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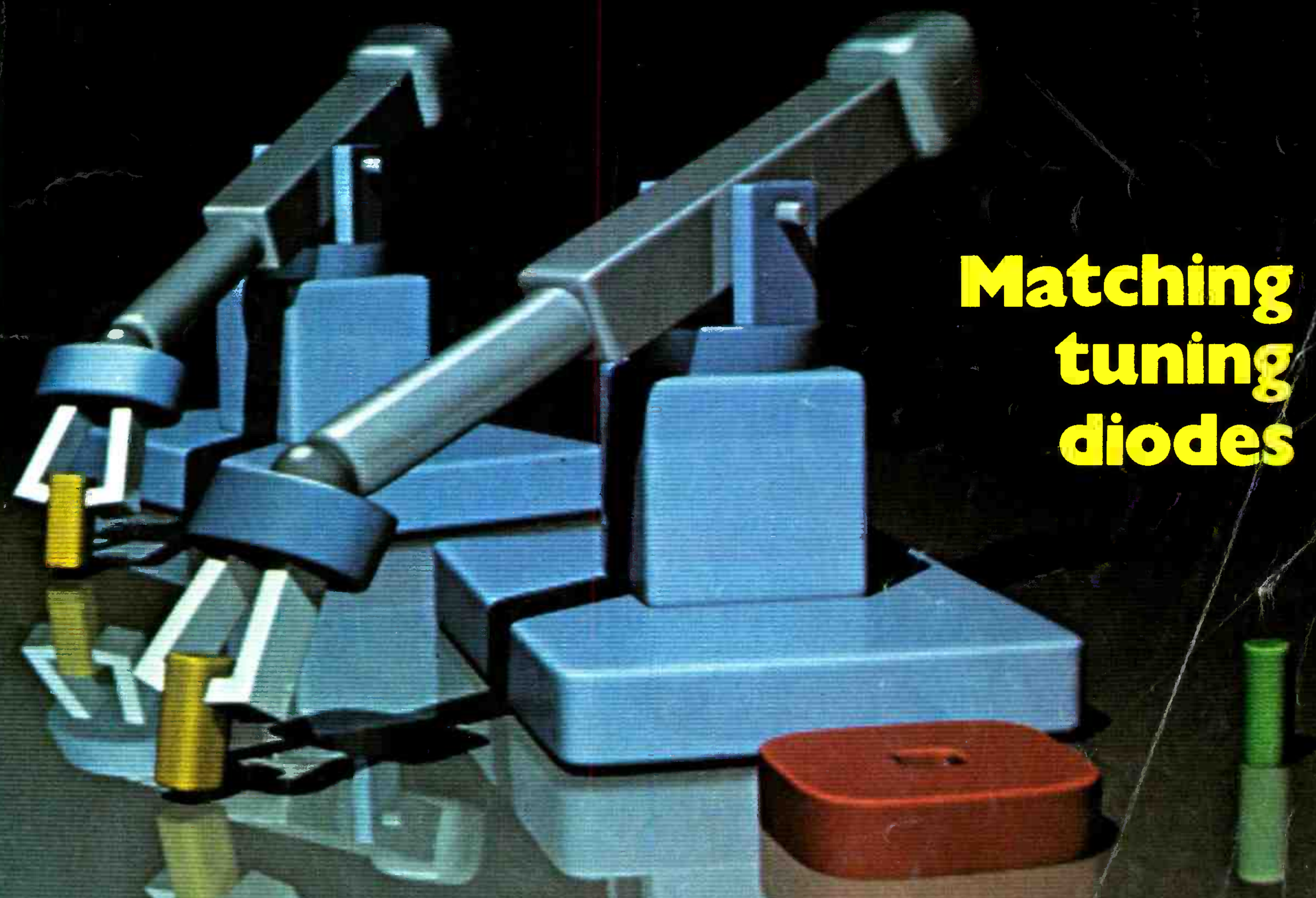

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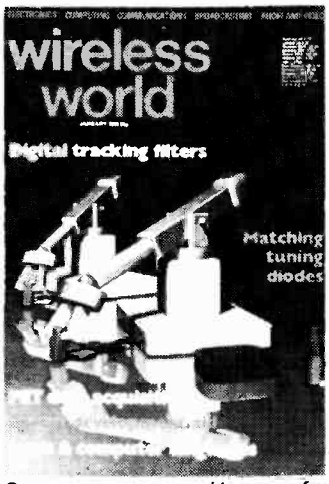

Computer-generated image of robot arms generated by Alan Barr of Raster Technologies Inc. of North Billerica (represented by Sintrom Electronics in the UK) using their model One/20 colour graphics controller.

NEXT MONTH

Scott Murray takes the lid off the wave theory of matter as it was developed by the Copenhagen School. Physics and metaphysics must be distinguished and kept separate. Schrodinger's "wave mechanics" has nothing to do with mystical "matter waves": that was the second great philosophical error of 1930's physics.

Bob Coates looks at microprocessor registers from a programming point of view in a tutorial article introducing assembly-language programming.

It has been postulated that power amplifiers with high open-loop output impedance and large feedback factor are more likely to produce intermodulation distortion at the loudspeaker interface. With the aid of computer simulations, this possibility is examined for contemporary amplifier circuits.

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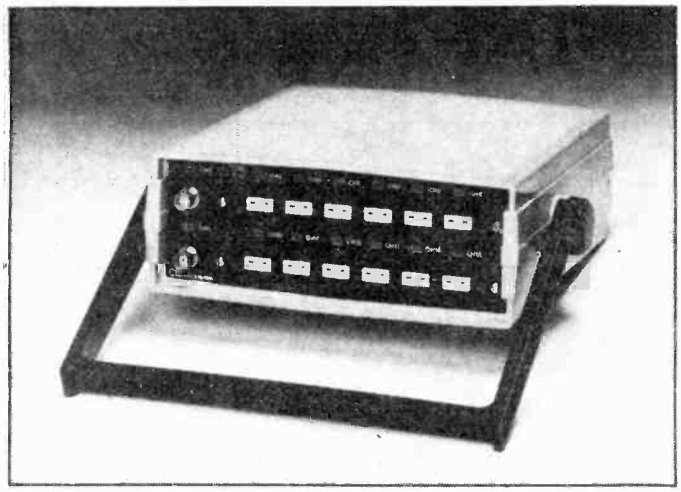
JANUARY 1983 VOL 89 NO 1564

PCI 1002 IEEE THERMOCOUPLE CONVERTER



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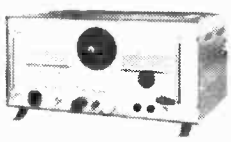

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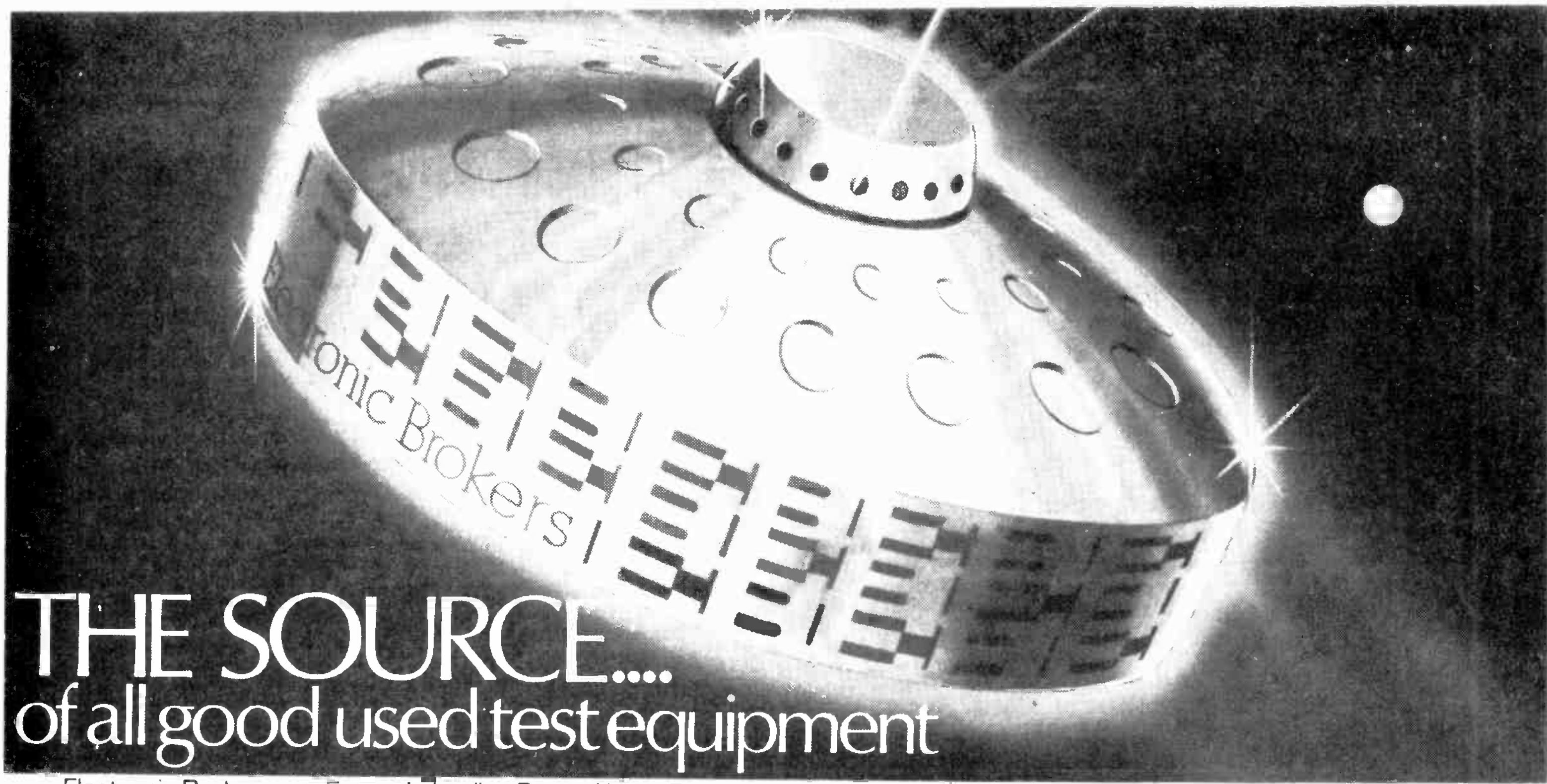

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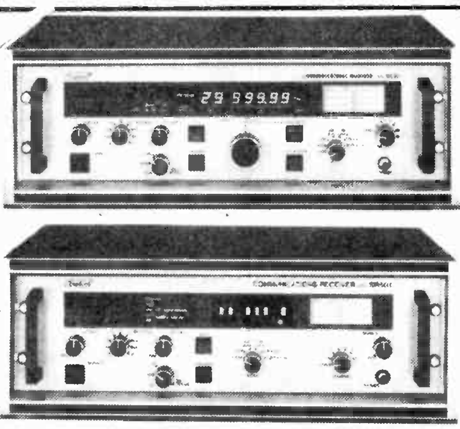

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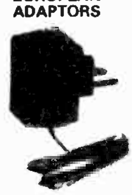

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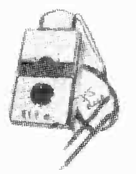

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Specification
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RX01 diskette storage subsystem.
PDP-8 control processor.
Diablo 1345 letter quality printer producing 540 words per minute with wheeled storage cabinet.
Bi-directional tractor feed fitted as standard.

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- Simple to use—prompts the operator automatically
- Letter quality printer with choice of print wheels
- Simultaneous editing and printing
- Powerful list processing package
- Flexible communications capability

System performance
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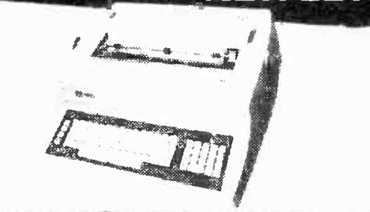

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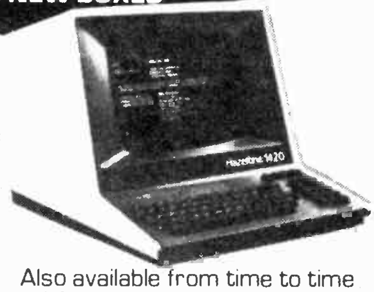

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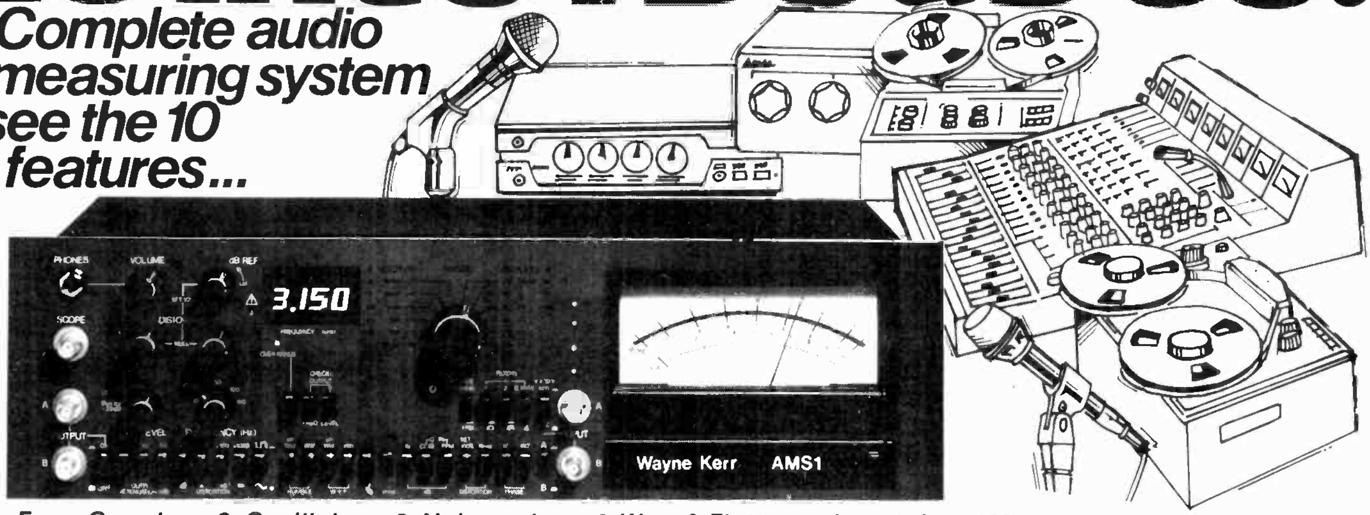

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E82CC	8.10
E83CC	8.40
E86C	8.25
E88C	8.25
E88CC	8.00
E90CC	8.61
E90F	9.90
E91H	6.25
E92CC	8.75
E99F	9.10

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
G55 1K	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	2.00
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
QQV02-6	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	1.75
UCC85	1.85
UCF80	2.00
UCH42	2.50
UCH81	2.50
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
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
6BL7GT	4.50
6BM6	115.00
6BN6	2.00
6BQ7A	3.50
6BR7	6.00
6BR8A	3.50
6BS7	6.00
6BW6	6.00
6BW7	1.50
6BX7GT	5.00
6BZ6	2.75
6C4	1.25
6CB6A	2.50
6CD6GA	5.00
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	170.00
12E14	35.00
13E1	20.00
19H4	27.50
19H5	47.50
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	6.00
90CG	14.54
90CV	15.45
92AG	12.96
92AV	12.96
95A1	8.45
150B2	6.50
150B3	8.35
150C2	3.25
150C4	4.05
211	35.00
723AB	125.00
803	25.00
805	45.00
807	3.75
811A	18.33
812A	18.33
813	125.86
833A	193.16
866A	20.03
872A	20.00
922	6.00
931A	18.52
1624	4.00
1625	3.50
2050	17.46
4212E	3.00
4212H	300.00
5544	81.97
5545	102.00
5551A	114.90
5552A	155.35
5642	9.00
5654	3.00
5651	4.45

5670	4.50
5675	28.00
5687	6.00
5696	4.50
5718	7.50
5725	5.50
5726	11.37
5727	7.05
5749	2.50
5751	4.00
5763	4.50
5814A	4.00
5840	4.00
5842	12.00
5876A	31.50
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
6067	10.23
6072	6.00
6080	14.00
6097A	235.00
6097B	200.00
6146A	8.25
6146B	8.25
6159B	19.00
6189	9.55
6201	11.40
6442	20.00
6883B	17.54
6973	4.00
7025	3.00
7551	6.25
7586	12.00
7587	18.50
7609	56.00
7868	6.00
7895	12.00
8005	110.49
8068	14.00
8122	90.00
8136	2.50
8417	6.00
18042	11.53
18045	10.49

Tested Ex-Equipment

4CX250B	6.50

BASES

B7G unskirted	0.22
B7G skirted	0.30
B9A unskirted	0.22
B9A skirted	0.30
Int Octal	0.35
Loctal	0.55
Nuvistor base	0.75
8 pin DIL	0.15
14 pin DIL	0.15
16 pin DIL	0.17
Valve screening cans all sizes	0.30

CRTs

2AP1	8.50
2BP1	9.00
3BP1	10.00
3DP1	5.00
3EG1	10.00
3FP7	6.00
3GP1	6.00
3JP1	8.00
3JP2	8.00
3JP7	10.00
3KP1	15.00
3RP1	35.00
3WP1	20.00

5ADP1	35.00
5BP1	10.00
5CP1	10.00
5CP1A	40.00
5FP15A	15.00
5UP7	25.00
DG7-5	63.32
DG7-31	58.07
DG7-32	58.07
DH3-91	56.83
DH7-11	113.12
VCR97	12.00
VCR138	12.00
VCR138A	12.50
VCR139A	8.00

VCR517A	10.00
VCR517B	10.00
VCR517C	10.00

Tube Bases Prices on application

INTEGRATED CIRCUITS

7400	0.16
7401	0.17
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	1.00
7484	1.05
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
74199	2.30
76013N	1.76
TAA570	2.30
TAA630S	3.50
TAA700	3.90

TBA480Q	1.84
TBA520Q	2.30
TBA530	1.98
TBA540Q	2.30
TBA550Q	3.22
TBA560CQ	3.22
TBA673	2.20
TBA700	1.52
TBA720Q	2.30
TBA750Q	2.07
TBA800	1.20
TBA920	2.90
TBA920Q	2.90
TBA990Q	2.90
TCA270Q	2.90
TCA760A	1.38

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6809	845p
68B09	1350p
6809E	1295p
6810	120p
6821	180p
68B21	215p
6840	390p
68B40	580p
6844	1295p
6845	795p
6850	140p
6852	250p
6854	680p
6875	490p
8T26A	120p
8T28	120p
8T95	90p
8T96	90p
8T97	90p
8T98	90p
8035L	340p
8039L	290p
8080A	380p
8085A	450p
8155	450p
8212	155p
8216	100p
8224	180p
8226	195p
8228	250p
8243	210p
8251	300p
8253	450p
8255	280p
8257	450p
8259	450p
8279	450p
75451	65p
75452	65p
75491	70p
75492	70p
AY-3-1015D	300p
AY-5-1013A	300p
MC1408	295p
MC1488	55p
MC1489	55p
MC3459	265p
Z80ACPU	350p
Z80APIO	300p
Z80ACTC	300p
Z80ADART	750p

MEMORIES

2114L	90p
2716	210p
2532	380p
2732	380p
4116	75p
4164	500p
6116	400p
6116L	450p

LINEAR ICs

AY-3-1270	725p
AY-3-1350	350p
AY-3-8910	435p
AY-3-8912	620p
AY-5-1230	450p
709	35p
741 8 pin	25p
741 14 pin	25p
741S	55p
747	65p
748	35p
CA3080E	70p
CA3130E	75p
LA4422	295p
LF355	80p
LF356	90p
LF357	100p
LM301A	26p
LM307	50p
LM308A	95p
LM311N	68p
LM324	35p
LM339	50p
LM348	75p
LM358	60p
LM380	95p
LM381	150p
LM393	90p
LM3909	85p
MC1310P	210p
MC1455	66p
MC1456	135p
MC1458	35p
MC3242A	630p
MC3302	95p
MC3340	120p
MC3401	65p
MC3403	70p
MC3456	107p
MC3480	580p
MC34001	58p
NE555	16p
555CMOS	90p
NE556	55p
NE565	155p
NE567	140p
TA7205A	125p
TBA480Q	175p
TBA540Q	130p
TBA800	90p
TBA920	190p
TCA650	390p
TCA910	180p
TDA1004	290p
TL061	40p
TL062	60p
TL064	98p
TL071	30p
TL072	50p
TL074	100p
TL081	25p
TL082	45p
TL084	95p
UPC575	149p
UPC1167	158p
UPC2002V	286p
UPD7002	450p

VOLTAGE REGULATORS

+Ve 100mA	
78L05	30p
78L08	30p
78L12	30p
78L15	30p
500mA	
78M05	40p
78M06	55p
78M08	55p
78M12	50p
78M15	50p
78M18	55p
78M24	55p
1A	
7805	45p
7806	65p
7808	65p
7812	45p
7815	45p
7818	65p
7824	65p
–Ve 100mA	
79L05	35p
79L12	35p
79L15	35p
1A	
7905	60p
7906	70p
7908	70p
7912	80p
7915	60p
7918	60p
7924	60p

TRANSISTORS

BC107	12p
BC107B	15p
BC108	12p
BC108B	15p
BC109	12p
BC109B	15p
BC109C	15p
BC147	9p
BC157	9p
BC158	9p
BC177	25p
BC178	25p
BC179	25p
BC182	10p
BC182A	10p
BC182B	10p
BC183A	10p
BC183C	10p
BC184	10p
BC184C	10p
BC212	10p
BC212A	10p
BC212B	10p
BC213A	10p
BC213C	10p
BC214	10p
BC214C	10p
BC237A	12p
BC237C	12p
BC238	12p
BC238A	12p
BC238B	12p
BC238C	12p
BC239	12p
BC307A	15p
BC307C	15p
BC308	15p
BC308A	15p
BC308B	15p
BC308C	15p
BC309	15p
BC309C	15p
BC327	15p
BC328	15p
BC337	15p
BC338	15p
BC477	28p
BCY70	18p
BCY71	20p
BCY72	20p
BD135	42p
BD136	45p
BD139	40p
BD140	40p
BD165	45p
BD166	45p
BD169	45p
BD170	45p
BD538	95p
BD677	60p
BD678	60p
BD679A	80p
BD680A	85p
BFY50	24p
BFY51	24p
BFY90	85p
BF244A	30p
BSX19	28p
BSX20	20p
MJ2955	95p
MJE241	80p
MJE251	80p
MJE340	50p
MJE350	90p
MJE370	95p
MJE520	90p
MJE2955	90p
MJE3055	85p
MPF102	45p
MRF475	290p
MPS2369	25p
MPS3640	30p
MPS3646	30p
MPSA06	20p
MPSA12	35p
MPSA13	20p
MPSA14	20p
MPSA18	20p
MPSA27	45p
MPSA42	25p
MPSA56	25p
MPSA63	30p
MPSA64	45p
MPSA77	50p
MPSA92	30p
TIP29	35p
TIP29A	35p
TIP29B	55p
TIP29C	40p
TIP30	50p
TIP30A	35p
TIP30B	50p
TIP30C	40p
TIP31A	40p
TIP31B	42p
TIP31C	45p
TIP32	50p
TIP32A	45p
TIP32B	60p
TIP32C	45p
TIP33	65p
TIP33A	65p
TIP33B	70p
TIP33C	75p
TIP34	75p
TIP34A	75p
TIP34B	99p
TIP34C	90p
TIP35	160p
TIP35A	165p
TIP35B	170p
TIP35C	185p
TIP36	170p
TIP36A	175p
TIP36B	185p
TIP36C	199p
TIP41	50p
TIP41A	50p
TIP41B	60p
TIP41C	50p
TIP42	58p
TIP42A	60p
TIP42B	75p
TIP42C	85p
TIP47	50p
TIP48	50p
TIP49	50p
TIP50	48p
TIP110	30p
TIP111	75p
TIP112	50p
TIP115	40p
TIP116	73p
TIP117	45p
TIP120	39p
TIP121	80p
TIP122	75p
TIP125	45p
TIP126	80p
TIP140	130p
TIP141	140p
TIP142	180p
TIP145	140p
TIP146	180p
TIP147	170p
TIP2955	70p
TIP3055	70p
TIS43	30p
TIS88A	48p
TIS151	50p
2N1613	25p
2N1711	25p
2N1893	35p
2N2218A	45p
2N2219	25p
2N2221	30p
2N2221A	30p
2N2222	25p
2N2222A	25p
2N2369A	20p
2N2904A	25p
2N2905	25p
2N2905A	25p
2N2906A	25p
2N2907A	25p
2N3053	30p
2N3054	70p
2N3055	45p
2N3439	80p
2N3440	60p
2N3771	160p
2N3772	160p
2N3773	250p
2N3819	25p
2N3821	120p
2N3822	120p
2N3823	95p
2N3824	95p
2N3866	90p
2N3903	15p
2N3904	15p
2N3905	15p
2N3906	15p
2N4123	25p
2N4125	25p
2N4391	70p
2N4392	70p
2N4400	20p
2N4401	25p
2N4402	25p
2N4403	25p
2N4410	45p
2N4416	95p
2N4856	80p
2N4857	80p
2N4918	95p
2N4919	120p
2N4920	130p
2N4921	105p
2N4922	95p
2N4923	95p
2N5190	75p
2N5191	75p
2N5192	75p
2N5193	90p
2N5194	90p
2N5195	90p
2N5400	40p
2N5401	40p
2N5415	85p
2N5416	90p
2N5457	35p
2N5458	35p
2N5459	35p
2N5460	35p
2N5551	40p
2SC495	80p
2SC1306	95p
2SC1678	105p
2SC2028	75p
2SC2078	105p
VN10KM	65p
40673	95p

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EC947 0.124" Lines
EC950/1 0.031" 90° Bends
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EC952/1 0.031" 30°, 45°, 60° Bends
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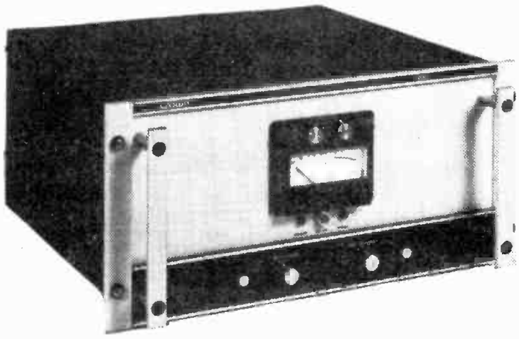

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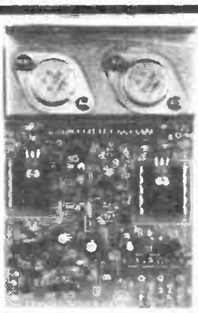

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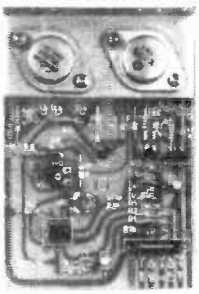
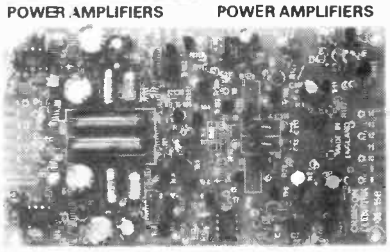


POWER AMPLIFIERS



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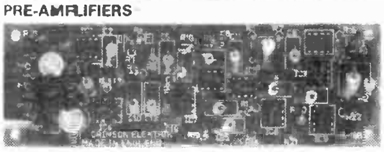
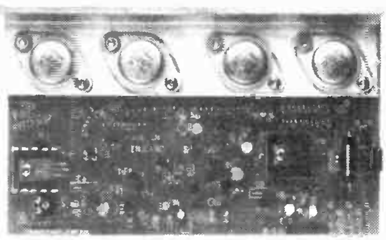


ACTIVE CROSSOVERS



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POLYESTER CAPACITORS: Axial Lead Type
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160V: 10nF, 12n, 39n, 100n 11p; 150n, 220n 17p; 330n, 470n 30p; 680n 38p; 1uF 42p; 1u5 45p; 2u2 48p; 4u7 58p.
1000V: 1nF 17p; 10nF 30p; 15n 40p; 22n 36p; 33n 42p; 47n, 100n 42p.

SIEMENS pcb Type Miniature poly. Capacitors
250V: 1nF, 1n5, 2n2, 3n3, 4n7, 6n8, 10n, 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 26p; 680n 30p; 1µF 34p; 2µ2 50p

POLYESTER RADIAL LEAD CAPACITORS: 250V 10n, 15n, 22n, 27n 6p; 33n, 47n, 68n, 100n 7p; 150n, 220n 10p; 330n, 470n 13p; 680n 19p; 1u 23p; 1u5 40p; 2u2 46p.

FEED-THROUGH CAPACITORS 1000pF/450V 8p

TANTALUM BEAD CAPACITORS 35V: 0.1uF, 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.

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SLIDER POTENTIOMETERS 0.25W log and linear values 60mm; 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

Telephone orders by Access. Just phone your order through, we do the rest

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, 800, 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+
1/4W	2Ω2–4M7	E24	2p	1p
1/2W	2Ω2–4M7	E12	2p	1p
1W	2Ω2–4M7	E12	5p	4p
2% Metal Film		E24	6p	4p
1% Metal Film		E24	8p	6p

100+ price applies to Resistors of each type not mixed.

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, CR033 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, 1N5408 19, 1S44 9, 1S921 9, 6A/100V 40, 6A/400V 50, 6A/800V 65

BRIDGE RECTIFIERS
1A/50V 18, 1A/100V 20, 1A/400V 25, 1A/600V 34, 2A/50V 30, 2A/200V 40, 2A/400V 46, 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 56, VM18 DIL 50

75 SERIES
75107/8 95, 75110 90, 75114/5 150, 75121/2 130, 75150 125, 75154 150, 75182/3 99, 75188/9 55, 75322 140, 75324 360, 75361/3 150, 75365 150, 75450 86, 75451/2 52, 75454 85, 75491/2 65

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

SCR THYRISTORS
5A/40V 32, 5A 400V 40, 5A 600V 48, 8A 300V 60, 8A 600V 90, 12A 100V 78, 12A 400V 95, 12A 800V 188, BT106 150, BT116 180, C106D 38, TIC44 24, TIC45 29, TIC47 35, 2N5062 32, 2N5064 38, 2N4444 130

TRIACS
3A 200V 54, 3A 400V 56, 8A 100V 60, 8A 400V 69, 8A 800V 115, 12A 100V 78, 12A 400V 82, 12A 800V 135, 16A 100V 103, 16A 400V 105, 16A 800V 220, 25V 500V 220, 25A 800V 295, T2800D 120

DIAC
ST2 25

NOISE Diode
Z5J 195p

VARICAPS
BA102 50, BB105B 40, BB106 40, BB109B 45, MVAM2 165

COMPUTER ICs
1702 350, 1802CP 650, 2114L-300n 90, 2114L-200n 95, 2147 425, 2532-450n 350, 2564 £12, 2708 225, 2716-5V 215, 2732-450n 350, 2764 725, 3242 590, 4816-100nS 225, 4027 190, 4116-150n 85, 4116-200n 80, 4118-250 325, 4164-200n 450, 4334-3-CMOS 125, 2114-3 325, 4816-100nS 225, 4864-3 64k 450, 5101-450 220, 6116-150nS 390, 6116L-120 550, 6117-100n 490, 6167-6 795, 6502CPU 325, 6503 800, 6504-250 550, 6505 600, 6520PIA 100, 6521 100, 6522VIA 300, 6530 £11, 6532RRIOT 570, 6545RTC 899, 6551ACIA 650, 6592PC £20, 6800 225, 6802 250, 6803 850, 6804 160, 6805 670, 6808 520, 6809 630, 6810 115, 6821 100, 6840 375, 6843 £12, 6845 685, 6846 685, 6847 650, 6850 110, 6852 250, 6854 599, 6875 500, 68000 £78, 74C922 420, 8080A 250, 8085A 350, 8088 £18, 8118-10 225, 8123 125, 8155 350, 8156 350, 81LS95 80, 81LS96 80, 81LS97 80, 81LS98 85, 8202 £25, 8205 225, 8212 110, 8214 425, 8215 300, 8216 100, 9224 110, 8226 250, 8228 220, 8243 270

8250 850, 8251A 250, 8253 400, 8255 255, 8256 £35, 8257 400, 8259 395, 8271 £36, 8279 385, 8284 350, 8288 £10, 8P8304BN 250, 8T26A 99, 8T27 150, 8T28A 120, 8T31 350, 8T95N 90, 8T97N 90, 9364AP 560, 9602 220, AM26LS31C 125, AM26LS32A 125, AY-3-1015 300, AY-5-1350 388, AY-5-2376 600, COM8017 275, COM8116 700, DM8131 275, iDS3691N 320, DS88LS120N 275, FD1771 £15, FD1791 £22, FD1793 £23, FD1795 £28, FD1797 £28, HD2650 75, IM6402 380, INS8060N 1050, INS8154N £9, MC1488 55, MC1489 55, MC14411 690, MC14412 790, MC3446 250, MC3447P 315, MK3886-2M £7, MM1702A 300, MM5280D 695, MM5303 635, MM5307 1275, MM5387A 475, MM58174 770, MM74C922 420, RO-3-2513 650, RO-3-2513L 650, RO-3-2513U 650, SFF96364E 800, SPO256AL2 £18, TMS2716-3V 725, TMS6011 365, TMS9928 £30, TMS9995 £12, ULN2003 90, UPD7002 440, Z80CPU 2.5 299, Z80ACPU 4 300, Z80CTC 250, X80ACTC 260, Z80B 875, Z80DART 495, Z80ADART 550, Z80DMA 675, Z80P10 260, Z80AP10 275, Z80S101 850, Z80AS10 960, Z80B £11

LINEAR ICs
555CMOS 80, 702 75, 709C 8 pin 35, 710 48, 741 8 pin 14, 747C 14 pin 65, 748C 8 pin 38, 753 8 pin 185, 810 159, 9400CJ 350, AY-1-1320 225, AY-1-5050 99, AY-1-5051 160, AY-1-6720 210, AY-3-1270 675, AY-3-1350 350, AY-3-8910 370, Booklet for AY-3-890 150, AY-3-8912 625, AY-5-1230 450, AY-5-1317A 630, AY-5-1350 388, CA3011 130, CA3012 175, CA3014 275, CA3018 86, CA3019 80, CA3020 210, CA3023 210, CA3028A 95, CA3035 255, CA3036 270, CA3043 275, CA3045 385, CA3046 70, CA3048 220, CA3059 285, CA3075 213, CA3080E 70, CA3081 190, CA3086 48, CA3089E 215, CA3090AQ 375, CA3123E 165, CA3130 90, CA3140 40, CA3160 95, CA3161 160, CA3162E 450, CA3189 200, HA1336W 240, HA1388 255, ICL7106 750, ICL7107 975, ICL7611 99, ICL7660 190, ICL8038CC 300, ICL8211A 150, ICM7205A 1150, ICM7207 475, ICM7215 1050, ICM7216AJ 1950, ICM7216B 1950, ICM7216C 1950, ICM7217A 790, ICM7224 785, ICM7240 300, ICM7555 80, ICM7556 150, LA3350 250, LA4031P 340, LA4032 295, LA4400 440, LC7120 300, LC7130 340, LC7137 395, LF347 150

LF351 48, LF353 96, LF355 85, LF356 95, LF357 110, LF398 475, LM10 325, LM301AO 24, LM307 5, LM308T 95, LM311 70, LM318N 150, LM319 215, LM324A 30, LM3342 90, LM335Z 128, LM339 47, LM348 84, LM349 115, LM358 60, LM377 175, LM379 480, LM380 75, LM381N 145, LM382 115, LM384 140, LM386 90, LM387 120, LM389 95, LM393 100, LM725CN 325, LM733 70, LM1458 45, LM1871 325, LM2917 195, LM301 24, LM307 45, LM558 75, LM3302 75, LM3900 50, LM3909N 80, LM3911 125, LM3914 200, LM3915 200, LM3916 250, LM13600 110, LS7220 280, M253AA 1150, M51513L 230, M51515L 320, M51516L 475, MB3712 220, MB3756 440, MC1204 250, MC1301 79, MC1303 88, MC1304P 260, MC1310P 150, MC1445 250, MC145106 695, MC1469 300, MC1494 694, MC1495 350, MC1496L 70, MC1596 225, MC1648 290, MC1709G 90, MC3302 90, MC3340P 120, MC3360P 120, MC3401 65, MC3403 75, MC3405 150, MC3423 180, MC4016 00, MF10 350, MFC6040 75, MK50398 635, ML924 275, MSM5526 820, NE515 275, NE529 225, NE531 140, NE534 150, NE543K 225

NE544 210, NE555 16, NE556 45, NE560 325, NE561 398, NE562B 410, NE564 420, NE565A 120, NE566 155, NE567V 140, NE570 410, NE571 400, NE5532 145, NE5534A 150, OM335 750, RC4136D 69, RC4558 45, S566B 225, SAB3209 425, SAB3210 325, SAB3271 485, SAB4209 595, SG3402 295, SL490 350, SN76003N 350, SN76013 350, SN76018 148, SN76023N 350, SN76033N 350, SN76227N 95, SN76477 420, SN76488 480, SN76660 120, SP8629 299, TA7204 200, TA7205 90, TA7205A 225, TA7210 150, TA7222 150, TA7310 160, TAA661A 190, TAA700 275, TAA900 395, TAD100 159, TBA120S 70, TBA540Q 275, TBA550Q 330, TBA641BX or BX11 290, TBA651 190, TBA800 80, TBA810 96, TBA820 80, TBA920Q 200, TBA950 300, TBA990Q 350, TBA540 275, TCA220 350, TCA270Q 350, TCA280A 220, TCA940 175, TCA965 120, TDA1004 290, TDA1008 310, TDA1010 198, TDA1022 499, TDA1024 115, TDA1034 350, TDA1490 325, TDA2002 325, TDA2004 495, TDA2020 320, TDA2030 295, TDB0701 420, TL170 50, TLO61CP 40, TLO62CP 60, TLO64CN 98, TLO71CP 24, TLO72CP 45, TLO74CN 100, TLO81CP 24, TLO82CP 45, TLO83CP 75, TLO84CN 90

TLO91CP 55, UA2240 120, UA78540 230, UAA170 170, UAA180 170, UAA1003/3935, ULN2003 75, ULN2004 75, ULN2283 100, UPC575 275, UPC1025H 375, UPC1182 330, UPC1156H 275, UPC1366 195, XR2206 300, XR2207 375, XR2211 575, XR2216 675, XR2266 380, ZN414 80, ZN419E 190, ZN423E 135, ZN424E 130, ZN425E 345, ZN426E 300, ZN427E 600, ZN428E 410, ZN429E 210, ZN459 570, ZN1034E 200, ZN1040E 675, ZNA234E 850

TTL 74
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74196 46, 74197 40, 74198 80, 74199 84, 74221 54, 74246 120, 74247 120, 74248 120, 74249 120, 74251 65, 74259 150, 74265 55, 74273 150, 74276 120, 74278 100, 74279 50, 74283 50, 74284 155, 74285 155, 74290 105, 74293 80, 74297 236, 74298 100, 74351 195, 74365 30, 74366 30, 74367 30, 74368 30, 74390 75, 74393 90, 74490 95

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74LS
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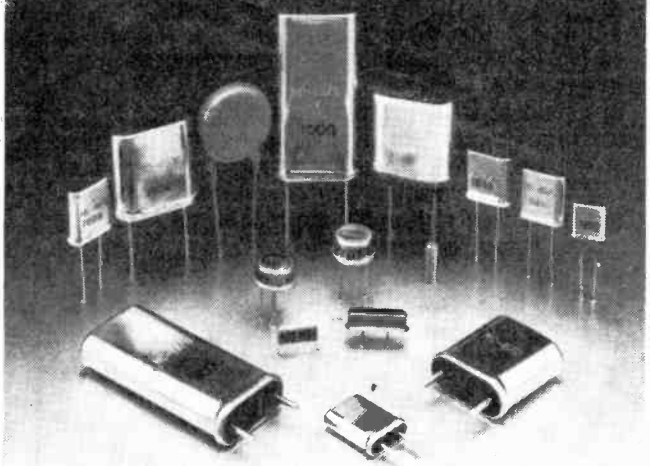
ZTX326 30, ZTX341 30, ZTX451 23, ZTX500 14, ZTX501/2 15, ZTX503 18, ZTX504 25, ZTX531 25, ZTX550 25, 2N697 23, 2N698 40, 2N699 48, 2N706A 19, 2N708 19, 2N918 35, 2N1131/2 24, 2N1302 46, 2N1303 65, 2N1304/5 60, 2N1306/7 65, 2N1308 68, 2N1613 30, 2N1670 150, 2N1671B 160, 2N2160 295, 2N2217 45, 2N2218A 25, 2N2219A 28, 2N2220A 26, 2N2221A 26, 2N2222A 25, 2N2297 25, 2N2303 46, 2N2368 25, 2N2369A 18, 2N2476 50, 2N2483/4 27, 2N2646 45, 2N2846 80, 2N2904/5 28, 2N2906/7 26, 2N2907A 26, 2N2926G 10, 2N3011 28, 2N3053 26, 2N3054 58, 2N3055 48, 2N3108 45, 2N3252 46, 2N3302 30, 2N3441/2 140, 2N3614/5 199, 2N3663 15, 2N3702/3 10, 2N3704/5 10, 2N3706/7 10, 2N3708/9 10, 2N3710/11 10, 2N3713 140, 2N3771 179, 2N3772 195, 2N3773 210, 2N3819 22, 2N3820 38

2N3822/3 45, 2N3824 65, 2N3866 90, 2N3870 150, 2N3903/4 15, 2N3905/6 15, 2N3906 17, 2N4037 46, 2N4041 40, 2N4058 10, 2N4061/2 10, 2N4064 115, 2N4069 45, 2N4220 78, 2N4234/6 48, 2N4264 24, 2N4286 15, 2N4289 18, 2N4314 78, 2N4400 18, 2N4427 80, 2N4859 78, 2N4871 55, 2N4898 135, 2N4901 175, 2N4921 55, 2N4922 70, 2N5135/6 20, 2N5138 18, 2N5172 18, 2N5179 46, 2N5180 45, 2N5190/1 75, 2N5194 80, 2N5305/8 30, 2N5457/8 30, 2N5459 30, 2N5485 36, 2N5777 45, 2N5879 190, 2N6027 32, 2SA671 250, 2SA715 60, 2SC495 70, 2SC496 70, 2SC1061 250, 2SC1096 85, 2SC1162 30, 2SC1173 125, 2SC1306 100, 2SC1307 150, 2SC1449 85, 2SC1678 140, 2SC1679 190, 2SC1923 50, 2SC1945 226, 2SC1953 90, 2SC1957 90, 2SC1969 140, 2SC2028 85, 2SC2029 210, 2SC2078 170, 2SC2091 85, 2SC2314 85

2SC2166 165, 2SC2335 225, 2SC2547 30, 2SC2612 225, 2SD234 74, 2SK45 90, 2SK288 225, 2SJ83 225, 2SJ85 225, 3N128 112, 3N140 112, 40097 120, 40250 95, 40311 60, 40313 130, 40315 90, 40316 95, 40317/20 80, 40323 60, 40324 100, 40326/7 70, 40347 90, 40348 120, 40360 60, 40361/2 70, 40407/8 75, 40411 285, 40412 90, 40467A 130, 40468 85, 40594 105, 40603 110, 40673 75, 40871/2 90

RF CHOKES Miniature PCB type
1uH, 2u2, 4u7, 10u, 22u, 33u, 47u, 100u, 220u, 330u, 470u 30p
1mH, 1m5, 2m2, 4m7, 10mH 35p
22m, 33m, 43m 60p
100m 75p

Quartz Crystals



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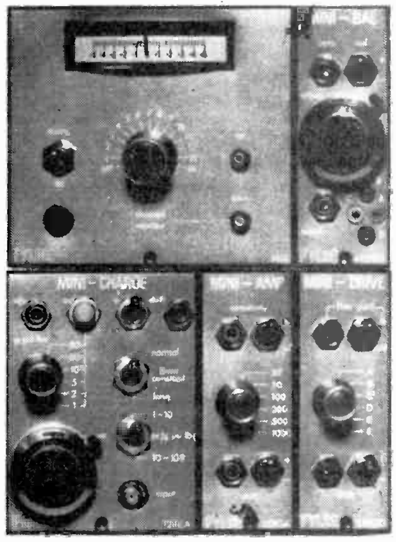

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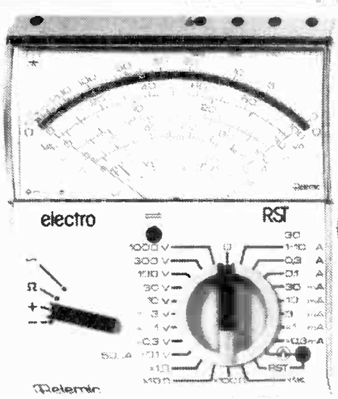

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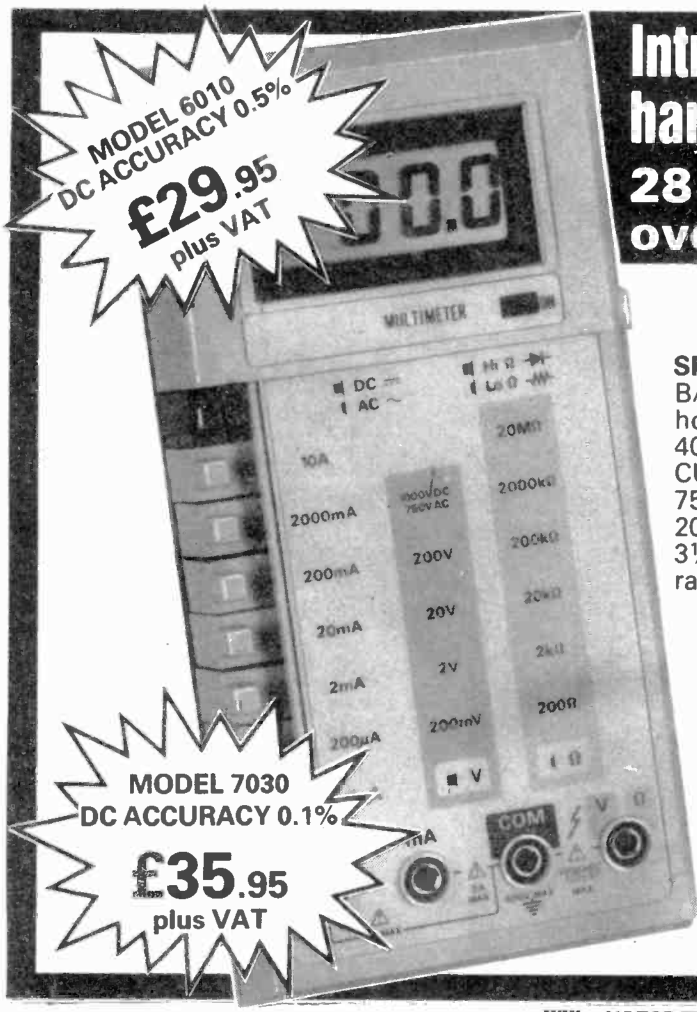

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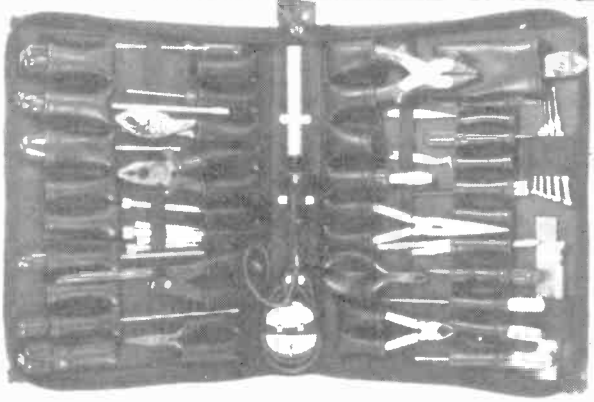

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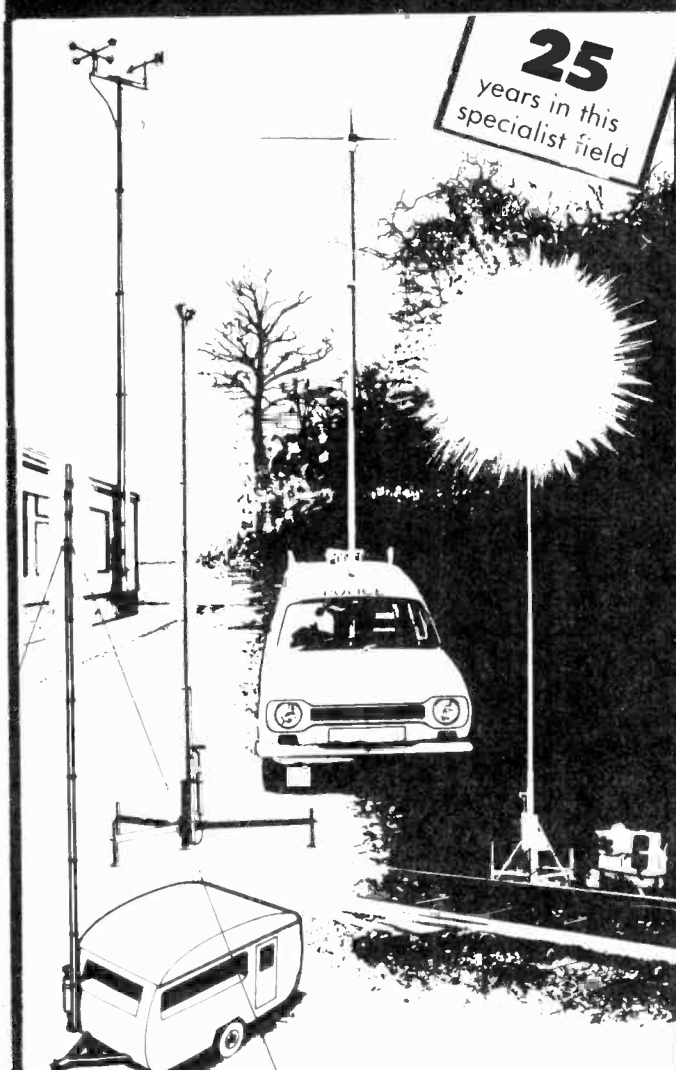

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6843	13.99
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68B50	2.86
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6502	3.45
6520	2.99
6522	2.96
6532	5.95
8080 FAMILY	
8085A	4.40
8212	1.55
8216	0.60
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BUFFERS	
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8T97A	1.35
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ZN588 2.45V	1.08
ZN Ref 025 2.49V	1.60
ZN Ref 040 4.10V	1.60

Device	Price
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ZN Ref 100 1.96V	2.56
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ZN450 KIT	17.35
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LM308N	0.89
LM311N	0.69
LM319N	2.14
LM324N	0.30
LM348N	0.59
LM555N	0.16
LM556CN	0.45
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LM474CN	0.64
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78L15	0.29
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6MHZ	1.45
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4002	0.12
4006	0.65
4007	0.15
4008	0.60
4009	0.34
4010	0.39
4011	0.11
4012	0.15
4013	0.24
4014	0.49
4015	0.49
4016	0.19
4017	0.37
4018	0.67
4019	0.41
4020	0.49
4021	0.69
4022	0.65
4023	0.15
4024	0.31
4025	0.16
4026	1.29
4027	0.23
4028	0.49
4031	1.69
4033	1.64
4034	1.90
4035	0.94
4040	0.49
4041	0.77
4042	0.44
4043	0.69
4044	0.64
4045	1.69
4046	0.64
4047	0.49
4048	0.54
4049	0.24
4050	0.24
4051	0.44
4052	0.59
4053	0.77
4054	0.84
4055	0.84
4060	0.59
4063	0.98
4066	0.29
4068	0.21
4069	0.15
4070	0.14
4071	0.14
4072	0.19
4073	0.14
4075	0.14
4076	0.45
4077	0.25
4078	0.25
4081	0.15
4082	0.20
4085	0.64
4086	0.51
4093	0.25
4502	0.89
4507	0.38
4508	1.29
4510	0.45
4511	0.44

Device	Price
4512	0.49
4514	1.14
4515	1.14
4516	0.54
4518	0.39
4519	0.28
4520	0.49
4521	1.09
4522	1.24
4526	0.69
4527	0.64
4528	0.69
4532	0.69
4541	0.99
4543	0.79
4553	2.44
4555	0.50
4556	0.50
4585	0.78
NB. Other devices available	
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00	0.10
01	0.11
02	0.11
03	0.11
04	0.11
05	0.11
08	0.11
09	0.11
10	0.11
11	0.13
12	0.11
13	0.15
14	0.29
15	0.12
20	0.12
21	0.12
22	0.13
26	0.12
27	0.12
28	0.12
30	0.12
32	0.12
33	0.14
37	0.12
38	0.12
40	0.12
42	0.27
47	0.34
48	0.45
49	0.60
51	0.14
54	0.14
55	0.15
73	0.18
74	0.18
75	0.19
76	0.17
78	0.24
83	0.34
85	0.47
86	0.15
90	0.28
91	0.80
92	0.31
93	0.25
95	0.40
109	0.27
112	0.20
113	0.20
114	0.22
122	0.35
123	0.35
125	0.24
126	0.25
132	0.39
136	0.23
138	0.27
139	0.29
145	0.70
148	0.69
151	0.39
153	0.28
155	0.34
156	0.34
157	0.25
158	0.29
160	0.35
162	0.35
163	0.34
164	0.39
165	0.54
166	0.63
173	0.64
174	0.40
175	0.44
181	0.90
190	0.36
191	0.44
192	0.44
193	0.44
194	0.34
195	0.34
196	0.45
197	0.45
221	0.54
240	0.55
241	0.65
242	0.64
243	0.64
244	0.59
245	0.89
247	0.40
248	0.40
249	0.68

Device	Price
251	0.29
253	0.30
257	0.34
258	0.35
259	0.57
261	1.95
266	0.19
273	0.59
279	0.59
283	0.39
290	0.57
293	0.40
365	0.29
366	0.29
367	0.29
368	0.39
373	0.59
374	0.64
377	0.69
378	0.45
379	0.65
386	0.34
390	0.49
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629	1.21

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DET22	28.00
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DF92	0.60
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DH77	0.90
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DK96	2.50
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E1148	1.00
EA50	1.00
EA76	1.95
EA79	1.95
EAA91	0.80
EABC80	0.68
EAC91	2.50
EAF42	1.20
EAF801	1.40
EB34	1.50
EB41	3.00
EB91	0.52
EBC33	2.50
EBC41	1.95
EBC81	0.85
EBC90	0.75
EBC91	0.75
EBF83	2.50
EBF80	0.50
EBF83	0.50
EBF85	0.95
EBF89	0.70
EBF93	0.95
EBL1	1.50
EBL21	2.00
EBL31	3.95
EC52	0.75
EC80	4.25
EC81	4.50
EC86	1.00
EC88	1.00
EC90	0.70
EC91	7.00
EC92	1.25
EC93	0.80
EC95	7.00
EC97	1.10
EC8010	6.00
ECC32	3.00
ECC33	3.50
ECC35	3.50
ECC40	3.00
ECC81	0.65
ECC81 Mullard	1.10
ECC82	0.55
ECC82 Philips	1.10
ECC83	0.65
ECC83 Mullard	1.35
ECC83 Philips	1.10
ECC84	0.50
ECC85	0.60
ECC86	1.45
ECC88	0.75
ECC91	2.00
ECC180	0.72
ECC189	0.78
ECC801S	3.50
ECC803S	3.50
ECC804	0.60
ECC807	1.95
ECC808	2.95
ECC2000	12.00
ECF80	0.72
ECF82	0.60
ECF86	1.70
ECF200	1.85
ECF202	1.85
ECF801	0.85
ECF804	8.00
ECF805	2.50
ECF806	10.25
ECH3	2.50
ECH4	3.00
ECH35	1.60
ECH42	1.00
ECH81	0.58
ECH83	0.78
ECH84	0.69
ECH2000	1.50
ECL80	0.60
ECL82	0.65
ECL83	1.35
ECL84	0.74
ECL85	0.69
ECL86	0.74
ECL805	0.69
ED5100	3.50
EF22	2.50
EF37A	2.00
EF39	1.00
EF41	3.50
EF42	3.50
EF50	1.50
EF55	2.25
EF71	1.50
EF72	1.20
EF73	1.00
EF80	0.55
EF83	3.50
EF85	0.50
EF86	0.95
EF86 Mullard	1.50
EF89	0.86
EF91	1.25
EF92	2.50
EF93	0.85

EF94	0.55
EF95	1.00
EF97	0.90
EF98	0.90
EF183	0.65
EF184	0.65
EF731	1.80
EF732	1.80
EF800	11.00
EF804S	9.85
EF805S	9.85
EF806S	9.85
EF812	0.65
EFL200	1.50
EH90	0.72
EK90	0.72
EL32	0.95
EL33	4.00
EL34	1.95
EL34 Mullard	2.95
EL36	1.50
EL37	9.00
EL38	6.00
EL41	2.25
EL42	2.00
EL81	3.95
EL82	0.58
EL84	0.69
EL85	4.50
EL86	0.85
EL90	0.82
EL91	6.00
EL95	0.70
EL183E	3.50
EL183P	3.50
EL360	7.95
EL500	1.40
EL504	1.40
EL508	1.90
EL509	3.75
EL519	4.50
EL802	3.65
EL821	10.35
EL822	10.35
EM1	4.00
EM4	9.00
EM34	7.50
EM35	1.50
EM80	0.70
EM81	0.70
EM84	1.10
EM85	1.10
EM87	1.10
EMM803	2.50
EN10	8.00
EN32	11.95
EN91	1.10
EN91(SQ)	2.50
EN92	4.50
ES1500	115.00
ET1	11.00
EY51	0.80
EY81	0.60
EY83	1.50
EY84	6.95
EY84W	10.00
EY86/87	0.50
EY88	0.55
EY91	5.50
EY500A	1.50
EY802	0.70
EZ35	0.75
EZ40	1.25
EZ41	1.25
EZ80	0.60
EZ81	0.60
EZ90	0.96
FW4/500	2.00
FW4/800	2.00
G1/371K	30.00
G55/1K	9.00
G180/2M	9.00
G240/2D	9.00
G400/1K	14.00
GC10B	17.50
GC10D	17.50
GC10/4B	17.50
GC10/4E	17.50
GC12/4B	17.50
GD86W	6.00
GDT120M	5.00
GE10	9.00
GN4	6.00
GN10	15.00
GR10G	4.00
GR10J	4.00
GS10C	12.00
GS10H	12.00
GS12D	12.00
GT1C	17.00
GT1C S/S	13.00
GTE175M	8.00
GTR150W	1.00
GU20	70.00
GU50	15.00
GXU1	13.50
GXU3	24.00
GXU50	15.00
GY501	1.20
GY802	1.00

GZ30	1.00
GZ31	1.00
GZ32	1.00
GZ33	4.50
GZ34	2.15
GZ37	4.50
HAA91	1.00
HABC80	0.90
HBC90	0.75
HBC91	0.80
HF93	0.75
HF94	0.60
HK90	1.05
HL2K	3.50
HL23DD	4.00
HL41	3.50
HL41DD	3.50
HL42DD	3.50
HL90	0.70
HL92	1.50
HL133/DD	3.50
HR2	4.00
HY90	1.00
HVR2	3.00
KT8C	7.00
KT33C	3.50
KT36	2.00
KT41	4.00
KT44	4.00
KT45	4.00
KT61	3.50
KT63	2.00
KT66 USA	6.00
KT66 GEC	9.95
KT67	15.00
KT77 Gold Lion	9.50
KT81	7.00
KT88 USA	7.00
KT88 Gold Lion	12.50
KTW61	2.00
KTW62	2.00
KTW63	1.50
KTZ63	2.50
L63	1.00
L102/2K	6.95
L120/2K	12.00
LCF801	1.35
LCF200	1.35
LCH200	1.35
LF184	1.00
LFL200	1.35
LY500A	1.75
M502A	135.00
M537A	160.00
M5143	155.00
M8079	6.00
M8082	7.50
M8083	3.25
M8091	7.50
M8096	3.50
M8098	3.20
M8099	4.00
M8100	2.85
M8136	7.00
M8137	5.50
M8161	5.50
M8162	5.50
M8163	3.85
M8190	3.85
M8195	3.00
M8196	3.25
M8204	2.00
M8223	2.00
M8224	2.00
M8225	2.00
ME1400	4.00
ME1401	29.50
ME1403	29.50
ME1501	14.00
MS4B	5.50
MU14	1.50
N37	13.50
N78	14.95
OA2	0.60
OA2WA	1.50
OA3	2.50
OB2	0.80
OB2WA	1.25
OC2	2.50
OC3	1.50
OD3	1.70
OM4	1.00
OM5B	3.00
OM6	1.75
OM9	4.00
ORP43	2.50
ORP50	3.95
P61	2.50
P41	2.50
PABC80	0.50
PC86	0.75
PC88	0.75
PC92	1.20
PC97	1.10
PC800	1.10
PC900	0.75
PCC84	0.40
PCC85	0.54
PCC88	0.70
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
PCF805	1.48
PCF806	1.00
PCF808	1.25
PCH200	1.10
PCL82	0.80
PCL83	2.50
PCL84	0.75
PCL85	0.80
PCL86	0.65
PCL200	1.60
PCL800	0.80
PCL805	0.80
PD500	3.50
PD510	3.65
PEN4DD	2.00
PEN25	2.00
PEN40DD	2.50
PEN45	3.00
PEN45DD	3.00
PEN46	2.00
PFL200	1.25
PL21	2.50
PL33	1.25
PL36	0.95
PL38	1.50
PL81	0.72
PL81A	0.72
PL82	0.60
PL83	0.52
PL84	0.80
PL88	1.00
PL95	1.20
PL302	1.00
PL345	12.50
PL500	0.95
PL504	0.95
PL508	1.95
PL509	4.85
PL519	4.95
PL802	4.50
PL820	2.95
PY32	0.60
PY33	0.50
PY81	0.70
PY82	0.70
PY83	0.70
PY88	0.52
PY500A	1.79
PY800	0.69
PY801	0.69
Q13-110BA	47.50
QB3-300	30.50
QEO3-10	3.50
QEO8-200	130.00
QP25	1.00
QQEO2-5	12.75
QQEO3-12	6.50
QQEO3-20	27.00
QQEO6-40	39.50
QQVO2-6	12.75
QQVO3-10	5.50
QQVO3-20	18.50
QQVO3-20A	17.00
QQVO3-20B	32.00
QQVO6-40A	18.00
QQZO3-20	42.50
QQZO6-40A	45.25
QS72/20	1.50
QS75/40	3.00
QS92/10	5.00
QS95/10	4.85
QS108/45	4.00
QS150/15	5.00
QS150/30	1.15
QS150/45	7.00
QS1200	3.95
QS1202	3.95
QS1203	4.15
QS1205	3.95
QS1206	1.05
QS1207	0.90
QS1208	0.90
QS1209	2.00
QS1210	1.50
QS1211	1.50
QS1212	3.20
QS1213	5.00
QS1215	2.10
QS1218	5.00
QU37	11.50
QVO3-12	3.50
QVO5-25	1.75
QVO6-20	29.50
QVO8-100	118.50
QY3-125	54.95

QY4-250	65.00
QY4-400	71.95
QY5-500	115.00
QZ06-20	32.50
R10	4.00
R16	12.00
R17	1.50
R18	2.50
R19	6.95
R20	1.20
RG1-125	4.95
RG1-240A	14.50
RG3-250A	25.00
RG3-1250A	52.50
RK2K25	62.50
RG4-1000	10.00
RK-20A	12.00
RL16	1.50
RPL16	12.00
RPY13	2.50
RPY43	2.50
RPY82	2.50
RR3-250	37.00
RR3-1250	65.00
RS613	45.00
RS685	54.95
RS688	52.15
S6F17	5.95
S6F33	28.95
S11E12	38.00
S30/2K	12.00
S104/1K	10.00
S109/1K	15.00
S130	5.95
S130P	5.95
SC1/800	5.00
SC1/1200	5.00
SC1/1400	12.00
SC1/2000	9.00
SP2	1.50
SP41	5.00
SP42	3.00
ST11	1.50
STV280/40	11.95
STV280/80	19.95
SU42	4.95
TB2.5/3000	60.00
TB2-300	45.00
TD1-100A	19.00
TDO3-10F	28.00
TD3-12	4.00
TP25	1.50
TSP4	7.00
TT11	1.50
TT15	34.95
TT21	19.50
TT22	19.50
TY2-125A	45.00
TY4-400	65.00
TY6-800	185.00
TY7-6000A	365.00
TY8-600W	365.00
TYS2/250	375.00
U18-20	2.75
U19	11.95
U22	1.00
U24	2.00
U25	0.90
U26	0.90
U37	9.00
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	1.75
UBC81	1.50
UBF89	0.60
UBL21	1.75
UC92	1.20
UCC84	0.70
UCC85	0.60
UCF80	1.00
UCH21	1.20
UCH41	1.20
UCH42	1.35
UCH81	0.65
UCL82	0.80
UF41	1.15
UF42	1.15
UF80	0.80
UF89	1.50
UL41	3.50

UL84	0.85
UU5	2.50
UU7	8.00
UY41	3.50
UY85	0.70
V339	3.50
VLS631	10.95
VP2B	2.50
VP4A	4.50
VP4B	4.50
VP6	2.50
VP41	2.50
VP133	2.00
VR37	1.50
VR75/30	3.00
VR91	1.50
VR101	2.00
VR105/30	1.50
VR150/30	1.05
VT52	2.50
VU39	1.50
VX6120	5.00
VX9133	5.00
VX9181	5.00
W77	5.00
W729	1.00
W739	1.50
X24	1.00
X79	3.50
XC12	1.50
XC15	1.50
XC25	0.50
XC900	1.35
XE3P	2.50
XFW47	1.50
XFW50	1.50
XG5-500	22.50
XL1-5V	1.50
XL509	4.95
XNP12	2.50
XNP28	2.50
XP1002	29.00
XR1-1600A	49.50
XR1-3200A	79.50
XR1-6400A	99.50
XSG2-0	3.00
Y63	1.50
Y602	12.00
YJ1060	265.00
YL1020	29.00
YL1060	15.00
YL1070	115.00
YL1071	109.00
YL1370	5.50
YL1371	8.50
Z77	1.20
Z300T	5.00
Z302C	12.00
Z303C	9.00
Z505S	15.00
Z520M	4.00
Z521M	8.00
Z700U	3.00
Z749	0.60
Z759	19.85
Z800U	3.00
Z801U	3.00
Z803U	18.95
ZA1000	9.00
ZA1001	1.50
ZA1002	1.50
ZC1040	8.00
ZM1000	7.50
ZM1001	5.00
ZM1005	8.00
ZM1020	8.00
ZM1021	8.00
ZM1023	7.95
ZM1041	14.00
ZM1050	14.00
ZM1080	12.50
ZM1082	9.00
ZM1084	10.00
ZM1177	9.00
ZM1202	55.00
ZM1263	4.00
ZM1612	3.00
2T1011	29.00
1AC6	1.20
1B3GT	1.95
1B5	2.50
1B22	10.00
1B24	14.95
1C1	1.20
1C5GT	1.00
1D5	1.00
1FD1	0.90
1G3GT	1.00
1L4	0.60
1L6	1.50
1LA6	1.00
1N5GT	2.50
1S2	0.55
1T4	0.45
1U5	1.00
1X2B	1.15
2AS15A	10.00
2C21	1.00
2C39A	18.95
2C39WA	29.50
2C40	37.00
2C40A	55.00
2C42	29.50

2C43	29.50
2C51	0.75
2C53	32.00
2B7	1.50
2D21	0.95
2D21W	2.50
2E26	7.95
2J42	93.00
2K25	17.50
3A/147J	7.50
3A/167M	10.00
3A2	3.95
3A3A	3.95
3A4	1.10
3AL5	0.95
3AT2	1.95
3AW2	3.35
3B2	3.00
3B7	4.50
3B24	7.50
3B28	12.00
3C4	1.00
3C45	17.50
3CN3A	2.50
3CX3	2.50
3D21A	29.50
3D22	19.50
3J187E	398.00
3J187G	398.00
3W4GT	2.50
4B551B	115.00
4-250A	65.00
4C27	25.00
4C28	25.00
4CX250B	37.50
4CX250R	48.50
4CX350A	63.75
4GS7	2.25
4GV7	2.25
4X150A	18.95
5A152M	9.00
5A163K	10.00
5A170K	6.25
5AN8	1.20
5AR4	2.00
5AU4	1.50
5B.110M	10.00
5B-254M	14.50
5B-255M	14.50
5B-257M	9.00
5B-258M	14.50
5C22	40.00
5R4GB	2.80
5R4GY	2.80
5U4G	0.75
5U4GB	2.50
5V4G	0.75
5Y3GT	0.80
5Z4GT	0.85
6/30L2	0.70
6A/203K	9.00
6A8G	1.50
6AB7	0.60
6AB8	0.66
6AC7	2.00
6AF4A	2.50
6AG5	1.50
6AG7	1.95
6AH6	1.50
6AJ4	2.00
6AJ7	2.00
6AK5	1.00
6AK6	2.00
6AL5	0.52
6AM4	3.25
6AM5	6.00
6AM6	1.20
6AN5	3.95
6AN8A	2.15
6AQ5	0.82
6AQ8	0.85
6AR5	2.00
6AR8	2.00
6AS5	1.50
6AS6	1.50
6AS7G	7.50
6AT6	0.75
6AU4	2.00
6AU6	0.55
6AV6	0.72
6AW8A	2.95
6B8G	1.50
6BA6	0.50
6BA6W	1.50
6BA7	4.50
6BA8A	3.50
6BC8	1.00
6BD4	1.50
6BD6	1.00
6BE6	0.72
6BF5	1.60
6BG6G	1.25
6BH6	1.95
6BH8	1.50
6BJ6	1.20
6BK4	4.00
6BK7A	1.95
6BM8	0.58
6BN4	1.65
6BN6	1.65
6BN7	4.50
6BN8	2.75
6BQ5	0.69
6BQ7A	0.72
6BL8	0.65
6BR5	0.70

6BR7	4.15
6BR8	2.15
6BR8A	2.15
6BS7	4.50
6BS8	2.50
6BW4	1.50
6BW6	5.35
6BW7	1.50
6BW8	4.00
6BX6	0.48
6BX7GT	3.50
6BZ6	2.00
6BZ7	2.95
6BZ8	0.95
6C4	0.80
6C6	0.50
6C8G	1.50
6C11	2.50
6C15	2.50
6C18	2.50
6CA4	0.60
6CA7	4.50
6CB6	1.50
6CD6GA	4.50
6CF6	1.50
6CH6	10.35
6CL6	3.50
6CL8A	2.00
6CM5	1.60
6CS6	0.75
6CW4	7.25
6CY5	1.00
6DC6	2.00
6DK6	1.15
6DQ5	2.30
6DR7	2.00
6EA8	2.50
6EB8	1.75
6EU8	1.75
6EW6	1.50
6F1	2.00
6F6G	2.00
6F12	1.50
6F13	3.00
6F14	1.00
6F17	2.75
6F18	1.50
6F19	0.48
6F21	2.50
6F22	0.70
6F23	0.60
6F24	1.25
6F25	1.25
6F28	1.25
6F33	9.00
6FG5	1.95
6GH8A	0.80
6GK5	1.50
6GK6	2.00
6GV7	2.50
6H3N	1.10
6H6	1.35
6H6GT	1.20
6J4	1.10
6J5	1.95
6J5G	0.75
6J6	0.55
6JB6A	3.95
6JE6C	3.50
6JS6A	3.50
6JS6C	3.50
6K7G	0.70
6KD6	4.50
6L1	2.50
6L19	3.95
6L6GC	2.50
6L6GT	1.15
6L7G	0.75
6LD20	0.60
6LF6	2.95
6LQ6	2.95
6N7GT	1.50
6P15	0.80
6P25	3.00
6P28	2.00
6Q7	1.20
6S7	1.10
6SA7GT	1.00
6SC7	1.50
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	1.95
6U4GT	1.75
6U5G	1.50
6U8	0.60
6U8A	1.50
6V6GT	0.80
6X2N	1.00
6X4	0.96
6X5GT	0.50
6X5GTY	1.00
6X8A	2.25
7A7	2.00
7AD7	1.75
7B7	1.40
7C5	3.00
7C6	2.50
7H7	2.00
7Q7	2.00
7S7	3.00

7Y4	1.95
10C1	5.50
10C2	0.70
10D2	1.25
10F1	0.75
10GK6	1.95
10P14	2.50
10P18	0.78
10LD11	1.00
10LD12	0.65
11E2	16.50
11E3	55.00
12AE6	0.85
12AG8	1.50
12AL5	1.00
12AT6	0.59
12AT7	0.65
12AT7WA	2.50
12AU6	1.50
12AU7	0.55
12AV6	0.80
12AX4GT	1.00
12AX7	0.65
12AX7WA	2.50
12AYZ	4.00
12AZ7A	1.95
12BA6	0.90
12BE6	1.05
12BH7	1.50
12BH7A	1.50
12BL6	0.70
12BY7A	2.75
12CX6	1.20
12E1	17.95
12E14	28.00
12GN7	3.95
12HG7A	3.95
12J7GT	0.70
12K5	1.00
12K7GT	0.60
12K8	1.10
12Q7GT	0.50
12SA7GT	1.00
12SH7	1.00
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
19H4	23.95
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
211	32.50
25L6GT	1.75
25BQ6	1.75
29C1	19.50
30	2.85
30C1	0.70
30C15	0.40
30C17	0.40
30C18	1.48
30F5	0.95
30FL1	1.10
30FL2	1.10
30FL12	0.95
30FL13	1.10
30FL14	1.25
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	0.80
30PL14	1.75
31JS6A	2.95
35A5	4.50
35L6GT	2.00
35W4	0.70
35Z3	1.85
38HE7	4.50
47	6.00
50B5	1.50
50C5	0.95
50CD6G	1.15
52KU	2.00
61SPT	4.50
75B1	1.50
75C1	1.35
76	1.50
83A1	7.00
84	3.00
85A1	6.50
85A2	2.00
90AV	10.00
90C1	2.70
90CG	13.50
91AG	9.00

92AG	11.85
92AV	10.00
95A1	6.50
108C1	1.50
150B2	3.95
150C2	1.50
150C4	2.15
155UG	25.00
185BT	1.50
205F	12.00
257A	6.00
307	5.00
329	5.00
388A	17.50
408A	4.00
425A5	8.00
431U	2.00
572B	35.00
705A	8.00
708A	8.00
715A	6.00
715C	45.00
801A	2.00
803	14.95
807	1.50
810	55.00
811A	12.95
813	18.50
813 USA	59.50
833A	115.00
866A	3.95
872A	16.00
873	60.00
884	5.50
954	0.50
955	0.90
958A	0.90
1299A	0.60
2050	8.95
3545	4.00
4212E	170.00
4313C	4.00
5642	8.50
5651	3.20
5654	1.95
5670	3.50
5675	19.50
5687	3.50
5692	3.50
5696	3.50
5718	6.50
5725	2.50
5726	2.50
5727	2.50
5749	2.50
5750	2.00
5751	3.50
5763	3.50
5814A	3.25
5840	3.50
5842	6.50
5879	3.90
5881A	4.60
5894	39.50
5899	4.50
5963	2.00
5965	2.25
5993	8.00
6005	1.95
6012	6.00
6021	3.95
6057	2.50
6059	3.75
6060	1.50
6062	4.50
6063	2.00
6064	3.25
6067	1.95
6072	4.20
6080	5.75
6080WA	8.50
6096	2.85
6132	10.00
6136	2.50
6146A	4.99
6146B	5.65
6201	6.95
6211	2.50
6267	1.50
6350	2.00
6360	4.50
6386	14.50
6545	8.50
6550	7.00
6550A	7.00
6870	11.50
6883B	13.95
7025	2.50
7027A	4.65
7032	2.00
7059	2.50
7189	2.50
7199	3.20
7247	2.00
7360	7.50
7475	5.00
7551	4.50
7558	11.50
7581A	3.00
7586	9.00
7591A	3.95
7868	3.95
8012	4.20
8136	1.00
8298A	4.95
8417	5.95
9001	0.90
9006	0.90
18042	7.50
18045	10.00

WIREWOUND RESISTORS

PREFERRED VALUES

4 Watt	4R7-1K8	0.15
	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

ZENER DIODES

BZX61 0.15

6V2 7V5 8V2 9V1 10V 11V 12V 13V
15V 16V 18V 20V 22V 24V 27V 30V
33V 36V 39V 47V 51V 56V 68V 75V

BZY88 0.07

2V7 3V 3V3 3V6 3V9 4V3 4V7 5V1
5V6 6V2 6V8 7V5 8V2 9V1 10V 11V
12V 13V 15V 18V 20V 24V 27V 30V

THERMISTORS

VA1040	0.23
VA1056S	0.23
VA1104	0.70
VA8650	0.45
VA1097	0.25

BATTERIES

7V Power Mike batteries
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other prices on request

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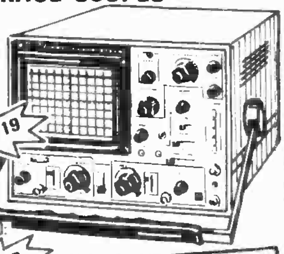
TRIO 20 MHZ DUAL TRACE 'SCOPES



140mm Tube: DC to 20 MHZ: 5mV Sensitivity: CH2 Invert:

CS1820 Delayed sweep: 0.2µsec to 0.5 sec sweep. Modes CH1, CH2, DUAL and ADD.
List Price £539.00 inc. VAT — Our Price **£420.00** inc. VAT — SAVE £119
(UK C/P £4)

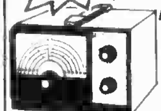
CS 1566A NOR, AUTO, VIDEO: 0.5µsec to 0.5 sec sweep: Modes CH1, CH2, ALT, CHOP and ADD:
List Price £368.00 inc. VAT — Our Price **£299** inc. VAT — SAVE £69
(UK C/P £4)

2 YEAR GUARANTEE

Optional probes – see below.

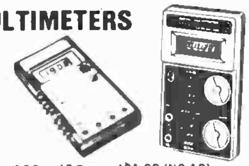
100 KHZ TO 30 MHZ

6 Band Trio RF Generator. Int/Ext MOD. Variable O/P to 100mV Am int 400HZ MOD.
SPECIAL PRICE £59.95 inc. VAT — SAVE £10+
(UK C/P £2)



AG202A matching 20HZ to 200 KHZ Audio Generator £ 78.00 inc. VAT **(UK C/P £2)**

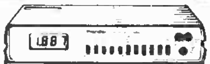
LOW COST DIGITAL MULTIMETERS

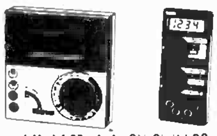


3½ DIGIT LCD HAND HELD DMM's:
(SW = slide switch; PB = push-button; RS = rotary) (models * with carry case)
UK C/P 65p all models

***KD25C** 13 Range 0.2A DC 2 megohm (SW)	£26.50
***KD30C** 26 Range 1A AC/DC 20 megohm (RS)	£37.50
***KD55C** 28 Range 10A AC/DC 20 megohm (RS)	£41.50
***601** 26 Range 2A AC/DC 20 megohm (PB)	£36.50
188m 16 Range 10A DC (NO AC) 2 megohm plus Hfe (TRANSISTOR) tester (RS)	£43.50
189m 30 Range 10A AC/DC 20 megohm plus Hfe Tester (RS)	£69.95
***DM2350** 21 range miniature auto ranging (SW)	£55.00

DIGITAL MULTIMETERS





All models complete with leads and batteries

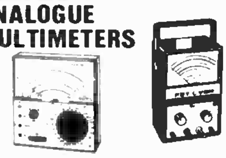
2010A LED 31 range. 10A AC/DC basic 0.1% (Sabtronics)	£81.50
TM353 LCD 27 range 2A AC/DC basic 0.15% (Sinclair)	£86.25
2015A LCD 31 range 10A AC/DC basic 0.1% (Sabtronics)	£89.50
TM351 LCD 29 range 10A AC/DC basic 0.1% (Sinclair)	£113.85
2001 LCD 28 range plus 5 range capacitance meter 10A AC/DC basic 0.1% (Pantec)	£108.00
TM451 4½ digit LCD every facility and function 0.02% basic (Thandar)	£171.00
1503A 4¾ digit LCD 30 ranges 10A AC/DC MHZ counter 4 KHZ osc. 0.05% basic (Thurlby)	£171.00
1503HA As above but 25A and 0.03% basic	£189.75

Hand Held Models 3½ Digit LCD **(UK C/P 65p)**

129 25 range 0.8% basic 10A AC/DC rotary switches (Keithley)	£79.35
130 as model 129 but 0.5% basic (Also see above)	£102.35

Bench Models 3½ digit LCD unless stated **(UK C/P 90p)**

ANALOGUE MULTIMETERS

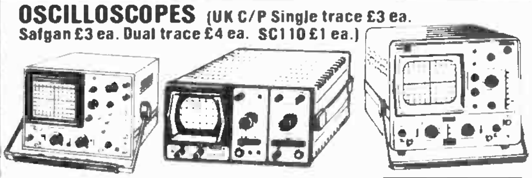


PROFESSIONAL RANGE **(UK C/P £1.20)**
All featuring AC/DC Volts/Current and Ohms ranges with Batts/leads

MAJOR 20K 29 range 20K/V. 2½A DC 12½A AC (PANTEC)	£33.90
MAJOR 50K 29 range 50K/V. 2½A DC 12½A AC (PANTEC)	£40.25
PAN3001 34 range 40K/V. 5A AC/DC 50 Meg. (PANTEC)	£59.80
Also 500KHZ - 500MHZ signal injector and 3 range cap. meter	
PAN3003 42 range 1 Meg/V. 5A AC/DC 1 µA FSD (PANTEC) (NOTE 3001 & 3003 Electronic Protection Mirror Scales)	£66.70

OSCILLOSCOPES

(UK C/P Single trace £3 ea. Salgan £3 ea. Dual trace £4 ea. SC110 £1 ea.)



HM307 Single trace 10MHZ 5mV:0.5 micro sec. Plus built in component tester 6 x 7 cm display (HAMEG)	£158.70
Optional Case	£18.40
3030 Single trace 15MHZ 5mV:0.5 micro sec. Plus built in component tester 95mm tube. Trig. to 20MHZ (CROTECH)	£172.50
HM203/3 Dual 20MHZ: Trig. to 30MHZ 5mV: 0.5 micro secs. 8 x 10cm display (HAMEG)	£253.00
HM203/4. As above but 2mV + Algebraic add (HAMEG)	£276.00
CS1562A Dual 10MHZ 10mV. 1 µ sec. 140mm tube (TRIO)	£276.00
3131 Dual trace 15MHZ trig. to 35MHZ 5mV: 0.5 micro sec. 130mm tube plus component tester	£276.00
3034 Battery-mains dual trace 15MHZ trig. to 20MHZ built in Nicads. 5mV 0.5 micro secs (CROTECH)	£414.00
(Eliminator charger optional	£36.00)
HM204 New model with component tester Dual 20MHZ delayed sweep: trig to 40MHZ. 5mV 0.1 micro sec 8 x 10cm display (HAMEG)	£419.75
(Optional case	£21.85)
SC110A New model 10MHZ battery portable. 10mV 0.1 µsec 2" trace. All facilities (THANDAR)	£171.00

(OPTIONS:

Carry case	£6.84
AC Adaptor	£5.69
Nicads	£8.63)

CS1577A Dual 35MHZ. 2mV 0.1 µsec. Single sweep facility. 140mm tube (TRIO) List price £540.00 Our price **£475.00**

CS1830 11 Dual 30MHZ. 2mV 0.2 µsec (fitted delay line) Delay sweep 140mm tube (TRIO) List £665.00 Our Price **£570.00**

HM705 Dual 70MHZ delayed sweep: Single sweep: Delay line: Trig to 70MHZ: 2mV:0.1 micro sec. 8 x 10cm display (HAMEG) **£667.00**

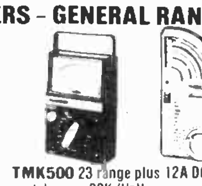
CS2070 70MHZ 4cm 8 trace List £965.00 **Our Price £918.85**

Also stocked
Trio Dual 100MHZ Thandar Channel logic analyser GSC 8 Channel scope adaptor.
Salgan all models 5mV sens 0.5 micro sec 6.4 x 8cm display.

DT410 Dual 10MHZ	£205.85
DT415 Dual 15MHZ	£217.35
DT420 Dual 20MHZ	£228.85

Scope probes all models — see below

ANALOGUE MULTIMETERS – GENERAL RANGE



Low cost reliable meters (All supplied with batts/leads) **(UK C/P 55p)**

BANANA 15 range pocket 20K/Volt plus cont. buzzer (illus)	£20.64
ET102 14 range 2K/Volt pocket	£5.95
ST5 11 range pocket 4K/Volt	£6.50
NH56R 22 range pocket 20K/Volt	£10.95
YN360TR 19 range plus Hfe test 20K/Volt	£12.95
KRT5001 16 range 10 amp DC range double 50K/Volt	£16.50
ST303TR 21 range plus Hfe Test 20K/Volt	£16.95
AT1020 18 range Deluxe 2KV and Hfe Tester	£17.50
TMK500 23 range plus 12A DC plus cont. buzzer 30K/Volt	£23.95
168m 36 range large scale 10A AC/DC 50K/Volt	£28.50
360TR 23 range large scale 10A AC/DC Hfe test 50 meg ohm. 1KV AC/DC 100K/Volt	£36.95

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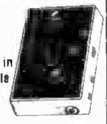
PORTABLE TV COLOUR GENERATOR



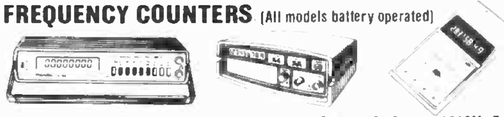
MC101
8 patterns/dots/lines etc. Built in nicads. Pal 8 UHF only. Complete with charger, case and leads
£147.00

VARIABLE POWER SUPPLIES

Mains input - Volts/Amps meter **(UK C/P £1)**

PP241 0/12 12/24 Volt. 0/1 amp	£35.00
PP243 0/12. 12/24 Volt. 0/3 amp.	£59.95
PS1307S twin meter 8-15V 0/7A	£35.95

FREQUENCY COUNTERS (All models battery operated)



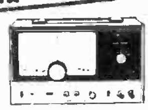
(UK C/P £1)

PFM200A Pocket 8 digit LED 200MHZ 10mV (THANDAR)	£67.50
Max 50 50MHZ 6 digit LED Pocket (GSC)	£56.35
Max 550 6 digit LED Pocket (GSC)	£97.75
8110A 8 digit LED 2 range. 100MHZ Bench (SABTRONICS)	£77.00
8610A 8 digit LED 3 range 600MHZ. Bench (SABTRONICS)	£94.00
Max 100 5HZ-100MHZ 8 digit bench LED (GSC)	£97.75
8610B 9 digit LED 3 range 600MHZ Bench (SABTRONICS)	£113.85
8000B 9 digit LED 3 range 1000MHZ Bench (SABTRONICS)	£178.00
TF040 8 digit LCD 40MHZ (THANDAR)	£126.50
TF200 8 digit LCD 2 range 200MHZ (THANDAR)	£166.75
Thandar prescalers for any counter up to 200MHZ	
TP600 600MHZ	£43.13
TP1000 with P/S 1GHZ	£73.00

OPTIONS

TF series carry case	£6.84
AC adaptors (TF Series)	£5.69
'B' series AC adaptors	£5.69
All models probe kits	£7.95

GENERATORS R-C ★ Pulse ★ RF Function ★ Audio



(UK C/P £1)
All models 220/240V AC

AUDIO 4 band Sine/SQ output	
TE22D Max distortion 1% 20HZ/200KHZ	£59.95
LAG27 Max distortion 0.5-1% (LEADER) 10HZ-1MHZ	£86.25
LAG120A 5 band 10HZ-1MHZ Sine/SQ 0.05-0.8% dist.	£146.00
LAG125 As LAG120A but 0.02% dist. (LEADER)	£273.00
AG203 10HZ-1MHZ 5 band 0.1% Sine/SQ (TRIO)	£129.95
RF (All with Int/Ext mod. variable output)	
TE200 100 KHZ - 100 MHZ 6 band (300 MHZ harm)	£49.95
LSG17 100KHZ - 150MHZ (450MHZ harm) LEADER	£71.30
FUNCTION (All Sine/SQ/Triangle/TTL etc.)	
5020A 1HZ - 200KHZ (SABTRONICS)	£90.00
TG100 1HZ - 100KHZ (THANDAR)	£90.85
TG102 0.2HZ - 2MHZ (THANDAR)	£166.75

PULSE

TG105 5HZ - 5MHZ Various outputs (THANDAR)	£97.75
4001 Ultra-variable 0.5HZ - 5MHZ (GSC)	£113.85

Also in stock

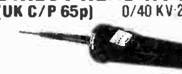
LDM170 20HZ-20KHZ distortion meter	£281.75
LFG1300 0.002HZ-2MHZ sweep function generator	£377.20
LSG231 100MHZ FM signal generator	£211.60
LCR740 RES/CAP/IND Bridge	£171.35
LVT72 FET. multimeter and transistor checker	£147.20
LTC907 Signal injector/tracer and transistor checker	£173.65

DIRECT READ TEMPERATURE

TM301 -50°C to +750°C LCD readout. Complete with battery and thermocouple **£68.43**

DIRECT READ HV PROBE

(UK C/P 65p) 0/40 KV 20K/Volt **£18.40**



OSCILLOSCOPE PROBE KITS

UK C/P 50p per 1 to 3

BNC plug	X1	£7.95
	X10	£9.45
	X1 - X10	£10.50
	X100	£16.95

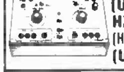
DECADE BOXES

RSB2 32 value Resis. box. 1 ohm to 4 Meg.	£18.50
CSB20 20 value Cap. box. 470 pf to 1 µF	£21.00

CLAMPMETER

ST300 0/300A: 600V AC: 0/1K ohm: 9 ranges **£28.50**

SCOPE ADD ON UNITS



LTC905 Semiconductor curve tracer (illus)(LEADER) £95.45 **(UK C/P 85p)**
HZ65 Component tester (HAMEG) £27.95 **(UK C/P 65p)**

Amateur radio and CB test equipment. TV pattern generators Pal and Sec am in stock. - Ask for details.

LOGIC PROBES/ MONITOR

Sabtronics LP10 10MHZ probe	£28.50
GSCLP2 1.5MHZ probe	£19.95
LEADER LDP076 50MHZ (with case)	£56.90
GSCLM1 monitor (8 to 16 pin IC's)	£33.00
GSCOP1 Digital pulsor. Single/100 pps	£58.50

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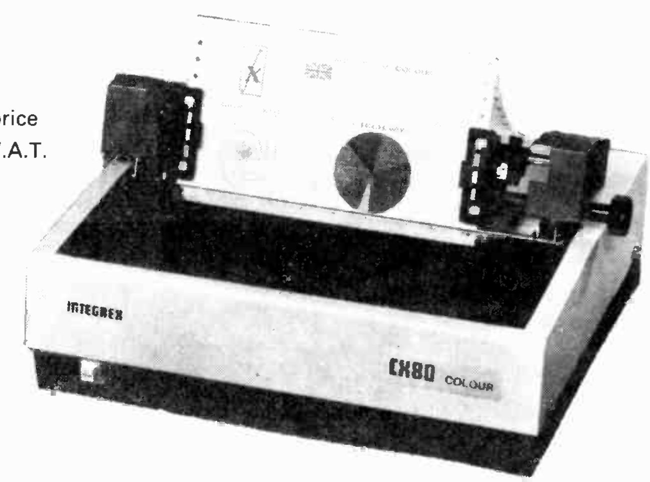
New low price
£795 + V.A.T.



At last a low-cost Colour Matrix Printer for Text, Graphics, Histograms, Colour VDU Dumps, etc.

Colour printout is quickly assimilated, makes graphics more understandable and is an ideal medium for the presentation of complex data or concepts.

Compatible with most microprocessors, prints in 7 colours – sophisticated internal programme makes the CX80 easy to use.

Dot Addressable + 15 user programmable characters, 96 ASCII and 64 graphics characters in rom. Centronics interface with RS232 and IEEE488 options. Apple II interface gives dot for dot colour dump. New viewdata interface prints out two pages side by side in full colour. See Prestel 200650.

The CX80 is a product of our own design and development laboratories. It represents a British breakthrough in colour printer technology. Colour brochure on request. OEM pricing available.

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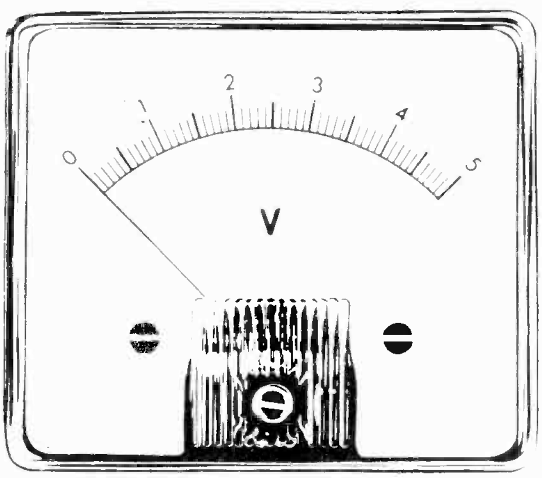

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360R	3k6	36k	–
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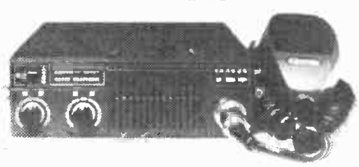

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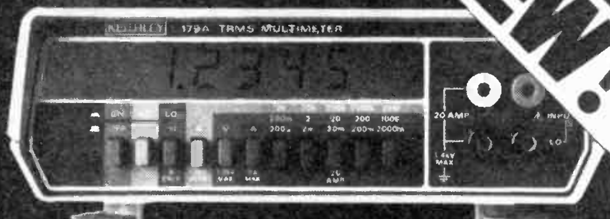

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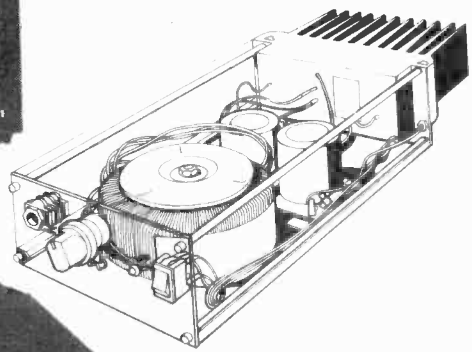

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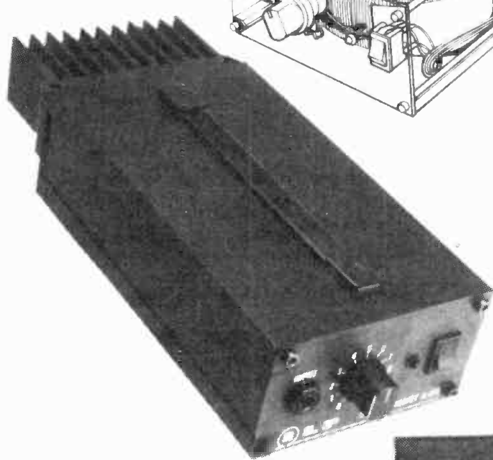

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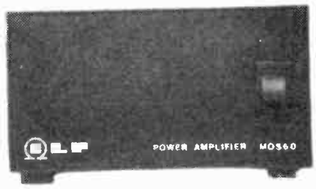

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Early link or cemented future?

The UK's desire not to lose out in the broadcast satellite export market in the mid-1980s has resulted in a proposal of "elegance and ingenuity" with the potential of a world standard being thrown out by both Sir Antony Part's advisory panel and the Government.

Of the only contender beside the BBC and IBA, the panel's report says "We are particularly attracted by the elegance and ingenuity of this proposal and we recognise that the authors of it have relevant technical experience. However, we have concluded, with some regret, that the time available between the presentation of this Report and the autumn of 1986 is much too short to allow for the further evaluation, development and international negotiation that would be required to make it a practical proposition in time for the projected start of DBS." And that's about as much space as the £35,000 report gives to the idea.

This appears to have been said because prototype equipment is not developed to the same degree as that of the other two contenders, the BBC and IBA. But Plymouth Polytechnic's scheme – outlined on the next two pages – could have been brought to readiness very quickly given the money says its proposer Martin Tomlinson (News, page 34). The techniques are already in use in military satellites (Dr Tomlinson has himself worked on Skynet 4 until recently) and equipment could presumably have been quickly adapted had there been enough enthusiasm for it.

We do not think the matter should rest there. As the EBU will try to settle on a European standard soon this year, they should make certain they have proper information on how quickly such a system can be evaluated. The EBU has so far shown a broadminded attitude over sound coding. Last September it resolved in favour of a Type A coding – the equivalent of six sound channels multiplexed onto a subcarrier – but they had agreed, as the Report points out, to keep open the door for reconsidering the merits of a Type C coding "if it could be shown within the timescale to be preferable in technical performance and to be in an adequately advanced state of development." (The IBA finalised on the C-type t.d.m. between-picture coding for MAC; besides its eight-channel capacity and superior technical performance it also has a 20Mbit/s capacity when pictures are not required.) The EBU should do the same for Plymouth, even though it's not a member.

Satellite tv system has digital-analogue phase modulation

Last month the government's advisory panel on technical transmission standards for satellite broadcasting came down in favour of the IBA's multiplexed analogue scheme. But a third proposal, described by the panel as elegant and ingenious, was rejected because four years was "much too short" to make it a practical proposition. That proposal, unlike those from the IBA and BBC, was excluded from the panel's report and is published below for the first time.

Being a hybrid digital/analogue method this proposal combines the advantages of digital and analogue transmission. The advantages that accrue due to digital transmission are limited impairments due to noise, straightforward implementation of time-division multiplexing, and the possibility of encryption which may be required for a subscriber type of service. Transmission of an analogue component ensures bandwidth efficiency and a demodulated signal-to-noise ratio that improves as the transmission signal-to-noise ratio is increased.

The standard proposed here provides 4.7MHz of luminance bandwidth and 1.9MHz of colour difference bandwidth. It is assumed that the colour difference channels alternate on each line so that the vertical resolution is equal to half that of the luminance channel. In addition, the standard provides a 2Mbit/s sound channel and a 2Mbit/s data channel allowing for expansion or new applications in the future.

The demodulated luminance and chrominance channels have equal signal-to-noise ratio and, unlike f.m. PAL signals, suffer equal degradation during impaired transmission conditions. Sound and data channels have the same error rate and provide a small margin over the luminance and chrominance channels. Output signal-to-noise ratio offers an improvement of 4 to 6dB over standards based on analogue frequency modulation.

The transmitted signal is on a single phase-shift-keyed carrier which can be transmitted through a saturating satellite transponder without impairment. Although phase modulation is a departure from currently used methods for satellite tv transmission, digital phase-shift-keyed carriers are commonplace on satellite data links. Moreover the increased bandwidth that is provided for luminance and chrominance channels is of benefit for higher definition receivers. Additional signal processing is required in the receiver but this is not excessive when compared to the signal processing that is carried out in domestic video cassette recorders.

Martin Tomlinson B.Sc. Ph.D. M.I.E.E. is head of the communication engineering department at Plymouth Polytechnic

by M. Tomlinson

The method is believed to be original and a provisional patent application is currently being filed by Plymouth Polytechnic.

Transmission method

For transmission efficiency the luminance and chrominance signals are each coarsely quantized into 16 amplitude levels and coded as in p.c.m., although the error signals from the quantization process are retained for transmission as well. Thus the important information is binary coded into four-bit p.c.m. words and these are transmitted digitally to the receiver. The quantization error signals are transmitted as analogue quantities simultaneously with the digital data. Sound channels are transmitted entirely digitally in a composite six-channel 2Mbit/s stream, and an additional 2Mbit/s digital stream is provided. Luminance, chrominance, sound and any data signals are time-division multiplexed as a composite 60Mbit/s digital stream. The analogue quantization error signals from the p.c.m. process are time-division multiplexed and phase modulated on the carrier at low level along with the digital data, so that the analogue and digital information are simultaneously transmitted using the same carrier. As the analogue modulation is at low level, no errors are caused to the digital information.

At the receiver, assuming no transmission errors, the p.c.m. components of the luminance and chrominance signals are faithfully reproduced noise-free into one of 16 amplitude levels. The analogue signals produce the fine detail information and although these are not received noise-free, the effect of this noise is limited to low levels. When the fine detail signals (plus noise) are added, the noise voltage at maximum can only be 1/16th of the total maximum signal reconstituted in the receiver, as shown in Fig. 1. Consequently if the analogue information is received at 11dB signal-to-noise ratio, the output reconstituted ratio is improved by 24dB ($20\log_{10}16$) to become 35dB.

Advantages of the proposal

- **Increased luminance bandwidth**
- **Increased chrominance bandwidth**
- **Increased output signal-to-noise ratio**
- **No crosstalk between luminance and chrominance signals**
- **2Mbit/s composite sound channel**
- **Encryption easily provided**
- **Equal luminance and chrominance s/n**
- **Provision of a spare data channel.**

Signal format

The transmitted signal consists of a carrier that is eight-level phase modulated at a symbol rate of 20Msymbol/s, bandlimited so that it may be transmitted without undue distortion in the satellite transpareter. The symbols are transmitted in ten symbol frames as shown in Fig. 2; the frame length is 500ns corresponding to a 2MHz rate. Each frame contains five luminance symbols and two chrominance symbols. Each of these carries three bits of the four-bit p.c.m. samples plus a phase modulated analogue component limited to the range $\pm\pi/16$ radians. These symbols have the state space diagram shown in Fig. 3. The three symbols remaining in the frame carry the sound and spare data bits plus the remaining luminance and chrominance

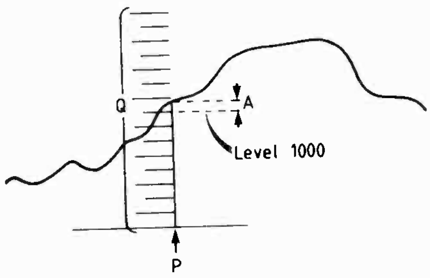

Fig. 1. Encoding the transmitter illustrating formation of a hybrid representation of the signal amplitude at a sample point.

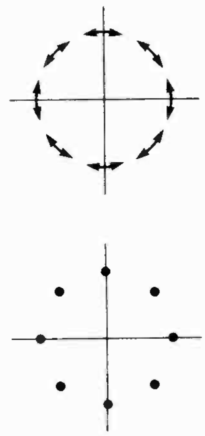

Fig. 3. State diagrams illustrate different phases of phase modulated carrier. Digital diagram bottom, analogue/digital diagram, top.

bits time multiplexed. These carry no analogue information and have the state diagram shown at the bottom of Fig. 3.

To summarise symbols 1, 3, 5, 7 and 9 carry luminance analogue and digital information. Symbols 2 and 6 carry luminance and chrominance digital information time multiplexed, plus chrominance analogue information. Symbols 4 and 8 carry luminance and chrominance digital information. Symbol 10 carries, the luminance, sound and spare data channel digital information.

In the receiver, Fig. 4, each 500ns frame is demodulated and the digital information fed to a digital demultiplexer and the analogue information to an analogue demultiplexer. The luminance and chrominance data bits are gathered together and the appropriate four-bit words fed to d-a converters to form 16 level p.a.m. samples. Analogue quantization error signals from the analogue demultiplexer are added to the p.a.m. samples to form luminance and chrominance p.a.m. samples. Luminance samples at a rate of 10Msample/s are filtered to a bandwidth of 4.7MHz. Chrominance samples at a 4Msample/s rate are filtered to a bandwidth of 1.9MHz. The digital demultiplexer also has sound and data channel output ports at 2Mbit/s.

The initial phase reference for the phase demodulator is provided by a short trailing signal at the beginning of each line. Thereafter, phase tracking is done on the symbols on each frame that carry no analogue information. With these symbols, the data information is stripped off and the residual phase error used for tracking. Frame and symbol timing is provided at the beginning of each line by the training signal.

One potential source of crosstalk is inter-symbol interference if the overall amplitude and phase response goes outside specification. The system can be readily designed so that the receiving earth station, which is the one most likely to be outside specification, has a minimal effect on the overall response. Even so, it may be prudent to rearrange the order of the luminance and chrominance symbols so that symbols 1-5 are luminance symbols carrying analogue information, symbols 8 and 9 are chrominance symbols carrying analogue information separated by symbol 6 which carries sound data and symbol 7 which carries only digital information. Symbol 10 carries only digital information. In this way the possibilities of crosstalk intersymbol interference are minimized.

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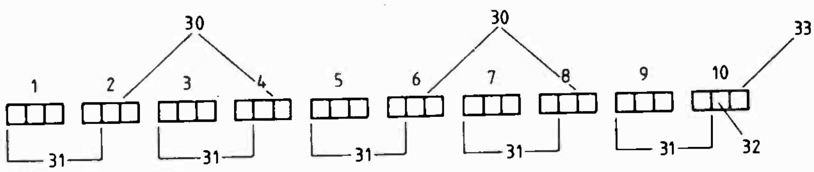


Fig. 2. Structure within each 500ns frame of digital bit stream formed at the encoder.

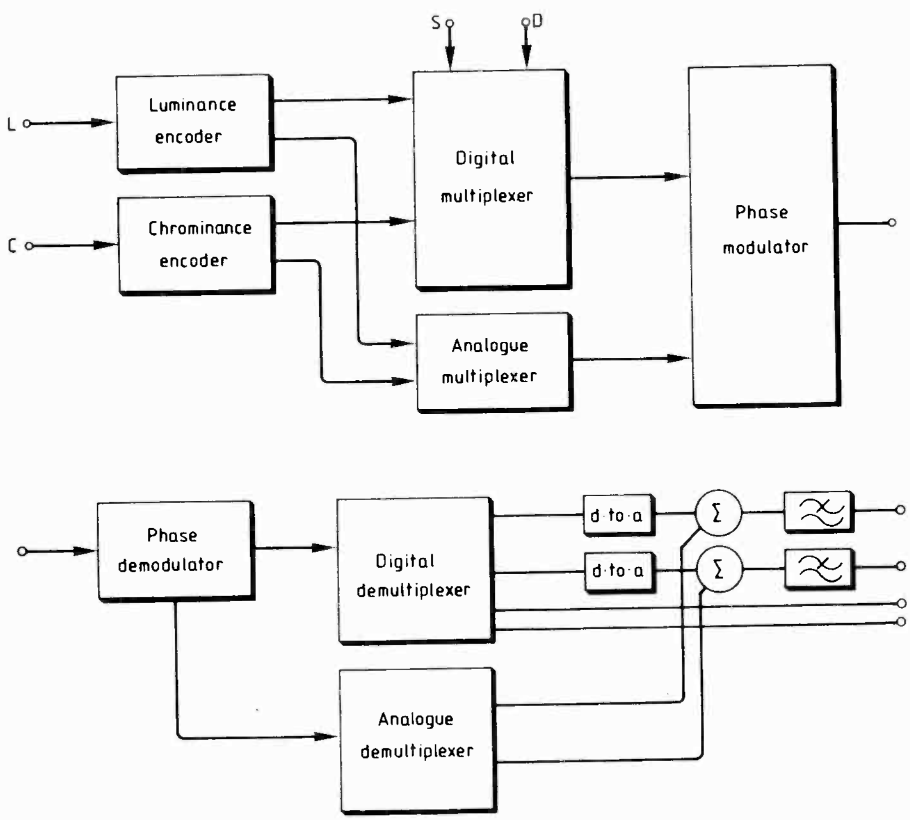


Fig. 4. Each 500ns frame is demodulated and fed to digital and analogue demultiplexers.

Before joining Plymouth Polytechnic in May 1982, Martin Tomlinson was in the satellite communications division at the Royal Signals and Radar Establishment, Malvern. His work there involved R&D in spread-spectrum modems for satellite communication and e.c.c.m. satellite signal-processing transponders, later followed by development of requirements and specifications of NATO IV and Skynet IV satellites. Prior to RSRE he worked for Plessey Telecommunications Research, Maidenhead, on satellite communications system modelling, R&D of advanced digital modems and modulation techniques for data transmission.

Matching tuning diodes

The usual criterion for matching variable capacitance diodes in f.m. receiver r.f. stages is that appropriate capacitances at certain voltages should be as close as possible. Good results may be achieved using a computer, especially when characteristics of diodes do not seem to be matched.

by A. Maciejewski, M.Sc.

Variable capacitance diodes are widely used as tuning devices. The BB104 is a typical device for f.m. receiver front ends but the manufacturers' specifications do not fully describe characteristics of the diodes. For example, the BB104B is defined as

$$C_{\text{at }3V}=34\ \ldots\ 39\text{pF}$$

$$C_{3V}/C_{30V}=2.5\ \ldots\ 2.8$$

Using this data it is impossible to predict the mistuning of circuits. The results obtained during tests carried out on eight samples of BB104B and seven samples of BB104G show that mistuning may be estimated at 500kHz, see Table.

The other criterion for diode matching assumes that capacitance ratio differences should not exceed a certain value, say 0.03. For the case discussed here:

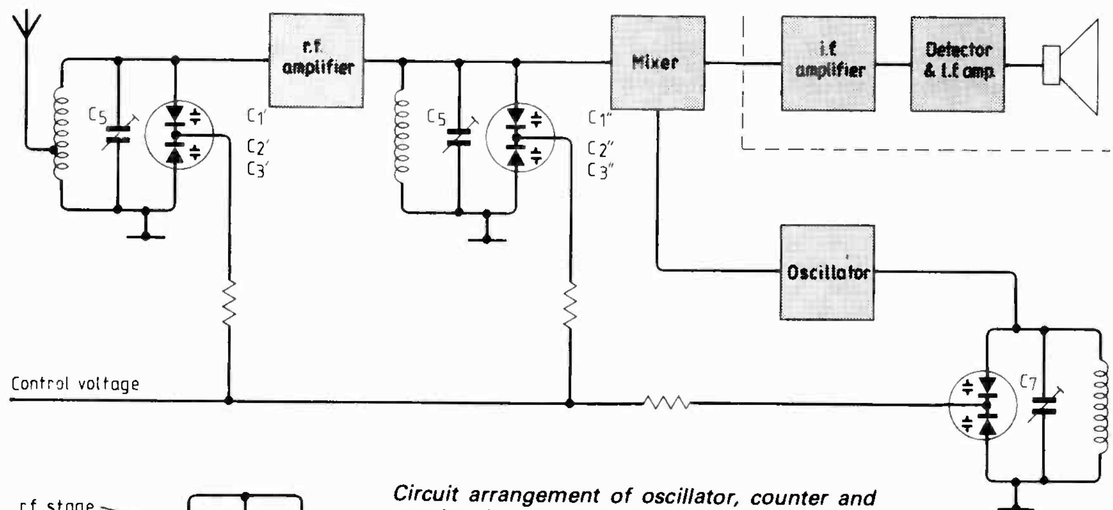
$$\frac{C_1'}{C_1''}=\alpha(1)\quad \frac{C_2'}{C_2''}=\alpha(2)\quad \frac{C_3'}{C_3''}=\alpha(3)$$

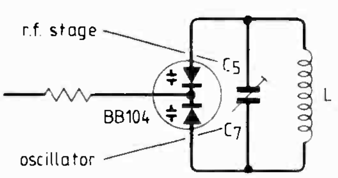
$$\alpha(k)-\alpha(n)\leqslant 0.03 \text{ for } k,n=1,2,3.$$

Theoretically, maximum mistuning of circuits using diodes matched in accordance with this criterion is $D/2=375$kHz and occurs for $\alpha(1)=1$, $\alpha(2)=1.03$ and $\alpha(3)=1$.

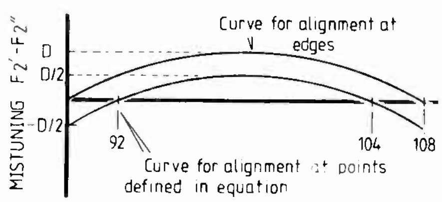
Front-end alignment

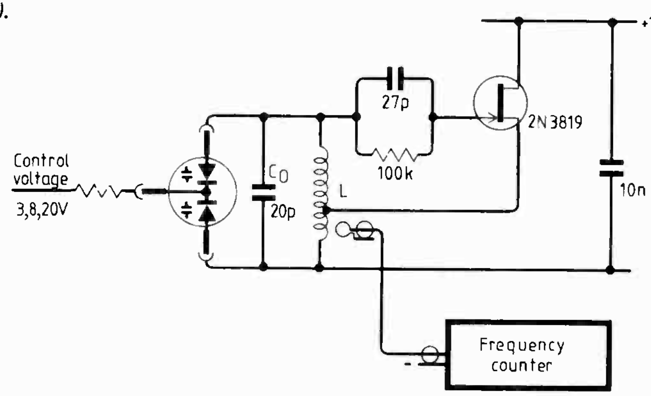
Assume that the tuning voltage and the desired frequencies range between 3 and 20V and $F_1=88$ and $F_3=108$MHz respectively, that the intermediate frequency I=10.7MHz, and that the BB104 capacitances C_1, C_2 and C_3 (treated as resultant capacitances of two serially-connected capacitors) will be measured at 3, 8, 20V respectively. (The BB104 is a common-cathode double capacitance device. An opposing connection is used to reduce capacitance variation versus r.f. signal.)





Circuit arrangement of oscillator, counter and regulated supply provides data for program to calculate 3, 8 and 20V capacitances (below). Normally, circuit alignment is achieved at points in between the extremes of frequency range, so the difference in F_2 for matched diodes is reduced(below left).





Symbols used in program and text	
C_0	test generator intrinsic capacitance
C_1, C_2, C_3	diode capacitances for 3, 8, 20V respectively
C_4, C_6	not used
C_5	r.f. amplifier parallel capacitance for alignment points F_1 and F_3
C_7	oscillator parallel capacitance for alignment points H_1 and H_3
D	difference between resonant frequencies F_2 for alignment points F_1 and F_3
D/2	as above, but for alignment points defined in the equation (3)
F_0	test oscillator frequency for circuit without diode but with capacitor C_0
F_1, F_3	lower/upper receiver frequencies or alignment points
F_2	r.f. amplifier resonant frequency for diode capacitance equal to C_2
F_4	not used
F_5, F_6, F_7	test oscillator frequencies with a diode for 3, 8, 20V respectively
H_1, H_3	lower/upper oscillator frequency
H_2	oscillator frequency for diode capacitance equal to C_2
I	intermediate frequency
K	current index
L	quantity of diodes+2
M	program switch
P(K)	index written for the case of diode no. K
Q(K)	r.f. amplifier resonant frequency F_2 for diode no. K
R(K)	oscillator frequency H_2 for diode no. K
Z_1, Z_2, Z_3	intermediate data storage
$\alpha(1), \alpha(2), \alpha(3)$	capacitance ratio of two capacitances for 3, 8, 20V respectively

Thompson's equation says

$$F=1/2\pi\sqrt{LC}$$

so one can calculate C_{max}/C_{min} ratio in the oscillator circuit, as

$$\frac{C_{max}}{C_{min}}=\frac{C_7+C_1}{C_7+C_3}=\left(\frac{F_3+I}{F_1+I}\right)^2 \qquad (1)$$

and the resonant circuit parallel capacitance C_7 in Fig. 2

$$C_7=\frac{C_1\,.\,(F_1+I)^2-C_3(F_3+I)^2}{(F_3+I)^2-(F_1+I)^2} \qquad (160)$$

(160 is line number in the Basic program).

The same value of C_7 is always achieved as a result of the circuit alignment no matter what method has been applied. However, the method mentioned above is easily realized by computer.

Calculations for the r.f. amplifier are similar,

$$\frac{C_5+C_1}{C_5+C_3}=\left(\frac{F_3}{F_1}\right)^2 \qquad (2)$$

and $$C_5=\frac{C_1\,.\,F_1^2-C_3\,.\,F_3^2}{F_3^2-F_1^2}. \qquad (150)$$

Thus we have the r.f. amplifier and the oscillator circuits exactly adjusted at the ends of the range. Now the most important question is what is going on with the frequencies at around the middle of the range. On calculating C_5 and C_7 we can easily find the resonant frequencies for tuning diode capacitances equal to C_2 by rearranging the equations (1) and (2) for the oscillator and the r.f. amplifier respectively.

For the oscillator

$$\frac{C_7+C_1}{C_7+C_2}=\left(\frac{F_2+I}{F_1+I}\right)^2$$

$$F_2+I=H_2=(F_1+I)\sqrt{\frac{C_1+C_7}{C_2+C_7}}, \qquad (180)$$

and for the r.f. amplifier

$$\frac{C_5+C_1}{C_5+C_2}=\left(\frac{F_2}{F_1}\right)^2$$

$$F_2=F_1\sqrt{\frac{C_1+C_5}{C_2+C_5}}. \qquad (170)$$

On having calculated the frequencies F_2 stored as Q(K) we have to sort them in increasing order so that the best set of diodes is easily chosen. The less the difference among the F_2 frequencies the better is the set for the r.f. amplifier; also the frequency H_2 for the oscillator should be as close to F_2+I as possible.

One thing must be taken into consideration: normally an r.f. stage is aligned not at the edges of the range but at points, say,

$$F_1+0.2(F_3-F_1) \text{ and } F_3-0.2(F_3-F_1) \qquad (3)$$

(in our case it makes 92 and 104MHz), so the difference in F_2 for matched diodes is reduced by half. Mistuning curves shown for the alignment methods mentioned above justify this statement.

Practical results

The data required for the calculations of C_1, C_2 and C_3 are measured in the test circuit shown, using the Hartley oscillator, frequency counter and regulated voltage source for measurements. Oscillator frequencies F_1, F_2 and F_3 for different diode voltages, together with the other data (program lines 80 and 40), are used by the Basic program to calculate C_1, C_2 and C_3 (program lines 110-130). Values of C_1 and C_3 are then used to align all LC circuits and to determine parallel capacitances: C_5 for the resonant circuit and C_7 for the oscillator (program lines 150-160). Calculated values of C_5 and C_7 together with C_2 determine resonant circuit frequency F_2 and the oscillator frequency H_2 for the diode capacitance C_2. This way the three diode capacitances C_1, C_2 and C_3 are transferred into the single parameter F_2. (Difference between H_2 and F_2 is approximately constant.) After sorting F_2 into increasing order (program lines 230-310) we get the print-out of desired data.

The Basic program shown prints the order number, diode index, selective circuit resonant frequency, difference in kHz between the current frequency F_2 and the preceding frequency F_2, and the oscillator frequency H_2.

Advantages of the method

1. The method enables presentation of capacitances measured in three points in the form of the single parameter.

2. The method makes selection of diodes possible which would otherwise be rejected by the use of the proportion criterion. This may not be clear at first glance so consider the following case:

Two diodes have nearly the same capacitance versus voltage characteristics. The

continued on page 33

	Diode number	C_1	C_2	C_3	Q(K)=F_2	D	R(K)=H_2
1	101G	18395	13225	8623	9.70500E+04	0	9.72000E+04
2	106B	18198	13093	8568	9.70700E+04	21	9.72210E+04
3	110B	18593	13325	8579	9.70960E+04	26	9.72470E+04
4	112B	20858	14850	9641	9.71630E+04	67	9.73140E+04
5	103B	18277	13028	8540	9.72500E+04	88	9.74010E+04
6	111B	21418	15105	9785	9.73190E+04	69	9.74700E+04
7	105G	18793	13292	8679	9.73460E+04	27	9.74970E+04
8	115G	18573	13192	8623	9.73750E+04	29	9.75260E+04
9	107B	20773	14581	9440	9.73950E+04	21	9.75470E+04
10	108B	21245	14930	9699	9.74060E+04	11	9.75570E+04
11	114G	18793	13258	8679	9.74110E+04	6	9.75630E+04
12	102G	19114	13458	8790	9.74250E+04	14	9.75770E+04
13	109B	21505	15000	9699	9.74870E+04	61	9.76380E+04
14	113G	19114	13391	8734	9.74950E+04	9	9.76470E+04
15	104G	19358	13093	8568	9.80880E+04	593	9.82400E+04

Capacitances in femtofarads, frequencies in kHz

Eprom development aid

It would be much simpler if program being developed for the Nanocomp eprom could be developed in those memory locations in which it is to reside.

by G. A. C. Bettridge

Used in conjunction with the eprom programmer described in the January issue, this device was developed as part of a system based on the Nanocomp.

When a program is being developed for inclusion in the Nanocomp eprom, it is normally necessary to develop it a little at a time, and burn it progressively using the programmer. Thanks to the ability of the 6809 to support position-independent code, this is a workable method, at least with the 6809 version of the Nanocomp. However, it would be much simpler if the program could be developed in the memory locations in which it is to finally reside, and this is the purpose of the development aid.

The device is used as follows. First the monitor eprom is transferred from the Nanocomp to the socket on the development aid. The 24-pin plug on the aid is then plugged into the Nanocomp in place of the eprom. It is also necessary to connect a probe to a read/write signal: pin 10 of a 2114 is a suitable point. Then, with the switches S_3 & S_4 in their original position, all read operations access the eprom, and all write operations access the ram. If a 2516 eprom is in use with a Nanocomp board wired for a 2532, then S_1 must be used to short pin 18 of the eprom to ground so that it will respond to the higher 2K block of addresses.

It is then a straightforward matter to copy all or part of the eprom into the ram. The Nanocomp then needs to be put into a continuous loop so that it is not addressing the device, and then switches S_3 & S_4 are changed over so that all operations access the ram. The program can then be developed, and burned into eprom using the programmer.

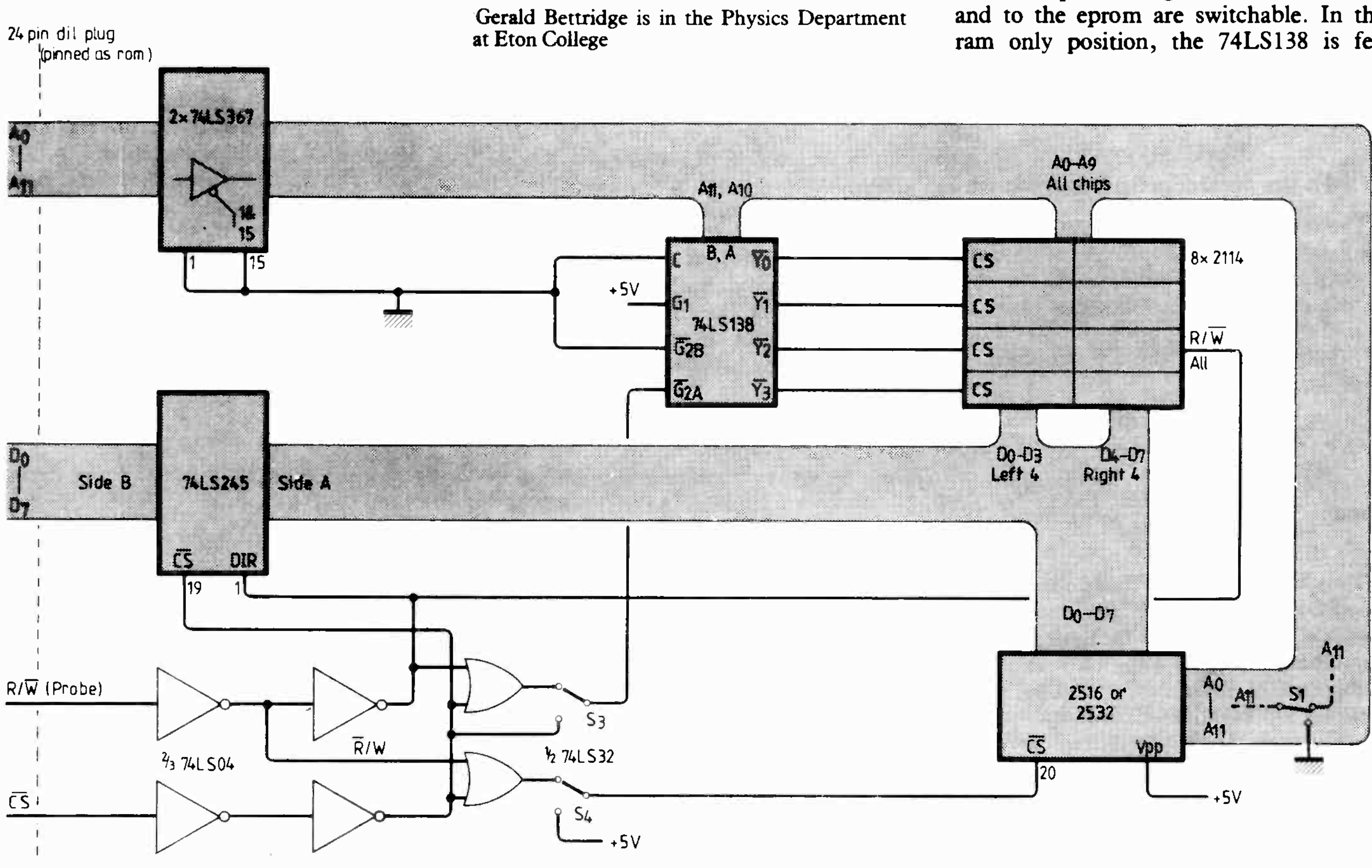
Gerald Bettridge is in the Physics Department at Eton College

Circuit description

The circuitry is fairly simple. All the lines from the 24-pin plug (and the probe) are buffered, as eight 2114 chips and the eprom might well overload an unbuffered system. The address bus is buffered by two 74LS367 hex buffers, permanently enabled. The data bus is connected to a 74LS245 octal transceiver chip, which is enabled by the chip select signal, the direction being controlled by the read/write line. Finally, the control signals read/write and chip select are buffered using a 74LS04, inverters being chosen since the read/write signal needs to have its complement available.

Address lines A_0 to A_9 go to all the ram chips. Lines A_{10} & A_{11} go to a 74LS138 decoder, where they are gated with a select signal to provide chip select signals for the four 1K blocks of ram. The eprom is connected directly to the buffered address lines, except that provision is made to short pin 18 to ground for use with 2516s.

The chip select signals to the 74LS138 and to the eprom are switchable. In the ram only position, the 74LS138 is fed

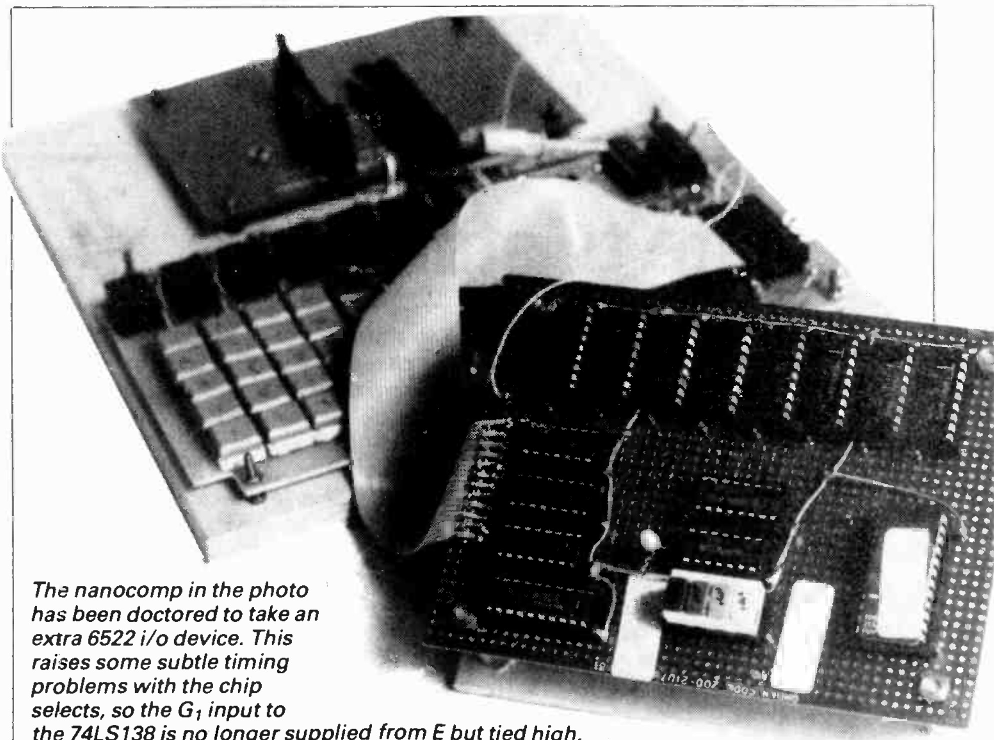


directly from the buffered chip select signal, and the eprom chip select line is held permanently high. In the other position, the 74LS138 is fed from chip select gated with read/write so that the ram only responds to write cycles; and the eprom is similarly fed from chip select gated with the complementary read/write signal so that it only responds to read cycles. A 74LS32 is used for this gating. Lastly, the data lines are simply connected to the data pins of both the ram and the eprom.

Construction

The device was built using wire-wrapping on a 3.75 by 5in piece of plain matrix board. Twenty-gauge tinned copper wire was used for the power supplies, ground on the bottom of the board and +5V on top. This ensures a low impedance for the supply lines and the device has worked perfectly up to now with only one 10μF tantalum capacitor decoupling the power lines, though it would doubtless be better practice to provide some disc ceramics as well. Connections to the system are via the 24-pin plug, except for the read/write probe which is an RS miniature clip-on probe to enable connection to be made to a convenient i.c. pin. The board is mounted on a plywood base with four 4BA screws, using plastics tube as spacers, which is both cheap and fairly shakeproof. The switches are all on a dual in-line package: a compact arrangement, but remember not to switch S_3 without S_4 – though no great harm is likely to result from a failure so to do. Switch S_2 is not used.

Although the device was developed with the Nanocomp mainly in mind, it has been used with an Acorn Atom as well, again using the Nanocomp programmer. In this way programs for the Atom user-rom socket can be developed easily; and any other way would in fact be difficult, since the 6502 processor does not support position-independent code.



The nanocomp in the photo has been doctored to take an extra 6522 i/o device. This raises some subtle timing problems with the chip selects, so the G_1 input to the 74LS138 is no longer supplied from E but tied high. It would be better still to supply it from O+E but this would need an extra chip, and it seems to work correctly without doing this.

The copy program is very simple, but may be of interest; when testing the device for the first time it is helpful to know that the software works.

```
START  LDX   #$7000
LOOP   LDA   ,X
       STA   ,X+
       CMPX  #$8000
       BNE   LOOP
STOP   BRA   STOP
```

This assembles as follows: 8E 70 00 A6 84 A7 80 8C 80 00 26 F7 20 FE. The "dynamic stop" at the end is important: it ensures that the microprocessor is not addressing the monitor when the switches are changed over. If this precaution is not taken corruption of the memory is likely to result, and the hardware might be unjustly suspected of being faulty. To copy part of the monitor only it is of course sufficient to change the addresses 7000 and 8000.

It ought to be a simple matter to adapt this program to the 6802 version, but experience makes me wary of guaranteeing even the simplest program I have not actually tried.

Finally, it is a good idea to set all unused bytes to FF, as further programs can be added later without the need to erase the chip. WW

continued from page 31

only difference is that C'' is, in the whole voltage range, 1pF less than the capacitance C'. If for 3 and 20V the C_1' and the C_3' are 20 and 10pF then C_1'' and C_3'' will be 19 and 9pF respectively. Dividing C'/C'' gives $\alpha(1)=1.05$ and $\alpha(3)=1.1$, i.e. the difference of ratios is 0.05. According to the previously described ratio criterion it makes the pair unmatched. From our assumption it is enough to add the fixed capacitance of 1pF (it can be realized by C_5'' – Fig. 1) and the ideal alignment of circuits incorporating C' and C'' will be achieved.

3. Usage of two identical diodes for the r.f. amplifier and for the oscillator gives mistuning of

$$D/2=(H_2-I-F_2)/2=(97.200-97.050)/2 =75\text{kHz}$$

(data from the Table, diode no. 1).

The method makes possible selection diodes for the r.f. amplifier and the oscillator. From the Table we can select diode no. 5 for the r.f. amplifier and diode no. 3 for the oscillator; that allows a mistuning D/2=1.5kHz. Note: exchanging diodes between the r.f. amplifier and the oscillator results in a mistuning of D/2=(97.401−97.096)/2=150kHz. WW

```
10 REM ***** Program for matching capacitance diodes
20 FILES     5 = LPR, 6 = CRD
30 DIM       P(100), Q(100), R(100)
40 INPUT#6   F1, F3, I, F0, C0
50 LET       H1 = F1 + I; H3 = F3 + I
60 LET       K = 2
70 REM ***** Read in data, last data is 0, 0, 0, 0
80 INPUT#6   P(K), F5, F6, F7
100 IF       P(K) = 0 GOTO 220
110 LET      C1 = C0*(F0*F0-F5*F5)/(F5*F5)
120 LET      C2 = C0*(F0*F0-F6*F6)/(F6*F6)
130 LET      C3 = C0*(F0*F0-F7*F7)/(F7*F7)
140 REM **** Count-selective circuit and oscillator
             frequencies
150 LET      C5 = (C1*F1*F1-C3*F3*F3)/(F3*F3-F1*F1)
160 LET      C7 = (C1*H1*H1-C3*H3*H3)/(H3*H3-H1*H1)
170 LET      F2 = Q(K)=F1*SQR((C1+C5)/(C2+C5))
180 LET      H2 = R(K)=H1*SQR((C1+C7)/(C2+C7))
190 LET      L = K=K+1
200 IF       K <= 100 GOTO 80
210 REM **** Start of sorting
220 IF       K < 4 GOTO 330
230 LET      M = 1
240 FOR      K = 2 TO L - 2
250 IF       Q(K) <= Q(K+1) GOTO 290
260 LET      M = 0; Z1 = P(K); Z2 = Q(K); Z3 = R(K)
270 LET      P(K) = P(K+1); Q(K) = Q(K+1); R(K) = R(K+1)
280 LET      P(K+1) = Z1; Q(K+1) = Z2; R(K+1) = Z3
290 NEXT     K
300 REM **** Is sorting completed?
310 IF       M = 0 GOTO 230
320 REM **** Print out results
330 LET      Q(1) = Q(2)
340 FOR      K = 2 TO L-1
350 LET      D = INT(1000*(Q(K)-Q(K-1))+.5)
360 REM **** For better readability i.f. is subtracted
             from R(K)
370 PRINT#5  K - 1, P(K), Q(K), D, R(K) - I
380 NEXT     K
390 STOP
400 END
```

NEWS

Satellite tv standards

The Part report, recommending that UK satellite broadcasting should use the IBA's Mac transmission encoding method, has had a cold reception from the BBC. "Our worry", says BBC engineering director T. B. McCrirrick, "is that the UK will end up being the only country using Mac, but we do not criticize the system." On the other hand, the IBA say that being a totally new system Mac could lead to the design of a domestic satellite-tv adaptor common to the whole of Europe. "The start of direct broadcasting by satellite", says the IBA, "is a logical time to introduce a standard capable of satisfying tv requirements well into the future."

Despite the long-term attractiveness of Mac and its potential as a world-wide standard, the BBC say its introduction could diminish the financial viability of direct satellite broadcasting. Germany and Spain use Pal and the French plan future tv sets capable of processing both Secam and Pal so the short-term prospects of Enhanced Pal in Europe are good from a programming point of view.

Sir Antony Part's advisory panel not only commends the technical quality of Mac but also considers it commercially attractive to both consumers and manufacturers. The BBC claim that acceptance of Mac would increase the cost of sets, reduce the potential market for British manufacturers and slow down the introduction of satellite broadcasting into Europe.

Both Mac and Enhanced Pal can be transmitted using f.m., thus conforming to the WARC 1977 plan for satellite broadcasting, and have the potential for at least six sound channels using a digital modulation. Teletext is possible with both systems, but multiplexed analogue component (Mac) signals lend themselves to f.m. transmission and provide better high-definition pictures on large screens given that suitable receivers are used, and recording studios continue their trend towards digital signal processing.

Initially, Enhanced Pal is attractive through its compatibility with existing Pal decoders – an antenna and down-converter are all that is required to receive pictures. Mac will require a more elaborate converter including a decoder with r.g.b. outputs to provide pictures better than current ones; a cheaper compromise would be a converter with a Mac-to-Pal circuit and r.f. modulator driving the set's antenna input. Future sets will have their own decoders.

The IBA warn that by the time the current 405-line television service is wound down it will have been in service longer after the decision to abandon it than when it was the primary UK standard, proving that changing standards is a slow process. Recent market research shows that cabling Britain in the near future could be expensive and the Part report sees satellite and cable tv working hand in hand. Satellite tv, being a means of linking commercially viable cable tv areas with the added attraction that unviable areas will still have an improved tv service, may be insurance for the early acceptance of cable tv with the assurance that existing broadcast organizations will have at least some say in programming.

The British Radio and Electronics Equipment Manufacturers' Association issued a statement soon after saying that it welcomes the Mac recommendation. They say that medium-term prospects of a pan-European satellite-broadcast standard based on British technology – with the possibility of the rest of the world following suit – must be attractive to the country at large.

In multiplexed analogue component, luminance and chrominance signals are in component or non-composite form, compressed and transmitted in time-division multiplex. For luminance the 53μs active line is compressed to 40μs, increasing base-bandwidth by 4/3 times maximum v.f.; chrominance compression ratio is 8/3 increasing the 3dB bandwidth from 1.3 to 3.5MHz.

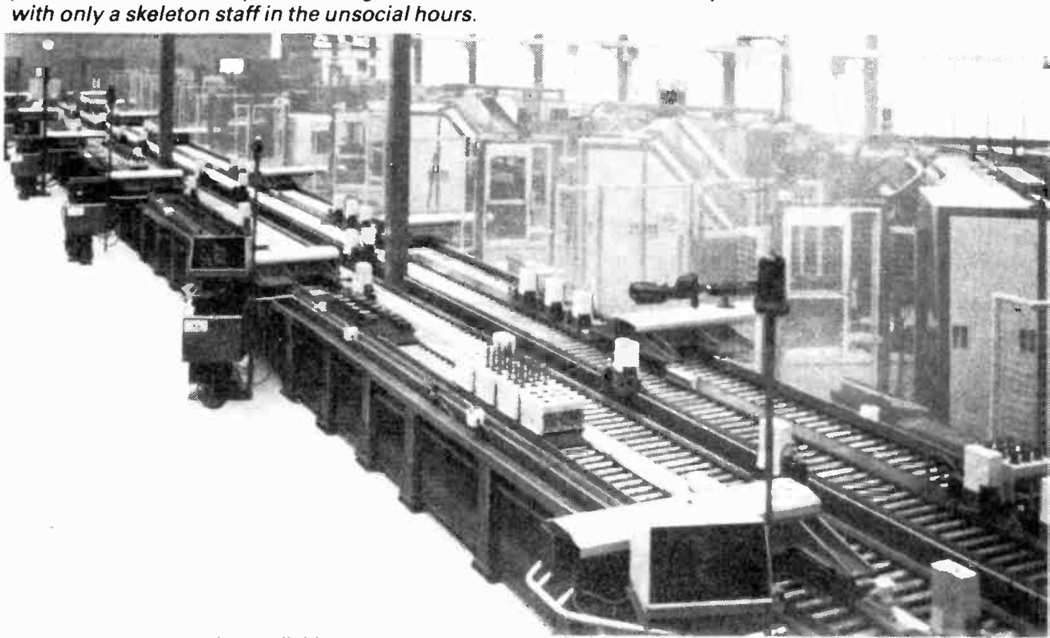
Part rejects "elegant and ingenious" alternative

Claims in the Part report that an "elegant and ingenious" alternative to Mac and E-Pal is a non-runner because of the 1986 deadline are rejected by project leader of the only other contending system, Dr Martin Tomlinson. Speaking on behalf of Plymouth Polytechnic's department of communications engineering, Dr Tomlinson said, "Given the funds, I have no doubt that we could meet the deadline and offer the UK a system that could put us ahead of the world in satellite tv broadcasting long into the future. Most of the technology required for our system already exists."

The IBA's main argument for their Mac system is that its long-term future benefits outweigh the advantages of a compromise in the transition period, and it seems that Plymouth Polytechnic's digital/analogue system offers an even better long-term future and an equally attractive short term compromise.

Asked about time scales, Dr Tomlinson said, "We could be carrying out satellite broadcast tests within three months, given the incentive". The Part report admits that the team has the relevant technical experience, so that leaves more than three years for further evaluation development and international negotiation – a time scale that could have been reduced had the Polytechnic received positive recognition earlier. "Besides being the most forward-looking of the three systems involved, ours

Machining small batches of components on its own using robots, computers and numerically-controlled machine tools, this so-called unmanned factory is the first of its kind in Britain. The idea for this 600 Group factory at Colchester, opened late in November by Industry Secretary Patrick Jenkin, was approved by the Callaghan Government in 1979. Costing £3M, more than half of which came from Government sponsorship, this unit is at present a 'show factory' illustrating automation, but it will eventually run around the clock with only a skeleton staff in the unsocial hours.



offers 100% secure encryption for subscription tv – being digital – and should not impede the introduction of cable tv", he adds.

Dr Tomlinson, formerly a main element in the design team of the UK's latest defence satellite Skynet 4, was first made aware of prospects of a new DBS system while working at RSRE, Malvern when the Department of Industry approached the Establishment for their ideas. With the experience of intensive work on Skynet 4's signal processing transponder, he says "Designers of telecommunication systems have long since seen the merits of digital transmission, so many of the techniques required to implement our system already exist."

During investigations by the Part advisory panel, Plymouth polytechnic received a phone call saying that an evaluator would look into their proposal during November, but further contact was not made. They were not invited to demonstrate their system alongside the other two, perhaps because their lack of funds and experience in public relations tempted them to imply that setting up a demonstration might be impractical. An impartial investigation into the best long-term solution for satellite broadcasting would ignore these incumbencies. On 29 November, a week after the Part report's publication the only information Dr Tomlinson had about results of the report was through us; after contacting the DoI he was allowed a free copy.

Had E-Pal been proposed, one could have seen reasons for a lack of interest in Plymouth Polytechnic's proposal but the panel's interest in Mac implies that this system has not had the airing that it deserves.

● Details of the new satellite tv system are reported exclusively on pages 28 and 29 of this issue.

Delay for cellular radio?

One of three main contenders for the cellular-radio licence claims that if Ferranti or Racal win, the supply of equipment may be restricted. Chairman of Cellular Radio Ltd, Lord Orr-Ewing, said "We believe that to grant a licence to a radio manufacturer would be a mistake . . . to substitute the present monopoly with another form of monopoly is contrary to the Government's declared intention. Absolutely fundamental is the right of all companies capable of manufacturing to be free to tender for cellular radio work."

Of the three, only Cellular Radio Ltd is not an equipment manufacturer. Though Plessey have applied for an exclusive agreement with AT & T to manufacture AMPS equipment, they are not applying for an operating licence.

The Government is expected to announce who wins the second licence by the end of this parliamentary session, but a report commissioned by the DoI evaluating the rival applicants had still not been delivered at the time of writing.

CRL are committed to the AMPS system, developed by AT&T and which is in trial use in Chicago. AMPS is comparatively easy to adapt for use in the UK, says CRL who have obtained a full specification of the system, as it would be adapted, from AT&T. They feel that AMPS is the only system worth considering and they have said they will pull out altogether if it were not adopted. They pour scorn on the MATS-E system which they point out is still only on paper, though it is the system selected by the Ferranti-led group and backed by Pye Telecom and Philips and by CIT Alcatel. MATS-E is criticized for using an off-air queuing method which contacts the caller when the connection is made. In an extreme case this could result in answering machines in conversation with each other. Such a queuing system has been used by the Deutches Bundespost in its Metz-C system. MATS-E supporters claim that AMPS uses poor spectrum management and that the "easy adaptation" for UK use would require major redesign of the system. They also claim that MATS-E is the most efficient system and is the only one capable of handling the projected 23,000 subscribers in London by 1990. They say that the system is most in line with CEPT proposals which could lead to a pan-European 900MHz system (CEPT are not expected to complete the definition of a European system until the end of 1986). Racal with Millicom have developed their own system and a fourth system, Nordic, developed in Sweden, has no backers in the UK yet but has much European support and is thought to be the system that BT are looking closely at in their evaluation. The successful applicant will have to negotiate with BT over the system to be used.

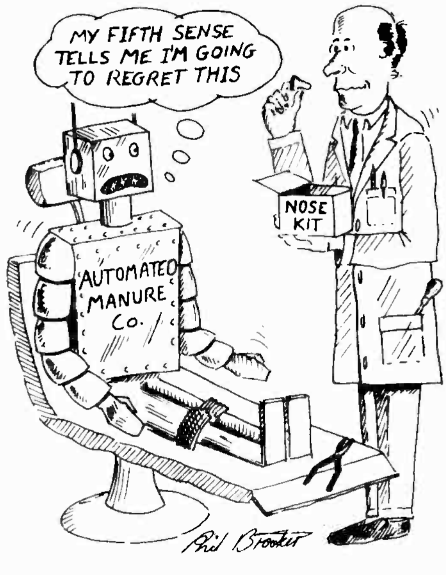
The cellular system could provide every car or mobile user with a telephone. Areas are divided into cells of about a square mile, each having its own transmitter with frequencies mutually excluded from those in adjacent cells. Computer-controlled switching at the transmitter/receiver hands on calls between cells and automatically selects the frequencies to connect the calls. Proposed band is 900MHz which will not be free from Government use until 1985 when cellular radio is due to start. There could be as many as 1,000 telephone channels with 25kHz spacing. The American system uses 30kHz spacing, hence the need for adaptation.

A nose for ideas

Through many years sniffing, mammals have developed a highly sensitive olfactory system capable of discriminating between many odours. Using what may be a similar system, researchers at Warwick University have developed an electronic nose to test their hypothesis that to make fine distinctions between complex odour mixtures without the need for highly specialized receptors, the olfactory system has feature detection using broadly-tuned receptor cells organised in a convergent neurone pathway.

The electronic simulation relies on principles of pattern clarification derived from artificial intelligence work. The sensing elements, which do not have to be highly specific receptors, are semiconductor gas sensors made to have overlapping odorant response distributions by varying doping levels. Outputs from three Figaro TGS sensors are arranged in a circuit so that the ratio of their outputs can be derived and passed to memory circuits via a window comparator.

The device responds to a wide variety of odours but has to be calibrated by exposing it to various odours and locating the response in the memory. Using three transducers the system can mimic the discrimination of the mammalian olfactory system at a gross level, but a nose that can make fine discriminations should be of interest as a quality control device in industries concerned with flavours, perfumes and odours, according to K. Peraud and G. Dodd. Their findings are described in volume 299 of *Nature*, 23 September 1982, pages 352-5.



Illegal transmission clamp-down

Amendments to the Wireless Telegraphy Act put forward in the recent Telecommunications Bill provide for a limited police power to arrest illegal radio transmitter users without warrant. Members of the Radio Interference Service, as well as the police, would have the power to seize apparatus for the purpose of proceedings, and the Secretary of State would control the sale and possession of specified wireless telegraphy equipment.

In their summary of wireless and telegraphy provisions in the November Bill – intended to rationalize and update penalties and introduce powers to enable more effective law enforcement – the Home Office say "the opportunity to implement the Government's decision to abolish the Advisory Committee on Radio Interference has also been taken.

"To reduce or prevent interference, the Secretary of State will have the power to control the sale and possession of specified equipment, as well as current powers allowing prohibition by order the manufacture and importation of such equipment." The Home Office claim that this will help curb illicit c.b. apparatus but do not comment on further aspects of this form of control.

Other than for two offences made triable either way, increased penalties for existing offences are not proposed, but under the Criminal Justice Act of 1982 the maximum fine for unlincensed use of a transmitter will be raised to £1000 from £400. Proposed powers of seizure will enable police or the RIS to apply to the court through a civil procedure for the forfeiture of illegally possessed apparatus, offering an alternative to conviction in some cases.

... and POUNC may lose telecoms

Embedded in the Telecommunications Bill – intended to "give effect to the Government's policy of creating a new structure for telecommunications and further the introduction of competition" – are plans to restrict the Post Office Users' National Council to dealing with complaints concerning postal matters.

According to the Bill, the POUNC have been criticized for "lacking teeth" but rather than giving them dentures, the Government wants to replace them by the new Director General of Telecommunications who will have the power to provide remedies when investigation of user complaints discloses unsatisfactory performance by licencees.

POUNC, who have often provided information supplementing reports from BT concerning fragile matters, finds gaps and confusion in the Bill and wonders how the new Director can possibly be judge, jury and advocate representing the small user.

Peaceful electronics front

Formation of a steering group and a set of aims, including encouraging industry to convert from military to civilian production, are results of the first Electronics for Peace meeting on 20 November. Action coordination, linking like-minded engineers and providing technical information for those working towards disarmament complete the set of aims, which are still open to discussion. The steering group is now busy organizing a larger meeting in London for March. Tel: (Ascot) 21167.

Leads for cable tv

Total expenditure on US cable tv advertising is less than that of a single daily newspaper in Los Angeles. As a percentage of the national total it amounted to less than 0.1% in 1981, according to a report forecasting the cable tv advertising market until 1987 by Knowledge Industry Publications.

The figures are likely to expand slowly with a small boost in subscribers when more than 20 national programming services start up, delivered by satellite to the local cable systems, but by 1987 advertising revenue will only represent about 1.5% of all advertising expenditure. A further forecast to 1990 sees that figure rise to only 2% of the total expenditure. As the advertising revenue will not pay for the services for many years to come, many cable programme providers will cease to operate.

A big rival to advertising-supported cable services is the subscription channel. One pay-tv service, Home Box Office, with more than 9 million subscribers, spends more on productions than all the advertising-supported networks combined. In addition cable viewing even to those homes wired up for cable is only 10% of the total viewing audience, most preferring the broadcast networks. The 10% must be divided up amongst all the cable services. There may be some lessons here for potential British cable services. The report, *Cable Television Advertising Market, 1982-87*, is available in the UK from IPI, 134 Holland Park Avenue, London W11.

Micro money

To further encourage microelectronics in industry, the DoI's MAP project is to receive a further £30m spread over three years. Kenneth Baker MP, Minister for Information Technology, making this announcement said "in only a few years, microelectronics has moved from being a laboratory curiosity to being a basic industrial tool essential to commercial survival. Map has been a significant factor in this achievement, but a lot more needs to be done."

The extra funds will continue Map's momentum for three years after the end of last year when the £55m previously allocated runs out. The scheme's main intention is to raise the awareness of microelectronics in industry by providing funds for projects and consultancy. Since its start in 1978, Map awareness events have attracted 160 000 attendees and over 2 200 consultancies have received aid.

Corrections

Digital polyphase sinewaves, by N. Darwood in the November issue, page 65, contained some misprints. The first paragraph of column 3 should read:

For a 5-phase program, N=5, and $\omega = 2\pi/5$. This makes $I = \sin 2\pi/5 - \sin 2.2\pi/5 + \sin 3.2\pi/5 - \sin 4.2\pi/5$ which totals 0.73. f may be found by selecting a step size. As the step size is I.f, suppose that we would like to make this 1°, i.e. 360 steps per cycle. I.f is then 0.075 radians and as we have established that I is 0.73, f is 0.024.

And in Table 4 the $-f^3$ and f^5 terms in the sin row should be displaced one column to the right.

Binaural recordings and loudspeakers, November issue, contains errors in the captions for Figs 2 & 11; in the last, "loudspeaker" should be for "headphone".

The transformers in the **Simple low-frequency oscilloscope** design of September were from Radio Components Specialists (see advertisement), using two 6.3V windings in series and RadioSpares, using a 4.5V transformer stock number 207267, flash tested to 2kV, for the tube heater. The author advises us that the x and y drive transistors may need heat dissipators, and that the sawtooth timing capacitor should be 10nF value. Resistors in the tail transistor base circuit should be interchanged in the x-amplifier, not the y-amplifier as given on page 77, November issue.

Logic and computer languages

If logical connectives are regarded as functions rather than operations, mechanization is simplified. Logically, all one needs to cover the field is the NAND or NOR operation. Using two computer languages Basic and Forth, some implications are examined together with some correspondences.

The very first lesson that we have a right to demand that logic shall teach us is, how to make our ideas clear; and a most important one it is, deprecated only by minds who stand in need of it. – C. S. Pierce

by Boris Allan

All that simple logic – the logic embodied in machines that perform arithmetic – can be reduced to one basic form. The two logical connectives with which we are most familiar are AND and NOT, where the compound

P AND Q

is only true if both P and Q are true, and the compound

P OR Q

is only false is if both P and Q are false. These two forms are related by De Morgan's rules

P OR Q equals NOT
(NOT P AND NOT Q)
P AND Q equals NOT
(NOT P OR NOT Q)

and so either AND or OR is superfluous, in the sense that one can be expressed in terms of the others. All one needs is NOT (i.e. NOT TRUE is FALSE, and vice versa).

The four key logical connectives are normally taken to be AND, OR, the CONDITIONAL, and the EQUIVALENCE or BI-CONDITIONAL. The compound

P EQUALS Q

is only true if both P and Q are true or if both P and Q are false; whereas the only time the conditional

P IMPLIES Q

is false is when P is true and Q is false. In other terminology, the conditional is true if P is a sufficient condition for Q. For example, if one has a monitorless computer, one must have a television, but if one has a television one does not have to have a monitorless computer. The various ways in which these connectives are related to the truth or falseness of P and Q are shown in Table 1, where 1 indicates true and 0 indicates false.

We can create our own rules to relate these other two connectives to AND and OR:

P EQUALS Q equals P AND Q OR
NOT (P OR Q)
P IMPLIES Q equals NOT P OR Q

and it is easy to see that wherever there is an AND, one could substitute the equivalent expression using OR, and vice versa. Note, however, the ubiguitous NOT, and so it seems that all is needed to construct any logical formula is one connective, and the negator (NOT). It seems that if we could in some way derive the negator from one of the connectives, we could reduce all of logic to just that one connective.

Charles Pierce found such a connective in a paper written circa 1880; a connective which meant 'neither . . . nor . . .', known usually as NOR, and is defined in one way as

P NOR Q equals NOT (P OR Q)
equals NOT P AND NOT Q

(the last from De Morgan's rules). The truth table for NOR is simple, the only time P NOR Q is true is when both P and Q are false. The possibility of a reduction was rediscovered by H. M. Sheffer in 1913, but Sheffer used a different connective which meant not P or not Q, usually known as NAND, defined by

P NAND Q equals NOT (P AND Q)
equals NOT P OR NOT Q

Table 1. Key logical connectives

P	Q	AND	OR	IMPLIES	EQUALS
1	1	1	1	1	1
1	0	0	1	0	0
0	1	0	1	1	0
0	0	0	0	1	1

Table 2. Basic logical connectives

P	Q	NAND	NOR
1	1	0	0
1	0	1	0
0	1	1	0
0	0	1	1

(see De Morgan's rules). Pierce chose his symbol for NOR "↓", called Pierce's dagger, and Sheffer used "/" for NAND, Sheffer's stroke.

Why are these two connectives so powerful? What do they have which means that they can be 'more basic' than the other connectives? If you examine Table 2, you can see that if P and Q are both true then the result is false, and if P and Q are both false then the result is true. Remembering that the use of OR or AND required the use of NOT (and NOT could not be derived from these two connectives), then when it is stated that

NOT P equals P NOR P
equals P NAND P

all you need is NAND or NOR.

To complete this section

P AND Q equals NOT (P NAND Q)
P OR Q equals NOT P NAND NOT Q
P NOR Q equals NOT
(NOT P NAND NOT Q)

or

P AND Q equals NOT P NOR NOT Q
P OR Q equals NOT (P NOR Q)
P NAND Q equals NOT
(NOT P NOR NOT Q)

and this is the reason why logical circuits can be constructed merely out of NAND or NOR gates. As NAND and NOR gates are usually the simplest gates to fabricate, and as all other gates can be derived from either of these two it is easy to see why theory and practice have – in this case – meshed. Nicod in 1917 showed that the whole of logical calculus could be based on a single axiom using the Sheffer stroke as the only symbol; and in the second edition of *Principia Mathematica* (1925) Bertrand Russell suggested that Nicod's formulation be substituted for the original formulation.

Set of basic routines

Instead of writing P NAND Q we could write NAND (P, Q) just as we write NOT(P), though often we lose the brackets in the last-mentioned case. This might seem rather pointless, but at least it emphasizes that logical connectives are really functions, functions which produce a value. The programming language Lisp

Table 3. Notational equivalences

FULL	SHORT
NAND	s
NOT	n
AND	a
NOR	d
OR	o
EQUALS	e
XOR	x
IMPLIES	i

used in artificial intelligence is a functional language, in that the language is merely a set of functions which can be used to define other functions. Lisp is – we are told – a very useful and flexible language, but not readily available on most small computers, and so I will use Spectrum Basic to obtain similar results.

Spectrum Basic differs from some other Basics in that when a function is being defined, the function can have more than one parameter (the function NAND(P,Q) has two parameters, P and Q). But as all function names can only be identified by one letter, we have to rename the logical connectives. Table 3 shows the equivalences to be used; most are self-explanatory except d for NOR (from Pierce's dagger) and s for NAND (from Sheffer's stroke), and XOR is the only new connective. XOR stands for exclusive-or and exists as a connective in some Basics, and most machine codes; XOR(P,Q) is true if P and Q differ (i.e. one is true and the other is false) and is the opposite of EQUAL (i.e. EQUAL(P,Q) is NOT(XOR(P,Q)).

To give a feel for this new form of notation, consider De Morgan's rules.

OR(P,Q) equals
NOT(AND(NOT(P),NOT(Q)))
AND(P,Q) equals
NOT(OR(NOT(P),NOT(Q)))

which shows the structure well, and then try the new one-letter method (without the brackets)

oPQ equals nanPnQ
aPQ equals nonPnQ

and finally try to relate this to the original formula

ePQ equals oaPQnoPQ

This extremely concise and readily mechanized method was invented by the Pole J. Lukasiewicz and is called Polish notation. That this method is easily mechanized is shown in List 1, which consists of a series of definitions of logical functions using NAND as the primitive functions (i.e. s, i.e. FN s). NAND is a primitive because it is the only function which has to be given a value from outside the system – in this case a simple multiplication (true is 1, false is 0). To assist in the interpretation of these functions, here they are in a more expanded form – except NAND –

```
20 NOT(P) is NAND(P,P)
30 AND(P,Q) is NOT(NAND(P,Q))
40 NOR(P,Q) is
   AND(NOT(P),NOT(Q))
50 OR(P,Q) is NOT(NOR(P,Q))
60 EQUALS(P,Q) is
   OR(AND(P,Q),NOR(P,Q))
70 XOR(P,Q) is
   NOT(EQUALS(P,Q))
80 IMPLIES(P,Q) is OR(NOT(P),Q)
```

and for those who feel that the use of a multiplication to give values for FN s(P,Q) (i.e. NAND(P,Q)) is not quite right, it is possible to substitute line 10, and add another line at, say, 5

```
 5 DIM a(2,2) : LET a(1,1)=1 : LET
   a(1,2)=1 : a(2,1)=1 : LET
   a(2,2)=0
10 DEF FN s(P,Q)=a(P+1,Q+1)
```

In arithmetic machines we would not even need to have such a definition of s (NAND) if it was wired for logic.

To calculate a truth table for a new logical formula, for example, the hypothetical syllogism

((P IMPLIES Q) AND (Q IMPLIES R))
IMPLIES (P IMPLIES R)

(If (if P then Q) and (if Q then R) then (if P then R) is a more familiar way of expressing the syllogism), we could start

IMPLIES(AND(IMPLIES
(P,Q),IMPLIES(Q,R)),IMPLIES(P,R))

and turn it into

iaiPQiQRiPR

Boris Allan . . .

is a sociologist who writes about the implications of the newer and older technologies, with special emphasis on computing. Trained as a scientist in the 1960s, he has taught at many levels from remedial maths in secondary modern schools to Fortran programming in universities. At present he lectures in the Department of Social Science, Manchester Polytechnic.

if you wish, and then – in immediate mode –

PRINT FN i(FN a(FN i(P,Q),FN
i(Q,R)),FN i(P,R))

for various values of P,Q,R.

Reversing the notation – going forth

Suppose that instead of writing the definition for equals (line 60) in a Polish notation, we reversed the notation, left out the brackets and commas, and produced

P Q EQUALS is P Q NOR P Q AND OR

in what is naturally called reverse Polish notation. In evaluating this formula (on the right-hand side) we would take the parameters in order, and as we reached a function use the parameters for that function. In this new notation the hypothetical syllogism becomes

P R IMPLIES Q R IMPLIES P Q
IMPLIES AND IMPLIES

but, we ask, to what purpose?

If the hypothetical syllogism is studied, we can notice first of all the utter simplicity (all we do is move down the line) and wonder if this simplicity could be used to some advantage, just as Lisp uses the functional form to advantage). Lisp is rarely implemented on small computers, but lately a language which uses the reverse Polish form has become reasonably common. The language is Forth, and Listing 2 is a set of basic Forth words, equivalent to functions, which covers the same ground as the program in List 1.

I will not give a detailed explanation of Forth, but I'll pick up points as I go through. Line 0 defines a new set of functions which will be called by the generic term logical, and line 1 is no more than a remark. Lines 2 & 3 define two constant values, that is true has the value 1 and false has the value 0, these values being unchangeable. Lines 4 and 5 define two words (DUP2 and UNDER2) which manipulate items on the stack – the stack is the place valves such as P or Q are stored before operating on them by the functions/words such as NAND. For example consider the hypothetical syllogism: place P and Q on the stack, and then apply the function IMPLIES leaving the result on the stack (but losing P and Q); then place Q and then R on top of the result, use IMPLIES on Q and R, another result (that is two results); do it yet again for P and Q (three results); the function AND is then applied to the top two *results* (there are no parameters to put on the stack); finally use IMPLIES on the results of the AND, and the first IMPLIES. In the colon definition

List 1

```
10DEF FN sP,Q)=1 – P*Q
20 DEF FN n(P) = FN s(P,P)
30 DEF FN a(P,Q) = FN n(FN s(P,Q))
40 DEF FN d(P,Q) = FN a(FN n(P), FN n(Q))
50 DEF FN o(P,Q) = FN n(FN d(P,Q))
60 DEF FN e(P,Q) = FN o(FN a(P,Q), FN d (P,Q))
70 DEF FN x(P,Q) = FN n(FN e(P,Q))
80 DEF FNi(P,Q) =FNo(FN n(P),Q)
```

List 2

```
SCR 201
0  VOCABULARY LOGICAL
1  ( LOGICAL CONNECTIVES BASED ON
   THE NAND RELATIONSHIP)
2  1 CONSTANT TRUE
3  0 CONSTANT FALSE
4  : DUP2 OVER OVER ;
5  : UDER2 ROT ROT ;
6  : NAND * 1 SWAP – ;
7  : NOT DUP NAND ;
8  : AND NAND NOT ;
9  : OR NOT SWAP NOT NAND ;
10 : NOR OR NOT ;
11 : XOR DUP2 OR UNDER2 NAND AND ;
12 : EQUALS XOR NOT ;
13 : IMPLIES SWAP NOT OR ;
14 : IS IF ."TRUE" CR ELSE."
   FALSE " CR THEN ;
15 ; S ( VERSION 3 )
```

(lines 6 to 14) the word being defined is the first in the string (for example NAND in line 6) and the remainder up to the semicolon defines what it is the word does – in line 6, takes the top two numbers off the stack, multiplies them together, puts a one on top of the stack, swaps the one with the result (so the result is on top), and subtracts the top of the stack from the second on the stack (i.e. subtracts the result of the multiplication from one). Apart from lines 11 and 14 the instructions should be obvious in their intent – line 14 looks at the number on top of the stack, and if it is one, TRUE is printed, else FALSE, and then the next thing is done. For example, these words would enable you to ask

TRUE FALSE IMPLIES

and be told

FALSE
OK

and in a similar manner for more complex formulae.

In the Basic listing, the order in which the functions were defined followed closely the order given in Forth. In Forth, however, NAND *had* to be defined before any other word used it, and NOT *had* to be second, because to use a word before it is defined is inadmissable. In Basics generally the order in which the functions are defined is immaterial, which means that one can define IMPLIES before one knows how to define NOT or OR (though they must be defined at some point).

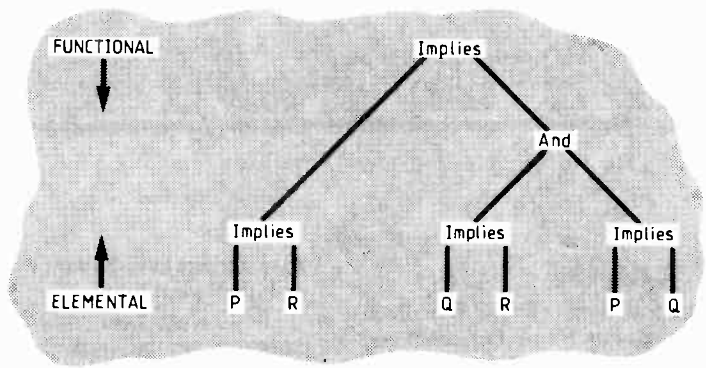
Functional v Elemental

Lisp and Basic proceed in a functional manner in the manipulation of logical connectives, exemplified in the expression for the hypothetical syllogism

IMPLIES(AND(IMPLIES(P,Q), IMPLIES(Q,R)),IMPLIES(P,R))

When coming to interpret the meaning of this expression the language analyser will encounter IMPLIES, a function it will recognise as having two parameters – it will store this information for later use, probably on a stack. The analyser will then encounter the first of the parameters, which is itself a function AND, so it stores this information, and finds that the first parameter of AND is another IMPLIES, store that away. This latest IMPLIES can operate immediately on two real parameters P and Q, and that result now becomes the first real parameter for the AND, the second real parameter is the result of IMPLIES on two parameters Q and R, and so on . . .

This is a tedious process to go through, though easy enough on a computer, and requires two stacks: one stack to store the functions, and one to store the parameters and results. In the Fig. the hypothetical syllogism is decoded into a tree, and a functional language goes through the tree from the top downwards – this is the way in which normal, non-computer languages work. It is easier to work from the bottom upward?



An elemental language such as Forth works from the bottom line upwards – see diagram for example

P R IMPLIES Q R IMPLIES P Q IMPLIES AND IMPLIES

and only needs one stack, because the user has already decoded the order in which the functions are to be applied. This is also why a word in Forth can only be defined in terms of words already known to the system; it makes it far easier for the system even if more tedious for the user.

Finally, a concrete example of the hypothetical syllogism:

IF ((If Boris then human) and
(If human then mortal))
THEN (If Boris then mortal)

EVENTS

January 4-7
Noise, its measurement, analysis and control; four-day course at the City University, Northampton Square, London EC1. Details from Dr J. S. Anderson at the University, 01-254 4399 ex. 4203.

January 5-14
Five two-day short courses on Pet/CBM microcomputers, at Department of Electronic and Electrical Engineering, University of Salford, Salford M5 4WT. Tel. 061-736 5843 ex. 248.

January 5
Microwave tube or solid state device? IEE Colloquium, Savoy Place, London WC2. Tel. 01-241 1871.

January 6
Seeing with long-wavelength eyes. 18th Appleton Lecture by Prof. A. P. Anderson. IEE, Savoy Place, London WC2.

January 7
Superconducting generators. IEE/IoP Colloquium at 14.00h, Savoy Place, London WC2.

January 10
Non-linear control system design techniques in attitude control. IEE Colloquium, 10.30h, Savoy Place, London WC2.

January 11
Reliability of automotive electronic systems and components. IEE Colloquium, 17.30h, Savoy Place, London WC2.

January 11
Electronic revolution comes to your car. IEE Lecture by M. H. Westbrook, 19.30h, SEB, Waterloo Road, Uxbridge, Middlesex. Details from R. M. Bennett, Tel. 01-567 5621.

January 12
Short range communications systems and techniques. IEE Colloquium, 17.30h, Savoy Place, London WC2.

January 12
Higher definition graphics for UK teletext. IEE Lecture by D. Brockhurst and M. Dyer, 17.30h, Savoy Place, London WC2.

January 12
Field emission of ions from liquid metals. IEE Discussion Meeting, 14.00h, Savoy Place, London WC2.

January 12
Telecommunicate or travel. IEEIE Lecture by R. C. Smith, 19.00h, Oxford Polytechnic, Headington, Oxford. Details from IEEIE 01-836 3357.

January 13
Man/machine interface using GKS, the new graphical standard. IEE Colloquium, 10.30h, Savoy Place, London WC2.

January 13
Computer recognition of speech. IEE younger members' lecture by R. Bell, 19.00h, at Marconi Avionics, Airport Works Site, Rochester, Kent. Details from G. F. Simms, Tel. 0444 457301 ex. 31.

January 14
Testing custom devices. IEE Colloquium, 17.30h, Savoy Place, London WC2.

January 17-21
Visodata 83, Audio visual media and data systems for education and communication. Congress and exhibition. Details from Münchener Messe- und Ausstellungs GmbH, Messegelande, Postfach 12 10 09, D-8000 München 12, Germany.

January 18
The Photon Connection. IEE Faraday Lecture presented by STC. Kelsey Kerridge Sports Hall, Cambridge. Two presentations, 10.30h and 19.00h.

January 18
Millimetre waves. IEE Colloquium, 17.30h, Savoy Place, London WC2.

Radio in cells

The recommendation of the Merriman Committee that the Home Office should make available to the land mobile radio services virtually all of the prime international television broadcasting v.h.f. bands seems oddly out of phase with the current developments in the advanced "cellular" systems for mobile radio. Within a few years these will be exploiting the very large chunks of spectrum space made available for the mobile services at WARC 1979. Using the more advanced techniques now being planned, the spectrum above 860 MHz can provide two-way communications for hundreds of thousands of users.

Indeed if the present applications to develop large cellular systems are granted, there will be room for vastly more two-way mobile communications than by expanding the current private mobile radio channels using individual base stations working on fixed channels to relatively modest numbers of mobiles over ranges up to about 20 to 35km. Several British firms and consortia, including British Telecom/ Securicor and Air Call, intend to operate large cellular systems. Motorola say they will manufacture suitable equipment at Basingstoke.

Overseas, considerable experience of cellular systems has been gained both in the field trials run by Bell Laboratories in Chicago since about 1978 for AMPS (Advanced Mobile Phone Service) and the operational system made by NEC for the Japanese telecommunications agency NTT in Tokyo. Another contender is the Nordic Mobile Telephone system.

Claimed in 1980 as the "world's first cellular system", the Japanese system uses a number of base stations sited in regular cells or lattices throughout the city and suburbs of Tokyo using frequencies above 800MHz. Each base station is designed to have coverage to about 10km in the suburbs. Initially the service covers 23 districts of Tokyo.

The distinctive feature of all cellular systems is that they are arranged so that a vehicle remains linked to the normal telephone system with coversations continuing virtually uninterrupted when the vehicle crosses a cell boundary and is automatically re-assigned new frequency channels. Unlike the long-established "extended-coverage" systems on v.h.f./a.m. and frequency off-sets, the base stations operate on entirely different frequencies.

In the NTT system the vehicles automatically transmit location registration signals which are stored at the electronic switching centre (that is to say the mobile telephone exchange) so that vehicles can be called selectively by the base station in the cell in which they are actually travelling. Base stations have 25 watt transmitters and mobiles 5 watt units.

The Chicago field trials of AMPS were based on ten cells covering about 2100 square miles of downtown and metropolitan area of Chicago. The system was tested by about 100 Bell System employees over a period of several years. When a vehicle crosses a cell boundary a command signal from the switching centre reassigns the channels, making full use of microprocessors and fast-acting frequency synthesizers.

The attraction of cellular or lattice systems from the viewpoint of frequency spectrum management is that the use of u.h.f. in compact areas permits the use of the same radio channel many times over within a single large city, allowing much more intensive use of the spectrum.

Spectrum saving

Cellular techniques for improving spectrum use also form a crucial part of the 10.5GHz microwave multipoint local distribution plans for the Mercury digital network being set up in the UK for voice and data transmission for business users. For the 2Mbit/s cellular networks within cities, digital equipment is being supplied by Telettra of Italy. The main Mercury inter-city networks will make use of digital fibre optics. Two main cable rings based in London, Birmingham and Bristol in the south of England, and Leeds, Manchester and Liverpool in the north, together with expected satellite links to North America form part of this first major "private" telecommunications network.

There can be little doubt that UK mobile radio is still far from the end of its growth potential. By 1980 there were some 15,300 p.m.r. licences covering 18,500 base stations and over 260,000 mobile units, with a growth rate of about 10% a year. For comparison, over 350,000 c.b. licences were issued in its first year, each covering a maximum of three units, and with a large number of non-licensed users. Although British industry appears to have largely abandoned hopes of competing with imported 27MHz equipment, a 934 MHz transceiver, priced at about £250, is being marketed by a Mildenhall firm.

The Merriman Committee interim report dismisses the value to mobile radio frequencies above 600 MHz and curiously makes no reference to the potential of cellular systems, using frequencies internationally available to the land mobile services. Key factor seems to be price; for a small organisation making heavy use of two-way radio in a local area it is still usually cheaper to run an independent base station – but wasteful of spectrum.

Careers in e.m.c?

It was probably the coming of v.h.f. television in the 1930s that first really brought to prominence the many problems of what has now become known as electromagnetic compatibility or e.m.c. – basically the difficulty of mixing together different types of electrical and electronic equipment without creating mutual problems. Topics that come together nowadays to form the "buzz" topic of e.m.c. are ignition interference, suppression of radiation from electrical motors and thermostats, harmonic radiation or direct breakthrough from local transmitters, simultaneous operation of transmitters and receivers from the same ship or vehicle or site, close proximity of complex electrics in spacecraft effects of the electromagnetic pulse (e.m.p.) following a nuclear explosion in the upper atmosphere, protection against lightning and other transient overvoltages, effective shielding or screening of equipment, and biological responses to non-ionizing electromagnetic radiation. Already you can make a career of being "an electromagnetic compatibility specialist engineer".

As might be expected this new discipline already has its own international conference circuit. I am reminded, for instance, that the fifth symposium and technical exhibition on electromagnetic compatibility is being held at Zurich on 8-10 March, 1983 with a formidable three-stream presentation of no less than 110 high-level scientific and technical papers plus five workshops. In an opening session on the "environment" the Polish Institute of Telecommunications is to report on an m.f. composite radio noise survey in Poland; Sheffield University has a paper "Ariel-4 observations of power-line harmonic radiation over North America and its effects on the magnetosphere"; followed by a Japanese university paper on "charge neutralization for a space shuttle" and a Canadian paper "Impact of lightning beams on a tall structure". Sessions on interference models, propagation and wave coupling, nuclear e.m.p., biological effects of exposure to r.f. radiation, power electronics, e.m.i. in microelectronics, spectrum management are all included in this crowded three-day event. Indeed one can think of very few people in communications and electronics whose work is not affected by one or more of these topics. And that is where questions begin to rise – should we encourage an all-embracing topic such as e.m.c. to become a highly specialized discipline of its own? Or would it not be better to aim at greater awareness of e.m.c. among all design engineers? Many of the current problems in consumer electronics, for instance, have known solutions, but still appear to be disregarded. When these excellent Swiss conferences began e.m.c. was still considered an integral part of electronic design. It would be a pity to see them becoming too specialised or too academic.

Too public a key?

Some time ago, I surveyed developing techniques for message and data encryption, highlighting the furious debate that arose over the security of the National Bureau encryption standard ("Electronic cryptography", September 1980 issue, pages 44-9). Based on a non-linear algorithm, 56bit main key, 18 data manipulation stages and 16 internal coding keys, it was generally considered that a 56-bit key – though secure for normal commercial purposes – could not be regarded as computationally secure against a really determined attack.

The alternative, and then still not fully developed, "public-key" systems were being advocated as providing greater security, as well as offering considerable operational advantages not available from more conventional systems.

Since then public-key systems have begun to be marketed amidst a growing spate of suggestions that not all are as secure as originally thought. A recent issue of *Electronics Letters* (14 October 1982) contained a strong warning from Belgium in respect of the Markle-Hellman public-key knapsack algorithm, including doubts whether there are useful knapsacks or conversely whether all useful knapsacks can be cracked. As long as this question is not answered positively the use of the knapsacks, even with interative transformations, is not recommended for cryptography. The same issue however included a new fast decipherment algorithm for RSA public-key systems from Philips in Belgium, and also a technique for the implementation of digital signatures for RSA from Israel. A. Shamir, the "S" of RSA has also raised the question of breaking the Merkle-Hellman cryptosystems. There does now seem a cloud over some of the public-key techniques.

In Brief

US Navy is to renew development of e.l.f. systems for communicating with submarines using a 28 mile underground aerial and a new 56 mile above-ground aerial. Previous work was halted when residents complained of possible radiation hazards . . . RCA have developed the first commercial communications satellite with a solid-state transponder. Each of 28 transponder amplifiers has an output of 8.5watts from gallium arsenide devices . . .

AMATEUR RADIO

Incentive licensing

An increasing number of British amateurs feel that the licensing system in the UK does not encourage licensees to continue theoretical or practical study of communications technology beyond the level required to obtain a pass mark in the Radio Amateur's Examination, as currently administered by the City & Guilds of London Institute. Formerly, home construction of transmitters and ancillary equipment, with the subsequent problems of debugging and maintaining them, meant that many amateurs not employed in the electronics industry acquired considerable practical know-how, to a degree not necessarily acquired in operating factory-built and professionally-serviced equipment.

While formerly most amateurs favoured the British once-and-for-all type of examination, today more are prepared to consider seriously the various incentive systems found in many overseas involving graded examinations that provide additional frequencies and facilities.

In the USA for example there are five grades: novice, technician, general, advanced and extra classes each requiring technical examinations at different levels. In the USSR many listeners begin by operation of club stations, but many obtain a "novice" licence for c.w. s.s.b. and a.m. on 1850-1950kHz with not more than 5watts input (EZ prefix). Such a licence can be obtained at 14 years of age. At 16 they can apply for a v.h.f. licence for all bands above 30MHz (in practice 144MHz upwards) but also covering 1.8 and 28MHz (R prefix). Neither novice nor v.h.f. licence involves a Morse test although one finds many R prefix stations using c.w. on 28MHz often with good operating standards. For the main h.f. licences there are three separate categories involving different restrictions on power, bands and modes. The first-class licence covers all h.f. bands but requires special permission to use r.t.t.y. Power limit is 200 watts input. Another grade has a power limit of 40watts.

A feature of the Russian system is that examinations are taken at the nearest regional radio club where "qualification commissions" consists of experienced local amateurs selected by the local radio sports federation. It is even possible to become a "Master of Sports of the USSR" via amateur radio contests! The problem of how accurately to judge true "champions" is currently the subject of much earnest debate. There can be little doubt that the Russian system is designed to encourage both technical and operating skills. A great deal of Russian amateur equipment is home-built, often to designs in *Radio* magazine – but one also has the impression that considerable store is set on building up a large reserve of first-rate cw operators. Indeed, despite the number of articles having political or military orientation in Russian and East European radio journals, it often appears that this part of the world is closest to the traditional interests of amateur radio.

RSGB move

After almost 40 years in Bloomsbury, central London, first in Little Russell Street and then in Doughty Street, the RSGB has moved its headquarters to larger premises at Alma House, Cranborne Road, Potters Bar near Barnet, Herts (Potters Bar 59015). In its annual report to June 30, 1982 the Society records a membership increase of about 10% from 29,337 to 32,215. However there were signs that as the year ended the rate of increase is falling, with a higher than usual drop-out rate perhaps reflecting the economic recession.

Here and there

The Ariel Radio Group, comprising radio amateurs working for the BBC, is currently celebrating the 50th anniversary of the start of BBC External Services on 19 December, 1932. Club stations using the special callsigns GB2BBC, GB3BBC and GB8BBC are all working from central London, G3BBC in west London and GB4BBC from Caversham, near Reading throughout December.

In filing application with the FCC to operate two geostationary communications satellites an American firm, Cablesat General Corporation, is proposing to include an amateur radio network transponder in each satellite. Uplink frequency about 5.65MHz, downlink about 3.4GHz. North American amateurs with 2m dish aerials and 10watt r.f. power would be able to work through the satellites. APRL have been asked to co-ordinate their use. If the FCC approves application a 1985 launch is planned.

SA-AMSAT has been conducting the balloon tests to obtain practical experience in airborne transponders and telemetry beacons and this project is not directly concerned with possible future satellite projects.

PAT HAWKER G3VA

Two-metre transceiver

These two sections of Tim Forrester's multi-mode transceiver are frequency demodulation and synthesizer modules. A further circuit diagram – for the power section constituting module 3 – concludes last month's article.

by T. D. Forrester, G8GIW

Rounding off last month's article, the circuit below shows the main power supply and transmitter output stage of module 3. Some modules have their own regulators fed from the main supply on this board.

Module 4, the f.m. i.f. section, has the smallest board but carries out the following functions,

- f.m. signal demodulation
- s.s.b./f.m. gate and squelch
- S-meter drive for f.m. receive
- noise-blanking on s.s.b.
- audio power amplification
- s.s.b./f.m. routing to the audio power amplifier.

Despite the number of functions the board carries out only one adjustment is required, for the f.m. discriminator. With the exception of the LM380 a.f. power amplifier, IC_{402}, the circuit is fed from a TO92-packaged 8V regulator, IC_{405}.

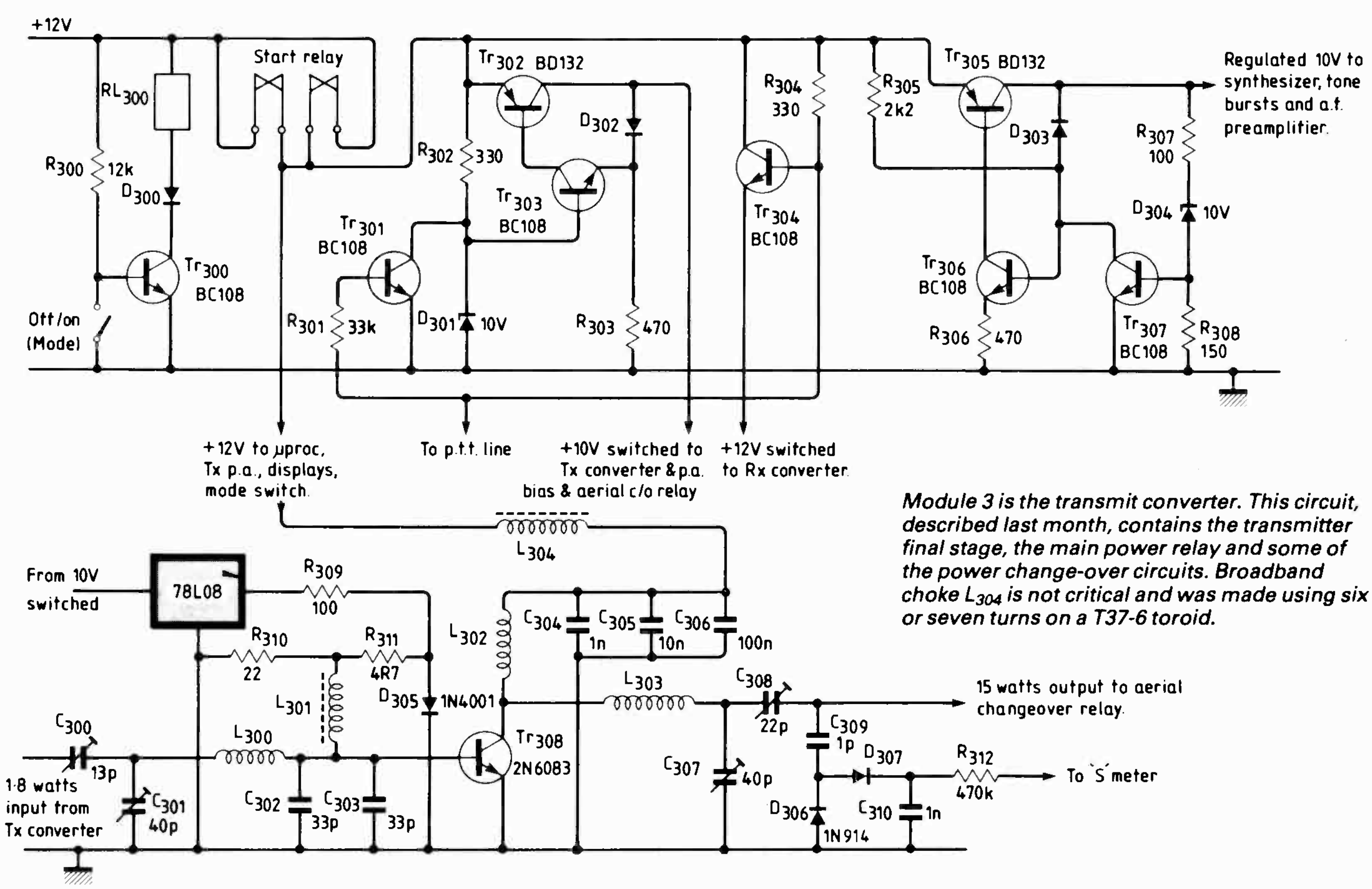
An SL6600, IC_{400}, carries out f.m. demodulation. This device has a mixer to convert 9MHz down to around 100kHz and provides adjustable squelch but requires no tuned circuits. The squelch output on pin six of this i.c. goes low when the phase-locked loop f.m. demodulator locks; the signal-to-noise ratio at which it locks is determined by a mute control on the front panel. Fast time constants of this device allow it to be used for both f.m. and s.s.b. muting.

In the prototype, a 9.09MHz crystal was used for the second conversion oscillator giving a second i.f. of 90kHz. The p.l.l. f.m. demodulator is set to 90kHz by adjusting C_{404}. Around 100kHz is preferred for the second i.f. although limits are between 80 and 500kHz. Choosing a frequency other than 90kHz will mean that the timing and loop-filter components $C_{403,404,405}$ and $R_{400,401}$ will have to be changed.

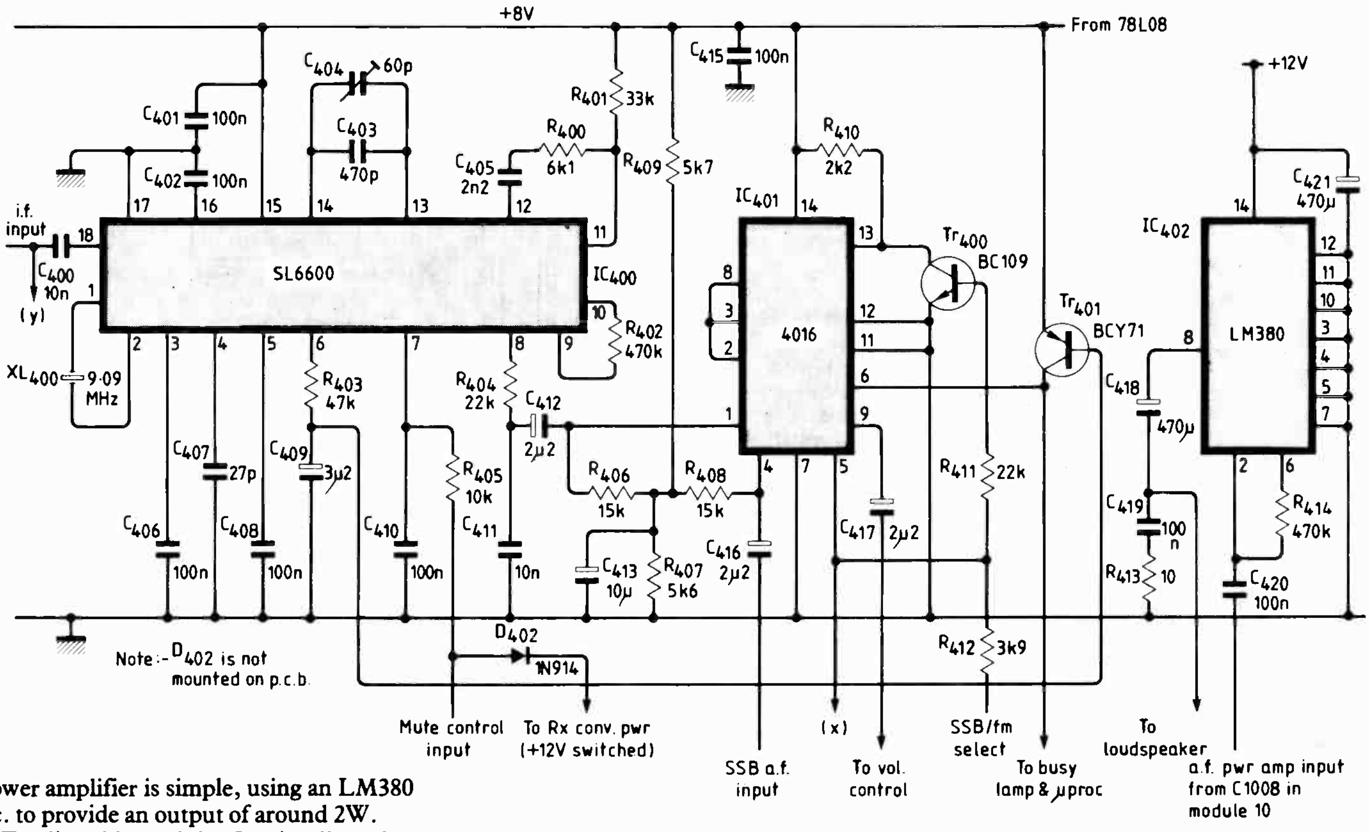
Only three parts of the quad analogue switch, IC_{401}, are used. Two form a single-pole change-over to select the source for the a.f. power amplifier and the third is used as a squelch gate to cut off the audio output when no signal is present.

The receive-converter input signal on 9MHz is split two ways on this board; part of the signal is fed to the f.m. demodulator and the rest goes to a 9MHz r.f. amplifier consisting of $IC_{403,404}$, then to a diode rectifier, $D_{400,401}$, used to convert the r.f. signal into d.c. to provide this amplifier's a.g.c. and to drive the S meter.

When s.s.b. is selected, Tr_{402} drastically shortens the time constant of the f.m. S meter and s.s.b. noise blanker feed and the output is used to drive the receive-converter noise blanking gate. The a.f.



Module 3 is the transmit converter. This circuit, described last month, contains the transmitter final stage, the main power relay and some of the power change-over circuits. Broadband choke L_{304} is not critical and was made using six or seven turns on a T37-6 toroid.



power amplifier is simple, using an LM380 i.c. to provide an output of around 2W.

To align this module, C_{404} is adjusted to obtain the best audio quality. If the busy lamp (to be discussed) will not light, i.e. the f.m. demodulator will not lock, the v.c.o. frequency may be adjusted by changing C_{403} and fine tuned by changing the value of R_{402}.

Any quartz crystal of around 27.3MHz working at its fundamental frequency of near 9.09MHz should be suitable for the second conversion oscillator. In the prototype a 27MHz crystal intended for remote-control applications was used.

A diode, D_{402} is connected between the power feed for the receive converter and the mute-control input to mute the receiver immediately after the transmitter is switched on.

Part of module 4 – f.m. i.f. mute and a.f. switching circuits with the audio-power amplifier. IC_{400} carries out f.m. demodulation and IC_{401}, a quad analogue switch, forms two single-pole change-overs to select the audio source, and a squelch gate. The fourth gate is not used.

Synthesizer logic – module 5

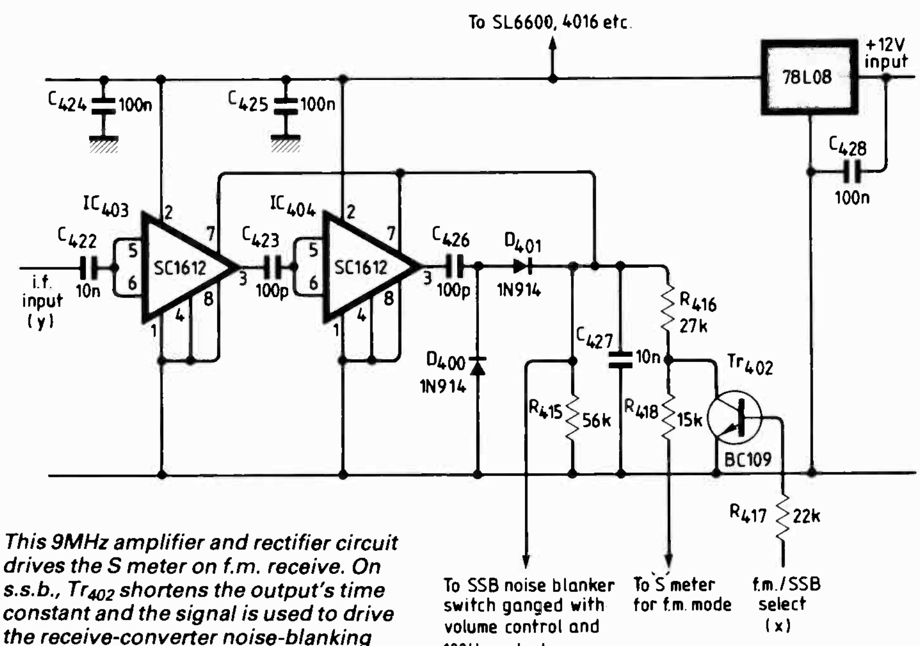
This module is designed around an SAA1058 32/33 prescaler and SAA1056 (Mullard) or LN1031 p.l.l. synthesizer which is a dual-modulus device with serial control. As the 1058 is only guaranteed to 125MHz, a further faster e.c.l. device, the MC10231 dual flip-flop, divides the incoming signal by two.

SAA1056 is a programmable divide-by-N counter, with reference oscillator and programmable divider, phase comparator and lock detector, currently costing under £5. To program the SAA1056, a 17-bit serial-data word with clock and a DLEN signal are necessary; this presents no problem due to the microprocessor controller.

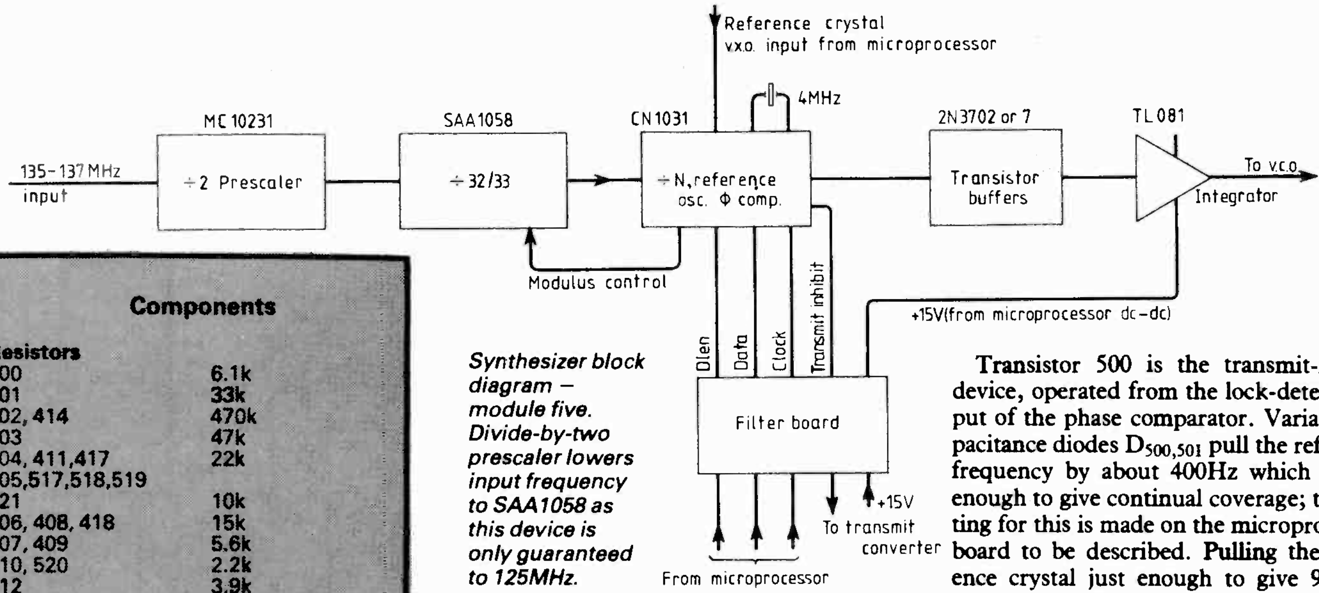
The synthesizer works in 10kHz steps at 135MHz, with a means of pulling the reference oscillator to give continual coverage in 100Hz steps. Since a divide-by-two pre-scaler preceeds the main programmable counter, the reference frequency in the SAA1056 is 5kHz. With a 4MHz reference crystal it is necessary to divide by 800 by setting the reference-select input, pin 3, to a 1 (+5V) on IC_{502}, and the reference-control bit to a 0 (0V). Through changing these two signals it is possible to select any of four dividing ratios shown in the table.

The output of the SAA1056 phase comparator is buffered by $Tr_{501,502}$ while IC_{503},

Control bit	Reference select	Dividing ratio	Reference frequency (kHz) with 4.00MHz clock
1	1	100	25
1	0	400	10
0	1	800	5
0	0	8000	0.5



This 9MHz amplifier and rectifier circuit drives the S meter on f.m. receive. On s.s.b., Tr_{402} shortens the output's time constant and the signal is used to drive the receive-converter noise-blanking gate.



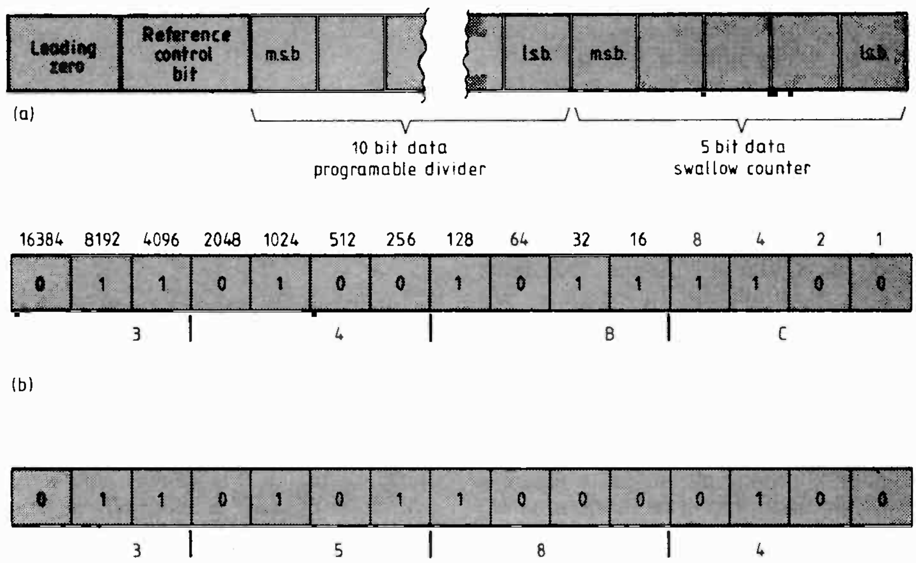
Synthesizer block diagram – module five. Divide-by-two prescaler lowers input frequency to SAA1058 as this device is only guaranteed to 125MHz.

Components	
Resistors	
400	6.1k
401	33k
402, 414	470k
403	47k
404, 411,417	22k
405,517,518,519 521	10k
406, 408, 418	15k
407, 409	5.6k
410, 520	2.2k
412	3.9k
413	10
415, 523	56k
416	27k
500, 502, 505, 506 513	1k
501	13k
503, 504	560
507	100
508,509	3.3k
510, 511, 516, 522	12k
512	10M
514, 515, 524	100k
all 1/4W, 5%	
Capacitors	
400, 411, 422, 427 503, 505, 508, 510 513	10n disc
401, 402, 406, 408 410, 415, 419, 420 424, 425, 428, 506 507, 509, 515	100n disc
403	470p
404	60p trimmer
405	2.2n disc
407	27p disc
409, 412, 416, 417	2.2µ tantalum, 15V
413	10µ tantalum, 15V
414	not used
418, 421	470µ electrolytic, 16V
423, 426, 511, 512 500, 501, 502, 504 514	100p disc
	1n disc
516, 519	22µ tantalum, 16V
517	4.7µ tantalum, 16V
518	47n paper
Transistors	
400, 402, 500	BC109
401	BCY71
501	2N3702
502	2N3707
Diodes	
400, 401, 402	1N914
500, 501	MV1650 varicap
Integrated circuits	
400	SL6600
401	4016
302	LM380
403, 404	SL1612
405	78L08
500	MC10231
501	SAA1058
502	LN1031
503	TL081
504	7805
Crystals	
400	9.09MHz HC18U or near frequency
500	4MHz HC18U
Transformer	
500	2 turns primary, 7 turns secondary on T37-12 toroid
Inductors	
500, 501, 502, 504	10µ sub-min. fixed
503	47µ sub-min. fixed

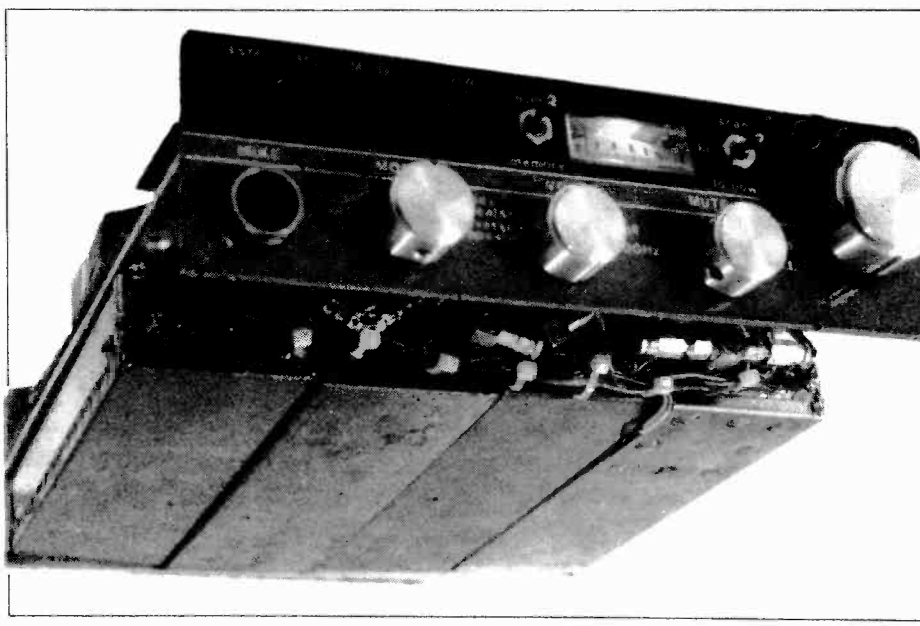
$R_{520,523}$ and C_{518} form the loop filter. Input current required by the TL081 is much lower than that required by the 741 usually used, resulting in more effective filtering of the reference frequency.

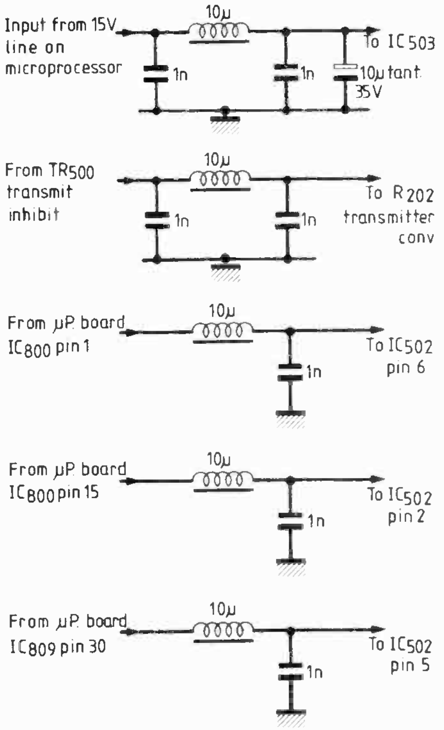
Transistor 500 is the transmit-inhibit device, operated from the lock-detect output of the phase comparator. Variable-capacitance diodes $D_{500,501}$ pull the reference frequency by about 400Hz which is just enough to give continual coverage; the setting for this is made on the microprocessor board to be described. Pulling the reference crystal just enough to give 9.9kHz shift at 135MHz results in the synthesizer being pulled too much at 137MHz due to n in the loop changing but this is not a problem in practice.

Emitter-coupled logic i.cs draw considerable current so the 5V regulator, IC_{504},



To produce 135MHz, the synthesizer is programmed with a 17-bit word, (a). The first binary word for 67.5MHz (though a divide-by-two prescaler) divided by 5kHz shown in (b) is for 135MHz and the second for 137MHz.





The filter board was mounted on the lid of module five's metal case directly above the synthesizer control logic. These components do not appear in the list.

should be mounted off the p.c.b. on the side of the metal case; the tab of this device is 0V so an insulating washer is not required. The TL081, IC_{503}, is powered with a 15V supply from the microprocessor board to allow an output swing of around 13V.

For the synthesizer i.c. to produce 135MHz, it needs to be programmed with a 17-bit binary word as shown in the diagram.

For example to produce 135MHz, then as the swallow counter sees 67.5MHz, due to the divide-by-two prescaler, n needs to be 67.5MHz/5kHz=13500

Note that the 5kHz is the channel spacing divided by two. Although there are two separate counters in the device, as shown above, it is convenient to consider them as one 15-bit counter.

So, to cover from 135-137 MHz only the 9 least significant bits needs to change, and this fact is used to advantage in the microprocessor, which also drives the control lines of the synthesizer.

The threshold of IC_{500} is adjusted by R_{501}, to set the input at about mid-logic level so any signal coming in from the v.c.o. through T_{500} will toggle this device; ideally an e.c.l. pre-amplifier could be used here, but due to size restriction this is not possible.

Data inputs to the synthesizer (Data, Clk, Dlen), along with the regulated +15V feed and the transmit inhibit line, all pass through a filter board, which is attached to the lid of the metal box. This is necessary to give greater filtering, and due to lack of space on the end of the metal box for usual 1000pF lead-through capacitors.

LITERATURE RECEIVED

The Electronic Industries Association catalogue of EIA and JEDEC Standards is available in the UK from American Technical Publishers Ltd, 68a Wilbury Way, Hitchin, Herts SG4 0TP. WW 400

Thyristors and triacs in TO-220 packages is the self-explanatory title of a short-form catalogue from Siemens Ltd, Siemens House, Windmill Road, Sunbury-on-Thames, Middlesex TW16 7HS. WW 401

Programming roms is explained in a booklet from Data IO. Various devices are described in some detail, which makes it a useful reference source as well as the data range of apparatus for rom programming. Booklet is available from Microsystems Services, 11 Duke Street, High Wycombe, Bucks HP13 6EE. WW 402

SEI publish a list of feerrite cores and accessories which gives their equivalents for the Mullard range. Salford Electrical Instruments Ltd, Times Mill, Heywood, Lancs. WW 403

Handbook for television subtitles, 2nd edition, published by the IBA in association with Oracle Teletext and the University of Southampton includes experiences gained from regular Oracle subtitling and the occasional subtitling of live programmes. Results of further research at Southampton by Robert Baker and Andrew Lambourne are included (WW News, September 1981). The Handbook is available free from IBA Engineering Information Service, Crawley Court, Winchester, Hants SO21 2QA. WW404

Catalogue of Babani Books oincludes something for nearly everyone in electronics, from the beginner to some useful reference books such as books of transistor equivalents and substitutes, and one on the 6809 microprocessor. Bernard Babini (publishing) Ltd, The Grampians, Shepherds Bush Road, London W6 7NF. WW405

The MEDL Microwave Materials and Components, catalogue has nine sections including coaxial and wave-guide circulators and isolators; waveguide loads, gaskets and load transitions; ferrite and dielectric materials; substrates; and ferrite Torriductor cores. Marconi Electronic Devices Ltd, Doddington Road, Lincoln LN6 0LF. WW 406

Lane Components Catalogue is in two sections, the first deals with fuseholders, fuse links, potentiometers, ferrites and resistors, but the second, and longer, is entirely devoted to connectors from a variety of manufacturers and includes a large number of multi-pin and edge connectors. F. C. Lane (Components) Ltd, Slinfold Lodge, Horsham, W. Sussex RH13 7RN. WW407

Two design catalogues for mosfets are available from Siliconix. One deals with the Mospower range and the other with fets in general. Both include data sheet specifications and application notes. Siliconix Ltd, Morriston, Swansea SA6 6NE. WW408

Cranfield Product Engineering Centre, part of the Cranfield Institute of Technology, has designed or redesigned a number of products which have led to reduced costs or improved sales. Their service and facilities are outlined in a glossy brochure from CPEC, Cranfield, Bedford MK43 0AL. WW 409

Equivalents for a wide range of Motorola linear i.cs are listed in a booklet which gives direct replacements having identical connections, packages and electrical characteristics. Also listed are 'similar' replacements which may differ in package, pin connections or specification, but perform an equivalent function. Booklet compiled by Axion Electronics Ltd, Turnpike Road, Cressex Estate, High Wycombe, Bucks HP12 3NR. WW 410

Consumer Integrated Circuit Handbook is a collection of data sheets for all the Plessey i.cs used in radio, tv and for remote control. The 220-page book is available from Plessey Semiconductors Ltd, Cheney Manor, Swindon, Wilts SN2 2QW. WW 411

Educational kits from simple circuitry to microprocessor applications are described in a catalogue from ELE Ltd. They use plug-in breadboards for the components in a series of modules which lead the student to complex analogue or digital circuits. Educational Division, ELE Ltd, Eastman Way, Hemel Hempstead, Herts HP2 7HB. WW 412

The Register of Engineering Designers has been launched by, but will be independent from, the Institution of Design Engineers. It is intended to list those engineers who "by their skill, creativity, knowledge and experience, should be recognised as being at the spearhead of this nation's drive to create wealth and prosperity for the continuance of our culture and way of life . . . it is not an endorsement or recognition of institutional membership or of qualifications obtained, academic or otherwise". Institution of Engineering Designers, 'Courtleigh', Westbury, Wilts BA13 3TA. WW 413

Modular preamplifier

The first two parts of this article (October and November) described the basic system, tone controls, filters and a head amplifier. This part continues the development into a complete unit, including the 'scratch' reducer

by J. L. Linsley Hood

THE first two sections of the article described the general philosophy of the design and the major circuit modules such as the gramophone pick-up equalization and the tone-control circuitry. There remain, however, several other parts of rather more specialized interest which I will deal with now, together with some comments on points which arose during the building of the prototype.

Microphone amplifier

Having the facility to mix the several inputs to the preamp. leads to the possibility of, for example, adding a spoken commentary to a tape accompaniment to a slide show, in addition to the more straightforward possibilities of taping direct from microphone. A low-noise microphone amplifier makes a very useful addition to the system in such cases.

Although a balanced-input circuit, using an input long-tailed pair as in the RIAA circuit, offers the possibility of a very low-distortion configuration, a straightforward single-transistor input arrangement can give very acceptable results, and I have shown such a circuit – very similar in general form to that which I had described in an earlier cassette recorder[3] but with one or two small changes, aimed mainly at reducing intermodulation effects due to wide-bandwidth noise components – in Fig. 17. This fits easily on to small printed-circuit board, which can be mounted close to the microphone input terminals. In the prototype preamp., these are mounted on the bottom left of the front panel so that the incoming cables shall be as convenient as possible to the right-handed person. I have also chosen this as the main chassis earthing point, to lessen the possibility of mains 'hum' pick-up at this very sensitive point.

A four-pole change-over switch is used to route the output of the microphone amplifier into aux.2 input, and to earth the inputs to both channels when the mic. amplifier is not in use: two gain options (×50 and ×100) are provided by the switch S_{32}. If different gain levels are more appropriate to the microphones in use, R_{87} is adjustable over the range 10-100kΩ without ill effect. The output trimmer pots $PR_{7a\text{-}b}$ are provided to allow the d.c. output level to be set sufficiently close to 0V to permit switching without clicks. The t.h.d. of the circuit is less than 0.03% at the threshold of clipping (approx. 10V r.m.s.) and the equivalent input noise resistance is around 700 ohms, which should be entirely adequate for this application. The current consumption is of the order of 3mA/channel.

Moving-coil head amplifier

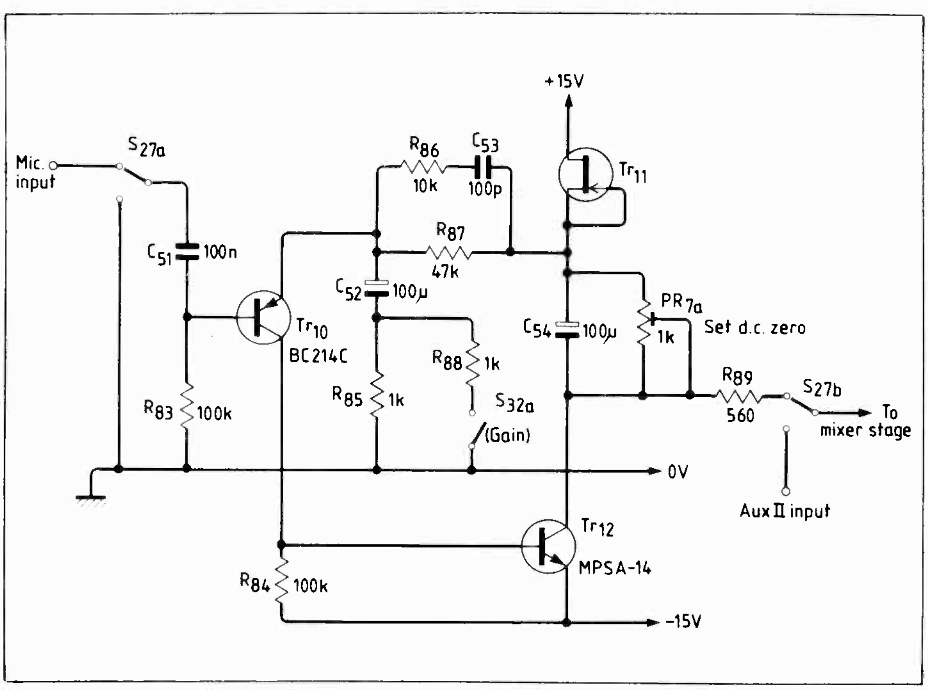
There is a growing preference among the seekers after perfection in the reproduction of gramophone records for moving-coil type pick-up cartridges as the input transducer. From personal observation, the reason for this preference appears to be a somewhat greater dynamic channel separation, which leads to a rather more 'three-dimensional' quality to the reproduced sound. Also, there is undoubtedly a greater difference in sound quality between differing makes of pick-up cartridges than there is, say, between different power amplifiers of comparable quality, and some of the m.c. pickups are indeed very pleasing to listen to.

However, by comparison with the normal moving-magnet or variable-reluctance type of cartridge, the normal m.c. unit has a very low output signal voltage, typically in the range 50μV to 200μV/cm/s groove modulation velocity, and require a low output load impedance – typically 50 ohms. For these reasons, some form of 'head amplifier' or step-up transformer is normally required as an interface between the m.c. cartridge and the RIAA input stage of the amplifier. Transformers can be quite good, and offer the lowest noise alternative, but they are often prone to induced mains hum pickup problems, and are felt by some to give some loss of musical detail.

To be adequate in this application, a separate head amplifier should have an input noise resistance which is preferably less than 30 ohms. Since a typical small-signal transistor, in an optimized circuit configuration, would have an equivalent input noise which is probably around 300 ohms, one early approach to the solution of this problem was to design the input stage so that there were ten (or more) input transistors connected in parallel, each with its own input capacitor, emitter and base bias networks. However, this seemed a rather clumsy way of resolving the difficulty, and recent designs have, in general, relied on the use of single transistors having an adequately low effective input-noise resistance. In this context, it will be found that many of the 4-5 ampere medium-power transistors in the TO-126 and TO-220 encapsulation make very satisfactory input devices for this type of circuit, though some experimentation to determine the best value of collector current is worthwhile if this area is explored.

The circuit shown in Fig. 18 is based on the use of a Motorola BD435, and the measured input noise resistance, with the input shorted, was within the range 20-25 ohms, at the maximum (×60) gain setting. The lower gain (×30) is selectable by the switch S_{28} and will probably be appropriate for most of the m.c. cartridges in the upper range of output levels. T.h.d. of this circuit is of the order of 0.03% at 100mV r.m.s. output, and very much less than

Fig. 17. Microphone amplifier.



this at the typical output levels in use. Very great care is necessary in the layout of the wiring to this unit, from the input sockets to the selector switch, and thence to the head amp. board, if 50Hz induced hum is to be avoided. This will manifest itself as a hum-free output when the inputs are open but an annoying buzz when the low impedance cartridge is connected across these. The simplest answer would be to make the unit a separate add-on assembly, but it is practicable to build it in, if care is taken with the layout.

For similar reasons, and also to avoid including any unwanted noise currents in the input circuit, it is strongly recommended that single-point earthing is used, and a suitable p.c.b. layout is shown in Fig. 19. The input 5V regulator prevents supply-line signal components from causing difficulties at the high-gain RIAA stage input. Because of the very low circuit impedances, no specific screening is necessary, though prudence suggested, in the prototype, that it should be mounted on the far side of a vertical metal plate from the remainder of the preamp. circuitry.

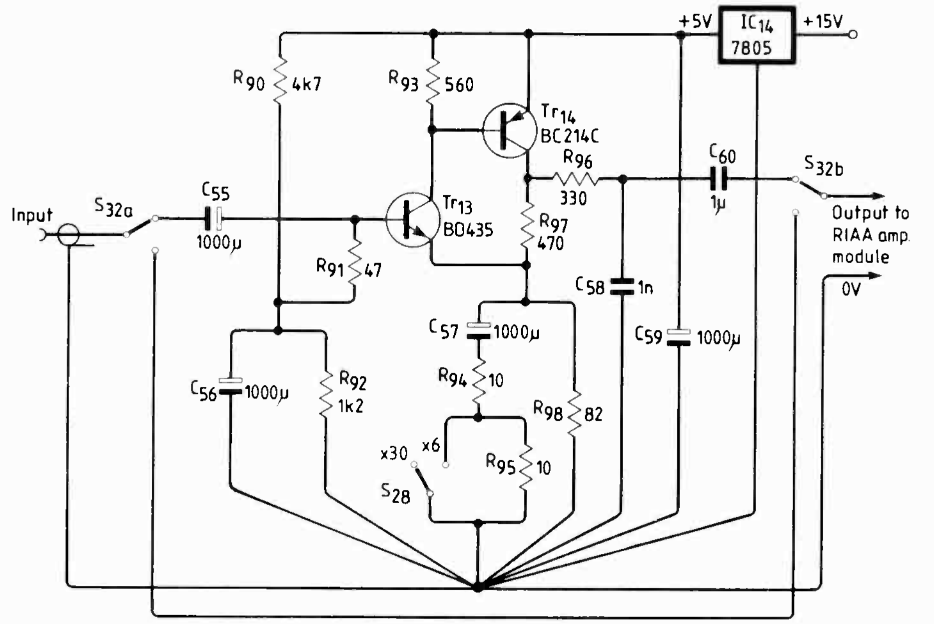


Fig. 18. Moving-coil pickup head amplifier. See text for advice on wiring.

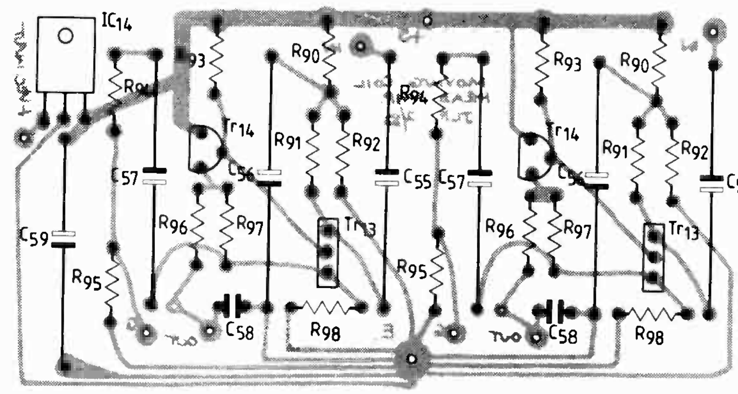


Fig. 19. Board layout for circuit of Fig. 18.

Stereo image-width module

It has been argued in these pages[4] that for the optimum enjoyment in headphone listening some degree of blending of the two stereo channels is desirable, and there are other circumstances, such as the transfer of an original 'stereo' signal on to a single track of tape, where some mixing is necessary. There are many ways by which this could be done, but the circuit arrangement of Fig. 20(a) will work, and will give unity at all settings, and also a constant, low, output impedance.

The thought has long been in my mind that it would be an interesting experiment to try to enhance the image separation between a pair of stereo channels, in that this might make the same difference as an extra amount of money spent on a more carefully engineered pickup cartridge. The rather sinful thought was also in my mind that it might allow some entertaining effects, though these were not in the minds of the programme producers.

The type of circuit shown in Fig. 20(b) has long been known to instrumentation engineers as a means of reducing 'common mode' signals, and it would work, in the form shown, as a means of enhancing channel separation. The circuits of Figs. 20(a) and 20(b) could therefore be combined to give the variable blend – separate arrangement shown in Fig. 21, and this does indeed work as intended. The channel width control pots, $PR_{8a\text{-}b}$, are ganged so that both channels move inwards in synchronism, and the resistor R_{109} is inserted between the mid-points to prevent an excessive degree of separate signal enhancement. If a spare switch contact was available, this could be switched across in the 'blend' position to allow a true mono output.

The resistors R_{101}, $_{102}$, $_{105}$, $_{106}$ are to prevent the op-amp inputs from being open circuited during switching, and the resistors R_{103}, $_{104}$ and capacitors C_{61}, $_{62}$ are included (they have no effect on the performance of the circuit otherwise) to prevent the capacitance to earth of the necessary screened leads, leading to the 'channel-separation' potentiometer and 'blend/separate' switch, causing IC_{12} to become unstable at certain settings of PR_8.

In use, the circuit has proved quite interesting in the modifications which it has allowed to the channel separation 'as received'. On an f.m. radio signal, it is found that a noticeable reduction in background noise can sometimes be obtained by a small degree of blending between channels, without a major loss of 'stereo' effect. On the other hand, the increase in image width causes an increase in f.m. background noise, as expected. On records, or other low-noise programme sources (and my reactions to f.m. radio are somewhat influenced by the fact that my best 'local' station is 90 miles away) an increase in channel separation can have some quite dramatic effects, especially on 'pop' music (where the indignation of the purists will be deflected) and on 'electronic' music where a large degree of channel separation is often specially desired. Somewhat to my surprise, even with some degree of separation enhancement, the central image is still retained, apparently unaffected, even though the off-centre instrument locations

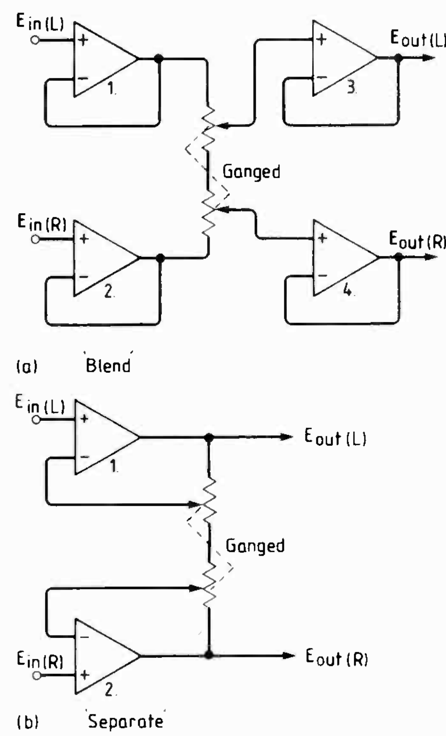


Fig. 20. Circuit to blend or separate stereo channels. Circuit at (a) mixes two channels, while (b) enhances separation.

are more definitely spread out, as the sound-stage is widened. It also makes my moving magnet cartridge sound rather more like my more expensive moving-coil unit.

Impulse-noise blanker module

Among my l.ps there are some, dating from the early to mid-1950s, which have acquired surface scratches which generate sufficiently loud 'crashes' from the speakers that the known advent of certain damaged areas on the disc discourages the playing of otherwise artistically satisfying performances.

A commercial unit for 'eliminating' record scratch noises made a brief appearance some years ago, and stimulated my own interest in such a device. Having played with these circuits, my appreciation of the possibilities is now more firmly based, and is the reason for the inverted commas above (and perhaps the lack of commercial success of the equipment marketed). There are many problems in this field, but perhaps the chief one is that there is no such thing as a standard scratch width. One consequence of this is that there is no universally appropriate length of time during which the signal feed through the amplifier should be suppressed.

Measurements on a number of scratched records (including one which was deliberately vandalized 'in the interests of science') showed noise pulse lengths ranging from about 0.3-7 ms. Most of the minor, relatively low-amplitude ticks due to dust in the groove, or small groove wall blemishes – many of which were due to the impact of the stylus on a dust particle on a previous playing – lie within the range 0.3-1 ms duration. However, these are a lesser problem than those groove injuries which cause the loud and disconcerting bangs and crashes. These lie in the range 2-7 ms, or sometimes even longer. If the system adopted is chosen to interrupt the signal path for the duration of the noise pulse, the question then arises as to what should be substituted for the signal during this period. If the length of noise blanking was, for example, 0.3 ms, then it would be feasible to hold the signal waveform at the point prior to the noise pulse to fill in the gap, but if the blanking duration were extended to 8 ms in order to cope with the worst-case noise pulse, which would by definition be the one that the user would most wish to avoid, then it would be very improbable that the signal waveform level would still be at the same point 8 ms later, which could give a larger discontinuity on restoration of signal than if a zero level had been substituted.

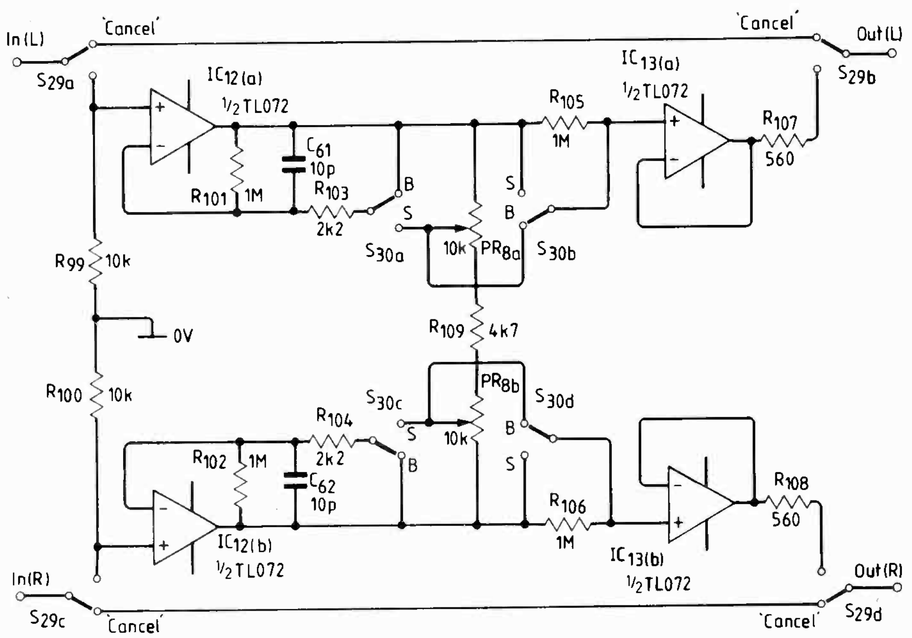
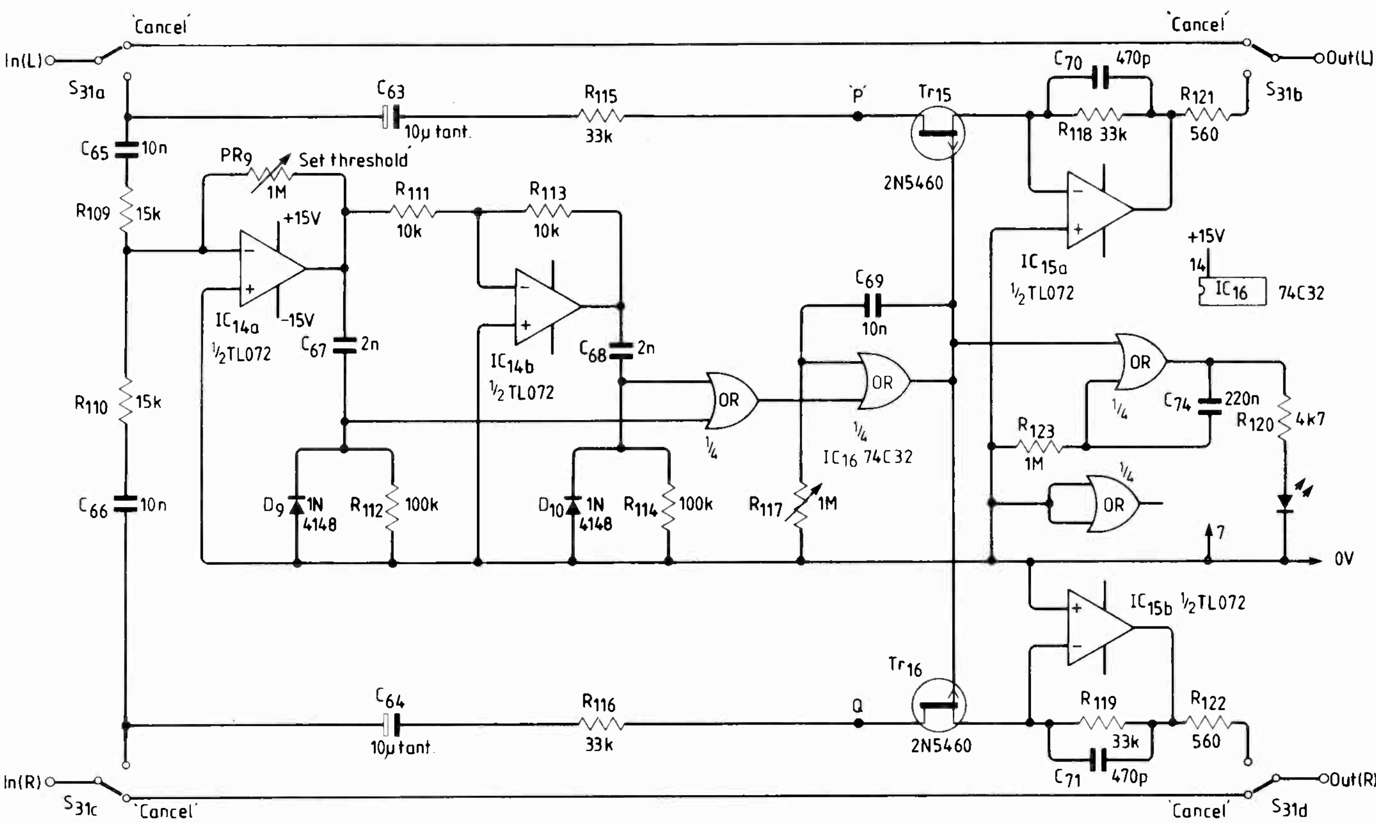


Fig. 21. Circuits in Fig. 20 combined to form complete 'image-width' module.

Fig. 22. 'Noise-blanker' circuit.



It will be appreciated from the foregoing that it is an unrealistic expectation to suppose that all noise pulses from this type of source can be excised silently and unobtrusively, unless one tailors the equipment to deal only with a certain very narrow class of minor defects. Within this limitation, however, it is possible to make a useful contribution to the comfort of the listener during the playing of records with this type of surface damage.

The circuit adopted, after a certain amount of experimentation during which my intentions were modified by experience, is shown in Fig. 22. In this, IC_{15} is a straightforward unity-gain, inverting amplifier with a junction fet acting as a switch in the input limb. Because of the very low signal voltages present at the 'virtual earth' input to the inverting amplifier, there is no significant signal modulation of the gate-source potential. Also, the small non-linearity of the f.e.t. conducting resistance is swamped by the 33k input limb resistor (R_{115}). For these reasons, the harmonic distortion of this circuit arrangement is very low (less than 0.01% at 10V r.m.s. output). The input signals from both channels are passed, via an input differentiating network ($C_{65, 66}$ and $R_{109, 110}$) into the fast mixer IC_{14a}, whose output is again differentiated and d.c.-restored across D_9. Because it cannot be specified in what phase the interfering noise pulse will occur, the input mixer IC_{14a} is followed by an inverter IC_{14b}, whose output is coupled through a similar differentiating network to the d.c.-restorer diode D_{10}.

These two positive-going noise spikes are added in the first Or gate of IC_{16} (a c.m.o.s. quad-Or), and fed to the second gate circuit which acts as a positive pulse generator, in which the output, once tripped by the input signal, is held high during the discharge cycle of C_{69} and R_{117}. The values chosen will give a pulse duration of about 8 ms, but this could be altered, at the discretion of the user, by his choice of the RC time-constant. This positive-going pulse is applied simultaneously to the gates of the f.e.t. switches ($Tr_{15, 16}$) in both channels, since it is improbable that only one channel will be affected by groove damage. However, this again is a decision the user may wish to make for himself, since a completely independent dual-channel unit with, perhaps, a variable blanking pulse length by adjustment to R_{117}, is certainly perfectly feasible.

As I had mentioned above, the question of what one should use to fill the excised gap in programme, is debatable. However, within the circuit, as it stands, there is the possibility of making the op-amp IC_{15} store a signal voltage level at the point at which it stood at the moment when the f.e.t. was made open-circuit (by the +15V positive pulse applied to its gate), by returning the resistors $R_{118, 119}$ to the points labelled P and Q in Fig. 22. This will make the 470pF integrating capacitors have an effective time-constant, for holding the input signal voltage, of several seconds. This approach, though, may be without benefit except on short pulse excision times.

The question of whether it would be useful to have some type of signal delay in the line, to allow the pulse generator to operate prior to the arrival of the noise spike on the signal line, was decided, mainly on grounds of cost and signal distortion, in favour of the simple integration capacitor across the inverting amplifier, which somewhat 'slugs' this in comparison with the noise pulse detection circuits built around IC_{14}. The threshold trigger level is adjustable by PR_9, and for best results should be set so that the circuit will just trip on the incoming noise pulse. The third Or gate is used to drive an led to give a visual indication of the action of the circuit. To make the flash more readily visible, this gate is also connected to act as a pulse-lengthener, giving an output pulse length of about 200 ms. This led also allows the user to check that the pulse-blanking circuit is not operating at unwanted times on legitimate signal transients.

After all this, the question must be asked: How effective is it in use? I must confess, after a lot of experimentation, that I was a little disappointed that it was not possible to make a circuit which will remove all clicks unobtrusively. It is certainly possible to remove some of them, in that the led will occasionally flash, when the circuit is in use, without the cause having been audible at all. On the other hand, even while dealing with a continuous range of scratch widths, which is typical of any normal scratched record, a correct trigger setting will give a substantial improvement. For example, on an early record of the Sibelius 2nd symphony – rather badly affected by the passage of the years – with a volume control setting chosen so that the maximum peak signal levels, as determined by a commercial Instantaneous Peak Drive Indicator, lay between 1-3 watts, some of the noises associated with scratches gave rise to peak drive levels in the range 10-30 watts, which although brief in duration, were predictably disconcerting to listen to. With the noise blanker module in use, at the same volume control settings, the peak noise levels registered were less than 1 watt, and were occasionally quite inaudible, at trigger level settings which were chosen so that no spurious triggering occurred on programme.

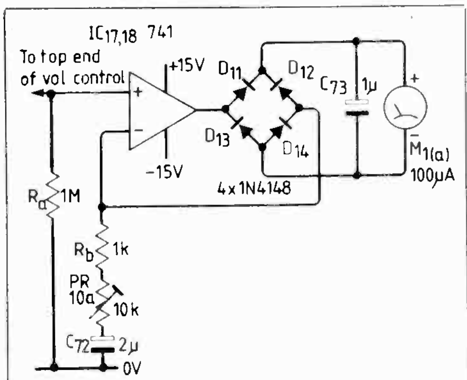


Fig. 23. Simple signal-level meter (one for each channel).

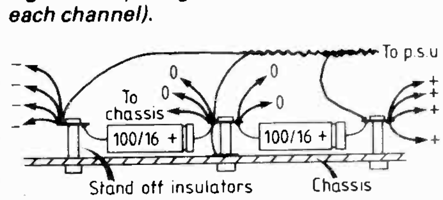


Fig. 24. Recommended supply distribution method to avoid inter-module supply coupling.

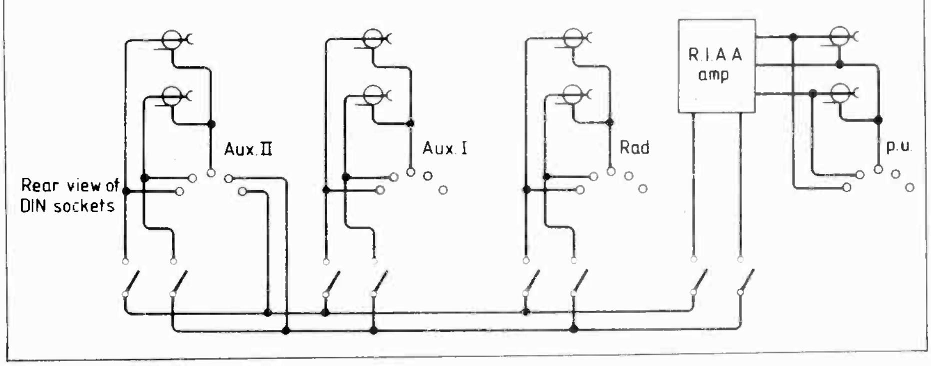
After the construction of this preamp, and the subsequent completion of the circuit description given above, it had been my intention simply to sit back and enjoy the use of it as a rather better and more versatile addition to the domestic record playing equipment, while I returned to other more pressing, if less enjoyable, domestic tasks. However, an unresolved question still remained as to whether, within the limitations of the relatively simple circuit arrangement shown in Fig. 22, it would be possible to organize the circuit time-constants so as to remove the minor, but irritating, ticks and pops due to dust, or the imprints on the groove walls of former particles trapped during previous playings, which measurements had indicated would lie in the 0.3-1ms duration, so some further experiments were made.

By making R_{117} a variable resistor, it was practicable to provide an adjustable blanking period, with the input ends of R_{118} and R_{119} connected to points 'P' and 'Q' so that the signal level was held during the noise pulse at the previously existing potential.

The problem then remained of ensuring that the trip circuit would trigger on the arrival of the unwanted noise pulse due to the dust particle, without triggering on wanted signals.

To be continued

Fig. 25. Socket wiring scheme.



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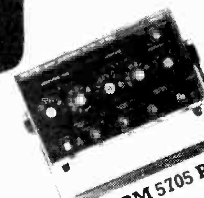

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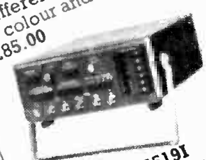

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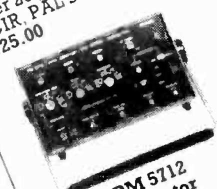

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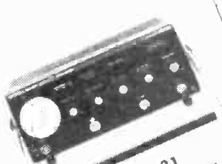

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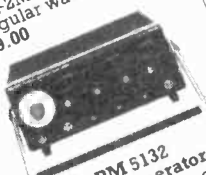

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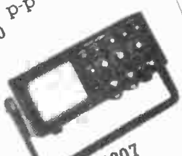

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Tracking digital filters for servosystems

Synchronous generation and filtering provides accurate feedback conditioning over wide frequency range.

by J. J. Tait

For a discrete-time filter algorithm, the frequency response effected is necessarily relative to the sampling frequency, which need not remain constant. This is inherently exploited in "data processing" but its potential in real time to achieve tracking of frequency response to frequencies of interest is rarely mentioned. In cases where tracking filters *have* been employed, the appropriate variable sampling rate has usually been generated artificially by circuitry specific to the application. The weakness of this approach is that small deviations in the sampling frequency can often cause unacceptably rapid phase changes in a sharp filter response. Outlined below is a generalized system philosophy for use in servo-control wherever the driving signal is periodic and relative feedback conditioning is desirable.

Fig. 1 depicts the generalized synchronous-generation-and-filtering type of approach. The master clock frequency may vary with time in any fashion – linear, logarithmic, repetitively, randomly swept or even stepped – according to the application. This clock defines both the period of the driving waveform *and* the sampling rate of the feedback filter, thus guaranteeing accurate tracking of the effective filter frequency response with the driving frequency spectrum over a range limited only by hardware capability. Careful design of the filter algorithm permits any form of harmonic cut or particular harmonic selection in the feedback signal. Most notably, many servosystems are driven by sinusoidal functions and generate harmonics which cannot be removed and are unwanted information in the feedback path. SGF permits precision feedback of only f_0 components, but anti-aliasing filters must be included with some degree of low-tolerance tracking depending on the range required.

The potential is illustrated by the following example.

Application to seismic vibrators

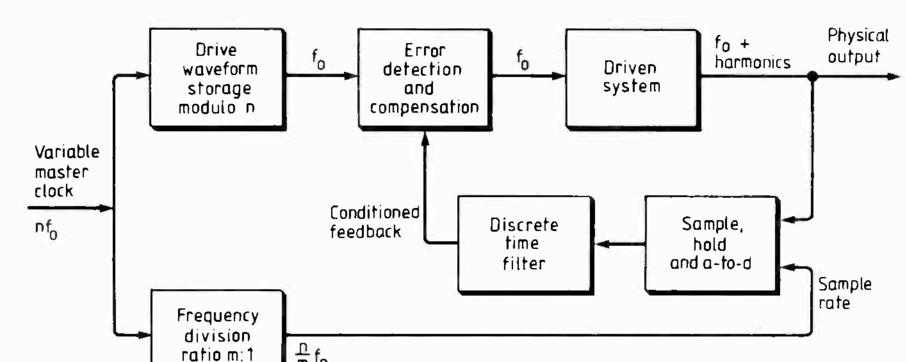
In one form of seismic survey, several hydraulic servosystems are simultaneoulsy vibrated over a swept frequency range of 7:1 or more. Closed-loop phase compensation is necessary within each vibrator due to the considerable errors introduced by the compressability of hydraulic fluid and by drift-compensation mechanisms. Problems arise in that non-linear couplings between each servo and the ground being driven cause heavy harmonic distortion in the mechanical output and plague attempts to keep the fundamental component in phase using any ordinary phase detection technique. The second and third harmonics are particularly troublesome and obviously cannot be removed by fixed filtering.

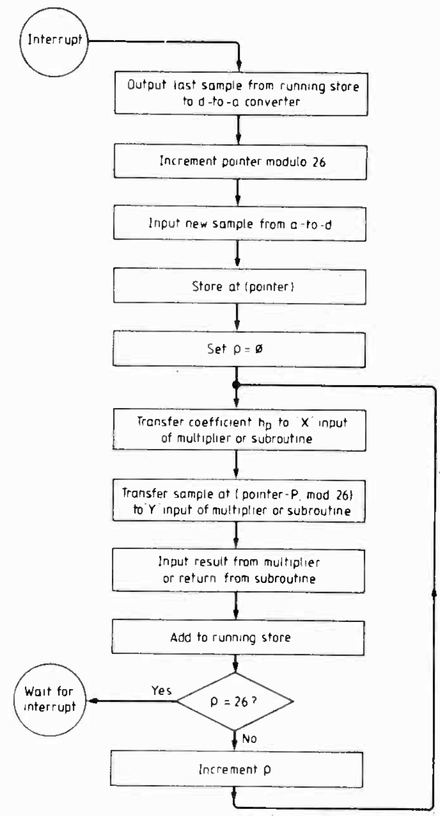
Distortion in itself is not a problem as reflected signals are later correlated against the "pilot" signal, but it is imperative that each vibrator's fundamental component remain accurately in phase with this pilot.) An SGF filter is thus used to block harmonics in the feedback path over the entire sweep range, with the master clock inputting samples to an interrupt-driven, microprocessor-based type of low-pass digital filter.

Implementation

Fig. 2 depicts the filter system for seismic vibrators and similar servosystems. Fig.3

Fig. 1. In this "synchronous generation and filtering" approach the clock frequency defines sampling rate of feedback filter.

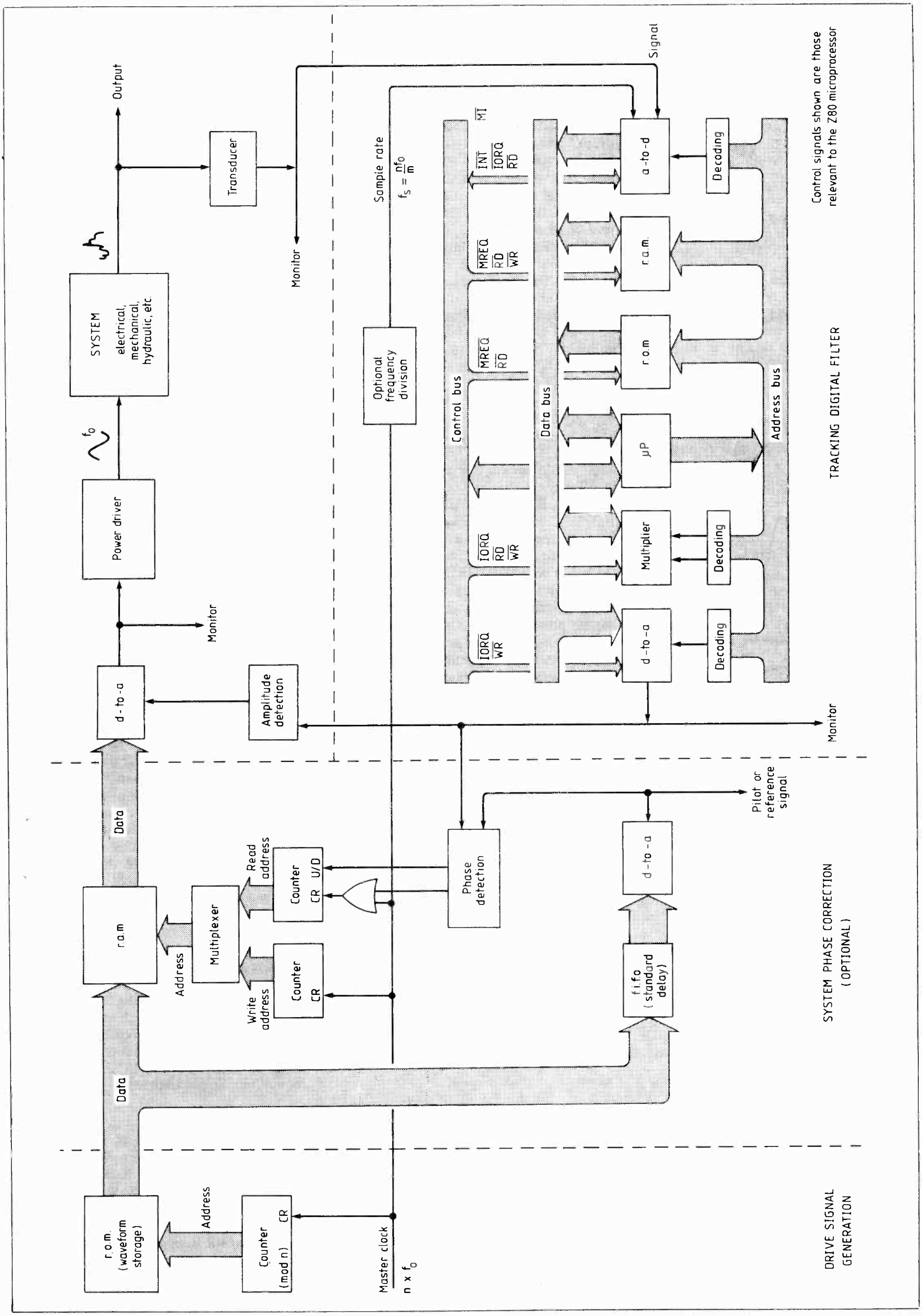




▲ ***Fig. 3.*** *Non-recursive interrupt-driven filter program with cyclic sample storage in ram.*

Fig. 2. *An SGF filter block harmonics in the feedback path over the sweep range.* ▶

The inherent consistency of phase and amplitude response as the fundamental sweeps and the absence of regular calibration make digital filtering a far better prospect than any sophisticated analogue equivalent. There are doubtless a multitude of applications in control engineering, research, design and testing where this general system concept will prove to be an extremely useful tool. Possible applications include impulse response measurement within noisy systems by correlated frequency insertion, start-up and subsequent phase-matching of synchronous motors to mains supplies, variable-speed tape decks, as well as frequency coding, numerical control and power generation.



Output
Transducer
Monitor
Signal
SYSTEM
electrical, mechanical, hydraulic, etc.
f_0
Power driver
Monitor
d - to - a
Amplitude detection
Sample rate
$f_s = \frac{nf_0}{m}$
Optional frequency division
Control bus
Data bus
Address bus
$\overline{MI}$
$\overline{INT}$ $\overline{IORQ}$ $\overline{RD}$
$\overline{MREQ}$ $\overline{RD}$ $\overline{WR}$
$\overline{MREQ}$ $\overline{RD}$
$\overline{IORQ}$ $\overline{RD}$ $\overline{WR}$
$\overline{IORQ}$ $\overline{WR}$
a-to-d
r.a.m.
r.o.m
µP
Multiplier
d-to-a
Decoding
Decoding
Decoding
Monitor
Control signals shown are those relevant to the Z80 microprocessor
TRACKING DIGITAL FILTER
Data
r.a.m
Multiplexer
Address
Read address
Counter CR U/D
Counter CR
Write address
Phase detection
Pilot or reference signal
d-to-a
f.i.f.o (standard delay)
Data
SYSTEM PHASE CORRECTION (OPTIONAL)
r.o.m. (waveform storage)
Address
Counter (mod n) CR
Master clock
$n \times f_0$
DRIVE SIGNAL GENERATION

is a typical non-recursive, interrupt-driven filter program with cyclic sample storage in ram. It is important that the latest output sample only be released on arrival of the next input sample, creating a fixed additional phase lag equal to $2\pi m/n$ radians at f_0 where n/m is the number of filter samples per fundamental period. (Immediate release of the latest sample would give a fixed time delay between input and output of the filter, constituting a sampling frequency-dependent phase lag significant at high frequencies.) Careful calculation of filter response to give a phase lead of $2\pi m/n$ at f_0 yields zero overall phase change. This is generally very much easier to do with non-recursive algorithms and there is the bonus of guaranteed stability. Fig. 4 shows such a response calculated for n/m=20, i.e. a phase lead of 18 degrees at f_0, derived from two ideal band-passes and limited to 26 coefficients by application of a Hamming window. Also tabulated are the coefficients for 16bit operation. Second and third harmonics are cut by 28dB and 35dB respectively, and the simple phase detection circuitry is then able to maintain phase accuracy of the mechanical output to the order of a few degrees.

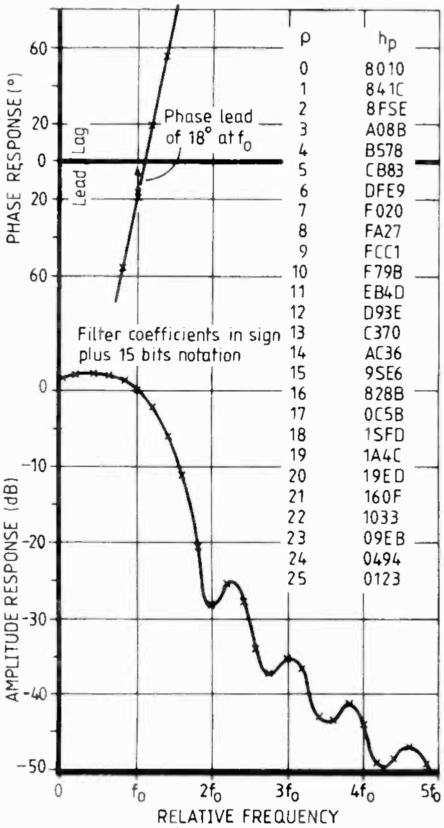


Fig. 4. Filter response is calculated to give phase lead of $2\pi m/n$, to cancel lag in Fig. 3.

Any microprocessor's operating speed is severely limited by multiplying algorithms and a parallel array multiplier such as the MPY8AJ from TRW is needed as an addressable device. For example, working in 16bit arithmetic and with 20 filter coefficients a Z80A alone could only handle sampling rates up to about 100Hz, useful for frequencies up to, say, 5Hz. With an addressable multiplier its capability is extended to well above 1kHz sampling. Still higher rates require micro-programmable logic, possibly with a microprocessor to handle power-up loading, house-keeping, normalization and transient pick-up. Low sample rates can be enhanced by use of linear interpolation circuitry as shown in Fig. 5; this is itself a discrete-time analogue filter and its frequency response must be taken into consideration.

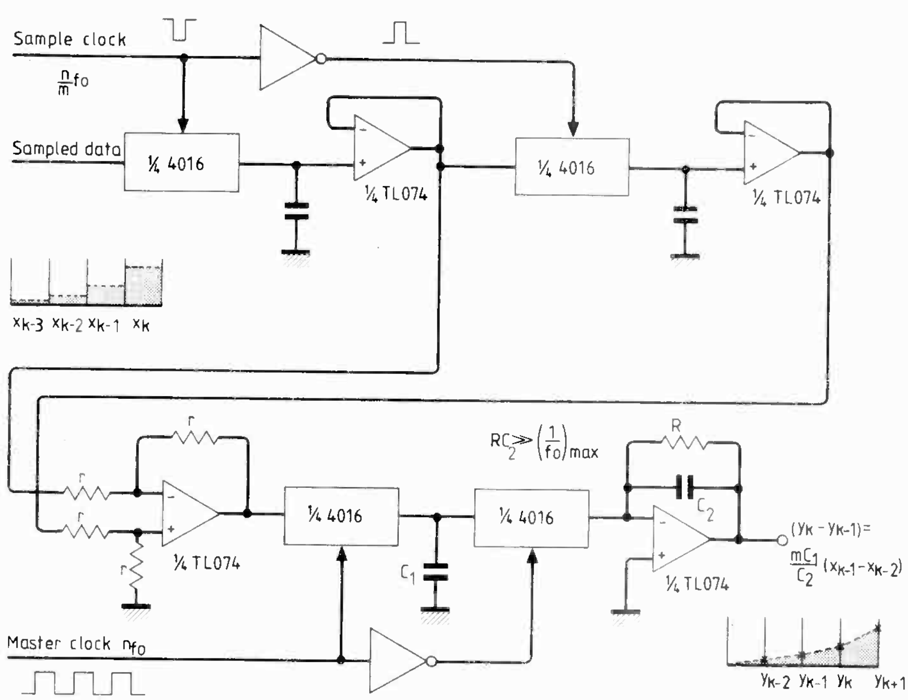


Fig 5. Low sampling rates can be improved on by linear interpolation circuit, itself a discrete-time analogue filter.

Electronic breath analyser

A new instrument can give a breath analysis which is as accurate in its estimation of the alcohol blood level as a laboratory tested blood sample. It has the advantage of giving a virtually instant result.

It uses an absorption line in the infra-red, and the various steps in the measurement sequence are controlled by a microprocessor. There are four fundamental steps, two measurements on the subject's breath and two on a mixture of inert gas and ethanol at a reference concentration. The measurements are interleaved, so the instrument is in effect re-calibrated for each measurement, and the effect of any zero drift is eliminated. The microprocessor ensures that the absorption chamber is purged with clean air between the steps: it also receives signals that satisfactory samples have been taken, and if not, lights a warning lamp so that the step may be repeated. Apart from this the whole sequence is effectively automatic, and the instrument does not require a medically or scientifically trained operator.

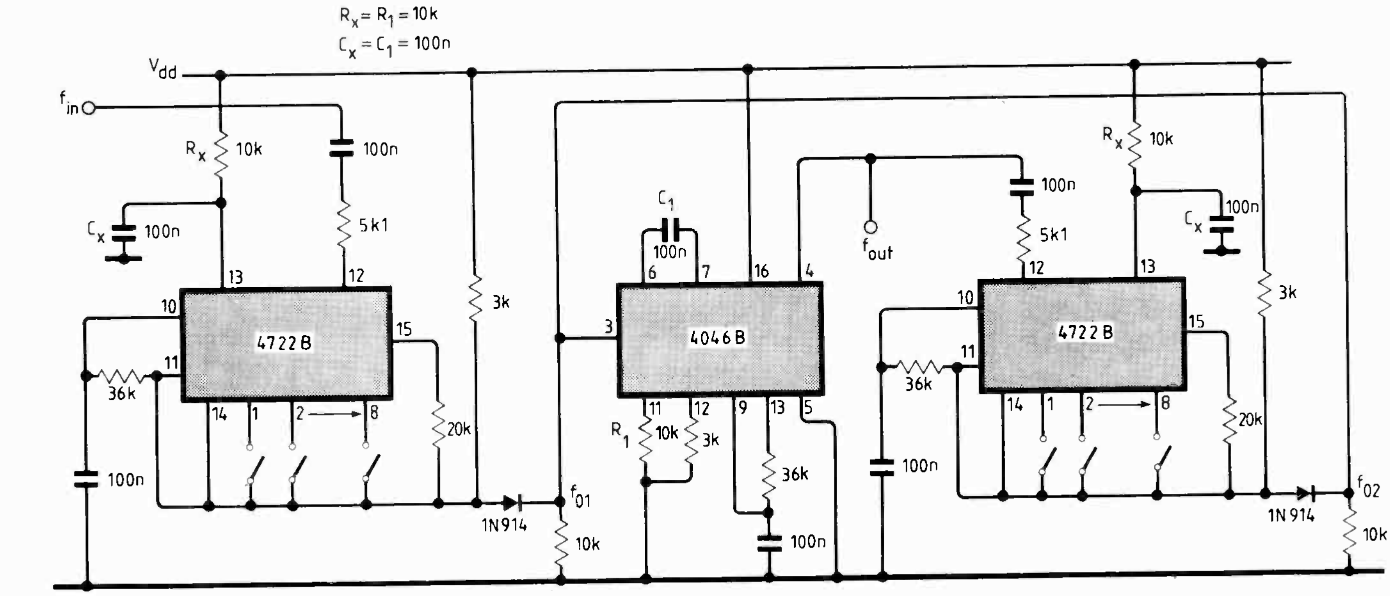
The infra-red radiation passing through the sample is chopped with a rotating sector plate, and filtered to a narrow band around the absorption line. The detector is followed by an amplifier and synchronous (i.e. phase-sensitive) detector, and the rectified analogue quantities obtained passed to an a-to-d converter and stored. The stored numbers are then manipulated by the microprocessor to give an answer in the desired units. Accuracy throughout is up to that of eight-bit arithmetic.

The answer appears on an l.e.d. display and also as hard copy as a print out on a strip of paper, a form free from human error and therefore suitable for presentation as evidence in court. Normally four copies of the print-out will be provided. An internal quartz clock allows the print-out automatically to carry the time and date. The instrument is mains-driven and will normally be left switched-on continuously: an internal secondary battery gives a 4-hour carry over of time and date information if there is a mains failure.

Marshall Wood of Croft-on-Tees, Darlington, are the design consultants for the project, and will be manufacturing the units for Camic, of North Shields, a firm of automobile gas analysers.

● The manufacturers said recently that they expect every police force in the country will have such a device by the end of the year. This statement was considered reasonable by the Home Office who add that Lion Laboratories, as well as Camic, have approval to supply these "evidential breath-testing devices", not to be confused with electronic screening devices currently used.

CIRCUIT IDEAS



Dividing by fractions

Main feature of this circuit for dividing by fractions is its wide frequency range. It uses two 4722B programmable timers and a 4046B phase-locked loop i.c. allowing direct multiplication of the input frequency by a fraction. The timer section is connected for harmonic synchronization.

Output frequency of the first timer f_{o1} is

$$f_{o1} = \frac{m}{M+1} f_{in}$$

where $1 \leq m \leq 10$ is the harmonic number and $1 \leq M \leq 255$ is the programmed counter modulus. For the second timer

$$f_{o2} = \frac{m}{N+1} f_{out}$$

As $f_{o1} = f_{o2}$ is a function of the p.l.l.,

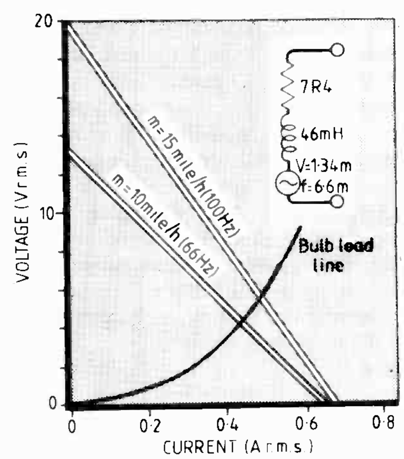
$$f_{out} = \frac{N+1}{M+1} f_{in}$$

So the input signal is multiplied by a fraction $(N + 1)/(M + 1)$ and 65 025 is the number of possible frequencies.

Kamil Kraus
Rokycany
Czechoslovakia

Bicycle lighting

A simple circuit combines battery and dynamo bicycle lighting and uses the high internal inductance of the dynamo to give good current regulation when driving a low-resistance load. Measurements on a Lucifer dynamo* with a nominal and normal output of 6V, 3W gave characteristics shown in the graph. Together with the non-linear bulb resistance, this gives a



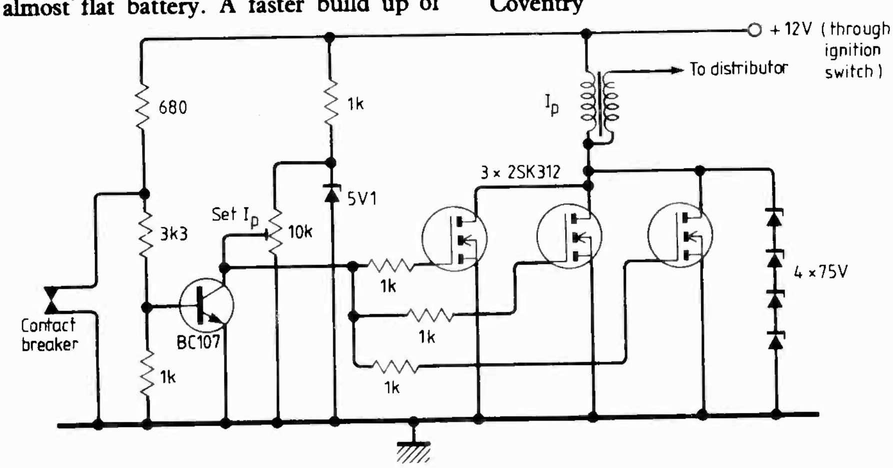
fairly constant load current of about 0.5A so a slightly smaller front-lamp bulb using 100mA less current allows a NiCd back-up battery to be charged.

The dynamo is isolated from the bicycle frame by, say, a piece of rubber tubing and the battery, designed to be charged continuously at 100mA, supplies the lights for at least 30min when fully charged. The double-pole switch prevents excessive charging which would occur when the lights are off and the dynamo running. Open-circuit bulbs should be replaced promptly and shorting of the cells is to be avoided; a fuse will protect cells from acci-

Electronic contact breaker

Using the on-state characteristic of vmos fets to provide a constant-current source, this circuit provides dynamic ballast and eliminates the need for a ballast resistor. This means that the optimum primary-coil current is adjusted automatically to compensate for supply voltage variations which is particularly useful when starting with an almost flat battery. A faster build up of current through the coil at high engine speeds is inherent, as vmos devices present a low on-resistance until a preset current limit is reached, hence reducing the drop in spark voltage. This ability to maintain a high spark voltage at high engine speeds is also a feature of capacitor-discharge systems but these have the disadvantage of increased complexity. Suitable vmos devices are, however, still fairly expensive.

M. J. Hooper
Coventry

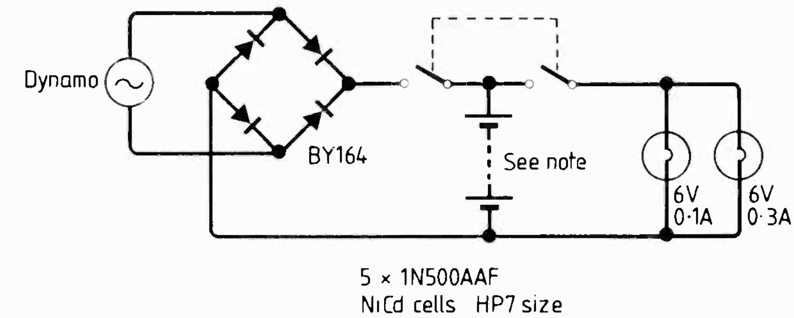


dents occurring when they are fitted.

Increased efficiency can be obtained by replacing the four diodes shown in the bridge by Schottky types such as BYV19s. This system has been used for an hour a day for several months without problem.

R. J. Grover
Manchester

* *Measurements of speed vs voltage for a Miller dynamo are included in the first of two letters, in the October 1978 and January 1979 issues, discussing B. J. Pollard's circuit idea of June 1978.*



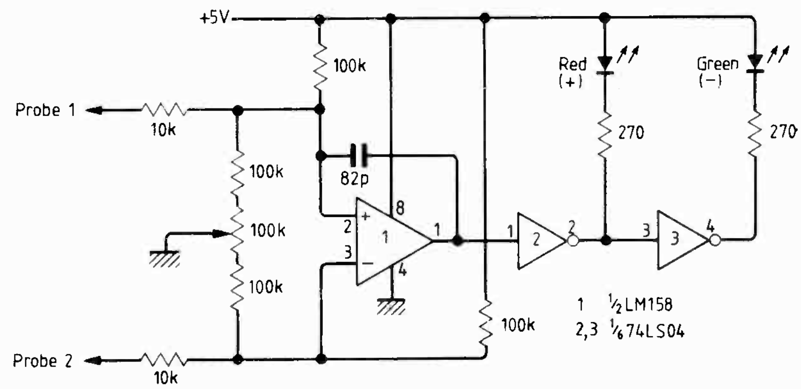
Multiple-line telephone indicator

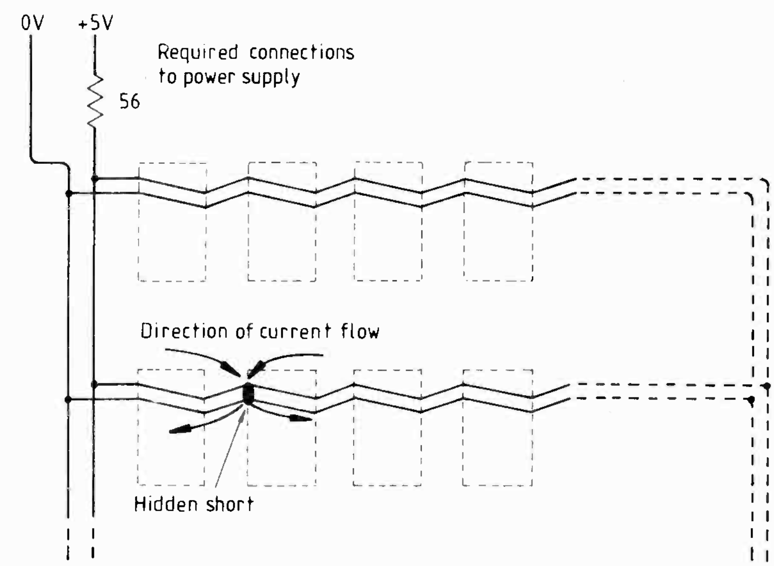
Incoming calls are indicated using this monitor circuit which detects bell voltages greater than 3V alternating on any line. An audible alarm and light-emitting diode indicate an incoming call while other l.e.ds indicated which line the call is on. Alarm signals are held by the circuit for a few seconds to help the operator identify the line concerned. Six lines are used in the prototype, each with an identical input circuit and individual opto-coupler to isolate the circuit from the lines. Parallel connection of the lines with possible signal detereoration and loss of privacy is not required.

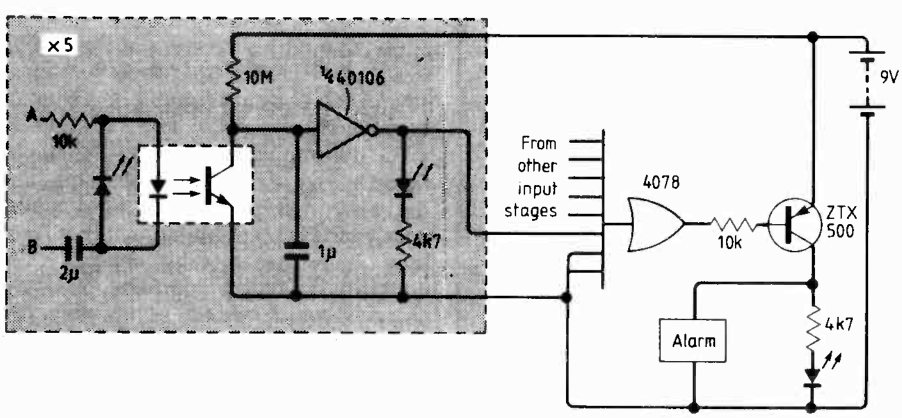
Each input has a 2μF blocking capacitor and 10kΩ resistor to reduce line shunting. This results in a low opto-coupler transfer ratio – compensated by a 10MΩ resistor on the output transistor collector. Delayed switching is provided by a 1μF capacitor over the opto-device output transistor to continue the indication for about 10s after the incoming signal ceases. Less than half a second passes before the circuit responds to an incoming signal. Light-emitting diodes indicate the incoming signal, the delay period and the presence of a signal on any line at the output of the gate.

Simple expansions envisaged are increasing the number of input lines, using the output to drive a relay switching bells and/or lamps, and battery back up.

H. T. Wynne
Glasgow







Short-circuit locator with navigation aid

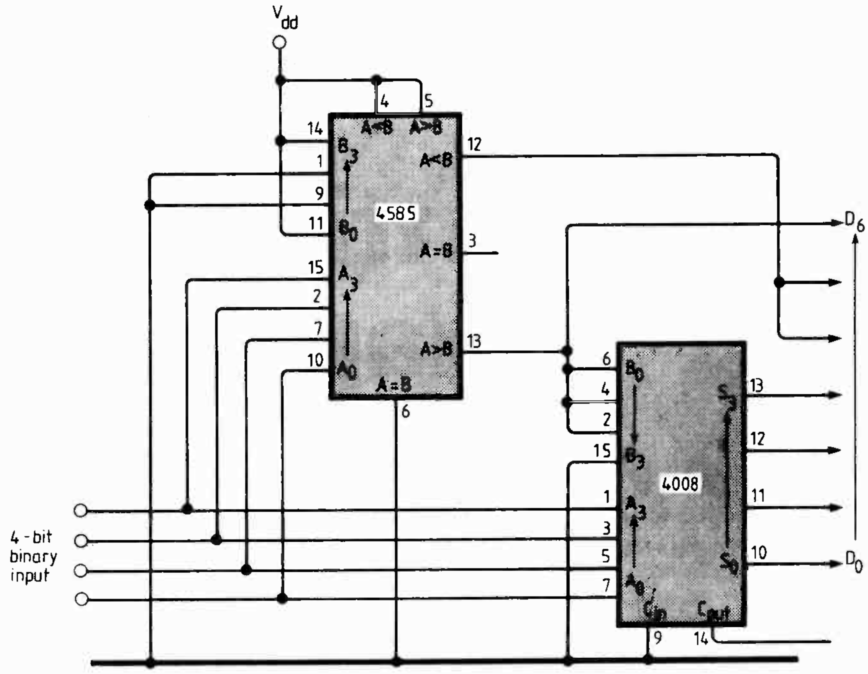
On complicated circuit boards especially those using buses, only half the job of short-circuit location is finding on which track the fault lies. Where the short is not visible the only way of finding it may be to cut tracks until the node concerned is isolated. This circuit is the simplest and most effective solution found while attempting to locate such a fault without cutting tracks.

To use the probes, current must flow through the tracks containing the short, see diagram. Where tracks are arranged as a grid, as on memory boards, a voltage applied to any two tracks on the array is sufficient; with open-ended tracks, the supply is connected to each end of the track. The probes are placed on the track a short distance apart and the l.e.d. indications noted. When the voltage of probe 1 is higher than that of probe 2, the red diode lights and when the polarity of the voltage across the probes is reversed the green diode lights; equal probe voltages may cause both to light. Shorts are located by moving the probes along the track and observing where the indication changes.

Experiments with 25μm-thick copper layers on p.c.bs with a standard reflow solder thickness showed that 0.38mm-wide tracks have a resistance of about 15.7mΩ/cm. A current of between 40 and 50mA through the track provides sufficient voltage to operate the indicator with probes about 1cm apart. Solder layer I use is about 15μm thick and has 11.5% the conductivity of the copper. Calculated value for bare tracks of 12.2mΩ/cm and measured value of 15.7mΩ/cm with solder suggest that this layer may be neglected. Suitably modified, either the probe supply or a 5V source from the board under test may provide the test voltage.

Within two minutes, this method located a short on a 32-i.c. memory board which eluded all attempts using standard methods.

J. E. Tully
Stourbridge
Worcs



4585 4-bit magnitude comparator V_{dd} 16
4008 4-bit full adder V_{ss} 8

Binary-to-ascii converter

Unable to locate a miniature four-digit hexadecimal display, I devised this circuit to convert four-bit hexadecimal words into their seven-bit ascii equivalent to drive displays such as the DL414.

Binary input is fed to a 4008 four-bit full adder, the output of which is equal to the input for values of less than nine. Three upper bits of the ascii word are provided by a 4585 magnitue comparator, whose outputs change from ascii three to four when the input exceeds nine. At the same time the two's complement of nine is added to the input resulting in the subtraction of nine from the four low-order output bits (see table).

I. Macalindin
Cupar
Fife

Input word	ASCII output	Hex display
0000	30	0
0001	31	1
.	.	.
.	.	.
1001	39	9
1010	41	A
.	.	.
.	.	.
1111	46	F

Z80-based 2516 programmer

Grayson noticed that the software he sent us for an eprom programmer to attach to the Wireless World scientific computer (Circuit Ideas, November 1982) was an early version and has a basic error despite the fact that it was given in assembly language. The subroutine at 0380 assumes that DE contains the current screen location, but this location is used as the ram pointer.

This routine uses BC as the ram pointer and checks data for FF bytes which need not be programmed. Verification is performed to ensure that the eprom location has been properly erased i.e. reads FF.

```
01 00 10     LD BC, 1000     Start of ram
21 00 60     LD HL, 6000     Start of eprom

0A           LD A, (BC)      Get byte from ram
FE FF        CP FF           Is if FF?
28 01        JRZ, 01         Yes, skip programming
77           LD(HL), A       Otherwise program byte
BE           CP(HL)          Verify eprom byte
28 04        JRZ, 04         OK, jump

CD 80 03     CALL 0380       Otherwise CR and print HL
C7           RST 00          Return to monitor

03           INC BC          Point to next ram byte
23           INC HL          Point to next eprom location
78           LD A, B         Get high byte of ram pointer
FE 18        CP 18           Finished?
20 EC        JRNZ, EC        No, loop
C7           RST 00          Otherwise return to monitor
```

Don't waste good ideas

We prefer circuit ideas with neat drawings and widely-spaced typescripts, but we would rather have scribbles on "the back of an envelope" than let good ideas be wasted.

Submissions are judged on originality or usefulness – not excluding imaginative modifications to existing circuits – so these points should be brought to the fore, preferably in the first sentence. Minimum payment of £20 is made for published circuits, normally early in the month following publication.

Quantization and quantization

The discussion broadens to encompass "matter" in addition to "radiation", by examining what the term quantization means. Dr Murray discovers a novel and important method of distinguishing between science fact (physics) and abstraction (metaphysics).

I am in favour of realism in physical thinking, and against twentieth-century mysticism. The doctrine of the duality of light as currently taught to physics students – that light consists sometimes of waves and sometimes of particles or "quanta", even though its wave particle forms are incompatible and mutually exclusive – strikes me as mysticism of the most blatant kind. I have suggested resurrecting an alternative view, attributable to Einstein, that light "waves" as inferred experimentally are manifestations of systematic variations in space and time of the density of photons: that is to say particle-like entities carrying energy and momentum' and travelling at the speed of light. The proposal leads to simple explanations of many well-known phenomena of light, but one is not surprised to find it in sharp conflict with electromagnetic theory.

Whether or not this particular alternative to electromagnetics and the duality doctrine, which may be called the photon-waves concept, will stand up to meticulous scientific inquisition is not at this moment of very great consequence since other alternatives are to hand, although perhaps none has quite the same appeal of simplicity. The concept could be tested experimentally and it would be prudent to speculate no further until the suggested experiments have been performed. I propose now to leave the paradox of the duality of light and to refer to it only in the context of its effect on the remainder of modern physics – in particular in the context of the consequential and even more mystical postulate of the duality of matter.

From now on in this review the terms quantum theory, quantum mechanics, and quantization will appear frequently, so it would be convenient to begin by defining what they mean. Unfortunately that is not easy, because they mean different things to different people and sometimes – shades of duality! – they even mean different things to the same person at different times or even at the same time. We are about to enter territory where "double-think" is the rule rather than the exception, and my purpose is, so far as I am able, to hack a path of old-fashioned scientific realism through a mystical jungle of confusions, *non-sequiturs*, and straight logical impossibilities. There are at least three different current uses of the word quantization, and we shall be philosophically safer if we understand what each of them means, how they differ from each other, and why.

by W. A. Scott Murray
B.Sc., Ph. D.

The first "quantization" to see the light of print was probably the one connected with Planck's original quantum hypothesis. It can be discussed in terms of a famous thought-experiment that we shall return to later in another context. Visualize, if you please, a beam of light falling to a half-silvered mirror set at an oblique angle to the beam. Of the light which falls on the mirror, some is reflected and enters a detector which we may consider to be an ideal photoelectric cell; the rest passes through the mirror and continues straight on indefinitely, into deepest space beyond our ken. The question being asked is, *how much* of the light is reflected into the detector, and how much is transmitted away and for ever lost to us?

For so long as light was believed to consist of electro-magnetic waves in an ether fluid there was no problem here; there was no restriction on the relative heights (amplitudes) of the reflected and transmitted wave crests. The reflected wave could be increased and the transmitted wave could correspondingly be decreased by any amount desired; in particular, there was nothing to prevent an adjustment being as small as one chose to make it. In mathematical terms we say that the light intensity, being the square of wave amplitude, could be changed *continuously*. By way of contrast, if light energy is really packaged into quanta as the experimental evidence so clearly demands, then the smallest adjustment that can be made is when one quantum, which was otherwise to have been transmitted and lost, is now reflected (and therefore detected) instead. The smallest possible change is now finite – one quantum – and we say that such changes are mathematically *discontinuous*.

Now if the light beam is bright enough to be visible, so that millions of quanta are being detected every micro-second, the gain or loss of one quantum isn't going to make much practical difference: the change of intensity is still effectively continuous. That is no longer so however in cases where quanta are in short supply (as in very weak light or in the case of very energetic quanta such as gamma rays). In the ultimate case, if there is only one quantum present the question of whether it is reflected or transmitted is unequivocal: either it is reflected and detected or it isn't, 1 or 0, yes or no. This is quantization type one. It arises because light comes in the form of discrete particles or quanta and is *not* wavelike. There is nothing indeterminate or hazy about it; it must be one of the most precise processes we can possibly imagine.

We can, if we insist on doing so, muddy these clear waters with a fog of irrelevances: we can say, truthfully, that the outcome is in doubt *before the event*, because we cannot predict *before the event* whether that particular quantum will be reflected or transmitted by the mirror. From this it is usually argued, according to established physical doctrine, and I hold – utterly in error – that our inability to predict the outcome is proof that the mechanism of the reflection of light by the mirror is fundamentally "indeterminate". For the moment I will suggest two thoughts to ponder on this issue, one old and one new.

The older thought is that we cannot predict which way a particular quantum will go because we don't know about the conditions of its encounter with the mirror surface in sufficient detail; for instance, we don't know beforehand whether it will hit one of the silver atoms or pass between them. As we shall discover when we come to discuss Heisenberg's "indeterminacy principle", there are good, non-mystical reasons why we cannot predict whether or not it will hit a silver atom; but broadly speaking, and without yet defining too tightly what we mean by hitting and missing, it is reasonable to say that those quanta that hit will be reflected, and those that miss will pass through. There would seem to be a fairly obvious causal connection here between hitting and bouncing, or missing and penetrating. The mere fact that we humans cannot predict the outcome in a particular case – because we are unable to measure its initial conditions – does not imply that the reflection process at the mirror surface is imprecise or indeterminate in any way. How could it imply that?

The new thought I introduce (at any rate I believe it to be a new thought) is this: there is no indication anywhere in physics that Nature ever makes a prediction! The whole idea of prediction is foreign to Nature and introduced by Man. It is in the nature of living matter – at all levels – to build enzymes, protein-coats, nests, aqueducts and aeroplanes for its own convenience. It does this by decreasing entropy locally at the expense of its environment (eg. energy profligacy, pollution), without violating the second law of thermodynamics overall. The desire to make predictions as an essential element in the management of one's surroundings is seen to be merely one aspect of this characteristic of life. Decisions which follow are not necessarily rational, nor are consequent actions always "determinate".

In clear contrast to this, all the evidence of observational and experimental physics tells us that inanimate Nature, the Nature of the physicist, takes no account of the future or of the past but "lives only for the present". The outcome of a physical interaction would seem always to be the strictly causal result of the integration of the conservation laws (expressed in terms of physical forces) over the ever-changing total situation at time *now*. The futuristic concepts of "will", "purpose", "intent", and also "prediction", are non-physical attributes of living matter, and physical Nature is not concerned with them. In line with ordinary linguistic usage we may properly call concepts of this kind metaphysical – transcending physics. This is the sense in which I shall use the word metaphysics from now on.

Once we have understood that prediction, the greatest aim of all science, does not in fact form part of the working of the kind of Nature with which physical science is concerned, a major source of confusion is identified and dealt with. It becomes easier to put our inability to make certain kinds of prediction, especially in the microphysical domain, into its proper perspective. Nature can get on very well without us! Overwhelming experimental evidence supports the view that the principal denizens of this smallest domain, atoms and molecules, protons and neutrons, electrons and light quanta (or photons), are quantized in the sense used originally by Planck: they are discrete, physical entities having real, free-standing existence independently of each other and of any observer, human or deputy. Moreover, the fact that an electron is so light that we cannot measure exactly where it is without disturbing it does not mean that the electron's location is not precisely defined; nor does it require that there must be anything indeterminate about the electron itself as a particle, or about its interactions with other particles. A lot of nonsense has been written about such things, by people who should have known better.

I have been labouring these issues because conventional doctrine takes the diametrically opposite view of every one of them. We shall discover the reasons for this when we come to review the origins of the quantum-mechanical theory. The point we have picked up here is that the word 'determinate" is not synonymous with "predictable by mankind". The arrogant assumption that it is has given rise to much philosophical trouble in physics. Let us be clear about our own humble position in the scheme of things: *we* may not be able to predict the reflection or transmission of any particular photon, but there is every reason to suppose that the behaviour of that photon is determined, and precisely determined, by causality and the conservation laws. Certainly there is no experimental evidence to suggest that it is not, whatever current doctrine, dogma, or "theory" may say.

So there we are. We have examined one meaning of the word quantization and found that it has to do with the essential granularity of microphysics. Electrons and photons behave like very tiny particles. Either you detect them or you don't: you never detect half an electron or three-quarters of a photon. That is all there is to it. Whether or not one can predict the outcome of a microphysical event is a completely different ball-game; the limiting accuracy of our predictions has nothing to do with whether light consists of particles or of waves. There really is nothing mystical here, and we need not be confused about it unless we choose to be.

The second historical meaning of quantization arose out of a famous piece of fundamental work by Niels Bohr. Visiting Manchester as a young exchange student, he came across the experiments and reasoning that led to Rutherford's atomic model – negatively-charged electrons circulating perpetually like tiny planets around a heavy, positively-charged nucleus. He also found that Rutherford's very clever and competent research team were stuck on two points which threatened to wreck their pretty model. There seemed to be no reason why the electrons should circulate in those particular orbits whose frequencies corresponded to the observed spectra of the light emitted by the atoms; and there seemed to be nothing to prevent an atomic system from running down like an unwound clock, as the electrons radiated their orbital energy away into space. The last-mentioned effect was predicted by the all-powerful electromagnetic theory on the grounds that a circulating electron is an "accelerated point charge", which according to that theory must radiate continuously. (Between ourselves, you may recall, we have grounds for believing that electromagnetic theory may have been wrong on that point, but that wasn't suspected in 1912 and we needn't go into its consequences until we are ready.)

Bohr was unusually well-placed to tackle these problems because he had recently made an advanced study of Planck's still-new quantum hypothesis, which said that (contrary to another statement of electromagnetic theory) the evidence of experiment is that light energy is not radiated continuously but in discrete packages. Bohr applied this as-yet unexplained hypothesis to the Rutherford atom, but in so doing he also applied a completely new and additional postulate of his own. "Light energy is quantized into packages; how would it be if all energy were quantized into packages?" he generalized.

As a first shot one could postulate that the energies of electrons in atomic orbits were quantized in this way, by assuming that only certain discrete energy-levels or states were permitted inside the atom. Inevitably, this postulate enabled the atomic spectra to be explained in principle; but the explanation was a brute-force one, *ad hoc* and untidy, since the packages of energy turned out to be of differing, awkward sizes. Bohr then examined the other properties of these permitted orbits and found that their angular momenta progressed evenly, in equal steps; always *and for all atoms* the step size was the same curious quantity $h/2\pi$. (For the specialist I will remark that this h is Planck's constant, as derived in his quantum hypothesis, while the 2π converts the dimensions of h from those of "action" – erg-seconds – to those of anular momentum). Atomic spectra could now be calculated from the Rutherford atomic model on the basis that the angular momenta of the planetary electrons, rather than their orbital energies, were quantized into systematic, discrete values. No explanation was offered by Bohr as to why angular momentum should be quantized: the assumption was to be justified by its spectacular results.

There can be no disputing the brilliance of this piece of work by Bohr in the year 1913, and what I next have to say must not be construed as detracting from it. That is not my intention. I wish merely to pinpoint what Bohr actually did.

Planck's quantization (type one) we have already found to mean simply that light

continued on page 73

LETTERS

IDEAS FORUM

On a number of occasions I have found that no-one makes quite the component I would have liked for an application, and that the design solution turns out to be disappointingly complicated for no other reason. Often in such a case the device could be a Schottky t.t.l. or c.m.o.s. i.c. and would simply be a rearrangement of on-chip components or gates already well-proven. This means that development of the chip should not pose any serious problems and the device could be manufactured easily enough.

This letter has been triggered by one such example. I am currently designing some equipment involving logic working from a +5V supply, and some audio circuits. To keep costs down, the audio circuits use ±5V supplies, requiring only the addition of an extra fairly small −5V supply derived from the same centre-tapped transformer secondary. The logic controls the audio by c.m.o.s. switches, either 4016 or 4066, with V_{DD} and V_{SS} at +5V and −5V.

Now the rub is that level shifters are needed to translate Schottky t.t.l. signals to ±5V logic swings needed by the analogue switches. This is not terribly hard; a p-n-p transistor and three resistors do the job (Fig. 1), but this niggles the switches themselves, and the number of them – four transistors and 12 resistors per switch package – increases manufacturing costs.

What makes the situation most frustrating is that the i.c. manufacturers have themselves already solved the problem elsewhere in the 4051, 4052, and 4053. These i.cs are cheap, and contain 4066-type switches and level shifters which do exactly the job I need done. They also contain a few gates, but that is not too relevant to this point, except that gates can also be included easily.

The conclusion is obvious. Take a 4066. Put it in a 16-pin package instead and add the third V_{EE} power supply pin and level shifters. This leaves one pin spare, and the only remaining question is what to do with it (leaving pins unsued is in my view a crime). It is not necessary to look very far for a solution to this! Some of my switches are controlled directly by microprocessor output port bits. If the switch i.cs also contained transparent input latches with the remaining pin as a strobe (active low to connect directly to the address decoder), they could interface directly with the data bus and save me the cost of a port register as well! For situations where the switches are to be controlled directly by the input lines, the strobe is simply tied permanently low.

Thus arose my invaluable but cheap, and unfortunately imaginary, analogue switch i.c. (Fig. 2), with d.c. specification basically those of the 4051/2/3. They'd sell millions, and I could have been happier.

All this brings me to wonder how often other *WW* readers have had comparable thoughts in different applications, and whether *WW* could usefully serve both i.c. manufacturers and users by providing a forum for such ideas, perhaps as an extension to the Circuit Ideas columns. I would love to hear comments from *WW*,* its readers, and the manufacturers on this.

Finally, in fairness to Analogue Devices, I must point out that the AD7590 does pretty well exactly the job mine does, but compared with 4000-series switches it is a relatively expensive high performance device capable of operating from ± 16V supplies.

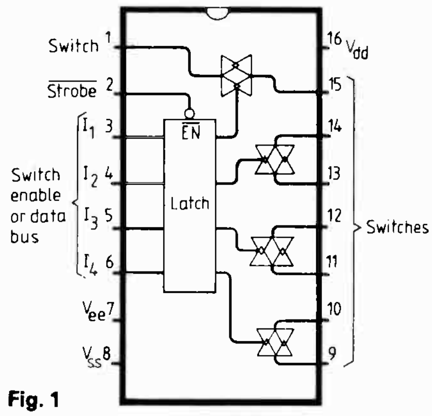


Fig. 1

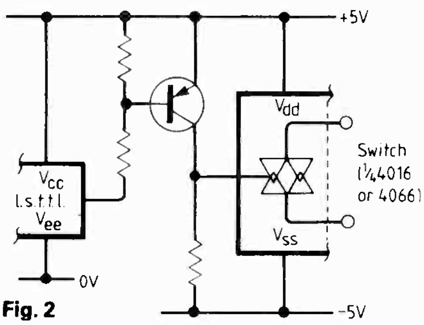


Fig. 2

Alan Robinson
London N11

* We will gladly collect together readers problems, and solutions where proffered, in a regular way given encouraging response – ed.

CLASS S

Mr Allinson's interesting letter (December) raises several points. I deal with them under his numbering.

1. Another altogether different class S may have been invented by B. D. Bedford in 1932 but neither I nor anyone I know had heard of it. As recycling and conservation is now in fashion I suggest that we recycle Mr Bedford's class S and associate the name with my circuit on the grounds of under-utilization!

From Mr Allinson's description the Bedford circuit sounds like class C with a filter added, hardly worth a class name to itself.

2. A2 may be a variant of the Howland circuit but it is novel, although the really novel feature of the scheme is the paralleling of the voltage and current drives to a load for the first time. However as now appears the voltage amplifier, far from being irrelevant, is vital.

3. Because the voltage source with its very low impedance is connected directly to the non-inverting input (my Fig. 4), A2 has no positive feedback applied to it. It is thus inherently stable.

4. Mr Allinson's figures of an improvement of 280 times or 49 dB runs counter to his general argument and strongly support the worth of the scheme. It is quite true that during the crossover region the load seen by A1 drops to about that of the load proper. But provided that the voltage amplifier can handle this i.e. that its output impedance is low, a quite achieveable target, the spikes can be negligable. There is of course nothing to stop A2 being designed with less crossover distortion. Contrary to the belief of British industry's managers, we design engineers have to pay our telephone bills in cash and even eat sometimes and so commercial considerations stop me publishing an improved and more practical class S circuit!

5. This in the conventional sense is not a multiloop amplifier. Finally I stand by my equations which clearly show that the problem of distortion can be pushed onto the voltage amplifier with all the advantages this has.

A. Sandman
London NW3

FREE SATELLITE TV?

When satellite television finally arrives, and I point my dish skywards, and only watch foreign broadcasts, will I still need to take out a licence?

Logic tells me "No, of course not", but a lifetime's experience of paying taxes on this sceptred isle makes me hazard a guess that I'll be required to take out *not one* – but *two* of them!

Douglas Byrne
Ryde, IoW

HERETICS GUIDE TO MODERN PHYSICS

I would like to echo M. G. Wellard's approval of the open-minded attitude taken by Dr Murray in his articles. I think, though, that he (Wellard) is being somewhat hard on Cerenkov and, for that matter, the Nobel Award Committee, my understanding of the situation is this. The speed of light is

$$c = \frac{1}{\sqrt{\mu_0\mu_r\epsilon_0\epsilon_r}}$$

For light in free space, μ_r and ϵ_r are unity. This is the value for c used in the calculation for relativistic mass, and so on.

In the case of a medium other than free space μ_r and ϵ_r are greater than unity resulting in the speed of light through that medium being reduced.

This means that a particle can travel through that medium faster than light can without violating relativity.

It seems straightforward to me, or is this kind of idea going to come under the scrutiny of Dr Murray?

B. D. Runagle
Burton on Trent

Several readers rose to the defence of the "crank Cerenkov", and I must apologise for drawing them into my private war with the Establishment. They all gave the official explanation of why the Cerenkov effect does not invalidate special relativity. B. G. Bainbridge, B. J. C. Burrows, F. MacAlister and K. Wood all wrote briefly. J. S. Lindfoot hopes being a heretic will not exempt contributors from the standard of competence expected from others. D. Rawson-Harris dealt at some length with Dr Murray's Heretic's Guide.

My letter was a reaction to a book I had read through several times very carefully. The book, Fiction Stranger Than Truth, is published in Australia by N. Rudakov. The Fiction of the book's title is Einstein's theory of special relativity. Rudakov has dissected Einstein's 1905 paper with the skill of a surgeon, phrase by phrase, sentence by sentence, and equation by equation. His book is not suitable reading for ardent Relativists. He begins with a comprehensive analysis of the Establishment's success in repressing all forms of criticism of its heroes and their theories, and he has collected, over a period of many years, more than enough evidence to show that the physics Establishment is in the hands of ideological extremists. Rudakov cites a review of H. Aspden's book, Modern Aether Science: Aspden is a crackpot, it says, and his book should not be acquired by libraries.

As Rudakov mentioned the Establishment's treatment of the late Herbert Dingle, I have since read Dingle's book Science at the Crossroads. This is a chronicle of Dingle's failure to extract from individual members of the Establishment, a simple answer to a simple question. His last failure was recorded in *Wireless World* July 1981 under the name of Wilkie. I first suspected the Establishment might be exhibiting symptoms common to all totalitarian states when I read in Relativity and Time Signals by L. Essen (*Wireless World*, September 1978) "The theory is so rigidly held that young scientists who have any regard for their careers dare not openly express their doubts." McCausland, in his comments accompany Dingle's article (October 1980) mentioned the "special provision" of editors of journals swearing allegiance to the Establishment, and quoted an article by Davies "Why Pick on Einstein" published in *New Scientist*. The *New Scientist* later published a short article summarising letters arising from Davies's article, headed Einstein 6, Cranks 1. We are the Greatest! I have deduced from a study of the behaviour of the Establishment of a country under the control of political extremists, that suppression of criticism is scientific proof that the theory – that the man in charge is there for the benefit of his charges – is seriously flawed, and I can only assume that the physics Establishment is suppressing criticism for the same reason, and is not defending a scientific theory at all. Herschel and Babbage formed the British Association in 1833 to destroy the corruption of the Royal Society. A repeat performance is overdue. *Wireless World* is now the only outlet for criticism of modern theory.

I have already given a simple mathematical analysis of special relativity based on Fourier's theory of dimensions, in my appreciation of Maxwell. Maxwell began his Treatise with an explanation of Fourier's theory, and in his chapter headed Dimensions of Electric Units, he analysed his electric and magnetic units, their products and ratios, into the three fundamental units of mass, time and length to show that the number of electrostatic units in one electromagnetic unit had the dimensions of a velocity, the velocity of light in free space. I cannot see how Maxwell could have developed his equations without the assistance of Fourier's theory. Using Fourier's theory, every quantity and equation of relativistic dynamics is absurd, and at least one third of Nobel Prizes for physics were awarded for theories and discoveries that cannot possibly fulfill Nobel's motive for his endowment. Cerenkov discovered his effect in 1934, but he had to wait 24 years for his prize because he was dismissed as a crank until someone amended Relativity.

Einstein attempted in his theory to justify Michelson and Morley's interpretation of their experiment, which implied that light did not obey Newton's laws of motion. Helmholtz had proved mathematically that the law of the conservation of energy could be derived from Newton's laws of motion. This is why Maxwell insisted that electromagnetism was a dynamic science, and why he succeeded in constructing a mathematical working model of his ether using the equations of dynamics. Therefore Maxwell's equations predict that light obeys Newton's laws of motion. But Michaelson and Morley implied that it didn't, and they also implied that light did not obey the law of the conservation of energy. The simplest way to avoid conforming to Newton's laws of motion is to vary the dimensions of the fundamental units of time and length.

There are two possible explanations of Michaelson and Morley's interpretation of their experiment. Either light suffers a temporary loss of kinetic energy when passing an observer, or the observer loses kinetic energy when passing a wave of light. As Einstein could only predict the velocity of light he chose the first explanation. His measuring rod represents the dimensions of the fundamental unit of length and the time between each tick of his clock represents the duration of the fundamental unit of time. There is a reason why he chose to multiply the dimensions of the fundamental unit of length by Lorenz's factor $\sqrt{1-(v/c)^2}$, which is less than one when you move, and divide the duration of the fundamental unit of time by the same factor. A velocity has the dimensions of L/T, and if Einstein reversed his mathematical operations, the velocity of light would increase. Special relativity is a very simple theory. An observer is forbidden to travel at a velocity in excess of that of light, because light would then travel backward.

The formula given by B. D. Runagle is due to Maxwell. The value of the quantity ϵ has been inverted in the SI system of units. Maxwell would have expressed this equation (squaring both sides) as $c^2=\epsilon/\mu$ in free space. ϵ is the ratio of the electromative intensity E, to the corresponding electric displacement D. Maxwell called this ratio "the coefficient of electric elasticity of the medium" (Art. 60 of his Treatise). This coefficient varies inversely as the specific inductive capacity, k. The electromotive intensity E is by analogy the stress in an elastic medium which produces a strain, the electric displacement of the medium, D. The ratio $E/D=\epsilon$ is the electrical equivalent of the mechanical ratio, stress/strain=Young's modulus of elasticity. μ is the ratio of the magnetic induction B to the magnetic force H, and represents the density of the electromagnetic medium. Magnetism is a flywheel effect of the medium with an electric current as its axle, and any change of the medium's density would change the flywheel moment of inertia. The equation $c^2=\epsilon_r\epsilon_0\mu_r\mu_0$ tells us that the square of the velocity of light is directly proportional to the electromagnetic medium's elasticity or pressure, and inversely proportional to its density, just as the square of the velocity of a sound wave is directly proportional to the air pressure and inversely proportional to the air density (see equation 4 of Aspden's Ether article, October 1982). The energy of the air at every point of a sound wave is half kinetic and half potential. In Art. 792 Maxwell proved mathematically "that at every point of the wave the intrinsic energy of the medium" is half kinetic and half potential. Presumably Maxwell as a crank.

I cannot understand the scientific meaning of the phrase "a medium other than a vacuum", if there is no medium in a vacuum. If light passes through a vacuum under the influence of a negative electrostatic field, light's velocity exceeds that of its 'constant' velocity in a vacuum, and a vacuum under the influence of a positive electrostatic field reverses this effect. If light passes through a hollow electromagnet in a vacuum in the same direction as the flow of the magnetic flux, the apparent velocity of light is in excess of its 'constant' speed. If light is directed against the flow of magnetic flux, its apparent velocity is below its 'constant' speed. This is a Doppler effect caused by the kinetic energy of a moving medium. Both ϵ and μ are ratios. Why then should the suffix r apply to a medium, and the suffix o apply to nothing, when their difference merely depends on changes of E, D, H and B? Maxwell said in Art. 428: "Magnetic induction is a directed quantity of the nature of a flux, and it satisfies the same conditions of continuity as electric currents and other fluxes do." The equation of continuity was discovered by mathematicians investigating the motions and strains of liquid media. To legitimately apply an equation of continuity to a system, a scientist should first be satisfied that a system has a continuous supply of a medium. The only medium to satisfy Maxwell's conditions is Aspden's continuum of positive electrostatic potential energy, if the word 'positive' is used to avoid all ideas of negative quantities.

Fiction Stranger Than Truth is available from the publisher, N. Rudakov, PO Box 723, Geelong, Vic. 3220, Australia. Price, including p&p Australian $12.

M. G. Wellard

IMPACT OF THE PHOTON

Dr Scott Murray (Impact of the photon, *WW* October) believes that a single photon of radiation is unable to produce interference with a later arrival. He might be right. No doubt the experiment of G. I. Taylor would be worth repeating with modern equipment.

However, I see no reason why *successive*, single, photons shouldn't produce interference effects. To produce interference one uses an interferometer (or a simple doubly-reflecting system) in which the two interfering beams have

(a) zero longitudinal displacement
(b) zero lateral displacements
(c) zero time displacement.

It is well-known that interference between two beams of radiation can *still* be obtained if (a) isn't quite satisfied, namely, if the two beams aren't quite the same lengths. In the case of light, the interference fringes look 'washed out' the blicks aren't quite black and the whites aren't quite white.

It is not so well-known that interference can still be obtained if (b) isn't quite satisfied, namely, if the two equal beams are laterally displaced. In the case of light, the fringes again look washy.

It doesn't appear to be known whether interference can take place if (c) isn't quite satisfied, namely, if any two photons don't arrive at their rendezvous at the same instant. My guess is that when Taylor made his experiment the disturbance of one photon lasted long enough to cause interference with its following photon.

In my opinion, if the above interference experiment were repeated with a stabilized laser as light-source, and sufficient time was allowed for

a single photon's disturbance to die away before the arrival of its successor, then and only then will Dr Murray's prediction come true.
A. H. Winterflood
London N10

Ideas about the fundamental nature of e.m. radiation, electromagnetism, the ether, elementary particles and so on become ever more diffuse. Contributions to *WW* over several years by Jennison, Wellard, Aspden and others are all fascinating but leave many of us lesser mortals more confused than ever. So many of the conflicting views seem eminently reasonable, at least until the next one comes along!

The latest by Aspden and Scott-Murray, (*WW* October, 1982), are likely to fuel the fires of the duality argument, i.e. waves *vs* photons. A unifying theme might possibly arise from phase-locked cavity research at the University of Kent, (*WW* June, 1979). Professor Jennisons' enormously impressive work does however seem to require an acceptance of relativistic concepts which may be claimed by some physicists to involve paradoxes which are difficult to resolve.

Perhaps someone (possibly Prof. Jennison?) might agree to draw the threads together and show in summary form how these differing ideas could be reconciled or, at least, how they may have common ground. The last may be the most important; quite possibly each of the learned contributors has glimpsed a little bit of the truth. For example it does seem possible that phase-locked cavities could co-exist with Aspden's ether, the last mentioned perhaps providing a reason for the finite and specific value of the velocity of e.m. propagation in space. Adopting a "Machian" approach, should we not after all suspect that "c" can only be due to the presence of space and therefore to some property it must possess?

If one accepts the remarkably elegant and persuasive arguments for p-l cavity electrons, is it not probable that all fundamental particles are similar, though presumably having differing trapped radiation frequencies? In this event the inertia of matter and what we call mass (i.e. the inertial behaviour of matter), are both explainable in terms of the internal mechanistic properties of the constituent particles. Where then does this leave gravity? That delightfully vague concept of the distorting effects of mass on the enveloping space no longer seems tenable. Mass as such is not even real any more, it is simply a symptom of inertia which is an inevitable property of a p-l cavity!

Thus p-l cavities perhaps need ether so that the trapped radiation fields can somehow interact with the surroundings to generate distortions which the relativists would presumably regard as distortions of space (the ether?), caused by the presence of mass. If these distortions could be shown to propagate, that may be gravity!

The possible existence of a family of p-l cavities having differing though specific sizes also needs to be explained. Does the presence of one size cause interations with the surroundings which will give rise to another size; the specific sizes perhaps being influenced by whatever determines the specific value of "c"?. Finally, with a family of p-l cavities, do we say that the smallest must be the ultimate fundamental particle?. It would be ironic if this turned out to be a photon!.

All this is very amateurish and speculative you may say. But then, can you do any better? If I have to believe in an expanding universe, I would at least prefer whatever is expanding to have some definable properties!
M. G. T. Hewlett
Midhurst
W. Sussex

ELECTRONIC IGNITION

Following recent correspondence on CD ignition systems, readers may be interested in my experience. I built a kit (Jermyn Industries) in 1973 and fitted it to my Vauxhall Victor FD, then one year old. I have had no faults or failures. Starting has always been at first touch. Hence batteries have lasted well, my third being bought last winter.

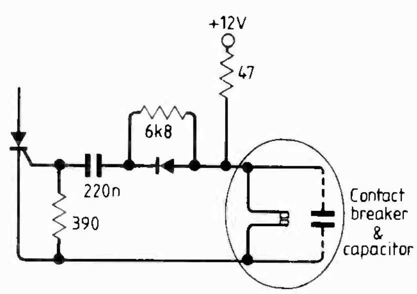
No electronic or electrical maintenance has been needed. A garage once replaced the contacts by mistake so I am on set number two. From time to time I reset the gap and check timing. The gap needs no cleaning and shows no wear. Plugs also last well but have been replaced after an estimated 20,000 miles use.

The real message after nine years is reliable starting requiring virtually no maintenance for an outlay of around £10.
J. M. Osborne
ILEA South London Science Centre

With reference to electronic ignition, the question of misfiring at certain engine speeds has been mentioned from time to time.

I found misfiring was due to the inverter oscillator locking in frequency, at various multiples of the ignition firing occuring when the oscillator would "pull" no more and changed, or tried to lock to the next notch. At these specific speeds the oscillator tended to "hunt" and spikes in the system degraded the firing pulse.

I used mostly 40506 thyristors in the few units I built, and theoretically a very small capacitor can couple enough energy to fire these. However, given a cause I up-rated the coupling values until the problem disappeared. I trust this may be of some help to others with the same problem.



G. Pirie
Craigavon
County Armagh

Mr Watkinson could not be aware of all the facts when he wrote his letter (WW November). I should be obliged for the opportunity to set the record straight and to correct some false impressions.

I had not hitherto regarded main distributors as normal retail channels of supply; nevertheless I extended my enquiries to them for the specified i.c. These included Quarndon Electronics who offered 54LS01J *in lieu* of SN5401J within a reasonable minimum order value of £5. It was soon apparent to me however that to buy the i.c. on its own (I had already acquired TIL31 and TIL81) would make it a relatively expensive component. Taken together with the cost of catalogues, postage, etc." incurred during my enquiries (expenditure which, incidentally, would have enabled me to replace the conventional points several times over) I concluded the opto-electronic contact breaker could not be a cost-effective addition to my 4-cylinder car. It was a simple economic decision to abandon it (for the present at any rate) and did not imply any criticism of the author's choice of the component.

On the other hand, if Mr Cooper's ignition unit was to remain cost-effective, as he obviously intended it should, I considered it advisable to find a source for the transformer he specified without the hassle and expense involved in shopping for the SN5401J. It seemed at the time to be a sensible action to seek this timely direction. In the light of the reaction it has provoked I am now not so sure. Needless to say, Mr Cooper was unstinting in the help he gave. I was particularly gratified to learn that he at least appreciated the difficulties in procurement that can sometimes confront the non-professional.

In the case of the opto-electronic contact breaker, it made little sense to me to publish a circuit in April 1981 and then to follow it up ten months later with a deal of further information in response to "several enquiries" which, in my humble opinion, could have been anticipated having regard to the universal appeal of a circuit with an automotive application. Moreover, if what was stated in February 1982 needed to be said at all, it would have been better, and indeed more helpful, to have said it when the circuit was presented to readers. But as Mr Watkinson so rightly comments, you cannot satisfy everybody all the time. I do hasten to assure him, however, that I was not among those who would presume to question his judgement about components which he regarded as crucial to the reliable operation of the circuit in the hostile environment intended for it. I am sorry that as a result of my letter he should therefore feel it incumbent on him to defend it yet again.
J. E. Stevenson
Purley
Surrey

TAPE VOICES

With reference to Mr Stein's letter in the October issue, the existence of these voices has really been attributed to known physical effects, such as broadcast breakthrough, and people's ability to find form in random noise.

David Ellis has researched the subject at great length under a scholarship awarded by a Cambridge college, and reluctantly found very little evidence for any paranormal happenings. His researches are available in a book *The Mediumship of the Tape Recorder* (ISBN 0 9506024 0 X) for £2.25 from him at Fernwood, Nightingales, West Chiltington, Pulborough, West Sussex RH20 2QT. The book includes practical details which enable readers to perform their own experiments.

Another reference on this subject is by Professor W. R. Bennett, in *Scientific and Engineering Problem Solving with the Computer* (Prentice Hall 1976 ISBN 0 13 795807 2). This is really a book on computing. He mentions the Voices, in an exercise on non-linearity, but an earlier section on generating random text messages from "probability sieves" is extremely interesting. You type in one or two pages from works by a certain author, and the computer produces pages of random letters with a similar probability distribution. When the book was written, it was only possible to get a third-order matrix. Even so, quite a few words were obtained, and those words were similar to those favoured by the author chosen. If someone were to adapt these techniques using a micro equipped with hard disc, then considerably more striking results could be achieved than those available to Prof. Bennett using two 16K minis working together. No doubt someone unaware of this work may one day decide that his computer is in contact with the dead.

John de Rivaz
Truro
Cornwall

THE RIGHT FORMULA

In reply to Ronald G. Young's letter, November issue, the answers to the questions he posed for me are

1) a theory which does not predict practical results has no practical use

2) R = E/ I by definition.

As to his third paragraph, I would assure him that by the word 'instrumentalist', (see his book "Conjectures and Refutations", RKP, 1963, p100,) Karl Popper does not mean people who use instruments like oscilloscopes and computers. The brilliant Wireless World editorial of July 1981 mentions instrumentalism, and puts Young's position into historical perspective.

As to my bitterness about instrumentalists, I give good reason in my September 1982 letter.

Those college professors, institution officials and Nobel prize winners who (unlike me) get salaries, expense accounts and fringe benefits from electromagnetic theory – I understand that the dinners for potentates in the IEE are very lavish – are seen in the recent *Wireless World* debate entitled "Dispacement Current" and "Death of Electric Current" to be abysmally ignorant of their subject, and yet those same people as referees of learned journals, have for ten years exercised their power by preventing me from publishing my results in any learned journal in Britain or the USA, including journals of the IEE, IEEE, Inst. Phys.

Some *Wireless World* readers will be surprised to learn that during 25 years of work, I have never succeeded in publishing any of my work in any British learned journal. The defences against new information are particularly strong in Britain. The Inst. Phys. broke their contract with us to publish the paper. "The History of Displacement Current" (later published in *Wireless World* March 1979) when they discovered that it contained new information. If one did not become bitter over such a scenario, when would one?

The arrogance of the ignorant power brokers in our society seems limitless when it comes to suppressing scientific advances by Catt, Heaviside, Galileo etc. The ability to manoeuver one's way to the top of the IEE or Inst. Phys. is no justification for suppressing advances in the disciplines which generate the financial base of those institutions. If these people resent their good faith being questioned, then I look forward to being invited to publish in their journals and lecture in their halls.

Further reading

1. T. Jaynes, Foundations of Probability Theory and Statistical Mechanics, from Delaware Seminar in the Foundation of Physics, ed. Mario Bunge, Springer-Verlag Berlin 1967. (Library of Congress no. 67-16650). First chapter "What makes theories grow?" pp. 77-83.

2. O. Heaviside, Electrical Papers Vol. 1. Macmillan London 1892, pp. vii-x. Heaviside discusses the way in which his publications were blocked. It includes "Perhaps it was thought that official views were so much more likely to be right that it was safe to decline the discussion of novel views in such striking opposition thereto. There seemed also to be an idea that official views, in virtue of their official nature, should not be controverted or criticised . . . "

Ivor Catt
C.A.M. Consultants

AMATEURS...AND CB...

I see from "Letters" in November's *WW* that Mr Wood, of the Home Office, announces that nine stations were traced and closed down for illegal broadcasting in 1981. Is he trying to disable us all with mirth? Really Mr Wood, this must represent the precentage of offenders who turned themselves in because of a guilty conscience. There must be many more "pirates" than that in the London area, per square mile, mostly using sections of the ten and two-metre bands. In my limited experience, the HO couldn't catch a mouse in a mouse trap.

Here is an example; a mini-cab firm, based at a garage at the Circle, Carshalton, controls its cars with modified citizens band sets on 28.00125MHz. At least two amateurs notified the Home Office with the details, including the address. A month or so later, an official paid a visit to the garage, but as luck would have it, none of the 18 or so drivers were working, and the controller was using his set on the legal UK CB frequencies. The offical told him to change his illegal high-gain aerial for a regulation one, and left. An amateur friend of mine called at the garage to inform the owner that he was illegally occupying an amateur frequency. The man said he did not realize that that was the case (I have heard amateurs informing him of this fact on two occasions) and promised to have all his rigs modified to go below the CB frequencies. He also claimed to have been arrested twice for using a linear amplifier; he is still using it and, three months on, still using 28.00125MHz.

If cases as blatant as this are difficult to bring to justice, then I can only conclude that the HO has its hands tied with absurd requirements for "conclusive" evidence. Meanwhile, I often hear CBers make reference to the "6.6MHz band" and "the a.m. channels" as if they were a natural and legal alternative to the UK system.

So, Mr Wood, if you need a lead to begin clearing the airwaves of pirates, ask the amateurs; they must each know of the whereabouts and the activities of more illegal stations than the HO prosecuted in 1981.

J. Baldwin
Ashtead
Surrey

. . . AND BAND 1 . . .

The letter by Mr Laven (page 65, October issue), and recent broadcasts by the RSGB's GB2RS news, is most gratifying if only offering a crumb to we v.h.f. people. The recommendations of WARC *viz a viz* v.h.f. as a definition should put 4m (70MHz band) and/or 6m (50MHz band) within the group of all Class B licence holders. That some very experimental outside-broadcasting-hours-only licences are, or have been, issued (to Class A holders only) is at least a step in the right direction.

However Mr Stacey, G8BXO, in the letter following the above-mentioned suggests 48 to 48.6MHz, on the very worthy grounds of harmonic interference. Whilst I must agree with some form of 6m activity, and concede his grounds for his choice, I say that it's less than the 50 to 52MHz band mentioned by Mr Laven (haven't we lost enough?), and that because it's the third harmonic into 2m band, it should not be used. Anyone who has used the 23cm converters (i.f. output on 2m band) in a contest will know the problems. Furthermore, if we were on 48 to 48.6 we'd not be able to do serious tropospheric work over the Atlantic – I understand that the USA uses 50-52MHz.

D. R. Coomber, G8UYZ
Leeds
N. Yorkshire

. . . AND BALLOONS

Having read a news item which stated that a South African radio-ham club was about to launch a balloon carrying a relay station powered by solar cells. The increase in cost over an orbiting relay at 100km when compared with a 200mb drifting balloon at under 13km is not much, but the launch is so much cheaper, and if Ghost-type balloons are used a stay in the air of two years or more is possible. Its tracking is easier as it will appear stationary in the short term and one could get away with pre-set aerials and not need continual tracking as for a satellite.

My idea is to use the balloon not only to carry the relay but also to carry Ghost experiments for the Met. Office. Not only would the worldwide Weather Watch get data but the hams would get a reduced launch cost. There would be chance of more launches worldwide with possible balloon-to-balloon links to increase range. The Weather Watch would gain from reduced launch costs if the relay had its cost split, or even better if amateurs did the data receiving using an add-on to their normal receiver, storing data on compact cassette and then sending them onto a central Met. Office. The more receivers the better as this would cover data losses. Having many disadvantages this is nevertheless a good way to build up experience until standby jump space becomes cheaply available from Nasa or ESA. (Has anyone ever tried the Russians?)

G. A. Cockburn
Edinburgh

STICKY WINCHESTER

I suppose there will always be more than one explanation for the origin of any nickname, so here's another one for Winchester (in connection with "Disc drives" WW Sept. issue), from an article in the American magazine:

> "The Winchester nickname for rigid drives comes, as does much of the technology, from the trail-blazing IBM which in 1973 brought out its model 3340. It was a dual drive with planned twin storage capacity of 30 megabytes each. The 30-30 configuration reminded some of the rifle; though IBM soon upped capacity to 35 and then to 70 megabytes, the name stuck."
>
> *Electronics* 10 Feb 1981, page 98.

R. Camp
Brentwood
Essex

LETTERS

CARTRIDGE ALIGNMENT

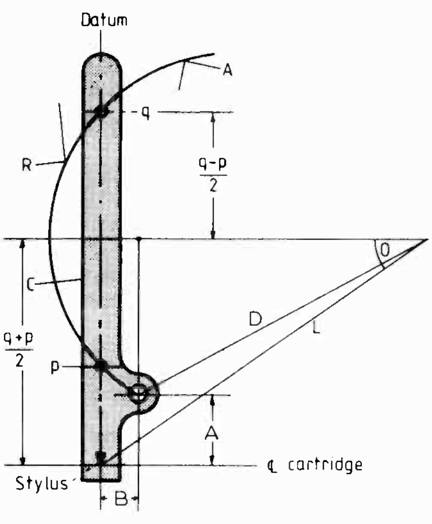
What an unfortunate misunderstanding. In no way did I contradict R. J. Gilson's articles on Cartridge Alignment. May I take each of the paragraphs in his August 1982 letter in turn?

1. All the information on my June 1982 diagram came from several space-consuming sketches. It does make a difference to the geometry (mis-quoted) – by simplifying. For instance, C/L and the sin O equation can literally be seen in the diagram if the omitted lines are visualized.
2. One or two popular magazines suggest the use of lengthy formulae for determining tracking errors and distortion for arms of different length. A short cut is provided by taking C/L and (p + q)/2L and then fixed proportions into account.
3. I thought it might be interesting that whenever B, the innermost groove radius, is greater than p in my diagram it must appear to the left of the datum line. Knowing only Gilson's figure off the cuff, I used it as an example. No difference in status is implied.
4. $pq = 213^2 - 200^2 = 5369$. O from his formula $4b = 21.9°$ (Again I treated this as an example – no proposal has yet been universally accepted – and have to assume here that 4380/c is not known) $\sin 21.9° \times 2 \times 213 = 159$ ($\sin O2L = p + q$) so the troublesome $pq/p = (p + q) - p$ becomes $5369/p = 159 - p$. For the less rusty this yields 49 and 110 (rounded off). Thus at the very least we have a supportive procedure.
5. Subject to the points already made, I could not agree more here.

An example of the possibilities that are opened up with the new visible facts is the formula $B = \sqrt{L^2 - x^2} - \sqrt{D^2 - (x - A)^2}$ where A and B respectively represent the 15.5 and 7mm dimensions on Gilson's gauge, L = eff. length, D = spindle to pivot dist. and x = (p + q)/2. The constructor is able from this to mark out a hole in just the right place to suit his turntable and "any required overhang rule" – (from Gilson's penultimate paragraph Nov. 81). The validity of this formula can be checked by letting A = p or q.

I have superimposed the outline of the gauge on a copy of my first diagram where even this becomes clearer.

P. E. Cryer
Thornlie
Western Australia



THE DREAM OF OBJECTIVITY

Your Editorial comment on my letter in last December's issue suggests that my criticism of your Editorial could be quite mistaken since I am using the word 'phenomenon' incorrectly. Also, a further letter in the February issue equally misconstrues my argument (from M. J. Walker).

Now the words 'phenomena' and 'phenomenon' are not very widely used these days. They belong more to the vocabulary of the early empiricist philosphers like Locke, Berkeley, Hume and Kant, who were fond of using such words as 'mind', 'ideas', 'impressions', 'intuitions' and 'apperceptions', etc.

These philosophers operated by using a pen, desk, books and chair. They were attempting to describe our knowledge, or perhaps better said, understanding of the world and universe, only by contemplation, i.e. without actually making any experiments at all, with objects, to discover how these behaved under various circumstances, and thus obtain clues as to their constitution, and the natural laws which they could demonstrate. As the modern sciences have shown, though, they grossly over-simplified the situation. Thus Berkeley, for instance, highly critical of scientists and their 'insensible particles' became firmly and too easily convinced that we can properly say that we only really know or perceive our own perceptions (for which he considerably altered the meaning of the word 'idea') which he considered to be entirely mental or 'in the mind'. He then simply concluded (as also did Ronald Knox, in M. J. Walker's letter) that when we were not perceiving the 'ideas' of an object, they must be a collection of 'ideas' being perceived in the mind of God. This conclusion, which I, for one, would not draw today, whilst giving good support to the Establishment, traditional theology and morality, did not at all advance our understanding of the constitution and behaviour of objects at all, i.e. develop any vocabulary to help us master our environment. It is also nonsense to write or talk of seeing or perceiving perceptions. As Ryle has said "a person cannot talk of 'seeing looks', since 'look' is already a noun of seeing". In fact, it was not until men began to experiment more systematically with objects that the sciences began to develop, and our vocabulary for dealing with the objects around us began to acquire deeper foundations.

I do not think, then, that there is any special problem about subjectivity or objectivity, especially regarding the application of scientific method. Subjectivity is only the expression of an individual viewpoint, and provided that normal observers are able, and are permitted, to exchange viewpoints, they can always move towards a greater objectivity, and thus broaden their understanding. This procedure should only be limited by abnormalities in the observer, such as colour blindness, etc., and these can usually be detected and allowed for.

We mostly tend to deal, nowadays, with words which are the result of operating with some quite sophisticated objects in specialized laboratories. It is, in my opinion, partly through the use of such words, developed by scientific experiment, theory, and sound engineering practice, that we, as human beings, can come to have more thoroughly objective and honest dealings with each other.

Peter G. M. Dawe
Oxford

MODULAR PREAMPLIFIER

I found part 1 of J. L. Linsley Hood's description of his modular preamplifier very interesting. I like his modular approach, and I agree with his comments on the various possible arrangements for equalization. However, there seems to be a discrepancy somewhere in the discussion of the noise level of his equalization module. With the input to the circuit of Fig 6 short-circuited, the base of each input transistor sees 270 ohms to 0V at audio frequencies (R_{10}, R_{16}), and there is 220 ohms between the emitters (PR_5), This makes a total of 270 + 270 + 220 = 760 ohms series resistance between the externally-applied short-circuit and the two base-emitter junctions of the input transistors. The input noise resistance of the stage (with short-circuited input) must always be greater than this actual resistance of 760 ohms. Yet Table 2 quotes a measured input noise resistance of 450 ohms, which is impossible with the circuit of Fig 6. (The change from "RIAA" equalization to the flat response used for the measurement would not alter the input noise resistance significantly if R_{16} remained unchanged.)

I suspect that the measurement may have been made without R_{10} and PR_5, and possibly with a lower value of R_{16}. But in any event, the noise of the circuit will be adequately low in practice – given good components. (To avoid the risk of PR_5 going noisy, it would be better to omit it and obtain adjustment of the output voltage – if necessary – by injecting an adjustable current into the junction of R_{16} and C_{14}; say through 10MΩ from a preset connected between the +15V and −15V supplies.)

I'm sure your readers would wish to know that the illusive BC447/BC448 transistors Mr Linsley Hood has used in many of his recently published circuits have Jedec equivalents – 2N2907A/2N5551.

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I must apologise for the somewhat misleading text of my article of October 1982 (pages 35 and 36), in which I referred to the noise resistance of the discrete component configuration I had employed as the amplifier stage for the equlization module.

My target and measured noise figure referred to the gain block itself, with the base of TR_1 connected to the zero volt line, and the equalization network ($R_{15\text{-}19}$ and R_{25} and C_{15}) replaced by a 10k/100 ohm feedback arrangement. A number of LF351 and TL071 operational amplifiers tested in the same circuit configuration gave effective noise resistance values (with inputs short-circuited) of the order of 2.0 to 4.5 kilohm for the same measurement conditions, which I felt was less good than one might wish for this particular application, though quite adequate for later stages.

Obviously, whatever gain block one employs will be influenced by the external resistor elements connected to its input or feedback terminals, and, fortunately in the case of an equalization network, by its bandwidth characteristics.

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Data acquisition on a Pet

Interface circuits and programs for reading both analogue and digital data using a Pet microcomputer, together with brief specific descriptions for 12, 10 and eight-bit analogue-to-digital converters.

by E. D. Harvey and D. A. Hills

Main factors that determine choice of an analogue-to-digital converter for data-acquisition are accuracy and conversion speed. An increase in accuracy means an increase in the number of bits in the digital-word output and hence an increase in the time taken for the conversion. If an analogue multiplexer is used before the converter input to capture a set of data, the overall conversion time is multiplied by the number of variables to be monitored.

If the amount of data to be acquired is small and the computer random-access memory is small, it may be necessary to transfer the incoming data directly into a back-up memory for later processing by the computer.

Although 16-bit a-to-d converters are available, they are expensive and line-shielding and power-supply requirements for them are rigorous and add considerably to circuit costs/complexities. For the majority of a-to-d applications the readily available and inexpensive i.c. converters discussed here suffice.

Precise a-to-d conversion

Twelve-bit converters such as the Intersil 7109 provide the greatest precision of the devices examined but have the slowest operation. The maximum sampling rate for this device is about 1/30s per channel. But this long conversion time means that computer programs for acquiring the data may be written in a high-level language such as Basic without the need for additional delays to allow the converter to catch up with the computer.

With the CBM Pet computer a user port attachment and small machine-language program allow the 7109 device to be used. This machine language, List 1, sets bits 6 and 7 of port E810 as outputs. Lines at E84F are inputs in the default condition so it is not necessary to set them using a program.

Output lines are data request, high byte and low byte; data request is also used to change channels. Inputs are eight data lines and a zero-channel indicator. Figure 1 shows the circuit diagram, in which the clock line is used to reset the multiplexer. This set up is most convenient when the converter i.c. does not have its own clock.

With twelve-bit converters the analogue multiplexing method shown in Fig. 1 is only appropriate when slow sampling rates are involved. For higher speed multiple-channel operation, it is possible to use a converter for each channel and digital multiplexing, taking a simplified version of the section of circuit shown in Fig. 1.

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List 1. Routine for setting up user port when using a 7109 analogue-to-digital converter with a Pet microcomputer.

```
78          SEI          ; disable interrupts
AE 11 E8    LDX$E811     ; preserve control register
A9 38       LDA#$38
8D 11 E8    STA$E811     ; bring in direction register
AD 10 E8    LDA$E810
09 C0       ORA#$C0      ; set up two most significant
                           bits as outputs
8D 10 E8    STA$E810
8E 11 E8    STX$E811     ; restore usual status to
                           control register
58          CLI          ; routine finished
A9 EC       LDA#$EC      ; set CB2 as output
8D 4C E8    STA$E84C
60          RTS          ; routine ends
```

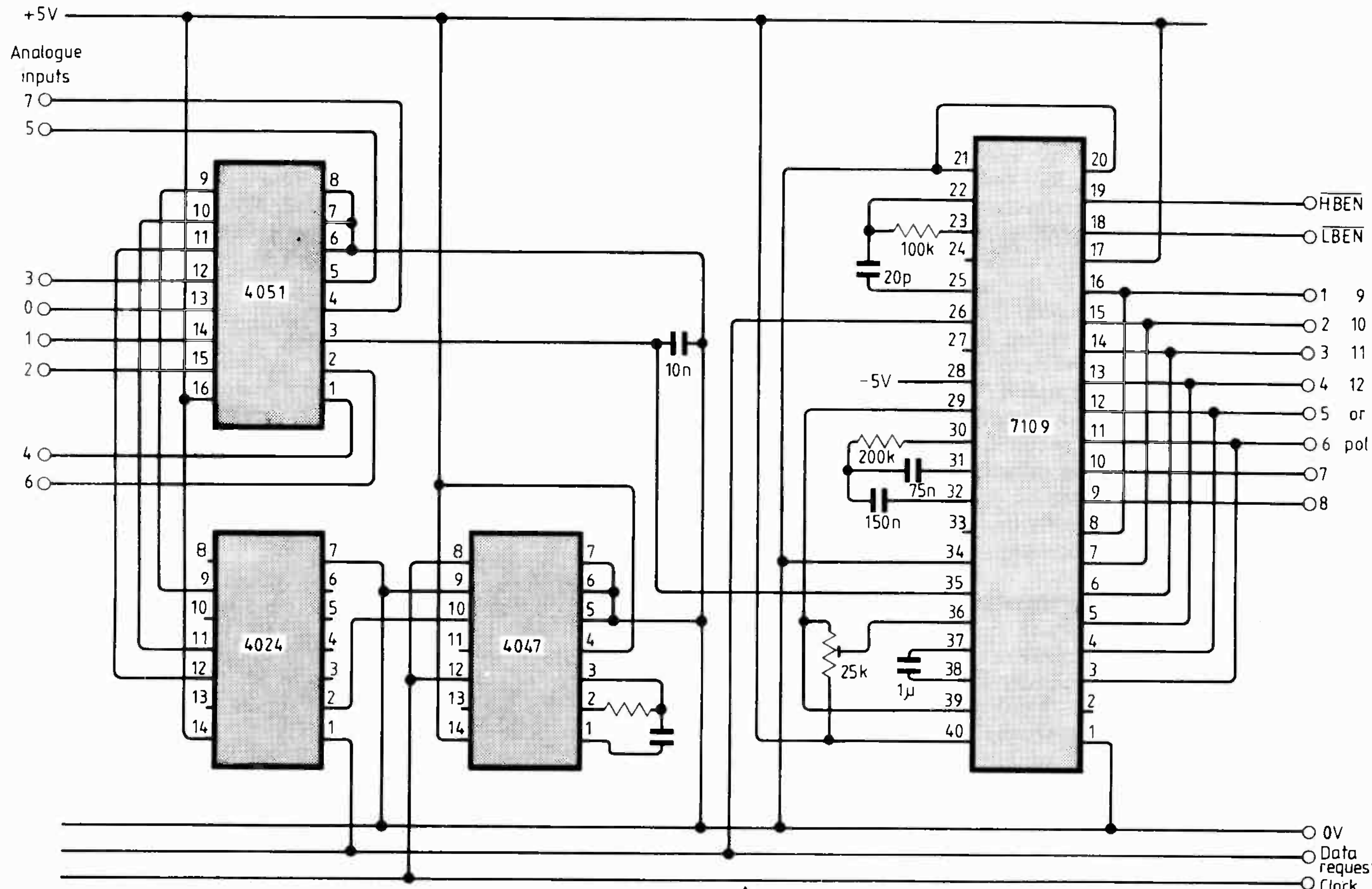
List 2. Program called by USR function for use with a Ferranti ZN433 analogue-to-digital converter and CBM 3032 computer.

```
380  20 D2 D6  JSR  $D6D2   (form-fixed number)
383  A9 10     LDA  #$10
385  8D 4B E8  STA  $E84B   (initialize clock pulses)
388  A9 9F     LDA  #$9F
38A  8D 4A E8  STA  $E84A   (initialize clock pulses)
38D  A9 00     LDA  #$00
38F  8D 48 E8  STA  $E848   (initialize clock pulses)
392  A9 FF     LDA  #$FF
394  8D 40 E8  STA  $E840   (data request)
397  20 BA 03  JSR  $03BA   (delay)
39A  A9 F7     LDA  #$F7
39C  8D 40 E8  STA  $E840   (remove request)
39F  20 BA C3  JSR  $03BA
3A2  88        DEY
3A3  D0 DE     BNE  $383
3A5  18        CLC
3A6  AD 10 E8  LDA  $E810   (read high byte)
3A9  29 C0     AND  #$C0
3AB  2A        ROL
3AC  2A        ROL
3AD  2A        ROL
3AE  AC 4F E8  LDY  $E84F   (read low byte)
3B1  20 6D D2  JSR  $D26D   (convert to floating point no)
3B4  A9 00     LDA  #$00
3B6  8D 4B E8  STA  $E84B   (remove clock)
3B9  60        RTS          (exit)
3BA  A9 0A     LDA  #$0A    (delay subroutine)
3BC  85 BF     STA  $BF
3BE  85 C0     STA  $C0
3C0  C6 C0     DEC  $C0
3C2  D0 FC     BNE  $3C0
3C4  C6 BF     DEC  $BF
3C6  D0 F8     BNE  $3C0
3C8  60        RTS
```

On a similar basis, it would be possible to use a group of converters with a single analogue input to provide more rapid sampling rates. The practicality of these multiple converter circuits is realizsed when the cost of faster precision converters is compared with that of the Intersil 7109.

Ten-bit devices such as the Ferranti ZN433 i.c. offer more speed and less precision. As these devices require clock pulses from the computer, a versatile interrupt line is required. On the CBM computer this is easily provided by the CB2 signal of the 6522 v.i.a. To reduce other line requirements for a multiple system, channel change and data request signals may be combined, as it is inconceivable that it would be required to visit a channel without reading data. The ZN433 samples continuously, and a single frame can be obtained when requested. If a reset to zero channel is required, this can be provided by including a monostable in the clock-pulse line; by turning off the clock and waiting for a short time, the monostable then resets the multiplexer to zero channel. The circuit shown in Fig. 2 includes this addition.

The Basic USR function is useful in connection with this type of converter and a program in 6502 machine code is given in List 2. It is capable of sampling the converter in about 10ms, but a more



▲ ***Fig. 1.** Analogue multiplexing using 12-bit 7109 analogue-to-digital converter is suitable for slow sampling rates. The clock line resets the multiplexer.*

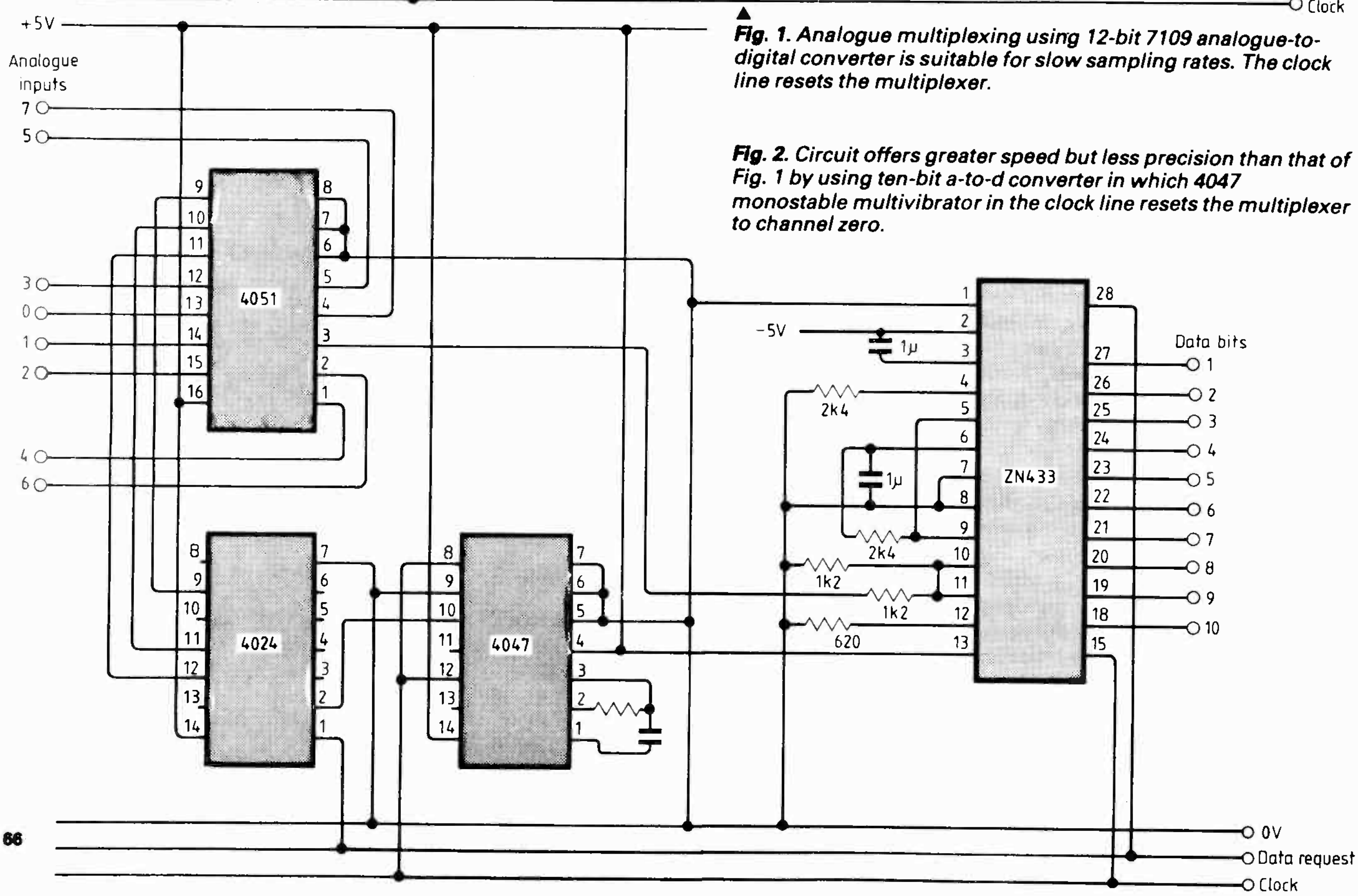


***Fig. 2.** Circuit offers greater speed but less precision than that of Fig. 1 by using ten-bit a-to-d converter in which 4047 monostable multivibrator in the clock line resets the multiplexer to channel zero.*

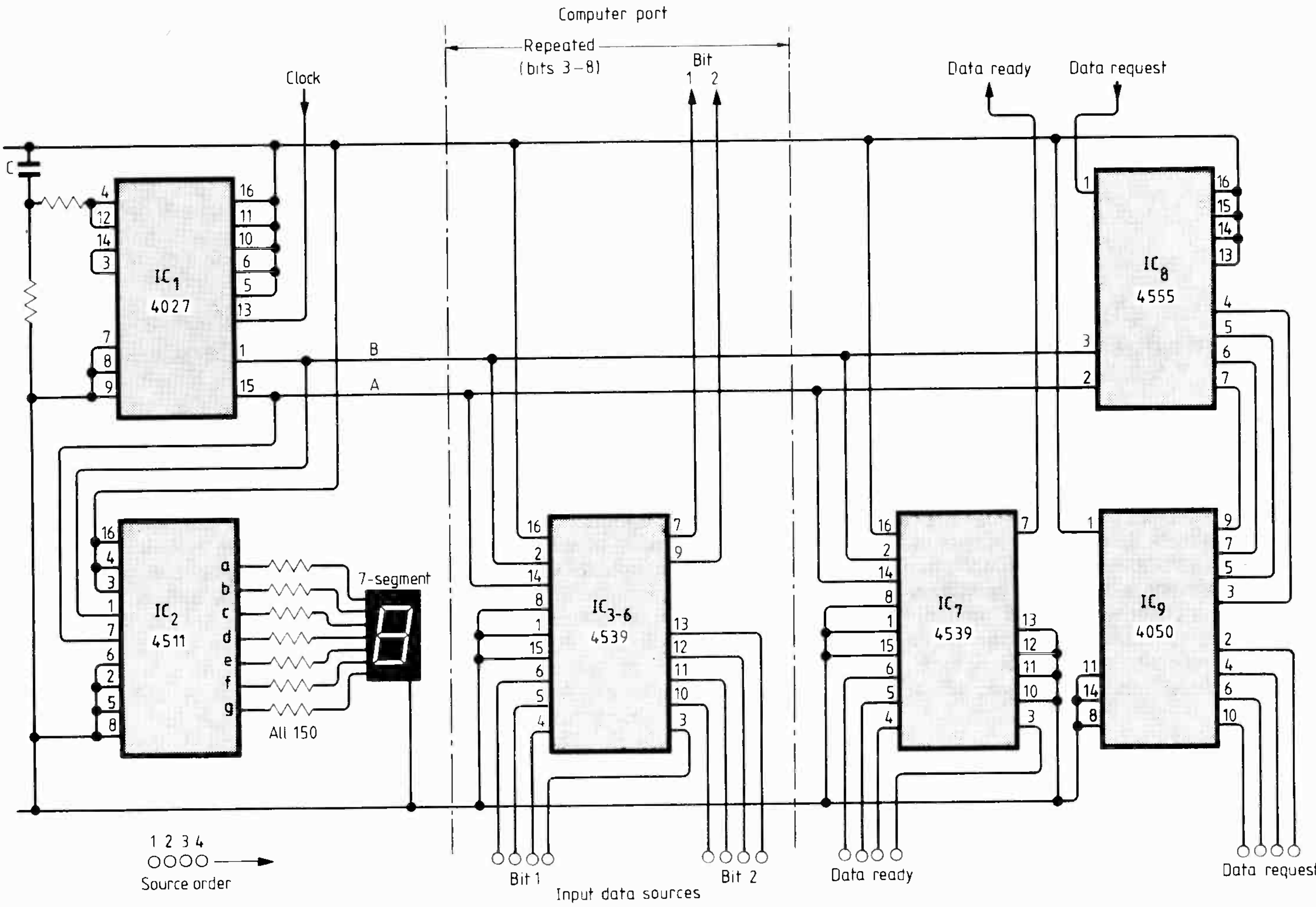


Fig. 3. In a transient-recorder application of this digital multiplexer with handshaking, computer requests data byte then resets recorder's data-ready flag. Computer than requests next byte, and so on, taking about 200ms for 1Kbyte of data using a machine-code program.

Arithmetic routines used appear at different locations in the various CBM computers as follows.

Basic version	1	2/3	4
fixed point	DB6D	D6D2	C92D
floating point	D278	D26D	C4BC

appreciable delay occurs due to the machine conversion routines used. Before entering the sequence, the USR function must be set to the starting byte. Data may then be obtained by the Basic statement,

A=USR (channel):PRINTA.

High-speed devices

Eight-bit converter i.cs such as the National Semiconductor ADC0804 provide high speed conversion with lower precision, but it is unusual to require both precision and speed. A conversion time of 30µs is possible, and the connection to the computer port is greatly simplified. A built-in clock facility is desirable and some 8-bit devices can be interfaced directly to the address and data buses of the microcomputer without a peripheral-interface adaptor. This is especially useful when other commercial computers without p.i.a. facilities are used (e.g. Apple II, TRS80).

The machine-code program is now important, and it must avoid the use of involved subroutines, e.g. USR function calls and floating-point arithmetic. Data must be stored in a protected region of memory which is most conveniently addressed by the indirect facility of the

continued on page 78

List 3. Program for taking data from a free running source using a 6502 computer with CBM 2/3 Basic.

```
350  78           SEI
351  AD  4F  E8   LDA  $E84F   (computer data port)
354  F0  16       BEQ  $36C
356  A2  08       LDX  #$08
358  D6  B8       DEC  $B8, X
35A  AD  4F  E8   LDA  $E84F
35D  81  B8       STA  ($B8, X)
35F  20  BC  03   JSR  delay $3BC
362  B5  B8       LDA  $B8, X
364  D0  F2       BNE  $358
366  CA           DEX
367  CA           DEX
368  D0  EE       BNE  $358
36A  58           CLI
36B  60           RTS
36C  AC  12  E8   LDY  $E812   (stop key address)
36F  C8           INY
370  F0  DF       BEQ  $351
372  58           CLI
373  60           RTS

Optional delay subroutine

3BC  A9  00       LDA  #$00
3BE  85  DD       STA  $DD
3C0  A0  01       LDY  #$01    (adjustable)
3C2  88           DEY
3C3  D0  FD       BNE  $3C2
3C5  C6  DD       DEC  $DD
3C7  D0  F7       BNE  $3C0
3C9  60           RTS
```

Introduction to v.d.us

James Tully looks into operational conditions, especially ergonomic, and into health and safety questions of display units. A previous article in this series, by Colin Carson, dealt with internal control.

As an increasing number of people begin to use display units in their everyday work, certain problem areas become apparent. An awareness of these areas leads to often simple avoidance measures and greatly improves the effectiveness with which a v.d.u. can be used; factors affecting readability are reflection, glare, flicker, focus, brightness and certain distortions of the image.

Reflection and glare

Glare may be caused directly by, or may be reflected from, the c.r.t. face. Direct glare is usually caused by the brightness or contrast controls being adjusted too high, or to a fault condition. Reflected glare can present considerable problems because of the height and angle of the c.r.t. face relative to the viewer.

Direct and reflected glare are affected by ambient lighting conditions in different ways. Acceptable screen brightness under high lighting conditions may seem too bright under reduced lighting conditions and reflected glare may disappear altogether under conditions of very dim illumination. Screen brightness and contrast can often by adjusted without too much difficulty to match the average illumination level of the room (300 to 500lux recommended[1]). Reflection, however, is more difficult.

There are a number of techniques for the reduction of reflective glare. The simplest and least expensive is to position the v.d.u. until the reflected glare disappears. If this results in the operator *facing* the light source then direct (contrast) glare will result due to the contrast ratio between the light source and the v.d.u. screen, and this will not be acceptable. A detachable keyboard may help, since screen and keyboard positions may be adjusted independently, allowing good body posture to be maintained. Alternatively, a variety of filter methods may be used on the c.r.t. face including polarizing filters and etching. These can produce good results but are expensive. A third method is to surround the equipment with a baffle to shade the screen from direct light.

Flicker

One of the most serious effects upon long-term viewing of a v.d.u. monitor is that of flicker. The effect is more pronounced during certain fault conditions but may be noticed under normal operation.

Electron bombardment of screen phosphor in a c.r.t. system exhibits the characteristics shown in Figure 1 (ref. 2).

Screen illumination increases to a maximum or saturation value during electron bombardment of the phosphor (fluorescence) and decays either exponentially or hyperbolically after bombardment has ceased (phosphorescence). The 'persistence' of the phosphor is the decay time to 10% of the peak value.

In a raster scanned system, where excitation consists of short pulses at regular

by J. E. Tully

time intervals, the peak illumination level will not occur as a result of a single pulse, but a gradual build up occurs over a period of time (the "accumulation process"). This build up leads to a stable state where the illumination level is represented by a sawtooth waveform with a constant average value, Fig. 2.

This periodic variation in luminance exhibits itself as flicker and its magnitude is defined by

$$F=\frac{L_{max}-L_{min}}{L_{ave}}$$

where $L_{ave}=\int_0^T L(t)dt$ and $T=1/f_r$, with f_r the refresh frequency.

From this it can be seen that flicker may be reduced by either:

– using a longer persistance phosphor, or

– increasing the display refresh frequency.

Short-persistence phosphors with refresh frequencies around 30 to 40Hz may produce flicker effects which interact with the natural oscillatory movements of the eye to give apparent movement effects[3]. Long-persistence phosphors produce a smearing effect when an image is moved from one part of the screen to another. These phosphors are also associated with shorter tube life. Further information on common phosphors is given in the Table.

Flicker, in addition to causing rapid fatigue, can trigger seizures in those who suffer from epilepsy. Not all epileptics are affected in this way but it should be determined from medical sources whether the person is subject to seizures before working with this type of display.

The effect of interlace, whilst allowing more information to be displayed on the screen, is to increase flicker unless the correct phosphor is used. Most of the commonly used phosphors are not suitable for interlaced use (see Table).

Direct health considerations

Since the introduction of the v.d.u. into the office environment there has been concern as to health and safety aspects associated with working with v.d.us. over a prolonged time period; and many questions have been asked regarding long-term viewing. Foremost among operator fears is probably the question of eye damage of one form or another. The most sensitive part of the eye is the fovea, a small area ($1mm^2$) at the centre of the retina containing only cone cells which each correspond to a unique nerve fibre. The action of the eye is to rotate the eyeball until the desired image is centred on the fovea. Because the fovea is so small, the eye scans the area of interest with tiny oscillatory movements to keep moving the image across the fovea. This relative movement of the image on the retina is essential[4] (although we are not aware of it) and if artificially stopped, the image disappears after a few seconds. Another involuntary

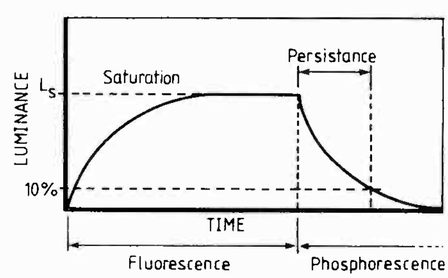


Fig. 1. Fluorescence builds up during electron bombardment until it reaches saturation; phosphorescence decays after the bombardment has ceased.

Characteristics of common phosphor types in monitors (ref. 8)

Type	Colour	Persistence	Remarks
P4	White	Med/Short (60μ)	Low cost, good focus, objectionable flicker during interlaced operation
P31	Green	Med/Short (38μ)	Good focus, may be easier to view for long periods, objectionable flicker during interlaced operation.
P39	Yellow/-Green	Long (150 ms)	Poor focus, suitable for interlaced operation, moving cursor appears to smear.

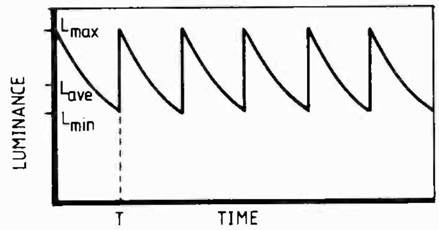


Fig. 2. Flicker associated with raster-scanned screens is caused by this sawtooth variation in illumination.

movement of the eye is a result of rod cells around the periphery of the retina which, in daylight, act as movement detectors around the extremes of the visual range and act as a trigger to rotate the eye toward an object which enters the visual field, centering the image on the fovea. Colour is perceived by a number of different types of cone cells which respond to blue, green and red light.

Fatigue and "eye strain"

The v.d.u. does subject the eye to unnatural stresses which are likely to result in fatigue of the eye and in general tiredness. V.d.u. operators occasionally complain of such things as burning sensations in the eye, impaired vision, twitching of eye muscles, headache, etc. These symptoms, which may collectively be called "fatigue", are afftected by lighting conditions of the room, general stress level of the person, brightness of the screen, boredom, noise level and posture. Eye fatigue does not, therefore, necessarily indicate that the source of the problem is visual.

If distractive movement takes place beyond the c.r.t. screen but within the field of vision, the eye will involuntarily rotate to investigate. This involves a change in focal length and fatigue will result if persistent visual interruptions occur. The effects of visual distraction are made more serious when the c.r.t. phosphor produces light of a prime colour only, since during the distraction other cone cells are activated temporarily.

In common with most electronic display devices the v.d.u. relies upon generated light rather than reflected light as used by more conventional display systems (e.g. ink and paper). This raises new problems relating to the long-term visibility of the display and its effects on the viewer or operator. Because of the nature of the image produced and the thickness of the glass at the face of the c.r. tube, the image appears to take on a certain "depth". Coupled with the characters having slightly fuzzy edges compared to printed material, this forces the eye to continually adjust its focal length, searching for the correct focal plane. This is an unusual and unnatural stress for the eye and is tiring after a prolonged period. The problem is further affected by an estimated 20 to 30% of the population having inadequately-corrected visual defects[1].

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Other factors affect the rate at which a person tires when operating a unit, including the difference in illumination levels between the characters on the c.r.t. and a printed page to be copied or compared, screen effects such as brightness, focus and flicker, and room environment conditions such as temperature and humidity.

Radiation and implosion hazards

It is true that dangerous voltages are applied to and are generated by a v.d.u. It is also true that ionizing radiation may be generated internally in some c.r.ts. This is mainly in the case of colour tv monitors where the extra energy associated with higher final-anode voltages may produce a certain level of leakage x-ray radiation. The radiation is confined to a screened area within the monitor section around the line output transformer or voltage multiplier. Measurement of radiation levels at the outer screen have been shown to be minimal and below general background radiation levels due to natural sources. Other, non-ionizing radiation including ultra-violet have been shown to be similarly insignificant[5].

Early c.r.t. monitors and television receivers employed a separate implosion guard between the viewer and the tube face consisting of either a thick toughened piece of glass or a thinner sheet of perspex, or sometimes a thin flexible plastic material bonded between two pieces of glass. Problems encountered with this system were dust entering behind the guard, loss of transmitted light; and reflected light from both surfaces of the guard. Modern monitors generally use a plastic membrane attached to the front of the c.r.t. or a bonded faceplate, ensuring adhesion to national safety standards.

Rest periods are essential to a person involved in continuous v.d.u. viewing, and should be taken away from the screen to enable the eye to focus on objects of varying distances, particularly long distances and to allow normal colour variations to be viewed. However, it has not been determined for precisely how long a display unit should be viewed before a rest period should be taken; this is a question currently being asked by representative of various industrial bodies[6], and is the subject of extensive international debate.

Environmental considerations

Lighting. The reading of a printed image is usually helped by the increased contrast associated with high illumination levels, while v.d.u. reading requires lower illumination due to the self luminous nature of the display. As both reading sources are usually required in the same room, a basic incompatibility exists requiring special precautions to be taken.

General lighting should be indirect with direct local lighting of printed material. If fluorescent lights are used, they should be parallel with the sides of the unit (not parallel with the screen) and should be fitted with diffusers. If ambient lighting levels are too high, increasing screen brightness in an attempt to maintain visibility will result in reduced resolution making viewing very difficult.

Immediate surroundings. The area behind the screen on the far side from the viewer should be free of movement and if possible should be of an illumination and colour which roughly approximates to the average of the screen[7].

The equipment should be positioned such that reflected glare and the effects of dazzling light sources are minimized. It would be useful to mask any unwanted light sources if no better method could be found.

Although some background noise is inevitable in a room with a number of people, it should be minimized in the interests of reducing the number of distractions with associated loss of concentration and refocusing of eyes.

Room temperature and humidity. In a room containing numerous pieces of electronic equipment, the room temperature may easily rise above comfortable levels if inadequate attention is not paid to air conditioning and ventilation.

In general it is preferable for equipment to produce low heat levels and to be placed in a position allowing natural convection rather than to introduce forced cooling into a room, as this is noisy and may cause draughts. A slight air movement may,

continued on page 72

Picotutor assembly-language trainer

Versatility of this small assembly-language training aid is demonstrated in showing how Picotutor can be used as a digital voltmeter by adding a small analogue i/o board. Construction and operation of the main board and a description of the analogue board are included in this second article.

Ease of construction for the Picotutor was considered of paramount importance and for many readers the component-position illustration and parts list given last month should suffice. Most of the following tips are peculiar to the Picotutor assembly and should be read before construction.

The processor – the last component to be mounted – is sensitive to static charges and should be mounted in a socket, partly because it is the most element of the circuit.

Resistor networks used have a spot on them to indicate the common pin. If preferred, each network may be replaced by eight individual resistors mounted on end with their tops connected together and taken to the pin one position.

Only 16 connections on the display are used. The left-most connection, when viewed from the front, is unused. A 12mm length of tinned-copper wire is soldered to each display connection before mounting. When mounted on the board using these lengths of wire, the display may to tilted to a suitable viewing angle, but care must be taken not to damage the display or lift the p.c.b. tracks. This component should be mounted next to last.

When construction is complete, a d.c. supply of between seven and ten volts may be connected to the supply terminals. Successful construction will result in a dash on the display at the sixth digit from the right; this is the right-most digit used on the Picotutor. Supplies of up to 30V may be used but the three-terminal regulator may require a heat sink.

Operation

At switch-on and after pressing the reset button S_1, the monitor program will respond with an indication that the system is ready to accept a command from the operator by displaying a dash at the left-hand side of the display.

Command keys are two and three-letter keys on the keypad. Memory open, or mo, is used to open a memory location and allow the operator to examine or modify data in it. Pressing the mo key will result in a memory-open sign in the form of an ⊓ at the right-most position on the display. The system is now waiting for a address to be entered.

The 68705P3 can address up to 2048 locations in the hexadecimal range 000 to 7FF. Hexadecimal keys on the Picotutor are indicated by single characters in the range 0 to F. Random-access memory locations in the 68705 are from 010 to 07F. Addresses 010 to 023 are used by the monitor program and an area at the top of the ram must be allowed to store a small group of microprocessor registers called the stack. Operator programs may occupy memory locations between 024 and about 0BF.

by R. F. Coates

After pressing the mo key, enter the address 024, and the data contents of this address will be displayed on the two right-most digits of the display. These two hexadecimal digits represent one byte (8 bits) of data. After switch on, data in the ram will be random so the number displayed may be any between 00 and FF.

Pressing a hexadecimal key will now result in its value being entered into the system and shown on the display as the right-most data digit. The original left-most data digit is shifted out and disappears from the two-digit data display. Entering a second digit will shift the first digit entered to the left and a data byte consisting of the two digits entered will be displayed with the last entered digit on the right.

A depression of the key with an arrow pointing to the mo key – the step-up key – will open the next memory location and allow it to be altered on command and pressing the key with an arrow in the opposite direction, the step-down key, will open the previous memory location; pressing either of these keys will result in an according change in the display address indication. If any other key is pressed while in command mode, the mode will change and the dash prompt will reappear.

When an address-location alteration is made the monitor program checks that the memory responds to the change, which should always be the case when ram alterations are made. An attempt to alter an unalterable eprom location (try 100) will result in an error message on the display; pressing any key will return the dash prompt required before all commands.

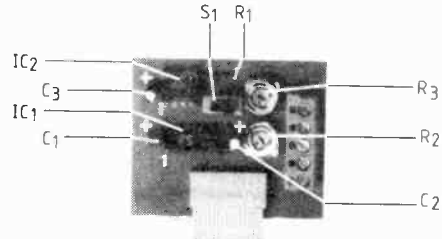
Now enter the following test program byte-by-byte by entering two digits then pressing the step-up key followed by the next byte, and so on, while in memory-open mode. The starting address, entered first, is not important but if in doubt use 030.

9C 4F AE 23 83 4C 20 FC

When program entry is complete, press any command key or the reset key to return the dash prompt.

The next step is to run the program, which entails passing control from the monitor to the program just entered, for which the go key is used. When pressed, this key causes a G prompt on the right of the display which is an indication that the program starting address is requested. On entry of the last digit of the starting address, in this case 030, the program runs.

Seemingly instantaneously, the program runs and control is passed back to the monitor by a software-interrupt instruction resulting in the return of the dash prompt. This program clears the c.p.u. accumulator and places the value 23 in the



With the switch toward the terminal block, the board acts as a digital-to-analogue converter. A 5V supply is provided by the regulator on the main board through a separate lead. The ribbon-cable connector is plugged into the switch socket on the main board with the display removed.

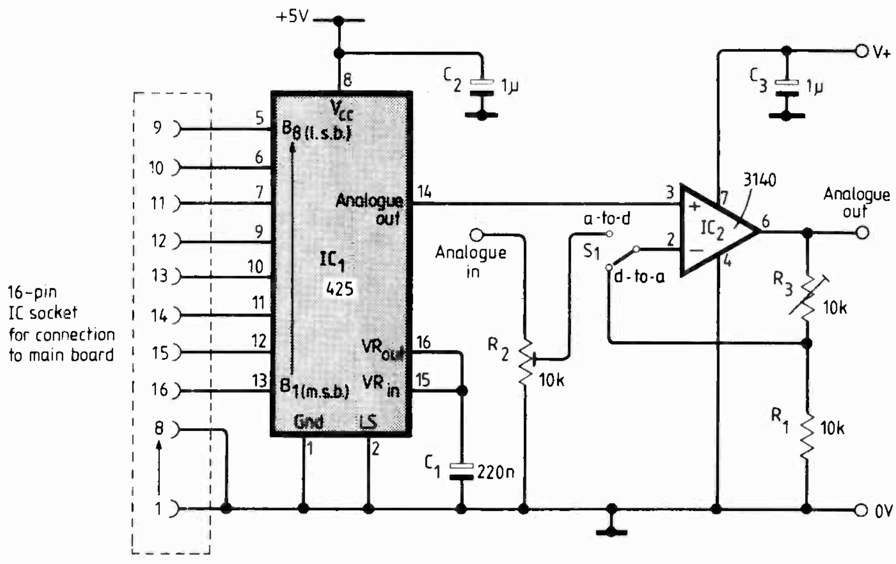
index register. Pressing the register-display key, marked reg, displays the processor-register contents when a software-interrupt instruction is encountered. This program-debugging function can be used to check that the program entered has run successfully.

The first register displayed holds condition code and isn't important in this article. Pressing the step-up key will display the accumulator, signalled by an A on the right of the display, which should hold 00. Another step up will signal the index register and display its contents, which should be 23. The next step up will show the program-counter value, which should be 35, and a P on the right of the display. Press step up again to return the dash.

Now press continue, abbreviated con on the keypad, and the program will run from where it left off resulting in an increment of the accumulator. Again a software interrupt passes control back on the monitor. On examining the registers, 01 should be found in the accumulator. This process of incrementing and looping can be repeated indefinitely.

Remaining keys are marked hdh, representing the number-base conversion function, and bc which is used for calculting branches. These keys are programming aids. The first converts hexadecimal numbers to decimal and vice versa as follows.

Press hdh, which results in blanking of the display, and enter a four-digit decimal number on keys zero to nine with leading zeros as required. Now press the step-down key and the hexadecimal equivalent of the number entered will be displayed.

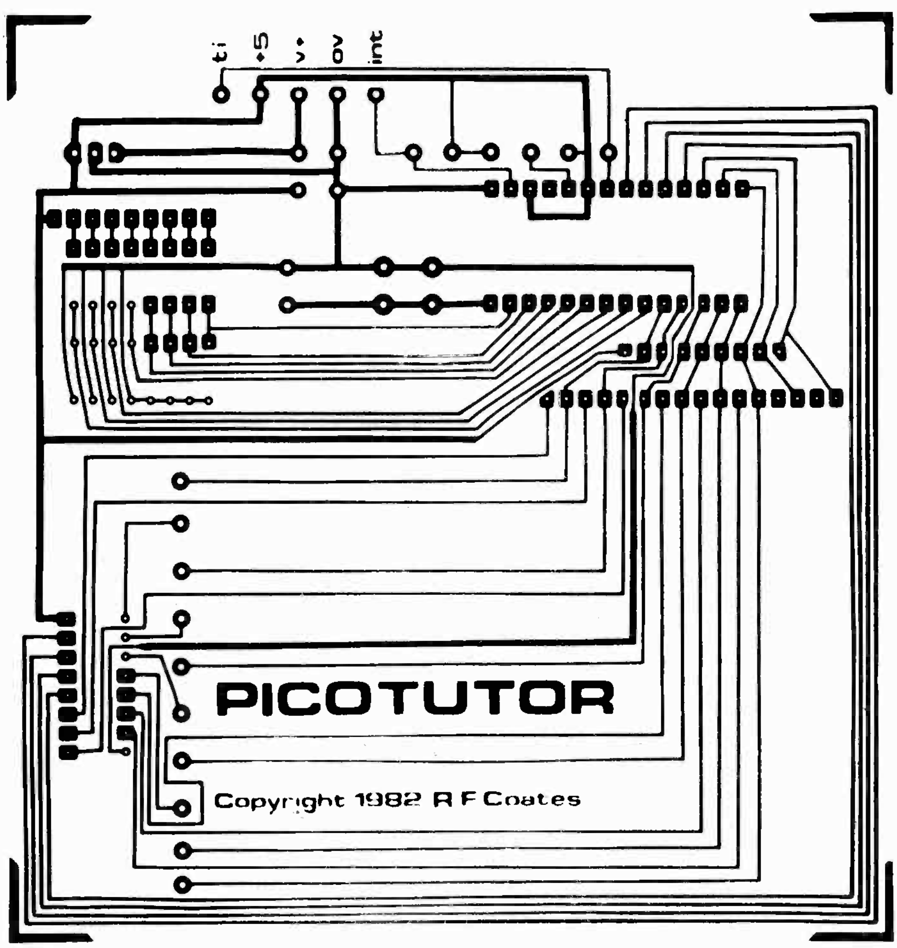


As shown, the analogue interface circuit operates as a digital-to-analogue converter. Software in the Picotutor converts values entered on the keypad into analogue output voltages up to 5.1V. Using the switch and an external connection (see text), the circuit acts as an analogue-to-digital converter. Software included demonstrates how the system can be used as a digital voltmeter.

Any key will return the prompt.

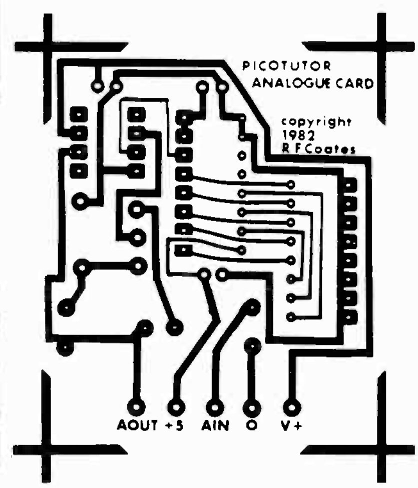
For hexadecimal-to-decimal conversion, press the hdh key and enter a four-digit hexadecimal number using keys zero to F then press the step-up key to obtain the number's decimal equivalent.

The conversion routine can handle numbers in the decimal range 0 to 9999; numbers outside this range and decimal numbers containing digits A to F will result in an error message.



Analogue interface components

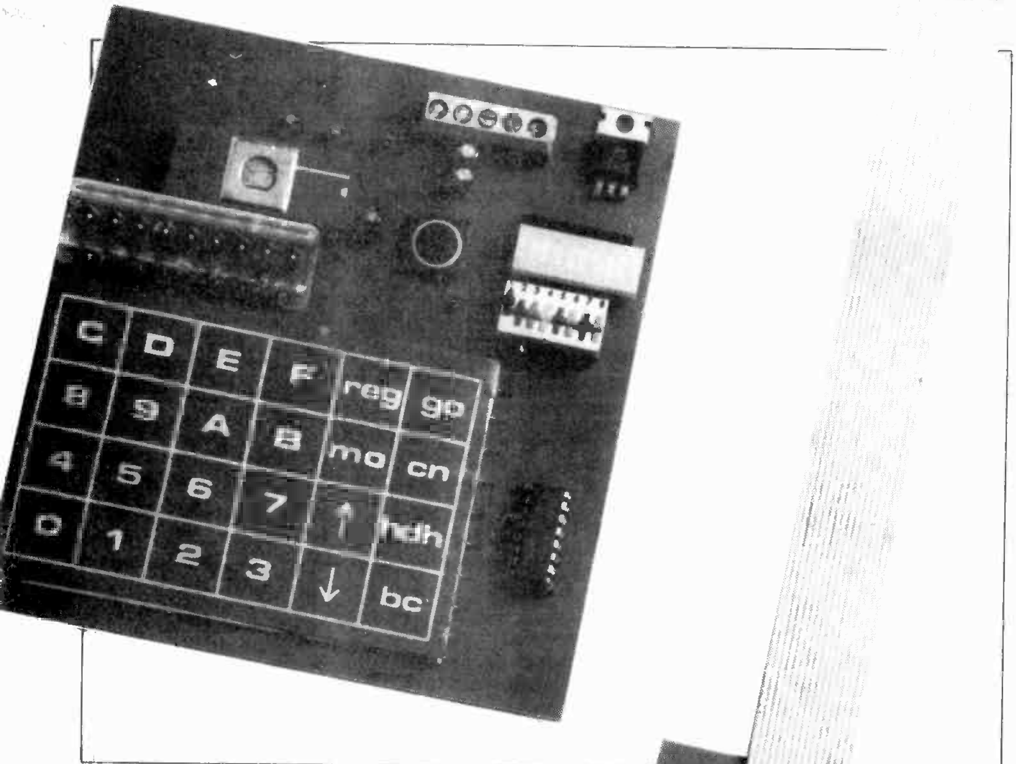
ZN425E (Ferranti)
CA3140 (RCA)
10k, 1/8W or greater
10k presets
220n electrolytic, 10V
1µ electrolytics, 35V
Single-pole changeover p.c.b.-mounting switch with 0.15in pin spacings.
16-way dil jumper lead connector
8-pin dil i.c. socket
5-way vertical p.c.b.-mounting terminal connector with 0.2in pin spacings

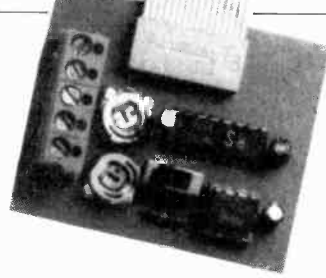


Key bc initiates a routine for calculating the two's complement offset required for branch instructions and will be described later.

Analogue interface

This small circuit board is connected to the processor A port using a ribbon cable plugged into the switch socket and can be connected to function as either an analogue-to-digital or digital-to-analogue converter.





Construction is straightforward: IC_2 is a static-sensitive device and mounted in a socket. Main connections between the two boards are through a 16-conductor ribbon cable with insulation-displacement type connectors on each end. Ready-assembled cables are preferred as clamping the plugs to the cable requires a special tool. The plug may be either soldered directly onto the anaolgue board or used with an i.c. socket. Component positions are shown in the photograph.

Voltage generation. A program for generating analogue voltages is included in the Picotutor software and may be used to check the operation of the interface board as follows.

Two wires link the Picotutor 5V output and analogue board 5V input and connect the main supply to the V+ terminal on the analogue board. Ground connection is made through the ribbon cable, the plug of which fits into the switch socket on the main board. The processor should be capable of driving the bar display but if problems are encountered, the display may be removed (pin one on socket and plug mate). Set the analogue-board switch in the d-to-a position, i.e. with slider towards the terminal block, and connect a voltmeter between A_{out} and ground terminals on the interface block.

Switch on the power, which results in a dash on the display, and key in go 0CE which is the starting address of the voltage-generator program. The display should now show 0.00 and the voltmeter should read 0V. Key in 510, which should appear on the display, and calibrate the analogue-board output using R_3 to give 5.1V on the meter. Voltages between 0.00 and 5.10 can now be set on the keyboard and represented on the display. Pressing reset will break the program.

Digital voltmeter. Software is included in the picotutor to allow it to be used as a digital voltmeter with the interface connected as an analogue-to-digital converter.

Set the interface in its a-to-d position and link terminal positions A_{out} on the interface and int on the main board. Terminals A_{in} and +5V on the interface board should also be linked and R_2 turned fully clockwise. Switch on and key in go 0CB to initiate the voltmeter program, causing the display to read 0.00. With these connections, R_2 may be used supply a variable input voltage to aid testing to give readings of up to 2.55V. Accuracy of the readings is determined by the tolerance of the ZN425 conveter reference voltage.

With the interface link between terminals A_{in} and +5V removed and R_2 turned fully anticlockwise, any analogue signal from 0 to 2.55V between terminals 0 and A_{in} will be shown on the display. Pressing the reset button stops the program.

A tutorial series introducing assembly-language programming will explain basics hardware and software design and include descriptions of various instruction sets. How to write programs to perform mathematical operations, convert codes and drive peripheral lines and interface devices such as the 6821 p.i.a. will be discussed, and operation of the analogue board and Picotutor detailed. Subroutines for binary-to-decimal and decimal-to-binary conversion, multiple-precision multiplication, division, addition and subtraction – and for simulation of the 6800 DAA instruction not available on the 6805 – will also be explained. WW

A hexadecimal list of software for the Picotutor can be obtained by sending an s.a.e. to Wireless World Picotutor, Room L303, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS. Complete kits or separate parts are available from Magenta Electronics (see advertisers' index).

Checklist

- ○ Correctly adjust contrast and brightness controls. Suggested method: reduce contrast to minimum, adjust brightness then increase contrast. Black level should be just below threshold.
- ○ Attention to room lighting. Do not use very bright lighting. Use desk lamps for illumination of printed material. Run fluorescent lamps parallel with v.d.u. sides and fit diffusers.
- ○ Position v.d.u. for minimum reflected glare but avoid operator facing a light sourse. Choose antireflective coating on c.r.t. whenever possible.
- ○ Select phosphor persistance for desired application.
- ○ Avoid visual distractions within operators field of vision.
- ○ Select keyboard, desk and chair for good posture. A detachable keyboard is useful for this.
- ○ Take rest periods away from the v.d.u. if possible.

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however, be beneficial as higher than normal dust concentrations can build up between the viewer and the screen, due to the high static charge at the c.r.t. face.

Temperature and humidity are important factors if only because continuous concentration at a v.d.u. screen can reduce the blink rate – this is especially important with contact lens wearers. Suggested room temperature is 22 to 26°C, with a relative humidity of 50 to 55%. WW

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continued from page 59

Interpretation of the "quantum" concepts

The mystical concept of duality in light was paralleled in 1925 by the even more mystical postulate of a particle/wave duality in matter. In this area confusion and "double-think" now reign supreme, and clarification is long overdue. Three completely different meanings are ascribed impartially to the single word "quantization". In its first sense (Planck) it refers to the natural consequences of the fact that the physical world is granular on the microphysical scale: both matter and radiation behave as if they were composed of independent, indivisible particles. Quantization in this sense means simply that a photon is either reflected or not reflected at a mirror surface – yes or no, definitely and without half-measures. The question of whether or not the outcome of the encounter can be predicted before the event is not related to quantization. That question has two important philosophical branches: (a) accurate prediction depends on detailed knowledge of the experimental conditions, and (b) prediction is never indulged in by inanimate Nature, but on the contrary is an activity characteristic of *living matter* only. This much-ignored truth enables one to distinguish between physics and metaphysics, and also between inanimate determinism and predictability; failure to maintain such distinction was the first serious philosophical error of modern physics.

The second historical meaning of "quantization" referred to the postulate (Bohr, 1913) that mechanical working-parameters such as energy and momentum may also be in some way granular, and that they may be exchanged between physical entities only in steps of discrete size. An attempt to rationalise this postulate by attributing quantization to the action of "matter-waves" proved abortive, but by convention that failure is not normally admitted or taught. The third common meaning of the word may be taken to refer to a mystical mechanism offered by way of "explanation" of any phenomenon by the wave theory of matter.

energy comes in packages which have all the experimental characteristics to be expected of discrete particles; on the scale of atoms and photons the physical world is granular in its nature. Bohr's quantization (type two) is totally different: it does not have to do with microphysical entities as such, either as to their size or their particulate form, but refers to the apparent restriction of a mechanical working parameter, in this case angular momentum, to certain universally-discrete values. One quantization acknowledges that microphysical entities are discrete, self-contained and indivisible; the other postulates that the laws of mechanics are essentially discontinuous in their operation. The only connection between these two completely different meanings of the word quantization is that thinking in terms of the one led Bohr's imaginative mind toward the concept of the other.

In retrospect Bohr's proposal was far more earth-shaking than Planck's, because while Planck's could be accepted by the overthrow of a theory, painful though that might be for the theory's supporters, Bohr's has never been explained. The conclusion was drawn generally, and I shall suggest prematurely, that ordinary mechanics had failed and that a new quantum mechanics in which energy, momentum, and angular momentum were in some mysterious way quantized must take its place. How else could the orbital electrons in the Rutherford atom be prevented from eradiating away their energy and coalescing with the nucleus? (Might there not be an alternative explanation?).

As I have said, no satisfactory explanation of Bohr's quantization has ever been forthcoming. Current doctrine adjures one to accept the outcome without explanation, on the grounds that "for fundamental reasons" it cannot be explained.

In the microphysical domain of atoms and electrons we physicists are to deal henceforth in miracles: for a miracle is a physical occurrence for which we can offer no physical explanation. Inventing "matter-waves" in an attempt to provide a rationale was an abject failure, but it led to a third common meaning of the word quantization, unconnected with the other two; we may define it as "A panacea which purports to explain any microphysical phenomenon, indiscriminately, in terms of the mystical tenets of the wave theory of matter". The subornment of physical thinking during the 1930's to the beliefs of the adherents of this theory is the final incredible tale I have to tell, but first I shall have to describe what the theory is about and explain where it came unstuck, and why. That in itself makes a fascinating story.

Architecture of an electronic book

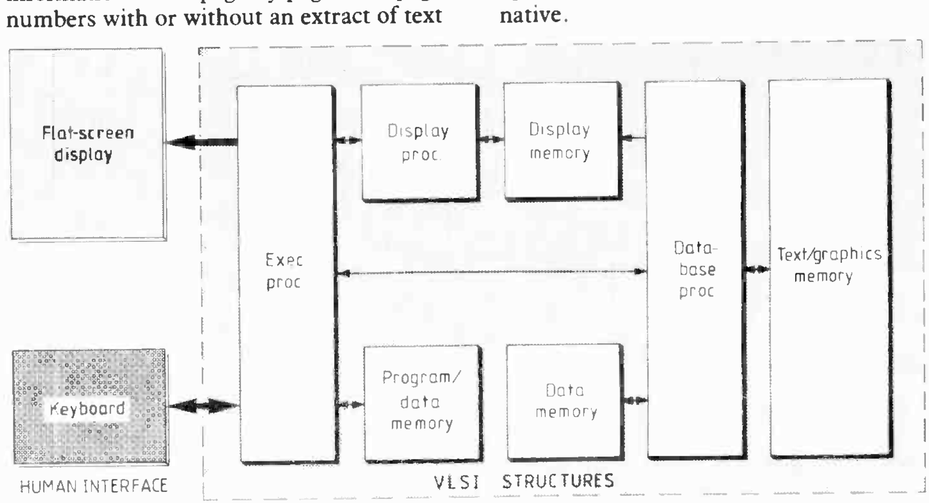
Rapidly increasing paper cost and advances in semiconductor and software technologies are prompting practical alternatives to the wood, glue and dye-based objects we know as books. Books intended to be read serially can conceivably be stored in a central bank and the information in them disseminated through networks similar to the ones currently being used as up-to-the-minute newspapers. But data manipulation necessary for electronic reference books, educational text books and technical manuals may require a different approach, mainly due to the need to search for information within them and because of their often specialised nature.

According to a recent proposal,* such books would be contained in plug-in roms and read on a flat-screen display. Perhaps anticipating the question, "Why not use an optical disc?", its authors remind us of the recent implementation of a 4Mbit wafer-scale rom which could be ready for manufacture in the mid-1980's.

"Current state-of-the-art flat-screen display technology suggests that it will be possible to house the display, keyboard, system-processor chips and a substantial number of rom structures each containing text and graphics for an entire book will fit into a package approximately the size of a conventional book," but the authors don't speculate on a possible introduction date.

Apart from saving trees, the book envisaged will also provide an efficient means of accessing information and make searching for concepts embedded in the text possible. In search mode, the processor thumbs the pages and presents the desired information either page by page or as page numbers with or without an extract of text from the page concerned.

Word-based encoding techniques give a factor of between three and five reduction in the amount of memory required over character-based encoding and straight-line approximation methods used allow engineering drawings and text-book illustrations to take up the same amount of memory as text, page-for-page. Roms of the type envisaged that lend themselves to storing high-resolution pictures are not expected to be available in the 1980's but the optical disc is suggested as a possible alternative.



**Architecture of an electronic book, J. M. Murray & K. J. Klingenstein, IEEE Transactions on Industrial Electronics, vol. IE-29, Feb. 1982, pp.82-91.*

Memory systems

Read-only memory provides non-volatile data storage, making it indispensable to microprocessor. This two-part introduction to the characteristics and application of memories to microprocessors by L. Macari concludes with manufacturers and user-programmable rom.

Read-only memories receive data only once or a small number of times compared with the number of read operations. It provides non-volatile data storage, which makes such memories important parts of microprocessor and digital systems. Some of these memories, which are all of the random-access type, must be programmed at the manufacturing stage, while others can be programmed by the user.

A simple example of a read-only memory is the diode matrix, shown in Fig. 5 (a). Although it is not used in today's computers, its basic principles are clearly illustrated, making this type of circuit a good introduction to the concept of fixed data storage.

A cell in the diode matrix shown consists of a diode or a space, representing 0 and 1 respectively. The diagram shows an 8-bit × 4-bit array in which each vertical data line is a diode-resistor And gate. Since only one of the horizontal word lines will be pulled low at any instant of time, the presence or absence of a diode will determine the state of the data line.

Two examples of cells of semiconductor roms are shown: fusible-link rom, (a), and the mask-programmable type at (b).

The fusible-link rom is supplied with all

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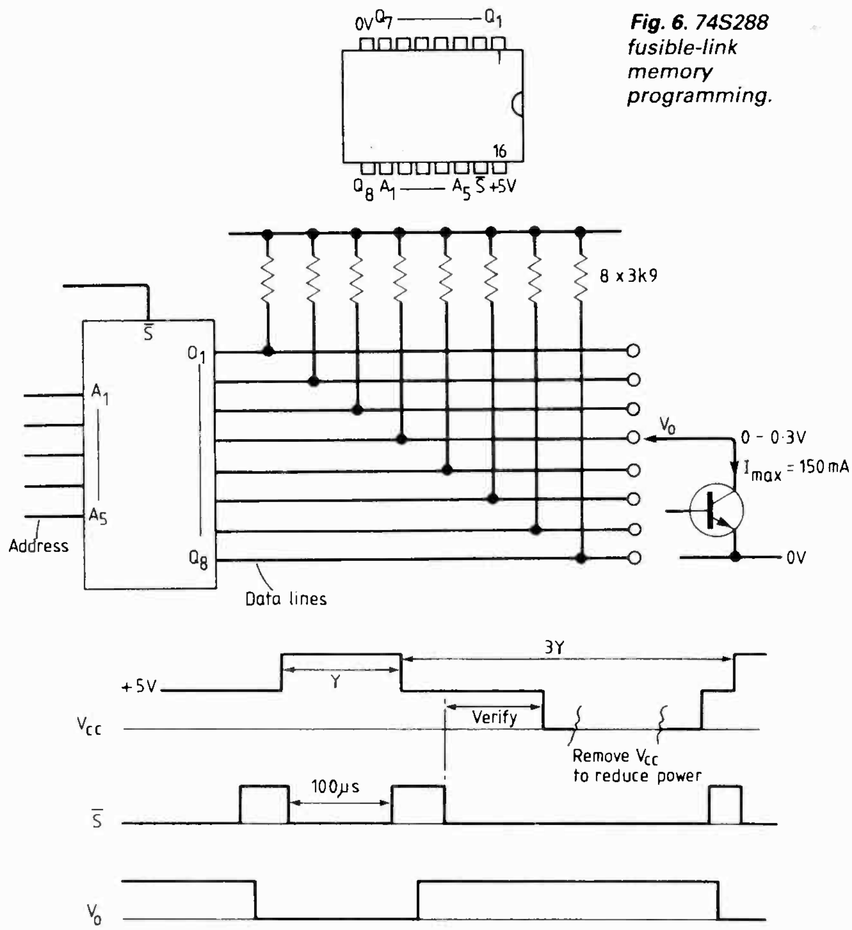


Fig. 6. *74S288 fusible-link memory programming.*

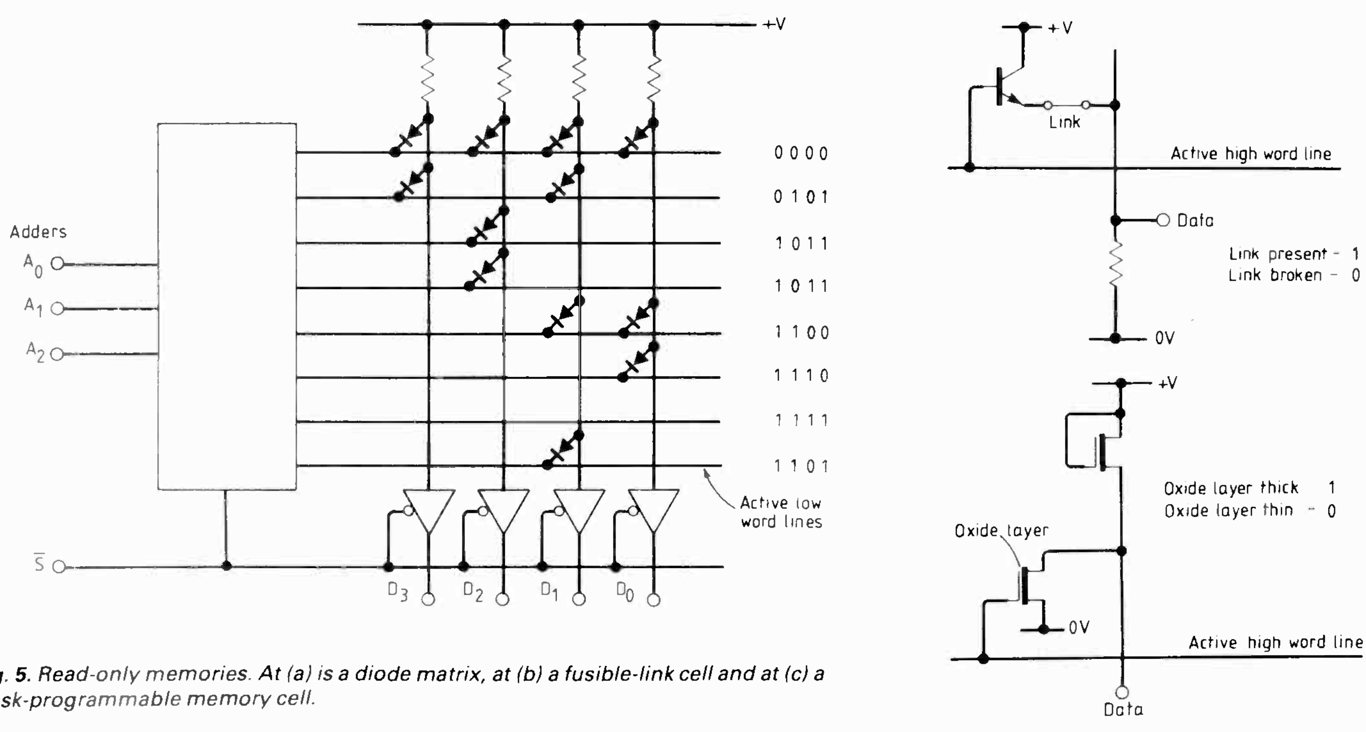


Fig. 5. *Read-only memories. At (a) is a diode matrix, at (b) a fusible-link cell and at (c) a mask-programmable memory cell.*

links unbroken: the programming procedure is to apply suitable voltages to the device to break the links, producing the necessary pattern of 1s and 0s in the memory.

Where large quantities of the same program are required, the mask-programmable device is of value. This type of rom has the data placed on it as part of the manufacturing process, the result of which is to produce some mosfet devices with thick insulation between the gate and the active device. Normal-thickness insulation gives rise to a device which can switch as usual, whereas the device with thick insulation will not switch when voltage is applied to the gate. This is therefore the means of producing 1s and 0s in the memory.

UV-erasable memories. These roms are user-programmable and, as the name suggests, can also be erased and reprogrammed instead of being discarded when it is discovered that the stored data is incorrect. The devices are widely used and lend themselves particularly to the development stage of any microprocessor system.

Each memory cell consists of a single, insulated-gate fet. In this case there are two gates, both electrically isolated from one another and the semiconductor material. If a voltage of the order of 25V is applied across the substrate and either the source or the drain, so that the avalanche effect takes place, high-energy electrons can be injected through the insulating medium to charge up the gate electrodes. This causes a change in the operating point of the transistor and since the charge is stored in a good insulator it does not leak away, providing the cell with a charge which is seen as a logic-level change when that cell is addressed.

Applying the high-intensity ultra-violet radiation to the transparent window in the i.c. package provides the necessary stimulation of the insulation structure to permit the charge to disperse. Repeated exposure to the u.v. source not only causes the stored charge to disperse but causes the impurity atoms in the semiconductor material to disperse a little and change the characteristics of the fet. This makes the device more difficult to program and there is eventually a stage where it becomes impossible to reprogram the device at all.

Programming roms

Fusible-link roms. An example is the 74S288, shown in Fig. 6, which is a 32 × 8 bit rom with tristate outputs. When unprogrammed, all bits are set to zero, so the programming procedure open-circuits the required links to change those bits from zero to one. If a particular bit has not been changed, it can be altered at a later date, but bits cannot be altered once they have been programmed. In this device the links are made of titanium-tungsten wire.

The i.c. package has the normal address and data lines and an active-low select line. No other signals are required for the purpose of programming. The programming

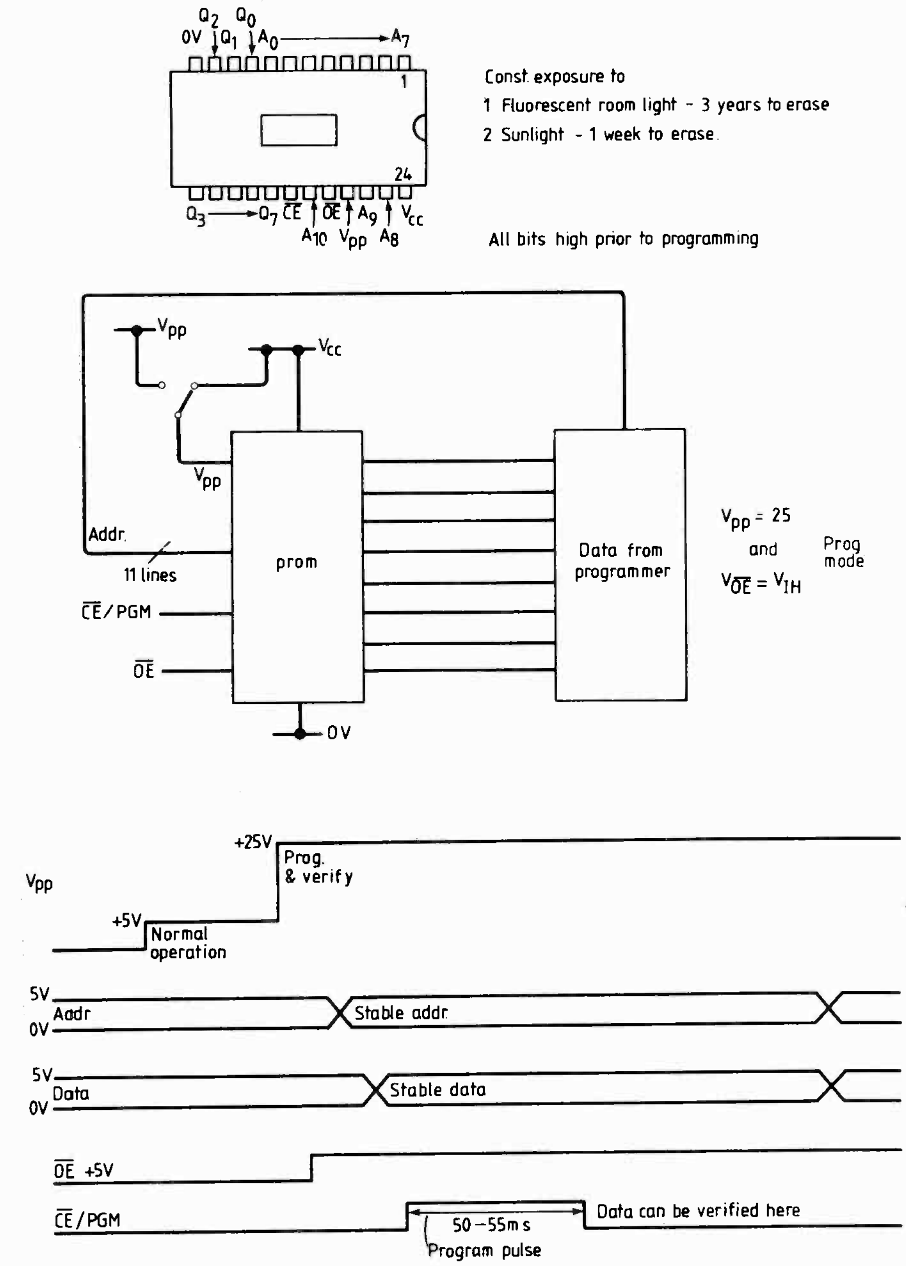


Fig. 7. Programming 2716 u.v.-erasable rom.

procedure is carried out one bit at a time at each address, passing over bits which do not need to be altered. While the $\overline{SEL}$ line is high, the required data line is pulled low, and all other data lines connected to +5V through 3.9k resistors. The V_{CC} supply to the i.c. is now altered to +10.5V. The $\overline{SEL}$ line is now brought low and held low for the programming time, as indicated on the diagram. Before carrying out any further programming, one can check each bit.

UV-erasable roms. A typical example of this type is the 2716 in Fig. 7, which is a 2K × 8 bit rom. In addition to the usual address data and select line, this device has an output-enable pin and a programming supply pin: the chip enable CE serves as a programming pin. This type of rom has all bits set to 1 when delivered from the manufacturer, and programming changes the required data bits to 0. Erasure, using a u.v. source, resets all the bits to 1 as before. The advantage of the 2716 rom is that, except for the programming supply, the other signals required during programming are standard t.t.l.-level signals.

In this case, the procedure can be used to program simultaneously all bits which have to be changed at one address. The V_{PP} pin is connected to +25V instead of +5V, which is its normal operating level: output-enable, $\overline{OE}$, is set to a logic 1. On setting up the required address, the data is applied to the data pins and the $\overline{CE}$ line is now taken high for a period lasting from 50 to 55 ms.

The data can be checked and the programming pulse applied again, if the data has not been entered correctly. Usually, the more the rom is erased, the more difficult it is to reprogram the memory and some limit would be placed on the number of attempts made to write data into the memory. WW

Data integrity in disc drives

Eighth part of this series details hardware and software required to ensure that data stored can be retrieved without corruption. Growing impact of computer technology on everyday life means these considerations have never been more important.

by J. R. Watkinson M.Sc.

A typical disk drive has circuitry not essential to the normal processes to detect fault conditions. The most common kinds are:

○ Write current without write gate – if current passing through any head is detected when no write function is taking place, there is an error. Heads are retracted and write circuitry disabled.

○ Write gate and no transitions – current reversals in the head are monitored during writing and their absence indicates an error.

This error detection circuit has to be disabled during an address mark write – see part 7 for definition.

○ Multiple head select – by forward biasing isolating diodes in the matrix, as shown in part 2. Bias current can be measured to ensure that only one head is selected at any one time.

○ Incorrect write current – (Part 2 showed that it was necessary to program the write current as a function of the cylinder address to compensate for change in the head flying height) – current is measured to ensure it is as specified.

The consequences of these errors vary from system to system, but typically the immediate function would be aborted, and the error bits would be made available to the host system. Many drives have an 'unsafe' indicator which would illuminate under these circumstances. No further functions would be possible until a drive clear is sent to reset the error conditions.

The subsystem contains parity generating and checking circuits which ensure that any corruption of data between drive and memory is detected. Again the detection of such an error would abort the current function, but a controller clear might also be required to recover, depending on where the error was found.

The latest microprocessor-based drives contain extensive diagnostic circuitry and firmware which checks out all functions every time the drive is run up. Some have dedicated tracks on the disk called field engineer cylinders, to verify the write and read capabilities of the heads before the drive comes on-line. These cylinders are beyond the address range of the positioner in normal operation. On a Winchester-type drive where the disc is not normally removed, this is the only way that the drive can be tested without overwriting customer data on the stack.

Media integrity

In the same way that magnetic tape is subject to dropouts, magnetic discs suffer from surface defects whose effect is to corrupt data. The shorter wavelengths – employed as disc densities increase – are affected more for the same size of defect. Attempts to make a perfect disk suffer from a law of diminishing returns, and eventually a state is reached where it becomes more cost-effective to expend capital in a subsystem which can handle defects.

There are four main methods of handling media defects, whose common goal is to make their presence transparent to the computer user. These vary in cost of implementation, and each find application on subsystems of different complexity. More than one of the techniques described here may be combined in a particular application.

Bad-block files. When a particular disc is first made known to an operating system, a process is started which writes known patterns everywhere on the disc, and verifies the surface by reading them back. Following this the system labels the disc with a volume name, and sets up a directory structure which keeps a record of every file subsequently written. The physical disc address of every block which fails to verify is allocated to a file which has an entry in the disc directory. In this way, when the first or subsequent genuine data files come to be written, the bad blocks appear to the system to be in use storing a fictitious file, and no attempt will be made to write there. Some discs have dedicated tracks where defect information can be written during manufacture or by subsequent verification programs, and these permit speedy construction of the bad-block file. Field engineers take pains not to overwrite these bad-block tracks when using test programs. Software prevents the system attempting to write files there.

In association with bad-block files, many drives allocate bits in each header to indicate that the block is bad. If a data

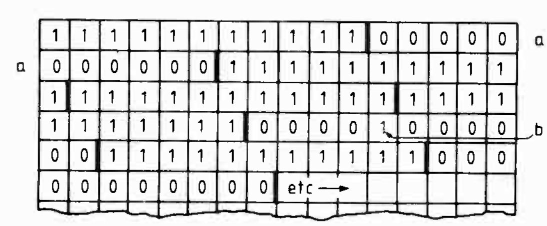


Fig 1. Before writing on a disc, the block usage bit map is searched for contiguous free space equal to or larger than the cluster size. The first available space is the second cluster shown at (a) in the bit map but the next space is unusable because the presence of a bad block (b) destroys the contiguity of the cluster – one bad block causes the loss of a cluster.

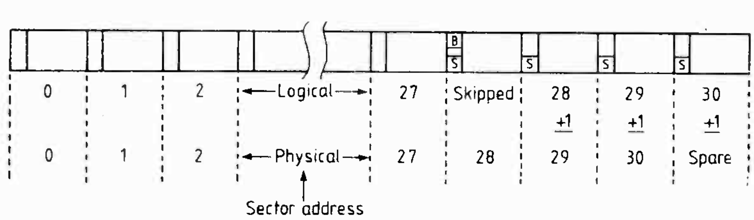


Fig. 2. The bad block in this example has a physical sector of 28. By setting a skip sector flags in the header this and subsequent logical blocks have a one added to their sector addresses, and the spare block is brought into use.

Comparison of media integrity techniques.

Technique	Data loss per defect	Software overheads	Hardware overheads	Application
Bad block files	One cluster	Simple. Bad blocks are allocated to a fictitious file.	No extra hardware required thus it can be used on any equipment.	Traditional approach. Reliable. Most smarter techniques revert to this when capacity exceeded.
Sector skipping	One block	Special verification program required to write skip headers. Reverts to bad block files if skip capacity exceeded.	Slight increase in disc control logic complexity, but no incompatibility with existing buses and protocol.	Useful for new medium capacity drives for use on existing bus system.
Defect skipping	Part of block	Special verification program required to format disc. Greater defect capacity than sector skipping before reverting to bad block files.	Highly complex disc control logic requires microsequencer for implementation.	Complexity rules this out except on very large capacity high speed units intended for existing bus system.
Revectoring	One block	Process has considerable software requirement, may be transferred to firmware in intelligent controller subsystem.	Drives remain relatively uncomplicated. Complex controller required but only one for several drives.	Requires complete integration of controller, bus and drives plus firmware, thus only suitable for *ab initio* subsystem designs. Very powerful.

transfer is attempted at such a block, the presence of these bits causes a 'bad sector error', which aborts the function. Properly used, this technique gives excellent protection against media defects. The only drawback is the amount of storage wasted by one defect. Part 7 showed that contiguously addressed blocks only require one function to be issued for a multi-block transfer and for this reason the system associates contiguous blocks into clusters: the presence of one bad block prevents the use of a whole cluster. Fig. 1 shows how blocks are formed into a bit map which is searched to find free space.

Sector skipping. When this principle is implemented, space is allocated at the end of every track for a spare data block, which is not normally accessible to the system. Where a track is found to contain a defect, the affected block becomes a skip sector. In this block, the regular bad block bits will be set, but in addition, a bit known as the skip sector flag is set in this and every subsequent block in the track when the block with the skip sector flag is encountered the effect is to add one to the desired sector address for the rest of the track, Fig. 2. In this way the bad block is unused, and the track format following the bad block has effectively slid along the track, which will eventually bring the spare block into use. All blocks subsequent to the bad block need the skip sector flag set to cater for a data transfer which begins after the bad block. Using this approach, the presence of a bad block does not cause the loss of a cluster, but it does require some extra hardware. A second defect in any one track, statistically much less likely, would cause the system to revert to the regular bad block file protection, described earlier.

Defect skipping. The two techniques described so far have treated the block as the smallest element. In practice, the effect of a typical defect is to corrupt only a few bytes. The principle of defect skipping is that media defects can be skipped over *within* the block so that a block containing a defect is made useable. The header of each block contains the location of the first defect in bytes away from the end of the header, and the number of bytes from the first defect to the second defect, and so on up to a maximum in this example of four defects, Fig. 3. Each defect contains a fixed number of bytes of normal preamble code (all zeros for m.f.m. or 33hex for 2/3 code – see part 2) followed by a sync byte. The skip is positioned so that there is sufficient undamaged preamble between the defect and the sync byte to re-synchronize the data separator v.c.c. Each defect lengthens the block, causing the format of subsequent blocks to be placed further along the track. A space left at the end of each track allows a reasonable number of skips to be inserted.

The position of defects is purely physical, and the sector in which a given defect may show up depends on the format used on the disc. To store the position of defects

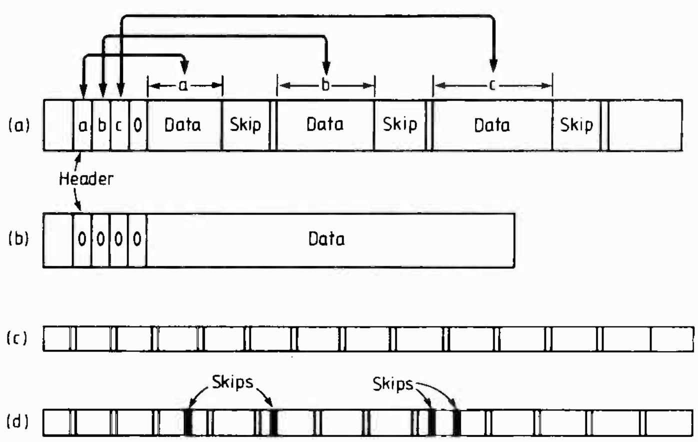


Fig. 3. In block containing three defects, the header contains parameters which specify how much data is to be written before each skip (a). To allow for lengthening over an error-free block (b), the track contains spare space at the end which is an error-free track (c). Four skips have caused the spare space to be used up in (d).

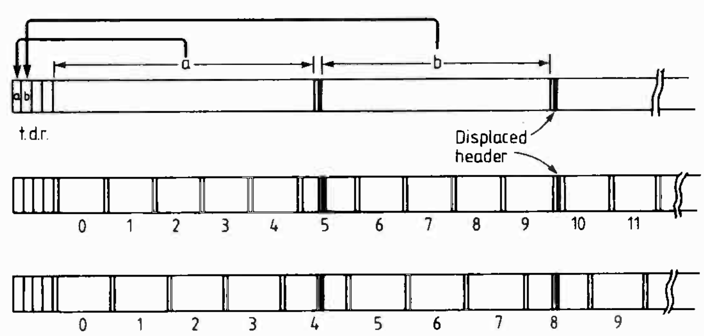


Fig. 4. The track descriptor record keeps a record of defects independent of disc format (top). Positions of the defects stored are used by the formatter to establish the positions relative to the format used. With the middle format, the first defect appears in sector 5, but the same defect would be in sector 4 for the bottom format. The second defect falls where a header would be written in top example so header is displaced for sector 10. The same defect falls in the data area of sector 8 in the bottom diagram.

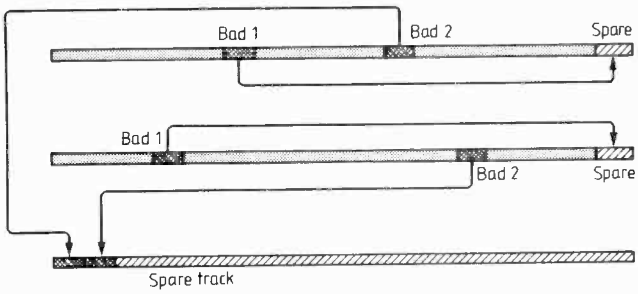


Fig. 5. The first bad block in each track is revectored to the spare block at the end of the track. Unlike skip sectoring, subsequent good blocks are unaffected, and the replacement block is read out of sequence. The second bad block on any one track is revectored to one of a number of spare tracks.

independently of format, a track descriptor record is written at the beginning of each track, which contains information about the position of defects relative to index. The t.d.r. is written by a special engineers program (a "scanner") which verifies the disc a track at a time. The formatter program must then refer to the t.d.r. to find the defect positions and calculate their positions relative to the format.

Fig. 4 illustrates the principle. Once the disc is scanned and formatted in this way defects are transparent to the system, unless there are more defects in one track than the skipping mechanism can handle, in which case the system reverts to the bad block file mechansim. This is rarely necessary in practice.

On reading a block containing a defect, data are read until the count specified in the header is reached. The data transfer then pauses until the sync byte at the end of the skip is detected, when it resumes. During a write, the skip has to be written during the interruption of the data transfer.

The disc control logic in a defect-skipping drive needs a good deal of agility to cope with such a flexible format and the use of conventional combinational logic would not be feasible. One successful implementation of defect skipping uses a microsequencer constructed from bit-slice chips.

Revectoring. A refinement of sector skipping which permits the handling of more than one bad block per track without the loss of a whole cluster is revectoring. A bad block caused by a surface defect may only have a few defective bytes, so it is possible to record highly redundant information in a bad block. On a revectored disc, a bad block will contain in the data area repeated records pointing to the address where the data displaced by the presence of the defect can be found, the spare block at the end of the track will be used to replace the first bad block in a track. In this case the spare block will be read within the same disc revolution. Unlike sector skipping, however, the block is read out of sequence which puts extra demands on the controller. In the less frequent case of more than one defect in a track, the second and subsequent bad blocks revector to spare blocks available in an area dedicated to the revectoring process. Fig. 5 shows the principle. In this case a seek is necessary to locate the replacement block. The low probability of more than one bad block per track means that the delay caused by revectoring seeks has an insignificant effect on overall system speed. The use of an intelligent disc controller is highly desirable for this kind of approach, as the operating system is then relieved of a significant software overhead.

All of these techniques can prevent data corruption caused by known disc defects. The Table compares the resources required by each technique.

As disc technology advances, manufacturers often introduce new drives which are plug-compatible with existing mass storage buses and require minimal software changes so that customers' investment in both hardware and software is protected. In this context, sector skipping and defect skipping are attractive, as both are transparent to the operating system once the format of the tracks is established; both however, add to the complexity and cost of each drive. Where a totally new bus structure is to be designed, revectoring is the natural choice, as all of the intelligence is controller resident and the dumb drives required must be less expensive. For less powerful machines, the controller intelligence can be transferred to operating system software to give a lower capital cost.

To be continued

Error Mechanisms

Mechanisms responsible for data corruption in disc storage fall into three categories – failure or marginal performance of components, of the disc medium, and of the environment. These mechanisms may combine to cause errors, which may be either "hard" or "soft": a hard error is a failure which can be duplicated at will be repeating the conditions which gave rise to the error, while a soft error is a failure which cannot be duplicated at will and which contains a statistical element. Any or all of the three mechanisms may combine to cause errors, as the following example illustrates. The read preamplifier of a disk drive has a drifting component which is starting to lower the gain of the circuit. First thoughts suggest that the process would continue until the drive would suddenly cease to work – a hard error by definition. In practice this does not always happen. The presence of noise in the system means that as circuit gain falls, probability of data corruption rises. The observed effect is that soft errors occur and increase in frequency as the hardware deteriorates.

A certain amount of noise in a system is beneficial because it gives rise to symptoms prior to total failure. Each error found is entered into the system error log, and in many cases regular study and correlation of the soft errors in the error log allows repair before the failure becomes total. In this example the error log might show that soft errors on a particular drive were affecting the even-numbered heads but not the odd-numbered heads. An engineer familiar with the drive would replace the head matrix which connects to heads on one side of the T-block, as this is the most likely failure. This replacement can thus be made during scheduled maintenance rather than disrupt normal operation of the system, which continues running with only a slight speed degradation owing to the error recovery process.

Data acquisition on a Pet

continued from page 67

6502 microprocessor. After acquisition, these data may be processed in the usual way, as timing is no longer critical.

An example of such a program is given in List 3. The requirement here was that the program should not start sampling data until the first non-zero byte had been obtained. Then 1Kbyte of memory is filled as indexed indirectly by bytes BA to C1. If multiple inputs are required, analogue multiplexing is appropriate.

Reading digital information

Many instruments will provide a digital output, either in b.c.d. or pure binary form. Automatic transfer of data from instruments to a microcomputer such as the CBM avoids much labour, permits fast data-transfer and eliminates errors. An example of an application where this is needed is when a rapidly varying signal initially in analogue form, needs to be captured and the rate of change is too rapid for an 0804 converter i.c. under computer control, to provide correct data. In such cases, the event must first be recorded on a transient recorder. The authors have used two transient recorders to capture rapidly varying parameters in an impact test. When the test was completed, information from each recorder was transferred to the computer for processing. The circuit used for this is shown in Fig. 3 and its extension to a variety of other applications is obvious. A four-input digital multiplexer is shown, designed to interface with Datalab type DL901 recorders, which require handshaking at each data-frame transfer.

This technique requires the computer to issue a request signal for the first byte of data and to reset the data ready flag of the transient recorder after the byte has been received. The computer may then request the next byte and the process is repeated for 1Kbyte. This transfer of data is usually accomplished in about 200ms for the 1Kbyte transfer using machine code.

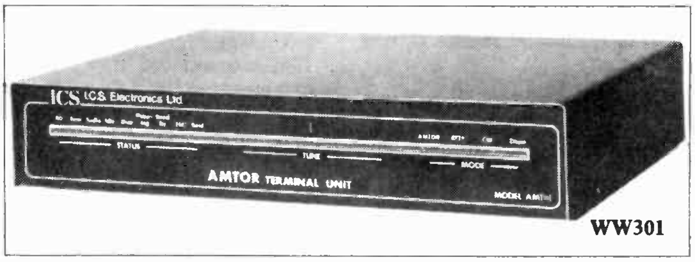
NEW PRODUCTS

AMATEUR TEXT TRANSMITTER

Amtor contains everything needed to convert an amateur radio station and personal computer into a fully operational data communications system. It contains an f.s.k. modem together with a microprocessor to handle the data transmission. It uses its own seven-bit code with 35 characters that have constant-ratio combinations, i.e. the same number of positive and negative elements. This allows for simple error detection by testing the ratio on each character. Error correction is also provided in its A-mode by including a 'request for repeat' signal if the information is received incorrectly.

An RS232/ASCII interface connects Amtor to the computer, or ASCII terminal. It can be used to transmit and receive standard rtty, to transmit morse code, and as a modem to connect computers directly. Transmit tones are crystal-controlled frequencies of 1,445(mark) and 1,275Hz(space). Full control is available through the computer, so there are no front panel controls on the unit. Amtor costs £275 inclusive from ICS Electronics Ltd, PO Box 2, Arundel, West Sussex BN18 0NX.

WW301

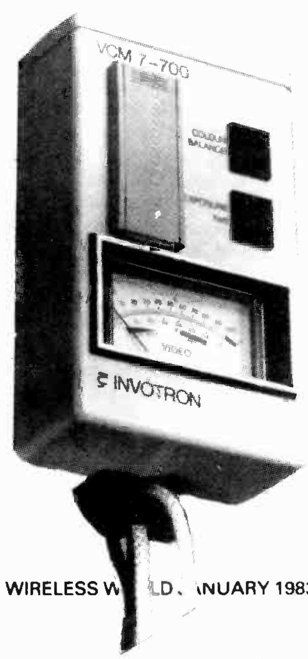


WW301

VIDEO COLOUR-BALANCE METER

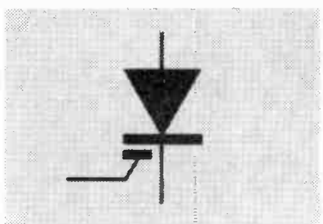
The VCM7-700 enables video cameramen to accurately control exposure with the use of oscilloscopes or waveform monitors. It also enables the operator to check and adjust the colour balance of the camera without elaborate test equipment. The meter can provide greater accuracy and is more practical than an oscilloscope, it is claimed, and with its internal filter system the meter can measure light levels in the presence of colour information or high frequency noise. The VCM 7-700 can also be used as a quality check the operation of video links. Invotron Ltd, 2a Brookfield Avenue, Blackrock, Co. Dublin, Eire.

WW302



THYRISTOR WITH MOS GATE

High impedance and fast switching of a power mosfet are combined with regenerative latching action in Motorola's t-mos thyristor. Derived from the vertical structure of t-mos with the substrate doping changed from n+ to p+ to give a



Motorola's suggestion for t-mos thyristor symbol

n-p-n-p layer structure, it is equivalent to a two-transistor analogue of a thyristor controlled by an n-channel mosfet. Designed for high-speed switching of high current the device may be used for logic control of power supplies, and fluorescent lighting. The first device to be introduced, MCR1000, controls voltages up to 600V with a gate trigger of 3V. Current rating is 15A r.m.s with a surge capability of 90A. Switch-on speed is 200ns and switch-off, 6μns. Motorola Ltd, York House, Empire Way, Wembley HA9 0PR.

WW303

PCB MAKER

In the CM1000 Circuit Maker a film positive master, which produces a positive image of the circuit without a negative, is placed over the circuit layout in a frame and exposed by a photoflood bulb. The film is developed and a similar process used to transfer the image to a copper surface of the p.c.b. using paint-on photoresist. The kit includes 12 sheets of 'autopositive' film, a frame, photoflood bulb, developing dishes, thermometer, six double-sided p.c.bs, chemicals and solder flux which also acts as a protective lacquer, cost £59.95, which works out at £5 for each board produced. A replacement kit for the consumable products means that further boards halve that price. Electrolube Ltd, Blakes Road, Wargrave, Berks RG10 8AW.

WW304

SNAP MOUNTING PCB SWITCHES

A rotary "pre-set" (!) switch, snap-mounted onto a p.c. board and turned by screwdriver, measures only 10mm dia. and 3.5mm deep. The switch may be operated from either end of the rotor and so may be switched from outside the equipment through an access hole in the casing. Two and three-position models are available, rated at 100mA, 50V. For small quantities the switches cost about 8p each from NSF Ltd, Keighley, Yorkshire BD21 5EF.

WW305

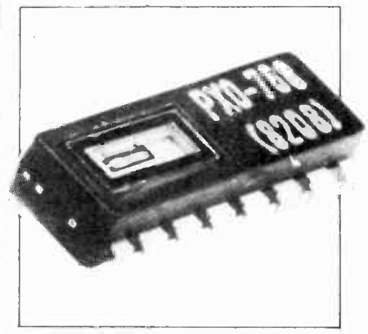
INSTANT BNC

The TwistOn r.f. coaxial connectors could not be easier to fit. After the cable is trimmed and stripped, one end is inserted into the connector and the connector is screwed onto the cable. No crimping or solder required. The idea is used for BNC plugs, bulkhead or panel-mounted receptacles and u.h.f. line jacks. (A u.h.f. plug needs to have the nose of the centre conductor crimped but still uses no solder.) Prices for the BNC connectors are £2.05 each and for the u.h.f. £1.92, from Intime Electronics Ltd, Colemans Bridge, Witham, Essex CM8 3HP.

WW306

PROGRAMMABLE CRYSTAL OSCILLATOR

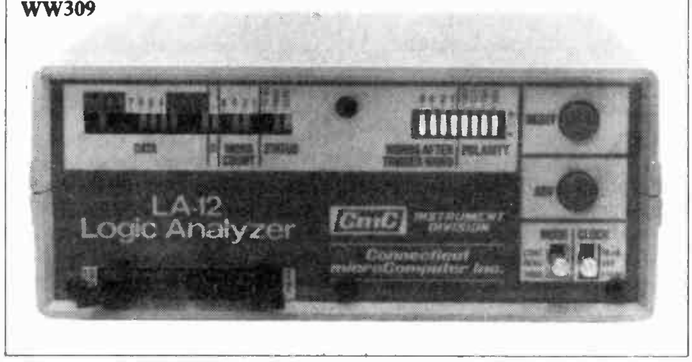
Fifty-seven different frequencies can be generated within a single device housed in a standard 16-pin dual in-line package. Frequencies range from 0.002Hz to the basic at crystal frequency; three models



have crystals base frequencies of 600kHz, 768kHz and 1MHz. Calibration tolerance is ±100ppm with a temperature stability of ±150ppm from −10 to +70°C. Two outputs, the crystal frequency and the programmed divided frequency, are available simultaneously and both are compatible with bipolar or c-mos circuits. The device may be used for such applications as data rate generators, in modems, timers and as computer clocks. IQD Crystal Electronics Ltd, 29 Market Street, Crewkerne, Somerset.

WW307

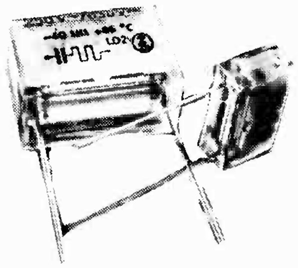
WW309



NEW PRODUCTS

RC SUPRESSOR

The compact PMR209 series of suppressors are made in such a way that the resistor element is an integral part of the capacitor, being formed in the processing of the metallised layer of the capacitor winding. Values in the series range from 47 to 470nF. They are designed for protection and supression in 50 or 60Hz a.c. mains or pulse circuitry. RIFA AB, Market Chambers, Shelton Square, Coventry.



WW308

LOW-COST LOGIC ANALYSER

A self-contained logic analyser bridges the gap between a simple logic monitors and expensive multi-feature analysers. The LA-12 has a 16-word memory that captures the state of the 16 logic events before or after the trigger event. Trigger and clock may be qualified to comply with user's system requirements. Once captured each data word can be stepped through the 20-segment l.e.d. display and can be analysed in terms of a 12-bit binary code, a hex code or a decimal code, as well as a timing diagram. Clock rates of 10MHz or over can be used. As the unit measures 190 × 65 × 150 mm and weighs less than 0.5kg it may be fitted into a toolkit or briefcase. The LA-12 costs £279 + vat from Reltech Instruments, Coach Mews, St Ives, Cambridge PE17 4BN.

WW309

AC CIRCUIT MODELLER

AC/MP is a software package for solving the simultaneous linear equations associated with circuit design. Suitable for use with any CP/M microcomputer the programme includes files, file editing, search and plotting capabilities for frequency response. Functions include gain, phase, input and output impedances, and bandwidth. Frequency response curves, log/log scaled, are printed on a normal printer. All passive and active components can be incorporated into circuit models with up to 32 nodes, typically an eight-transistor circuit. Processing speed is enhanced by optimally coded inner loops using macro-assembler. The c.a.d. package is available for £125 inclusive from Harcourt Systems, 9A Keswick Road, Orpington, Kent BR6 0EU. (See also "Circuit modelling by microcomputer," WW, August 1982.)

WW310

NEW PRODUCTS at Viewdata 82

The wider public has not yet been convinced of the need for the information and services (currently put at well over 200,000 frames-full of uneven range and variable datedness) . . . and many of those who have toyed with the idea have not found the cost structure sufficiently attractive. Commerce and industry, however, used as they are to the costs of other electronic information and communication services, and more confident that the 'product' of the service can meet their needs, have increasingly seen the value of the system in either public or private forms.

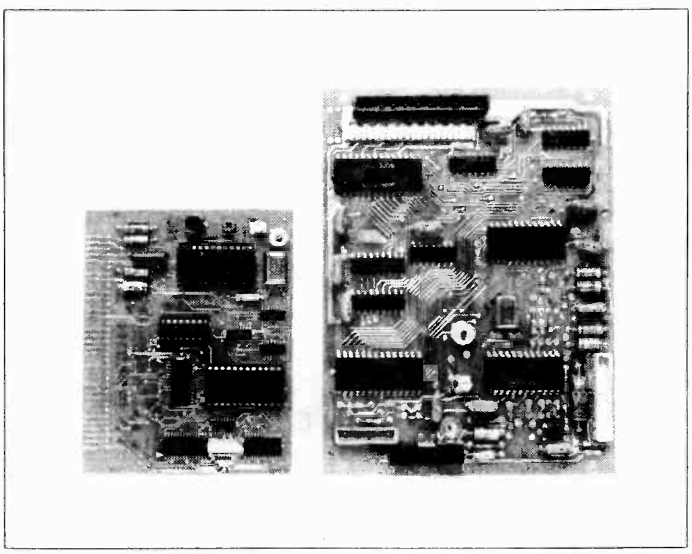
○ The company whose computers are at the heart of the London Stock Exchange's Topic videotex system with well over 1000 terminals, Modecomp, used the exhibition to launch ViewTracs – a new mainframe transaction processing system via viewdata. This enhancement for the Modcomp ViewMax private videotex system extends the information display and entry data facilities at the terminal by allowing interaction with a transaction processing system running in an external computer. In this mode Viewtracs provides the facility to front-end an existing complex mainframe application. WW500

○ A new VME version of ICL's Bulletin private videotex system is announced for use on its larger mainframes. Bulletin has a window facility to enable viewdata users to access normal data files and applications on their viewdata tv sets. Improvements to the Bulletin system include messaging facilities, improved editing, and what is called 'interactive up-date' enabling up-dates to be passed automatically between data files and the viewdata base. WW501

○ On the o.e.m. level, Mullard showed visitors how its Lucy unit has been joined by Lucinda (New Products, December) to reduce the number of integrated circuits needed in a viewdata decoder. Lucinda is an n-mos device which as well as replacing a number of filters and limiters, replaces six i.cs and many discrete components needed for coupling the dialling pulses to Lucy. Between them they cut the number of i.cs needed by up to 25. WW502

○ Switzerland's videotex service is planned to start in Bern and Zuürich in September next year, Digital Equipment Corporation reported the details of its share, with STR (the Swiss ITT company) and the Canadian Infomart organisation, it will be equipped with two VAX11/780 at each centre, and feature keyword search. WW503

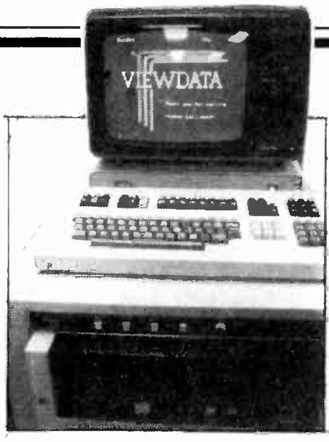
○ A live demonstration of British Telecom's next generation Picture Prestel used a 4065 system on GEC Computers stand. Other demonstrations included the Zycor MicroView, an intelligent package to provide viewdata, Dialcom, PSS Databases, Euronet and Dialog facilities, and the Infotron Supermux 790 network concentrator designed to make the most efficient use on data communications. WW504



SYSTEMS DEVELOPMENTS

○ Equipments and systems which are the basis of Aregon International's worldwide sales of videotex were on show. As well as the basic IVS-3 product there was also the recently announced IGS-1 gateway system, Salescom and Officecom for viewdata office communications, including mailbox, display of hand-written input and management graphics using geometric displays. Aregon also took part, along with Telidon company Infomart of Canada, on the stand of the Digital Equipment Company to show their combined videotex opportunities. WW505

○ Among companies with IBM-related products was Brown's Operating Systems Services, the "Brown's Box" viewdata interface with IBM mainframes firm. New lines are the BDU, a full-colour asynchronous terminal enabling a viewdata user to switch between a standard 24 + 80 character screen and 20 + 40, for viewdata operating mode, and the VPM, a mainframe viewdata package which allows the presentation of existing mainframe information in a viewdata/Prestel format. It provides a viewdata editing interface to store information on a page database, including sub-routines to retrieve the data pages and to merge the information with customer data. WW506



○ Also with an IBM tie, the Maidenhead-based systems firm MicroScope, unveiled two new systems. One, called Videogate, is an intelligent network concentrator said to provide all the tools required for users of IBM systems to implement, cost effectively, any size of interactive private videotex system. It emulates Prestel gateway and interfaces to the IBM systems via standard IBM X25 software under NCP. The other is Space Agent, a micro-based videotex reservation and accounting system for the operators or for others in the travel, tour or holiday sector. Using a four-port controller called Teleport, Space Agent provides a service for typically 80 or more travel agent terminals. WW507

○ A first sight of the latest version of its PVS-990 private viewdata system was provided by Mars Group Services. The system, which runs on the Texas Instruments DS990 range, now has an 80-column option and claims enhanced electronic mail facilities, kept within the user-friendly area by naming the features by familiar self-explanatory names like "carbon copy" and "recorded deliver". WW508

○ Computex Systems, with its private videotex system of the same name, had new software, including support of a high resolution graphics microcomputer as a terminal device, as well as Teldir, a telephone directory system and Ctxmail, a new electronic mail system. WW509

TERMINAL & ADAPTERS

○ At the terminal end of the market, the Plessey integration of the normal telephone function with that of Prestel or private videotex in one unit, first revealed in its Vutel instrument, has been updated in a Mk II version by addition of a detachable full alphanumeric keyboard and printer interface. The new model continues with the 5½-in monochrome screen, built-in numeric pad, two-page memory and several telephone sophistications. (Plessey also has its IBIS integrated business videotex system package based on the PDP11 processor, to provide keyword search, strong security by password control, and access regulation.) WW510

○ Viewdata Electronics (VEL) presented the Comptex 80 intelligent terminal offering programmable autodialler, automatic frame access, bulk update, tele-software transcoder and extensive off-line editing when used with the VEL intelligent keyboard. The internal magazine of up to 100 pages forms a carousel which can be cycled, for display purposes, at mixed speeds and with different effects under the control of a menu program. WW511

○ Cameron Communications, handling Barco products in the UK, reinforced its line-up of general videotex products for professional and business use with some custom-designed item. There was for instance the CV33 Telidon/Prestel unit, shown accessing several of the Canadian services such as Faxtel complete with alphageometric graphics. Another was a CV33 terminal with the 'Simplicty' touch-screen keying facility, and a third was a CV33 40/80 unit able to access the Dow Jones service from the US. WW512

○ Tandata improved their styling and design for the alphanumeric viewdata adaptor, TD1100, at £225 plus vat can make up a package with a colour monitor and printer to suit many business needs, says the firm. It has a qwerty keyboard as before but with greater spacing, more keys and improved keys layout. WW513

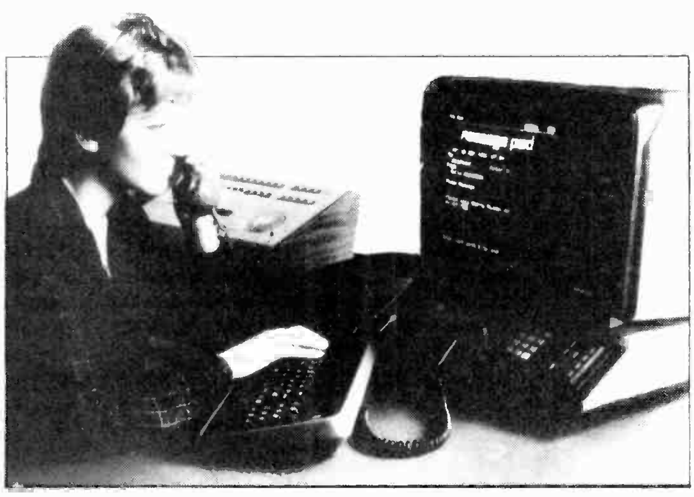
○ From its South Wales plant Sony previewed its viewdata adaptor, designed to link up with the recently-launched KX20PSI monitor in the firm's Profeel modular television system, to give this concept a viewdata facility. The 14 inch KTX1400UB terminal has been upgraded so it can be used with a wider range of message and edit keyboards. A new Sony printer SM1-7020UB can produce up to six frames in black-on-white paper on one A4-sheet. WW514

○ Datawand seeks to do away with number and character dialling by replacing them with specially developed bar code. Pre-selected pages are printed in a directory of barcodes and the electronic wand gives the signal with a simple stroke of the tip across the wanted page's code. The wand plugs into the standard keypad socket of the terminal. The suppliers, Ubaward Ltd, claim that this is not only 50 times faster than keying but gives a dramatic reduction in line and connection charges as a result. WW515

○ Integrex, the company with the first colour printer for viewdata, demonstrated its follow-up black-and-white version, the VMX80. Two-page store (in both models) leaves the terminal free for use while the printing-out is under way. WW516

FINNISH DIMENSION

○ The Finnish private system, Mistel, is available in the UK from InterCom Data Systems, who distribute it here under licence from Bell Information of Antwerp. It runs on DEC's range of mincomputers and on VAX and has also been developed for the Honeywell Level 6 range. As well as Prestel it can support alphageometric and photographic frame generation and it allows service programs (calculations, frame generation from non-videotex bases, interaction with other systems etc) to be connected to the videotex pages. InterCom also has a Nokia terminal which, with Mistrel, can display the mosaic, geometric and photographic images – "sometimes all three on the same frame." WW517



○ Another launch with a Finnish connection at Wembley was the Systel system, presented jointly by Datema, the UK bureau and systems company, and Perkin Elmer. Systel Oy of Finland developed the software for the system on Perkin Elmer equipment, jointly with Viewdata AB in Sweden. It runs in a multi-programming environment and can operate concurrently with other applications software. Access to IBM and other mainframes is made possible via a variety of emulators, including IBM 3270. Special features include automatic bar chart generation, keyword search, and 'picture building' with dynamic curser control, and there are other options. WW518

○ Denmark's Christian Rovsing company, whose CR80 is the basis of the Danish Teledata videotex trial, has announced the extension of its private videotex system to enable it to handle Telidon, the Canadian standard. The Danish system uses a form of keyword search and, in the CR80XX 25 packet switching package, connections can be made not only to British Telecom's PSS but also to international systems such as Euronet, as well as to Prestel and other systems via gateways. Its modular design philosphy enables the CR80 system to be expanded on-site to keep pace with growth requirements. WW519

○ Telidon, described as the North American PLP Standard is the basis of products handled in Britain by Poulter Computervision Systems, who showed the Image Creation Terminal spotted by WW earlier this year (May issue, page 40). It claims a 'palette' increased to 35,000 colour combinations with 16 of them able to be used simultaneously on the screen while creating data. The compatibility with PAL tv enables quality graphics to be transferred to a variety of presentations such as 35mm slides, videotape, solid-state "slides", etc. New from Poulter was the GC100 stand-alone computer, designed for the marketing, advertising and communicators industry. Its functions include graphics and data creation based on the 709E/AT&T standard, dual terminal handling both Telidon and Prestel, computer terminal able to access other databases, and word processing ability – all for £8750. WW520

One thing was very clear at the Viewdata 82 Exhibition, while progress on the residential market side of Prestel may be sluggish – recent initiatives may change this – there is no sign of slackening in the pace of business equipment developments and sophistications. – Owen Ascroft.

RANDOM ECHOES

By Chirp

THE WEAKEST LINK

They now have an intelligent telephone exchange in our office building: I think BT call it the Monarch. It is very impressive, with a great many facilities that must be extremely useful to anyone who knows how to drive it.

For a start it has a push button keypad instead of a dial so that one's fingers no longer suffer. Its attractive features include the ability to remember the last number you keyed in, and this can be re-selected by pressing a single button. Very useful if the number is engaged and you are trying it at intervals. There are all sorts of other facilities, such as the ability to transfer your calls to someone else's extension without even picking up your handset; or, conversely, you can pick up a call intended for another extension without leaving your desk if nobody else answers it. Moreover, the switching system is software controlled, so that each installation can be programmed to suit the subscriber's requirements.

But the snag is that there are no plain language instructions on the instrument. So it is only the enthusiast who really knows how to take advantage of all the goodies. Indeed the facilities provided can lead into mild trouble. One of my colleagues remarked that he was wondering why nobody rang him up one morning, when he discovered that a glowing l.e.d. beside the 'sounder' button means it is switched off not on. The light flashes to indicate a call, but he did not notice that.

One is led to the conclusion that these intelligent telephones are just another example of the way in which the advanced technology makes life more complicated, not simpler. But it could be that we are at a halfway stage, where the technology has not yet advanced enough.

There was a programme on television the other day about computer-controlled speech synthesis systems; and I have written articles myself about systems capable of interpreting human speech. I must admit that they were somewhat restricted, with a vocabulary of only about sixty syllables; but great things develop from small beginnings.

Perhaps the day will come when such devices are developed to the degree where the spoken word becomes the normal way of communicating with computers. And perhaps British Telecom will adopt such systems on a grand scale. Instead of a complex instrument with its l.e.d.s and push buttons, the telephone on your desk will be a simple compact unit with no manual controls.

When you lift the handset there will be no dialing tone. Instead a synthesized voice will say, "Number please?" You ask for a number anywhere in the world and the computer system connects you instantly. Or, if it happens to be engaged, you simply tell the system to keep trying and call you back.

Of course, we all know that such simplicity will never be introduced in reality. High technology warrants visible evidence when the subscriber is paying for it, and it is certain that the equipment on your desk will get more elaborate rather than simpler.

Actually I do not have an intelligent telephone on my desk. By and large I am quite happy with my stupid one. I would be glad, however, if we could do away with that irritating cable between the instrument and the wall connection. It seems a pity that signals that have been carried by such advanced multiplex systems, with microwave links, satellites and fibre optic techniques to preserve their integrity, should finish their journey (or start it) on a grotty bit of wire lying on the office floor, tripping people up.

This is the weakest link in my system, and if it could be replaced by a radio link, electromagnetic coupling or some similar channel I would gladly do without the magic computerized switching systems.

LISTEN TO THAT SPEC!

Do you remember when the term "high fidelity" described the quality of the sound that came out of the loudspeaker? When we played gramophone records on high quality instruments in cabinets designed to look like pieces of furniture?

It's not so long ago as you might think. We have such a machine in our sitting room. It employs all-solid-state electronics, it plays stereo or mono records and it can receive a.m. or stereo f.m. wireless waves. It also has a special socket at the back that enables you to connect it to the stereo cassette recorder in our portable radio to make illicit tapes from borrowed discs without paying royalties. Quite modern really. But you won't see many in the shops like it now.

They call 'em music centres now and they've gone all technical. At a recent press reception to announce a big share issue for an electronic engineering company the stock broker, who had a much better speaking voice than the engineers, was explaining the finer technical points of the equipment to the non-technical city journalists. He referred to a rack mounted u.h.f. transmitter as "that thing like glorified hi-fi" and everyone understood.

He was right. Domestic audio equipment nowadays is a bit forbidding, with moving coil meters on brushed aluminium panels, and all those knobs and switches. Sales literature often contain technical performance specifications that you wouldn't expect members of the general public to understand. (Come to think of it, even experienced engineers find a lot of it not too meaningful).

I suppose that there are still those among us who like their canned music to have a "lovely mellow tone", as my Aunt Kitty used to say, but there is clearly a fashionable status advantage in owning a rack mounted quadraphonic system with a megawatt peak music power output (whatever that is). They sell them opposite my office in a shop boasting an anechoic demonstration room on the first floor. I ventured into this chamber the other day in a desperate search for an assistant to sell me a calculator battery. He turned out to be a zealot, dedicated to the conversion of humanity into a race of audio enthusiasts.

"Do you like music?" he asked, "Try these on." He steered me to a confortable chair and fitted an enormous pair of stereo headphones over my ears.

I listened to superb quality jazz piano, Count Basie I think, but only for a about ten seconds because he pressed a button which switched from tape to disc, and I heard a tiny fragment of the last movement of Beethoven's Pastoral Symphony, then a few bars of some deafening rock and roll. I removed the 'phones (why do they call 'em cans), and explained that I just wanted a calculator battery.

As he led me downstairs to the shop he told me of the wonders of his audio equipment. "Thirty watt amplifiers with less than 0.001% distortion,' he claimed.

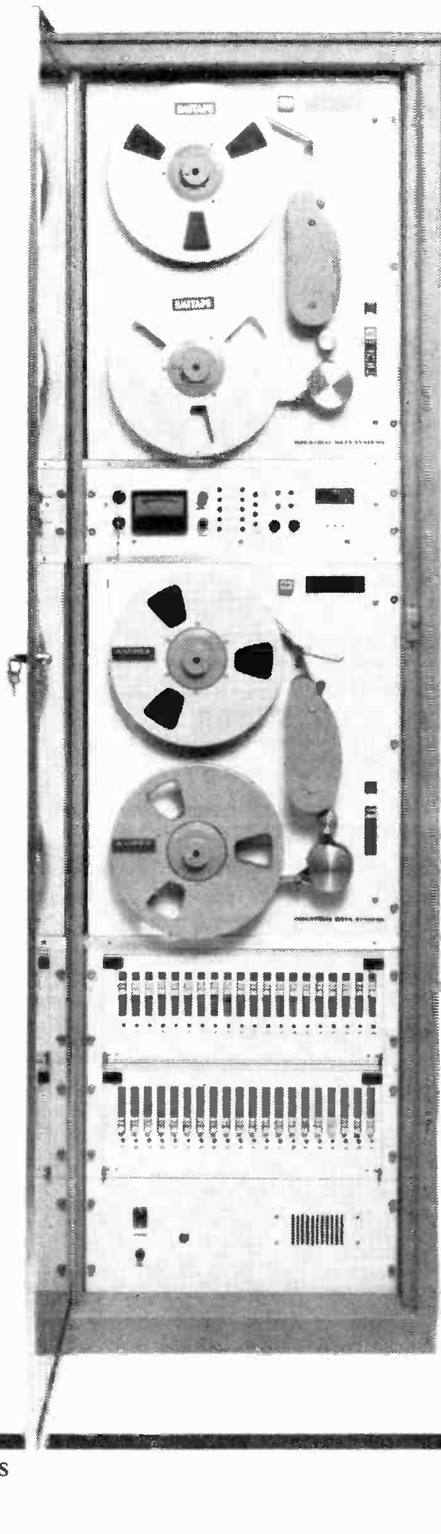
"How do you measure it?" I asked. He answered by slapping the sales leaflet on the shop counter and pointing to the relevant clauses of the performance specification, translated from the Japanese. Ah well, ask a silly question!

"But the loudspeakers must introduce about two per cent distortion," I said.

He gave me a long suffering look and held up the leaflet. "This equipment does not include the loudspeakers."

He handed me my battery and change for a fiver in silence. I left the shop with the feeling that his true hi-fi buffs do not actually listen to the music. Perhaps they enjoy looking at the stereo waveforms on double beam oscilloscopes.

Incidentally, I noticed that the upper 3 dB frequency limit of these amplifiers was specified as 20 kHz. Not much use to us humans but probably fascinating for that HMV dog. Is that what the trade mark is all about?



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18V	7818	40p	7918	45p
24V	7824	40p	7924	45p
5V 100mA	78L05	30p	79L05	45p
6V 100mA	78L06	30p		
8V 100mA	78L08	30p		
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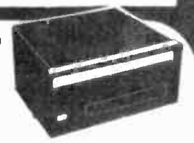

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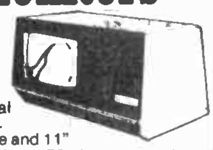

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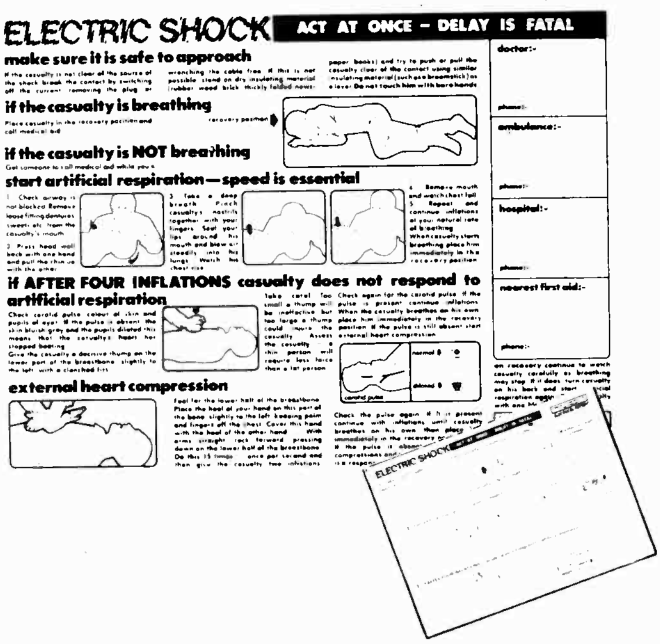

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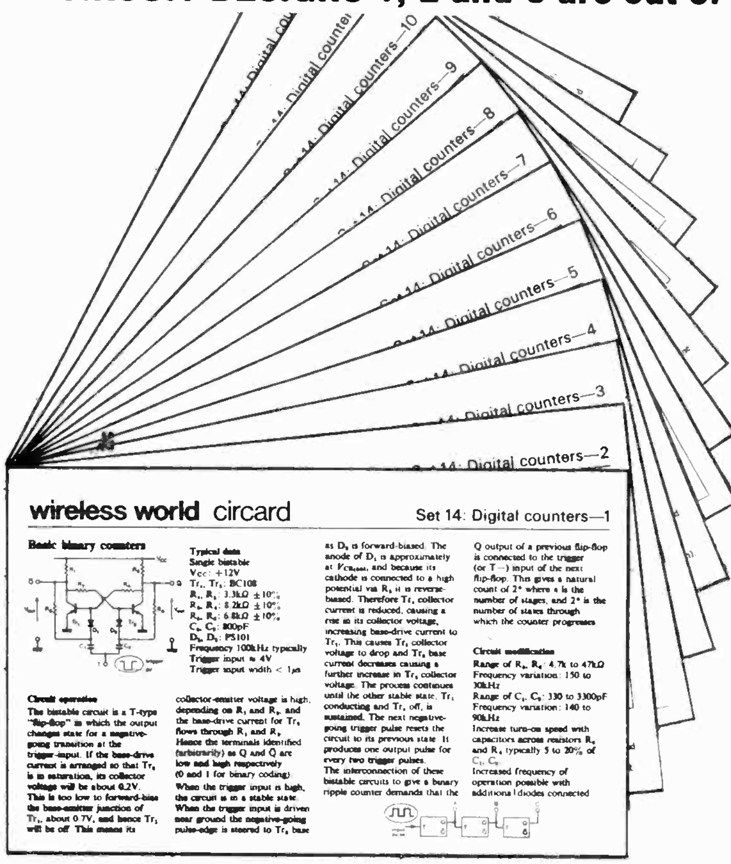

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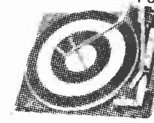

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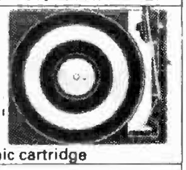
BSR P170 RIM DRIVE QUALITY DECK **£20** Post £2



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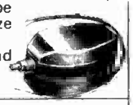

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Stabilised output, 9 volt 400 m.a. U.K. made in plastic case with screw terminals. Safety overload cut out. Size 5x3¼x2½in. Transformer Rectifier Unit. Suitable Radios, Cassettes, models, **£4.50**. Post 50p.

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"Final Clearance". **Sale Price** **£8** Post £1.50
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RESISTORS. 10Ω to 10M. ¼W, ½W, 1W, **2p**: 2W **10p**.
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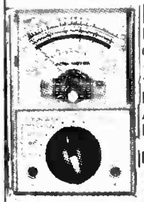
5kΩ to 2MΩ. LOG or LIN. L/S **50p**. DP **90p**. Stereo L/S **£1.10**. DP **£1.30**. Edge Pot 5K. SP **45p**.

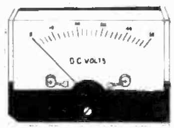
MINI-MULTI TESTER NEW



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.
DC amps 0-250μA, 0-250mA.
Resistance 0 to 600K ohms.
£6.50 Post 50p

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.

RCS SOUND TO LIGHT CONTROL BOX

Complete ready to use with cabinet size 9×3×5in. **£27**
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 **£33**. PP £1.
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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. Can be ganged to make multi-way stereo mixers **£2.95** Post 65p

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		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

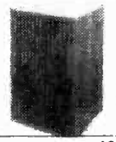
Tapped outputs available	Price	Post
2 amp. 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 25 and 30V	£6.00	£2
1 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£6.00	£2
2 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£10.50	£2
3 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£12.50	£2
5 amp. 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			
12V. 750 ma	£2.00	80p	35V 2 amps	£4.00	£1
12V 3 amps	£3.50	£1	TOROIDAL 30-0-30V 4a		
12-0-12V. 2 amps	£3.50	£1	and 20-0 20V ½a	£10.00	£2

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

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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; 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**.
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2200mF 63V **90p**. 2500mF 50V **70p**; 3000mF 50V **65p**;
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16/350V	45p	150+200/275V	70p	16+16/350V	80p
32/500V	95p	220/450V	95p	32+32/350V	85p
32/350V	50p	32+32+32/325V	75p	32+32/500V	£1.80
50/450V	95p	50+50+50/350V	95p	50+50/300V	50p

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**. 600V **20p**. 1000V **30p**. 1750V **50p**.
.47MF 1500V **10p**. 400V **20p**. 630V **30p**. 1000V **60p**.
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GEARED TWIN GANGS 25pF **95p**.
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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.
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MODEL	INCHES	OHMS	WATTS	TYPE	PRICE	POST
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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.
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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.

FAMOUS LOUDSPEAKERS "SPECIAL PRICES"

MAKE	MODEL	SIZE	WATTS	OHMS	PRICE	POST
SEAS	TWEETER	4in	50	8	£9.50	£1
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	£27	£2
GOODMANS	WOOFER	8in	25	4/8	£6.50	£1
GOODMANS	HB	8in	60	8	£12.50	£1
WHARFDALE	WOOFER	8in	30	8	£9.50	£2
AUDAX	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

SPEAKER COVERING MATERIALS. Samples Large S.A.E.
B.A.F. LOUDSPEAKER CABINET WADDING 18in wide 35p ft.

MOTOROLA PIEZO ELECTRIC HORN TWEETER, 3⅜in. square **£5**
100 watts. No crossover required. 4-8-16 ohm, 7⅜x3⅛in. **£10**

CROSSOVERS. TWO-WAY 3000 c/s 30 watt 8 **£3**. 100W **£4**.
3-way 950 cps/3000 cps. 40 watt rating. **£4**. 3 way 60 watt **£6**. 100W **£8**.
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3 ohm, 5in, 7×4in, **£2.50**; 6½in, 8×5in, **£3**; 8in, **£3.50**. 10in, **£5**.
8 ohm, 2⅝in, 3in, **£2**; 5×3in, 6×4in, 7×4in, 5in, **£2.50**; 6½in, 8×5in, **£3**; 8in, **£4.50**; 10in, **£5**; 12in, **£6**.
15 ohm, 2¼in, 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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WW-7

Appointments

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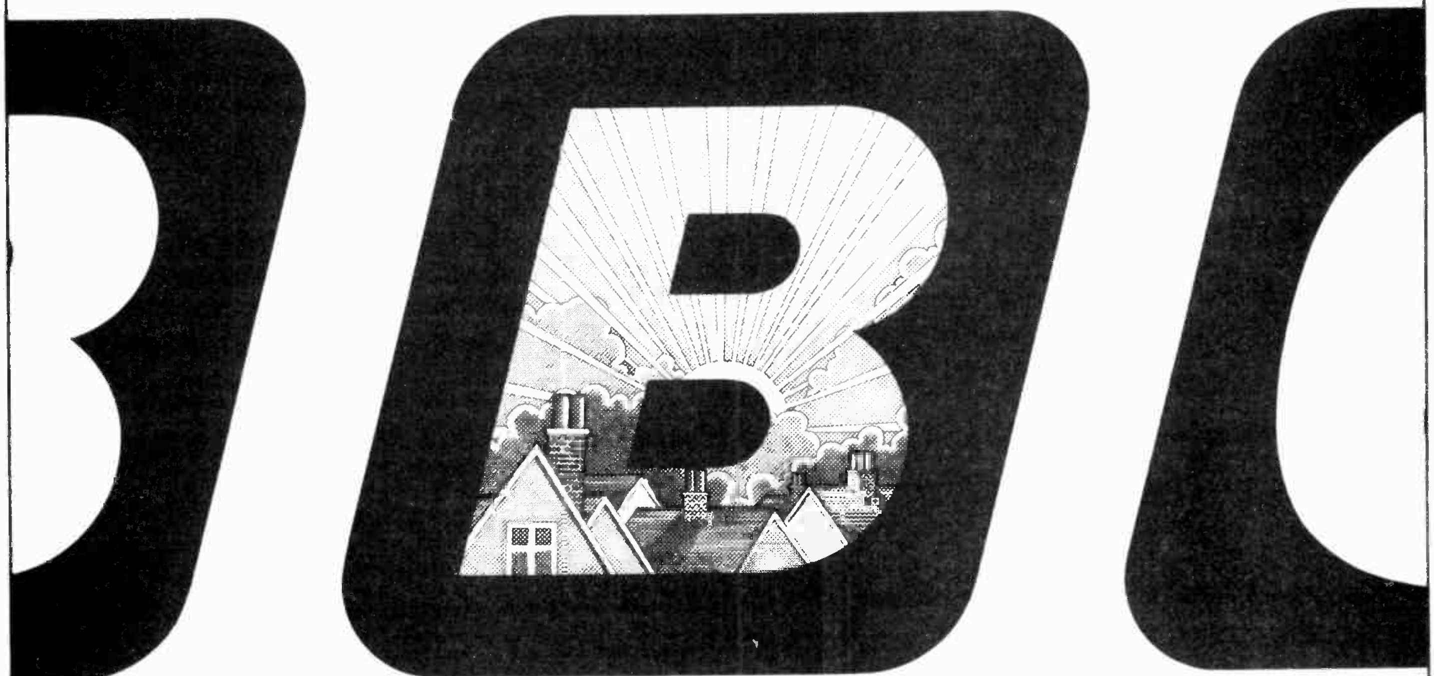
(1925)

TELEVISION ENGINEERS



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BBC

(1931)

Appointments

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(1908)

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1914

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REDIFFUSION

(1899)

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(1912)

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(1589)

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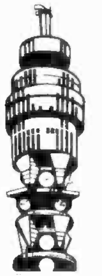
Miss L. J. Walker
Communications Administrator
United Press International
8 Bouverie Street
London EC4Y 8BB

(1900)



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(1902)

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(1924)

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Applicants should telephone or write to:

R. L. C. STINTON, C.Eng., M.I.E.E.
Director, Systems Engineering Division
Electrosonic Ltd, 815 Woolwich Road
London SE7 8LT. Telephone: 01-855 1101

1978

(1921)

Bloomsbury Health Authority

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CIRCA £10,000

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GCHQ

(1531)

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For further information (1904)

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(1930)

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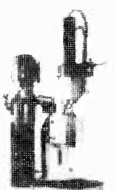

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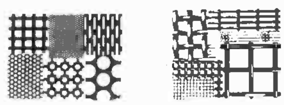

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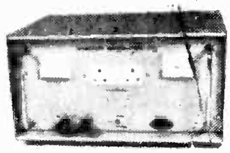

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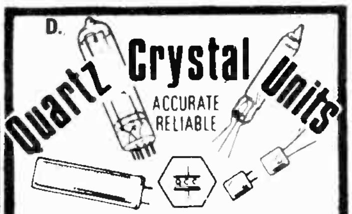

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RW67X	13A nylon Mains Plug British	157	79p	100	45p
WL27E	LED 0.2in. Red	182	12p	500	6p
WL28F	LED 0.2in. Green	182	19p	500	10p
WL29G	LED 0.2in. Orange	182	33p	250	19p
WL30H	LED 0.2in. Yellow	182	17p	500	9p
RK07H	Panel Meter 100uA	197	£2.95	25	£1.95
RK09K	Panel Meter 1mA	197	£2.95	25	£1.95
RK19V	Panel Meter VU	197	£2.95	25	£1.95
YQ47B	Dual VU Meter	197	£3.90	25	£2.30
YR84F	Professional Plugblock	201	£6.95	10	£4.95
RX96E	20mm Fuse Holder	250	45p	250	24p
M10R-M1M	Metal Film 0.4W 1% Resistor	262	2p	1000	1p
FW00A-FW09K	Rotary Potentiometers linear	265	45p	250	32p
FW21X-FW29G	Rotary Potentiometers log	265	45p	250	32p
QL80B	1N4148	270	4p	1000	2p
QL22Y	741C 8-pin DIL	270	23p	500	12p
QH66W	NE555	270	21p	500	12p
QQ06G	4164 64K dynamic RAM	271	£5.99	100	£3.98
BL18U	DIL Socket 14-pin	336	11p	500	7.5p
BL17T	DIL Socket 8-pin	336	9p	1000	4.5p
WF14Q	Stereo Headphone with slide volume controls	342	£7.99	10	£4.95
FH00A	Sub-min Toggle Switch SPDT	347	70p	100	45p
FH04E	Sub-min Toggle Switch DPDT	347	99p	100	59p
FF73Q-FF76H	Rotary Switch break before make	348	74p	100	46p
FH42V-FH45Y	Rotary Switch make before break	348	70p	100	42p
YW93B	1000 ohm per volt Multimeter	362	£4.85	25	£2.95
YW68Y	20,000 ohm per volt Multimeter with Transistor Tester	363	£16.25	5	£10.45
BR75S	Box-joint Insulated 4½in. Cutters	370	£6.93	10	£4.45
BR78K	Box-joint Insulated 4½in. Pliers	371	£5.72	10	£3.95

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