0.13
ZTX301	0.14
ZTX302	0.18
ZTX303	0.18
ZTX304	0.20
ZTX311	0.13
ZTX314	0.25
ZTX500	0.14
ZTX501	0.14
ZTX502	0.18
ZTX503	0.19

ZTX504	0.21
ZTX531	0.24
ZTX550	0.25
1N914	0.05
1N916	0.09
1N4001	0.06
1N4002	0.06
1N4003	0.06
1N4004	0.07
1N4005	0.09
1N4006	0.11
1N4007	0.12
1N4009	0.07
1N4148	0.04
1N5400	0.13
1N5401	0.13
1S44	0.04
1S920	0.08
1S921	0.09
2G301	1.00
2G302	1.00
2G306	1.00
2N404	1.30
2N696	0.32
2N697	0.32
2N698	0.32
2N705	1.25
2N706	0.25
2N708	0.25
2N930	0.25
2N1131	0.30
2N1132	0.30
2N1302	1.20
2N1303	0.80
2N1304	1.20
2N1305	1.00
2N1306	1.50
2N1307	1.10
2N1308	1.75
2N1309	1.20
2N1613	0.32

2N1671	5.00
2N1893	0.32
2N2147	4.00
2N2148	3.75
2N2218	0.32
2N2219	0.32
2N2220	0.20
2N2221	0.20
2N2222	0.20
2N2223	4.25
2N2368	0.25
2N2369A	0.25
2N2484	0.25
2N2646	0.50
2N2904	0.32
2N2905	0.32
2N2906	0.21
2N2907	0.21
2N2924	0.26
2N2925	0.22
2N2926	0.15
2N3053	0.26
2N3054	0.55
2N3055	0.65
2N3440	0.70
2N3441	0.85
2N3442	1.25
2N3614	2.20
2N3702	0.11
2N3703	0.11
2N3704	0.11
2N3705	0.11
2N3706	0.11
2N3707	0.11
2N3708	0.10
2N3709	0.11
2N3710	0.10
2N3711	0.10
2N3771	1.40
2N3772	1.60
2N3773	1.80

2N3819	0.30
2N3820	0.39
2N3823	0.60
2N3866	1.00
2N3904	0.17
2N3905	0.17
2N3906	0.17
2N4058	0.20
2N4059	0.20
2N4060	0.16
2N4061	0.16
2N4062	0.16
2N4124	0.16
2N4126	0.16
2N4286	0.15
2N4288	0.18
2N4289	0.18
2N5457	0.32
2N5458	0.32
2N5459	0.32
2S017	10.00
2S019	12.00
2S026	25.00
2S103	1.50
2S302	2.00
2S303	1.50
2S322	3.50
2S324	3.50
2S701	2.00
2S745A	0.95
2S746A	0.95

VALVES

A1834	9.00
A2087	13.50
A2134	17.50
A2293	16.00
A2426	18.75
A2521	22.50
A2900	22.50
A3343	45.00
AZ31	2.75
AZ41	2.60
BK448	114.90
BK484	155.35
BS90	58.00
BS452	60.00
BS810	60.00
BT5	58.95
BT17	151.00
BT19	44.05
BT29	349.15
BT69	354.80
BT95	129.00
CBL31	4.00
CL33	4.00
CY31	3.00
C1K	20.00
C3A	22.00
C3JA	22.00
DA41	25.00
DA42	18.70
DAF91	1.75
DAF96	1.75
DET22	35.00
DET24	49.00
DF91	1.75
DF96	1.75
DK91	1.75
DK92	2.00
DK96	1.75
DL92	2.00
DL94	1.75
DL96	1.75
DLS10	14.00
DLS15	12.50
DLS16	12.50
DLS19	12.50
DM70	2.00
DM71	2.00
DM160	4.75
DY87	1.50
DY802	1.50
E55L	22.00
E80CC	8.81
E80CF	11.27
E80F	13.58
E80L	13.37
E81CC	8.00
E81L	12.57
E82CC	8.10
E83CC	8.40
E86C	8.25
E88C	8.25
E88CC	8.00
E90CC	8.61
E90F	9.90
E91H	6.25
E92CC	8.75
E99F	9.10

E130L	18.50
E180CC	10.50
E180F	9.90
E182CC	13.25
E186F	11.50
E188CC	8.25
E280F	22.51
E283CC	12.00
E288CC	17.50
EA52	32.25
EA76	2.50
EABC80	1.25
EAC91	3.50
EAF42	2.50
EAF801	2.00
EB41	4.00
EB91	1.50
EBC33	2.50
EBC41	2.50
EBC81	1.50
EBC90	1.25
EBF80	1.50
EBF83	1.75
EBF89	1.50
EBL31	4.00
EC90	1.25
EC91	8.00
EC92	1.75
EC157	325.40
ECC33	4.50
ECC35	4.50
ECC40	4.50
ECC81	1.75
ECC82	1.75
ECC83	1.75
ECC84	1.75
ECC85	1.75
ECC86	2.50
ECC88	2.10
ECC89	2.00
ECC91	8.93
ECC189	2.10
ECC807	1.75
ECC808	3.50
ECF80	1.55
ECF82	1.50
ECF86	2.50
ECH35	3.00
ECH42	3.50
ECH81	3.00
ECH83	2.50
ECH84	2.50
ECL80	1.50
ECL81	1.75
ECL82	1.50
ECL83	3.00
ECL84	1.50
ECL85	1.50
ECL86	1.75
EF37A	5.00
EF39	2.75
EF40	5.00
EF41	3.50
EF42	4.50
EF50	2.50
EF54	5.00
EF55	3.50
EF80	1.75
EF83	4.00

EF85	1.75
EF86	1.75
EF89	2.50
EF91	2.95
EF92	6.37
EF93	1.50
EF94	2.50
EF95	5.99
EF98	2.00
EF183	2.00
EF184	2.00
EF804S	12.00
EF805S	9.80
EH90	1.75
EK90	1.50
EL32	2.50
EL33	4.00
EL34MUI	3.00
EL36	2.50
EL41	2.80
EL42	2.50
EL81	5.25
EL83	6.00
EL84	2.25
EL86	2.75
EL90	2.25
EL91	9.69
EL95	2.00
EL156	25.00
EL360	8.50
EL500/504	3.00
EL509	7.00
EL821	13.00
EL822	13.97
EM34	5.00
EM80	2.50
EM81	2.50
EM84	2.00
EM85	2.75
EM87	2.50
EN32	17.46
EN91	7.50
EN92	6.96
EY51	2.75
EY81	2.50
EY83	2.50
EY84	9.24
EY86	1.75
EY88	1.752
EY500A	3.00
EY802	1.75
EZ35	1.75
EZ40	2.50
EZ41	2.50
EZ80	1.50
EZ81	1.50
EZ90	2.00
FW4-500	3.50
FW4-800	3.50
G1.371K	35.00
GS51K	12.00
G180.2M	17.50
G240.2D	12.00
G400.1K	17.50
GN4	9.00
GN4A	9.00
GS16	16.00
GT1C	15.00
GU50	20.00

GU51	20.00
GXU1	15.35
GXU2	30.00
GXU3	25.00
GXU4	44.50
GXU50	20.00
GY501	3.00
GZ32	2.50
GZ33	4.75
GZ34	3.00
GZ37	4.75
KT61	5.00
KT66	8.00
KT88	11.00
KTW61	2.50
KTW62	2.50
KTW63	2.50
M8079	12.34
M8080	8.25
M8081	9.82
M8082	9.69
M8083	8.58
M8091	10.43
M8096	6.80
M8097	8.10
M8098	6.15
M8099	8.00
M8100	9.52
M8136	10.23
M8137	10.23
M8140	6.00
M8141	6.50
M8142	8.75
M8144	7.50
M8149	6.50
M8161	9.35
M8162	10.40
M8163	8.25
M8190	5.00
M8195	10.85
M8196	7.50
M8204	7.05
M8212	11.37
M8223	6.00
M8224	6.30
M8225	4.50
M8248	14.03
MD2901	60.00
MU14	2.50
MX119	55.00
MX123	72.00
MX145	56.70
MX151	17.25
MX152	131.25
MX161	152.25
MX163	20.25
MX164	25.52
MX166	147.00
MX168	48.00
N78	15.00
OA2	3.25
OA3	2.50
OA4	6.00
OB2	4.35
OB3	2.50
OC2	4.35
OC3	2.50
OD3	2.50
OZ4	3.50

PC86	2.50
PC88	2.50
PC95	1.75
PC97	1.75
PC900	1.75
PCC84	1.50
PCC85	1.50
PCC88	2.00
PCC89	1.75
PCC189	2.50
PCC805	1.60
PCC806	1.60
PCE82	2.00
PCF80	2.00
PCF82	1.50
PCF86	2.50
PCF87	2.00
PCF200	3.25
PCF201	3.25
PCF801	2.50
PCF802	2.50
PCF805	1.70
PCF806	1.70
PCF808	1.70
PCL82	2.00
PCL83	3.00
PCL84	3.00
PCL85	2.50
PCL86	2.50
PCL805/85	2.50
PD500	6.00
PE06-40N	30.00
PFL200	2.50
PL36	2.50
PL81	1.75
PL81A	2.00
PL82	1.50
PL83	2.50
PL84	2.00
PL504/5	2.50
PL508	2.50
PL509	6.00
PL519	6.00
PL801	1.50
PL802	6.00
PPV03-10	14.00
PY33	2.50
PY81	1.75
PY82	1.50
PY83	2.50
PY88	2.00
PY500A	3.00
PY800	1.50
PY801	1.50
QQV02-5	16.50
QQV03-20A	48.38
QQV06-40A	48.38
QQV07-50	66.90
QQZ06-40A	62.20
QU37	12.50
QV03-12	6.80
QV04-7	3.50
QV08-100	136.85
QY3-65	54.26
QY3-125	60.40

QY4-250	73.15
QY4-400	76.80
QY5-500	175.00
QY5-3000A	335.00
QZ06-20	32.70
R10	6.00
R17	3.00
R18	3.00
R19	9.24
R20	2.50
RG3-250	32.68
RG3-250A	32.68
RG3-1250	59.50
RG4-1250	61.60
RG4-3000	99.45
RR3-250	40.00
RR3-1250	45.75
S11E12	65.00
S130	6.00
S130P	6.00
STV280-40	14.00
STV280-80	21.00
SU41	5.00
SU42	10.00
TD03-10	35.00
TD03-10F	35.00
TT15	35.00
TT21	23.00
TT22	23.00
TT100	60.00
TY2-125	60.00
TW4-400	71.40
TY4-500	98.35
TY5-500	175.00
TY6-800	188.00
TY6-5000A	375.00
TY6-5000B	395.00
TY6-5000W	325.00
TY7-6000A	374.00
TY7-6000W	303.60
TZ40	25.00
U18-20	3.50
U19	13.75
U25	2.50
U26	2.50
U37	12.00
UABC80	1.25
UAF42	2.50
UB41	3.00
UBC41	2.25
UBF89	1.50
UCC84	2.50
UCC85	1.85
UCF80	2.00
UCH42	2.50
UCH81	1.50
UCL82	1.75
UCL83	2.75
UF41	2.00
UF42	2.10
UF80	1.75

UF85	1.75
UF89	2.00
UL41	3.50
UL84	1.75
UM80	2.00
UY41	2.25
UY85	2.25
VLS631	15.00
XG1-2500	45.80
XG2-6400	141.90
XG5-500	26.60
XG2-6400	162.00
XR1-1600A	53.75
XR1-3200	81.97
XR1-3200A	
XR1-6400	102.00
YD1120	395.00
YD1240	351.00
Z759	25.00
ZM1000	8.00
ZM1001	8.00
ZM1020	9.00
ZM1021	9.00
ZM1022	9.00
ZM1023	9.00
ZM1040	19.36
ZM1041	16.66
ZM1042	17.77
1B3GT	3.00
1B24	25.00
1B35A	48.00
1B63	64.00
1R5	1.75
1S5	1.75
1T4	1.75
2AS15	11.50
2C39A	60.00
2C43	70.00
2D21	3.25
2E26	8.25
2J42	98.00
2J55	175.00
2J70A	383.00
2J70B	336.00
2K25	125.00
3-400Z	85.00
3-500Z	85.00
3A5	3.00
3B24	11.00
3B28	15.35
3B29	20.00
3B240M	17.50
3B241M	17.50
3C23	25.00
3C45	24.50
3CX100A5	47.00
3E29	45.00
3S4	2.00
3V4	1.75
465A	60.00
4-125A	60.00
4-250A	80.00
4-400A	87.00
4B32	20.00

4C35	78.00
4CX250B	40.00
4CX350A	73.00
4X150A	60.00
4X150D	56.00
5B254M	35.00
5B255M	35.00
5C22	160.00
5J180E	1650.00
5R4GY	3.50
5U4G	3.00
5U4GB	2.50
5V4G	2.50
5Y3GT	2.50
5Z3	4.00
5Z4G	2.50
5Z4GT	2.50
6-30L2	1.75
6AB4	1.75
6AB7	3.00
6AC7	3.00
6AF4A	4.25
6AG7	3.00
6AH6	5.00
6AK5	7.10
6AK6	2.50
6AL5	1.50
6AM4	4.00
6AM5	9.69
6AM6	6.00
6AN5	4.75
6AN8A	3.50
6AQ5	2.25
6AS6	8.66
6AS7G	8.75
6AT6	1.25
6AU5GT	5.00
6AU6	2.50
6AV5GA	4.50
6AV6	1.50
6AX5GT	3.00
6B7	3.25
6B8	3.25
6BA6	1.50
6BA7	5.00
6BA8A	4.00
6BC4	4.00
6BE6	1.50
6BH6	2.50
6BJ6	2.25
6BK4	4.50
6BL6	85.00
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6BM6	115.00
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6BW6	6.00
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6BX7GT	5.00
6BZ6	2.75
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6CD6GA	5.50
6CG7	2.50
6CH6	13.00
6CL6	3.75

6CW4	8.00
6D2	1.50
6DK6	3.00
6DQ6B	4.75
6EA8	3.00
6EB8	2.50
6EW6	2.25
6F6	3.00
6F23	1.60
6F28	1.60
6F33	33.50
6H1	14.00
6H2N	2.75
6H3N	2.75
6H6	3.00
6J4	5.50
6J6	8.93
6J7	4.75
6K4N	2.50
6K6GT	2.75
6K7	3.00
6K8	3.00
6KD6	7.00
6L6G	3.00
6L6GA	2.25
6L6GT	2.25
6L6GC	2.25
6L7	2.50
6N2P	2.50
6N3P	2.50
6N7	3.00
6P25	4.00
6Q7	3.75
6R7	3.25
6SA7	3.00
6SC7	2.75
6SF7	2.50
6SH7	3.00
6SJ7	3.25
6SK7	3.50
6SK7GT	3.00
6SN7GT	3.00
6SQ7	3.40
6SR7	4.00
6SS7	2.75
6U5G	3.50
6U8A	2.25
6V6GT	2.25
6X4	2.00
6X5GT	1.75
7B7	2.50
7C5	4.00
7C6	2.50
7H7	4.00
7R7	4.25
7S7	3.50
7Y4	2.25
7Z4	2.00
11E3	55.00
12AH8	5.00
12AT6	1.50
12AT7	1.75
12AU6	2.50
12AU7	1.75
12AV6	2.50
12AV7	3.50
12AX7	1.75
12AY7A	4.00
12B4A	3.50

12BA6	2.50
12BE6	2.50
12BH7	1.50
12BY7	3.00
12E1	20.00
12E11TT	176.00
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19H4	27.50
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24B9	67.25
30C15	2.00
30C17	2.00
30C18	2.00
30F5	1.60
30FL1/2	1.38
30FL12	1.80
30FL14	2.00
30L1	1.50
30L15	2.00
30L17	2.00
30P4	2.50
30P19	2.50
30PL1	3.00
30PL14	1.80
30PL15	1.80
35W4	1.00
50C5	1.50
75B1	6.05
75C1	3.50
85A1	7.50
85A2	4.45
90AG	12.96
90AV	12.96
90C1	3.20
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90CV	15.45
92AG	12.96
92AV	12.96
95A1	8.45
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150C2	3.25
150C4	4.05
211	35.00
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805	45.00
807	3.75
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872A	20.00
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5642	9.00
5654	3.00
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5670	4.50
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5696	4.50
5718	7.50
5725	5.50
5726	11.37
5727	7.05
5749	2.50
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5763	4.50
5814A	4.00
5840	4.00
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5879	5.00
5886	12.50
5963	2.50
5965	3.50
6005	2.25
6021	4.50
6057	10.23
6058	12.34
6059	6.00
6061	6.00
6063	3.75
6064	8.58
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7402	0.17
7403	0.17
7404	0.18
7405	0.18
7406	0.43
7407	0.43
7408	0.20
7409	0.20
7410	0.17
7412	0.29
7413	0.32
7416	0.32
7417	0.32
7420	0.18
7422	0.20

7423	0.33
7425	0.30
7427	0.30
7428	0.43
7430	0.17
7432	0.30
7433	0.40
7437	0.32
7438	0.32
7440	0.32
7441	0.90
7442	0.72
7447AN	1.17
7450	0.18
7451	0.18
7453	0.18
7454	0.18

7460	0.18
7470	0.38
7472	0.33
7473	0.38
7474	0.38
7475	0.54
7476	0.42
7480	0.56
7482	0.75
7483	1.05
7484	1.00
7486	0.39
7490	0.60
7491	0.82
7492	0.60
7493	0.60
7494	0.82

7495	0.73
7496	0.82
7497	3.15
74100	1.54
74107	0.45
74109	0.73
74110	0.51
74111	0.71
74116	1.85
74118	1.00
74119	1.54
74120	0.83
74121	0.43
74122	0.62
74123	1.18
74125	0.58
74126	0.58
74128	0.63
74132	0.72

74136	0.51
74141	0.89
74142	2.30
74143	2.60
74144	2.60
74145	1.00
74147	2.00
74148	1.76
74150	1.80
74151	0.94
74154	1.80
74155	0.90
74156	0.90
74157	0.75
74159	2.20
74170	2.40
74172	4.40
74173	1.42
74174	1.60

74175	1.02
74176	1.16
74178	1.36
74179	1.36
74180	1.20
74190	1.90
74191	1.90
74192	1.90
74193	1.90
74194	1.25
74195	1.20
74196	1.35
74197	1.35
74198	2.70
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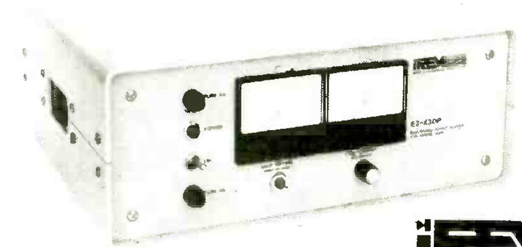

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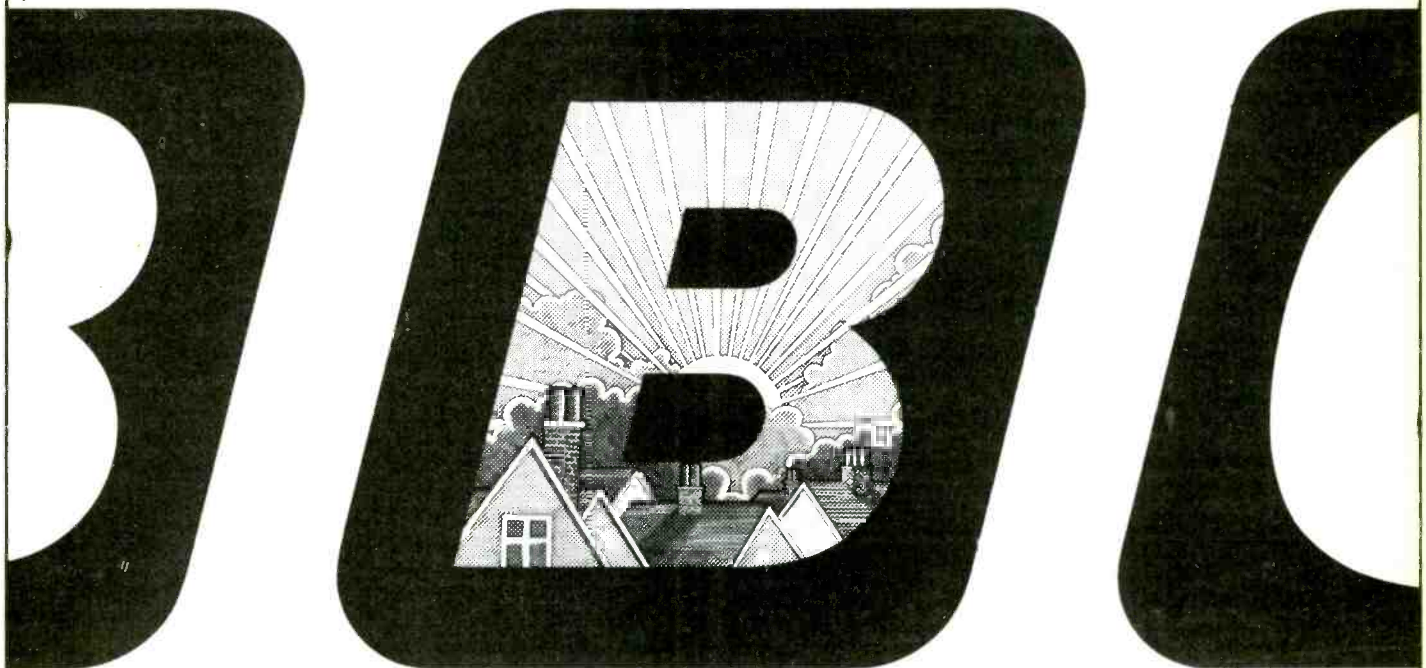

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Candidates must have at least four years' experience and must possess **either** ONC in Engineering including a pass in Electrical Engineering "A" **or** City and Guilds Telecommunications Technicians Certificate No 271 or the Intermediate Certificate plus Mathematics B, Telecommunications Principles B, and either Radio and Line Transmission B or Telephony B or Telegraphy B **or** City and Guilds Radio, Television and Electronics Technicians Certificate No 272 **or** a pass in the Council of Engineering Institutions Part I examination **or** TEC/SCOTEC Certificate in a relevant discipline **or** an equivalent qualification.

Ex-Service personnel with formal approved Service technical training and at least three years' appropriate service in a senior technical capacity will also be considered.

Applicants should be familiar with the operation, maintenance and testing of radio communication equipment and should have a knowledge of current radio systems.

Salary: £5980-£8180; Kenley £454 more, London up to £1087 more. Starting salary may be above the minimum for those with additional relevant experience. Good promotion experience.

RELOCATION ASSISTANCE MAY BE AVAILABLE.

For further details and an application form (to be returned by 11 November 1982) write to Civil Service Commission, Alencon Link, Basingstoke, Hants RG21 1JB, or telephone Basingstoke (0256) 68551 (answering service operates outside office hours). **Please quote ref: T/5845.**

Home Office

(1823)

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Required to work in a team testing and aligning the Company's precision laser plotters and digitisers. A working knowledge of TTL is essential, and knowledge of microprocessors an advantage. Industrial experience of both digital and analogue circuitry is necessary and experience in the use of lasers and associated optics would be useful. Education qualification to a minimum of HNC in Electrical and Electronic Engineering is required.

To the successful applicant we can offer pleasant working conditions, competitive salaries, non-contributory sickness scheme and other fringe benefits.

Application forms obtainable from:
Personnel Officer, Laser-Scan Laboratories Ltd, Cambridge Science Park, Milton Road, Cambridge CB4 4BH. Telephone: (0223) 69872.

(1800)

TRINITY HOUSE LIGHTHOUSE SERVICE, LONDON

ELECTRICAL ENGINEER

GRADE PTO II SALARY £9,021-£10,328 p.a.

Applicants must have had a sound training in radio and light current work associated with UHF, VHF and MF communications, remote monitoring and control systems. Experience in detailed planning, preparation of procurement specifications and drawings, manufacturers' acceptance testing, field trials and commissioning is essential.

Some knowledge of landline signalling techniques, simple computer programming and micro-technology would be an advantage.

Possession of a degree in electronics/radio engineering or equivalent is required.

Generous leave allowance, pension scheme and flexible working hours.

Apply to The Establishment Officer, Trinity House Lighthouse Service, Tower Hill, London EC3N 4DH or Telephone 01-480 6601 Ext. 289.

(1812)

Are you flying high like the Sony Broadcast bird?

The silver bird is the symbol of Sony Broadcast Ltd, a Company which in just over 4 years has become one of the world leaders in professional broadcast television equipment. Our exciting range of products includes video cameras, VTR's/VCR's, editing control systems and a range of digital audio equipment. We are about to commence a significant planned expansion programme and applications are invited for the following new career positions.

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Two vacancies exist within our Technical Training Department. A Lecturer is required to conduct theoretical and practical courses on our range of cameras and a second opening exists for a person to concentrate on editors. Applicants should have experience of professional broadcast television equipment and possess the ability to present ideas clearly. Scope exists for occasional overseas travel and training on our range of products and in lecturing skills will be given where appropriate.

Product Engineer (Editing Systems)
To provide technical support to the Marketing and Engineering divisions of the Company on our range of professional video tape editors. The position combines in-depth technical involvement with inter departmental and customer liaison and there will be an opportunity for overseas travel.
Applicants should be graduate electronic engineers who have some experience in video technology gained either in operational television or its allied manufacturing industry.

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To join a small team responsible for the evaluation of product performance. Key activities will include commissioning, assistance in product customisation and the establishment and maintenance of ATE. Full product training will be given and there will be an opportunity for overseas travel.

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To join a young and enthusiastic team involved in the design, manufacture and commissioning of complex static and mobile television systems. Candidates for this challenging and responsible position should have direct experience of sound and television principles gained in operational television or its allied manufacturing industry.

Proposals Engineer
Ideal for engineers experienced in the Broadcast TV industry who now wish to utilize their knowledge in a dynamic commercial environment. Duties will include the preparation of detailed and concise customer proposals, complete with pricing information and extensive customer and inter Company liaison will be necessary.

Field Service Engineer
To be engaged in the service and repair of a wide range of sophisticated equipment, including video cameras, VTR's and editing control systems. A high level of self motivation and initiative is required in order to successfully undertake customer visits throughout Europe, Africa and the Middle East.

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Reporting to the Service Manager, who is based in Basingstoke, the successful applicant will be responsible for the service and repair of the full range of our equipment. Candidates should live in the London area, possess a relevant qualification in electronics and have several years experience in operational television or its allied manufacturing industry.

Sales Engineer (UK)
An engineer with experience in operational television or its allied manufacturing industry is required to join our UK sales team. Applicants should be aged 25–35, highly motivated and able to work on their own initiative. Previous sales experience would be advantageous although this is not essential.

Senior Engineer – Measurement and Maintenance
To be responsible for a wide range of equipment in our Technical Training Department. Applicants should have extensive experience in practical maintenance and measurement techniques on VTR's, editing systems and cameras. Many of our products are micro processor controlled, and a knowledge of micro processors, logical analysers and signature analysis techniques is desirable. Extensive product training will be given where necessary.

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SONY® Broadcast

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City Wall House
Basing View, Basingstoke
Hampshire RG21 2LA
United Kingdom

(1835)

CAMBRIDGE HEALTH AUTHORITY
Medical Physics Department
ADDENBROOKE'S HOSPITAL
Hills Road, Cambridge

Medical Physics Technicians (Electronics) Grades III and IV

Two electronics technicians are required to provide a wide range of support services within the Cambridge area. Duties include maintenance, repair, development and construction of a wide range of equipment. The MPT III will also provide support to the CT Head Scanner in conjunction with other staff.

Minimum qualification OTEC or equivalent but HTEC/HNC preferred. MPT III applicants must have three years' relevant experience. Applicants should hold a valid driving licence.

Salaries:
MPT III £5,536 (starting) rising to £7,155 per annum.
MPT IV £4,668 (starting) rising to £6,137 per annum.
(NB Pay award pending)

For further details contact Mr. P. E. Ward, Principal Medical Physics Technician, Addenbrooke's Hospital, Hills Road, Cambridge. Tel. (0223) 245151, Ext. 471.

Application form and job description from: Personnel Department, Addenbrooke's Hospital, Hills Road, Cambridge. Tel. (0223) 245151, Ext. 7350.

(1805)

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To serve in Field Service missions. Must be available for assignment any part of the world.

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RADIO TECHNICIANS must have a diploma from a Radio Technical School and be able to install, maintain and operate fixed transmitters up to 40 kW, mobile and portable transmitting equipment, communications receivers, diversity systems and ancillary equipment associated with above, FSK, Teletype equipment and power generators. Must also be able devise and erect omni-directional antennae and feeder lines. Climbing antennae masts may be required as field missions do not normally employ riggers for this purpose. Maintenance and repair teletype equipment of Teletype Corp. and Siemens make may be required. If candidates not experienced in these operations at recruitment time, they should be willing to acquire proficiency on teletype within a reasonable time. Salary US$20,715 (net after Assessment $16,880 with dependents, $15,891 at single rate).
All candidates must have a valid driver's licence and must have a very good knowledge of English. Appointments are for six months to one year, with possibility of renewal and are subject to medical examination. In addition to salary a monthly mission allowance will be paid in local currency. This allowance varies according to duty station. Good additional benefits.

Candidates may apply in writing to:

Miss Faith Metcalf, Office of Personnel
UNITED NATIONS – Room UNDC 200
New York, NY 10017 USA

(1806)

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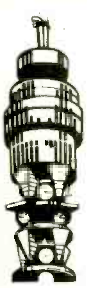

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We are looking for young electronics design engineers to support existing teams working on microprocessor-based systems, and/or analogue circuit design covering a variety of interesting tasks of a multi-disciplinary nature.

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We are looking for draughtspersons to be responsible for mechanical and printed circuit board design for complete projects from initial concepts through to issue of production drawings.
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Tel: 01-805 7222

(1857)

The Royal Marsden Hospital
Downs Road, Sutton, Surrey

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Required to work in a technical group in the busy Radiotherapy Department of this hospital. The person appointed will be chiefly responsible for maintenance work on a Linear Accelerator.

Applicants should possess an ONC, HNC, HND or similar qualification in electrical engineering or electronics and have at last 3 years' technical experience.

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For an application form and further details please contact the Personnel Department – Tel: 01-352 8171 ext: 446.

(1817)

UNIVERSITY OF YORK
Department of Electronics

Applications are invited for the post of

SENIOR TECHNICIAN
(GRADE 5)

in the central workshop of the new Department of Electronics. The workshop staff are responsible for the maintenance of electronic instruments and for the development and construction of electronic equipment for teaching and research purposes.

Applicants are expected to have an appropriate qualification and considerable experience of electronics engineering, preferably including computers. The salary scale is currently £5,695-£6,650 (under review).

Applications giving full details of age, education and experience together with the names and addresses of two referees, should be sent to: Mrs. E. D. Heavens, Senior Administrative Assistant, University of York, York YO1 5DD, by Friday, 12th November.

(1836)

The Royal Marsden Hospital
Fulham Road, SW3

Medical Physics Technician Grade II/III

Required in the Radiotherapy and Physics Electronics Workshop of the above hospital. The person appointed will work in a small group responsible for the maintenance of radiotherapy equipment including three Cobalt units, a Philips 10 MeV Linear Accelerator and orthovoltage X-Ray equipment.

Applicants should have experience in electronics and electrical and mechanical servicing.

Applicants for MPT III should hold ONC, HNC or similar qualification in electrical, engineering or electronics with at least three years' relevant technical experience. Entry to MPT II grade is open to a technician who has served at least two years as a Technician III.

MPT III Salary on scale: £6468-£8087 (pay award pending)
MPT II Salary on scale: £7600-£9248 (pay award pending)

For application form and further details please contact: The Personnel Department, Royal Marsden Hospital, Fulham Road, London, SW3. Tel: 01-352 8171 Ext 446.

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In addition, he/she will be concerned with the introduction of new products, following through from design specification to in-house or sub-contract volume manufacture. This will involve working closely with Development Engineering, Purchasing, Production, Finance and Sales Departments.

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Applicants should have had previous experience and knowledge of the airborne electronics industry and must be familiar with CAA and MOD Quality requirements.

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Please write with brief personal and career details to Mr R Shead, Airadio Spares and Service Unit, 22-26 Dalston Gardens, Stanmore, Middlesex HA7 1BZ.

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(1798)

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requires an

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(Basic grade) to join a small team providing electronics support to clinical and scientific groups in Southampton hospitals.

The post is based in the electronics section of the medical physics department at the large and modern Southampton District General Hospital.

The work involves the application of the latest electronic techniques to a wide variety of problems in many different areas of medicine and the successful candidate will be expected to design and construct equipment to a high standard under the supervision of a senior electronics engineer.

A good Honours degree in electronics or physics is essential and relevant practical experience is desirable. The starting salary will be in the range of £5,667-£6,745 per annum (under review) according to postgraduate experience.

For further information or to make an application please contact:
Professor T. Shelley, Dept. of Medical Physics, Level D, Centre Block, Southampton General Hospital, Tremona Road, Southampton, SO9 4XY. Tel: Southampton 777222 ext. 4205.

(1799)

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GRADE II

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Further details may be obtained from Mr P. Hall, Assistant Area Engineer, Tel. (0482) 223191 ext. 108.

Application forms and job description available from the District Personnel Office, Hull Health Authority, Victoria House, Park Street, Hull, tel. (0482) 223191, ext. 99.
Closing date: 3rd November 1982.

(1841)

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For an application form, please write to the **Recruitment Officer, (Dept. W/W11), HM Government** Communications Centre, Hanslope Park, Milton Keynes, MK19 7BH.

(1589)

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This successful, monthly magazine is read by senior electronics engineers in the Middle East, and the Editor is looking for a responsible number two to develop the journal's potential.

Usual writing and subbing skills essential plus knowledge of the industry and preferably experience of developing countries and their technology problems. Computer Science background an advantage.

Our UK office is located in Morden, Surrey, but we offer opportunities for travel and a salary of £8,400 per annum.

Terms and conditions are in accordance with the IPC/NUJ agreement.

Write or phone for an application form to the Editor, Ray Ashmore, Middle East Electronics, Crown House, 14th Floor, London Road, Morden, Surrey SM4 5DX. Tel: 01-543 3051.

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Candidates must hold an Ordinary National Certificate in Electronic or Electrical Engineering *or* a City and Guilds of London Institute Certificate in an appropriate subject *or* a qualification of a higher or equivalent standard and have 3 years' appropriate experience.
Some assistance may be given with relocation expenses.
A valid UK driving licence is essential.
Application forms and further information are obtainable from Scottish Office Personnel Division, Room 110, 16 Waterloo Place, Edinburgh EH1 3DN (quote ref PM/PTS) 2/3/82 (031-556 8400, ext. 4317 or 5028).
Closing date for receipt of completed application forms is 12 November, 1982.

(1808)

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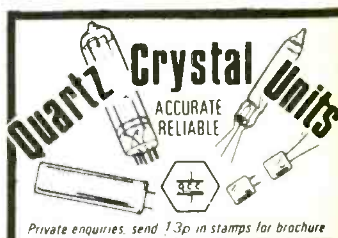

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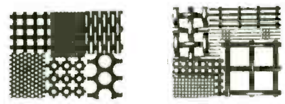

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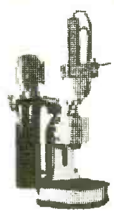

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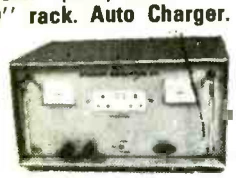

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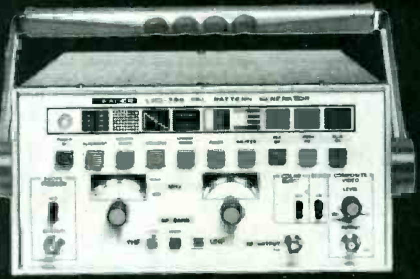

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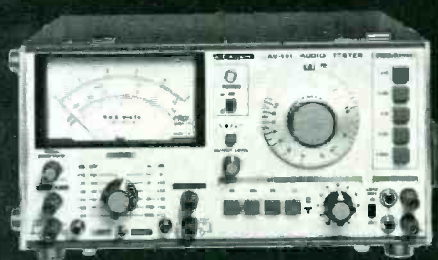

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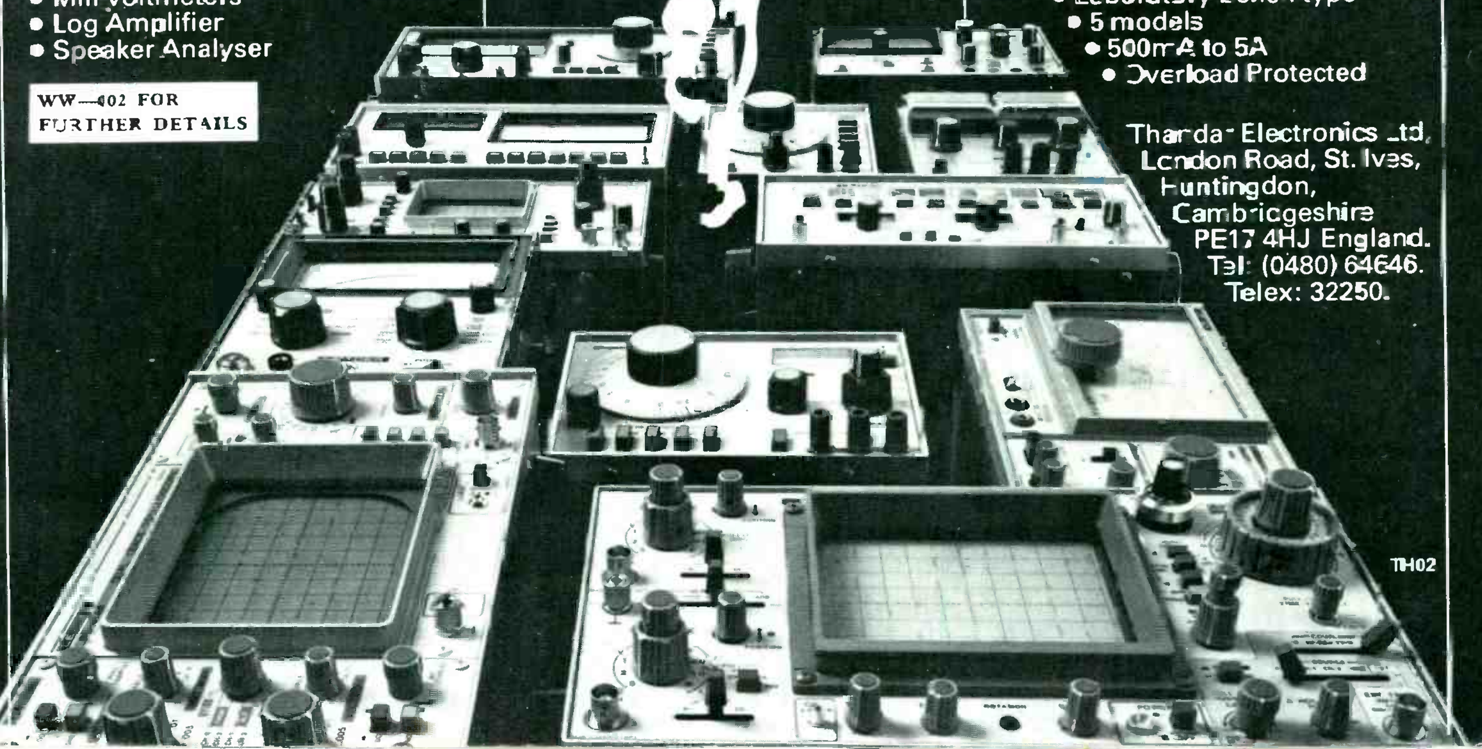

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