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Wireless World

AUGUST 1983

80p

Daisywheel typewriter interface

Spectrum analysis on the cheap

Did Morse get it right?

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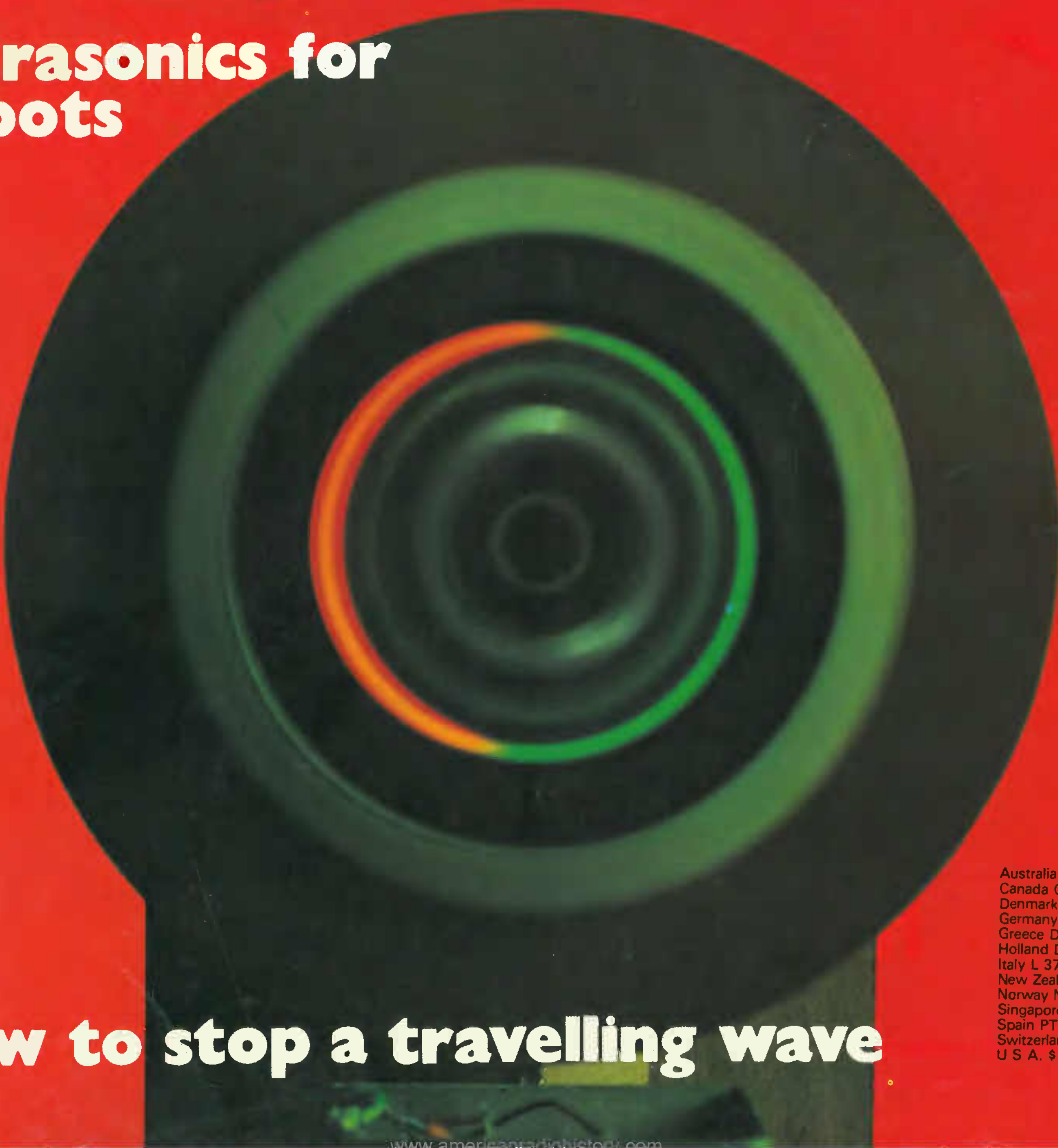

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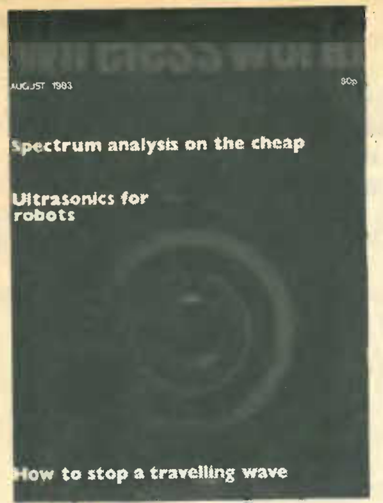
AUGUST 1983 VOL 89 NO 1571



Red and green arcs of light represent crests and troughs of an electromagnetic wave brought to rest in the laboratory, as described by Professor Jennison on pages 36-38.

NEXT MONTH

During his work on crises control R. E. Young saw a connexion between shock caused by a mass of data too enormous and possibly suspect to comprehend and the 'shell' condition of hyperautism in the mentally handicapped. R. E. Y. describes how electronics is now being applied to help people escape from the shell by communication.

Ian Wade's RTTY program runs on a basic Nascom 1 or 2 microcomputer and displays received text on a tv screen in lower-case letters, transmitted text in upper case.

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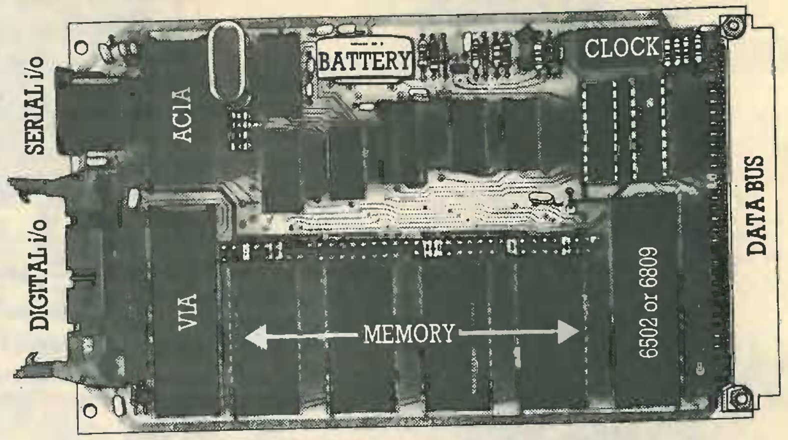

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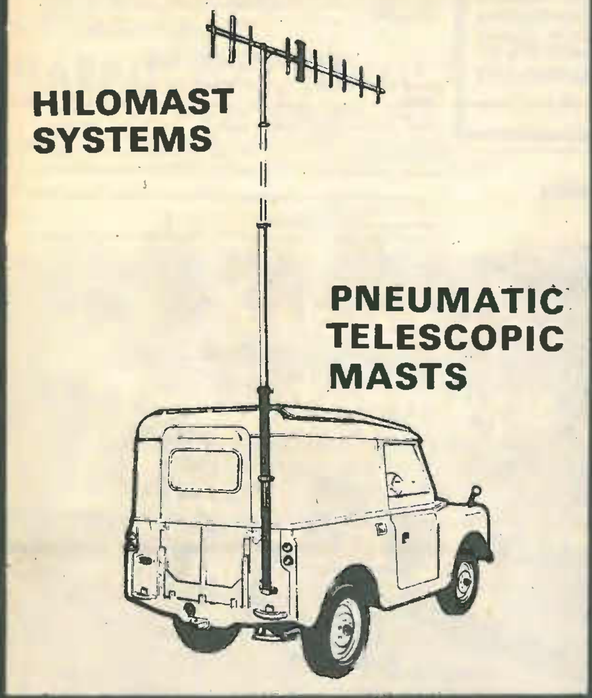

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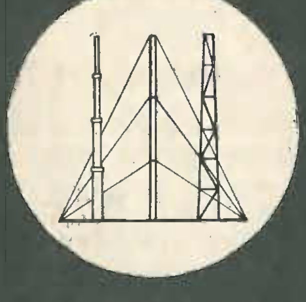

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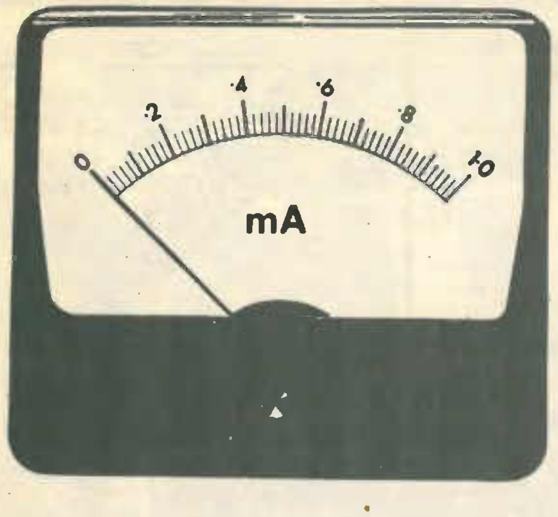

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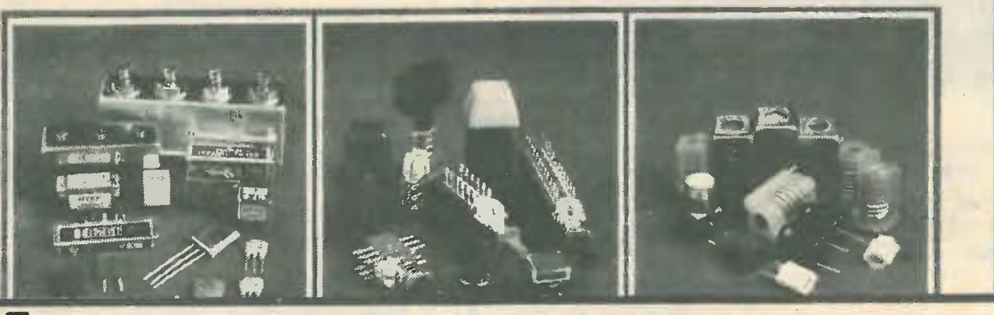

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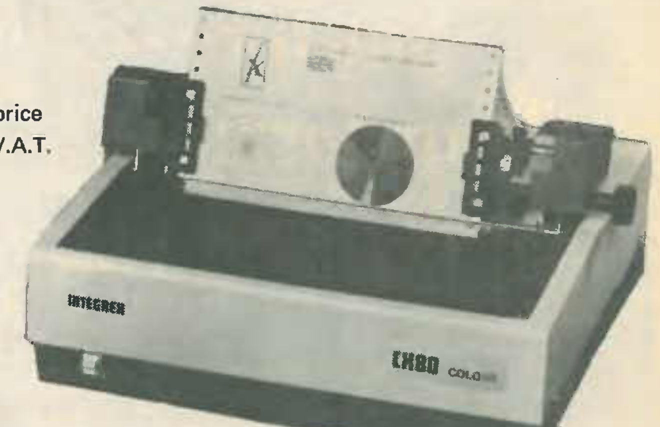

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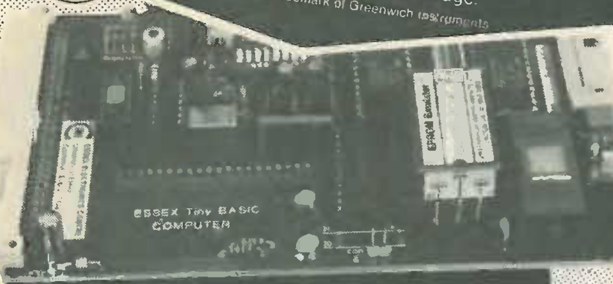

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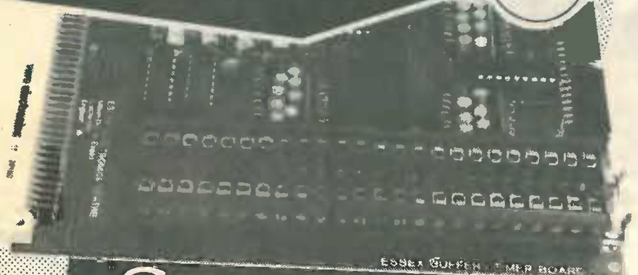

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Personality cards and hardware changes are not required as the machine configures itself for the different devices.

The EP4000 with 4k x 8 static RAM is still available with EPROM programming and emulation capacity up to 4k x 8 sizes.

FEATURES

- Software personality programming/emulation of all EPROMs up to 8k x 8 bytes including 2704, 2708, 2716(3), 2508, 2758A, 2758B, 2516, 2716, 2532, 2732, 2732A, 68732-0, 68732-1, 68766, 68764, 2564, 2764. Programs 25128, 27128 with adaptors.
- No personality cards/characterisers required.
- Use as stand alone programmer, slave programmer, or EPROM development system.
- Checks for misplaced and reversed insertion, and shorts on data lines.
- Memory mapped video output allows full use of powerful editing facilities.
- Built-in LED display for field use.
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2708
2716(3)
2508
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2758B
2516
2716
48016
2532
2732
2732A
68732-0
68732-1
68766
68764
2764
2564
MK2764
25128
27128

- Checks, Programs, Compares up to 8 devices simultaneously
- Handles all NMOS EPROMS up to projected 128K designs with no personality modules or characterisers – See list
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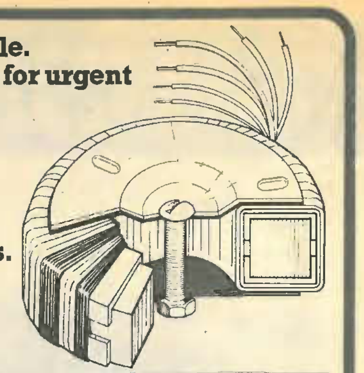

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	0x015	22+22	0.34	
	0x016	25+25	0.30	
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	1x013	15+15	1.00	
	1x014	18+18	0.83	
	1x015	22+22	0.68	
	1x016	25+25	0.60	
	1x017	30+30	0.50	
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	2x012	12+12	2.08	
	2x013	15+15	1.66	
	2x014	18+18	1.38	
	2x015	22+22	1.13	
	2x016	25+25	1.00	
	2x017	30+30	0.83	
	2x028	110	0.45	
	2x029	220	0.22	
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	3x015	22+22	1.81	
	3x016	25+25	1.60	
	3x017	30+30	1.33	
	3x028	110	0.72	
	3x029	220	0.36	
	3x030	240	0.33	
120 VA 90x40mm 1.2Kg Regulation 11%	4x010	6+6	10.00	£7.42 + p&p £1.72 + VAT £1.37 TOTAL £10.51
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	4x014	18+18	3.33	
	4x015	22+22	2.72	
	4x016	25+25	2.40	
	4x017	30+30	2.00	
	4x018	35+35	1.71	
	4x028	110	1.09	
	4x029	220	0.54	
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	5x012	12+12	6.66	
	5x013	15+15	5.33	
	5x014	18+18	4.44	
	5x015	22+22	3.63	
	5x016	25+25	3.20	
	5x017	30+30	2.66	
	5x018	35+35	2.28	
	5x026	40+40	2.00	
	5x028	110	1.45	
	5x029	220	0.72	
	5x030	240	0.66	
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	6x013	15+15	7.50	
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	6x016	25+25	4.50	
	6x017	30+30	3.75	
	6x018	35+35	3.21	
	6x026	40+40	2.81	
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	6x033	50+50	2.25	
	6x028	110	2.04	
	6x029	220	1.02	
	6x030	240	0.93	
300 VA 110x50mm 2.6Kg Regulation 6%	7x013	15+15	10.00	£10.88 + p&p £2.05 + VAT £1.94 TOTAL £14.87
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	7x015	22+22	6.82	
	7x016	25+25	6.00	
	7x017	30+30	5.00	
	7x018	35+35	4.28	
	7x026	40+40	3.75	
	7x025	45+45	3.33	
	7x033	50+50	3.00	
	7x028	110	2.72	
	7x029	220	1.36	
	7x030	240	1.25	
500 VA 140x60mm 4Kg Regulation 4%	8x016	25+25	10.00	£14.38 + p&p £2.40 + VAT £2.52 TOTAL £19.30
	8x017	30+30	8.33	
	8x018	35+35	7.14	
	8x026	40+40	6.25	
	8x025	45+45	5.55	
	8x033	50+50	5.00	
	8x042	55+55	4.54	
	8x028	110	4.54	
	8x029	220	2.27	
	8x030	240	2.08	
625 VA 140x75mm 5Kg Regulation 4%	9x017	30+30	10.41	£17.12 + p&p £2.55 + VAT £2.95 TOTAL £22.62
	9x018	35+35	8.92	
	9x026	40+40	7.81	
	9x025	45+45	6.94	
	9x033	50+50	6.25	
	9x042	55+55	5.68	
	9x028	110	5.68	
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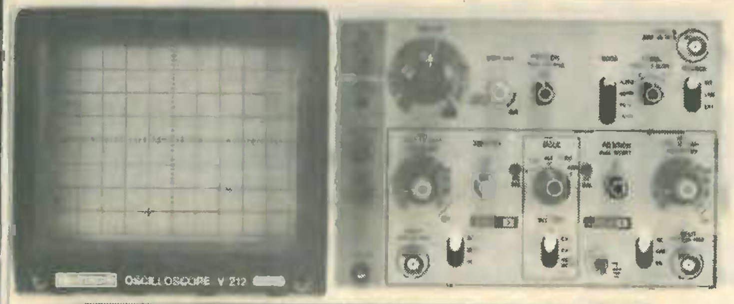

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Prices start at £295 plus vat (model illustrated) including 2 probes and a 2-year warranty. We hold the range in stock for immediate delivery.

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RST **Tel: 01-677 2424 Telex: 946708** RST

SEMICONDUCTORS

Type	£
AA119	0.10
AAY30	0.17
AAY30	0.17
AAZ13	0.15
AAZ15	0.15
AAZ17	0.15
AC107	0.55
AC125	0.25
AC126	0.25
AC127	0.25
AC128	0.30
AC141	0.28
AC141K	0.35
AC142	0.28
AC142K	0.35
AC176	0.30
AC187	0.28
AC188	0.28
ACY17	1.30
ACY18	1.15
ACY19	1.10
ACY20	1.10
ACY21	1.15
ACY39	2.50
AD149	0.75
AD161	0.35
AD162	0.35
AF106	0.35
AF114	0.75
AF115	0.75
AF116	0.75
AF117	0.75
AF139	0.33
AF186	1.00
AF239	0.39
AFZ11	4.00
AFZ12	4.00
ASY26	1.40
ASY27	0.90

Type	£
ASZ15	1.20
ASZ16	1.10
ASZ17	1.00
ASZ20	2.30
ASZ21	2.50
AU113	2.50
AUY10	3.00
BA145	0.13
BA148	0.15
BA154	0.10
BA155	0.11
BA156	0.10
BAW62	0.05
BAX13	0.06
BAX16	0.06
BC107	0.16
BC108	0.16
BC109	0.16
BC113	0.15
BC114	0.15
BC115	0.18
BC116	0.19
BC117	0.23
BC118	0.18
BC125	0.18
BC126	0.18
BC135	0.18
BC136	0.19
BC137	0.19
BC147	0.12
BC148	0.12
BC149	0.13
BC157	0.13
BC158	0.13
BC159	0.13
BC167	0.11
BC170	0.11
BC171	0.11
BC172	0.11

Type	£
BC173	0.11
BC177	0.28
BC178	0.28
BC179	0.28
BC182	0.11
BC183	0.11
BC184	0.11
BC212	0.11
BC213	0.11
BC214	0.11
BC237	0.11
BC238	0.11
BC301	0.33
BC303	0.34
BC307	0.11
BC308	0.11
BC327	0.12
BC328	0.12
BC337	0.12
BC338	0.12
BCY30	1.25
BCY31	1.50
BCY32	1.50
BCY33	1.10
BCY34	1.00
BCY39	3.40
BCY40	2.80
BCY42	0.30
BCY43	0.30
BCY58	0.19
BCY70	0.17
BCY71	0.18
BCY72	0.17
BCZ11	1.75
BD115	0.42
BD121	1.70
BD123	2.80
BD124	2.00
BD131	0.44

Type	£
BD132	0.48
BD135	0.40
BD136	0.40
BD137	0.40
BD138	0.48
BD139	0.48
BD140	0.50
BD144	2.00
BD181	1.20
BD183	0.80
BD237	0.54
BD238	0.54
BDX10	0.91
BDX32	2.00
BDY20	1.50
BDY60	2.75
BF115	0.35
BF152	0.16
BF153	0.16
BF154	0.17
BF159	0.17
BF160	0.17
BF167	0.24
BF173	0.30
BF177	0.35
BF178	0.35
BF179	0.35
BF180	0.28
BF181	0.28
BF182	0.28
BF183	0.28
BF184	0.28
BF185	0.30
BF194	0.14
BF195	0.12
BF196	0.13
BF197	0.14
BF200	0.40
BF224	0.25
BF244	0.28

Type	£
BF257	0.27
BF258	0.28
BF259	0.28
BF336	0.34
BF337	0.33
BF338	0.36
BFS21	4.00
BFS28	2.25
BFS61	0.20
BFS98	0.20
BFW10	0.97
BFW11	0.96
BFX84	0.30
BFX85	0.30
BFX87	0.30
BFX88	0.30
BFY50	0.25
BFY51	0.25
BFY52	0.25
BFY64	0.30
BFY90	0.95
BSX19	0.27
BSX20	0.27
BSX21	0.29
BT106	1.20
BTY79/400R	2.00
BU205	1.30
BU206	1.50
BU208	2.00
BY100	0.40
BY126	0.13
BY127	0.14
BZX61	0.17
Series	
BZY88	0.10
Series	
CRS1/40	0.60
CRS3/40	0.75
CRS3/60	0.90
GEX66	3.00

Type	£
GEX541	5.00
GJ3M	1.50
GM0378A	1.75
KS100A	0.45
ME0402	0.20
MJE340	0.60
MJE370	0.73
MJE371	0.71
MJE520	0.47
MJE521	0.73
MJE2955	1.30
MJE3055	1.10
MPF102	0.35
MPF103	0.35
MPF104	0.35
MPF105	0.35
MPSA06	0.26
MPSA56	0.28
MPSU01	0.53
MPSU06	0.65
MPSU56	0.69
NE555	0.45
NKT401	3.50
NKT403	2.50
NKT404	2.20
OA5	1.20
OA7	0.60
OA10	0.55
OA47	0.12
OA70	0.25
OA79	0.12
OA81	0.17
OA85	0.17
OA90	0.08
OA91	0.08
OA95	0.08
OA200	0.15
OA202	0.15
OA211	1.50
OAZ200	1.50
OAZ201	1.50
OAZ206	1.50

Type	£
OAZ207	1.50
OC16	2.50
OC20	2.50
OC22	2.50
OC23	2.50
OC24	3.00
OC25	1.00
OC26	1.00
OC28	2.00
OC29	2.00
OC35	1.50
OC36	1.50
OC41	0.90
OC42	0.90
OC43	1.50
OC44	0.85
OC45	0.65
OC70	0.55
OC71	1.00
OC72	1.00
OC73	1.00
OC74	0.70
OC75	0.65
OC76	1.00
OC77	1.00
OC81	0.65
OC81Z	1.20
OC82	0.90
OC83	1.00
OC84	0.80
OC122	2.75
OC123	2.00
OC139	3.00
OC140	4.00
OC141	4.25
OC170	1.25
OC171	1.25
OC200	1.50
OC201	2.50
OC202	2.75
OC203	3.00
OC204	3.00

Type	£
OC205	2.75
OC206	2.75
OC207	2.50
OCP71	2.00
ORP12	1.00
R2008B	2.00
R2009	2.25
R2010B	2.00
TIC44	0.27
TIC226D	1.20
TIL209	0.16
TIP29A	0.43
TIP30A	0.45
TIP31A	0.33
TIP32A	0.36
TIP33A	0.54
TIP34A	0.67
TIP41A	0.44
TIP42A	0.42
TIP2955	0.70
TIP3055	0.56
TIS43	0.43
ZS140	0.25
ZS170	0.21
ZS178	0.54
ZS271	0.23
ZS278	0.57
ZTX107	0.12
ZTX108	0.12
ZTX109	0.12
ZTX300	0.13
ZTX301	0.14
ZTX302	0.18
ZTX303	0.18
ZTX304	0.20
ZTX311	0.13
ZTX314	0.25
ZTX500	0.14
ZTX501	0.14
ZTX502	0.18
ZTX503	0.19

Type	£
ZTX504	0.21
ZTX531	0.24
ZTX550	0.25
1N914	0.05
1N916	0.09
1N4001	0.06
1N4002	0.06
1N4003	0.06
1N4004	0.07
1N4005	0.09
1N4006	0.11
1N4007	0.12
1N4009	0.07
1N4148	0.06
1N5400	0.13
1N5401	0.13
1S44	0.04
1S920	0.08
1S921	0.09
2G301	1.00
2G302	1.00
2G306	1.00
2N404	1.30
2N696	0.32
2N697	0.32
2N698	0.32
2N705	0.25
2N706	0.25
2N708	0.25
2N930	0.25
2N1131	0.30
2N1132	0.30
2N1302	1.20
2N1303	0.80
2N1304	1.20
2N1305	1.00
2N1306	1.50
2N1307	1.10
2N1308	1.75
2N1309	1.20
2N1613	0.32

Type	£
2N1671	5.00
2N1893	0.32
2N2147	4.00
2N2148	3.75
2N2218	0.32
2N2219	0.32
2N2220	0.20
2N2221	0.20
2N2222	0.20
2N2223	4.25
2N2368	0.25
2N2369A	0.25
2N2484	0.25
2N2646	0.50
2N2904	0.32
2N2905	0.32
2N2906	0.21
2N2907	0.21
2N2924	0.26
2N2925	0.22
2N2926	0.15
2N3053	0.26
2N3054	0.55
2N3055	0.65
2N3440	0.70
2N3441	0.85
2N3442	1.25
2N3614	2.20
2N3702	0.11
2N3703	0.11
2N3704	0.11
2N3705	0.11
2N3706	0.11
2N3707	0.11
2N3708	0.10
2N3709	0.11
2N3710	0.10
2N3711	0.10
2N3771	1.40
2N3772	1.60
2N3773	1.80

Type	£
2N3819	0.30
2N3820	0.39
2N3823	0.60
2N3866	1.00
2N3904	0.17
2N3905	0.17
2N3906	0.17
2N4058	0.20
2N4059	0.20
2N4060	0.16
2N4061	0.16
2N4062	0.16
2N4124	0.16
2N4126	0.16
2N4286	0.15
2N4288	0.18
2N4289	0.18
2N4400	0.11
2N4401	0.11
2N4402	0.11
2N5457	0.32
2N5458	0.32
2N5459	0.32
2S017	10.00
2S019	12.00
2S026	25.00
2S103	1.50
2S302	2.00
2S303	1.50
2S322	3.50
2S324	3.50
2S701	2.00
2S745A	0.95
2S746A	0.95

VALVES

Type	£
A1834	9.00
A2087	13.50
A2134	17.50
A2293	16.00
A2426	18.75
A2521	22.50
A2900	22.50
A3343	45.00
AZ31	2.75
AZ41	2.60
BK448	114.90
BK484	155.35
BS90	58.00
BS452	60.00
BS810	60.00
BT5	58.95
BT17	151.00
BT19	44.05
BT29	349.15
BT69	354.80
BT95	129.00
CBL31	4.00
CL33	4.00
CY31	3.00
C1K	20.00
C3A	22.00
C3JA	22.00
DA41	25.00
DA42	18.70
DAF91	1.75
DAF96	1.75
DET22	35.00
DET24	49.00
DF91	1.75
DF96	1.75
DK91	1.75
DK92	2.00
DK96	1.75
DL92	2.00
DL94	1.75
DL96	1.75
DLS10	14.00
DLS15	12.50
DLS16	12.50
DLS19	12.50
DM70	2.00
DM71	2.00
DM160	4.75
DY87	1.50
DY802	1.50
E55L	22.00
E80CC	8.81
E80CF	11.27
E80F	13.58
E80L	13.37
E81CC	8.00
E81L	12.57
E82CC	8.10
E83CC	8.40
E86C	8.25
E88C	8.25
E88CC	8.00
E90CC	8.61
E90F	9.90
E91H	6.25
E92CC	8.75
E99F	9.10

Type	£
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	6.00
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

Type	£
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	1.75
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
G551K	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

Type	£
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	15.00
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

Type	£
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
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
QQV03-10	14.00
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

Type	£
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

Type	£
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

Type	£
4C35	78.00
4CX250B	40.00
4CX350A	73.00
4X150A	60.00
4X150D	56.00
5B254M	35.00
5B255M	35.00
5C22	160.00
5J180E	1650.00
5R4GY	3.50
5U4G	3.00
5U4GB	2.50
5V4G	2.50
5Y3GT	2.50
5Z3	4.00
5Z4G	2.50
5Z4GT	2.50
6-30L2	1.75
6AB4	1.75
6AB7	3.00
6AC7	3.00
6AF4A	4.25
6AG7	3.00
6AH6	5.00
6AK5	7.10
6AK6	2.50
6AL5	1.50
6AM4	4.00
6AM5	9.69
6AM6	6.00
6AN5	4.75
6AN8A	3.50
6AQ5	2.25
6AS6	8.66
6AS7G	8.75
6AT6	1.25
6AU5GT	5.00
6AU6	2.50
6AV5GA	4.50
6AV6	1.50
6AX5GT	3.00
6B7	3.25
6B8	3.25
6BA6	1.50
6BA7	5.00
6BA8A	4.00
6BC4	4.00
6BE6	1.50
6BH6	2.50
6BJ6	2.25
6BK4	4.50
6BL6	85.00
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

Type	£
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
6L6GC	3.00
6L6GT	3.00
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

Type	£
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	4.50
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	6.00
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	18.50
1624	4.00
1625	3.50
2050	7.00
4212E	300.00
4212H	300.00
5544	81.97
5545	102.00
5551A	114.90
5552A	155.35
5642	9.00
5654	3.00
5651	4.45

Type	£
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

Type	£
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

Type	£
2AP1	8.50
2BP1	9.00
3BP1	12.00
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

Type	£
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

Type	£
VCR517A	10.00
VCR517B	10.00
VCR517C	10.00

Tube Bases Prices on application

INTEGRATED CIRCUITS

Type	£
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

Type	£
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

Type	£
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

Type	£
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

Type	£
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

Type	£
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
TAA570	2.30
TAA630S	3.50
TAA700	3.90
TBA480Q	1.84

Type	£
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

Terms of business: CWO. Postage and packing valves and semiconductors 50p per order. CRTs £1.50. Prices excluding VAT, add 15%. Price ruling at time of despatch. In some cases prices of Mullard and USA valves will be higher than those advertised. Prices correct when going to press. Account facilities available to approved companies with minimum order charge £10. Carriage and packing £1.50 on credit orders. Over 10,000 types of valves, tubes and semiconductors in stock. Quotations for any types not listed. S.A.E.

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WW-11

WW – 038 FOR FURTHER DETAILS

Accurate Digital Multimeters at Exceptional Prices

NEW ANALOGUE METER WITH CONTINUITY BUZZER AND BATTERY SCALE

28 RANGES, EACH WITH FULL OVERLOAD PROTECTION

SPECIFICATION MODELS 6010 & 7030

* 10 amp AC/DC
* Battery: Single 9V drycell. Life: 200 hrs
* Dimensions: 170 x 89 x 38mm.
* Weight: 400g inc. battery.
* Mode Select: Push Button.
* AC DC Current: 200μA to 10A
* AC Voltage: 200mV to 750V
* DC Voltage: 200mV to 1000V
* Resistance: 200Ω to 20MΩ
* Input Impedance: 10MΩ
* Display: 3½ Digit 13mm LCD
* O/load Protection: All ranges

OTHER FEATURES: Auto polarity, auto zero, battery low indicator, ABS plastic case with tilt stand, battery and test leads included, optional carrying case.

NEW HM 102 BZ SPECIFICATION

* DC Voltage; 0-25, 1, 2.5, 10, 25, 100, 250, 1000 volts 20,000 ohms/volt.
* AC Voltage: 0-10, 25, 100, 250, 1000 volts 10,000 ohms/volt.
* Decibels: -20 to +22dB
* DC Current: 0-50, 500μA, 0-5, 50, 500mA
* Ohmmeter: 0-6 Megohms in 4 ranges. 30 ohms Centre Scale
* Power Supply: One 1.5V size 'A' battery (incl)
* Size & Weight: 135 x 91 x 39mm, 280gr.

HM 101 POCKET SIZE MULTIMETER SPECIFICATION

* DC & AC Voltage: 0-10, 50, 250, 1000 volts, 2000 ohms/volts
* Decibels: -10 to +22dB
* DC Current: 0-100mA
* Ohmmeter: 0-1 Megohm in 2 ranges, 60 ohms Centre Scale
* Power Supply: One 1.5V size 'A' battery (incl)
* Size & Weight: 90 x 60 x 29mm, 92gr. incl. battery battery
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Quantity discount for trade on application.

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STEREO DISC AMPLIFIER 4

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Supersedes Stereo Disc Amplifier 2. Unique Response Variable Filter which provides, through a single control knob, a 3dB turnover frequency variable between 13 and 4kHz but always with an appropriate phase and amplitude characteristic for psychoacoustic considerations. Ring or write for full specifications:

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METAL FILM RESISTORS

100R	1k	10k	100k
110R	1k1	11k	110k
120R	1k2	12k	120k
130R	1k3	13k	130k
150R	1k5	15k	150k
160R	1k6	16k	160k
180R	1k8	18k	180k
200R	2k	20k	200k
220R	2k2	22k	220k
240R	2k4	24k	240k
270R	2k7	27k	270k
300R	3k	30k	–
330R	3k3	33k	330k
360R	3k6	36k	–
390R	3k9	39k	–
430R	4k3	43k	–
470R	4k7	47k	470k
510R	5k1	51k	–
560R	5k6	56k	560k
620R	6k2	62k	–
680R	6k8	68k	680k
750R	7k5	75k	–
820R	8k2	82k	820k
910R	9k1	91k	1M

¼ Watt, 1% tolerance, 3p each. 89 Values, E24, see left. Minimum order £20. Minimum 10 pcs per value. VAT, P&P incl.

SPECIAL OFFER
10 pcs of each value, 890 pcs
£25.30

SPECIAL 'POP' PACK
100 pcs: 100R, 1K, 4K7, 10K, 47K, 100K, 1M. 50 pcs: 330R, 470R, 1K5, 2K2, 3K3, 22K. Total 1000 pcs. £28.50.

One of each pack £50 only

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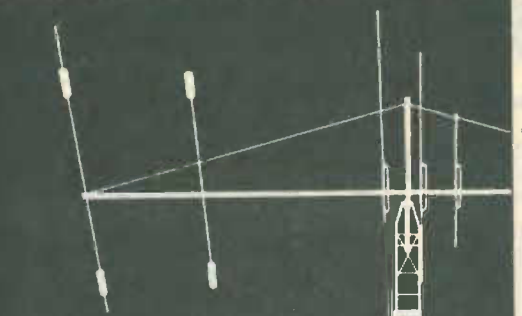

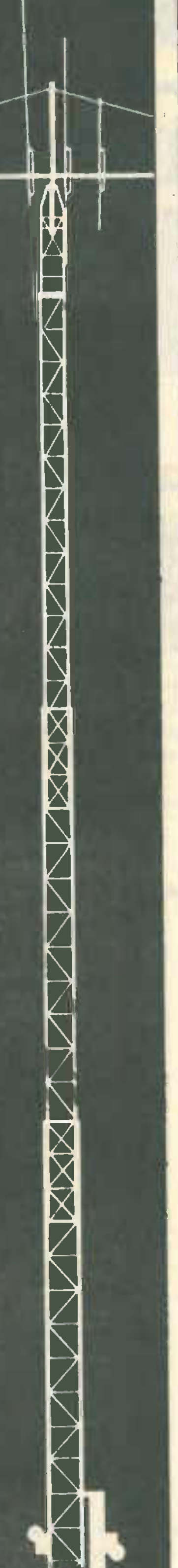

Designed in accordance with CP3 Chapter V: part 2: 1972 **for a minimum wind speed of 85 mph in conditions of maximum exposure** and specified by professionals world-wide where hostile environments demand the ultimate in design, quality and reliability.

Suitable for mounting equipment in the fields of:
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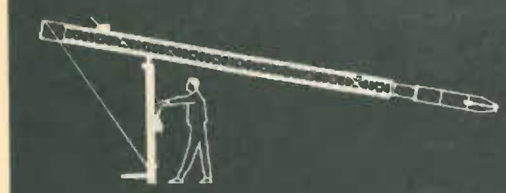
Further details available on request.



Strumech Engineering Limited,
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Brownhills, Walsall, West Midlands,
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Telephone: Brownhills (05433) 4321.
Telex: 335243 SEL G.

WW – 020 FOR FURTHER DETAILS

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nearly 50% more with the NEW LARGE 6 inch rectangular CRT with illuminated inner face graticule, 6KV accelerator voltage for a brighter, higher resolution display with guaranteed accuracy.

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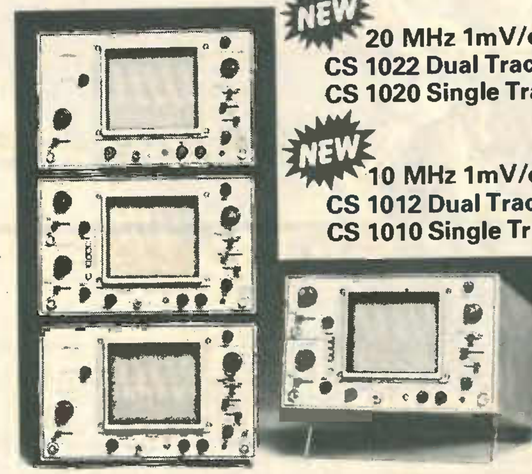

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CS 1022 Dual Trace
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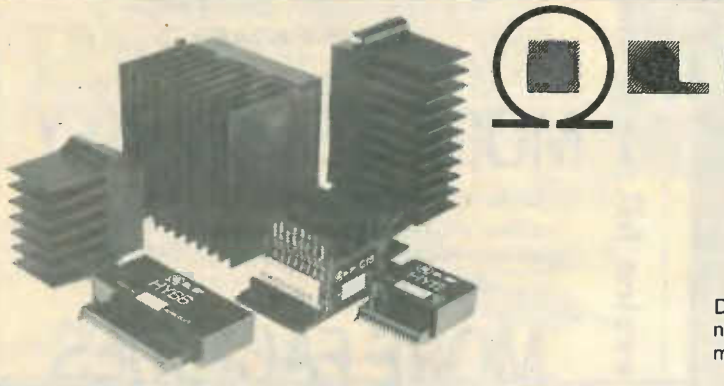
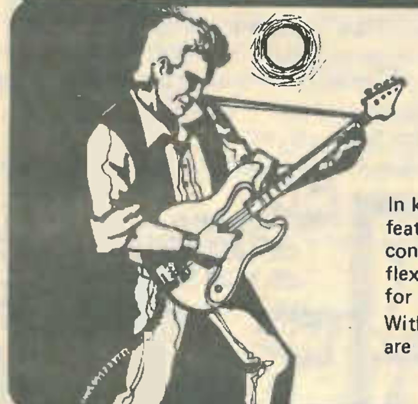
GET BIG POWER



ILP Modular Amplifiers
the third generation

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



WE'RE INSTRUMENTAL IN MAKING A LOT OF POWER

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

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

BIPOLAR MODULES

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

Protection: Full load line. Slew Rate: 15v/µs. Risetime: 5µs. S/N ratio: 100db.
Frequency response (−3dB) 15Hz − 50KHz. Input sensitivity: 500mV rms.
Input Impedance: 100K Ω. Damping factor: 100Hz >400.

PRE-AMP SYSTEMS

Module Number	Module	Functions	Current Required	Price inc. VAT
HY6	Mono pre amp	Mic/Mag. Cartridge/Tuner/Tape/ Aux + Vol/Bass/Treble	10mA	£7.60
HY66	Stereo pre amp	Mic/Mag. Cartridge/Tuner/Tape/ Aux + Vol/Bass/Treble/Balance	20mA	£14.32
HY73	Guitar pre amp	Two Guitar (Bass Lead) and Mic + separate Volume Bass Treble + Mix	20mA	£15.36
HY78	Stereo pre amp	As HY66 less tone controls	20mA	£14.20

Most pre-amp modules can be driven by the PSU driving the main power amp. A separate PSU 30 is available purely for pre amp modules if required for £5.47 (inc. VAT). Pre-amp and mixing modules in 18 different variations. Please send for details.

Mounting Boards

For ease of construction we recommend the **B6** for modules HY6—HY13 £1.05 (inc. VAT) and the **B66** for modules HY66—HY78 £1.29 (inc. VAT).

MOSFET MODULES

Module Number	Output Power Watts rms	Load Impedance Ω	DISTORTION T.H.D. Typ at 1KHz	I.M.D. 60Hz/ 7KHz 4:1	Supply Voltage Typ	Size mm	WT gms	Price inc. VAT
MOS 128	60	4-8	<0.005%	<0.006%	± 45	120 x 78 x 40	420	£30.41
MOS 248	120	4-8	<0.005%	<0.006%	± 55	120 x 78 x 80	850	£39.86
MOS 364	180	4	<0.005%	<0.006%	± 55	120 x 78 x 100	1025	£45.51

Protection: Able to cope with complex loads without the need for very special protection circuitry (fuses will suffice).
Slew rate: 20v/µs. Rise time: 3µs. S/N ratio: 100db
Frequency response (−3dB): 15Hz − 100KHz. Input sensitivity: 500mV rms
Input impedance: 100K Ω Damping factor: 100Hz >400.

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C15

Mono Power Booster Amplifier to increase the output of your existing car radio or cassette player to a nominal 15 watts rms.

Very easy to use.

Robust construction. **£9.14 (inc. VAT)**

Mounts anywhere in car.

Automatic switch on.

Output power maximum 22w peak into 4Ω
Frequency response (−3dB) 15Hz to 30KHz, T.H.D. 0.1% at 10w 1KHz
S/N ratio (DIN AUDIO) 80dB, Load Impedance 3Ω
Input Sensitivity and impedance (selectable) 700mV rms into 15KΩ 3V rms into 8Ω
Size 95 x 48 x 50mm. Weight 256 gms.

C1515

Stereo version of C15. **£17.19 (inc. VAT)**

Size 95 x 40 x 80. Weight 410 gms.

POWER SUPPLY UNITS (Incorporating our own toroidal transformers)

Model Number	For Use With	Price inc. VAT
PSU 21X	1 or 2 HY30	£11.93
PSU 41X	1 or 2 HY60, 1 x HY6060, 1 x HY124	£13.83
PSU 42X	1 x HY128	£15.90
PSU 43X	1 x MOS128	£16.70
PSU 51X	2 x HY128, 1 x HY244	£17.07

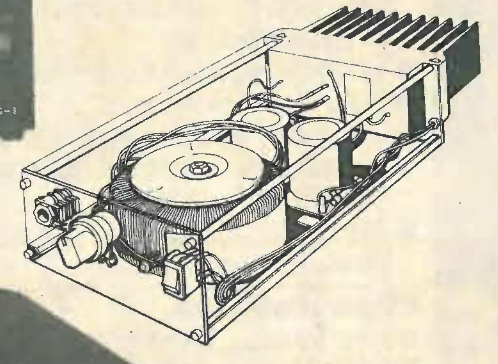
Model Number	For Use With	Price inc. VAT
PSU 52X	2 x HY124	£17.07
PSU 53X	2 x MOS128	£17.86
PSU 54X	1 x HY248	£17.86
PSU 55X	1 x MOS248	£19.52
PSU 71X	2 x HY244	£21.75

Model Number	For Use With	Price inc. VAT
PSU 72X	2 x HY248	£22.54
PSU 73X	1 x HY364	£22.54
PSU 74X	1 x HY368	£24.20
PSU 75X	2 x MOS248, 1 x MOS368	£24.20

Please note: X in part no. indicates primary voltage. Please insert "O" in place of X for 110V, "1" in place of X for 220V, and "2" in place of X for 240V.

WITH A LOT OF HELP FROM ILP ELECTRONICS LTD

PROFESSIONAL HI-FI THAT EVERY ENTHUSIAST CAN HANDLE...

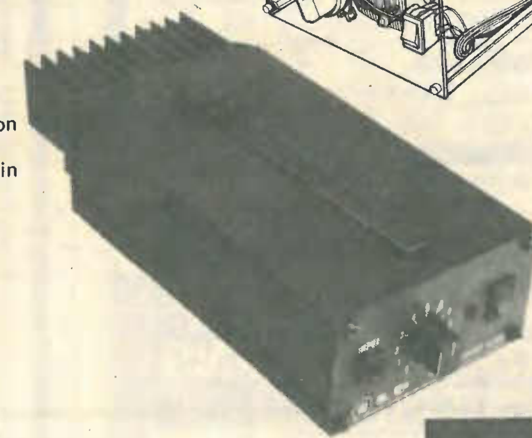


Unicase

Over the years ILP has been aware of the need for a complete packaging system for it's products, it has now developed a unique system which meets all the requirements for ease of assembly, adaptability, ruggedness, modern styling and above all price.

Each Unicase kit contains all the hardware required down to the last nut and bolt to build a complete unit without the need for any special tools.

Because of ILP's modular approach, "open plan" construction is used and final assembly of the unit parts forms a compact aesthetic unit. By this method construction can be achieved in under two hours with little experience of electronic wiring and mechanical assembly.



Hi Fi Separates

UC1 PRE AMP UNIT: Incorporates the HY78 to provide a "no frills", low distortion, (<0.01%), stereo control unit, providing inputs for magnetic cartridge, tuner, and tape/monitor facilities. This unit provides the heart of the hi fi system and can be used in conjunction with any of the UP Unicase series of power amps. For ultimate hum rejection the UC1 draws its power from the power amp unit.

POWER AMPS: The UP series feature a clean line front panel incorporating on/off switch and concealed indicator. They are designed to compliment the style of the UC1 pre-amp. Performance for each unit which includes the appropriate power supply, is as specified on the facing page.

Power Slaves

Our power slaves, which have numerous uses i.e. instrument, discotheque, sound reinforcement, feature in addition to the hi fi series, front panel input jack, level control, and a carrying handle. Providing the smallest, lowest cost, slave on the market in this format.

UNICASES

					Price inc. VAT
HIFI Separates					
UC1	Preamp				£29.95
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UP2X	60W/4Ω	Bipolar	Mono	HiFi	£54.95
UP3X	60W/8Ω	Bipolar	Mono	HiFi	£54.95
UP4X	120W/4Ω	Bipolar	Mono	HiFi	£74.95
UP5X	120W/8Ω	Bipolar	Mono	HiFi	£74.95
UP6X	60W/4–8Ω	MOS	Mono	HiFi	£64.95
UP7X	120W/4–8Ω	MOS	Mono	HiFi	£84.95
Power Slaves					
US1X	60W/4Ω	Bipolar	Power	Slave	£59.95
US2X	120W/4Ω	Bipolar	Power	Slave	£79.95
US3X	60W/4–8Ω	MOS	Power	Slave	£69.96
US4X	120W/4–8Ω	MOS	Power	Slave	£89.95

Please note X in part number denotes mains voltage. Please insert 'O' in place of X for 110V, '1' in place of X for 220V (Europe), and '2' in place of X for 240V (U.K.) All units except UC1 incorporate our own toroidal transformers.

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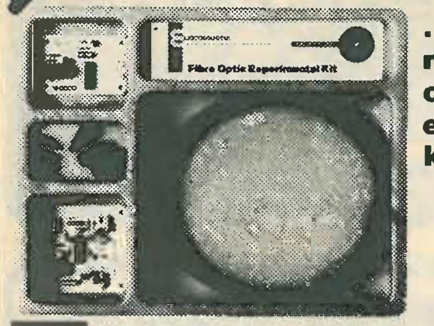
NEW Get started in Fibre Optics



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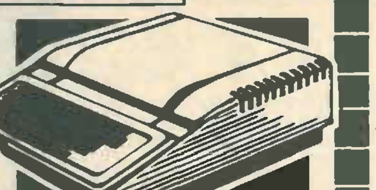

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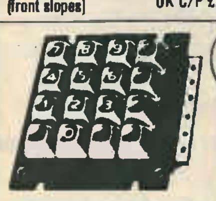

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TBA395	1.50
TBA396	0.75
TBA440N	2.55
TBA480Q	1.25
TBA510	2.50
TBA510Q	2.50
TBA520	1.10
TBA520Q	1.10
TBA530	1.10
TBA530Q	1.10
TBA540	1.25
TBA540Q	1.35
TBA560C	1.45
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TBA570	1.00
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TBA890	2.50
TBA920	1.65
TBA920Q	1.65
TBA950/2X	2.35
TBA990	1.49
TBA990Q	1.49
TBA1441	2.15
TCA270	1.10
TCA270SQ	1.10
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TDA1270	3.95
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UPC1167C2	1.15
UPC1181H	1.25
UPC1182H	2.95
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ZTK33B	0.50
555	0.35
556	0.42
723	0.50
741	0.35
747	0.50
748	0.35
4042	0.50
7805	0.60

SEMICONDUCTORS

AAY12	0.25
AC126	0.22
AC127	0.20
AC128	0.20
AC128K	0.32
AC141	0.28
AC141K	0.34
AC142K	0.30
AC176	0.22
AC176K	0.31
AC187	0.25
AC187K	0.28
AC188	0.25
AC188K	0.37
AD142	0.79
AD143	0.82
AD149	0.70
AD161	0.39
AD162	0.39
AD161/2	0.90
AF115	0.75
AF124	0.34
AF125	0.35
AF126	0.32
AF127	0.32
AF139	0.40
AF150	0.42
AF239	0.42
AU106	2.00
AU107	1.75
AU110	2.00
AU113	2.95
BC107A	0.11
BC107B	0.11
BC108	0.10
BC108A	0.11
BC108B	0.12
BC109	0.10
BC109B	0.12
BC109C	0.12
BC114	0.11
BC116A	0.15
BC117	0.19
BC119	0.24
BC125	0.25
BC139	0.20
BC140	0.31
BC141	0.25
BC142	0.21
BC143	0.24
BC147	0.09
BC147B	0.09
BC148A	0.09
BC148B	0.09
BC149	0.09
BC157	0.10
BC158	0.09
BC159	0.09
BC160	0.28
BC161	0.28
BC170B	0.15
BC171	0.09
BC171A	0.10
BC171B	0.10
BC172	0.10
BC172B	0.10
BC172C	0.10
BC173B	0.10
BC174	0.09
BC174A	0.09
BC177	0.15
BC178	0.15
BC182	0.10
BC182LB	0.10
BC183	0.10
BC183L	0.09
BC184LB	0.09
BC204	0.10
BC207B	0.13
BC208B	0.13
BC212	0.09
BC212L	0.09
BC212LA	0.09
BC213	0.09
BC213L	0.09
BC214	0.09
BC214C	0.09
BC214L	0.09
BC237	0.10
BC237A	0.09
BC237B	0.09
BC238	0.09
BC239	0.12
BC251A	0.12
BC252A	0.15
BC258	0.25
BC258A	0.39
BC284	0.30
BC300	0.30
BC301	0.30
BC303	0.26
BC307	0.09
BC307A	0.09
BC307B	0.09
BC327	0.10
BC328	0.10
BC337	0.10
BC338	0.09
BC347A	0.13
BC461	0.35
BC478	0.20
BC527	0.20
BC547	0.10
BC548	0.10
BC549A	0.08
BC550	0.08
BC557	0.08
BC557A	0.08
BC557B	0.08
BC558	0.10
BCY33A	1.60
BD115	0.30
BD124P	0.59
BD131	0.32
BD132	0.35
BD133	0.40
BD135	0.30
BD136	0.30
BD137	0.32
BD138	0.30
BD139	0.32
BD140	0.30
BD144	1.10
BD159	0.65
BD166	0.55
BD179	0.72
BD182	0.70
BD201	0.83
BD202	0.65
BD203	0.78
BD204	0.70
BD222	0.46
BD223	0.48
BD225	0.48
BD232	0.35
BD233	0.35
BD234	0.35
BD236	0.49
BD237	0.40
BD238	0.40
BD241	0.40
BD242	0.50
BD246	0.75
BD376	0.32
BD410	0.55
BD434	0.55
BD437	0.50
BD438	0.60
BD506	0.50
BD508	0.40
BD520	0.65
BD538	0.65
BD597	0.75
BD697	1.10
BD698	1.10
BD707	0.90
BDX32	1.50
BDY57	1.65
BF115	0.35
BF127	0.39
BF154	0.12
BF158	0.22
BF160	0.27
BF167	0.24
BF173	0.22
BF177	0.38
BF178	0.26
BF179	0.34
BF180	0.29
BF181	0.29
BF182	0.29
BF183	0.29
BF184	0.28
BF185	0.28
BF194	0.11
BF195	0.11
BF196	0.11
BF197	0.11
BF198	0.16
BF199	0.14
BF200	0.40
BF241	0.15
BF245	0.30
BF256/LC	0.28
BF257	0.28
BF258	0.28
BF259	0.28
BF271	0.26
BF273	0.15
BF336	0.34
BF337	0.29
BF338	0.32
BF355	0.37
BF362	0.38
BF363	0.38
BF371	0.25
BF394	0.19
BF422	0.32
BF457	0.32
BF458	0.36
BF459	0.36
BF595	0.23
BF597	0.25
BFR39	0.23
BFR40	0.23
BFR41	0.28
BFR81	0.25
BFR88	0.30
BFR90	1.50
BFR91	1.75
BFT42	0.28
BFT43	0.28
BFW92	0.85
BFX29	0.30
BFX84	0.26
BFX85	0.32
BFX86	0.30
BFX88	0.25
BFY50	0.21
BFY51	0.21
BFY52	0.25
BFY90	0.77
BLY48	1.75
BR100	0.26
BR101	0.30
BRC4443	0.85
BT106	1.49
BT108	1.49
BT116	1.20
BT119	1.65
BT120	1.65
BU105	1.22
BU108	1.69
BU124	1.25
BU125	£1.25
BU126	1.60
BU204	1.55
BU205	1.30
BU206	1.75
BU208	1.39
BU208A	1.52
BU326	1.20
BU407	1.24
BU500	2.25
BU526	1.90
BUY69B	1.70
MJ3000	1.98
MJE340	0.40
MJE520	0.48
MPSA12	0.20
MPSA13	0.29
MPSA92	0.30
MRF450A	12.50
MRF453	17.50
MRF454	23.50
MRF475	2.90
MRF477	10.00
OC23	1.50
OC42	0.55
OC44	0.55
OC45	0.55
OC70	0.45
OC71	0.40
OC81	0.50
R2008B	1.70
R2010B	1.70
R2322	0.58
R2323	0.66
R2540	2.48
RCA16334	0.90
RCA16335	0.80
SKE5F	1.45
TIP29	0.40
TIP29C	0.42
TIP30C	0.43
TIP31C	0.42
TIP32C	0.42
TIP33B	0.75
TIP34B	0.75
TIP41A	0.45
TIP41C	0.45
TIP42C	0.47
TIP47	0.65
TIP120	0.60
TIP125	0.65
TIP142	1.75
TIP146	2.75
TIP161	2.95
TIP2955	0.80
TIP3055	0.55
TIS91	0.20
TV106/2	1.50
2N1219	0.28
2N2905	0.40
2N3053	0.40
2N3054	0.59
2N3055	0.52
2N3702	0.12
2N3703	0.12
2N3704	0.12
2N3705	0.12
2N3706	0.12
2N3708	0.12
2N3773	1.95
2N4427	1.50
2N4444	1.15
2N5294	0.42
2N5296	0.48
2N5298	0.60
2N5496	0.95
2SA715	0.60
2SC495	0.80
2SC496	0.80
2SC1096	0.80
2SC1172Y	2.20
2SC1173	1.15
2SC1306	1.00
2SC1307	1.50
2SC1449	0.80
2SC1678	1.25
2SC1945	2.10
2SC1953	0.95
2SC1957	0.80
2SC1969	1.95
2SC2028	1.15
2SC2029	1.95
2SC2078	1.45
2SC2091	0.85
2SC2166	1.95
2SC2314	0.80
2SD234	0.50
3N211	1.95

DIODES

AA119	0.08
BA102	0.17
BA115	0.13
BA145	0.16
BA148	0.17
BA154	0.06
BA155	0.13
BA156	0.15
BA157	0.30
BAX13	0.04
BAX16	0.06
BB105B	0.30
BT151	0.79
BY126	0.10
BY127	0.11
BY133	0.15
BY164	0.45
BY176	1.20
BY179	0.63
BY182	0.55
BY184	0.35
BY199	0.40
BY206	0.14
BY208-800	0.33
BY210-800	0.33
BY223	0.90
BY298-400	0.22
BY299-800	0.22
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BYX71-600	0.50
BZY95C30	0.35
OA47	0.09
OA90	0.05
OA91	0.06
OA95	0.06
OA202	0.10
IN914	0.04
IN4001	0.04
IN4002	0.04
IN4003	0.04
IN4004	0.05
IN4005	0.05
IN4006	0.06
IN4007	0.06
IN4148	0.02
IN4448	0.10
IN5401	0.12
IN5402	0.14
IN5403	0.12
IN5404	0.12
IN5405	0.13
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PCF801	1.35
PCF802	0.60
PCF805	1.25
PCF806	1.00
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PCH200	1.10
PCL82	0.80
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PCL84	0.85
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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
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UCH41	1.20
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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
6BL7GTA	3.95
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
6BW6	4.00
6BX6	0.48
6BX7GT	3.50
6BZ6	2.00
6BZ7	2.95
6BZ8	0.95
6C4	0.80
6C5	1.95
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
6DQ6B	2.50
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	17.00
6FG5	1.95
6GH8A	0.80
6GK5	1.50
6GK6	2.00
6GV7	2.50
6GW6	2.50
6H3N	1.10
6H6	1.35
6H6GT	1.20
6J4	1.10
6J5	1.95
6J5G	1.50
6J6	0.65
6JB6A	3.95
6JE6C	3.50
6JS6C	3.50
6K7G	0.70
6K8Y	3.95
6KD6	4.50
6L1	2.50
6L19	3.95
6L6GC	2.75
6L6GT	1.15
6L7G	0.75
6LD20	0.60
6LF6	2.95
6LQ6	2.95
-6N7	2.50
6N7GT	1.50
6P15	0.80
6P25	4.00
6P28	2.00
6Q7	1.20
6Q7GT	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	0.85
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
8FQ7	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	0.95
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
12B4A	3.50
12BA6	1.50
12BE6	1.05
12BH7A	1.80
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12BY7A	2.75
12CX6	1.20
12E1	17.95
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12GN7	3.95
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12J7GT	0.70
12K5	1.00
12K7GT	0.80
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	2.75
18D3	1.60
19AQ5	1.15
19G3	17.00
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
21LU8	2.50
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	1.00
30FL2	1.00
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	0.60
30PL14	1.75
31JS6A	4.15
35A5	4.50
35L6GT	2.00
35W4	0.70
35Z3	1.65
38HE7	4.50
40KD6	4.50
47	6.00
50B5	1.50
50C5	0.95
50CD6G	1.15
52KU	2.00
61SPT	4.50
75B1	1.50
75C1	1.70
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	12.50
92AV	12.50
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
425A5	6.00
431U	2.00
572B	35.00
705A	8.00
708A	8.00
715A	6.00
715C	45.00
725A	275.00
801A	2.00
803	14.95
805	39.00
807	1.50
810	55.00
811A	12.95
813	18.50
813 USA	59.50
833A	115.00
866A	3.50
872A	19.00
873	60.00
884	5.50
954	0.50
955	0.90
958A	0.90
1299A	0.60
1625	3.00
2050W	9.50
2050	7.00
3545	4.00
4313C	4.00
5642	8.50
5651	3.20
5654	1.95
5670	3.50
5675	23.50
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	4.95
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	16.00
6021	3.95
6057	2.50
6059	3.75
6060	2.25
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	6.95
6146B	6.45
6201	6.95
6211	2.50
6267	1.50
6350	2.00
6360	5.50
6386	14.50
6545	8.50
6550A	7.00
6870	11.50
6883B	13.95
6973	3.75
7025	2.50
7027A	4.65
7032	2.00
7059	2.50
7189	2.50
7199	3.95
7247	2.00
7360	7.50
7475	5.00
7551	4.50
7558	11.50
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	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	0.26

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	0.14
14 Pin DIL	0.15
14 Pin DIL/Q	0.30
16 Pin DIL	0.17
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

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Engineering, not politics

Even in the pre-war days when Japanese industry was best known for its imitative tendencies, its imitations were often better products than the originals. Modern Japanese engineering demonstrates little need to take other nations' ideas and has made Japan an industrial giant.

In design and reliability, products from Japan have gained a formidable reputation for quality – to the extent that they now dominate world markets in several important groups of product. With the exception of those Western companies who refuse to be intimidated and who also possess reputations for high quality, European and American firms tend to see the reply to imports from the Far East in political, rather than in commercial and engineering terms. They require the Japanese to restrict their exports voluntarily and frequently ask politicians to apply pressure to that end.

An approach as negative as that to the imbalance of trade can surely not succeed over a long period. In reply to huge imports from Japan, the proper action is to redress the balance by exporting, not politicking. Admittedly, it is not easy to sell to the Japanese but, according to the Department of Trade, "formal barriers are disappearing and the desire of the Japanese to be self-supporting – the 'Buy Japanese' policy – is on the way out. Import tariffs on over 2000 products have now been reduced to a lower level than those of European countries or the US".

In common with any other manufacturers, the Japanese want the best products at the lowest price. If a UK exporter can supply well-designed products, either to fill a gap in Japanese production or to beat local efforts on quality or price, he will win orders.

An important point to watch is that the customer must be given what he wants, not what the vendor thinks he ought to want. Time and time again, Western makers of, for example, audio equipment have introduced new models in enclosures which they thought were sensible and attractive, in spite of the fact established by the successful marketing of Japanese products that customers prefer satin chrome, coloured lights and masses of knobs and switches. Presentation is a matter of taste and who is to say that the customers are wrong?

This office recently received a note from a maker of illuminated switches, in which he claimed that his company has taken massive orders from Japan and is now going into Hong Kong. The customers say that the switches are visually attractive to them, they are reliable and are cheaper to buy than locally made types: there is therefore a ready sale for them in Japan.

British industry began the industrial revolution and was able to dominate world markets when it was possible to tell customers what they could have and why they should want it. In the words of Adam Smith: we "founded a great empire for the sole purpose of raising up a people of customers". Perhaps more of our industrial base would still be firm if our manufacturers had recognised a good deal earlier that the world has developed while they were not looking, and will not now buy equipment that is not designed and made with customers in mind.

George Moore said that "a man travels the world over in search of what he needs and returns home to find it". Perhaps we could reduce the number of homing customers by making sure they find what they need here, not what we feel they should need.

COMMUNICATIONS COMMENTARY

C.B. market collapse?

The Home Office tells me that fewer new CB licences were issued during the first quarter of 1983 than the number of licences that lapsed. At the end of April valid licences totalled 289,108 compared with 313,318 at the end of November 1982. The percentage of renewed licences seems to vary widely from month to month: 42% in October 1982; 72% in November; and only 27%; in December. Fidelity Radio has claimed that its CB division lost £700,000 in the year to March 1983 and the firm has since disposed of the division "for a nominal sum", blaming "the collapse of the CB radio market".

The Japanese radio communications industry seems to be setting its sights on the para-military field with increasing emphasis on such products as v.h.f./u.h.f. manpack equipment providing digital encryption. European communications firms have long been worried at the prospect of a full-scale entry of Japan into defence electronics.

Antennas galore!

I have to confess that I did not attend ICAP 83 (Third International Conference on Antennas and Propagation, London, April 1983) but I have been making up for this omission by ploughing (or at least skimming) through the two thick volumes of papers (IEE Conference Publication 219). This is no lightweight matter: 193 papers filling 961 pages from authors whose names literally span A to Z (O. Aboul-Atta to Zi Shen Lui in volume 1 and I. Y. Ahmed to Z. W. Zhang in volume 2!). One really does wonder how many of the delegates managed, in four days, to absorb almost 200 papers – or indeed whether thereby they learned much that was of vital importance to them. These large international conferences, free from the constraints of "commercial" exhibitions do tend to take off into the stratosphere or, more appropriately in this case, the ionosphere. Radio propagation and aerials (to get back on the editorial wavelength of *Wireless World*) are both subjects that envelope themselves in an unusual degree of mythology and mysticism. I hasten to add that there are interesting and some thoroughly practical papers among the 193 but it could be argued that, since these come over clearly from the printed page, attendance was possibly not the optimum learning process. It is always said, of course, that the most interesting discussions at conferences are those that take place out in the bar rather than in the conference hall. Experience tends to support that view – although the more memorable conversations seldom seem to relate to conference topics!

The difficulty for the non-specialist reader (or delegate) is to decide what really is new and what is not. ICAP 83 included some useful invited survey papers, though apparently prepared independently of the other contributions.

A. W. Rudge of ERA Technology Ltd in "Current trends in antenna technology and prospects for the next decade" highlights three major themes, the influence of environmental factors, the impact of v.l.s.i. electronics and the continuous search for improved characteristics. He aptly quotes Professor Mayes of the University of Illinois: "The popular conception in 1950 was that electromagnetics was a mature field and that it was improbable that any new discoveries remained to be made in the field of antennas. The development of frequency-independent antennas was certainly evidence to the contrary. Today similar sentiment seems to be prevalent. History shows it prudent to be sceptical." 193 papers suggests there must still be rich ore to be mined in these subjects.

Moral persuasion?

The BBC took the opportunity, as hosts of the 17th European DX Council Conference, to launch another strong attack on the 10% increase in "jamming" of h.f. broadcasts by the USSR since the Polish crisis of December 1981. Douglas Muggeridge, managing director of BBC External Broadcasting, protested "The h.f. bands are very congested. There is more broadcasting than they can contain satisfactorily. A conference is soon to be held, the first session in 1984, with the task of trying to plan and regularize this position. Its job is made extremely difficult, if not impossible, by the large amount of 'deliberate, harmful interference' – better known as 'jamming' – which is present within the shortwave bands.

Many people have not been aware of the extent to which this is a worldwide problem. Every country that broadcasts on h.f. and all who listen on h.f. are affected. Perhaps there may be a solution. If there is not, then it is difficult to see how any order can be brought out of the chaos that exists at certain times of the day".

The BBC apparently hopes that "moral persuasion", plus the fact that the USSR is anxious that its own transmissions should be well received throughout the world may prove a powerful argument to reduce jamming. Keith Edwards presented data showing co-channel and adjacent-channel jamming as monitored in Vienna and at Caversham that underline the extent of the current problem. This is particularly true on the 15, 17 and 21MHz broadcast bands, with between 70-80% of channels (pre-WARC 1979) affected from about 1200 to 1800 hours on 17MHz, over 60% on all three bands around 1600 hours, etc. Other statistical data show the massive use made of the 6MHz broadcast band. Although WARC 1979 gave Western broadcasters much less additional spectrum than they sought, over 30 countries are already using the new frequencies despite the WARC agreement not to do so until after the 1984-86 planning conferences. There are also a number of countries using parts of the spectrum not allocated to broadcasting. China, for example, has quit out-of-band operation at 7.0 to 7.1MHz but is now using many channels around 8.3MHz!

A happier prospect arises from the use of satellite feeds. The BBC are using digital audio at 128kilobits (two adjacent 64kb/s speech channels) to distribute programmes via satellite to overseas relays; these links have uniform frequency response to 6kHz, distortion around 1% or less and s:n ratio of about 50dB. One result is that the BBC may soon reduce long-distance h.f. coverage from the UK of areas better served from the relay bases of the BBC or the Foreign & Commonwealth Office: Atlantic Relay on Ascension Island; Caribbean Relay (Antigua); East Mediterranean Relay (Cyprus); Far Eastern Relay (Singapore); Eastern Relay (Masira) and (later) a possible relay at Hong Kong, and an East African Relay in the Indian Ocean.

Stereo all ways

A new twist to the American a.m.-stereo fight between the four competing systems has been given by demonstrations at NAB of the prototype of a new Sansui multisystem a.m. stereo tuner, type TU-S77AMX, that uses a Japanese-manufactured single-chip decoder handling signals in any of the four systems. A.m.-stereo in the USA has been delayed by the FCC "leave it to the market place" decision. By April 1983 there were 50 stations using the Harris system, around 30-plus with Kahn, six using Motorola and three using Magnavox out of some 4600 commercial a.m. stations. However, retail price of the Sansui tuner is around $400 and their car radio tuner around $50. Even with multisystem decoding it will still be necessary for American broadcasters individually to make the difficult choice between the four systems.

Mercurial thoughts

I do not know what the new Mercury communications network will do for British business – but it must already be helping our printers and typographers and illustrators. That is if the three very large and very glossy advertising brochures that have come my way are anything to go by. They proudly proclaim: "Mercury is the new force in communications . . . it exists to facilitate the dynamic interchange of ideas that are vital to your business . . . Mercury means communications. At the speed of thought". The global village, I am told, is no longer a concept but a reality. Pages are filled with large colour pictures of eggs, a charming little chameleon, a chisel, a honeycomb and a small globe in the palm of a giant hand. All this represents "a new approach to communications for the '80s and beyond".

Just the thing presumably for the businessman who has caught a chameleon, intends to put it inside an egg-shell after slicing the top off with his chisel, and is not afraid of being stung by bees. Or is my dynamic interchange of ideas failing me?

In brief

Costs of the NASA Space Telescope project may exceed $1000-million instead of the original estimate of $435m and is unlikely to be launched until 1986 or later . . . Launch of the second Tracking and Data Relay Satellite (TDRS) is being delayed in the hope that NASA can find out what went wrong with the first launch last March . . . A spate of fraud and cheating – "doctoring" and "massaging" data – in scientific research papers has led to Nicholas Wade of the *New York Times* claiming: "It is not just a matter of rotten apples in the barrel but something to do with the barrel itself" . . . the opportunities to cheat are becoming more frequent because of the readiness of laboratory chiefs to put their names to papers prepared by junior colleagues with little or no supervision".

AMATEUR RADIO

Planning the bands

The problems of spectrum regulation are increasingly reflected inside the amateur bands. There have been some gains – 7000 to about 7030kHz or so is now refreshingly clear of Radio Beijing (Radio Peking) in the evenings and has become a far more usable piece of spectrum. The upper part of the world "exclusive" 7000-7100kHz however, still includes broadcast "intruders" such as Radio Tirana on 7065kHz.

But there is increasing unease within the amateur movement over the future of "voluntary band-planning".

For very many years mandatory sub-band allocations have been part of North American amateur licensing in the USA and Canada, to provide exclusive A1A (c.w.) segments and also in connection with American "incentive licensing" whereby higher "grades" are given access to additional segments of the bands.

Until the immediate post-war period no attempt was made to segment the frequency bands available to British amateurs. In 1948 the RSGB set-up a working party (I was a member) which, *inter-alia*, recommended a voluntary h.f. band-plan (our first effort was so unpopular that we promptly revised it). Basically this followed North American practice in locating exclusive A1A segments at the low-frequency ends of the bands, and later formed the basis of the IARU Region 1 recommendations. These also took into account the then still rare use of r.t.t.y., although neither IARU or RSGB are official regulatory bodies.

As the years have gone by the band-plan has been extended to v.h.f. and u.h.f. bands and covers more and more modes and special activities, offering protection to minority interests, such as "raynet" emergency services, beacons, space satellites, "local" and "long-distance" working, repeaters and dividing bands into simplex channels, etc.

The IARU decided that, in view of the limited (50kHz) bandwidth, there should be no s.s.b. on the new 10.1MHz band (for different reasons the Home Office has *temporarily* similarly restricted UK operation on 18 and 24MHz). Where countries, such as South Africa, have declined to follow these recommendations, both IARU Region 1 Bureau and the RSGB officials have separately urged the South Africans to reconsider their decision. Being primarily a c.w. operator, I personally benefit from the new IARU recommendations, but nevertheless it does raise important matters of principle: are such organizations as the IARU justified in assuming a "regulatory" role that goes well beyond the original concepts of "voluntary bandplanning" without first providing greater "accountability" to those whose activities are being restricted? Individual amateurs have no direct control over IARU decisions, member societies have one vote per member, regardless of the size of the individual societies.

The 1983 IARU statistics show that there are now roughly 1.8-million amateur radio operators world-wide, using 1.4-million stations. Licensed members belonging to IARU member-societies are, however, under 450,000, despite the fact that 22% of the countries make membership of their national society an obligatory condition of the licence. The RSGB is listed as having, as members, precisely 50% of the UK's 40,000 licensed amateurs, of whom the majority are v.h.f.-only operators. In such circumstances can "voluntary bandplanning" continue to work?

No r.m.s. power!

W. J. Omer, G3DOJ, who lectures in electrical and electronic engineering in higher education, is concerned to find that some 90% of his students believe that power in an a.c. circuit can correctly be defined as an r.m.s. quality. The term r.m.s. watts has been creeping into the literature for the past 20 years – stemming largely from the audio field where it first came to be used to distinguish between "continuous average output" ratings and "music power" ratings (now tending to be replaced by "dynamic headroom") and the even less demanding peak envelope power rating.

Bill Omer has for some time been waging virtually a one-man crusade against 'r.m.s. power' which, since the definitions of r.m.s. voltage and current in an a.c. circuit are themselves derived from power, is a technical nonsense. He notes that 'r.m.s. power' has spread from the audio field to r.f. amplifiers and transmitter ratings in the editorial and advertising columns of many technical journals. When challenged some writers and firms have dismissed his objections as semantics while others insist that power *is* an r.m.s. quantity. To Bill Omer, r.m.s. watts is as ludicrous as 'average feet'.

A problem for the transmitter engineer is that "continuous wave" or c.w. has come to mean the A1A mode which is far from continuous. Nevertheless there do seem very good reasons for *not* using either r.m.s. watts or even watts (r.m.s.)!

Notes and news

Since June 1 the Home Office has imposed a 50 per cent increase in the annual amateur radio licence fee: from £8 to £12. This means that with RAE, Morse Test fees, training fees, travelling expenses, etc, it now costs around £50 or more to obtain a Class A transmitting licence issued for purposes of "self-training, inter-communication and technical investigations". It seems regrettable that at a time when emphasis is being placed on the need to encourage expansion of "sun-rise industries" such high barriers are being erected, affecting particularly the younger enthusiasts, or those who may later be seeking employment in the still-expanding communications field.

There must be a diminishing number of people who can recall actually hearing Pip Eckersley announcing that they were listening to "Two Emma Toc (2 MT) Writtle testing". The historic callsign, converted to G2MT, was due to come on the air on July 2 and should be heard frequently later this year. The Home Office has re-allocated the callsign at the request of the recently formed "Marconi Radio Society", formed by enthusiasts at the Stanmore headquarters of Marconi Space and Defence Systems.

The RSGB has decided to hold future annual National Amateur Radio Exhibitions and Conventions at the National Exhibition Centre in Birmingham. The 1984 dates are April 28-29.

PAT HAWKER, G3VA

Typewriter to daisywheel printer

With an Olivetti Praxis typewriter, this interface makes one of the cheapest word-processing printers around. It can be used with any microcomputer fitted with an RS232 or RS423 port.

by Neil Duffy

A typewriter-printer offers a number of advantages over a conventional daisy-wheel printer with no keyboard. For example, headings can be added to its output and margins set from the keyboard without the requirement to send special control codes from the computer, although this can be done if required. When not in use as a printer the typewriter can still be used in the normal manner.

The typewriter chosen for conversion here is the Olivetti Praxis series compact typewriter which was one of the first electronic typewriters and is well proven. It is also used as the basis of a number of commercially available printers and has turned out to be an excellent choice for this application. It is available in two versions, the Praxis 30 and the Praxis 35. Both feature interchangeable daisywheels, automatic correction of the last ten characters typed, and cartridge ribbon loading with a choice of correctable, carbon or fabric ribbons. The two models are almost identical but the 35 has a type-head position indicator and keyboard selection of 10, 12 or 15 characters per inch. Type pitch on the Praxis 30 is preset in the factory by means of links on the circuit board.

Daisy-wheel printers are in general much slower than their dot-matrix or thermal counterparts and are intended for use where letter quality output is required. They are not ideal for day to day listing of programs because of their relatively low speed. The basic typewriter mechanism is capable of a maximum print speed of around 8 to 10 characters per second and so a standard baud rate of 75 was chosen for the computer-interface to give a print speed of 7.5 characters per second.

A special feature of the interface is the provision of an electronic paper sensor on the typewriter to halt the computer output when the paper has run out. This feature is seldom provided even on high cost printers but has been found to be invaluable when errors are made in estimating the length of text that can be printed on a page.

The typewriter keyboard circuit (Fig. 1) operates on a matrix scanning principle. Each of the matrix columns is pulsed low in turn. When a key is pressed the appropriate pulse is fed on to a particular keyboard matrix row. The typewriter electronics uses the row and pulse timing information to determine which key has been pressed.

The interface (Fig. 2 and Fig. 3) consists of a circuit board powered from the typewriter 5V power supply. Connection to the typewriter is made via a 40-way ribbon cable. In the interface, data from the computer is received by a uart and decoded by eprom IC_4. The three least significant bits output from the eprom are fed to multiplexer IC_6 which has its inputs connected to the keyboard columns and which selects the appropriate strobe pulse. The next three bits from the eprom route the selected pulse via demultiplexer IC_7 to the selected keyboard row. The seventh bit controls the typewriter shift function and the eighth triggers a circuit which signals back to the computer to halt data transmission until the typewriter has completed a carriage-return, line-feed operation.

Circuit operation

Incoming serial data is buffered by the RS232 receiver IC_1 and fed to the uart IC_2 which decodes the serial data and presents it in parallel form to the eprom IC_4. The clock to the uart is derived from a 2.4576MHz crystal via the divider IC_3, configured for 75 baud operation and providing clock pulses to the uart at 16 times this rate. The uart must be set up to match the format of the incoming serial data from the computer. This is done by selecting links on the circuit board according to Table 1.

Neil Duffy, M.Sc., M.I.E.E. is a lecturer in the department of electrical and electronic engineering of Heriot-Watt University, Edinburgh.

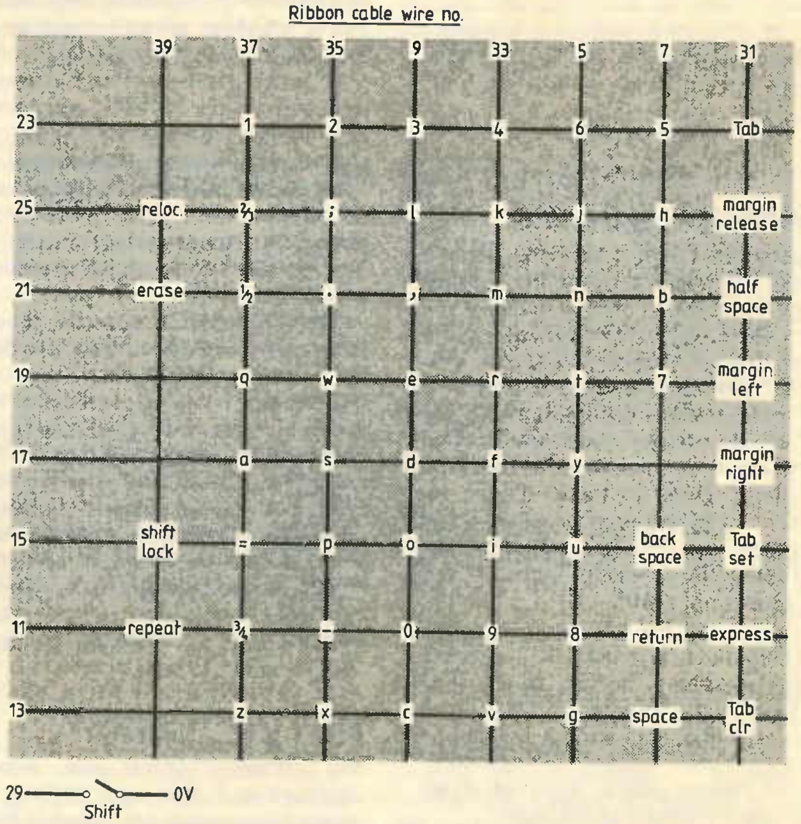


Fig. 1. Typewriter keyboard matrix: columns are each pulsed low in turn and pressing a key connects a column to a row. For clarity, diagram shows lower-case characters only.

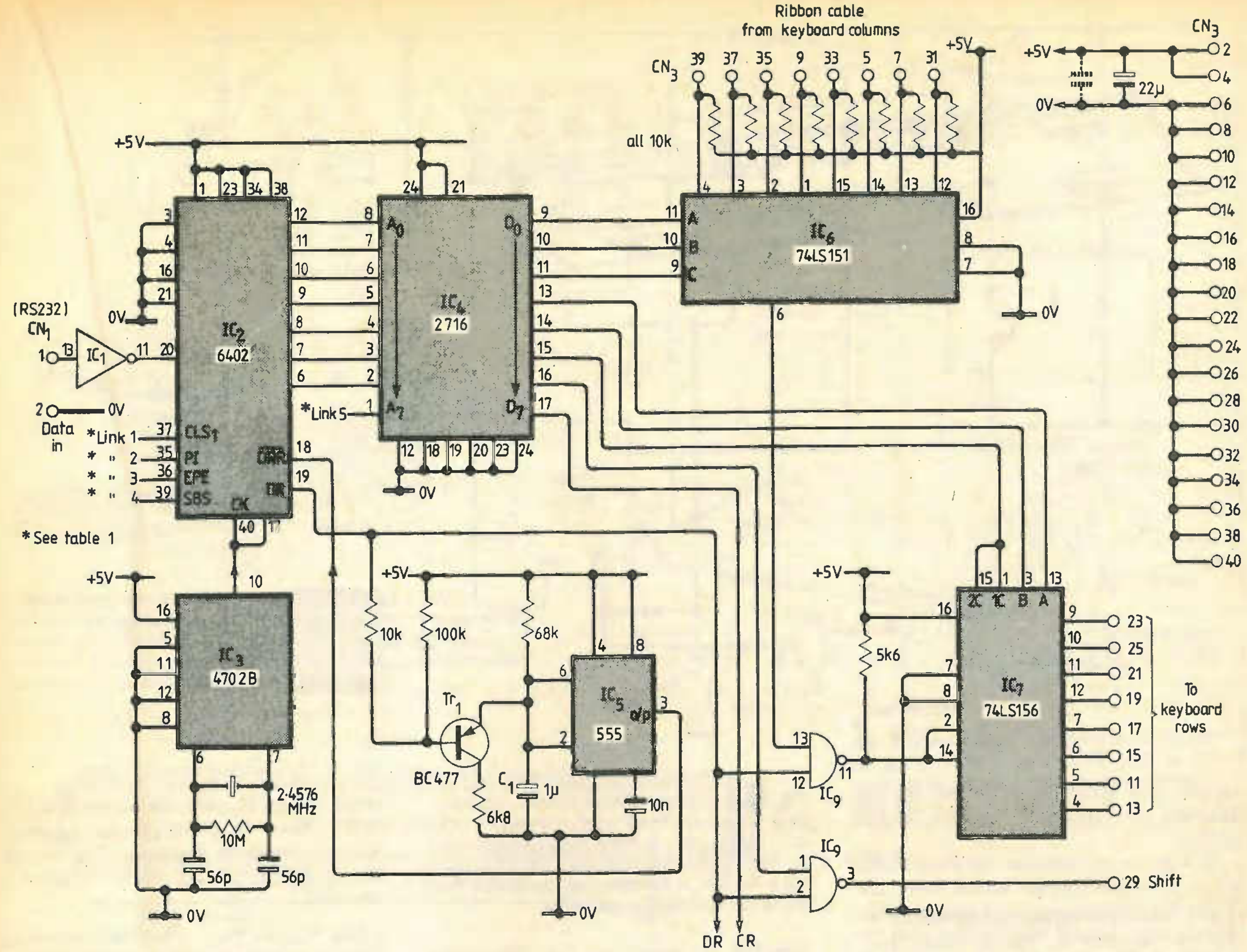


Fig. 2. Incoming serial data from the computer is converted by the interface into parallel data in a form suitable for connection to the keyboard matrix of the typewriter. IC_1 is a section of an MC1489 line-receiver device.

When a data word is received by the uart it generates a high-going data-ready signal which turns off Tr_1 releasing the short circuit across C_1 on the 555 timer IC_5. Capacitor C_1 charges up towards 5V and at the end of a time period of approximately 70ms reaches the timer threshold voltage level. The output from the 555 goes low and resets the data-ready signal from the uart. Transistor Tr_1 turns on, discharging C_1 until the voltage on C_1 falls below the timer trigger voltage. The 555 output then reverts to the high state. The data-ready signal from the uart is used to strobe data to the keyboard via IC_9.

The eprom is used to convert the incoming ASCII code from the computer into an output code suitable for energising the keyboard rows at the correct time. The contents of the eprom are shown in Table 2. The eprom is programmed to cause the typewriter to print spaces in place of ASCII codes for which the daisy-wheel has no corresponding symbol. ASCII codes from 0 to 32 are programmed to cause the typewriter to set and clear tabs, margins and so on.

During typewriter carriage-return/line-feed operations the data output from the computer must be halted by setting negative the clear-to-send (CTS) line on its RS232 port. This is done to prevent data loss caused by the typewriter buffer overflowing. When a carriage return signal is received from the computer, IC_{10b} latches with its $\overline{Q}$ output low. The $\overline{Q}$ output is reset to the high state when S_1 on the interface is pressed or when the typewriter has completed a line-feed operation. This latter is detected by monitoring an existing limit switch on the line-feed mechanism.

For the handshake circuit to operate correctly, the typewriter must perform a carriage-return and then wait until the print head has returned to the left margin before performing a line-feed and thus operating the limit switch. If this is to happen the computer has to output a carriage-return and a line-feed symbol in the correct sequence. Because there is no convention for the sequence the interface has to allow for both possibilities. This is done by connecting a link on the interface board to select data either from locations 0 to 127 or from locations 128 to 255 on the eprom. The data in the first set of locations is identical to that in the second except that in the second set, incoming carriage-return commands cause the printer to carry out a line-feed operation and line-feeds cause it to carry out a carriage-return.

The paper sensor is a reflective opto-switch device with built-in infra-red led. Resistors R_1, R_3 and the sensitivity adjusting potentiometer R_2 are mounted on a small circuit board which is attached to the sensor mounting bracket. The paper-low signal from the sensor is fed back along the ribbon cable to the interface card.

Paper-low signals are inhibited by IC_8 until the CR output from the eprom indicates that a carriage return has been received from the computer. If the paper is low, then at the end of the current print line IC_{10a} latches with its Q output low. Led_1 lights and Tr_2 is turned off sending the CTS line to the computer negative to prevent any further data transfer. IC_{10a} is restored to the high state by pressing S_1 after feeding a fresh sheet of paper into the typewriter. If S_1 is pressed when the paper low signal is still active then a further line of text will be printed. A $-5V$ supply for the collector resistor of Tr_2 is provided by the negative-voltage generator IC_{11}. Note that the CTS signal taken from Tr_2 collector is not a full-specificiation RS232 signal in terms of voltage swing but is perfectly adequate for the short cable likely to be required.

Construction

There is a shortage of space inside the typewriter casing so the interface was housed outside in a small metal box. It connects to the typewriter via a 40-way

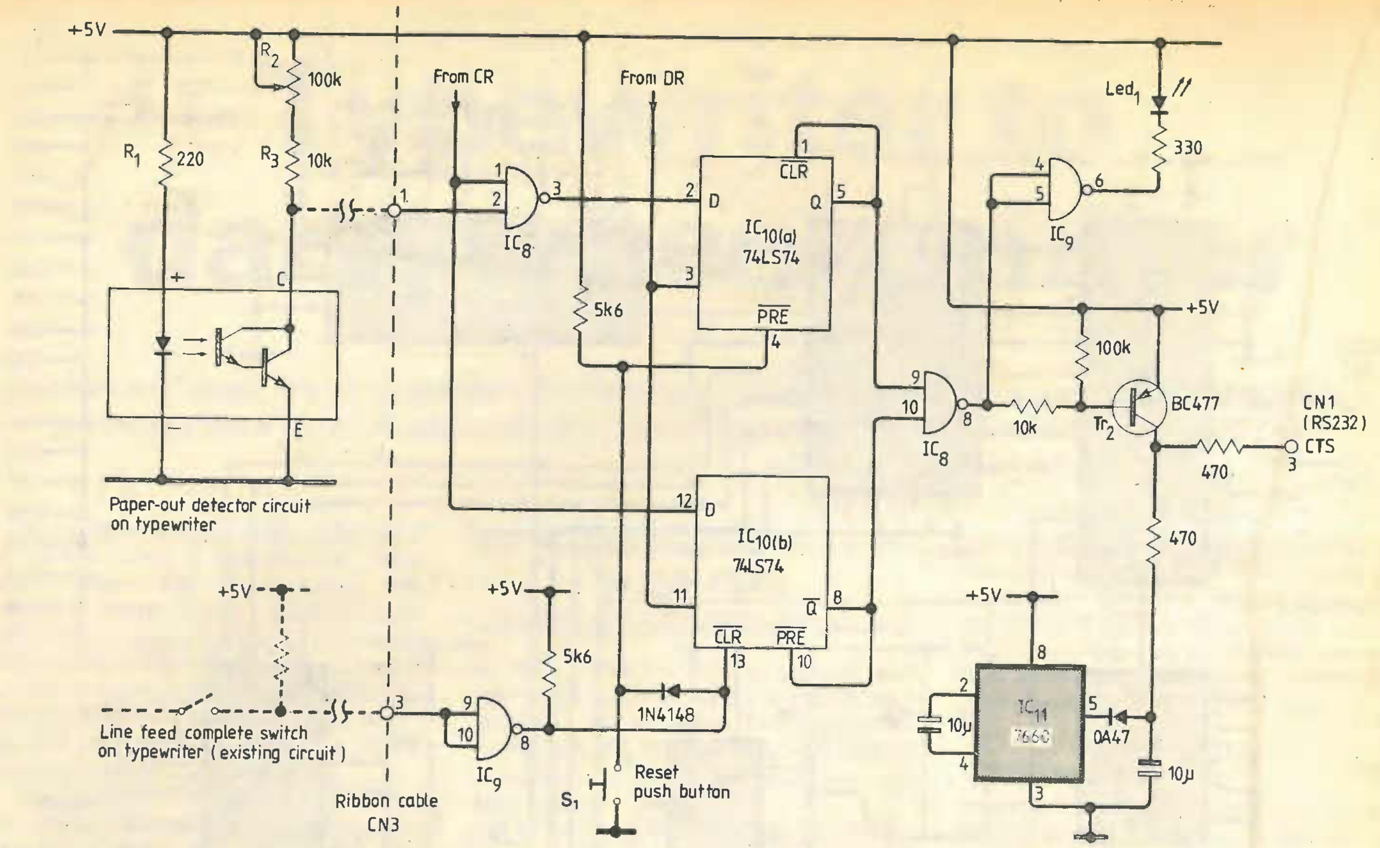


Fig. 3. Output from the computer is halted by this sensor circuit when the paper runs out. This feature is often not provided even on high-cost printers. IC_8 is a 74LS132 abd IC_9 a 74LS03. A suitable opto-switch is type 307-913 from RS Components.

ribbon cable which passes through the gap between the typewriter top and bottom covers.

The prototype interface was constructed on a Eurocard circuit board using the Verowire interconnection technique. The 40-way cable header which mates with the ribbon cable from the typewriter is mounted on the end of the interface board and protrudes through a slot cut in the side of the case. The cable header serves to locate one end of the board. The other end is attached to the case by two screwed spacers. A DIN socket attached to the case provides the RS232 connection to the computer and a flying lead from this socket mates with a connector on the circuit board.

A 22µF tantalum bead capacitor decouples the power supply at the ribbon connector and 0.01µF decoupling capacitors are fitted to the board, one capacitor for every two i.cs. Remember when connecting wires both to the typewriter and to the interface that some of the i.cs are static-sensitive m.o.s. devices.

The photoelectric sensor is fitted onto a bracket mounted underneath the typewriter platen roller and views the paper through a hole cut in the paper guide (Fig. 6).

Commissioning the interface

With the interface disconnected from the typewriter, feed a sheet of paper into the typewriter and monitor the voltage at pin 1 of the connector at the end of the ribbon cable. Adjust R_2 until the voltage just falls to 0V. Give the potentiometer a further turn in the same direction. The voltage should now rise to 5V when the paper is removed.

Table 1: Links 1 and 4 in this table set up the uart for the expected serial data format. Link 5 selects appropriate data from the eprom for the expected carriage-return, line-feed sequence from the computer (see text).

Link	Function	Low (0V)	High (+5V)
1	character length	7 bits	8 bits
2	parity inhibit	enable	inhibit
3	even parity enable	odd	even
4	stop bit select	1 bit	2 bits
5	CR-LF sequence	LF-CR	CR-LF

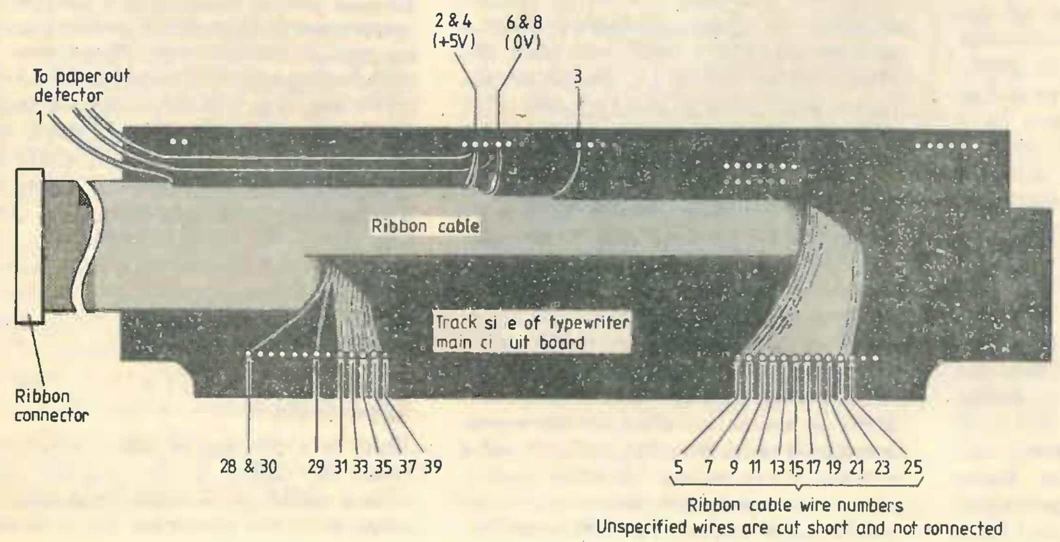


Fig. 4. 40-way ribbon cable connects the interface to the underside of the typewriter main circuit board. Alternate wires in the ribbon are connected to +5 or to 0V either at the interface end or at the typewriter end. This helps to prevent crosstalk between the signal wires.

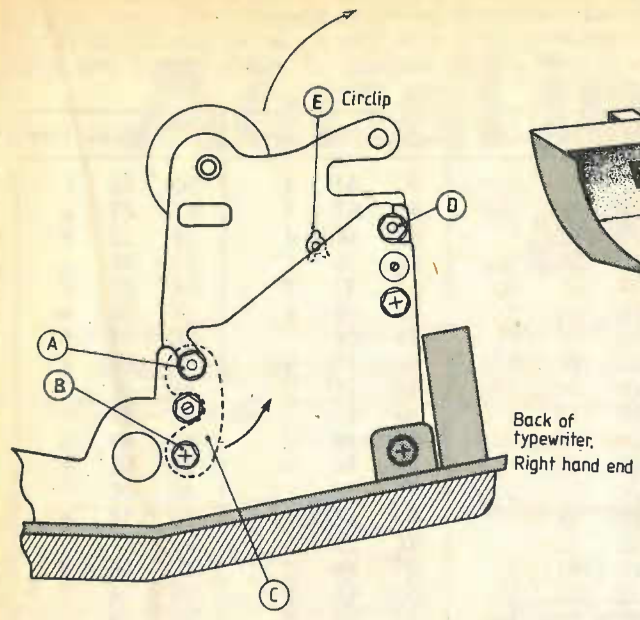


Fig. 5. Platen roller must be swung upwards to allow access for fitting the paper-out detector. Remove screw B on the right-hand roller support bracket. Swing plate C clear on the right-hand bracket and swing the platen roller assembly upwards, pivoting it about nut D.

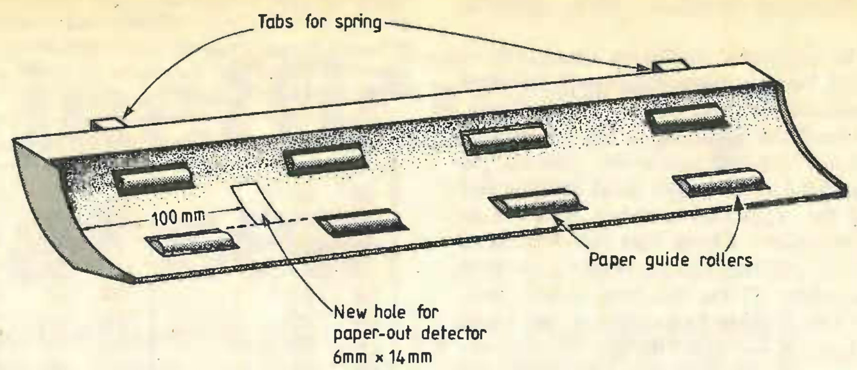


Fig. 6.

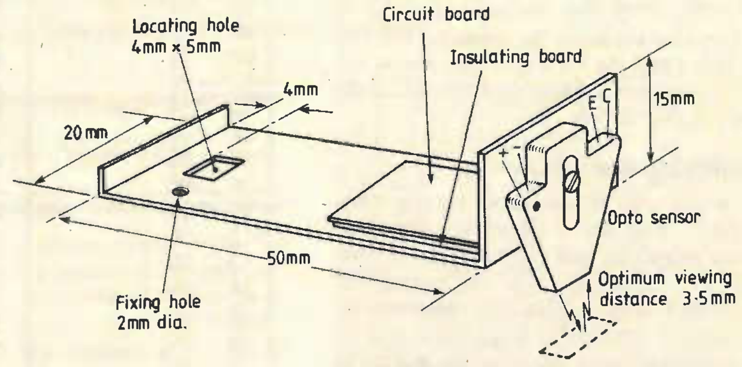


Fig. 7. Opto-sensor mounted underneath the platen roller views the paper through a hole cut in the paper guide roller carrier (Fig. 6).

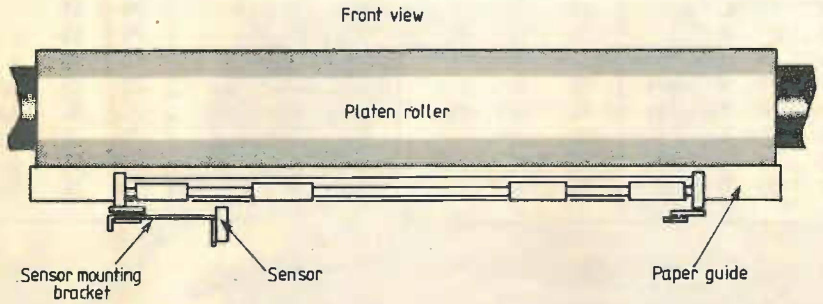
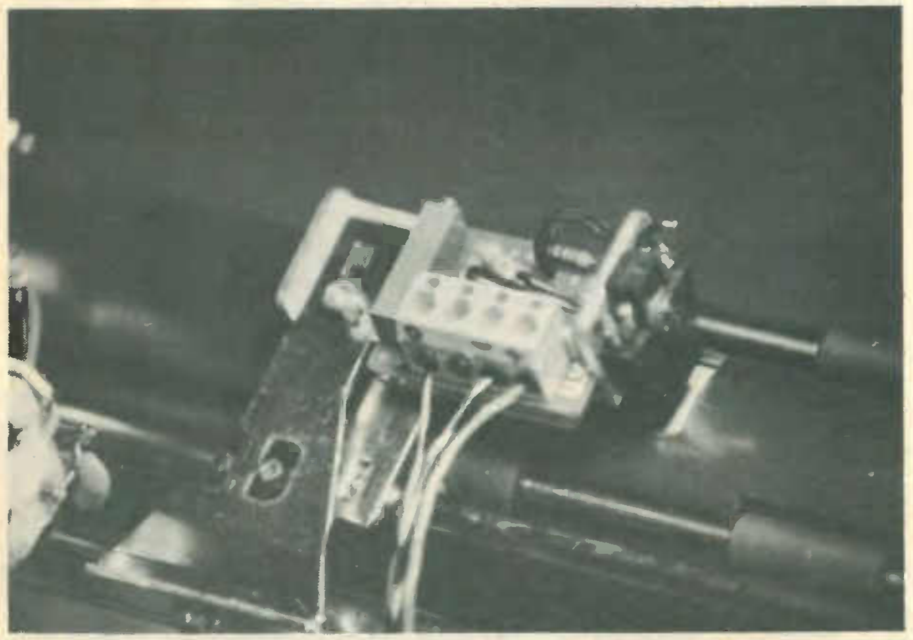


Fig. 8.



Attaching the paper sensor

The paper sensor is mounted on a bracket on the underside of the platen roller. A hole must be cut in the paper guide under the platen roller for the sensor to view the paper through. To cut the hole the guide must be removed from the typewriter. Remove from the rear of the platen roller the four springs which tension the paper guide and the paper bail bar. Next refer to Fig.5 and pivot the whole platen roller assembly upwards. Remove the small spring which can now be seen on the underside of the assembly at the right hand end. Remove circlip E from the right hand bracket and pull the bar that was retained by the circlip out of the bracket. The bar can now be sprung to enable the paper guide to be removed. To avoid damaging the guide a hot soldering iron can be used to melt a hole in the plastic in the position shown in Fig. 6. The hole should be carefully trimmed with a file to ensure that there are no sharp edges that can snag the paper. The mounting bracket for the sensor is shown in Fig.7 and is attached as shown in Fig.8 to the left hand spring bar on the underside of the platen roller by a single screw.

Test the connections to the typewriter by shorting out rows and columns at the connector on the end of the ribbon. Check by referring to Fig. 1 that the typewriter prints the correct character.

The interface should next be connected to the computer RS232 port and powered up, preferably from an independent 5V supply. Press S_1 to reset IC_{10}, ensure that the led goes out and the CTS line to the computer goes high. A short program loop should be written to send a continuous stream of characters to the interface. Do not forget that it will be necessary to configure the computer for the correct baud rate. The row outputs from the interface should be monitored to ensure that the appropriate row is pulsed low (use an oscilloscope or else a led in series with a 390Ω resistor to +5V). Check each row in turn by sending an appropriate character to select each one.

The interface should now be connected to the typewriter. Data should be sent by the computer to test the entire character set.

The computer should be configured to output both carriage-return and line-feed characters whenever a new line is required. To check the sequence of the carriage-return and line-feed characters, position the print head at the right hand margin and send the typewriter a return signal from the computer. Check that the print head returns to the left margin before a line-feed takes place. If the line-feed occurs first, then link 5 should be changed (see Table 1). Led_1 should flash during the carriage-return period and computer output should be halted.

Finally check that the paper-out circuit is operating correctly by ensuring that the led lights and the CTS line goes low at the end of the line following a paper-out condition being detected.

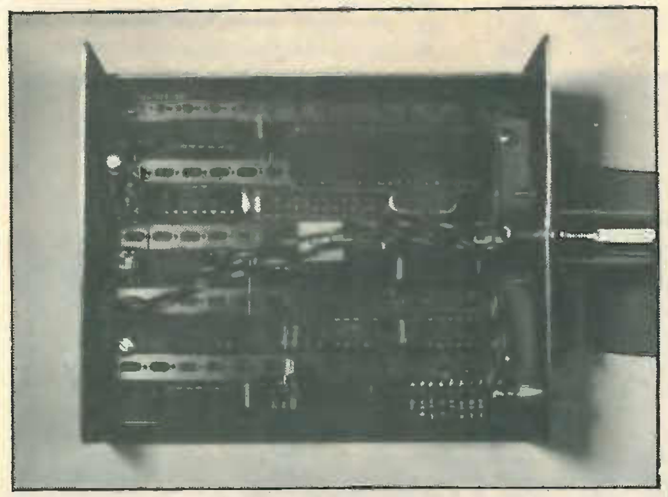
Modifying the typewriter

To attach the ribbon cable to the typewriter it is necessary to remove the typewriter top cover and the keyboard assembly. The pivoting cover on top of the typewriter should first be removed by swinging it upward and springing one of its ends away from the retaining bar on to which it is clipped. The other end can then be unclipped and the cover removed. The knobs on either end of the platen roller should then be removed by unscrewing them.

Next the four top cover retaining screws should be removed from the underside of the typewriter and the top cover taken off. Undo the two retaining screws at either side of the keyboard and lift the keyboard assembly away, taking care in the process to unplug the cables from its underside. The cable connectors are easily distinguished so there is no need to mark them for later re-assembly. The keyboard assembly consists of two circuit boards folded together and held apart by three spacers. The three nuts that fasten the circuit board to the spacers should be removed and the keyboard assembly unfolded. The ribbon cable should now be soldered to the main circuit board as shown in Fig.4 so that it emerges from between the two boards when they are folded together again. During re-assembly, take care to position the flexible ribbon to the print head so that it is not under tension when the head is at the extremes of its travel. It is necessary to cut away some projections on the inside of the top cover to prevent damage to the cable when the cover is refitted. WW

Table 2: *Eprom converts data received by the uart into a code to select the typewriter keyboard rows and columns via multiplexer and de-multiplexer. Table shows data and typewriter response to each incoming ASCII code. Data for eprom locations 80 to FF is identical to data in locations 00 to 7F with the exception of location 8A with data 36 and location 8D with data B7.*

Addr	Data	Char	Addr	Data	Char	Addr	Data	Char	Addr	Data	Char
00	00		20	3E	Spc	40	44	@	60	46	£
01	00		21	3E	Spc	41	61	A	61	21	a
02	00		22	42	"	42	56	B	62	16	b
03	00		23	3E	Spc	43	7B	C	63	3B	c
04	00		24	3E	Sp	44	63	D	64	23	d
05	00		25	51	%	45	5B	E	65	1B	e
06	00		26	5E	&	46	64	F	66	24	f
07	00		27	75	'	47	7D	G	67	3D	g
08	2E	B.Spc	28	74	(	48	4E	H	68	0E	h
09	07	Tab	29	73	)	49	6C	I	69	2C	i
0A	B7	Express	2A	41	*	4A	4D	J	6A	0D	j
0B	00		2B	69	+	4B	4C	K	6B	0C	k
0C	00		2C	13	,	4C	4B	L	6C	0B	l
0D	36	Return	2D	32	-	4D	54	M	6D	14	m
0E	00		2E	12	.	4E	55	N	6E	15	n
0F	00		2F	43	/	4F	6B	O	6F	2B	o
10	00		30	33	0	50	6A	P	70	2A	p
11	00		31	01	1	51	59	Q	71	19	q
12	00		32	02	2	52	5C	R	72	1C	r
13	00		33	03	3	53	62	S	73	22	s
14	00		34	04	4	54	5D	T	74	1D	t
15	00		35	06	5	55	6D	U	75	2D	u
16	00		36	05	6	56	7C	V	76	3C	v
17	00		37	1E	7	57	5A	W	77	1A	w
18	17	½ Spc.	38	35	8	58	7A	X	78	3A	x
19	0F	M.Rel.	39	34	9	59	65	Y	79	25	y
1A	1F	M.Left	3A	4A	:	5A	79	Z	7A	39	z
1B	27	M.Right	3B	0A	;	5B	3E	Spc	7B	3E	Spc
1C	2F	Tab set	3C	3E	Spc	5C	3E	Spc	7C	3E	Spc
1D	3F	Tab clr	3D	29	=	5D	3E	Spc	7D	3E	Spc
1E	28	S.Lock	3E	3E	Spc	5E	3E	Spc	7E	3E	Spc
1F	30	Repeat	3F	72	?	5F	45	_	7F	10	Del



Praxis typewriters are available through Wilding Office Equipment and other Olivetti dealers at around £260 for the Praxis 30 and £290 for the Praxis 35. Programmed eproms are available from the author at 18 Carnoustie Gardens, Glenrothes, Fife KY6 2QB for £9.60 each including postage and v.a.t. The other components can be obtained as a kit from Technomatic Ltd.

Aerial inefficiency at sea

Innovation in marine aerials is badly needed: British thought in this area has been 'fossilized' for 50 years. But North Atlantic sea trials earlier this year of new British-designed components have shown 'excellent results.' This is the third of John Wiseman's startling revelations on the state of marine aerials.

by J. J. Wiseman

We at sea are not the only people who have been forced by an unfavourable environment, to operate low-frequency transmitters into aerials less efficient than the textbook optimum. The photograph on this page shows a trench transmitter of the First World War, operating on wavelengths between 500 and 2000 metres with an aerial only a metre above the ground, and a range of 3 or 4km. With an aerial of specified 40 foot length and 15 foot height, range was up to 80km. Even from this inadequate aerial, a useful service was still obtained, even more remarkable considering the primitive receivers of those days. Other 1914-18 War transmitters worked into aerials actually *inside* the trench, below ground level, operating at 80 to 100 metres wavelength.

The efficiency of the 500kHz marine aerial depends, as for any other other, on its height and dimensions; the special variable factor in the marine environment is leakage. A correspondent (*WW* February 1983 issue) has pointed out that an aerial height of 0.1λ, at perhaps 40 or 50% efficiency is about the least we can hope to get away with, and at 500kHz this corresponds to 60 metres, an impossible height. But according to a BBC Research Department report by H. Page, published in 1963: ". . . a capacitative top is often added to a low aerial with the object of increasing the radiation resistance. In this case, a large top changes the current distribution on the vertical portion of the aerial from linear to substantially constant, thus approximately quadrupling the radiation resistance . . .". This might lead to the

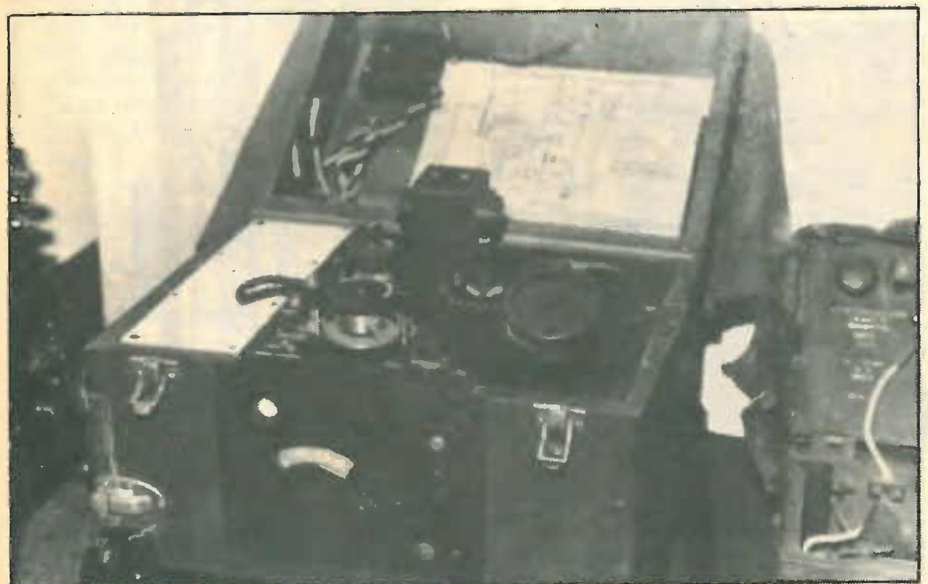


Fig. 1. This l.f. trench transmitter operated into an aerial only a metre above ground, but others worked from aerials inside the trench. (20watt Mk 3 transmitter, 1917, has single-valve tuned-anode oscillator, but a second valve could be switched in parallel for maximum power. HT supplied by 1,000-volt battery or induction coil.)

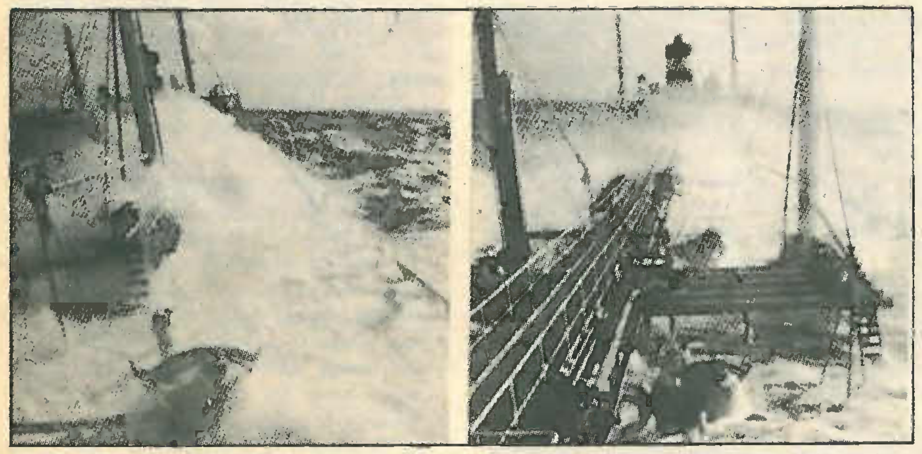


Fig. 2. Those whose experience of a storm at sea is a rough ride to Calais on a stabilized passenger ferry can have little idea of the force of a North Atlantic winter gale. (Photo: P. F. Barber, Scarborough)

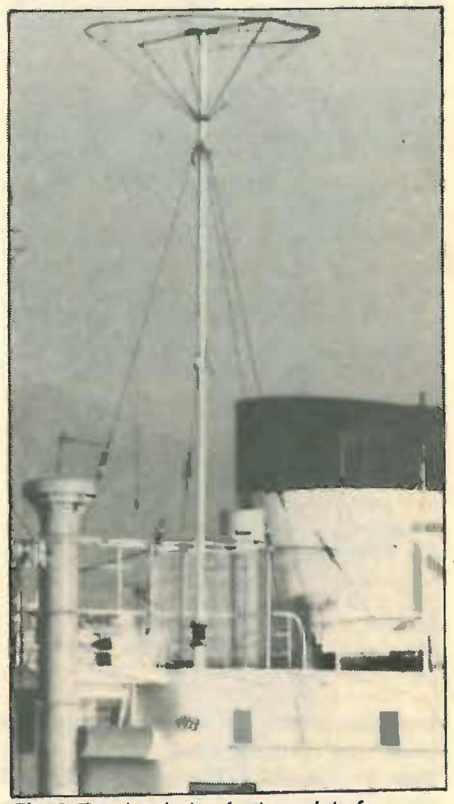


Fig. 3. Top-loaded unipole aerial of Scandinavian origin. The stays add to the top capacitance, also to the leakage. Has little height. (Photographed at Eleusis, Greece, 1982)

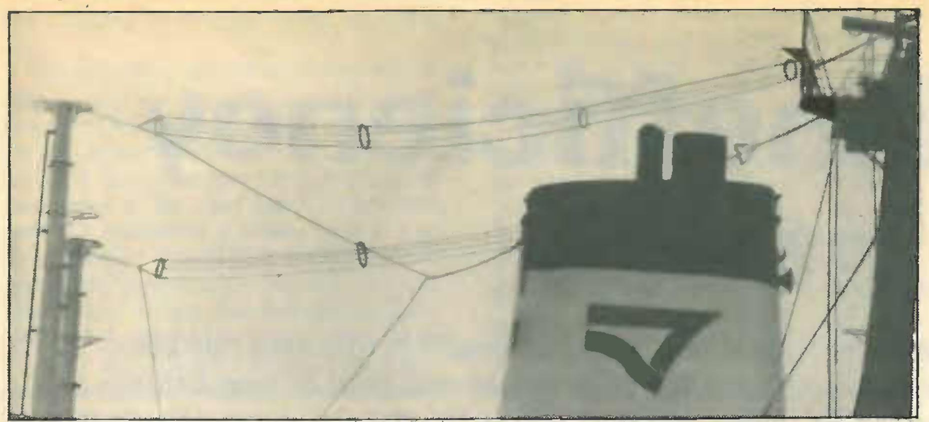


Fig. 4. Hard-to-find classic French all-wire sausage aerials with high top capacitance, well sited on available structures. ('Dumont d'Orville,' French flag, b.1977, 23910 g.r.t. photographed at Cr. Couronne, 1983.)

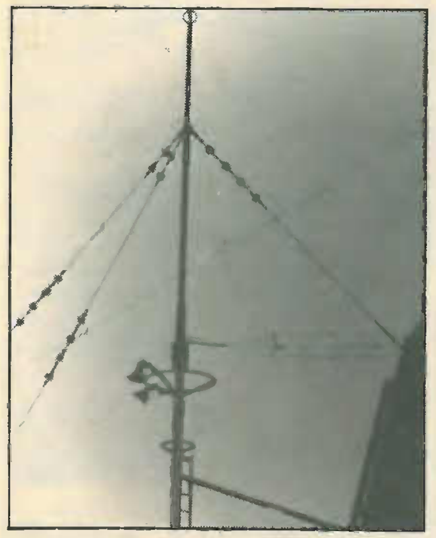


Fig. 5. This stubby mast accounts for 5% of aerial capacitance, 2% of its radiation, and 90% of its cost! It makes no economic or functional sense. Cargo cult design. ('Ile de la Reunion,' French flag, b.1969, 16671 g.r.t. photographed at Rouen, 1983.)

Fig. 6. Traditional British feedthrough set-up, unchanged since the days of silent movies, photographed in 1983.

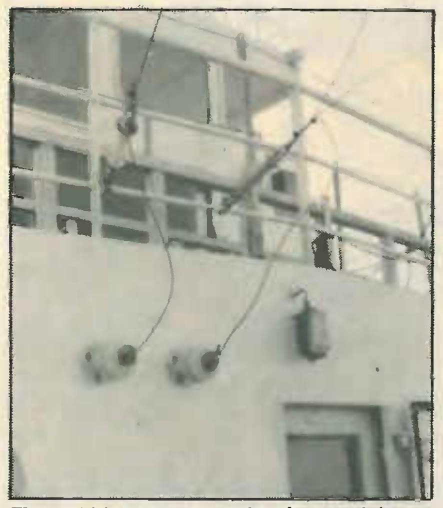


Fig. 7. Abbreviated version for a quick, cheap job on a 900-ton supply vessel failed repeatedly at sea. (Australian flag, photographed in Tasmania, 1976.)

hope that, with a good capacitive top, one *could* work with an aerial only 15 metres high with useful efficiency. We will get some lift over ground-level figures because the base of the aerial is already well elevated by the hull of the ship. Figures 3 & 4 show about the least and the most that can be done about 'tops' on an average ship. The bizarre arrangement in Fig 5 has all the correct *ingredients*, but has got them upside down: the money has been invested in the wrong end of the aerial. As well as improving radiation resistance, the 'top' improves the L/C ratio, minimizing arcing. As manufacturers keep on supplying transmitters specified to match aerials of "250 to 750pF", and shipyards tend to supply aerials toward the lower end of the 80 to 400pF range, the 'top' can only help, avoiding tuning difficulties particularly at the low end of the 405 to 535kHz band.

If the RC product is too small, charge put into the aerial each cycle may leak away almost as fast as it can be supplied (R is parallel leakage). Time between peaks is longer at lower frequencies. This is a further good reason for making C as large as possible. But what can be done about R?

The standard British feedthrough insulator arrangement, unchanged since 1930, is at its best and at its worst in Figs 6 and 7. The strain insulators are also standard British issue. Their presence adds to

Fig. 9. Simple and effective conical skirts of common British telegraph pole insulators, in use for nearly a century, and only now recently adopted for marine use, Figs. 10 and 11.

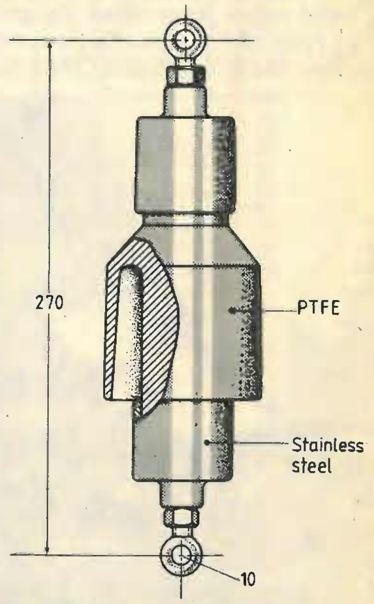


Fig. 10. Tough German aerial strain insulator using skirt principle. Rated at 50kV (dry) at 500kHz. 700kg tensile load, mass 1.5 kg. (Dieckmann & Klapper.)

leakage, and cancels any useful effect the bells might have. In earlier times the trunking (Fig 6) would have been made of oiled teak, and *could* have contributed to the overall insulation. These days it is soggy plywood, even steel.

British thought in this area has been fossilized for 50 years; there has been reluctance to innovate or to produce any aerial hardware requiring much manufacturing. Books like "101 Things a Boy Can Make" have a lot to answer for. The ends of this kind of feedthrough insulator are sometimes unglazed and porous, absorbing water, and usually sealed with cork washers. A British firm makes a solvent-based silicone preparation which causes water on the surface of a ceramic insulator to collect in small drops, preventing formation of a conductive film. It requires oven curing. I have never seen it used at sea; it could be useful. The old 'bitumastic strap' insulator, a yard-long tough rubber thong, worked on this principle, although it might have fried at 17MHz!

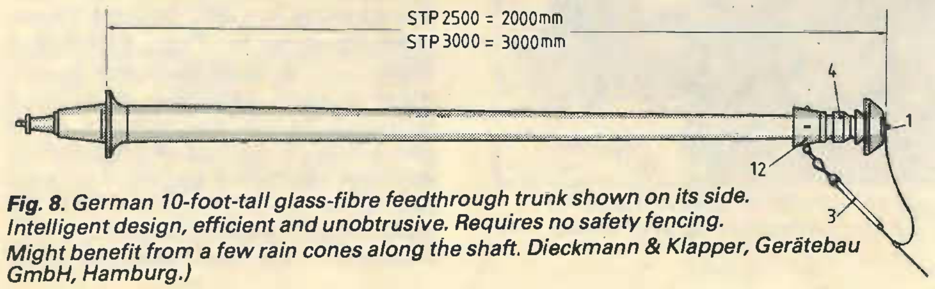


Fig. 8. German 10-foot-tall glass-fibre feedthrough trunk shown on its side. Intelligent design, efficient and unobtrusive. Requires no safety fencing. Might benefit from a few rain cones along the shaft. Dieckmann & Klapper, Gerätebau GmbH, Hamburg.)

A German-made feedthrough trunk, based on a tough glass-fibre tube, is up to three metres long (Fig 8); polyester stays are available to brace it. There is minimal shunt capacitance, small surface area, and a long way indeed to leak or arc. It is rated at 30kV at 500kHz. A neat arrangement: beats soggy plywood, and probably doesn't cost much more.

The insulator shown in Fig 9, with its deep skirt, has been on British telegraph poles for nearly 100 years – simple and effective. Only recently has a German firm adapted the principle to insulators for marine use, Fig 10. The same idea is seen again on the base of a Russian mast aerial in Fig 11. Why has it taken so long?

The feedthrough insulator of Fig 12, with metal jacket and metal rain cone, was photographed on the British cruiser, HMS Belfast. If the Navy had advanced ideas, they did *not* seem to get passed on to the merchant fleet.

But British ingenuity, neglected as it may be, is still very much alive and well, and living in Britain.

Recently patented, British developed feedthrough and aerial link insulators (Figs 13 & 14) with protective mantles of elegant design have undergone testing by a national h.v. laboratory and sea trials in the North Atlantic in winter with excellent results, see Fig 15. The shrouding domes are made of transparent high impact plastics. The feedthrough unit is held to the bulkhead by non-metallic nylon bolts, and a stream of air blown into the inner dome to prevent penetration by moisture, warmed as well if necessary to prevent icing. The link insulator unit has a vaned, wind-driven rotating outer dome, running on non-metallic rollers. Water entering is thrown out through small holes in the rotating part. With salt-water spray directed into the gap between inner and outer domes for 30 minutes in laboratory tests, flashover occured at 57kV. An unprotected insulator under similar conditions began to spark over at 11kV.

In North Atlantic sea trials, carried out on a British tanker from late January to early April, one aerial retained its British 'standard' brass bell fitted feedthrough, the other being supplied with the domed shrouding mantle assembly. The day-to-day log kept shows typically an equal 4A up either aerial in dry weather, but 'tuning impossible' with the standard aerial in bad weather, while the modified aerial was still drawing a good 2.8A, from the same 100watt transmitter at 500kHz. Later, link insulators with protective mantles were added to that aerial, with further improvement in results. While the standard aerial drew only 0.5, the modified aerial took 3.9A. What more can man do? Perhaps combine the best features of several of the systems described, no more. WW

Fig. 11. Base of Russian mast showing three deep-skirted rain cones on the central glass-fibre pole. (Photographed at Rouen, 1983.)

Fig. 12. Metal-jacketed naval feedthrough insulator on HMS Belfast, World War 2 cruiser, now museum. Plumbing suggests it might have been air blown.

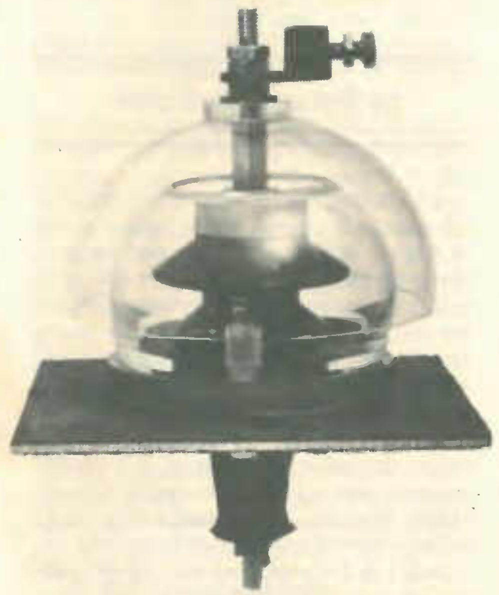


Fig. 13. Recently-developed British feedthrough assembly with dual-domed protective mantle. Moisture is expelled from domes by air blower. (By P. F. Barber, Scarborough.)

Fig. 14. British invented link/strain insulator assembly with protective shrouding. Wind-driven rotating outer dome expels water by centrifugal action. (P. F. Barber, Scarborough.)

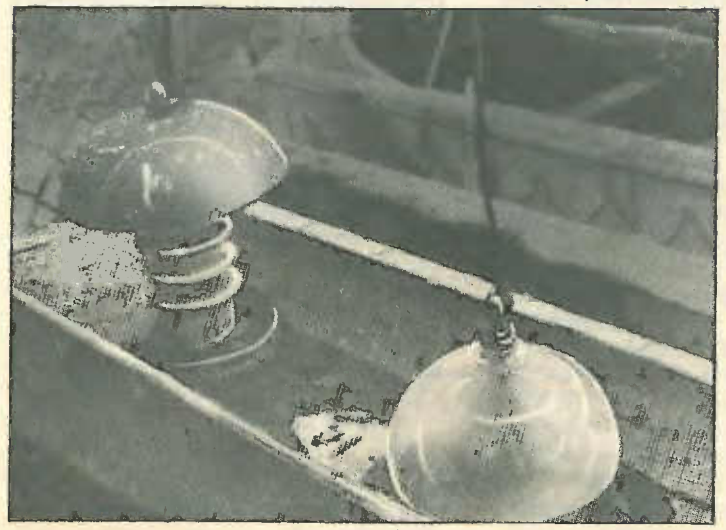


Fig. 15. Sea trials with one feedthrough protected, the other traditional. In later trials protected link insulators added. In bad weather at 380 miles, on 500kHz, US coastguard gave (typically) QSA1 from traditional side, QSA4 from protected side, same transmitter. Had the usual shunting strain insulator been present traditional side would have fared even worse. (P. F. Barber, Scarborough.)

Loudspeaker measurements simplified

Acoustic measurement techniques designed to avoid the vagaries of personal prejudice and room acoustics normally require a calibrated microphone. Using the principle of reciprocity three transducers can be calibrated with reasonable accuracy and no specialized equipment

by Peter F. Dobbins

The design of loudspeaker cabinets may be reduced to the analysis of an equivalent electrical circuit[1]. In principle it should be within the capabilities of an electronics engineer to devise his own speakers for special applications, or simply as a less expensive and/or better quality option to commercial offerings. Problems arise however when attempting to confirm the performance of the finished product. A subjective listening test may be adequate in some circumstances, but the vagaries of personal prejudice and room acoustics can affect the results, and it is difficult to determine the cause of a fault should the speaker not sound satisfactory.

The subject of acoustic measurements has been discussed previously in *Wireless World*. Hiscocks[2] described a gated tone-burst method of eliminating the effects of reverberation and echoes, and Grubb[3] showed how a fast Fourier transform spectrum analyser might be used to achieve the same end. But before such sophisticated signal processing can be applied the acoustic field must be measured. This implies the use of a microphone of known sensitivity and response, probably not available to the home constructor. An application of the principle of reciprocity is described in this article which leads to the absolute calibration of three transducers by means of purely electrical observations.

The three transducers required are a transmitter, a receiver and a reversible device. Most forms of acoustic transducer in general use are reversible, and the method is admirably suited to the calibration of a microphone and a pair of loudspeakers.

The reciprocity theorem states that in a passive linear four-pole network the ratio of excitation to response is constant when the positions of excitation and response are interchanged. But more particularly, the two open-circuit transfer admittances are equal.

Two reversible electroacoustic transducers coupled to the same medium and accessible only through the two pairs of electrical terminals form a four-pole network. A general proof of the validity of the law has not been given for this case, to my knowledge, but it has been proven for special cases. Furthermore, in practice it is easy to check that a particular network is reciprocal, as described, and for this reason the validity is assumed. It is further assumed that the principle applies to individual transducers. Consider Fig. 1(a), which shows a current i_1 flowing into terminals 1 & 2 of a network causing an open-circuit voltage e_1 to appear across terminals 3 & 4. In (b) the connections are reversed, and an input current i_2 at terminals 3 & 4 causes an open-circuit output voltage e_2 at terminals 1 & 2. Reciprocity may be stated as

$$i_1/e_1=i_2/e_2. \qquad (1)$$

In a transducer terminals 3 & 4 may be regarded as a point in the acoustic medium

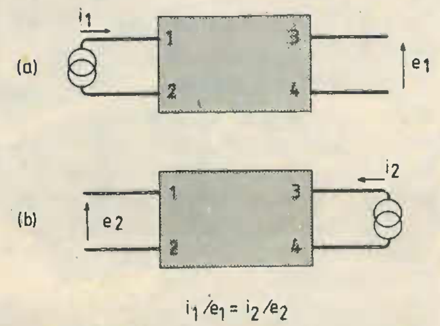


Fig. 1. Four-port network is reciprocal if its transfer admittance is the same in both directions.

at a distance r from the device. Network (a) represents a transmitter or loudspeaker. An input current i produces a sound pressure p at the output. Network (b) represents a receiver or microphone and an acoustic source of strength Q at the input produces an open-circuit voltage e_o at the output terminals. Equation 1 may then be written:

$$i/p=Q/e_o. \qquad (2)$$

For those unfamiliar with acoustic terminology, the rate of flow in the medium from source is

$$\dot{Q}(t)=\int_A u(t).dA$$

where A is the area of the vibrating surface and u(t) is the velocity of that surface. Generally, for simple harmonic motion

$$Q(t)=Qe^{j\omega t}$$

where Q is the strength of the source. At low frequencies a loudspeaker cone may be regarded as a rigid piston, and the source strength is simply the effective area multiplied by the cone velocity. The acoustic pressure p at a distance r from this source is inversely proportional to r, if spherical spreading is assumed, and related to Q by the equation

$$p(t)=\frac{j\rho ck}{4\pi r}Qe^{j(\omega t-kr)}D(r,\theta,\phi)$$

ρ is the density of the medium, c is the sound speed, $k=\omega/c$ is the wave number or spatial frequency, and D is a function describing the directivity of the source with arguments r,θ,ϕ in spherical co-ordinates. For this discussion directivity is neglected, as once the sensitivity has been found in the straight-ahead direction it is a simple matter to rotate the source and measure the relative response in other directions and so determine the beam pattern. Phase angle may be retained in these calculations but is generally neglected because of experimental difficulties encountered in accurately determining both the distance between transducers and the sound speed in the medium, so only the amplitude is considered here. Thus D is set equal to one, and the exponential time dependence may be dropped:

$$p=\frac{\rho ck}{4\pi r}Q \qquad (3)$$

where p and Q are r.m.s. amplitudes. Both spherical radiation and free-field conditions are implicit in equation 3, and the consequences of these assumptions will be discussed when the practical application of this theory is considered.

The free-field voltage sensitivity m of a transducer used as a microphone is the ratio of the open-circuit voltage output e_o to the free-field sound pressure p:

$$m=e_o/p. \qquad (4)$$

The transmitting voltage (or current) response, $s_v(s_i)$, of a transducer used as a speaker is the ratio of the sound pressure at unit distance from the transducer to the voltage applied across (or the signal current flowing into) the electrical input terminals:

$$s_v=p/v \text{ or } s_i=p/i. \qquad (5)$$

Combining equations 3 & 4:

$$m=\frac{4\pi re_o}{\rho ckQ}. \qquad (6)$$

From equation 5 and the reciprocity relationship (equation 2):

$$Q=e_o/s_i.$$

Thus, substituting for Q in equation 6,

$$m=\frac{4\pi rs_i}{\rho ck}. \qquad (7)$$

Noting that s is defined for unit distance (i.e. r=1), and that k may be expressed in terms of frequency, $k=2\pi f/c$, equation 7 becomes

$$\frac{m}{s_i}=J=\frac{2}{\rho f} \qquad (8)$$

where J is the reciprocity parameter or acoustical transfer admittance for spherical radiation. By modifying the form of equation 3, reciprocity parameters may be derived for other conditions, such as plane waves, and examples will be found in reference 5. Equation 8 is derived from MKS units and if other systems are used a conversion constant must be included. A note on units used in acoustics is given in the Appendix.

As engineers prefer everything in logarithmic form so that they can add and subtract rather than multiply and divide, equation 8 may be re-written

$$S=M+20\log f+20l\log \rho/2-20\log|Z|$$

where $S=20\log s_v$ (dB relative to 1Pa/V at 1m), $M=20\log m$ (dB re 1V/Pa), and |Z| is the input impedance of the transducer (only the magnitude is needed as only the magnitudes of M and S are to be found).

Finally, taking the density of air as 1.2kg.m^{-3}, a new reciprocity factor K is defined by

$$S=M-K \qquad (9)$$

$$\text{with } K=20\log|Z|-20\log f+4.4. \qquad (10)$$

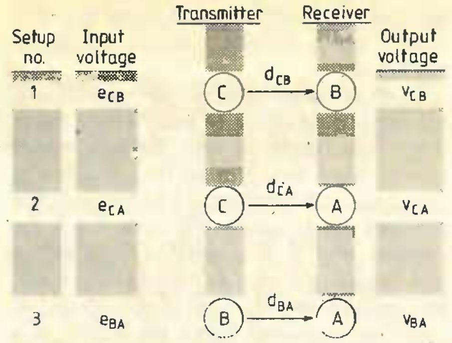


Fig. 2. Schematic three transducer reciprocity calibration. Drive voltage e_{CB} is applied to transducer C, which transmits to transducer B, at a distance d_{CB}, giving an output voltage v_{CB}. Test is repeated with C transmitting to A and B transmitting to A.

Three transducer method

The practical application of reciprocity in acoustic calibration requires three linear transducers, of which at least one is reversible, and also that measurements be carried out under free-field conditions and in the far field of each transducer. These conditions must be met if results are to have any meaning, and some simple checks are described in the section on measurement techniques.

The three transducers required are a microphone A, a reversible device B and a speaker C. The terms microphone and speaker refer only to the usage of the transducer for these tests, and the term transducer is taken to mean any device that converts acoustic energy to electrical energy or vice versa. A transducer is reversible if the conversion operates in both directions, and this is true of almost any device that contains no active components, obvious examples being the ordinary moving coil loudspeaker and dynamic microphone.

Both transmit and receive sensitivities may be obtained for all three transducers under test by full use of reciprocity. Three sets of measurements are done:

speaker to reversible device
speaker to microphone
reversible device to microphone

The sequence is shown schematically in Fig. 2. Assuming spherical spreading, the relationship between drive voltage and received voltage for a test between transmitter I and receiver J is

$$e_{IJ}=\frac{v_{IJ}m_Is_J}{d_{IJ}}$$

or in logarithmic form and with some rearrangement

$$A_{IJ}=D_{IJ}-S_I-M_J \qquad (11)$$

where $A_{IJ}=20\log(v_{IJ}/e_{IJ})$ is attenuation and $D_{IJ}=20\log d_{IJ}$ is spreading loss. The relationship between M and S for one transducer is given by equation 9 as $S_I=M_I-K_I$, where K is the reciprocity term from equation 10.

The three sets of measurements give

$$A_{CB}=D_{CB}-S_C-M_B \qquad (12)$$
$$A_{CA}=D_{CA}-S_C-M_A \qquad (13)$$
$$A_{BA}=D_{BA}-S_B-M_A \qquad (14)$$

Combining the first two by eliminating S_C gives

$$M_A=D_{CA}-D_{CB}+A_{Cb}-A_{CA}+M_B$$

But $M_B=S_B+K_B$ and substituting for S_B from the third equation leads to

$$M_A=1/2(D_{CA}-D_{CB}+D_{BA}+A_{CB}-A_{CA}-A_{BA}+K_B$$

The receive sensitivity of the microphone has now been found in terms of distances and electrical quantities by use of the reciprocity factor. The rest is plain sailing. Using equations 13 & 14

$$S_C=D_{CA}-A_{CA}-M_A \text{ and}$$
$$S_B=D_{BA}-M_A-A_{BA}$$

and by reciprocity:

$$M_B=S_B+K_B.$$

The transmit sensitivity of the speaker and both transmit and receive sensitivities of the reversible device are now known. The speaker and microphone may not be reciprocal. For instance, an electret microphone usually has a built-in preamplifier so is obviously not reversible, and as the terminals of the transducer are not directly accessible the impedance cannot be calculated. However, if either or both of these transducers are reversible the remaining sensitivities are easily found:

$$S_A=M_A-K_A$$
$$M_C=S_C+K_C.$$

These last six equations give absolute calibrations for each of the transducers, obtained without a reference transducer. The measurements and calculations must be repeated at each frequency of interest, and at first glance the process may seem tedious. But the amount of experimental work is no greater than carrying out three separate frequency response procedures using a standard transducer, while the calculations are simple arithmetic and easily programmed for a computer or calculator. If practicable, some easing of the workload can be achieved by making distances and drive voltages constant for all tests.

Measurement techniques

Before the calibration procedure can begin the impedance of each transducer must be found as a function of frequency so that the reciprocity factor can be calculated. If a bridge is not available the simple circuit of Fig. 3 generally provides satisfactory results. To keep errors low, R should be a low resistance (R<|Z|/100) if the transducer is a high impedance device, and the impedance obtained from $|Z|\approx V_IR/V_2$. If the transducer is a low impedance device then R should be a high resistance (R>100|Z|) and the impedance obtained from $|Z|\approx V_3R/(V_1-V_3)$.

Most transducers have very low electromechanical coupling coefficients so no special precautions need be taken, provided the active face is not pointing directly at a nearby reflecting surface. Some devices such as piezoelectric tweeters are very efficient, and any obstacle within several wavelengths may affect the measured impedance. A sensible procedure is to suspend the transducer in mid-

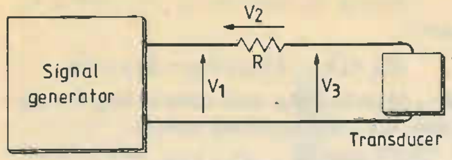


Fig. 3. In the absence of a bridge the input impedance of a transducer may be determined by measuring the voltage drop across a series resistor.

air, allowing it to swing freely. If the impedance does not appear to change as the device moves then all is well. Transducers such as tweeters, whilst not requiring a cabinet for their operation, should be mounted as they will be in service, because the presence of baffle will affect both impedance and sensitivity at frequencies where the device is small compared with the wavelength.

The basic measurement set-up is shown in Fig. 4. The hardware need not be sophisticated, but before discussing the instrumentation the acoustic environment and the necessary conditions must be considered.

Measurements should be made in the far-field of the transducers, which means that the projector is assumed to be a point source from which spherical waves spread, and the receiver is assumed sufficiently small that the wavefront may be considered plane over the transducer face. As both have finite size there must be sufficient distance between them before the assumption can be considered valid. For a working rule the minimum distance should be a^2f/c or 5a, whichever is the greater, where a is the maximum dimension of the larger transducer and c is the sound speed. In air, $c=343ms^{-1}$. The size should include the housing, not just the active face of the transducer, as any discontinuity can act as a secondary source.

The free-field condition is generally the most difficult to deal with, and essentially means that the sound waves must be free to radiate spherically with no disturbance by boundaries or obstacles within the field of interest. In principle the receiving transducer should not distort the wavefront, but there is little that can be done to ensure this, given a particular device. There are a number of ways to tackle the free-field problem:

1 – measure in an anechoic chamber
2 – measure out of doors
3 – use pulse techniques
4 – measure in a room and correct for reverberation by calculation or signal processing
5 – measure in a room and ignore room effects.

The effect of reverberation is to introduce ripples into the measured frequency response. If the ultimate in precision is not required it is generally possible to estimate the mean level, and (5) may prove satisfactory. An anechoic chamber is not usually available, so weather permitting, (2) may be the best compromise. Solution (4) usually requires specialized instrumentation or vast computing power, but an interesting discussion of a typical technique is given in reference 6. The pulse method (3), is described in detail in references 2 and 3, but the principle is summarized here.

In an enclosed environment signals travel from transmitter to receiver by paths other than the direct one. Because sound travels fairly slowly in air it is possible to transmit short tonebursts and measure the received signal before reflections reach the receiver, Fig. 5. It is usual to use a gating and sampling system to achieve this result, but careful oscilloscope observation can result in accuracies better the 0.5dB. If a gated signal generator is not available, a simple fet switch can be constructed, as described in reference 2.

Maximum pulse length is determined by the difference between direct and first reflected path length. The minimum pulse length is determined either by the rise-time (and therefore the bandwidth) of the transducers or by the time constant of the detector. As frequency becomes lower a longer pulse is needed to encompass a sufficient number of cycles, and the method becomes unuseable when the wavelength approaches the differences between direct and reflected path lengths. In average-sized rooms this is typically around 500Hz. The maximum pulse repetition rate is determined by the time it takes for reflections to decay to negligible amplitude. These times may be calculated, but are easily set empirically by direct observation of the signals.

Free-field and far-field conditions are easily checked by confirming compliance with equation 3. If the transmitter is driven at constant frequency, constant voltage, and the receiver output voltage measured as a function of distance, this voltage is then inversely proportional to distance.

The total transmission chain should be linear, with no saturation effects. It is not generally appreciated that the acoustic medium itself may become non-linear at high pressure amplitudes, especially at high frequencies or when the transmission path is constricted as in a horn. Testing for proportionality between transmitter drive voltage and receiver output will check for both linearity and an adequate signal-to-noise ratio.

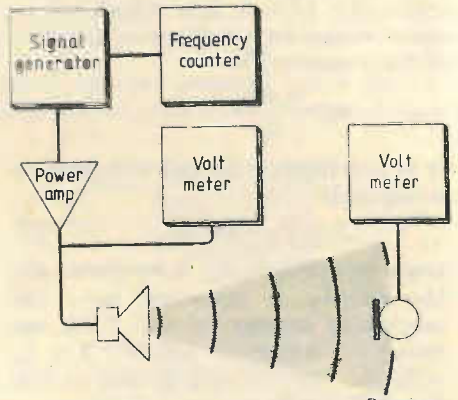
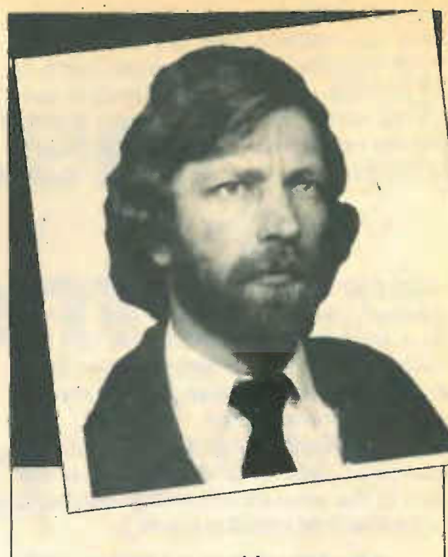


Fig. 4. Minimum instrumentation is a signal generator and suitable power amplifier, a frequency counter and a means of monitoring the transmitter drive level and receiver output voltage.



Peter Dobbins began his career as a technician apprentice with BAC, Hurn, obtaining a City & Guilds qualification in aeronautical radio and instrumentation at day release and evening classes. His first professaional contact with acoustics was at Ultra Electronics, Greenford, where he worked on the development of transducer arrays for sonobuoys. He joined BAe at Weymouth (formerly Sperry Gyroscope) in 1976 to work in electronics design, but transferred to the underwater technology department in 1981. Since then he has gained an honours degree in applied mathematics from the Open University, and has recently been elected a member of the Institute of Acoustics. In 1982 he became a founder member of a specialist transducer group at BAe, and is now a senior engineer working on underwater acoustic transducer and array design, with interests in long-range propagation and non-linear generation of low frequency sound.

Reciprocity must also be confirmed. It is not possible to check that the individual transducers are reciprocal without direct measurements on the acoustic field, but it is possible to test the combined transmitter/receiver chain, simply by measuring the transfer admittance in both directions. With two transducers in their final measurement positions drive one, noting the input current i_1 and measure the output voltage e_1 from the other. Reverse the connections and measure the new input current, i_2, and output voltage, e_2. This should be repeated at a number of frequencies over the range of interest. If $i_1/e_1=i_2/e_2$ at each frequency, then both transducers may be regarded as reciprocal.

Making the calibration measurements is straightforward. It is assumed that continuous rather than pulsed signals are being used and that some suitable location has been found, perhaps out of doors, enabling free-field and far-field conditions to be met. Typically the transducers under test will be two loudspeaker drivers and a microphone, one of the speakers being used as the reversible device, taking care to distinguish between the two speakers.

The first job is to select the frequencies to be used, and common practice is to have third-octave steps, the sequence being 1, 1.25, 1.6, 2, 2.5, 3.15, 4, 5, 6.3, 8, 10 etc. This is not essential, the point being to keep to the same frequencies for each set of measurements.

The speaker and reversible device should be positioned, pointing directly towards one another, at the appropriate free-field distance and as high above the ground as possible to reduce the effect of reflections. The distance between the transducers should be measured. Measure from the diaphragm, if exposed, otherwise from the plane of the baffle or front of the mounting structure.

Instrumentation is set up as in Fig. 4, using the speaker as transmitter and reversible device as receiver in the first test. There are no special requirements of the signal generator and three-digit accuracy is adequate for the frequency counter. The power amplifier could be one channel of a hi-fi unit, and to get the best signal-to-noise ratio the drive level should be as high as possible, subject to linearity, transducer power handling and complaints from neighbours.

One point about the detector. The theory described here applies specifically to open-circuit output voltage, so the detector input impedance must be much greater than the output impedance of the transducer or results will be meaningless. It is not necessary to have seperate instruments to measure transmit and receive voltages, but it does make the work less complicated.

Once the equipment is operating satisfactorily the drive voltage and received voltage must be noted at each frequency of interest. This procedure is then repeated with the speaker as transmitter and microphone as receiver, and finally with the reversible device as transmitter and microphone as receiver. The required sensitivities can then be calculated from equations.

Results

Repeated and careful reciprocity measurements can result in a sensitivity accuracy of 0.5dB or better, but real life acoustics is not that exact. The transducers themselves are not particularly stable. Their sensitivity will certainly vary with temperature. More importantly, the radiation resistance is proportional to the density of the air and the speed of sound, both of which can change with temperature pressure and humidity. This change will be reflected in the input impedance, and with an efficient transducer the impedance term in equation 10 might vary by ±0.5dB over the normal range of meteorological conditions. Additionally, density is included directly in the reciprocity relationship. The density of air can vary from less than 1.0 to over $1.3kg.m^{-3}$, which represents an uncertainty in equation 10 of over ±1dB.

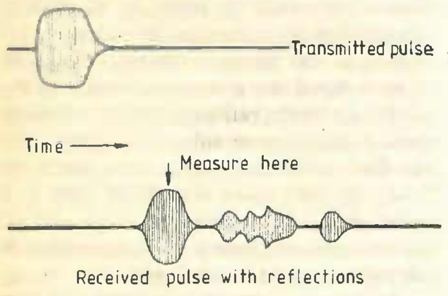


Fig. 5. In suppressing echoes by pulse technique, the transmitted pulse is short enough to allow the received signal to be measured before the arrival of reflections.

Another potential source of error, neglected in the theory, is absorption. Generally the dissipation of acoustic energy in air due to mechanisms such as molecular relaxation and viscous losses is low enough to be ignored. At high audio frequencies, however, and under conditions of high relative humidity the attenuation due to absorption may be as high as 1.0dB per metre.

These, and many other imponderables, mean that an accuracy of better than 1 or 2 dB cannot be guaranteed in uncontrolled conditions. This, however, is more than adequate for most domestic applications, where the main requirement is to ensure that the frequency response of a transducer is essentially flat, and that there are no unwanted resonances. It is unlikely that these results can be bettered with a calibrated microphone under similar conditions.

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Appendix: units

Rationalized MKS units have been used throughout this article, which is something of a novelty in acoustic circles. In underwater acoustics MKS is in general use, but the Navy sticks by the traditional fathoms, knots, kiloyards, millibars and so on. Hi-fi people seem happy to use a similar mixture, with an annoying habit of quoting sound levels in decibels without stating a reference pressure, and who knows what terms like Noy, Sone and NEF mean, as used by environmental noise and architectural acoustics people.

Conversions between imperial, c.g.s. and MKS units are straightforward, but take care over whether to add or subtract when dealing with decibels. One worth remembering is

1 yard=0.9144m=–0.8dB relative to 1m.

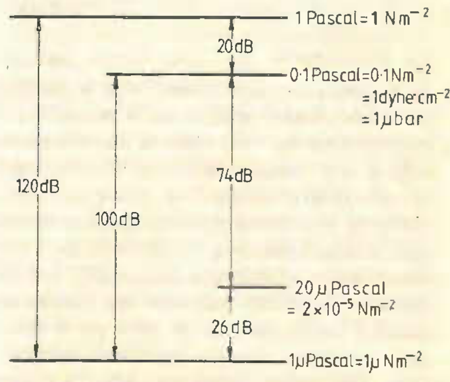
It is customary to specify air at a temperature of 20°C and at standard atmospheric pressure in defining standards of acoustic intensity, impedance, pressure, and so on. Under these conditions the density of air is $1.21kgm^{-3}$ and the speed of sound is $343ms^{-1}$, giving for the standard characteristic impedance of air $\rho c=415$ rayls. Unless other conditions of temperature and pressure are known to exist in a particular situation, the above values should be used for the solution of problems.

The commonly used reference standard of intensity for airborne sound is 10^{-12} watt m^{-2}, which is approximately the intensity of a 1kHz pure tone that is barely audible to normal human ears. This corresponds to an effective (root mean square) pressure of

$$p=\sqrt{I\rho c}=\sqrt{415\times10^{-12}}=2\times10^{-5}\mathrm{Nm}_{-2}$$

The diagram gives the relationships between the most commonly used reference pressures. Although calculations are made much easier by keeping to MKS units throughout the results may be expressed in any convenient units A simple example demonstrates its use. A typical speaker sensitivity would be

S=110dB re 1Pa/V at 1m
=110-26=84dB re 2×10^{-5} Nm^{-2}/V
=110–100=10dB re 1 bar/V at 1m
=110–120=–10dB re 1Pa/V at 1m.



Reference pressure levels in common use and the relationships between them.

A more complicated conversion might be as follows. A loudspeaker manufacturer states that the sensitivity of one of his products is

96 dB at 1 yard for 0.6W input.

Experience suggests that the reference pressure is probably 2×10^{-5} Nm^{-2}. If the impedance is nominally 8Ω an input power of 0.6W requires a drive of 2.2V.

20 log 2.2=6.9dB relative to 1V.

The sensitivity is thus

S=96–6.9=89.1dB rel. 2×10^{-5} Nm^{-2}/V at 1 yard.

Subtract 0.8dB to refer to 1m

S=89.1–0.8=88.3dB rel. 2×10^{-5} Nm^{-2}/V at 1m.

And subtract 94dB to refer to 1 Pa

S=88.3–94=–5.7 dB rel. 1Pa/V at 1m.

WW

How to make electric charge from a radio wave

A wave in free space can be persuaded to enter a transmission line where its velocity may be reduced whilst still conserving its field pattern. If the transmission line is formed into a closed circle it may be spun at the same angular velocity as that of the wave to produce an electrostatic field in the laboratory, just as from a charged surface, but the primary energy is entirely in the wave field. Which then is the more fundamental, charge or field – do we really need two criminals where one may suffice?

by R. C. Jennison

In recent years there have been a number of controversial articles in *Wireless World* questioning the very basis of the principles which are fundamental to wireless and wired communication. One is often tempted to comment in the letter columns but it is entertaining to sit back and witness battles which, too frequently, are replays of conflicts that one has fought on similar battlegrounds in days gone by. I will not enter directly into the controversies, although it may be clear in which direction my sympathies lie, but I will present a little conundrum and show how a partial solution has been demonstrated with simple apparatus that can be constructed at home by many readers of *Wireless World*.

What is electric charge? What is it made of and why does it have, and appear to behave as the source of, an associated electric field, whatever that may be? If you do not like the concept of an electric field, but prefer to live in my old friend Sandy Scott Murray's particulate world, substitute for the field a horrific flow of virtual photons, whatever they may be. The answer that charge is simply an excess or deficit of electrons, is not sufficiently fundamental. What is the nature of the charge on a single electron? Even if the electronic charge is made of miniscule sub-particles which defy discovery the same question remains: what *is* charge, is it a special sort of green cheese which acts as the source of an electric field? Its only purpose seems to be to support the field, or complex of virtual photons, and couple it to matter, but after all it is a very old concept that predates Friday's work on fields. At the present time we appear to have two separate unknown criminals who travel hand-in-hand, the electric charge and the electric field. Can we not form a model which causes the two criminals to coalesce and thereby remove at least one of the unknowns?

Start by considering an imaginary experiment using some of the radiation that has been around since the time of the 'big bang'. The 3K radiation which pervades our part of the universe is thought to be the dying remnant of immaculately conceived radiation which cannot be associated with the radiation from particulate matter. We can pick up some of this radiation on a millimetre-wave antenna and pop it down a transmission line in which the velocity of propagation of the disturbance depends on the dielectric properties of the line. In principle the dielectric constant can be as high as we wish so that the disturbance moves at a leisurely pace. (Wave velocity in a transmission line is given by the reciprocal of the square root of the product of the inductance and capacitance per unit length, which is

$$c'=(LC)^{-1/2}=(\mu\epsilon)^{-1/2}=c/(\mu_r\epsilon_r)^{1/2},$$

the same as for an electromagnetic wave in the medium when no conductors are present). Coil the line around so that the circumference is precisely one wavelength in the line, Fig. 1(a). We now have to work very quickly but remember that we are discussing an imaginary experiment at this stage! Chop a section out of the line which carries exactly one wavelength and couple the input of the section immediately to the output of the same section, (b). We now have one wavelength trapped in a continuous transmission line of one wavelength circumference. The radiation will quickly decay but we can at least imagine a transmission line with very low losses so that the wave circulates for a finite time.

You may not care for the idea of changing the connection so quickly, so if you wish to be a little more practical, substitute the arrangement in Fig. 2 where two isolators are used to achieve the same result.

Now take stock of the situation. We have a single loop of transmission line which originally contained no energy other than that associated with its rest mass but which now contains an additional packet of pure electromagnetic energy whose origin can be traced right back to the start of our present universe, about 15,000,000,000 years ago. This energy, in the good old-fashioned concepts of wireless, is in the form of an electromagnetic wave comprising a sinusoidal pattern of electric and magnetic fields which are together in phase and are travelling around the loop at the languid velocity c'. The fields are not coming directly from the electrons in the conductors of the transmission line but these electrons mirror the passage of the wave as they are influenced by the induction from the waves whose origin we have traced. The frequency at which the wave circulates around the loop is the same as that of the original received signal, say 300GHz in round figures, whereas the wavelength is reduced by the effect of the dielectric to only a tiny fraction of its original length.

We are now ready to perform the final trick. Take the little loop containing the wave and spin it, about an axis through its centre, in the opposite direction to that in which the wave is travelling, increasing the speed of rotation until it is rotating anticlockwise at exactly the same angular speed as the wave is rotating clockwise. The trapped wave is now precisely at rest in the laboratory although the transmission line is spinning round at high speed. It is in fact spinning at −c', very much less than the free space velocity of light c, so that from the point of view of the mechanics the principle is demonstrable, as indeed we shall shortly see.

If we now examine the space in close proximity to the little loop we find a static electric field. It is not a standing wave but a truly stationary, unvarying field, the intensity of which is a maximum in one

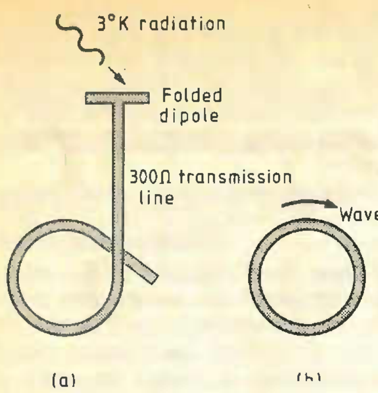


Fig. 1. A wireless wave from the original 'big bang' radiation is picked up on a folded dipole and fed into a 300 ohm transmission line, as shown (a). In principle, the coiled section may be removed and connected full circle whilst the wave is still in the line (b).

direction (say +) in one part of the line, a maximum in the other direction (say −) diametrically opposite and a minimum at the two quadrant points in between. Remember that this is the field that we originally trapped from space and the electrons in the wires are simply slaves to its influence. Relative to the centre of the disc, it is in fact a static dipole field for the particular configuration of the experiment in which both conductors are in the plane of the disc, one of slightly smaller radius than the other. Relative to the laboratory as a whole the vectors are continuous in the upper and lower halves.

Returning to the fundamental point raised at the beginning of this article, we have produced a static field but where are the charges which provide the source of that field? There are none; the electrical energy is the original wave energy and the electronic charges in the conductors are simply catalytic. We have essentially produced a 'charge' from the electromagnetic wave, for one cannot differentiate between the static field that we have produced and another that could be set up by a suitable distribution of 'real' electric charges on a stationary ring in the laboratory.

Practical demonstration

It may well be that you consider that all the above is a lot of academic guesswork and that nothing like it could be achieved in practice. To prove the point I constructed two demonstration systems. One of these uses inexpensive and readily available electronic components and can be built quite easily at home. To this end the frequency is scaled down to the sub-audio range but the apparatus could still, in principle, contain a wave from the virgin past. The apparatus and its implications have been discussed in *Journal of Physics-A* vol. 15, 1982, pp.405-8.

To achieve exceptionally slow velocities of propagation in a transmission line it is usual to increase the permeability and permittivity μ_r and ϵ_r or *equivalently* to increase the capacitance and inductance per unit length by the use of 'lumped' circuits, in which discrete large values of L and C are cascaded to form a continuous line of discrete sections. The physical principles in such a line remain the same electromagnetic principles as those in a continuous distributed line which for an equivalent propagation velocity would require impractical values of permittivity and permeability. Phenomenologically, the set of lumped circuits in the apparatus to be described form a dense medium, whereas at low frequencies the molecules in a 'continuous' dielectric behave, on a microscopic scale, as separate systems below resonance.

The arrangement uses a lumped-circuit transmission line in which there are 32 sections giving a total delay of 120ms. The inductors are small 1:1:1 transistor coupling transformers (RS Components) with their windings connected in series to increase the inductance. The capacitors are 1μF polycarbonate types from the same supplier. There is a small loss of the order of 1dB in each section of the line and small linear repeater amplifiers are included in the circuit to compensate for this loss. These repeater amplifiers consist of an f.e.t. input stage feeding a bipolar output stage and the gain is set to compensate for the loss in the adjoining section of line. The complete line is looped on itself in a geometrically circular configuration as in Fig.3.

Energizing the linear repeater amplifiers in the completely closed circular loop causes an oscillation to build up in which a sinusoidal wave with a period of approximately 120ms propagates around the system in a clockwise direction. A slight roll-off in the response of the system, together with the maintenance of just sufficient gain to compensate for the losses, ensures that the waveform remains sinusoidal for long periods. The continuity of the cycling sinusoidal wave places the system in the general category of phase-locked particles*, the particular mode corresponding to one complete wavelength around an annular system. It is possible to inject a signal into the system to initiate the circulation of the wave but one cannot differentiate such a wave from that resulting from self-oscillation, and the last-mentioned serves equally well to demonstrate the phenomenon under discussion.

The whole system is arranged mechanically in a well-balanced configuration on a strong laminated plastics disc, and power to the repeaters is supplied from two small 9 volt batteries strapped symmetrically behind the disc. At the centre of the disc there is a hub which is firmly attached to a small variable speed electric motor.

Upon energizing the repeater amplifiers, a travelling wave moves round the system in a clockwise direction and the travelling field may be sampled at take-off points associated with each of the capacitors. The 32 elements give a sufficiently close approximation to a continuous line and a reasonably pure sinusoidal wave may be detected passing each of these points. An alternative display system consists of a set of red light-emitting diodes, each of which glows on the passage of the positive crests of the wave, and a set of green light-emitting diodes, each of which glows on the passage of the negative troughs. When at rest the disc then exhibits a circle of rapidly flickering red and green lights corresponding to the circular rotation of the wave system at about 8Hz.

The disc is now spun in an anticlockwise sense at such an angular frequency that it is precisely equal and opposite to that of the wave. At this velocity, the wave, whilst still travelling relative to the disc, becomes stationary in the laboratory. The resulting potentials may be sampled to confirm the stationary state of the field system, but the most vivid demonstration of its state is given by the light-emitting diodes which form two stationary arcs, as shown on the front cover, one of positive (red) and the other of negative (green) potential relative to the centre. With careful adjustment of the speed of rotation, this static dipole electric field may be maintained indefinitely in the laboratory.

It should be stressed that the effect is truly that of a static field and neither a rapidly reversing field, as in standing wave systems, nor a stroboscopic artefact. The crests and troughs of the travelling wave are truly brought to rest in the laboratory and indeed it is possible to reverse the original direction of propagation, without reflection, by increasing the rotational speed of the motor.

An interesting conceptual problem then arises with regard to the magnetic field of the wave. The particular apparatus described here is not designed in such a way that the magnetic field may be sampled and there can be two schools of thought on whether or not it is also stationary. One argument is that as the charges are not moving in the laboratory there ought to be no magnetic component. The other argument is that as the travelling wave has a magnetic field in phase with the electric field this magnetic field should appear stationary when the electric field is ren-

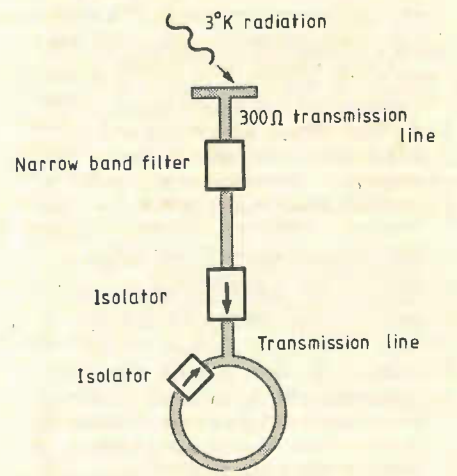


Fig. 2. More practical arrangement for putting the wave into the circular line.

* Jennison, R. C. and Drinkwater, A. J. *J. Phys. A*. vol. 10 1977. pp. 167-79. Jennison, R. C. *J. Phys. A*. vol. 11 1978, pp. 1525-33. *J. Phys. A*. vol 13 1980 pp. 2247-50. Second Oxford Quantum Gravity Conference (London: OUP) pp. 657-69. *J. Phys. A*. vol. 15 1982, pp 405-8. *Wireless World* vol. 85 1979, June pp. 42-7.

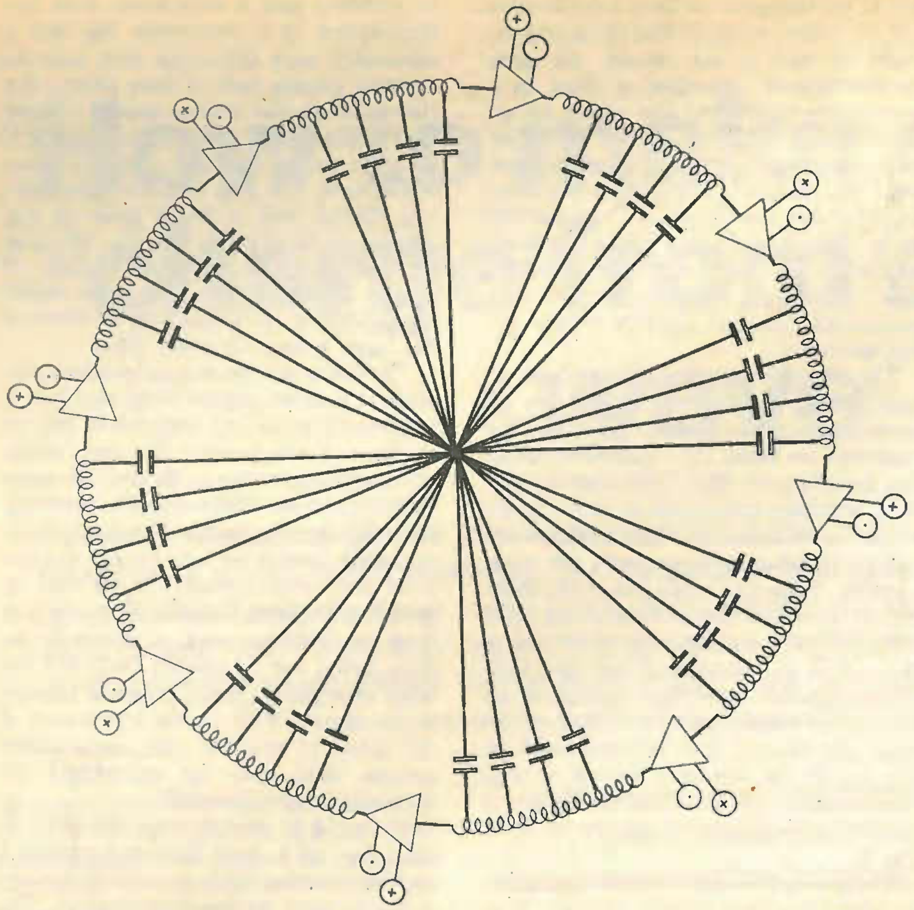


Fig. 3. Artificial delay line whose construction is described in the text in which a wave runs in the clockwise direction. Rotation of the system in an anticlockwise direction at the same angular frequency as that of the wave produces a static field. Red and green light-emitting diodes, connected at the points marked + and ·, indicate the stationary wave, as on the cover photograph.

dered stationary. It appears that the first argument is fallacious for it ignores the motion of the system relative to the wave and there is also no known mechanism whereby the Maxwellian property of the wave system should break down even when the velocity, relative to the observer, is reduced to zero.

This demonstration is crude but very enlightening. We have got rid of one of the criminals who were travelling hand-in-hand at the beginning of this article. Nature probably has a much better way of achieving the same thing by so convoluting the electromagnetic field in the unique mechanism of electron-positron pair production that a perfect system is formed which has all the stable and wonderful properties of an electron and merits the concept of charge which is now fully ingrained in our conception of the properties of matter.

Having formed a static field from a travelling electromagnetic wave I am quite content, contrary to other views expressed in *Wireless World*, that if I hurl it around on a string it will give rise to freely propagating electromagnetic waves at the frequency of rotation, the energy coming from my muscles as I whirl the string. If, however, you ask me what these electromagnetic fields are then I must confess, along with Feynman, that I have not the faintest idea. It is a pity that some of the classical apparatus has disappeared from modern teaching. It is my belief that every budding researcher should be given a gold leaf electroscope to contemplate for a few minutes every day. Ultimately someone may really explain the phenomenon which keeps the leaves apart. WW

Professor Roger C. Jennison, B.Sc., Ph.D, C.Eng., FIEE, FIP, FRAS, PPIE, FRSA, was born in Grimsby and studied engineering in Hull before volunteering for aircrew in 1942. Demobilized in 1947, he decided to start again and read physics at Manchester University, graduating with an Honours degree in 1950 and a Ph.D. in radio astronomy in 1954. In this period he deduced that the Cygnus A radio 'star' was double, invented 'closure phase' and a number of other techniques and was successively lecturer in radio astronomy, then senior lecturer in radio astronomy, and later in physics. In 1959 he turned his attention to medium-wave radio astronomy and cosmic dust research. He developed the first foil detectors and with experiments on rockets and the Ariel II satellite he showed that there was no danger to space travel from the cosmic dust which had previously been thought to be a severe hazard. In the early 1960s he became interested in problems of gravitation and rotation and was also elected President of the Institution of Electronics. In 1965 he accepted the chair of physical electronics at Canterbury where he founded the Electronics Laboratories and recently added a chair of radio astronomy to his titles. He has maintained an interest in trying to understand fundamentals and has contributed an alternative explanation of inertia and quantization among his 90 published works.

LITERATURE RECEIVED

Over 40 different types of **coaxial cables** for data transmission, radio and microwave frequency transmission and communications are listed in a brochure from Greenpar Connectors, PO Box 15, Harlow, Essex, CM20 2ER. **WW401.**

A tutorial manual describes the generation of **graphics** using Regis (remote graphics instruction set) for use with the VT125 terminal. The VT125 Regis Primer consists of 11 chapters in 130 pages and provides a full description of each command or function with worked examples and illustrations. £6 from Rapid Terminals, Denmark Street, High Wycombe, Bucks HP11 2ER. **WW402**

'Magnetic materials and components' is a folder containing information on the Arnold ranges of Mo-permalloy powder magnetic cores, and other iron powder cores, tape-wound cores, and other magnetic materials. Walmore, who issued the folder as well as stocking other manufacturers' magnetic materials, also manufacture ferrite toroidal cores for use in switching power supplied. Walmore Electronics Ltd, 11 Betterton Street, London WC2H 9BS. **WW403**

The **Toolrange** catalogue in its latest 1983/84 edition is even bigger than its predecessors, listing tools, tool kits and tool boxes as well as a range of test instruments and other production aids. Anything from tweezers to power drills. Toolrange Ltd, Upton Road, Reading, Berks RG3 1BR. **WW404**

SATN and TK!SATN, two publications from Software Arts, are for users of Visicalc and TK!Solver **data processing** packages. Available from Software Arts Products Corp, 27 Mica Lane, Wellesley, MA 02181, USA. **WW405**

Photomultiplier tubes (with high efficiency arc rubidium-caesium types), according to literature from Thorn EMI Electron Tubes Ltd, Bury Street, Ruislip, Middlesex HA4 7TA. The new tubes are plug-in replacements for the older ones in the Thorn EMI range. **WW406**

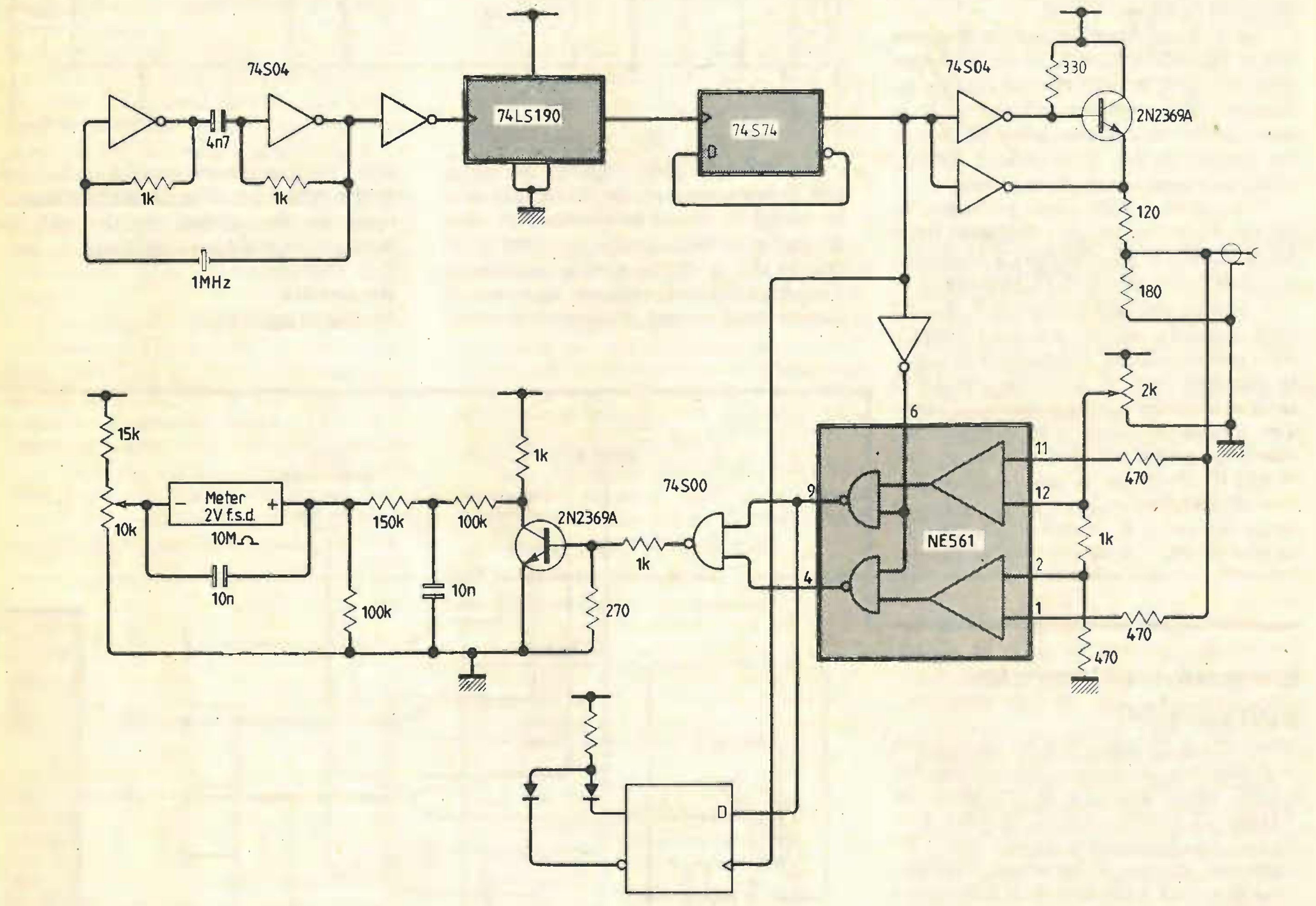
CIRCUIT IDEAS

Direct reading cable reflectometer

This circuit measures the length of a cable by comparing the delay of a reflection of a rising edge sent down the cable with a standard time interval.

A 20µs 2V square wave is driven into the cable from 75Ω and a fast dual comparator NE521 and nand gate give 0 output during the period that the waveform is between ½ and 1½V. **During negative half-cycles** the comparator is gated off to prevent falling edges on an open circuit triggering it. The resulting waveform is amplified and clipped, filtered to leave only average d.c., and applied to a digital panel meter. Zero cable length gives approximately 1V d.c.; 1000m gives approx. 2V, thus 1mV = 1m = 10ns. Open/short circuit indication is given by latching the output of the comparator with the higher (1½V) threshold just before the falling edge of the drive waveform.

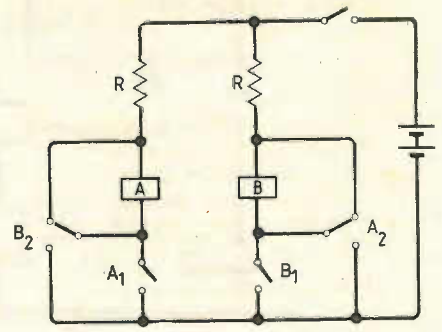
J. Andrew Suter
Thames TV Ltd
London



Predictable relay oscillator

A single relay connected to interrupt its own supply simply behaves like a buzzer. And the same is true for a pair of relays connected so that each cuts the supply to the other when energized. So the usual oscillator employed by British Telecom uses three relays, as described by Atkinson (Telephony II, page 304). The relays are arranged in a ring, so that each when energized cuts the supply of its predecessor. Also each coil has a resistor connected in parallel, to delay release. When power is applied to the ring there is a short and unpredictable struggle, followed by regular cyclic oscillation.

A predictable two relay oscillator is shown below. Contact positions are drawn for S open *(Except for B_2 – sorry)*.



This arrangement cannot act like a buzzer, because of the toggle action. Thus relay A cannot cancel its instruction to relay B at once, but instead its changeover contact must move right across its gap. Output can be taken from a further contact. Frequency is 3-10Hz, depending on obvious factors.

A relay oscillator will usually be started by the contact S when output is required, so start-up is of interest. The version illustrated has entirely predictable start-up, and saves a relay. It has functioned cheerfully for 20 years in a private telephone exchange.

M. McLoughlin
Haberdashers' Aske's School
Elstree

Opto-coupled trigger for electronic ignition

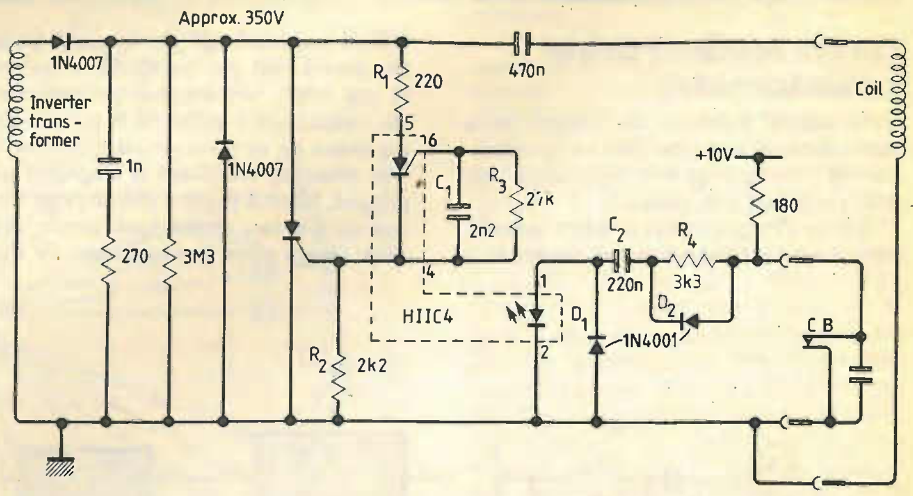
This circuit is designed to improve the triggering performance of capacitor-discharge ignition systems using thyristors as the discharge element. This is accomplished using an opto-thyristor which, while providing an enhanced drive to the discharge s.c.r., requires a reduced drive from the points circuit. This circuit has been tested with both the Marston (Jan 1970) and Cooper (March 1982) circuits described in *Wireless World*.

One of the problems in ignition design is that of the gate sensitivity of the discharge thyristor; if it is high the circuit can be triggered by transients and the s.c.r. is more costly. If it is low, large RC values are needed in the differentiator circuit, which may upset timing at high revs.

This circuit avoids these problems by the use of an opto-s.c.r. obtainable from RS as 308-001 or the GE H11C4/Monsanto MCS2-400. It is a 6-pin d.i.l. package.

A 100mA gate-sensitivity s.c.r. is used with a 2.2kΩ resistor mounted directly from gate to cathode. When the opto-s.c.r. is triggered current flows via the 220Ω resistor until the conventional s.c.r. fires. The opto-s.c.r. then self commutates, effectively giving d.c. gating. Components C_1 and R_3 are chosen to give best suppression of transients over a wide temperature range. Reducing R_3 would reduce the sensitivity of the opto-s.c.r. but would increase the light drive required for operation at low temperatures. If the unit is to be potted C_1 should be increased in value to cope with the increased coupled dV/dt due to the μ_r of the potting compound. The drive circuit is basically that used by Cooper with revised differentiator values and a diode in inverse parallel to the l.e.d. in the opto-s.c.r. The circuit has been in operation for several months and has shown no sign of false triggering.

P. J. Dinning
Burnopfield
Newcastle upon Tyne

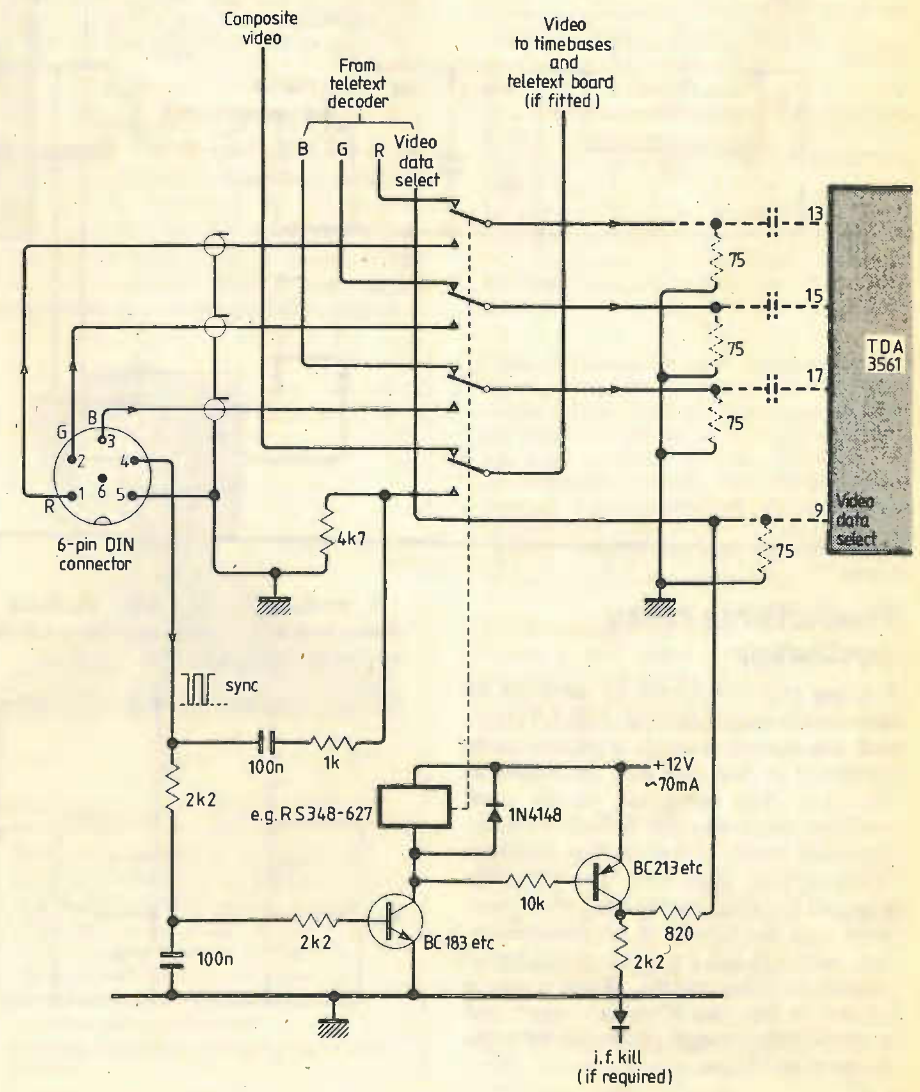


Economical monitor conversion

Many recent teletext colour tvs can be used as RGB-input monitors as this interface for a BBC computer and a tv set using the TDA3560 series colour-decoder i.cs shows. Synchronization signals from the computer operate a miniature four-pole relay to switch RGB signals to data inputs of the TDA3561 and route computer sync. signals to line and field timebases. The p-n-p transistor forces the TDA3561 data/video control terminal to the data state and might be used to disable the i.f./detector i.c. to prevent video breakthrough. RGB outputs of this computer are not standard video levels and require attenuation; long connecting leads should be avoided since synchronization output is t.t.l.

Teletext decoders are often fed by the composite-video signal sent to the tv timebases and it is worth ensuring that the decoder also receives computer synchronization signals at its video input. With some makes of receiver, switching to teletext mode will remove interlace flicker on the computer display. Check that the receiver chassis is mains isolated before making the modification.

Richard Norwood
London SE25



Non-volatile ram module

A non-volatile ram module can be constructed using a low-power static chip and a few additional components. The basic requirement for non-volatility is to maintain the static ram in a standby mode when it is removed from the external circuit or when the external power supply is switched off. The stand-by mode is achieved by maintaining about 3 to 5 volts on the supply pins of the ram and by holding the chip enable line, $\overline{CE}$, within a few millivolts of the positive rail. The low-power static rams, such as the HM6116LP-4, draw only 4μA in a stand-by mode. Thus small mercury cells may be used as a 'power' supply that will last, theoretically, for years. It is important that the stand by cells do not drain down to the external circuit when the external supply is switched off. It is also important that no voltage exists between any two pins of the non-volatile ram module when unpowered.

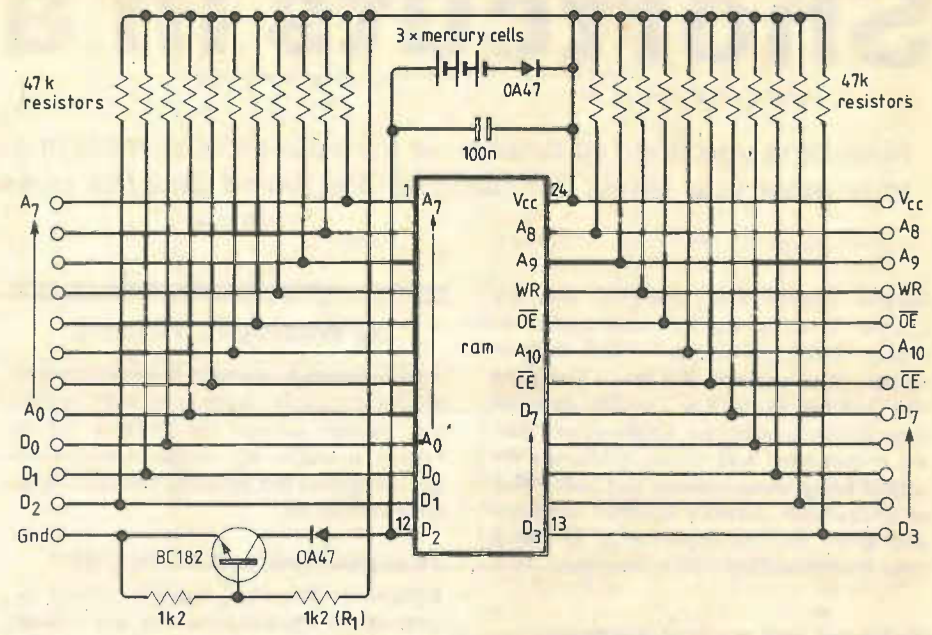
The circuit shown achieves all these requirements. Three 1.4V mercury cells (type MP675H, or similar) maintain a potential of about 4V on the chip in the absence of external power. The OA47 diode, in series with the cells, protects them from the external supply. All other pins of the chip (except GND) are maintained at the positive supply rail potential through 47kΩ resistors. To isolate the module from external circuitry when the external supply is switched off, a transistor switch is placed in the GND line. The presence of an external supply turns the transistor 'on' and its absence turns it 'off'. The OA47 diode in series with the transistor prevents the mercury cells from discharging through R1 and the transistor's base-collector diode.

N.B.: The 6116, 2K by 8 bit, low-power static rams come in many guises; some lower power than others. The following information may be of some help:

HM6116P-3 150ns access time, 180mW active, 100μW stand-by
HM6116P-4 200ns access time, 180mW active, 100μW stand-by
HM6116LP-3 150ns access time, 160mW active, 20μW stand-by
HM6116LP-4 200ns access time, 160mW active, 20μW stand-by

These are pin-equivalent to the 2716 eprom.

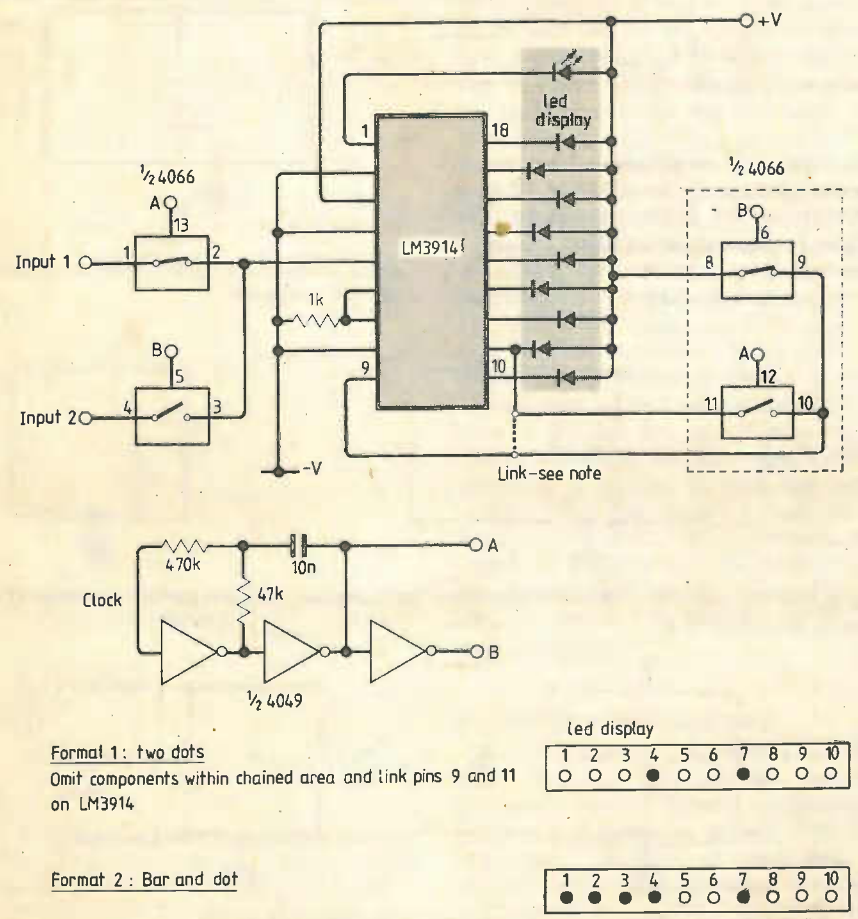
A. J. Ewins
North Harrow
Middlesex



Two-signal bargraph

Here is a circuit which enables two signals to be displayed on one driver/display. Suitable drivers are type LM3914,5,6 which provide linear, logarithmic or VU response. The simplest arrangement is to use a dot mode display and mulitplex the two input signals at high speed. Two leds are thus lit and represent each of the input signals. A stereo VU meter can therefore be configured with one display. The multiplexer uses two sections of a 4066 analogue switch and three inverter gates to form a clock oscillator. The remaining gates of the 4066 can be used to give an alternative display format by switching the display driver between dot and bar modes in synchronism with the input multiplexer. One input signal is then represented as a bar and the other as a dot. Clearest indication is obtained when the dot amplitude exceeds that of the bar. This arrangement was used to provide simultaneous display of peak and r.m.s. values of an audio signal.

Richard Golding
Shrewsbury
Salop



Sound-generator interface. Pins nine and 15 of this circuit idea in the May issue are transposed and so are their signal names.

Shortcuts in analysis

Next time you need to determine the voltage or current in a circuit, one of these shortcuts may save you time. Calculations are saved and the possibility of making an error is reduced.

by Wesley A. Vincent

Several simple but powerful network analysis shortcuts can be easily applied to reduce circuit calculations. These include voltage and current dividers, Thévenin and Norton equivalent circuits and the superposition principle. Quite often, they are overlooked, and circuit problems are solved using more tedious methods. This article reviews network analysis shortcuts and gives you an opportunity to check your understanding with a short quiz.

Voltages and current dividers

Perhaps the simplest shortcut is based on the voltage and current divider effect. The voltage divider effect allows one to calculate the voltage or IR drop across any resistor in a series circuit without first finding the current. For example, the IR drops across R_1 in Fig. 1, is obtained using the expression

$$\frac{V_{IN}R_1}{R_1+R_2+R_3},$$

and equals two volts. In general, the voltage across any series resistor is obtained by multiplying the source or input voltage times the resistor of interest and then dividing by the total series resistance of the circuit.

In many circuit applications, resistors are connected in parallel to form current dividers as shown in Fig. 2. The current divider principle allows one to quickly determine the current in each branch. The formula is analogous to the voltage divider with one important difference: the reciprocal of each resistor is used. For example, in Fig. 2(a), the branch current through R_1 is found using the formula

$$I_1=\frac{I_T\times\frac{1}{R_1}}{\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}}.$$

The particular case involving just two parallel branches occurs frequently as shown in Fig. 2(b). Resulting expressions are

$$I_1=\frac{I_T\times R_2}{R_1+R_2} \text{ and } I_2=\frac{I_T\times R_1}{R_1+R_2}.$$

For these special cases, each branch current is found by multiplying the opposite branch resistor times the total current and then dividing by the sum of the branch resistors. In Fig. 2(b), $I_1 = 3mA$, using the above shortcut. When using the current divider principle, there is no need to find the voltage across the resistor before branch currents are found. Calculations are saved, and the possibility of making an error is reduced.

Wesley Vincent is an electronics engineer in Bringhurst, Indiana.

Thévenin and Norton theorems

Frequently in circuit analysis, we are interested in determining how the voltage varies at two terminals. In the amplifier circuit, for example, the effect of changing the load resistor may be required. Thévenin's theorem reduces circuits using resistors, capacitors and inductors, along with voltage or current sources to a simple series circuit. To illustrate the theorem, the circuit in Fig. 3 is used as an example. To find the Thévenin voltage, denoted V_{TH}, first open the terminals a-b for the network on the right and then calculate the open circuit voltage without R_L connected. For this circuit, V_{TH}, is found using the voltage divider

$$\frac{V_{IN}\times R_3}{R_1+R_3} \text{ or } 3V.$$

Note that, with the terminals a-b open, no current exists in R_2, so it has no effect in determining the Thévenin voltage. The Thévenin equivalent resistance, R_{TH}, is determined by calculating the equivalent resistance seen looking into the terminals a-b with the voltage source shorted. For the circuit shown, R_{TH} is the parallel combination of R_1 and R_3 in series with R_2 and equals 2.5 kΩ. If current sources are present in a circuit, they are opened (removed) when finding R_{TH}. For the Thévenin equivalent circuit in Fig. 3, it's easy now to calculate the output voltage across the terminals a-b as R_L varies. All that's needed is application of the oltage divider principle as discussed in the last section. More complex circuits are reduced in a similar manner, even though V_{TH} and R_{TH} may be more difficult to determine. But it's easier than the alternative of solving simultaneous loop equations for each different value of R_L.

Another useful circuit theorem, called the Norton theorem, results in the "dual" of the Thévenin circuit and is shown in Fig. 4. The Norton current source, denoted I_N, is the current through the terminals a-b if they were shorted. The equivalent resistance, R_N, is the resistance seen looking into the terminals a-b with any voltage sources shorted or current sources removed from the circuit. The Norton equivalent circuit is particularly useful for determining the current through different load resistors connected to the output terminals.

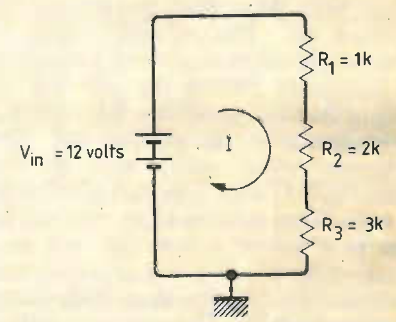


Fig. 1. Voltage divider consists of a voltage source and series resistors. (Positive current notation is used in this article.)

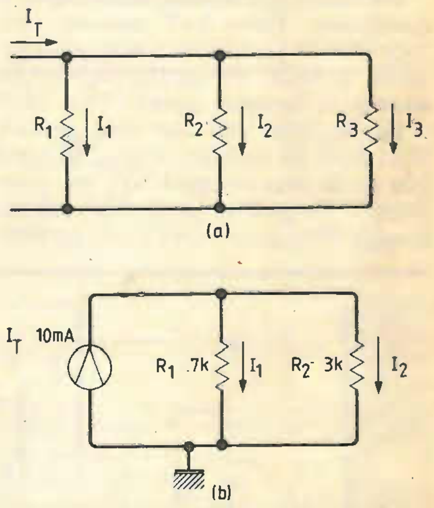


Fig. 2. Current dividers formed with parallel branch resistors.

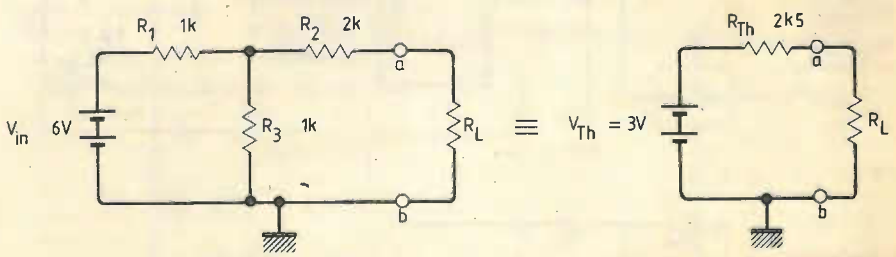


Fig. 3. Making use of the Thévenin theorem; both circuits have the same responses at the output terminals a-b.

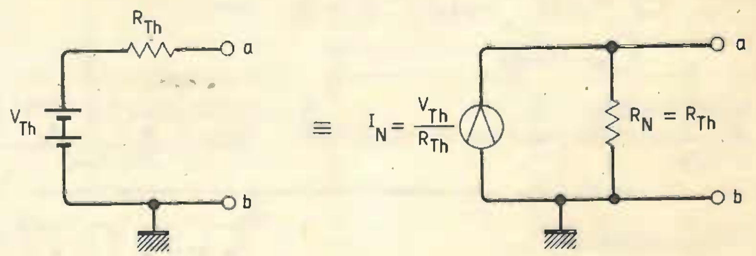


Fig. 4. Finding the Norton circuit from the Thévenin circuit.

Superposition principle

One of the most powerful circuit analysis tools is the concept of superposition. This principle applies to circuits containing more than one voltage or current source and allows the total response from a circuit to be found as the sum of each source acting alone.

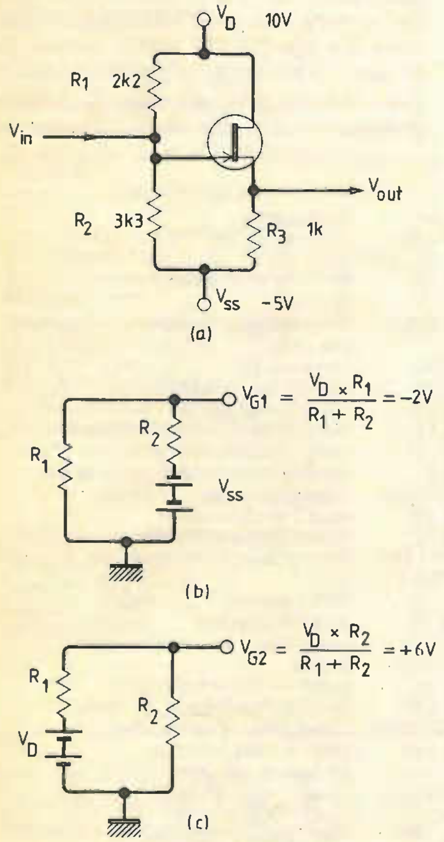


Fig. 5. Using superposition to find the dc bias on the gate of a j-fet amplifier. Original circuit (a), determining the effect of V_{SS} (b), and determining the effect of V_D (c).

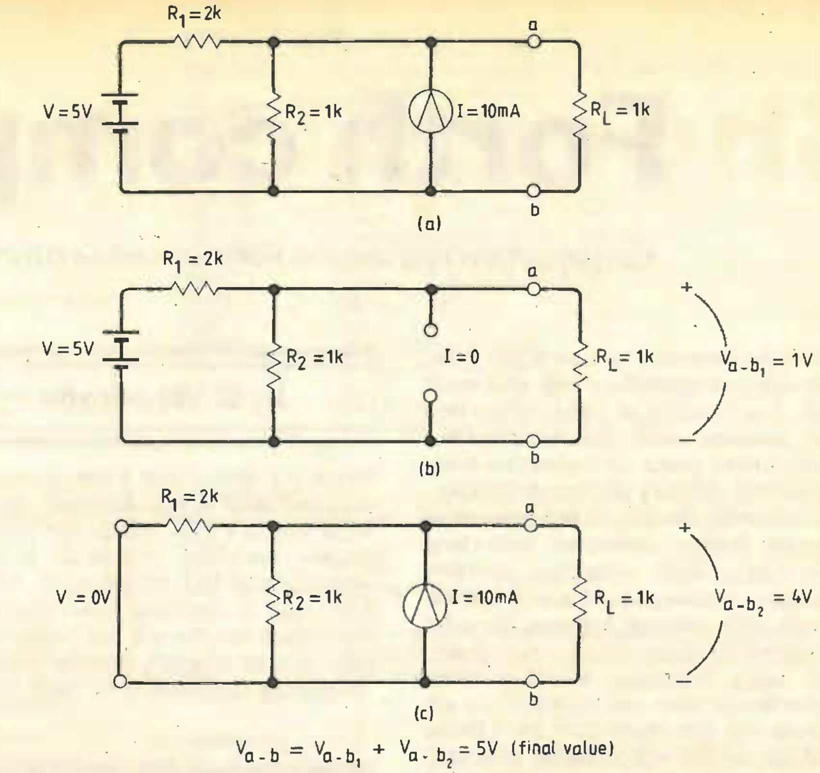


Fig. 6. Using superposition with a current and voltage source. Original circuit (a), circuit with current source open (b), and circuit with voltage source shorted (c).

The usefulness of superposition is demonstrated by finding the d.c. bias on the gate terminal of the j-fet amplifier in Fig. 5(a). (Only leakage current exists through the gate terminal of the j-fet, and its effects will be considered negligible in the calculations.) The effect of each source acting alone is determined from the circuits shown in (b) and (c). The responses from each circuit are added together to give a gate voltage of 4V for the circuit in (a). The gate voltage can be found almost by inspection using this technique. It's important to note that, except for the source under consideration, other voltage sources in the circuit are shorted and current sources are opened.

Figure 6 illustrates the use of superposition, along with voltage and current dividers, when a current source is present. In (b), the current source is first removed, and the output across terminals a-b is found. Here, the voltage divider principle is used with R_1 and the parallel combination of R_2 and R_L. In (c), the voltage source is shorted, and the current divider principle is applied to find the output voltage. Once the output voltage for the circuits in (b) and (c) are determined, their results are added to give the output voltage for the original circuit in (a). For the circuit shown, the voltage across the terminals a-b is 5V.

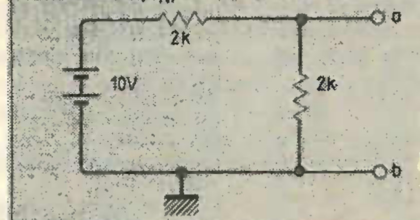
Capacitors and inductors

All of the circuits in this article contained only resistors. But all the shortcuts discussed apply to circuits containing capacitors and inductors as well. Instead of resistance, reactance is used and impedance replaces combinations of resistors and resistance. WW

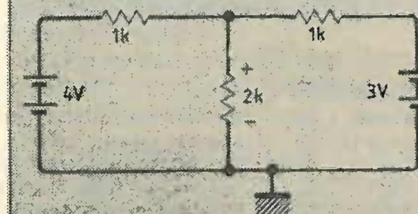
Test yourself

As a test of your understanding of the principles discussed, try your hand at the quiz below. Then turn to page 57 to determine your score.

Question 1. What is the voltage across R_2 in Fig. 1, using the voltage divider principle?
Question 2. What is the voltage across R_3 in Fig. 1?
Question 3. For the circuit shown in Fig. 2(b), how much current exists through R_2?
Question 4. What is the IR drop across R_1 in Fig. 2(b)?
Question 5. If R_2 = 1k instead of 2kΩ in Fig. 3, what is the value of the Thévenin voltage V_{TH}?
Question 6. If R_2 = 1k instead of 2kΩ in Fig. 3, what is the value of the Thévenin resistance R_{TH}?
Question 7. What is the Norton equivalent current, I_N, for the circuit below?



Question 8. What is the Norton equivalent resistance, R_N, for this same circuit?
Question 9. Using the superposition principle, what is the IR drop across the 2kΩ resistor in the circuit below?



Question 10. If the polarity of the 4V source is reversed, what is the IR drop across the 2kΩ resistor?

Forth computer

Construction tips for the 6809-based Forth computer – part four.

by B. Woodroffe

Most of the prototype version of this computer was constructed on one wire-wrap board. The number of signal buses rendered anything other than a multilayer printed circuit board an impractical solution without splitting the circuit into sections. Splitting the circuit was rejected to eliminate buffers associated with long cable runs. Wire wrapping provides connections at least as good as solder joints through cold welding between the wire and edges of the pin.

All main memory, refresh circuit, microprocessor rom and interface i.cs are mounted on the main 229 by 178mm board, as are the video-display processor and memory. The analogue video gate and RS232 driver are built on two 16-pin dip headers. User-port hardware and the disc-drive interface between the floppy-disc controller and the drive are housed on a second wire-wrap board. There are many connections on the board so a powered wrapping tool, a stripping tool and different coloured wires for different functions are useful. Copper-clad board was used for the power supply, which should be constructed before the main processor board.

Dynamic ram takes little static current but substantial pulses, reaching toward 80mA per device over a few nanoseconds on some clock edges. Although the rams work within a 10% voltage tolerance, for reliable operation substantial local decoupling must be included in the +12 and −5V rails to overcome power-line inductance; each ram has a 0.1μF ceramic capacitor on both supplies. Further 10μF bulk decoupling capacitors were used, one between each four devices. Decoupling capacitors for the 5V rail were used throughout the design at the rate of one 100nF component for each six i.cs. As with the RAS/CAS/WE damping resistors, the design seems robust since the ram was initially built and worked without decoupling (see photograph).

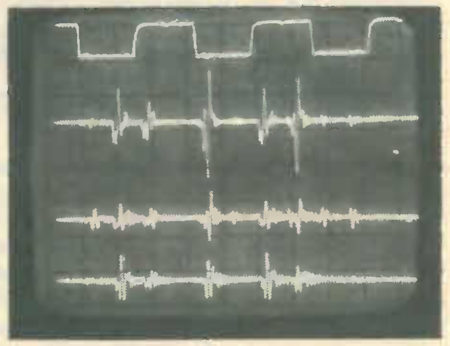
This is a large project and all construction errors were found to be the result of either miswiring or plugging in the i.c.s wrongly. Dynamic rams I currently use got very hot when I plugged them in back-to-front. Construction should start with a minimum system, i.e. c.p.u., p.i.a., eproms and a 16K ram. At switch on, the lamp connected to the p.i.a. B-port D_0 line will go on then off. The state of this lamp then monitors the state of i/o data on the line. Ram-select lamps will stay off. V.d.u. hardware is self-contained so an idea of its performance can be seen on a tv screen without involving the main processor as the video i.c. generates its own characters.

Connection of the parity circuit to HALT should only be made after the ram circuits are known to work, i.e. when the system ready message can be displayed consistently. Should the RS232 connection fail to work, the most likely cause, especially if a signal at the a.c.i.a. output can be seen on resetting, is that data lines on pins two and three are crossed. Another problem could be that the RS232 terminal takes too much current from the −5V supply, an indication being that the rams persistently give parity errors on power up which disappear when the RS232 terminal is disconnected. Forth response OK is preceded by the stack depth.

The problem of driving capacitive loads with l.s.t.t.l. outputs showed up as undershoot in signals passing from the interface board to the controller. Although the prototype worked with the undershoot, it was cured by taking an inverted version of the required signal back to the main board and inverting it there with a spare l.s.t.t.l. gate. Capacitance of the insulation-displacement connection between the two boards was avoided in this way. Spare connections on the inter-board connector should be grounded and ground should be placed near active signals, e.g. clocks, disc data.

Although for 8K of memory one gets a compiler and operating system and programming and execution unit there is still much to be done. I think that games are one of the best ways to learn about computers for the definition of a problem to be solved is often as difficult as solving the problem. Forth is particularly suited to games programs – the *Byte* game contest was won by a game written in Forth[10].

Brian Woodroffe works in research and development at Hewlett Packard.



Voltage transients at the 4116 dynamic rams showing from top to bottom the E clock signal and +12V, +5V and −5V supply lines with a 200ns/div timebase.

Main-board components

Resistors

Value	Qty	Function
10k	8	pull-up, FIRQ, IRQ, NMI, VFOE, RESET, video and RS232 output
10k	2	pull-out parity, video ram, 9-resistor sil packs
100	1	dot-clock
500	1	dot-clock trimmer
20k	1	monostable timing, 5%
400	4	pull-up, led
33	5	damping, RAS, CAS, R/W
75	1	video output
150	1	video output
1k	5	video and RS232 output
2.3k	1	video output
4.7k	1	video output
2k	1	video output
2k	1	video output, trimmer
5.1k	2	RS232 output

Capacitors

Value	Qty	Function
100μ	2	+5V decoupling, 25V
20μ	2	+12V decoupling and reset, 25V
10μ	8	−5V and +12V decoupling, 25V
100n	57	−5, +5 and +12V decoupling
20p	2	crystal decoupling, 10%
51p	1	dot clock, 5%
20p	1	monostable timing, 5%

Integrated circuits

Ref	Qty	Pins	Type	Comments
11	1	14	LS280	parity checker
12-110	9	16	4116	see note
21	1	28	I3242	address multiplexer
22-210	9	16	4116	see note
31,67	2	20	LS245	bi-directional buffer
32-310	9	16	4116	see note
41,44	2	14	LS04	hex inverter
42,47	2	14	LS00	quad 2-input NAND
43,72	2	12	LS02	quad 2-input NOR
45	1	16	LS112	dual JK bistable multivibrator
46,53	2	16	LS161	sync. binary counter
47,48	2	14	LS37	quad 2-input NAND clock driver
51	1	40	M6809A	microprocessor, 1.5MHz
52	1	16	LS139	dual 2-to-4 decoder
53	1	14	LS122	monostable multivibrator
54	1	40	WD1793	floppy-disc drive controller
55	1	40	M6821	p.i.a.
62,63	2	24	I2732	4K by eprom, T_{acc}=450ns
56	1	16	LS175	quad D bistable
66	1	16	LS157	quad 2-to-1 line multiplexer
71	1	24	M6850	a.c.i.a.
73	1	14	LS86	quad 2-input ex-OR gate
74	1	14	LS132	quad 2-input Nand, schmitt
75	1	28	EF96364	video display controller
76	1	20	LS240	octal 3-state inverter
77,78	2	18	2114	1K by 4 static ram
81	1	14	LS00	quad 2-input NAND
83	1	14	LS04	quad 2-input NOR
84	1	16	LS161	sync. binary counter
85	1	24	I2716	2K by 8 eprom, T_{acc}=450ns
86	1	20	LS273	octal D bistable
95	1	16	LS165	8-bit serial shift reg.

See note for other i.c. locations

Other components

2N2222	5	video, RS232 output transistors
1N4150	2	video, RS232 output diodes
2N2907	1	RS232 output transistor
L.e.ds	4	parity checking, high-efficiency red

6.00MHz crystal
1.008MHz crystal
DIP headers for video and RS232 output
25-pin D-type connector for RS232 output
Single-pole two-way switch for display-page select
Three, 16-way insulation-displacement connectors
Vero 07-0130A wire-wrap board
Wire-wrap pins (1 packet), wire, tool, un-wrap tool and wire stripper. **Wire-wrap sockets:**

Pins	Quantity
14	14
16	39
18	4
20	4
24	4
28	2
40	3

Notes

Memory circuit was designed using Mostek MK4116-3 data sheet and most critical timing specification was T_{acc}=135ns (column-address strobe). Positions $IC_{57,82,92}$ are 16-pin dil for plugs a,b and c respectively. Positions $IC_{91,93}$ are also 16-pin dil for RS232 and video signals. Resistors are 10% and capacitors are +80/−20% except where tolerances are given.

Power supply

MC3405	op-amp/comparator, alternative 158 op-amp and 193 comparator
LM7812	12V, 1A regulator
2N2222	n-p-n (4 off)
2N2907	p-n-p (2 off)
2N4036	p-n-p (2 off)
2N6476	p-n-p (2 off)
2N4443	s.c.r.
1N437	ref. diode, alternative 1N960B 9V zener
1N4371	zener, 2.7V
1N4372	zener, 3V, alternative 2.7V
1N751	zener, 5.1V
1N963	zener, 12V
MR852	fast recovery diode
MDA970-2	bridge rectifier, 4A
1N4150	diode, alternative 30V switching diode, pref. Schottky
HLMP-1300	high-efficiency red led, 2.2V drop

Capacitors

1n	10%
470n	(2 off)
100n	(2 off)
22μ	10V tantalum
22μ	20V
1m	12V low equivalent series resistance, e.g. Sprague 672D046 or Dubilier UPC1052
8m	40V, alternatively 4m

Resistors

0.13	1W
100	(2 off)
133	0.25W
200	
680	0.25W
1k	0.25W (6 off)
1.5k	
1.96k	
3.16k	(2 off)
10k	(6 off)
28.7k	
75k	
100k	(5 off)
50k	preset pot.

Transformer is a 15V r.m.s. 2A type and should be protected by a 500mA slow fuse. A mounting kit is required for the 2N6476, a cooling tab for the T05 transistor, and the toroid is an Arnold A-930157-2 with 35 turns of 21 s.w.g. (not 19 s.w.g. as on the drawing). The toroid is available from Walmore Electronics Ltd, 11 Betterton Street, Drury Lane, London WC2H 9BS.

Disc interface

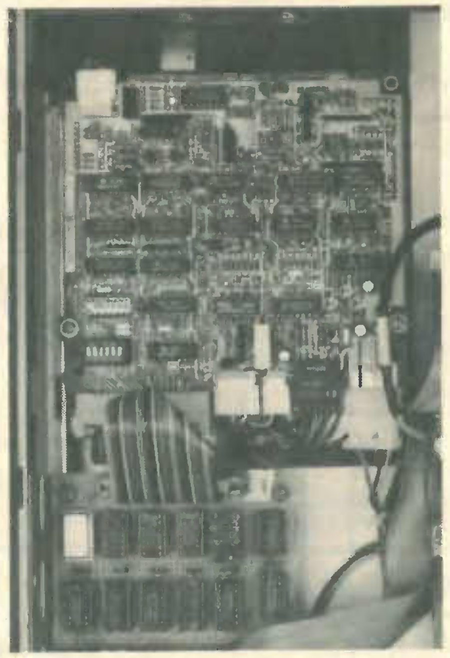
Type	Qty	Pins	Comments
LS244	1	20	octal buffer
'38	2	14	standard t.t.l. quad NAND, o.c.
LS123	1	16	dual monostable multivibrator
LS161	1	16	4-bit binary counter
LS163	1	16	4-bit binary counter
LS74	1	14	dual D bistable multivibrator
LS14	1	14	hex inverter, schmitt
LS04	1	14	hex inverter
K1160	1	14	8MHz oscillator (Motorola)
LS138	2	16	3-to-8 line decoder

Other components

Wire-wrap socket, 14 pin (4 off)
Wire-wrap socket, 16 pin (10 off)
Wire-wrap socket, 20 pin
Wire-wrap board 176 by 110mm, e.g. Vero 02-0120H
34-way insulation-displacement connector
34-way insulation-displacement cable to drive
Disc drive, e.g. Teac FD50A (up to 4)
Drive power connector (AMP1-480424-0)
Pins for above connector (AMP60617-1, 60619-1, 4 off)
Decoupling capacitors, 100n (6 off)
Decoupling capacitor, 100μ
Input resistors, 333 (4 off)
Input resistors, 220 (4 off)
Timing resistors, 30k (2 off)
Timing capacitor, 2μ 10V
Timing capacitor, 33μ 10V

Alternative oscillator components

Hex inverter, LS04
Resistor, 464 (2 off)
Capacitor, 20p
Crystal, 8MHz



Wire-wrapped disc interface board bottom, and the disc-drive main circuit board.

Reference

10. A. Saunton-Angus, Cosmic conquest, *Byte*, Dec. 1982, p.124.

Further reading

C. H. Ting, Systems Guide to Fig-Forth, Mountain View Press.
Forth Dimensions, Forth Interest Group, PO Box 1105, San Carlos, CA94070 (house magazine for members).

Brian Woodroffe has found a way of speeding up disc operations and data-transfer rates so that faster units such as the Sony Microdrive and 8in drives can be used with the Forth computer. Descriptions will follow.

300baud full-duplex modem

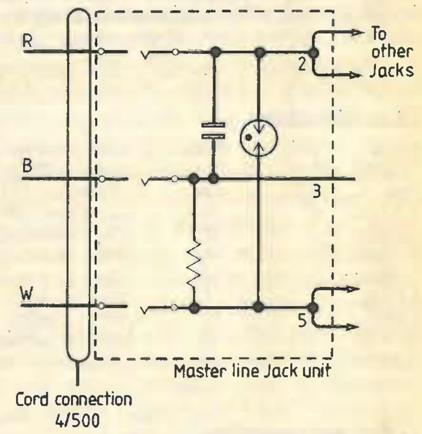
Direct-coupled modem described in the July issue has a separate circuit board for the auto-answer protocol required by CCITT

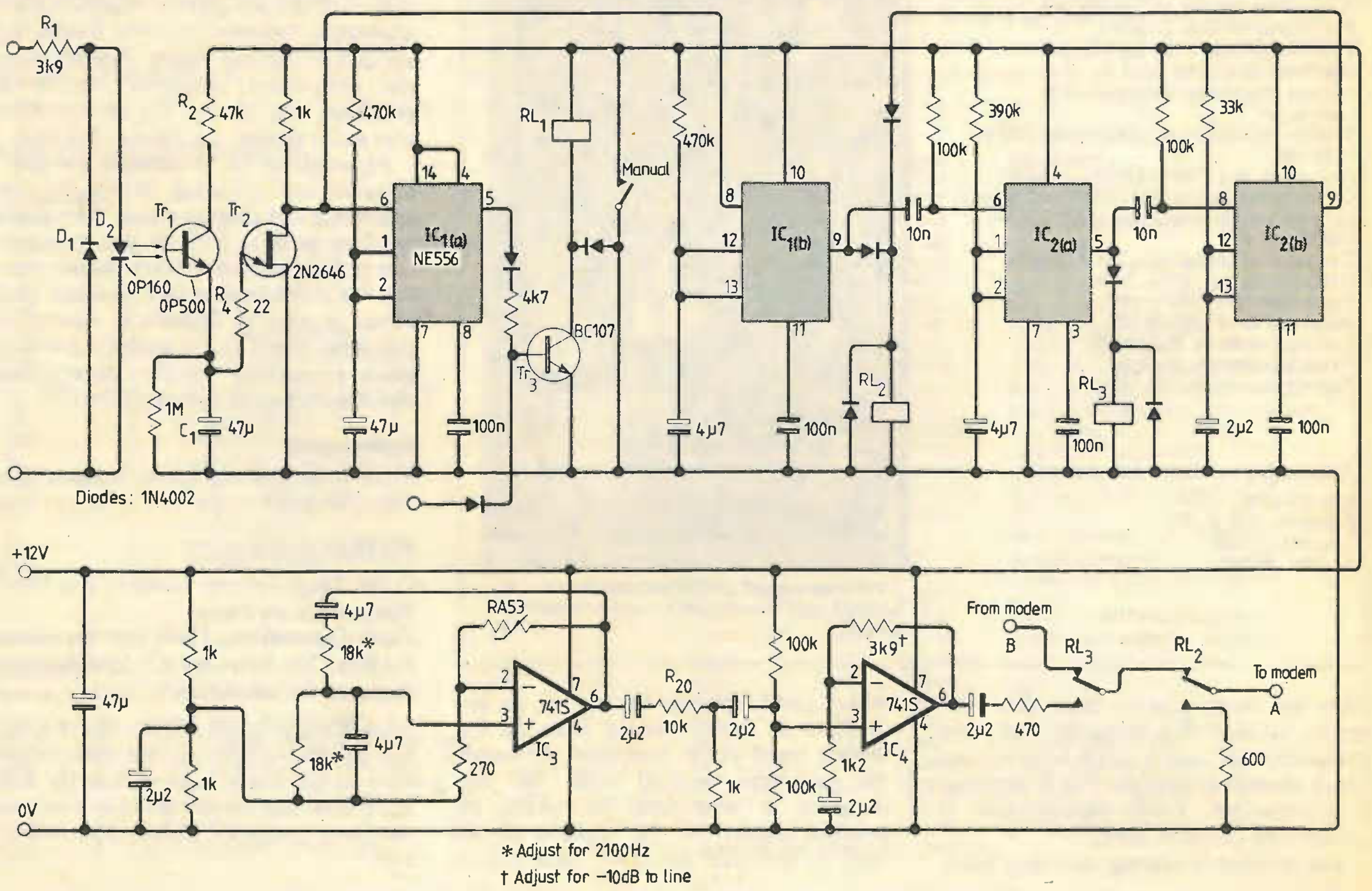
by Des Richards

This unit provides the interface between the telephone line and the equipment and is suitable for both private wire circuits and the public switched network. It also provides the necessary isolation of dangerous voltages and the transmission of the required signals together with the auto-answer protocol required by British Telecom in accordance with CCITT recommendation V25. The isolation is achieved in two ways: the ringing current is isolated by a discrete-component opto-coupler D_2 and Tr_1 and both the a.c. signal isolation and d.c. terminating conditions are achieved by a reed relay and isolating hybrid transformer (which will carry a primary current of up to 120mA d.c. without causing transmission loss to the signal path).

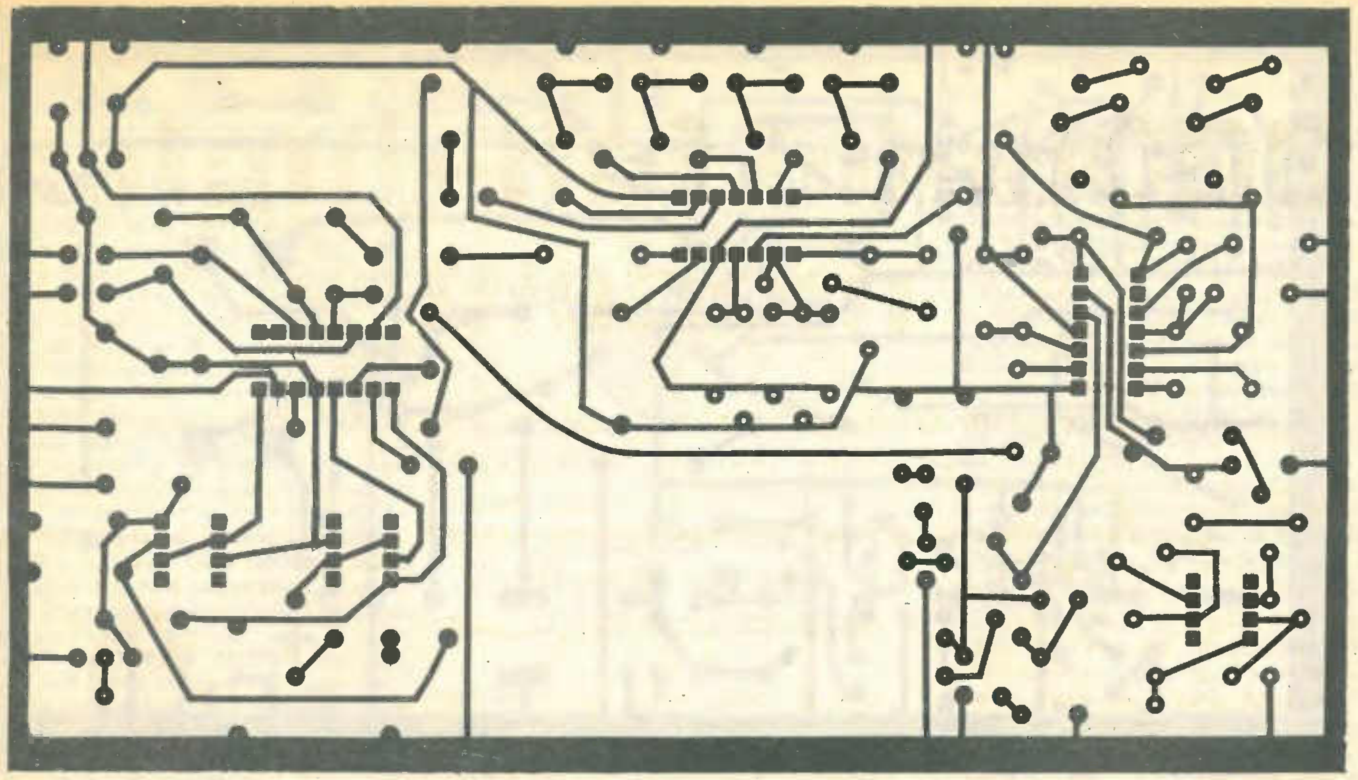
Operation is as follows. The ringing current is detected by D_2 and Tr_1, and causes C_1 to be charged via Tr_1 and R_2 until the voltage across C_1 reaches the threshold potential of the unijunction Tr_2. This conducts, discharging C_1 and causing the collector voltage to fall from 12V to about 0.7V. This negative-going transition changes the state of the two monostables IC_{1a} and IC_{1b}. The first has a time constant of approximately 30 seconds and the second a time constant of 2.15±0.35 seconds. The output of IC_1 drives Tr_3 to operate the reed relay RL_1 and answer the incoming call by placing a d.c. loop (T_1 primary) across the line terminals.

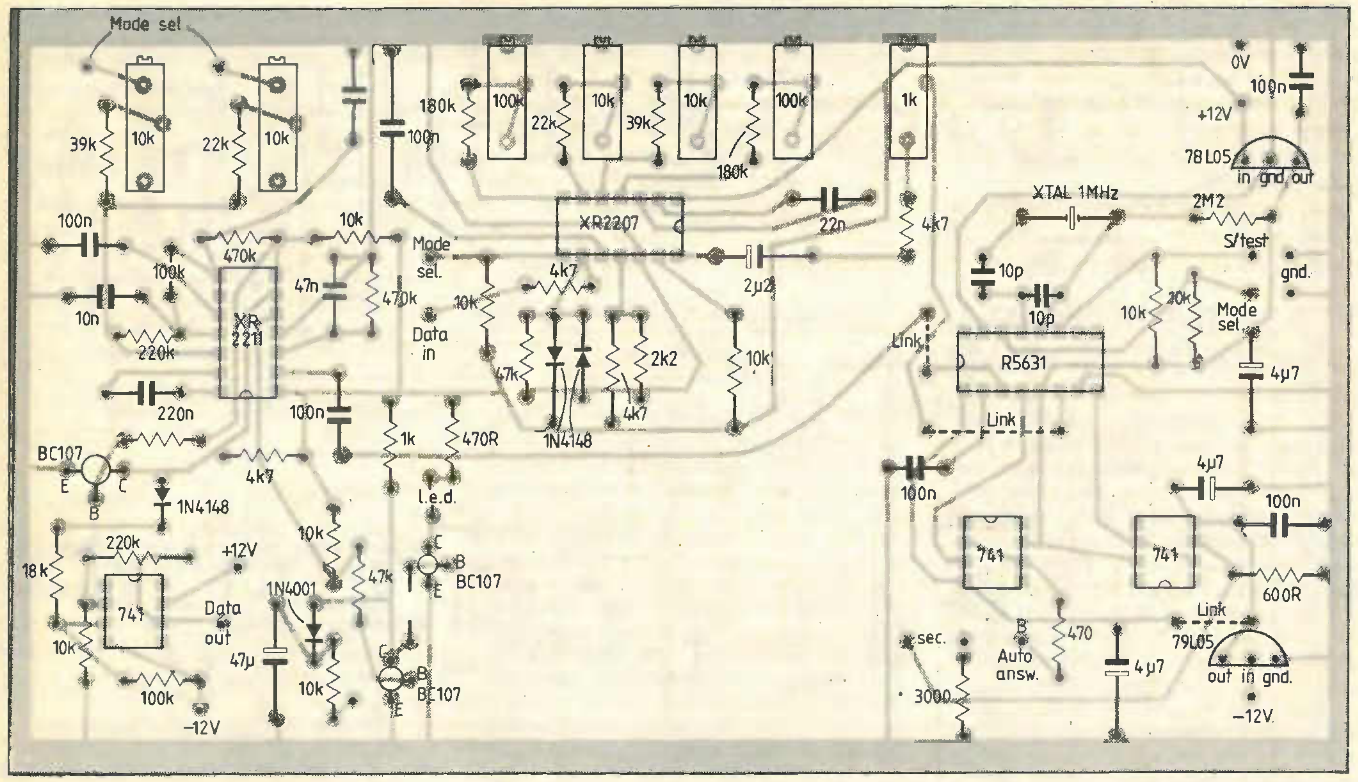
Simultaneously with the call being answered IC_{1b} triggers and operates RL_2, which places a 600Ω termination on the equipment side of the hold transformer. This gives the silent period of 1.8 to 2.5 seconds as required by V25. When IC_{1b} returns to its stable state the negative-going output triggers IC_{2a} which has a time constant of within 3.3±0.7. This operates RL_3 to switch the secondary of the transformer to the output of the 2100Hz oscillator, to feed tone at −12dB to line. This is another requirement of V25, to disable any echo suppression equipment as used on the telephone trunk and international circuits. When IC_{2a} returns to its stable state it triggers IC_{2b} to switch RL_2 and give another silent period of 75±20ms. This completes the auto-answering protocol and the secondary of the transformer is fed via RL_2 and RL_3 to the modem board.





The 2100Hz oscillator is a standard Wein-bridge circuit with a thermistor to stabilize its amplitude. The output level of the oscillator to line should be less than −10dB and is normally set at −12dB.





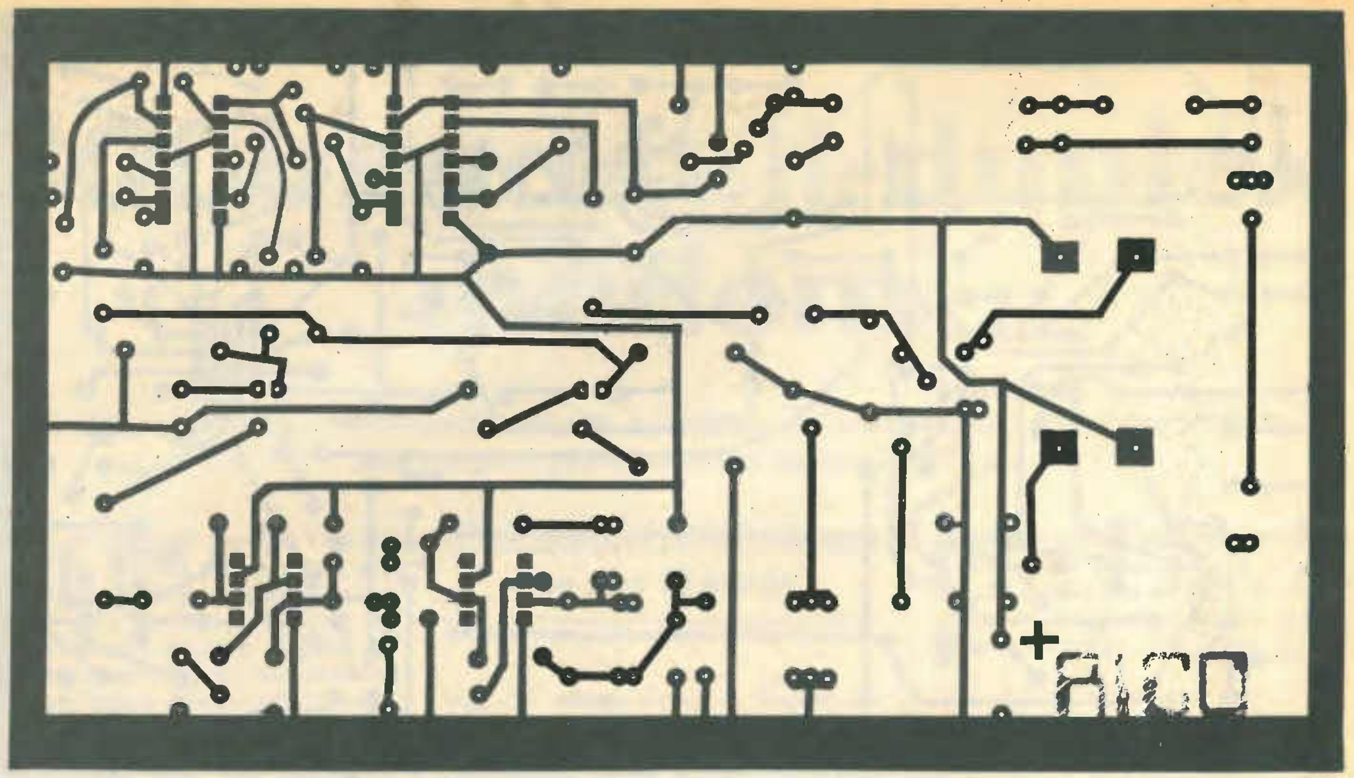
Power supply

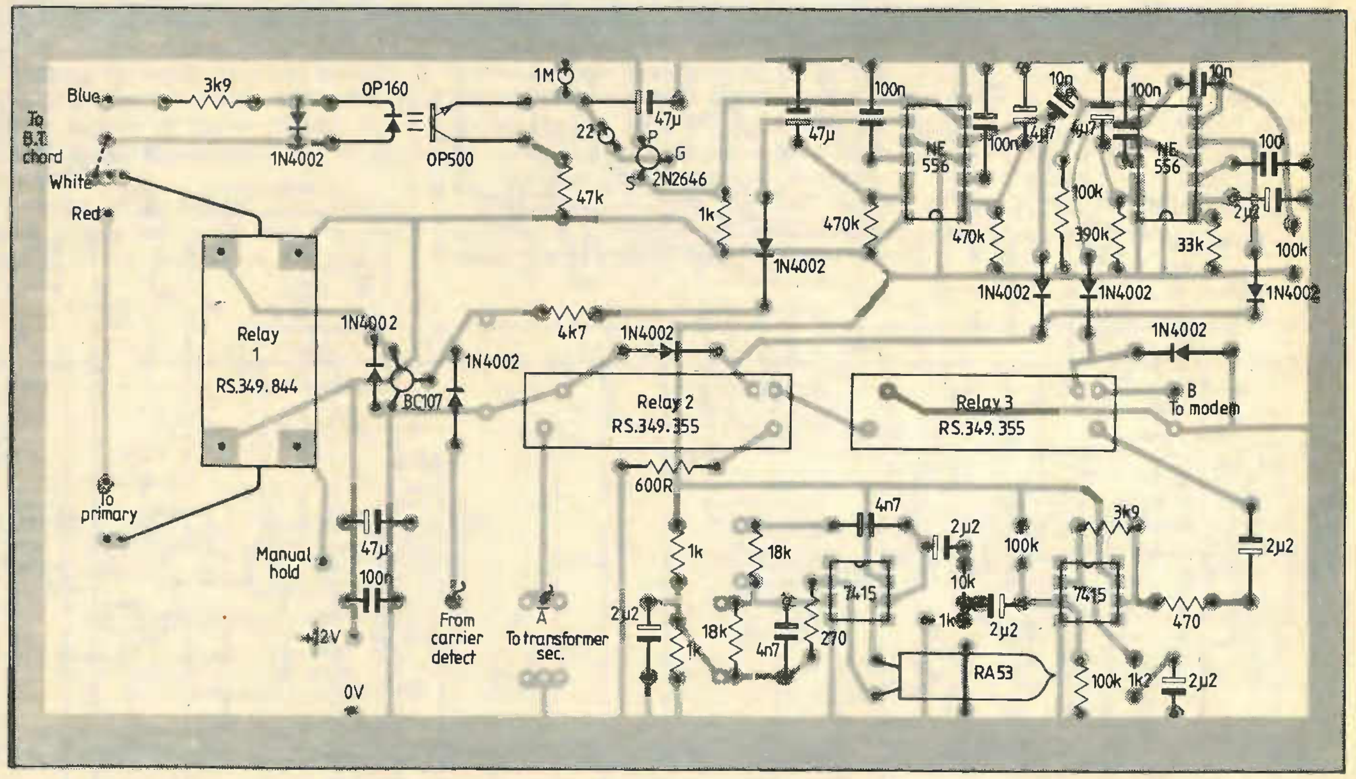
The mains input is fully isolated from the d.c. outputs and protected by a 100mA anti-surge fuse, in the author's circuit. Regulated to give outputs at + 12 and − 12 volts, there are no adjustments necessary and the voltages should be as specified ±0.5 volts. The supply is capable of supplying a total of 25VA and can power a number of modems. A straightforward circuit and board layout are obtainable from the editorial office.

Construction

The complete modem was designed to be housed in two four-inch, 3U high rack modules, one being the power supply and the other containing the auto answer unit and the modem. The power supply p.c.b. mounts on the side of the module and all the components, except mains transformer are mounted on this board.

A modified rear plate has been made to enable the mains input to be made by a separate connector to the d.c. outputs. An





IEC 3-pin connector is used for the mains supply and a 24-way connector for the d.c. supplies. The mains socket and fuseholder should be fully shrouded and all wiring to the board and 24-way connector sleeved at both ends.

The modem unit is built in the second module with two p.c.bs mounted on either side of the unit. The holding transformer is mounted on the base plate between the boards. Connections in and out of the unit are made by a 24-way edge connector at the rear of the module.

Assembly of both boards should not present any problems especially as the components mount directly on the boards, with the exception of the l.e.ds which are wired to the front panel.

The infra-red diode and phototransistor are glued together with epoxy resin and painted black. This method gives greater pin spacing on the p.c.b. on the ring-detect circuit than would be achieved by using a d.i.l. opto-isolator, and thus meets BT specifications for p.c.b. spacing within protection barriers. Again, all connections to the p.c.b., switch and rear connector should be sleeved to prevent accidental bridging of the protection barriers created by the opto-coupler and the isolating transformer.

The transformer should be 600 ohm impedance type with 1+1:1 turns ratio.

The Reticon switched-capacitor filter shown in the July circuit can be obtained from Reticon's UK agent EG&G Instruments, at 34 Market Place, Wokingham, Berks RG11 2PP (tel. 0734 788666) for £8.50. A complete kit of parts including transformer and printed circuit boards is being organised by the author – send a stamped and addressed envelope for details to 18 Tulsa Close, Berryhill, Stoke-on-Trent ST2 9PT.

LETTERS

AERIALS AT SEA

It is hard to understand the logic of Mr Benyons' statement (Letters, *WW*, May, 1983) that it is "unfair" to look at Soviet ships' aerials because these ships are "under military control". I would like to point out that:

- By no means *all* Soviet bloc ships have "good" aerials. As General Booth said to the Salvation Army band, "why should the devil have all the best tunes?", *so* why should the "red peril" have all the best aerials?
- The experience of the Falklands war shows that British ships are also under "strict military control". Even Mr Benyon would wish them the best possible radio communications capability.

Could it be that the USSR has better trained engineers than we have, not subject to the dollar veto of penny-pinching shipowners, nor rubber-stamp government supervision?

Mr Benyon correctly perceives that short aerials lack much radiation resistance, but I don't see his 20 foot vaulting pole aerial as being any "great leap forward", for the following reasons.

All existing marine transmitters, at 500 kHz, rely on the aerial to provide the tank circuit capacitance. The helical whip has none.

Only low driving-point impedance will confer any benefit. As well as altering all transmitters, it would be necessary to provide feeders and matching coils, introducing more losses than gains. Marine transmitters, unlike their broadcast counterparts, are free from this extra paraphenalia at present.

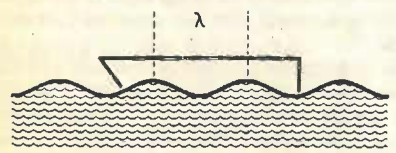
ARRL "antenna book" points out that a vertical helical wound aerial of quarter wave electrical equivalence, should be a minimum of 0.05 wavelength long. At 600 metres, that comes to 30 metres, so nothing is gained in the area of the height problem. The same book also relates that "some helical antennas have acted as Tesla coils with high power transmitters and have actually caught fire at the high impedance end"!

Back to the drawing board, Mr Benyon.

John Wiseman
Hawthorn
Victoria, Australia

ELECTROMAGNETIC DOPPLER

In the answer to Mr D. Hall (June letters) I suggest that he studies the following picture.



It represents a boat on a lake. Waves are being generated and are propagating across the lake at constant velocity. The point of interest is that there is no way of telling whether the boat is stationary or is moving, the reason being that the wavelength is the only observable parameter and that is unaffected by the velocity of the boat.

The frequency is the number of waves passing the boat in unit time. Clearly the faster the boat moves in the same direction as the waves the less waves will overtake it in unit time. If there are two boats travelling across the lake at different velocities they will experience different frequencies and if we call the velocity of propagation C then the formula is:

$$\frac{f_1}{f_2} = \frac{c-v_1}{c-v_2} \qquad (1)$$

This is a general formula for any two observers, observing the same wave. If one of the observers is also coincident with the source he may be conventionally described as the source. The wavelength which the source would have produced if it had not been moving is a non-existent parameter, because the source is moving and at no time does that wavelength appear even to the observer at the source. Not only is the propagation velocity constant, but so is the wavelength. The difference in frequency is due purely to the fact that the velocities of the two observers relative to the waves are different. I claim that this model for water also holds for sound waves and therefore cannot be the same for e.m. waves without violating the constant-velocity postulate of relativity.

Mr Hall suggests that the e.m. Doppler equation is only an approximation and should more accurately be as equation 1. This cannot be so because the second order terms such as $v_2(v_2-v_1)/c^2$ cannot be expressed purely in terms of the relative velocity (v_2-v_1). If accurate measurement did in fact detect such a term it would also have detected other drift. The relativistic Doppler equation is supposed to be accurate even when v is very close to c and the term it contains is $(c-v)/c$.

Mr Hall's point about photons, waves and interference I accept. I'll go away and think about it.

J. Kennaugh
Callington
Cornwall

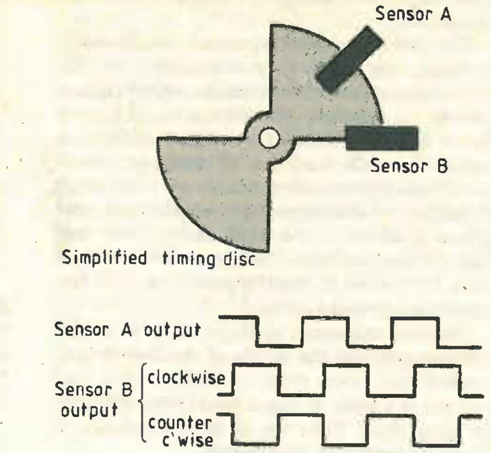
DIGITAL TAPE CLOCK

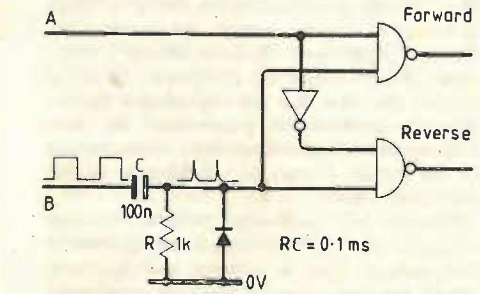
The following alternative method for producing the 'forward' and 'reverse' inputs to the counter/display section may be of interest.

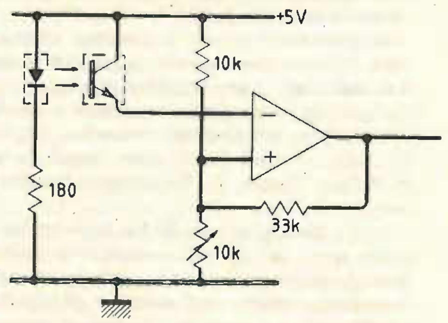
The two optical sensors are both mounted on the 'length-of-tape' timing disc, with a quarter-cycle 'phase' difference between them, as simply shown in Fig.1. If these sensors' outputs are fed, suitably buffered, into the circuit of Fig.2, a 90Hz version of the forward and reverse signals results. This can easily be counted down with 2 more 74192s.

Also I am unable to understand the buffering circuitry for the 'length-of-tape' opto-coupler. I would use a circuit like that of Fig.3., with positive feedback for jitter-free operation.

M. S. Farmiloe
Camberwell
London







A HERETIC'S GUIDE TO MODERN PHYSICS

Tut, tut, Mr Coleman of July! A photon of visible light has a wavelength?

If it did not bounce back and forth between and amongst its neighbours it would simply keep going in a straight line without a wavelength. But then, a photon, being a packet of energy carried by a bouncing building block doesn't bounce at all, does it? The building blocks merely play "pass the parcel", and the parcel moves linearly if spewed out of a laser, otherwise it is split up providing the so-called square-law effect which is part of an expansion of a spherical surface.

As I said in my letter of July, it takes one particle an impossible amount of work to make a wave. A wave is an integrated effect of a lot of moving particles. It is hoped that there is not some mental mix-up here with spin velocity, which determines the amount of energy within the particle and thus its relativistic mass, and thus in turn the gravitational gradient in the immediate environment of the particle?

I doubt very much indeed whether an individual photon can remove even a conduction electron from a metal, at least not in these parts: its spin velocity would have to be so high that catastrophe was being approached, somewhere near the boundary of the universe perhaps? Of course it takes a wave, an integration of a lot of bouncing building blocks, and therein lies the strength of wave mechanics which sadly explain nothing more than the cause of an effect at the subjective level of apparency, delightfully demonstrative of a shallow and superficial analysis.

LETTERS

Until the specialists of this world come to realise and thus accept that the absolutes are really asymptotes, modern science will remain stuck in its glorious mud. I have in mind absolute zero, absolute resistance, the speed of light, and the basic building block. The asymptotes can not be reached because a multiple lamination of short Planck's constants gets there first.

Space, of course, is purely reactive, there being no friction within chaos: only genuine fully-fledged masses can demonstrate friction at work, in their interactions so demonstrating the decay therefrom. Space, like any other reactive device, is an energy-store out of which mass condenses.

How I wish that the specialists of this world would stop their silly arguments and learn!

James A. MacHarg
Wooler
Northumbria

I continue to read with interest Dr Scott Murray's series on modern physics. However, I must take issue with what I regard as a fallacious argument in the 7th part.

He points out that it is possible, after the event, to determine the position and momentum of an electron "to any accuracy we please". He then goes on to assert that our ability to do this indicates that the electron's behaviour was determinate, and that it must have obeyed the law of causality. Hence, the Copenhagen doctrine is false.

Later, though, he admits that he is unable to prove that the law of causality is obeyed throughout inanimate nature, although there is no evidence against that assertion. Herein lies the flaw, for we can only determine the past properties of the electron if the law of causality has been obeyed. That is, we deduce where the electron was and what it was doing by knowing where it has been subsequently and what interactions it has undergone. If causality did not apply, then we would still be faced with the indeterminacy of instantaneous observation, so an argument that assumes causality cannot be used to refute any doctrine to the contrary.

Almost 30 years ago I was taught by my professor of physics that causality was the underlying assumption in the study of physics. This meant that, given a knowledge of the causal relationships governing inanimate matter, it would be possible to predict the future from a knowledge of the present, which was the goal of the Victorian physicist. The indeterminacy principle, we were told, strikes not at causality but at our knowledge of the present. If that is uncertain, our predictions must change from certainties to probabilities. Perhaps I move in the wrong circles, but I have not met anyone who seriously contested that interpretation. I have to admit that much of my working life has been spent among engineers.

R. T. Lamb
British Telecom
Milton Keynes

Dr Scott-Murray's articles on a heretic's guide to modern physics have clearly shown that the Copenhagen philosophies and mathematical theories of statistical wave mechanics have left scientists without a fundamental theory of matter.

Probably the most glaring error made by the Copenhagen School is their deduction that superfluid helium is a special type of quantum liquid, to which they have devoted many papers and given many names: Liquid Helium II, Landau's two-fluid liquid, Bose-Einstein Condensate.

The common sense approach of Faraday, Newton, and Galileo, recommended by Dr Scott-Murray, easily deduces that superfluid is a powder. It is a fluid like table salt and pepper but it is not a fluid like vinegar, which is a liquid. Scientific studies of all the properties of superfluid helium show that every experiment demonstrates that superfluid helium is the solid phase of helium in the physical form of a very fine transparent amorphous powder which is only 3°C below its boiling point; hence it is a rapidly subliming powder.

Because university students have to accept without question the beliefs of the Copenhagen statisticians, they have to believe that this powder is a form of magic liquid with antigravity properties. They are all baffled because it doesn't behave like other liquids.

Throughout my career in science I have used the wave concept of light and the particle concept for an electron. I can explain the photoelectric effect without resorting to a photon particle concept and I can explain the behaviour of an electron in an electron microscope without resorting to a wave concept for an electron. Hence I agree with Dr Scott-Murray's statement "All the indications explored in this series support the view that the Copenhagen myths, although undoubtedly propounded by their originators in complete sincerity, constitute one of the biggest hoaxes of self-delusion of the twentieth century".

When I left Cambridge (with a first-class science degree) in 1949 I was a firm believer in the photon, wave mechanics and quantum liquid, but thirty years of scientific experiment and study has shown to me that photons, phonons and rotons are myths and superfluid helium is, as one would expect by common sense, solid helium in the form of a very fine powder. When this powder melts at 2.2K it absorbs latent heat (the λ effect) and becomes normal liquid helium which boils at 4.2K.

P. Holland
Egremont, Cumbria.

Now that Dr Scott Murray's series of articles on physics has ended, I hope that you will continue to have a physics section in Wireless World. If so, why not name it, "Frontier Physics". There are no doubt others like myself who buy your journal not for its electronics but solely to enjoy reading those controversial physics articles – and, of course, the Letters section in which wayward physicists express their ideas can certainly stimulate one's own thoughts.

It is a pity that physics has become dogmatic. Some years ago I proved that Special Relativity was mathematically and physically wrong, but I couldn't convince others. However, I did discover that there was a 'closed loop' acting in physics.

The closed loop is an argument. It consists of a main theme, which cannot be disputed, and which begins and ends any discussion. For example, the closed loop of Special Relativity can be used to prove that time dilates as follows:

1. Special Relativity is true (main theme)
2. Its equations show that time dilates.
3. Its equations cannot be wrong.
4. Therefore time must dilate.
5. Special Relativity is true. (main theme).

In a scientific journal recently, the closed loop is used to show that the cost of accepting common time (Newtonian time) would be too high a price to pay in physics. The closed loop is as follows:

1. Special Relativity is true. (main theme).
2. Inserting common time into Special Relativity's equations gives a daft answer for the speed of light.
3. This daft answer means that either Special Relativity's equations are wrong or that common time is wrong.
4. Special Relativity's equations cannot be wrong.
5. Hence, common time must be wrong.
6. Special Relativity is true. (main theme).

In the past, the closed loop has been used to give a satisfactory answer to the late H. Dingle's challenging question, "Of two uniformly-moving clocks, A and B, which ticks the faster?" The closed loop gives the well-known answer.

1. Special Relativity is true. (main theme).
2. Moving A ticks slower than stationary B.
3. But stationary B can be regarded as moving and moving A can be regarded as stationary (by the principle of relativity).
4. So A ticks slower than B and B slower than A!
5. Either commonsense is wrong or Special Relativity is.
6. Special Relativity cannot be wrong.
7. Therefore commonsense is wrong.
8. Special Relativity is true. (main theme).

It can be seen that the closed loop is an invincible argument. Of course, the above examples seem obviously silly because they are presented in skeletal form. When the closed loop is clothed with advanced maths, though, its use is by no means obvious; you must look carefully for it!

A. H. Winterflood
Muswell Hill
London

DESIGN COMPETITION

Although I applaud your initiative in setting a competition for electronic devices to assist the disabled, I fear that many potentially suitable devices will not be entered. This is because they may originally have been designed for other purposes, where their commercial value is such that publication of their design is precluded. It would be useful if your journal could also act as a clearing house for information on the existence of these devices.

In many cases, I imagine that the designers of these devices would be prepared to spend some of their own time in adapting them to the needs of disabled people, but cannot reveal how they work.

As an example, Hydraulics Research Ltd has collaborated with the Weed Research Organisation on the development of a low-cost "plant sensor". At present the devices exist in two forms:

(i) is a linear readout instrument which can be used to indicate the relative health of plants, their degrees of maturity, or the proportion of a field of view which contains plants. It can, for example, indicate on an analogue meter the degree of wear on a grass playing field.

(ii) is a switch which energises a load when it sees a plant. This is intended for incorporation into a "robot" crop sprayer, when the load would be the coil of a solenoid valve in the line to a spraying nozzle.

The designs originate from the need to make

simple measurements of crop cover during a project which was intended to evaluate the protection which leaf canopy provides from soil erosion by heavy rainfall, and version (ii) is a natural extension of the resulting design into a commercial application.

Both versions will shortly be available from Churchill Controls Ltd of Headley Road East, Woodley, Reading.

One of my colleagues has commented that modified versions of these devices might be very useful to blind or partially sighted people. Such applications would be outside our experience, but we would be pleased to discuss them with anyone who could provide a specification for what is needed, or would like to incorporate one of these sensors in a design of their own.

D. K. Fryer
Hydraulics Research
Wallingford
Oxfordshire

I was interested to see that one reader has come up with the idea of informing blind persons the contents of cans and packages without opening them. No further information was given.

I should like to suggest (if this is not the method used) that it would be a simple matter to 'read' the bar codes that are appearing increasingly on modern packaging by means of a light reader: decoding the information and removing extraneous information normally used in stock control; and presenting the edited information to the blind person by means of a voice synthesizer through a private earpiece.

Being completely without technological training I would nevertheless suggest that in this day of the Chip it would not be beyond the realm of possibility to produce a fairly light-weight pack which could be worn like a handbag over the shoulder and weigh about the same.

Once the technique had been perfected there is no reason why bar-code labels could not be used in other circumstances to aid the blind to read. We already see these codes on the edges of supermarket shelves and on packaging. Why not make complete sentences and print books in the same manner. Naturally a monotonous Dalek 'voice' would never replace the enjoyment of silent reading as Braille offers but this would be ideal for official pamphlets for the blind, direction signs and other informatory instructions.

J. Devereaux
Wordsley
West Midlands

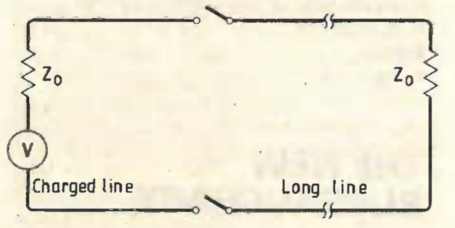
WAVES IN SPACE

Ivor Catt (March, 1983) says "the voltage is half of what one would expect". The curious point to me is on what he bases his expectations. If the charged line is regarded as a voltage source of impedance Z_0 (the characteristic impedance) connected to another impedance Z_0 through the switches, as in the accompanying sketch, then the voltage is exactly what one would expect. The finite duration of the pulse stems from the fact that the charged line is an energy storage device (electrostatic field) and not a source of e.m.f. which implies energy conversion. It is worth adding that the impedance technique also enables one to predict occurrences when the Z_0 of the long line is not equal to that of the charged line.

As to the claimed paradox that "electromagnetic energy promptly rushes away from the path suddenly made available", if Mr Catt will examine Poynting's vector in the charged line after the switches are closed, he will find that the electromagnetic energy moves only into the long line, that is, from left to right.

It is possible to regard the condition of the charged line as the result of interference between two waves travelling in opposite directions, just as one can treat a straight line as the arc of a circle of infinite radius. There are times when they are useful models of reality. The real paradox of the article is the question of where Mr Catt (and, for that matter, *Wireless World*) have been all this time. To my knowledge, the Royal Air Force used this approach to transmission lines as pulse generators in 1959, and I have no doubt that the technique goes back much further in time.

R. T. Lamb
British Telecom
Milton Keynes



I refer to Mr Catt's article in the March 1983 issue.

In a letter, I could not hope to reproduce the great body of scientific and engineering knowledge that has amply demonstrated the non-relativistic interpretation of Maxwell's Equations or of Einstein's treatment using special relativity. If the theory is so seriously flawed it is surprising that we can design and build antennas and microwave devices. Nevertheless, I cannot let Mr Catt's analysis of te pulse generator go unchallenged, especially as it is so easy to demolish his arguments.

Firstly, if a piece of charged coax. really has equal and opposite waves running in each direction why are they not attenuated by the losses in the line? After all in one second each of his waves would have travelled nearly 2,000 miles in lossy coax.

Secondly, if I connect an antenna to a piece of coax. I can still charge up the line. Why do not these waves of which he speaks radiate into space? Or, at least, the high-frequency components of the pulse to which the antenna will be matched.

The conventional solution to his 'exotic' problem can be found by solving the transmission line equations for a cable under the stated starting conditions (see reference). As this is rather tedious and since Mr Catt seems to prefer hand waving to mathematics I will at least demonstrate where the 2m pulse length comes from.

When the extra length of line is connected to the 1m line, charge starts to move down the new line charging the distributed capacitance of the line through its distributed inductance as it goes. (Maxwell's equations applied to circuits show us that capacitors connected together share their charge). This leaves a void which the 10V (1m) line fills. The void propagates towards the open end of 1m line at the speed of the line. The charge close to the open end of the line will be liberated at a time equivalent to 1m of line and will take 1m to propagate to the other end, explaining the 2m length of the pulse.

The pleasing aspect of the above argument is that we do not have to destroy a century of succesful electro-magnetic theory to produce it. If Mr Catt has so much more insight into electro-magnetic theory than the rest of us it is surprising that he has not produced any new microwave devices that demonstrate his superior understanding.

Timothy C. Webb
Columbia, MD
USA

Reference: Brown and Glazier: Signal Analysis pp. 345-349.

I was not too sure whether I should be amused or startled by Ivor Catt's article on "Waves in Space" in which he postulated the existence of electromagnetic energy in a static electric filled, when I reminded myself that the date was 1st April. It had never occurred to me, even remotely, that a magnetic field could be directly caused to exist by the presence of an electric field. However, being sympathetic to the idea that all things appear to be possible in this day and age, I allowed my mind to be bent a little further and read on.

The production of a voltage pulse in a transmission line which is half the amplitude and twice the length of that existing statically in piece of coaxial cable, can form the basis of a number of interesting experiments. For example, Mr Catt's travelling pulse can be converted back into a static charge again if his coaxial cable is terminated into an open circuit but with a pair of switches 1 metre from the end as shown in Fig. 1. When the switch at B is closed and the resulting pulse eventually reaches D, it will of course, be reflected (double back on itself); however, if switch C, is opened at the instant the leading edge meets the trailing edge, no great drama ensues but we are left with a 1 metre piece of statically charged coaxial cable as before. It is also interesting to consider what happens if point D is terminated into a short circuit. This time, the pulse will be converted into one of twice the current at zero voltage and the leading and trailing edges will be locked together and oscillate back and forth converting the pulse between a current at zero voltage and a voltage at zero current until this activity decays due to losses.

However, perhaps it would be more interesting to consider what would happen if this final 1 metre of coaxial cable is made superconducting and instead of isolating switches at C, a short circuiting switch is provided as shown in Fig. 2. If the switch at C is closed at the instant the leading and trailing edges meet, electrons at zero voltage, will continue to flow around the 1 metre coaxial circuit as a direct current. It would, perhaps, be better to say that current drifts around, because depending on the construction of the coax., it could take hours for any single electron to work its way around the circuit. It should, of course, be remembered,

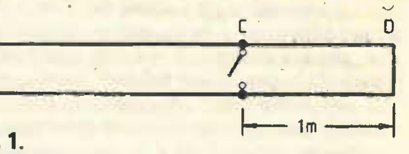


Fig. 1.

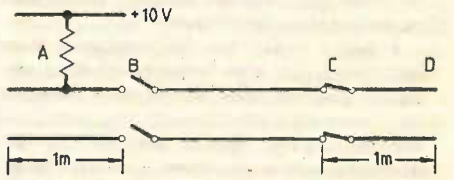


Fig. 2.

that as no voltage is present, the density of the electrons in the closed circuit is the same as that in the remainder of the uncharged transmission line.

Unless someone comes along and throws into doubt that an electric field exists between adjacent electrons and protons it is easy to demonstrate that in the above circuit condition, countless billions of electric fields exist alongside the magnetic field caused by the current, although no measurable voltage exists. Similarly in the case of the purely electrostatic condition, the same large number of magnetic fields exist due to the rotating and spinning electrons. However, I doubt somehow whether this has anything to do with the way the charged section of coaxial cable propagates a pulse whose length is twice that of the charged section. And I must confess, that the prospect of opposing magnetic fields oscillating back and forth along the cable as Mr Catt suggests, appears to be even less likely.

Surely, the answer to his paradox is simply that on closing the switch at B, the electrons that flow out of the negatively charged conductor and those that flow into the positive conductor of the cable not only cause a wave front of current and voltages to be transmitted along the line but also back into the charged section itself. And since the energy has to be shared between both fronts, the voltage will be halved. The discharging current flowing into the charged section will set up a magnetic field, which, on collapsing, will produce an equal pulse of voltage and current to follow on the heels of the pulse which has already departed from he originally charged section.

R. J. Hodges
Bath
Avon

ORBITING ELECTRONS

A puzzling feature of the atomic model which depicts the positively charged nucleus of the atom surrounded by negatively charged particles (or electrons), is that the orbiting electrons do not radiate away energy in the form of electromagnetic waves, and so spiral into the nucleus. This follows from the fact that electrons, when accelerated, generate e.m. waves, by means of which the energy given to the electrons to accelerate them is carried away by the wave, and since the electrons orbiting the atomic nucleus are said to be accelerating towards the nucleus, with the value of the acceleration being v^2/r where v is the velocity of the electron in orbit, and r the radius of the orbit, they should radiate e.m. waves.

I would suggest that the reason they do not, is that it is not sufficient merely for the electron to be accelerating – but energy needs to be given to the electron from outside the system (if we regard the electron in its orbit as a closed system of constant energy), in order to raise its energy level. This system then behaves in such a way as to oppose the input of energy, ie. to lower its energy level and return to its original state. This it does by means of the e.m. waves travelling at the velocity c, via the lines of force which radiate out from the electron.

A change under "inertial" conditions (ie. at rest, or moving with uniform velocity), possesses a constant amount of energy, hence, no e.m. waves are emitted from it. The electron will only gain energy when an external impressed force acts on it in which case a human observer located on the electron would be able to detect this force, and measure it.

If we consider an electron in orbit around the atomic nucleus, and we replace the electrostatic force which keeps it in orbit with a gravitational one of the same strength, then a human observer, since he would be accelerating at the same rate as the electron, would not be able to detect any force acting on the electron, or anywhere in its vicinity, thus, he would conclude that the electron was under inertial conditions, and would not see any e.m. waves emitted, indeed, if he did see such a phenomenon, he would be unable to account for it. In order for such a system to radiate energy in the form of e.m. waves, I would suggest that it would be sufficient for the electron to collide with some other particle e.g. a photon or another electron. Then, a force could be detected by the observer on the electron, and he would conclude that energy had been given to the electron, and e.m. waves would be radiated, whether or not this raised the level of the system as a whole.

P. R. Griffiths,
Retford,
Notts.

THE NEW BUREAUCRACY

I could write at length to refute D. W. Scott's extraordinary assertion in March, 1983 Letters, that "None of us (programmers) likes the von Neumann architecture – we spend our lives trying to circumvent it." Those experienced in the art know this to be false.

I shall limit myself to a simple test of loyalty for Scott and other programmers who might want to bite the (von Neumann) hand that feeds them.

As an accredited MAPCON consultant, the government pays up to £3,000 of my consultancy fees provided my recommendations to my client are that the system he installs contain a von Neumann machine. Please would Scott and other forward-looking programmers write to *Wireless World* to the effect that MAPCON should remove the following paragraph from page 9 of their book entitled "Guidelines for Feasibility Study Grants, March, 1982."

"Note that the use of the word "microelectronics" implies electronic large-scale integrated circuits (LSI) of at least the complexity of microprocessors. Applications which solely use medium and small scale integrated circuits (MSI and SSI) do not fall within the scope of MAPCON."

This quote relates neatly to my first paragraph on page 48, *Wireless World*, December, 1982.

Ivor Catt
St Albans
Hertfordshire

MIXED LOGIC

On page 29 of the July issue, M. B. Butler writes

"A new symbol is introduced to indicate application of a convention: the 'flag' or polarity indicator."

This is not a new symbol. The second most commonly used standard for drawing logic diagrams, the IEEE's ASA Y32.14 – 1962, says on page 8

"4.4.1 A small, open, right triangle at the point where a signal joins a logic symbol indicates that the line's 1-state (activating) with respect to that logic symbol is the less positive potential (current)."

The competing, and much better, symbol is the small circle. The de facto standard for logic diagrams, US MIL-STD-806B, 26 Feb. 1962, used in 80% of logic diagrams today, says on page 4

"5.3.1 A small circle at the input to any element . . . indicates that the relatively low (L) input signal activates the function. Conversely, the absence of a small circle indicates that the relatively high (H) input signal activates the function.

"5.3.2 A small circle at the symbol output indicates that the output terminal of the activated function is relatively low (L). This small circle shall never be drawn by itself on a diagram."

On page 32, Butler writes

". . . an oblique 'slash' is placed across any line over which a logical not operation has occurred."

Butler should withdraw this proposal, because it contradicts MIL-STD-806B, page 8, and elsewhere, which defines the oblique slash as indicating multiple lines. This has gained a degree of acceptance in the industry.

The main thrust of Butler's article is to introduce the good philosophical approach outlined in Tony Cassera's article, *WW* November, 1980. It is a pity that neither writer gave credit to S. U.S.MIL-STD-806B for originating it.

My approach to this important and neglected subject is contained in the chapter "Choice of type of logic symbols" in my book Digital Electronic Design Vol. 2, pub. C.A.M. Publishing, 1979.

(Perhaps I should repeat that in my opinion U.S. MIL-STD-806B is the best, and that I am willing to supply copies at cost.)

Ivor Catt
St. Albans
Hertfordshire

WOODPECKER

In June 1983 issue of *WW*, Pat Hawker described the "woodpecker" as following "the m.u.f. up and down the h.f. band" Rather than the m.u.f., I would have thought that it follows, more precisely, the optimum traffic frequency.

No doubt I will be corrected if I am wrong.

P. Thompson
Southport
Lancashire

ORGAN INTERFACE

We have been asked to point out that a recording system for pipe organs with electric actions, similar in principle to that described in these articles, has been marketed by Christie Music Transmission Systems Limited, Colchester, since 1979. This orginally used a 32Kbyte ram and tape back-up but is now available with 64K memory and disc back-up, giving uninterrupted solid-state recording or playback for about 20 minutes (depending upon the complexity of the music).

A full length item can be saved or loaded from disc in 3 seconds, and a short item using less than 9Kbytes, requiring only one track of the disc, is dealt with in half a second. Provision is made for listing items to give a recital of several hours duration.

Developments in Teletext (IBA Technical Review No. 20): Independent Broadcasting Authority, Crawley Court, Winchester, Hampshire SO21 2QA. Teletext users who have noticed the mysterious pages of apparent rubbish lurking here and there in the Ceefax and Oracle services will be aware that development of the UK Teletext system still continues. This collection of articles describes some of the advanced techniques now in use and some that are still to come. Subjects covered include the preparation of subtitles for deaf viewers; alpha-geometric coding methods for transmitting high-definition graphics; and techniques for redefining the character set to give alternative alphabets.

Guide to amateur radio: 19th edition, by Pat Hawker G3VA. 154pages. Radio Society of Great Britain, Alma House, Cranborne Road, Potters Bar, Hertfordshire EN6 3JW. Price £2.75, by post £3.44, paperback. This new edition has been expanded to include some of the latest developments in the world of amateur radio, rules and regulations as well as techniques and equipment. An excellent guide for the newcomer.

VHF/UHF Manual: fourth edition, edited by G. R. Jessop, G6JP. Radio Society of Great Britain. 528 pages. Price £8.50, by post £10.31 worldwide, hard backs. This handbook provides practical information and a full range of constructional designs for amateur bands from 30MHz to the microwave region. The new edition has been revised extensively – notably the chapters on propagation and space communications, which should be of interest even to black-box operators.

Teleprinter Handbook: second edition, edited by A. G. Hobbs, E. W. Yeomanson and A. C. Gee. Radio Society of Great Britain. 368 pages. Price £12, by post £13.84, hardback. Conversing by teleprinter might be thought a rather unsociable method of communicating, but it has its enthusiasts. What is surprising about this book in view of the advanced techniques being used in other areas of amateur radio is that it confines itself almost exclusively to the care and operation of electromechanical equipment. It might be supposed that the newcomer to data communications would want to make use of his home computer. But apart from a nine-page chapter describing the construction (using standard t.t.l.) of a v.d.u. for radio-teleprinter use, there is nothing about AMTOR or packet -switching or indeed about computers or computer techniques at all.

Nothing Local about it: London's Local Radio by Local Radio Workshop. 213 pages. Marion Boyars Publishers and Comedia, £3.95 paper cover.
BBC Radiophonic Workshop by Desmond Briscoe & Roy Curtis-Bramwell. 175 pages, BBC £7.75 paper cover.
Introduction to Video by D. K. Matthewson, 175 pages. Bernard Babani £1.95 paper cover.
Tomorrows Television Today by Michael J. Stone 118 pages. M. Stone £9.85+65p p&p paper cover.
Television Engineers Pocket Book by Malcolm Burrell & S. 314 pages. Newnes £7.95 paper cover.
Tower's International Digital IC Selector by T. D. Towers. 246 pages. Foulsham £9.95 paper cover.
Interface Projects for the Apple 11 by Richard C. Hallgren. 170 pages. Prentice Hall International £10.35 paper cover.
Radio Antennas by Stephen Gibson. 165 pages. Prentice Hall International £11.85 paper cover
Medical Effects of Nuclear War by British Medical Association. 188 pages. Wiley £4.50, $8.95.
Digital PLL Frequency Synthesizers (Theory and Design) by Ulrich L. Rohde. 494 pages. Prentice Hall International £44.95 hard cover.
Local Telecommunications by J.M Griffiths. 265 pages. Peter Peregrinus £19.
Broadcasting and Society 1918-1939 by Mark Pegg. 293 pages. Croom Helm Ltd £14.95 hard cover.
Bond Graphs for Modelling Engineering Systems by Alan Blundell. 151 pages. Wiley £16.50 hard cover.
Transistor Circuit Techniques by G. J. Ritchie. 168 pages. £10.95 hard cover.
RF Circuit Design by Chris Bowick. 176 pages. Prentice Hall International £17.20 paper cover.
Microchips with Everything by Paul Sieghart. 150 pages. Comedia £3.50 paper cover.
CBasic Users Guide by Adam Osbourne, Gordon Eubanks, Martin McNiff, 212 pages. McGraw-Hill £11.95 paper back.
Confidential Frequency List by Oliver P. Ferrell. 224 pages. Gilfer Associates Inc (PO Box 239, 52 Park Avenue, Park Ridge, NJ07656, USA) $14 paper cover.
The World Wired Up by Brian Murphy. 154 pages. Comedia £3.50 paper cover.
What's this Channel Four? by Simon Blanchard and David Morley. 186 pages. Comedia £3.50 paper cover.
Annual Report and Handbook 1983 by BBC. 240 pages. BBC £4.50 paper cover.
Television & Radio 1983 by IBA. 224 pages. Independent Broadcasting Authority £3.50 paper cover.
Handbook of Antenna Design by A. W. Rudge, K. Milne, A. D. Olver, P. Knight. 945 pages. Peter Peregrinus hard cover.
Power of Speech (History of STC) by Peter Young. 221 pages. George Allen & Unwin £9.95.
Fiction Stranger than Truth by N. Rudakov. 175 pages. N. Rudakov (PO Box 723, Geelong, Vic 3220, Australia) $10 paper cover.
Popular Circuits
Electronics Projects
Digital Circuits
Communication Circuits
and Special Circuits (Ready Reference series) by J. Markus. 161-216 pages. McGraw-Hill £9.50 each paper covers.
Electronics: A Course Book for Students by G. H. Olsen. 425 pages. Newnes £17.50 hard cover.
Practical Electronic Building Blocks – 2 by R. A. Penfold. 94 pages. Babani £1.95 paper cover.
Computer Programs for Electronic Analysis & Design by Dimitri S. Bugnolo. 261 pages. Prentice Hall £15.25 paper cover.
Microcomputer Experimentation with the Synertex SYM-1 by Lance A. Leventhal. 500 pages. Prentice Hall £19.75 paper cover.
Basic & Pascal in Parallel by S. J. Wainwright. 60 pages. Babani £1.50 paper cover.
ZX Spectrum User's Handbook by R. J. Simpson & T. J. Terrell. 199 pages. Newnes £6.95 paper cover.
STD Bus Interfacing by Christopher A. Titus, Johnathan A. Titus & David G. Larsen. 286 pages. Prentice Hall £11.15 paper cover.
Interfacing to Microprocessor & Microcomputers by Owen Bishop. 147 pages. Newnes, £4.95 paper cover.
ZX8000 Handbook by Martin L. Moore. 390 pages. Prentice Hall £11.95 paper cover.
Basic Handbook second edition, by David A. Lien. 480 pages. Compusoft $19.95 paper cover.
Assembly Language by Randy Hyde. Prentice Hall £16.95 paper cover.
Introduction to Electronic Speech Synthesis by Neil Sclater. 134 pages. Prentice Hall £7.60 paper cover.
Electronically Speaking: Computer Speech Generation by John P. Cater. 230 pages. Prentice Hall £12.70 paper cover.
Z-80 Microprocessor Advanced Interfacing with Applications in Data Communications by J. C. Nichols, E. A. Nichols & K. R. Musson. 347 pages. Prentice Hall £16.95 paper cover.
Microprocessors and Microelectronics by Ian Williamson. 171 pages. Cambridge Learning £6.50 paper cover.
6502 Assembly Language Subroutines, by Lance A. Levanthal & Winthrop Saville. 550 pages. McGraw-Hill. £10.50 paper cover.
Interface Projects for the TRS-80 by Richard C. Hallgren. 152 pages. Prentice Hall. £11 paper cover.
Practical Interfacing Techniques for Microprocessor Systems by James W. Coffron & William E. Long, 401 pages. Prentice Hall £25.15 hard cover.
TRS-80 Model III Assembly Language by Hubert S. Howe 344 pages. Prentice Hall £14.40 paper cover.
Radiation safety of laser products, BS4803 parts 1-3. British Standards Institution. 13 + 16 + 30 pages. Members £33 paper cover.
European Electronic Component Distributor Directory by Mackintosh Consultants. 464 pages. Benn Electronics Publications £37.50 paper cover.
New Technology and Industrial Change by Ian Benson and John Lloyd. Kogan Page £4.95 paper cover.
Newton's Error by A. H. Winterflood. 72 pages. From H. K. Lewis & co, 136 Gower Street, London WC1E 66S £3 paper cover.
Transient Analysis Aided by Network Theorems by Harry E. Stockman. 176 pages. Sercolab (PO Box 78, Arlington, Mass. 02174, USA) $13.30 (abroad +10%) soft cover.
Telegraphy on Stamps by W. C. L. Gorton. 16 pages. Picton (Citadel Works, Bath Road, Chippenham, Wilts) 95pence paper cover.
Art of Programming the 16K ZX81 by M. James & S. M. Gee. 125 pages. Babani £2.50 paper cover.
Computer-Assisted Home Energy Management by Paul E. Field. 182 pages. Sams $15.95 paper cover.
Learning IBM Basic by David A. Lien. 425 pages. Compusoft $19.95 paper cover.
Art of Programming the ZX Spectrum by M. James. 138 pages. Babani £2.50 paper cover.

Literature Received this month appears on pages 38 & 73.

Ultrasonic ranging for robots

Simple ultrasonic transmitters and receivers with microprocessor control can give a robot the capability of determining the distance of objects near to it, even in a noisy environment.

by H. W. Gleaves

Ultrasonic transducers provide highly directional characteristics which permit the construction of a ranging system that operates on principles similar to those of radar.

The underlying principle is simply to measure the time interval between the transmitting and receeiving of ultrasonic pulses. I have used momentary bursts with a fundamental frequency of 40kHz. The velocity varies with temperature, pressure etc, and the greatest accuracy can only be obtained if these factors are taken into account. However over the comparatively short range of the system it is doubtful that any normal variations of these factors will significantly affect the measurement.

The time interval between the transmitted and reflected pulse is a linear function of the distance. If we call the velocity of sound V, and the target range r then the timing interval δt is $2r/V$. Thus the accuracy of the measurement depends chiefly on the accuracy of the time measurement. We need now to examine how this can be interpreted by the robot's computer into useful sensory information. Most robots incorporate a microcomputer to convert incoming data, from sensors, and from instructions in the control program, into responsive actions. The complex relationship between input data and output action is determined by the software of the control unit.

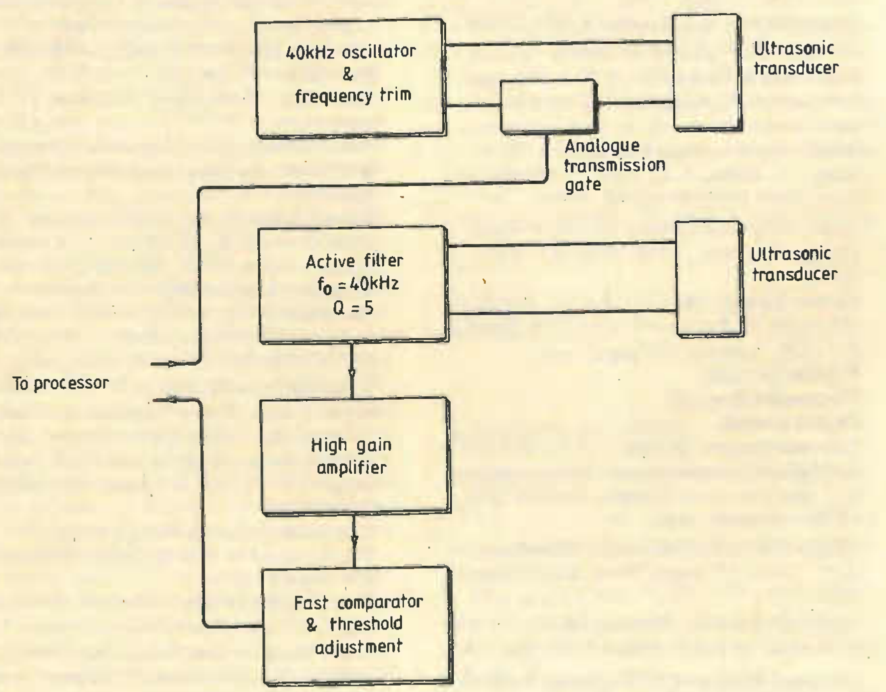
Hardware. A block diagram of the sensing unit is shown below. The ultrasonic transmitter is a simple c-mos squarewave oscillator which may be adjusted a few kHz each side of the chosen frequency of 40kHz. The squarewave output is fed through a c-mos analogue transmission gate and transmitted in short bursts. The receiver is a combination of op-amps designed to amplify and filter the very weak received signals. The overall gain of the receiver is over 80dB. The amplified signal is fed to a comparator which switches very rapidly between 5V and 0V on the receipt of a signal. This output is used to interrupt the robot's computer. I decided to compromise between hardware and software by using the computer to count the time delay. Other parameters such as pulse width and p.r.f. were chosen to suit the application and may be varied for different ranges, etc.

Only two connections were needed

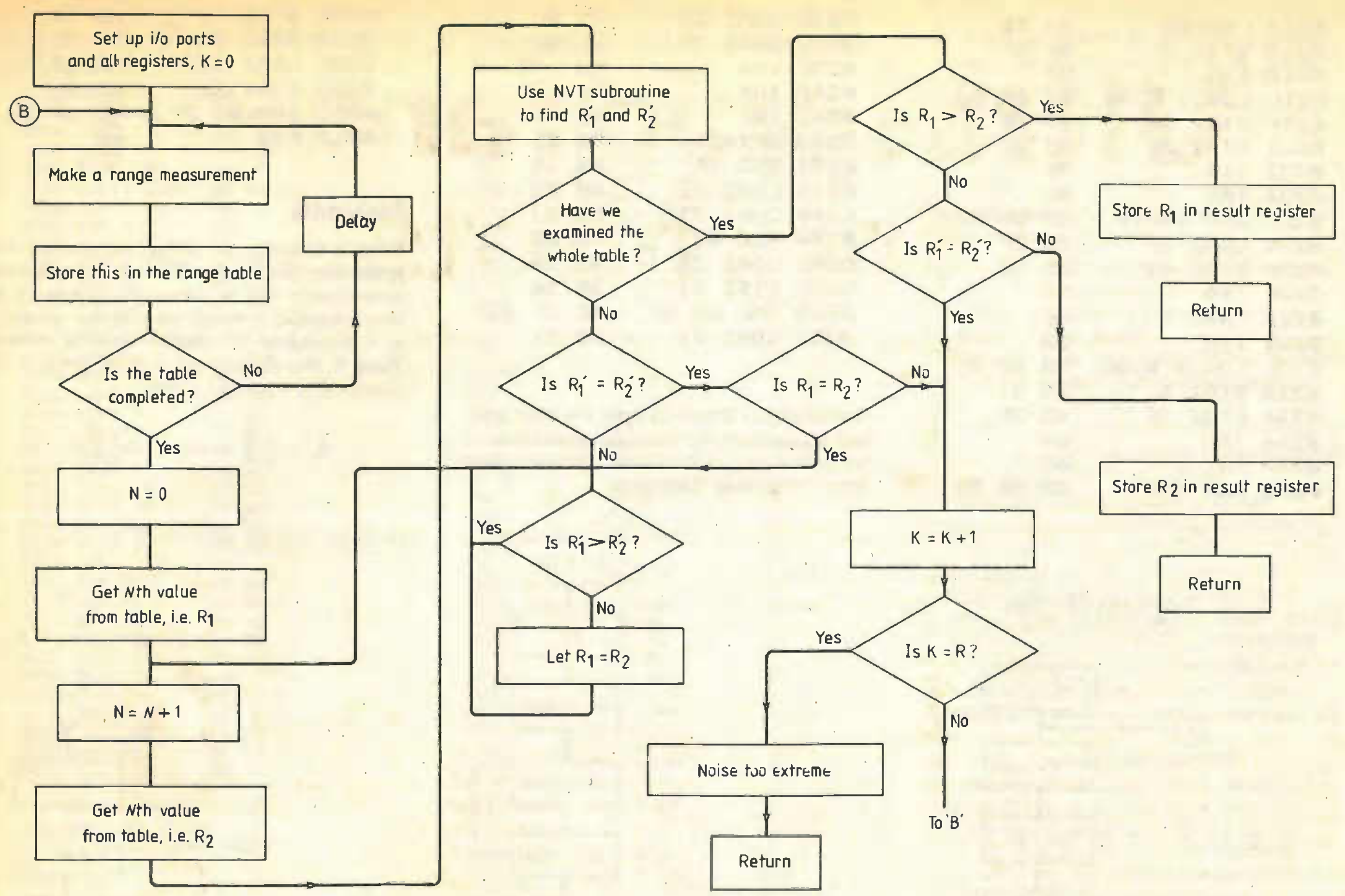
"My main interest is in designing robot systems. At present I am working on a machine using two microprocessors and ultrasonic ranging. I believe that robot software will need to be considerably different from normal computer software, since unlike a computer a robot has very poorly defined data entering its system.

"Because of the employment difficulty, I took A-level mathematics and physics at night school. From there I entered Old Swan technical college to finally receive a diploma in telecommunications."

between the ranging sensor and the computer. I used an Acorn system 1 microcomputer which has proved to be excellent. It is physically small, of two vertically stacked boards with the upper one having a hexadecimal keyboard for programming. Only one bit of an 8-bit port was used to pulse the transmitter on for a period determined by the software. The output from the receiver is connected to the microcomputer's interrupt request, IRQ, terminal and will interrupt the processor whenever sounds containing a 40kHz component are detected. The IRQ on the 6502 microprocessor used in the Acorn system 1 may be ignored or acted upon, the choice being under software control, depending on whether the 'interrupt disable bit' in the 6502 status register is set or clear. The software is designed so that while the transmitter is active, the interrupt is disabled and as soon as the transmitter has stopped, the interrupt is enabled. At the moment when the interrupt is enabled, a special test register is cleared and an 8-bit register starts counting. As long as the test register remains clear, the counter continues to increment. When an interrupt signal is received the test register is set to FF_{16} and



Block diagram of the ultrasonic frequency ranging system.



Flowchart for FDA (frequency distribution analysis). R_1 and R_2 are two range values in the range table. R_1' and R_2' are the frequency of occurrence in the table of R_1 and R_2.

the count stops. The processor returns to the main program but the count register contains a number proportional to the distance measured.

The effect of noise. Ideally only one measurement is required as described above, but in any normal environment there are inevitably extra noises that could trigger false readings. I have given a full explanation of the mathematical method used to determine the probability of noise affecting readings in the appendix. It is sufficient to say here that if a number of measurements are taken, then a certain proportion of them will give the same reading while noise will add random readings. So if a number of readings are compared, those that have the same reading most often will indicate the true distance while the other readings may be ignored. For example, I set up the transducers some 150mm away from a fixed object. With no ambient noise, 32 measurements were all the same. I then repeated the experiment while jangling a bunch of keys about 100mm away from the transducers. There was a wide diversity of measurements but the most common value, occurring seven times, was the correct value, identical to that in the first experiment, while the remaining values were random, with no value occurring more than three times.

Software. A machine-code program is uses the range measurement technique discussed. Two versions are included for two processors; the 6502 and the Z80. I have called them 'Mode' as they calculate the mode of the acquired data. Users of other processors may be able to compile similar programs by referring to the flow-charts. 'Mode' on the 6502 can process a block of data up to 255 bytes length. The program will determine the value that occurs most frequently and place this in a specific location in memory (address 0020) with the frequency stored at address 0022. If all the values in the table are different, a value of 01 is placed in the 'Error' address, 0024.

The first value is taken from the top of the table. The number of times the same value occurs in the table is counted. This count is then compared with the next count derived in the same way and the value corresponding to the greater is stored. The process is repeated to the end of the table. If, during the process two counts are the same, then Error is set to 01 if subsequently another count is greater, then Error is reset to 00.

The program for the Z80 is very similar. It can process a block of data longer than 255 bytes if necessary, provided that no single value occurs more than 255 times.

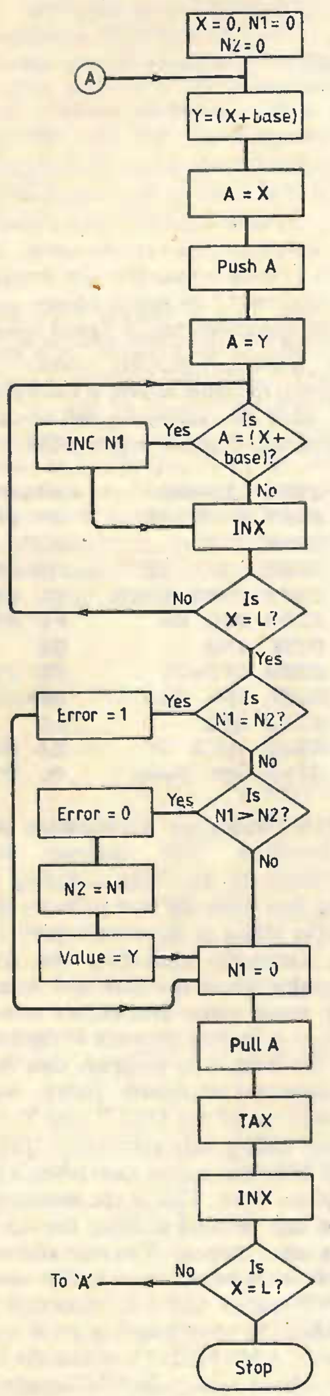
NVT (number of values in a table) subroutine. This subroutine accepts an 8-bit number that has previously been stored at address 002E and then determines how often it appears in the table of values stored in ram. The count is stored in 002F. Other important addresses are 020E which contains the value of the length of the table (+1), so if the table contains 32 values the number 21_{16} is stored; 0208 and 0209 contain the 2-byte base address of the table (in low-byte/high-byte order). In my system, the table started at 0300 and ended at 0320 so addresses 0208 and 0209 contained 00 and 03 respectively

```
0200 LDA*00        A9 00
0202 STAZ 2F       85 2F
0204 TAX           AA
0205 LDAZ 2E       A5 2E
0207 CMPX 0300     DD 00 03
020A BEQ 06        F0 06
020C INX           E8
020D CPX*21        E0 21
020F BNE F6        D0 F6
0211 RTS           60
0212 INCZ 2F       E6 2F
0214 JMP 020C      4C 0C 02
```

FDA (frequency distribution analysis) subroutine. This analyses the data obtained by the range sampling process, and then gives the true value for the range of the object in the robot's path. It works by internally examining the frequency distribution of the data and determining the range value that occurs most often, i.e., it is finding the peak of the histogram of the data. The program uses the NVT subroutine explained above, and also makes use of the 6502 X and Y registers. After calling this subroutine (JSR 0217), the value that occurs most often is found in address 0034. This is the measured range and may be used to direct the robot or for any other purpose. The start address of the table must be the same as that used in the NVT routine and it is important that the table is the same length or gross errors will occur. Address 0243 contains the length of the table +1, as in the NVT routine.

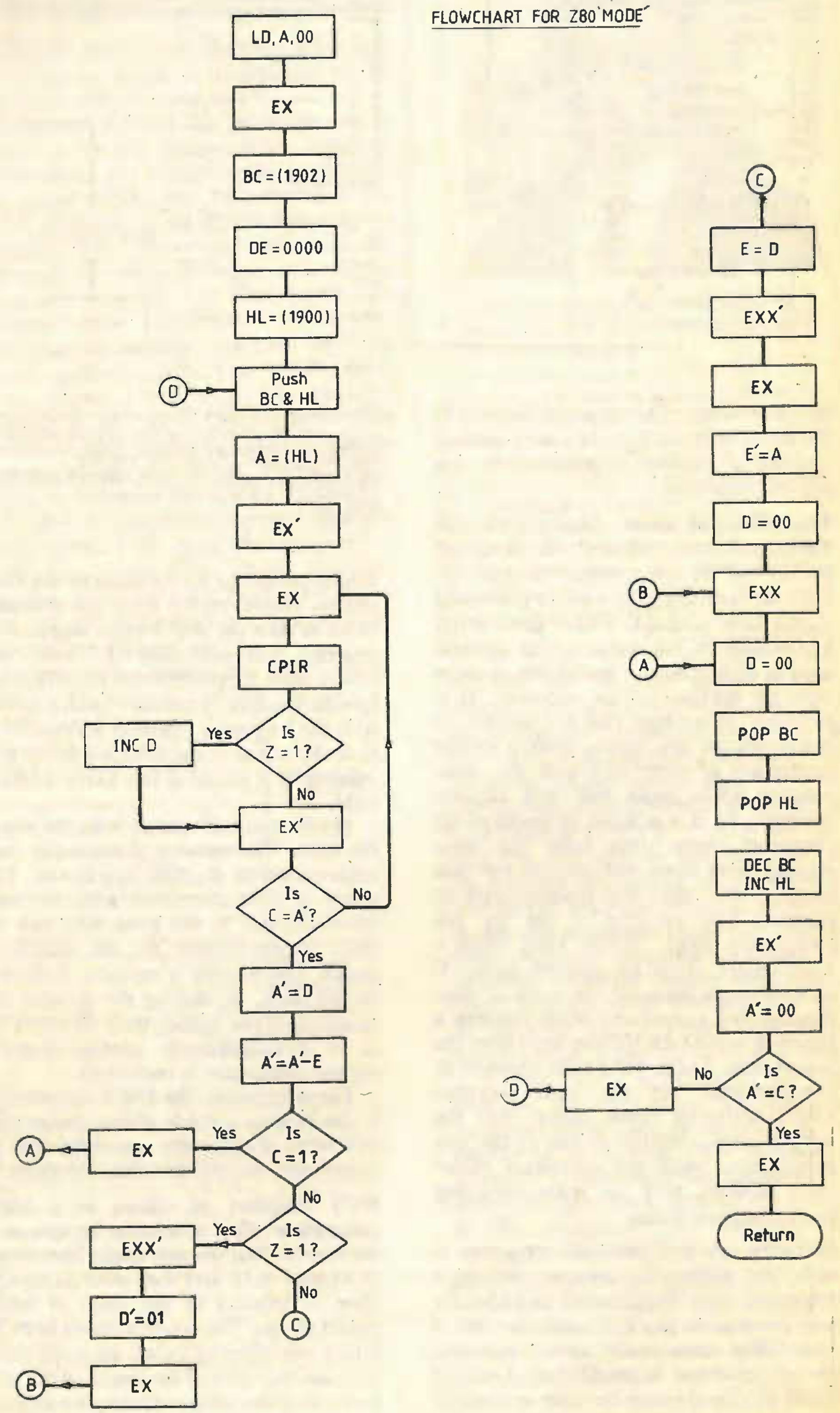
```
0217 LDA*00        A9 00
0219 STAZ 2F       85 2F
021B TAX           AA
021C LDA,X 0300    B0 00 03
021F STAZ 30       85 30
0221 STAZ 2E       85 2E
0223 TXA           8A
0224 TAY           A8
0225 JSR (NVT)     20 00 02
0228 LDAZ 2F       A5 2F
022A STAZ 32       85 32
022C TYA           98
022D TAX           AA
022E INX           E8
022F LDA,X 0300    B0 00 03
0232 STAZ 31       85 31
0234 STAZ 2E       85 2E
0236 TXA           8A
0237 TAY           A8
0238 JSR (NVT)     20 00 02
023B LDAZ 2F       A5 2F
023D STAZ 33       85 33
023F TYA           98
0240 TAX           AA
0241 INX           E8
0242 CPX*21        E0 21
0244 BEQ 1A        F0 1A
0246 LDAZ 32       A5 32
0248 CMPZ 33       C5 33
024A BCC 07        90 07
024C LDAZ 30       A5 30
024E STAZ 34       85 34
0250 JMP 02 2F     4C 2F 02
0253 LDAZ 31       A5 31
0255 STAZ 34       85 34
0257 STAZ 30       85 30
0259 LDAZ 33       A5 33
025B STAZ 32       85 32
025D JMP 02 2F     4C 2F 02
0260 RTS           60
```

FLOWCHART FOR MODE PROCEDURE-6502



Flowchart for Mode for both the 6502 and Z80 processors. It should be possible to compile a program for any other processor from comparing the charts.

FLOWCHART FOR Z80 MODE



Appendix

Noise is of course, by definition, random. The probability that a noise will occur during a range measurement can be calculated. Supposing we have a number n which can take the value of 1 or 0 depending on whether noise is present. Then if the duration of a noise pulse is d_m separated by a period t_m, then

$$d_m = \frac{1}{n}\sum_{j=1}^{n} d_j \text{ and } t_m = \frac{1}{n}\sum_{i=1}^{n} t_i$$

Assembler and machine code program for Mode with the 6502.

```
0200 CL D          D8
0201 LDA #00       A9 00
0203 TAX           AA
0204 STAZ 21       85 21
0206 STAZ 22       85 22
0208 LDY,X 0300    BC 00 03
020B TXA           8A
020C PSH A         48
020D TYA           98
020E CMP,X 0300    DD 00 03
0211 BNE 02        D0 02
0213 INCZ 21       E6 21
0215 INX           E8
0216 CPX Z23       E4 23
0218 BNE F4        D0 F4
021A SEC           38
021B LDAZ 21       A5 21
021D SBCZ 22       E5 22
021F BEQ 0F        F0 0F
0221 BCC 0A        90 0A
0223 LDAZ 21       A5 21
0225 STAZ 22       85 22
0227 STYZ 20       84 20
0229 LDA #00       A9 00
022B STAZ 24       85 24
022D SEC           38
022E BCS 04        B0 04
0230 LDA 01        A9 01
0232 STAZ 24       85 24
0234 LDA #00       A9 00
0236 STAZ 21       85 21
0238 PLA           68
0239 TAX           AA
023A INX           E8
023B CPX Z23       E4 23
023D BNE C9        D0 C9
023F RTS           60

The following locations
are used by 'MODE':
Z20 = value (i.e. MODE)
Z21 = N1
Z22 = N2
Z23 = length
Z24 = error
For details see flow chart.
```

Assembler and machine code program for the Z80.

```
      Label  Source          Object
1800         LD A,00         3E 00
1802         EX AF,AF'       08
1803         LD BC,(1902)    ED 4B 02 19
1807         LD DE,00 00     11 00 00
180A         LD HL,(1900)    2A 00 19
180D  LB6.   PUSH BC         C5
180E         PUSH HL         E5
180F         LD A,(HL)       7E
1810         EX AF,AF'       08
1811  LB2.   EX AF,AF'       08
1812         CPIR            ED B1
1814         JR NZ :LB1      20 01
1816         INC D           14
1817  LB1.   EX AF,AF'       08
1818         CP C            B9
1819         JR NZ :LB2      20 F6
181B         LD A,D          7A
181C         CCF             3F
181D         SUB E           93
181E         JR C :LB3       38 20
1820         JR Z :LB4       28 18
1822         LD E,D          5A
1823         EXX             D9
1824         EX AF,AF'       08
1825         LD E,A          5F
1826         LD D,00         16 00
1828  LB7.   EXX             D9
1829  LB8.   LD D,00         16 00
182B         POP HL          E1
182C         POP BC          C1
182D         INC HL          23
182E         DEC BC          0B
182F         EX AF,AF'       08
1830         LD A,00         3E 00
1832         CP,C            B9
1833         JR NZ :LB5      20 02
1835         EX AF,AF'       08
1836         RET             C9
1837  LB5.   EX AF,AF'       08
1838         JR     :LB6     18 D3
183A  LB4.   EXX             D9
183B         LD D,01         16 01
183D         EX AF,AF'       08
183E         JR     :LB7     18 E8
1840  LB3.   EX AF,AF'       08
1841         JR     :LB8     18 E6
```

where d_j is the individual noise duration and t_i the individual time between pulses. We can see that if a noise pulse occurs once between the times t_a and t_b it could have occurred a total of b times equal to $(d_m+t_m)/d_m$. The probability that noise will occur at any one time is the inverse of b, i.e. $d_m/(d_m+t_m)$. The longer we extend the listening period, the more likely we are to get a noise pulse ($\rightarrow 1$). So the probability that our range measurement is true will tend towards $1-b$. There are no controllable parameters because noise is random. However there is a way to overcome this and introduce control into the range measurement. If the maximum range of the measuring system is 1m, then the time taken to take a measurement is 6.06ms. We are using an 8-bit counter to measure the distance so we can measure in 255 increments of distance. If the measured distance is 255 then we call this an over-range reading and ignore it, for safety. So if the true distance is R, the time taken to make the measurement is 6.06R/254. The chance that a noise pulse is received in this period is 1/R and if we combine this with the probability of a noise pulse being detected at any time 1/b we get $1/bR = d_m/R(d_m+t_m)$. If we call this P for probability and then if we make two such measurements then the probability that there will be a noise pulse detected during both periods becomes P^2 and if we make a large number of measurements then the probability that if I is the number of measurements that are identical, then the probability that these are due to noise, P_I is equal to P^I. I is the number of identical range values and is partly controllable depending on the number of measurements taken. If P_I is the probability that I identical values are due to noise, the probability that these readings are in fact the true range measurements is therefore $1-P^I$, or $1-(d_m/R(d_m+t_m))^I$. The effectiveness of the system thus depends chiefly on the number of readings taken, but it may also be possible for the computer software to determine the values of d_m and t_m, i.e. the duration and spacing of noise pulses and then optimise the number of readings taken. This could vary with different environments. A further refinement could be for the robot to move the sensor a specific distance, take another set of readings, and then confirm the first set by comparison, taking into account the offset caused by the movement.

Non-industrial robots

People are designing robots to solve specific problems in areas where immediate financial benefit is likely. But areas where financial gain appears unlikely at present, are not being researched very enthusiastically. It is in this area that amateurs can be of great help, by designing and discussing their own robot projects and experiments. Robots made for personal scientific interest and curiosity are bound to be more far-reaching in scope than so-called robots built merely as an economical answer to a tricky engineering problem. The author would like to hear from readers who are pursuing the subject of robodynamics from a hobbyist viewpoint, in an attempt to make some real progress in a field which might be called "non-industrial robots". Readers interested in forming a non-industrial robot group can make contact at the following address:

H. W. Gleaves
20 Hartington Road
Liverpool 8, L8 0SG

Test yourself in circuit analysis

Here are the answers to Wes Vincent's circuit analysis quiz on page 43.

1. 4V	5. 3V	9. 2.8V
2. 6V	6. 1.5kΩ	10. −0.4V
3. 7mA	7. 5mA	
4. 21V	8. 1kΩ	

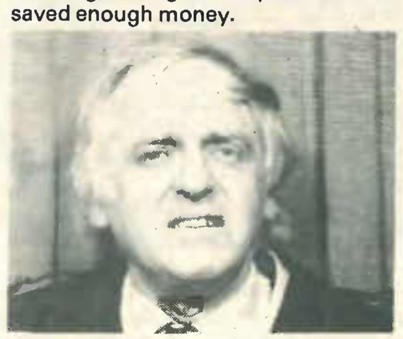
Count the number you answered correctly and compare below.

10	Congratulations! You pass as an expert
8-10	Above average
6-8	Average
4-6	Below average. Review the concepts presented in the article.
<4	Well below average. Review this article at a later date and try the quiz then.

An electronics engineer at Delco Electronics division of General Motors, Kokomo, Indiana, Wes Vincent designs integrated circuits for automotive electronics. He is typical of *Wireless World* readers in enjoying electronics as a hobby, and says he wrote the article "to help the hobbyist, technican and practising engineer to sharpen their skills with respect to circuit analysis".

John Wiseman

John Wiseman, born 1931, Melbourne, must be an expert on South America: he's spent years "wandering about" Argentina, Brazil, Chile, El Salvador, Guatemala, Honduras, Mexico and Uraguay, supporting himself by translating pieces for the Australian press from Allendes Chile. As a freelance radio officer based in London on foreign-flag shipping the offer of a very cheap sea passage to Buenos Aires proved irresistible. It was boredom of working as a radio operator off the Australian coast that had previously led him to change course and take up teaching, fleeing to Europe when he'd saved enough money.



Back in the antipodes in the mid-seventies, a "very bad experience in a storm" in the Bass Strait – between Tasmania and the mainland – concentrated his interest in aerial design. And taking up aerial matters with the radio surveys ministry found him up against a "never wrong" bureaucracy. "So I bought a camera" he explains, "and started to photograph some of the atrocities such bureaucrats have given their approval to". This resulted in articles in *Safety at Sea*, *Nautical Review* as well as *Wireless World* (see "Transmitting aerials of modern merchant ships" September issue, "Practical problems with aerials at sea" March issue with subsequent letters, and "Aerial inefficiency at sea", page 29 this issue). 1983: Further time in the UK, he tells us, "has been vetoed by the Home Office".

Hobbyist's spectrum analyser

Television tuner module and oscilloscope form the basis of this useful and versatile piece of test-gear

by Roy Hartkopf

Home experimenters occasionally have a chance to lift their activities to a new and previously unattainable level. The catalyst here is the voltage-controlled variable capacitance diode television tuner and the piece of equipment is the spectrum analyser. This article looks at these tuners and their power supply requirements in some detail and shows how to take the first steps toward a practical 'backyard equivalent' of the expensive all-singing all-dancing commercial spectrum analysers. This project is one where results can be obtained almost from the beginning and where each stage can provide the facilities for building and checking the next. The final result should be limited only by the patience, care and enthusiasm of the constructor.

But first of all, what is a spectrum analyser and what can it do? Essentially it shows an instant picture of the position and the strength of every signal in a selected frequency band. It shows what radio and television stations are on the air, their strength and frequency. It instantly detects spurious or harmonic radiation from the oscillator you built or from a transmitter. It can help to trace and identify electrical noise and interference, and it can make the building and alignment of filters and high frequency amplifiers a matter of minutes instead of days.

The principle on which the spectrum analyser works is simple. By applying a sawtooth waveform, preferably taken from the oscilloscope itself, to both the oscilloscope deflection circuits and the tuner we cause the tuner to sweep over part or the whole of its range in synchronism with the spot moving across the oscilloscope screen. At the same time a rectified output from the tuner is applied to the vertical amplifier of the oscilloscope causing a vertical spike to appear at any frequency where there is a signal. Since the height of this spike is proportional to the strength of the signal we have a picture or panorama of all the activity in this frequency band.

One cannot work entirely without tools and the major requirement in this case is an oscilloscope. The simplest home-made one will do because although we may be viewing frequencies of hundreds of megahertz the oscilloscope is coping only with rectified a.c. and the sweep should be as slow as possible. About 25 sweeps per second will be fast enough to avoid too much flicker.

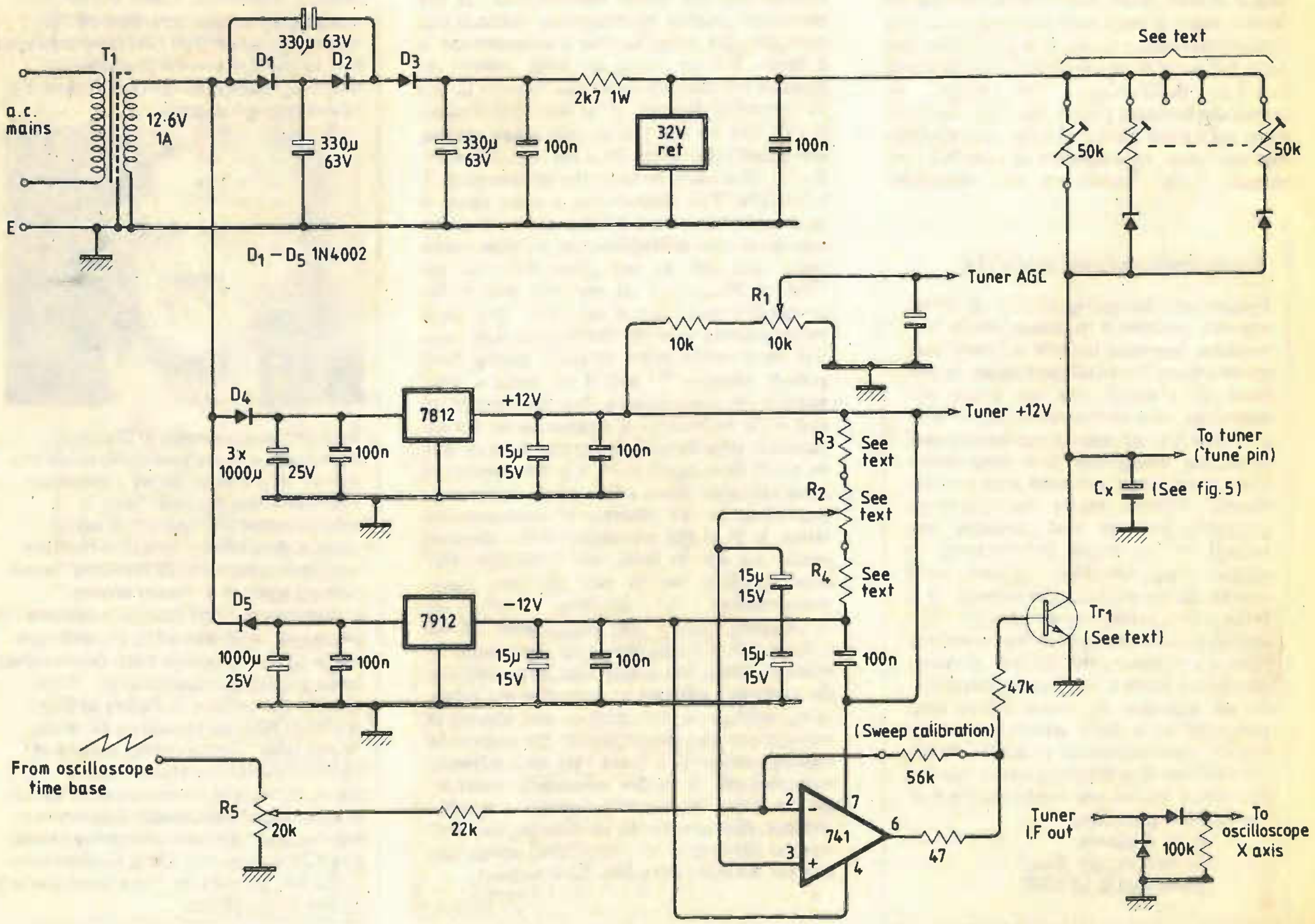


Fig. 1. Power and control-voltage supplies for the tuner module. Tuner is swept across its range by a waveform derived from the timebase of an oscilloscope; after rectification its i.f. output is applied to the vertical deflection input. Network at the collector of Tr_1 *provides correction for the non-linearity of the tuner's tuning characteristic.*

The other major item is the television tuner itself. It must of course have voltage controlled tuning and preferably cover both the v.h.f. and u.h.f. television bands. The most useful bands are from about 100-220MHz and 450-850MHz. The tuner mentioned in this article is a Philips ELC2060 but any other type could equally well be used.

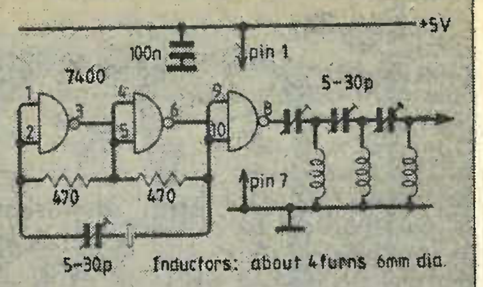
Once the printed circuit board is made the assembly of the components should be done in stages, beginning with the power supplies. The 12 volt positive and negative supplies are quite standard and since the current required from the negative supply is likely to be very low – even allowing for future additions – only one 1000μF capacitor was used for smoothing. The third supply is used for the voltage-variable capacitor tuning and consists of a tripler circuit which generates about 50V. The voltage used for tuning must be extremely stable: a voltage change of about 25V tunes the u.h.f. section over 400MHz, a rate of 16MHz per volt; so a jitter of even 1mV will cause a frequency jitter of 16kHz. There are integrated-circuit voltage stabilizers specially made for television tuners and a typical one is the TAA550, a two-lead device in a TO-18 case. The positive lead is connected to the case so be careful about shorts when using a heat sink. With a small clip-on heat sink the device will carry about 6mA comfortably and drop about 32V. It is the stability, not the voltage, which is critical. To prevent any possibility of the TAA550 dropping out of regulation it is wise to allow for a minimum current of a couple of milliamps to be flowing through it at all times. This leaves about 4mA as the maximum which can be drawn by transistor Tr_1, so the load resistor should be at least 8kΩ. On the small plug-in board we can temporarily set one of the trimmers (the one which has a wire link in series rather than a zener diode) to 8kΩ and, without soldering in any of the zener dodes, plug the board into its place.

The range-setting resistors R_3 and R_4 have to be adjusted and it is necessary to substitute two trimmers to determine the final values. Use two 100k pots, set them about mid-range and solder them to inch-long tails of wire which can be soldered into the holes for the resistors. Any transistor which will stand the 32V rail will do for Tr_1 but select one for a very *low* gain (50 or even less). A high-gain transistor can make subsequent adjustments impossibly critical.

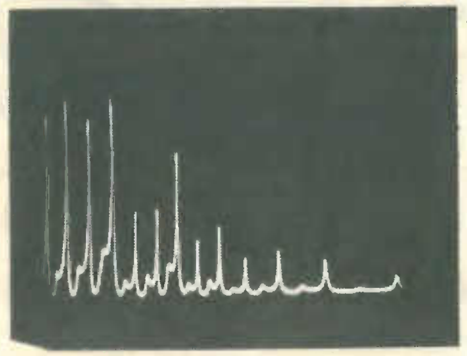
Apart from the power transformer the only components external to the board are the v.h.f.-u.h.f. switch (if required) and R_2. R_2 is a critical component because it controls the centre position of the sweep. A good quality 10-turn pot should be used; or if that is too expensive or hard to get use a ten turn trimmer, the kind used in presetting push-button television tuners. Otherwise the control will be too sensitive. R_2 sets the voltage applied to the non-inverting input of the op-amp; and the circuit is adjusted so that, with the slider of R_5 grounded, R_2 can vary the tuner voltage through the full range from 0 to 30V. This is achieved by adjusting the trimmers which temporarily replace R_3 and R_4 while measuring the voltage on the collector of

Simple comb generator

The comb generator gets its name from the fact that the pattern it produces on a spectrum analyser resembles an ordinary hair comb with its prongs pointing vertically upward. Because these 'prongs' are harmonic multiples of the fundamental frequency it follows that the frequency difference between each one and the next must be exactly the same, the same as the fundamental frequency of the oscillator. So if they are evenly spaced across the screen we can be certain the sweep is linear (except for possible variations between the spikes, so the more spikes within reason the better). If we know the fundamental frequency we can get a quick indication of the total range of the sweep and if we also know the frequency of any individual spike we can use the comb as a "frequency ruler" to measure any other signal.

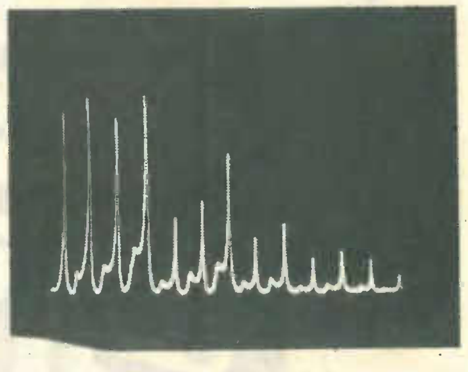


Electrically the comb generator is just an oscillator. But where normally we try to get a clean signal and suppress the harmonics here we try to produce as many as possible. We make a high pass filter by feeding the output through two or three (or more) small capacitors in series with inductors. Choose a convenient frequency for the oscillator (e.g. 10, 20, 25 or 50MHz) and fiddle both the capacitors and inductors while watching the result on the screen.

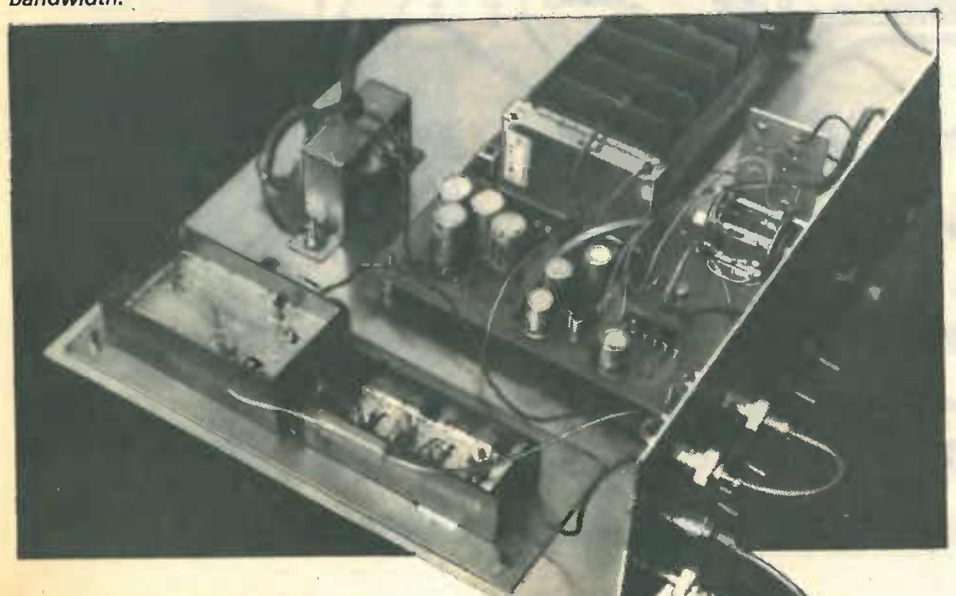


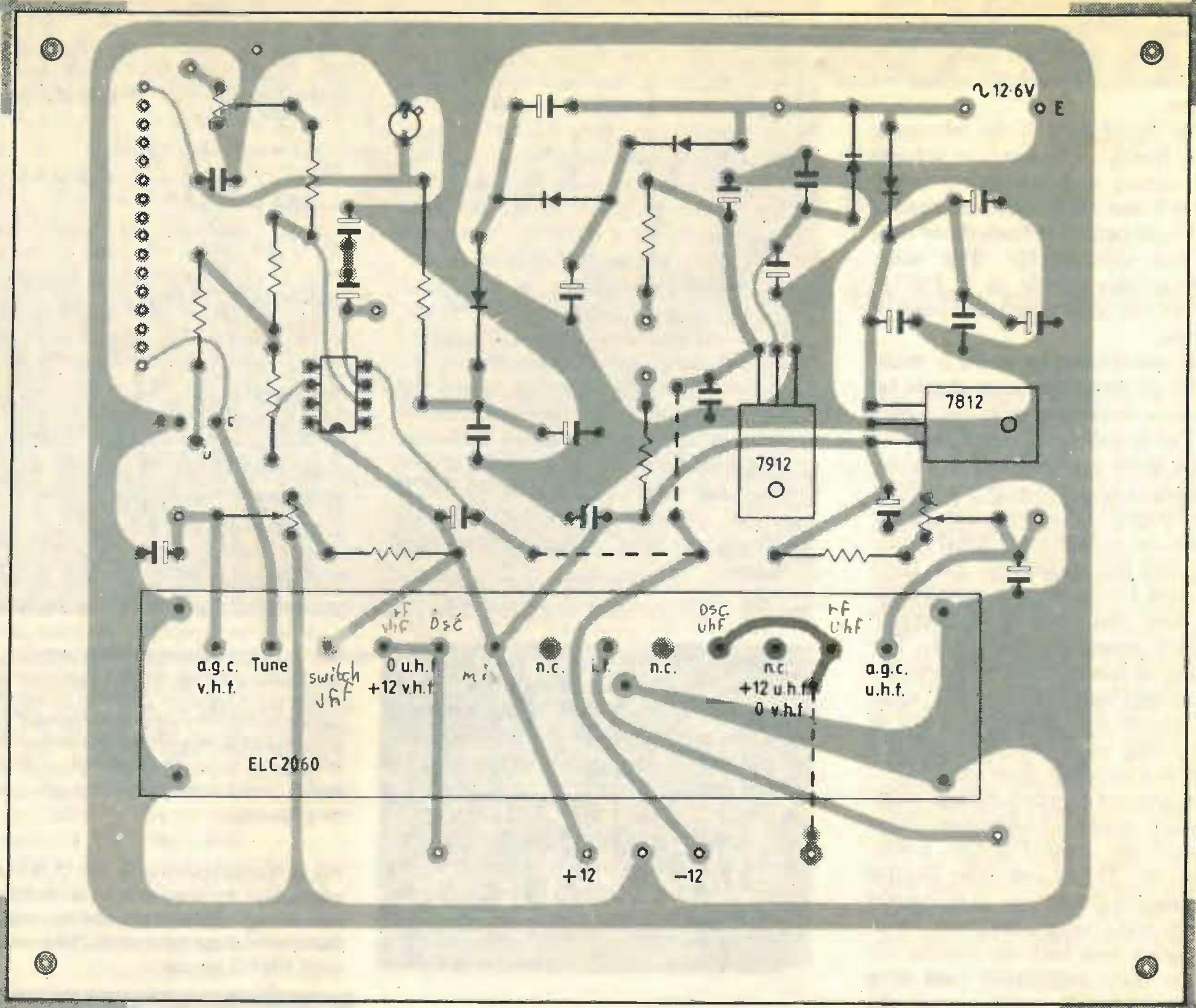
◀ *Fig. 2. Output from a typical comb generator as seen on the home-made spectrum analyser. Uneven spacing between the 'prongs' is corrected by adjustments described in the text; height difference is unimportant. Bumps at the bases of the spikes may indicate tuner overloading.*

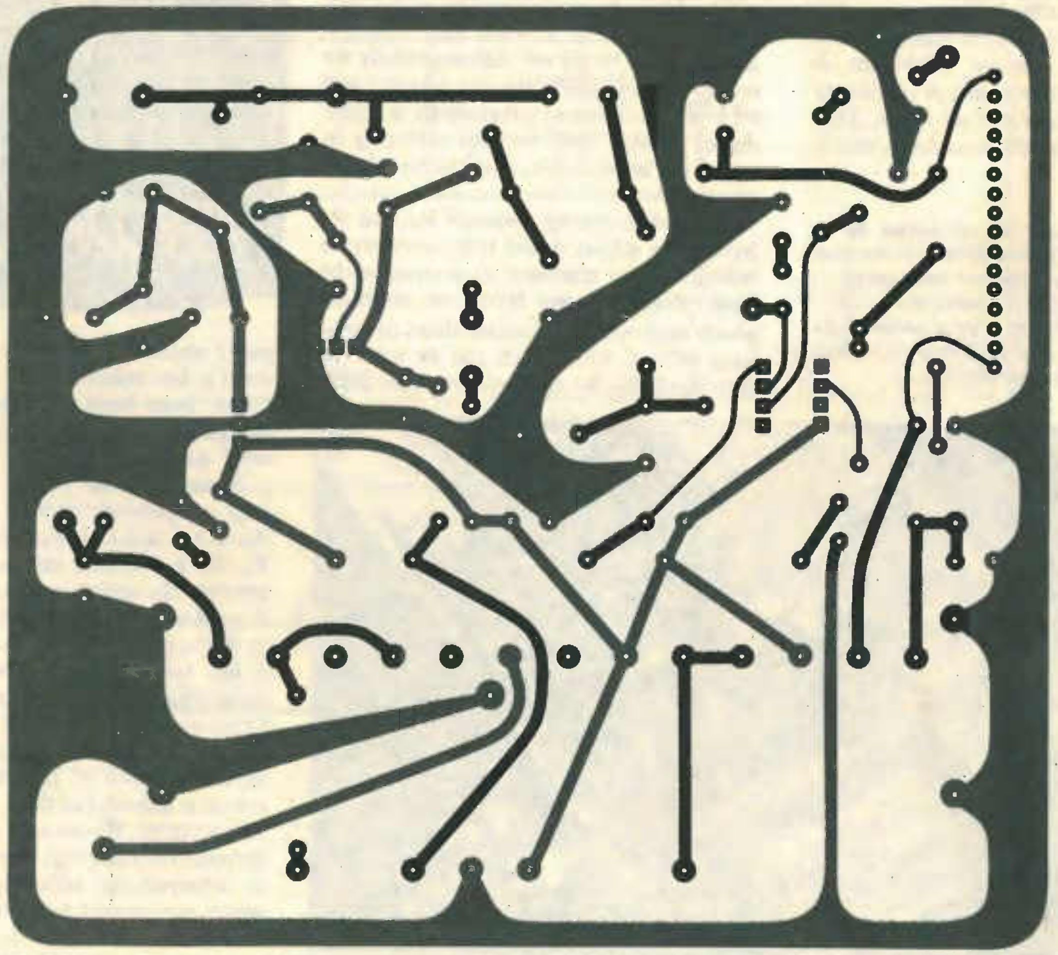
Fig. 3. Same comb as in Fig. 2, but after correction for linearity. Note improvement in spacing between the spikes on the right-hand side. Display covers 100 to 200MHz with 10MHz spacing.

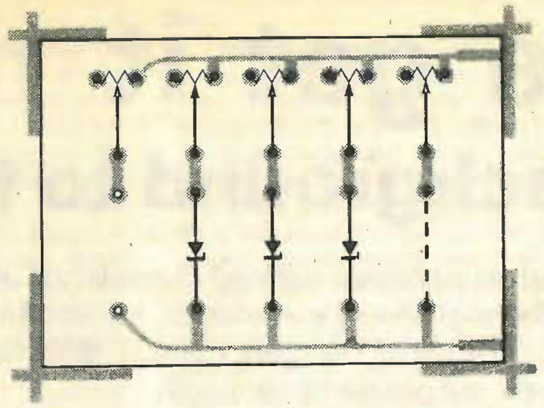


Basic instrument can be enhanced by additions such as heterodyne mixers and filters to provide additional frequency ranges, switched input attenuators, logarithmic amplifier to give a wide-range calibrated display, and switched handpass filters to select an appropriate i.f. bandwidth.









For flexibility, the loading network at the collector of Tr_1 is constructed on a separate board which plugs into the main one.

Tr_1. Remember to set the a.g.c. trimmer R_1 to give about 2.5V to the tuner a.g.c. pin (or pins as the case may be). Finally make up a rectifying circuit with a couple of signal diodes and a 100Ω resistor as shown in Fig. 1 and connect it between the tuner output and the oscilloscope probe. Having connected the sawtooth waveform driving the oscilloscope to R_5, set the sweep to a very low speed (about one sweep every five seconds), put the voltmeter on the collector of Tr_1 and adjust R_5, the shift control R_2, and if necessary, everything else, until the tuner control voltage is sweeping through the full 30V. Then increase the sweep frequency enough to give a readable trace and put a signal within the frequency range into the tuner. One or more spikes on the trace should show that the first stage of your spectrum analyser is working.

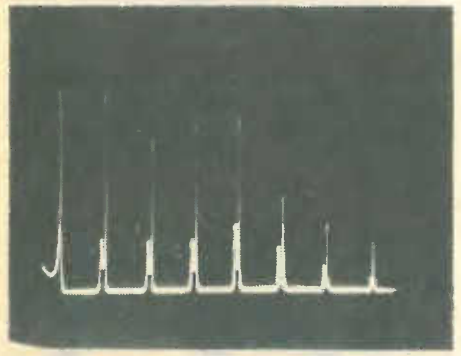
The next job is to make a comb generator (see box 00). When this is connected to the tuner the display should resemble that shown in Fig. 2. The main purpose of the comb generator is to help in optimising the linearity of the sweep. Note how in Fig. 2 the spikes are crowded together at the left and spread out at the right. This indicates that the same control voltage change causes more tuning shift at the beginning of the sweep than the same change causes at the finish. To put this right, zener diodes are fitted to the small plug-in board to modify the load resistance for Tr_1. As the voltage across the load increases the diodes will successively conduct, reducing the load resistance and compensating for the increased frequency-to-voltage sensitivity.

Now that we have a picture to work to, we can easily make the whole system linear. Remove the small plug-in board, readjust the trimmer from 8kΩ to about 15kΩ and wire in the first zener. Use a 15V type for a first try, and set the trimmer in series with it to the maximum 50kΩ and replace the board. Now fiddle the load trimmer and R_5, and if necessary R_2 and the rest, until the display is similar to what it was before. Use R_2 to make sure there are no harmonics off the right hand side of the screen. Now close up the spacing until a centimetre or so on each side of the screen is clear and reduce the resistance of the trimmers in series with the 15V zener diode. If the value of the zener is correct then all the harmonic spikes except the last two on the right should move to the left. If either of the last two moves the zener voltage is too low. Try one of, say, 18V. If three or more of the right hand spikes do *not* move, the voltage is too high. When you get the voltage correct, adjust the trimmer until the third spike from the right has exactly the same spacing as the first two. With any luck the fourth may also now be correct.

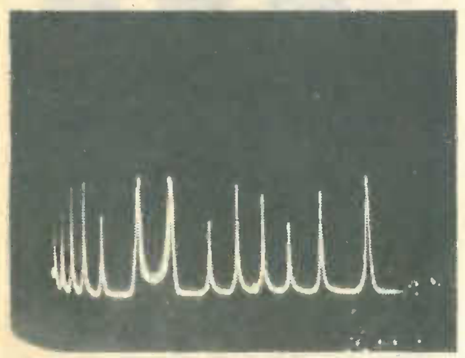
Continue in exactly the same way with another zener diode, selecting one which shifts only the spikes not already spaced correctly, until the display is similar to that shown in Fig. 3. If you are very unlucky and the tuner has both v.h.f. and u.h.f. ranges you may have to use a second plug-in board for the other range; but in every case experienced so far (several tuners have been tried) the same compensation settings are adequate for both ranges. The more zeners and trimmers used, the more accurate the correction; but three are usually enough, at least for a first attempt. As a final check, make sure that with all zeners conducting the load current is about 4mA. If it is more and the regulation is dropping out then increase the level at R_5 and try again.

The basic spectrum analyser is now complete, although it still has a number of limitations. It is uncalibrated, it is not very sensitive, it has a restricted frequency range and the i.f. bandwidth is too broad for some applications. But by progressive additions such as switched bandpass i.f. filters, a logarithmic amplifier to improve the sensitivity and the range, heterodyne mixers to extend the frequency range and a calibrated variable sweep the final result could be limited only by the patience and enthusiasm of the constructor.

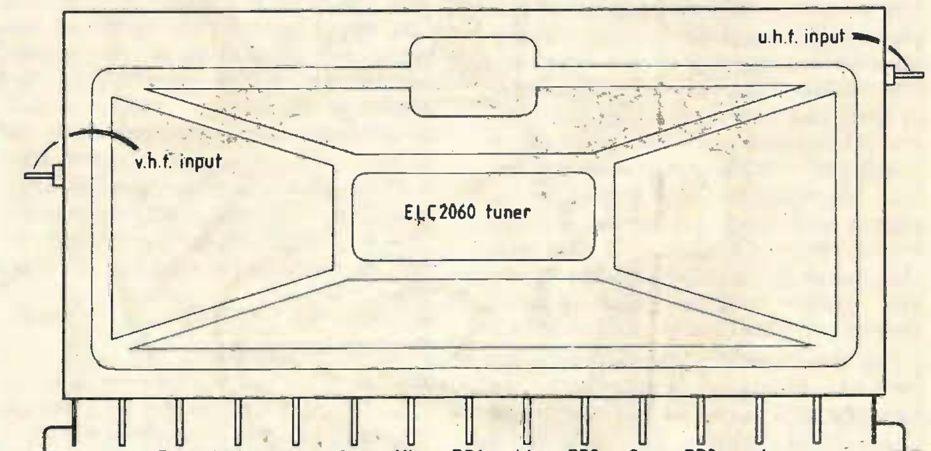
The ELC2060 tuner is available for £8.63 including inland postage and v.a.t. from Sendz Components, 63 Bishopsteignton, Shoeburyness, Essex SS3 8AF.



The same linearity correction should be effective on more than one band. This shows a u.h.f. display from 500 to 850MHz with 50MHz spacing.



If the oscilloscope sweep speed is too fast, as it is here, the tuner frequency may still be dropping when the next sweep begins. This can arise because voltage-controlled tuning circuits usually incorporate some capacitance for stability, for example, C_x in Fig. 1.



	a.g.c. u.h.f.	Tune	Switch v.h.f.	r.f. v.h.f.	Osc.	Mix	TP1	i.f. out	TP2	Osc. u.h.f.	TP3	r.f. u.h.f.	a.g.c. u.h.f.	
Pin	1	2	3	4	5	6	7	8	9	10	11	12	13	
u.h.f.	0	·5–28	12	0	0	12	n.c.	–	n.c.	12	n.c.	12	2·5	Volts
v.h.f. band III	2·5	·5–28	12	12	12	12	n.c.	–	n.c.	0	n.c.	0	0	Volts
v.h.f. band I	---Not used-----													

Connection details for the Philips tuner. Other tuners may be equally suitable.

Did Morse get it right?

A statistical background to the code

Morse speed in words-per-minute presupposes a defined mean word. A value for this can be derived from an analysis of Samuel Morse's own data. Recent trials support the original work for English but not for French or German. Certain aspects might even have surprised the great man himself.

by A. S. Chester
M.I.E.E., G3CCB

Morse code must be reasonably familiar to most readers of Wireless World but some of the finer points of its structure and certain practical difficulties in its application might not be immediately obvious to the non-specialist. In particular, there is an inherent uncertainty in relating transmission rate to the more traditional measure of words per minute. The last-mentioned introduces the concept of a standard word length which must be statistically derived from an analysis of plain language text, and the results may differ significantly between one language and another. This article looks at present-day practices and relates these to statistical data available for English and five other European languages. The need for such a reappraisal can be justified by the increasing use of automatic keyers, practice code generators and the like, which, with their capability for greater precision in code formation, has led to a general desire to define transmission speed more closely and more uniformly than has been the custom in the past.

Statistical beginnings

By the early 1830s Samuel Morse had become fully aware of the potential that a variable code would offer in arranging shorter combinations of signals to be allocated to the more frequent letters of the alphabet and it is recorded[1] that a visit to a local newspaper printing room enabled him to deduce from the number of type pieces held for each letter of the alphabet the relative frequency of use. From this information, Morse devised combinations of short and long signals specifically designed to maintain the product of character length and frequency at a more constant level than would otherwise be the case, and thereby to produce the shortest messages overall. Morse's original code (not quite the same as that in use today, see Appendix) together with the letter frequency table he compiled are given in Reference 1.

For the immediate task of providing a basis for calculation, it is necessary to state here the parameters of the mark-space structure as follows. The dot length (period) can be regarded as the basic element and the dash is given a length equal to three dots. The spaces between the elements within one character are equivalent to one dot and the spaces between characters are given three dots duration. Words are separated by seven dot elements. For brevity, the term bit is used synonymously with dot element making the dot rate equal to half the bit rate (baud or bit per second).

The length of a morse character can be expressed in terms of the number of dot elements or bits it contains: for example, the letter A (dot dash) can be said to comprise five bits. However, as one character cannot follow another without inserting a space of some kind, it is preferable to include the standard inter-character space (three bits) as part of the letter itself bringing the letter A to eight bits*, alphabet shows a range from four to 16 with a mean value of 11.23 bits. The full range of bit counts is given in the Appendix.

Random code

When letters are selected at random they appear, by definition, at uniform relative frequency and a mean five-letter word in code is equal to five times the mean letter plus four bits to make up the remainder of the word space. Taking a rounded value for the mean letter as 11.2 bits, the mean word comes to 5 × 11.2 +4 = 60 bits. Code speed in words per minute is then numerically equal to the bit rate or twice the dot rate. Figure characters also can usually be regarded as random in their occurrence and a similar analysis to that for letters gives the mean character length as 17 bits from which the mean five-figure group (including word space) comes to 5 × 17 + 4 = 89 bits. Speed in word/min can then be shown to be equal to 1.35 × dot rate.

English language

The fact that plain text does not make use of all letters of the alphabet with uniform frequency presents the major difficulty in setting a value for the mean (plain language) word. It is safe to say, however, that the figure is bound to be significantly less than the value for the random case, otherwise there would be no benefit to be gained from the use of a variable length code and, in fact, the ratio of the two figures can be regarded as a measure of achievement in optimizing the design.

Before going on to report the results of trials it must be conceded straight away that a standard word for a plain language does seem to have established itself already: a scrutiny of published material shows a concensus for a nominal standard of 50 bits (including word space) and the word 'Paris' is sometimes quoted as representing this value. Frequently the information is given directly in terms of word/min and dot rate as, for example, word/min = 2.4 × dot rate (1 word/min = 50 ~~s~~/60 baud). Seldom is the reader provided with any basis for the figures quoted and variations do appear from time to time not only in the literature but in the observed calibration of automatic keyers and practice tapes.

It was against this background that I felt the need to satisfy myself that any standard being quoted, and in particular the 50 bit word, had a reasonably sound statistical basis for its application and had not established itself merely by common usage. At the same time, it had to be admitted that, even if a 'better' result were to be found, there might still be a case for retaining a round figure such as 50 bits in the interests of easy standardization, providing the figure did not depart too far from reality.

To derive a standard word for plain language it is necessary to combine the bit count for each letter with its relative frequency of occurrence to obtain a measure of the overall effectiveness of the letter in a long run of text. Relative letter frequencies must, of course, be estimated by statistical trial and in the first instance I selected three quite different sources of available data.

The first was the original frequency table[1] compiled by Samuel Morse around 1830 and reproduced in ref. 1. The second was taken from a work[2] on cryptography by H. F. Gains first published in the late 1930s, which not only provided two sets of data by different analysts (Meaker and Ohaver) on English but data on five other European languages as well. The third was obtained during correspondence following publication of an article[3] by a beginner operator describing his attempts to relate the dot rate on his automatic keyer to the amateur radio morse test at 12 word/min. It was not in the least way possible to foretell what the outcome of the exercise might be, but in the event the results proved to be so gratifying that I undertook a count of letter frequencies myself to provide extra data for analysis. The method used for this exercise and the results obtained are given at the appendix.

Given suitable data on letter frequencies, the procedure to determine the length of the standard word was the same for all sources of material. For all letters designated r_1 to r_n the product of bit count x_r and frequency f_r gave a table of values from which an overall mean letter size could be calculated. In the usual notation, the mean value x is

$$\bar{x} = \frac{1}{N}\sum_{r=1}^{n} x_r f_r$$

where N is the size of the sample. Defining the mean word as comprising five mean letters plus four extra bits to make up the word space, a value for the standard word was calculated. The results of the exercise using letter frequency data from the five sources listed are given in Table 1. The total dispersion of the mean over the five results is gratifyingly small considering the wide differences in source and sample size. A global mean value for the mean word comes to 49.4 bits and is unchanged (to three significant figures) when the data points are restricted to the middle three values.

Other languages

In addition to two sets of data on English, reference 2 provides letter frequency tables for five other European languages. The exercise to find a value for the standard word was extended to include these languages and the results obtained are given in Table 2. Data for French, Italian and Spanish were compiled from a count made by the author, but the origins of data for German and Portuguese are said to uncertain.

The results show significantly low values of the mean word for French and German relative to the other language trials, including English. This seems likely to be due to the fact that the frequency table for German shows zero count for letters J, Y, Q, and Z (all long symbols in morse) while the count for letter E (the shortest symbol) was the highest encountered over all languages. The relatively low value for French cannot be so easily explained with zero count for K and W (letters of around average size in morse) but a fairly high count for E. Spanish and Portuguese, producing equal results, are the only two languages in the six tested to show a mean word exceeding 50 bits.

The standard word

Results for English show a value for the mean word estimated over five trials as 49.4 bits with an overall dispersion of +0.4 to −0.3 bit. There can be little doubt therefore that a standard word of 50 bits will meet all normal requirements for the measurement of morse speed in English. Of the five other languages, Italian, Spanish and Portuguese all show values for the mean word within ±1% of 50 bits which value can be accepted as the standard for these languages also, albeit on the basis of smaller samples.

Table 1. Results of five independent trials to determine the mean word for English.

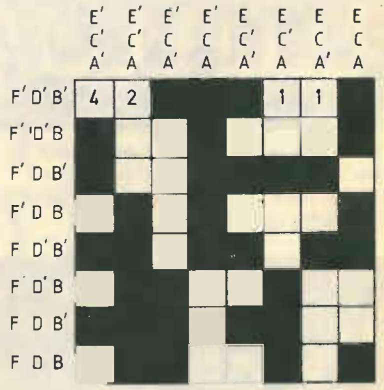
Origin	Sample size	Mean word (bits)
Morse	106,400	49.8
Gains (Meaker)	10,000	49.5
Gains (Ohaver)	10,000	49.3
Chester	10,000	49.3
Wood	1,798	49.1

French and German deviate much more from the 50 bit standard at −4.8% and −7.4%, respectively, and it may be worth considering whether any additional trials should be undertaken on these languages to verify the low values obtained from the published data used.

Given a standard word length of 50 bits, the word Paris is often used to represent this value. Whether it is really necessary to quote an actual example of a 50 bit word is debatable but there must be other internationally recognisable words of this length

Morse symbols and bit content including inter-character space together with frequency count. Taken from the *Sunday Times* of 18 July 1982 using a wide range of material by different writers. But specialist subjects were avoided, as were passages containing undue repetition of proper names and frequent use of foreign words. The combined result is from a total sample of 10,000 letters. Following the style of Gains, relative frequencies are given as the percentages of the sample while dropping the decimal point gives the actual count.

Letter	Morse symbol	Bit content	Relative frequency
A	· —	8	8.25
B	— · · ·	12	1.78
C	— · — ·	14	3.14
D	— · ·	10	3.38
E	·	4	12.77
F	· · — ·	12	2.38
G	— — ·	12	2.04
H	· · · ·	10	5.06
I	· ·	6	7.03
J	· — — —	16	0.19
K	— · —	12	0.58
L	· — · ·	12	4.30
M	— —	10	2.29
N	— ·	8	7.02
O	— — —	14	7.13
P	· — — ·	14	2.03
Q	— — · —	16	0.14
R	· — ·	10	6.30
S	· · ·	8	7.06
T	—	6	9.17
U	· · —	10	2.83
V	· · · —	12	1.20
W	· — —	12	1.80
X	— · · —	14	0.28
Y	— · — —	16	1.76
Z	— — · ·	14	0.09



Clues

B' D' E' F' = 6	A' B D F' = 6
B' D E' F = 4	B' D E = 6
B D E F' = 6	A D' E F' = 3
B D E F = 6	C E F = 8

Crossword – by N. Darwood

Using the digits 1 to 8 each row and each column adds up to eight. The first clue, and its consequences for the top row, is given. No entry need be guessed. Solution next issue.

*On this basis a bit count for all the letters of the...
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from which to choose. It was during a search through a list of suitable candidates for an alternative to Paris that I stumbled on the fact that the word Morse is one of precisely 50 bits (including word space) and, being more than relevant to the subject in hand, could hardly be bettered as an international standard.

Table 2. Results of trials to determine the mean word for the five European languages given.

Language	Origin	Sample size	Mean word (bits)
German	Uncertain	Not given	46.3
French	Gains	10,000	47.6
Italian	Gains	10,000	49.7
Spanish	Gains	10,000	50.4
Portuguese	Uncertain	Not given	50.4

Morse practice and test criteria

Traditionally, morse speed for plain language transmission is estimated by marking off groups of five letters in a passage of text (ignoring word spaces) and then sending the passage normally arranged in groups of five and the counting of 'words' is then straightforward. It is common practice to send code at a rate some 20% lower than that for plain language with the intention of presenting the same overall degree of difficulty to the operators. Whether this practice is entirely justified is arguable but a quantitative measure of one aspect of the problem is given in the following paragraphs.

Table 3. Standard words for three categories of morse against corresponding wpm/dot rate (dot rate in dots per second = half a bit rate).

	Plain	Code	Figures
Standard word (bits)	50	60	89
Ratio wpm/dot rate	2.40	2.00	1.35

Given a standard word length for each of the three categories of morse, it is simple to find the corresponding ratio of transmission speed in word/min to dot/s. Table 3 gives standard word lengths derived from the data produced in this article with the required ratio. The dot rate for plain language can be adjusted down if necessary by 1% since the mean word length for English estimated by trial has been found to be about this much short of 50 bits. For certain other languages, the dot rate could be much greater in error; see the results for these in Table 2.

When using automatic keyers, the dot rate can readily be set to a level corresponding to the required word speed. In such cases, it may be useful to remember a few equivalents such as 24 word/min in plain language corresponds to 10 dot/s. It is also interesting that this same dot rate will produce a speed in code of 20 word/min and on this basis a combined morse test in plain and code would have to be sent at word speeds in the ratio 24/20 to represent the same 'pace' to the operator. The method, however, would not take into account the difference in letter predictability between the two categories of text and it could be argued that if plain text in the operator's own language is easier to copy than random code at the same dot rate, then the word-speed ratio between the two should be *increased* to redress the balance. Unfortunately, this aspect is difficult to quantify and seems to depend on the individual operator's training and experience.

An exercise which started out to test the validity of the 50 bit standard word has shown the figure to agree with the result of statistical trials to within about ±1% for English and three other European languages. But unfortunately, the standard doesn't seem to fit the German or French languages as well as the others and users in these countries may wish to consider whether conformance to a round-figure standard is more important than precise alignment with the result of one statistical trial. More generally, and especially for non-European languages, the problem of the standard word can be avoided altogether by the universal adoption of dot rate as the only reliable measure of the 'pace' of transmitted morse.

References

1. C. Cherry, On Human Communication, p.35. Wiley, New York; Chapman & Hall, London.

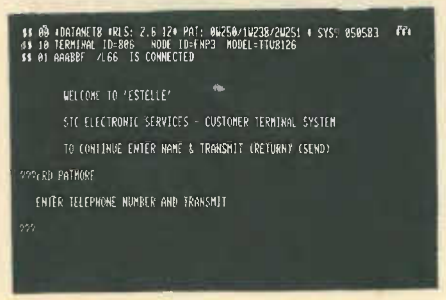
2. H. F. Gains, Cryptanalysis, appendix. Dover Publications. 1956 New York.

3. I. T. Wood, The true measurement of morse speed, *Short Wave Magazine*, vol. 39, February 1982.

WW

Electronic mail-order for electronics

Items from the large component catalogue issued by STC Electronic Services can now be ordered electronically. A new service called Estelle allows direct access to the company's mainframe computer at Harlow for any customer equipped with a suitable modem and a computer or v.d.u. having an RS232 port. Estelle (a somewhat tortured acronym standing for Electronic Services telephone link for order entry) claims to be the first system of its kind introduced by a major components distributor. Users can obtain up-to-the-minute information about product availability and pricing and may place orders straight away or else browse through catalogue items. A menu system enables them to find their eay about. The service is aimed not only at business and industrial customers: the company is keen also to attract the hobbyist, who can gain access with a home computer linked to a low-cost acoustic modem and pay for goods by typing in a credit-card number.



Services similar to Estelle, although perhaps less comprehensive in scope, are available from two retailers already well known to the hobbyist – Ambit International and Maplin Electronics. Ambit's Rewtel is predominantly an information service. It allows customers to make rapid searches of the company's database by typing in keywords; and the system responds by sending any pages containing those keywords in their heading. There is also an electronic bulletin board which allows customers to leave messages for the company or for other users. Component ordering and the several other facilities on Rewtel are available only to subscribers, who pay a fee of £10 per year.

The service launched by Maplin, called Cashtel (standing for computer-aided shopping by telephone), is available to Maplin's existing mail-order customers. To make a purchase the user enters the appropriate code numbers from the company's catalogue. Cashtel also allows users to check on stock levels and to follow the progress of their previous orders. Like the other systems it has features designed to ensure confidentiality and to protect against misuse. Later on there is to be a bulletin board for private or public messages and an information service for various home computer user-groups: pages for Atari computer owners are already available. One attraction for potential Cashtel users is a modem offered by Maplin in kit form for less than £40: the modem conforms to the 300 baud CCITT standard and is transformer-coupled to the telephone line.

The telephone number for Cashtel is 0702-552941; and for Rewtel (300-baud Datel 200 service) the number is 0277-232628. Estelle is available on three numbers – 0279-443511 (300baud Datel 200 service); 0279-441188 (1200baud Datel 600 service); and 0279-441222 (1200baud Datel 1200 service).

Another company, Display Electronics of Thornton Heath, Surrey, though not a component retailer in the ordinary sense, can claim to have been the first in this field with its 300baud Distel service. This allows customers to search the company's large stock of computer and electronic goods and to order by credit card. Distel can be accessed 24 hours a day on 01-683 1133.

For further information, code WW500 (Estelle), WW501 (Rewtel), WW502 (Cashtel), WW503 (Distel).

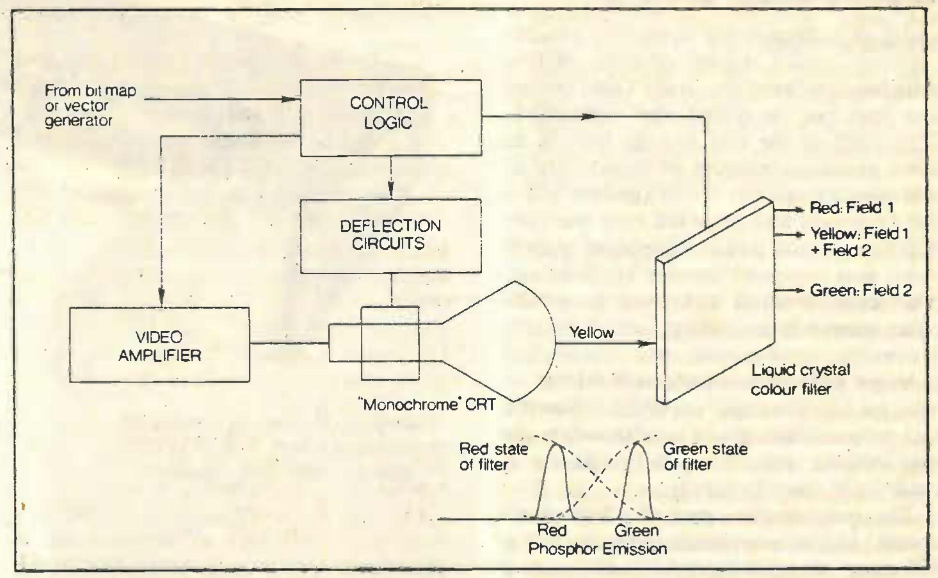
* in a given time. For random code letters are..

NEWS

Liquid crystals add colour to monochrome c.r.t.

A solution to the problem of producing colour display devices with a high enough resolution for measuring instruments and computer displays has been developed by Tektronix in the form of a monochrome c.r.t. with a two-colour liquid crystal switch. This is not the first display of its kind, but the developer claims to have solved the problem of colour-switch speed. Tektronix manufacture their own tubes and the liquid crystal switch is described as 'proprietary' but Fred Rose, information officer of Tektronix UK, could not tell us in plain terms whether or not his company manufactures the device. "We have tried to clear up one or two ambiguities" he said, "but Tektronix are not prepared to release any more details. The display is ready to be used and I speculate that we could see it incorporated in one of our products within the next twelve months."

The display has the same resolution as current monochrome tubes and does not suffer from convergence problems. A high contrast ratio is claimed, as is ruggedness through the absence of a shadow mask and complex gun, but Tektronix are not so clear about the price of such a display and will only say that it is "potentially low cost." Phosphor coating on the tube is plain with two separate emission peaks that are typically, but not limited to, red and green. In any field, information written on the screen appears in the colour selected by the electronic switch. Each colour is repeated at 60Hz, requiring the two-field system to run at 120Hz. This field-sequential system provides all possible mixtures of the two primary colours emitted by the phosphor and research is continuing to extend the concept to three fields to produce the full colour spectrum.



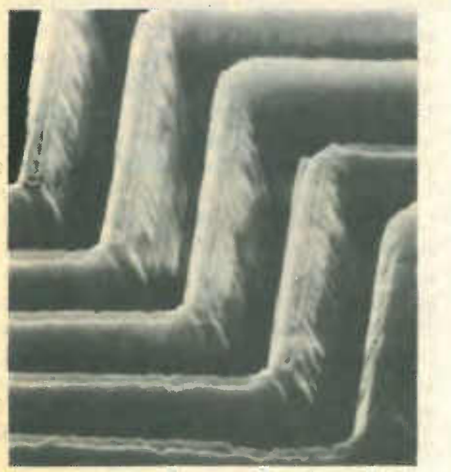
Colour displays for measuring instruments and computers with the resolution of current monochrome instrument tubes could appear within the next twelve months. Tektronix have developed a system combining a fast liquid-crystal filter and monochrome c.r.t. to provide a high-resolution display producing all colours between red and green on a field-sequential basis. Research into producing a three-colour version continues.

Heatless laser etching

A new phenomenon has been discovered which allows organic polymers and biological materials to be etched by laser without heating. Called ablative photodecomposition by its IBM discoverer R. Srinivasan, the phenomenon could be used to directly etch images in photolithographic i.c. fabrication, which would greatly simplify the production process by eliminating the image development stage using photosensitive layers and chemical solvents. In the medical field, the phenomenon could mean precise laser surgery, since cuts are determined solely by the geometry of the beam and, because heat produced is negligible, charring associated with laser surgery is eliminated.

Using far-ultraviolet lasers, Srinivasan found that an intensity threshold exists above which "numerous small molecules are suddenly ejected from the irradiated area of the material". High intensity is not directly responsible for the etching effect. Srinivasan believes that absorbed radiation probably breaks chemical bonds between atoms in the organic material producing smaller molecules that vaporize at relatively low temperatures. These smaller molecules carry away excess energy from the laser pulse – hence the term ablative.

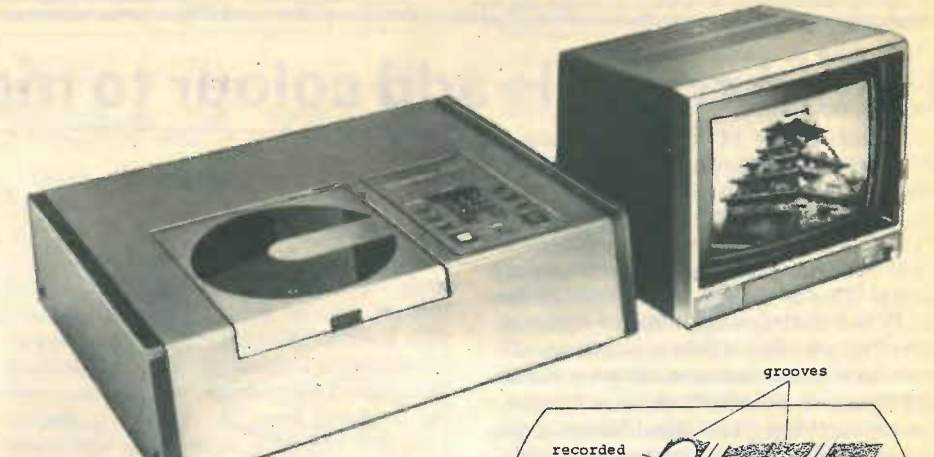
Pulses of 12ns at 1Hz or higher from a 193nm argon-fluoride excimer laser were used in Srinivasan's experiments. Other experiments using this type of laser have shown that ultraviolet radiation may be the key to submicron lithography.



Heatless laser etching could be used to directly etch images, left, in photolithographic i.c. fabrication, eliminating the usual image development stage using photosensitive layers and chemical solvents. This scanning-electron micrograph shows a commercial plastic film with 5μm-wide lines etched using a phenomenon known as ablative photodecomposition. With biological and polymer materials, a far-ultraviolet laser above a certain intensity threshold causes excess energy to be carried away in ejected molecules and the material remains cold.

Potential for heatless laser etching in medical applications, right, is illustrated by these cuts in cartilage tissue. Heating and charring caused by commonly used visible and infrared lasers, left, is not apparent in the 250μm-wide channel on the right which was cut using a far-ultraviolet laser and the ablative photodecomposition phenomenon. Geometry of the cut is determined solely by the beam geometry.

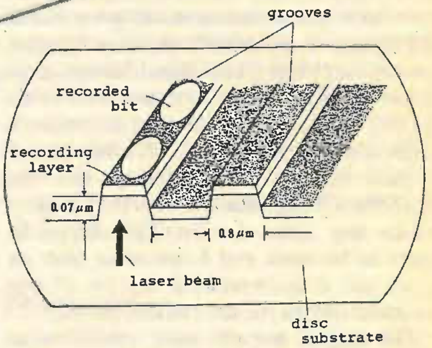
Erasable optical disc



A Matsushita laser disc recorder that can play back one of 15 000 images in under half a second.

Using an enhancement to existing record-playback optical storage systems, Matsushita has developed the world's first optical disc that can be erased and rerecorded. Sensitivity of the disc is high enough to allow broadcast pictures to be recorded in real time, its capacity is one gigabyte and it can be erased and recorded over one million times which makes it suitable for both video and computer storage applications. This would seem to make both perpendicular magnetic recording (see February News) and metal-powder tape obsolete but it is too early to compare such factors as cost-per-bit of storage, portability of media and manufacturing costs. Matsushita do not indicate that their development is ready to be manufactured.

The erasable disc, part of a $600m research and development project, has a tellurium suboxide layer the same as used in existing optical-disc record/playback systems. Heating this layer results in it changing its reflective properties (see March News). But by adding metals such as germanium, indium and lead to the suboxide layer and using two separate laser beams, the change in reflectivity caused by changing the layer from a crystalline to amorphous state is made reversible. In the record process the high-reflectivity crystalline phase is converted to a low-reflectivity amorphous state; during erasure, the opposite occurs. Two semiconductor lasers are used – a 0.83μm 8mW device for recording and playback and a 0.78μm 10mW type for erasure – with a common optical system.



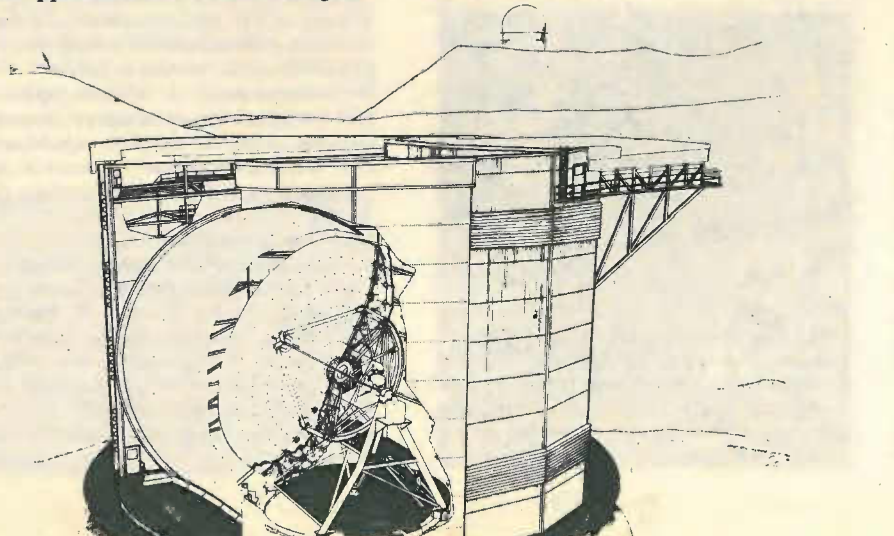
An erasable optical storage disc for video images and data developed by Matsushita uses two separate lasers for recording and erasing through a common optical system. The one gigabyte disc can record broadcast pictures in real time and be erased over one million times but when the disc might be available is not yet certain.

Submillimetre-wave telescope

Work has begun in Hawaii on the world's largest telescope capable of operating at wavelengths shorter than 1mm. Due to be completed in 1986, the telescope will help explain the formation of new stars, the nature of quasars and the evolution of galaxies. "Chemists", say the Science and Education Research Council, "will have the opportunity to study complex molecules in space which may provide the key to life itself."

SERC, who are building the telescope in conjunction with the Netherlands Organization for the Advancement of Pure Science, says requirements are pushing microwave technology beyond the limits of current applications. Detectors using elements as small as 1μm² and cooled to a few degrees above absolute zero have been developed to solve a main problem of viewing at submillimetre wavelengths – that of the receiver sensitivity. Engineering and installation of the telescope is being carried out at SERC's Rutherford Appleton Laboratory by a team working in collaboration with universities and observatories in the UK and Netherlands including the Mullard Radio Astronomy Observatory at Cambridge University and the council's Royal Observatory in Edinburgh.

Tolerance of the 15m-diameter paraboloid form will be within 50μm – including distortions due to gravity when the antenna is turned.



Ariane launches new satellites

A much needed boost for Europe's satellite-launching program came on 16 June with the near perfect launch of Ariane L6 in Guiana. Had the rocket failed – representing the third failure of six attempts – orders said to be worth about £300m could have been lost and the future of Europe's independent means of launching satellites put into serious doubt. Ariane's payload consisted of Europe's first communications satellite ECS-1 and the German Amsat Phase 3B

ECS is a continuation of the OTS formula to provide trunk telecommunication between countries belonging to CEPT (European conference of posts and telecommunications), especially telephony and data transmission. Its other purpose is to provide colour television relays with sound and multiple commentary channels. Designed for a lifetime of seven years, ECS has a payload that includes twelve 20W, 11-to-14GHz repeaters and six antennae.

The other satellite launched from Ariane L6 is the Amsat III-B, called Oscar 10 when fully operational. This satellite for amateur radio is designed to serve as an educational aid – to establish back-up communications networks over long periods covering most of the Earth using simple and inexpensive components, to study multi-uer transponders and frequency-division multiple-access, to assess the effectiveness of a highly eccentric orbit, and to demonstrate the practicability of using an onboard microcomputer for managing and monitoring the satellite's operation.

The telecommunications module consists of four main transponders, the first one (L1) with an uplink frequency of 435.175MHz downlink of 145.828MHz: Transponder L2, uplink 435.165MHz downlink 145.838MHz: Transponder H1 uplink 435.025MHz, and downlink 145.978MHz: Transponder H2 uplink 435.030MHz, downlink 145.973MHz. There is also an Amsat net and calling frequency with an uplink of 435.040MHz and a downlink of 145.936MHz. The general beacon is transmitted at 145.810MHz and an engineering beacon at 145.987. At the time of writing the satellite has yet to be fully oriented toward the sun – battery charging is low and so the beacons are only being activated for short periods. The satellite has an expected life of three years.

Ariane L7, 8 and 9 launchers have been assigned to Intelsat V satellites F7, F8 and F9 and are scheduled for launch on 26 August, 4 November 1983 and January 1984 respectively.

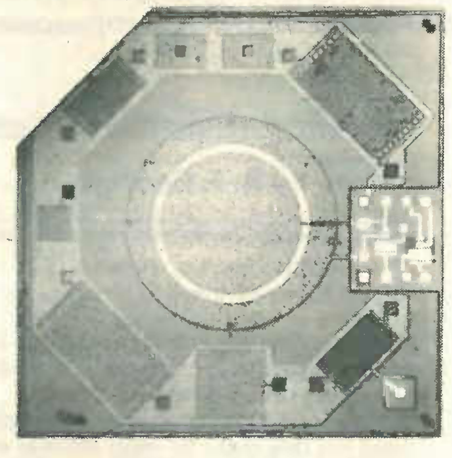
Satellite news trial

To give "a valuable early indication of benefits from using satellites on a commercial scale in the future", BT are to carry out a three month trial distributing news and information by satellite starting in July. In the trial, Europe's first, Exchange Telegraph Co (Extel) will send speech and data from BT's Fleet building in London to its nine regional offices in the UK via European test satellite OTS. Working experience of locating and using small satellite aerials for businesses in urban areas will also be gained from the trial. Receive-only dish antennas of one or 1.8m diameter will be used at the regional offices.

Microphone on a chip

Using its recently developed zinc-oxide thin-film deposition technique, Honeywell has produced a microphone with microelectronics on a single silicon substrate, which is said to give better performance, sensitivity and reliability than current ceramic microphones at a fraction of the cost. Compared with ceramic devices which lose sensitivity at around 20Hz, the integrated zinc-oxide device operates at frequencies down to 0.1Hz. Honeywell say their 6.5 by 6.5mm 'mike-on-a-chip' can detect 1μbar, at which pressure the signal-to-noise ratio is 5:1, and that it is smaller and lighter than its ceramic counterpart measuring typically 6.5 by 12.5mm excluding electronics and leads.

Zinc-oxide thin-film techniques used produce a substance with characteristics similar to those of piezoelectric crystals but compatible with standard i.c. fabrication processes. Like piezoelectric ceramic materials, zinc-oxide produces thermally-induced voltage fluctuations but the manufacturer claims to have eliminated this effect by using concentric electrodes. Existing semiconductor processes and equipment are used to fabricate the sensors which presumably accounts for their low cost.



Data-base for telecomms

Abstracts and references to articles from more than 250 international periodicals, congress proceedings and reports are contained in a data base for the telecommunications industry recently brought on line by a Dutch company, Samsom Data Systemen bv. Including some 100 000 bibliographic references dating from 1976, the data base also contains information on 250 000 products, 7000 systems and 18 000 companies. The service is conveyed through the Euronet, Tymnet, Telenet, Teleglobe, Datapak and normal telephone channels. Search languages used are Common-Command Language, CCL, which was developed for the Commission of European Communities, and the IBM-related Storage Information Retrieval System known as Stairs.

In June, Russian satellite monitors received mayday signals from a radio distress beacon and an air/sea search was carried out. The beacon was later found in the wardrobe of a man living in Erskine near Glasgow.

● Two new data banks covering electronic satellite equipment produced in Europe, Sateldata, and information on spacecraft components, Spacecomps, have been opened by European Space Agency Information Retrieval Service. These banks are produced by ESA Research and Technology Centre in the Netherlands and by ESA-IRS. Computers holding the information are based in Italy and liked to all major national/international data tranmission networks and ESANET.

In brief . . .

During June, the Radio Regulatory Department was transferred from the Home Office to the Department of Trade and Industry but the Broadcasting Department and Directorate of Telecommunications stay with the Home Office. The Radio Regulatory Department is responsible for band planning and general policy on the use of the UK radio spectrum, civil radio licensing, representation of the UK in international frequency negotiations and liaison with foreign administrations. RRD also has general responsibility for the Wireless Telegraphy Acts, including their enforcement, and control of interference.

Corrections

Precision analogue voltmeter in W. J. Hornsby's design, June 1983, the junction of D_7 and D_8 should be linked to R_{17}, R_{18} and IC_3 by a 0.47μF capacitor (C_7) and not by a direct connection as shown in Fig. 1. Also omitted from Fig. 1 was a 68μF capacitor (C_{10}) across the positive supply. Both components are shown correctly on the printed circuit layout. In the resistance measuring unit (July issue), R_{21} (180Ω) should be a fixed-value resistor.

Autoranging frequency meter. In the article by F. P. Caracausi on page 36 (March issue), or second line of the centre column, for MCP read MST. On page 37, line 13 should read "from the timing module" not the counting module. Line 4 under the subheading "Timing," MCE goes low, not high. Line eight under "timing," MCE *also* goes low if . . . In the caption under Dr Caracausi's picture, he works at the Cassa Centrale di Risparmio and not as printed. In Fig. 1, the pin marked 17 on the display should be 7. Fig. 2, the pin marked 5 on the IC_{12} should be 15, and finally in Fig. 6, the inputs marked DP on the counting module should have the same designation as the inputs from the scaling circuit to which they are connected.

Mixed logic. M. B. Butler tells is he made two errors in his July article (page 28 et seq.) – in Fig. 18 the flag or polarity indicator was missed off the 7427 gate, and also off the first output marked A in Fig. 27. But to come clean we also made a few. In Fig. 8, negate the C symbols in both output functions; and Fig. 9 refers to the third point in the summary, not the fourth (delete 'below'). In Fig. 15 case (vi), transpose the A and B columns, and in Fig. 16 make the bottom output of the voltage table H, not L Insert the symbol 1 in the lower three alternative rectangles of Fig. 17, and finally note that IC_{31} in Fig. 28 is an or-gate, not a nand-gate.

Assembly language programming

To avoid extra processing time, microprocessors manipulate negative numbers in twos complement signed binary form. In this fifth article, converting such numbers, branching and bit manipulation conclude the section on microprocessor instructions for the 6805.

by R. F. Coates

In twos complement conversion, positive numbers are represented as before but negative numbers are a ones complement with one added. For minus five,

+5	0000 0101
ones complement	1111 1010
twos complement	1111 1011

Adding plus eight and minus five becomes

+8	0000 1000
−5	1111 1011
binary sum	(1) 0000 0011

and the binary sum of plus three is now correct.

The branch instruction expects to find a twos complement value in the immediate byte which it adds to the program counter and execution proceeds from the new address. When assembling, the assembler (or you if you are programming by hand) must calculate this value and insert it in the object code. Assembled, and with the addresses filled in, the example discussed last month,

```
          LDA  #$05
     LOOP DECA
          BNE  LOOP
          SWI
```

becomes

```
030  A605      LDA  #$05
032  4A   LOOP DECA
033  26xx      BNE  LOOP
035  83        SWI
```

where xx is the twos complement offset. One calculates the offset by subtracting the branch address of the instruction following the branch (035) from the branch destination address (032)

$032	0011 0010
$035	(1) 0011 0101
result	1111 1101

In hexadecimal, the result is FD; (1) is an imaginary borrowed number. During execution, the two bytes of the branch instruction enter the c.p.u. from program memory and the program counter is incremented. The program counter will now contain 35 (hex.). If the branch condition is met, the program counter and offset byte are added together

$035	000 0011 0101
$FD	(111) 1111 1101
result $032	(1) 000 0011 0010

As the offset has fewer bits than the program counter, the sign bit is extended into the remaining three bits.

Twos complements may seem complicated but they make the most efficient use of the microprocessor and result in fast execution. Computer assemblers calculate the offset automatically and there are easier ways of determining the offset when working by hand. Using the previous example count in hexadecimal past each byte of the op-code starting from the address of the instruction following the branch until the destination address is reached. When going backwards count 00 is followed by FF then FE, etc, as in the example

Offset	Op-code	
$00	83	
$FF	xx	
$FE	26	
$FD	4A	(destination address)

This method is quick in practice but it is easy to make mistakes with long branches. To solve this problem, a branch calculator program is included in the Picotutor (and Nanocomp) monitor. With Picotutor*, press the bc key and S will be displayed to request a three-digit starting address for the branch. This is the address of the branch instruction and not the instruction following it. When 033 from the example is entered d is displayed, indicating a request for the destination address, 032, and entering this will display the twos complement offset required, FD.

A branch can only go forward 127byte or back 128 – if you try to branch further the error message will be displayed. Should you wish to branch conditionally, further than this, there are two means. One way is to use a second, or more, branch instruction to hop to the desired location

```
        BEQ  LABEL1
        .
        .
        .
LABEL1  BRA  LABEL2
        .
        .
        .
LABEL2
```

A second method is to use a combination of the complement of the branch instruction required and a jump. Extended jumps will allow the program to jump anywhere in memory

```
        BNE  BYPASS
        JMP  LABEL
BYPASS  (next instruction)
        .
        .
        .
LABEL
```

When the branch-not-equal-to-zero (BNE) condition is true, the program branches past the jump and executes the next instruction, in effect just continuing the sequence. If the condition is not met, JMP is executed and the program can jump anywhere in the memory. Combining BNE and JMP amounts to a jump-if-equal-to-zero instruction.

To summarize, when assembling by hand leave blanks in the object code where a branch offset is required, assemble the program and fill in the addresses then use the branch calculator program to help fill in the offsets.

Branch instruction range. There are 17 branch instruction for the 6805, excluding bit-test-and-branch described in the next section. They all require two bytes, the op-code and the eight-bit offset. None of them affect the condition-code register; only one addressing mode applies, which is relative.

Branch always, BRA, is an unconditional branch, that is, a branch will always occur when this instruction is encountered

Branch never, BRN, a branch instruction which never causes a branch, has the dubious function of performing a two-byte no-operation which takes the same time as two NOP instructions. Its only value is with the cmos 6805 where it only requires three cycles to execute so timing delays can be set to a resolution of one cycle instead of two.

Branch to subroutine, BSR, unconditionally branches to a subroutine and is the same as BRA except that the return address is stored on the stack.

Branch if lower or same, BLS, causes a branch when either C or Z bits in the condition-code register are set. If a comparison (subtraction) is performed prior to this instruction and the numbers are the same, the Z bit will be set. When the number in the accumulator or index register is less than the number being subtracted from it, a borrow value occurs and the C bit is set, i.e.

```
CPX  #$12
BLS  LABEL
```

will cause a branch if the index register contains 12 or less.

Branch if higher, BHI, is the complement of BLS, causing a branch if both C and Z bits are clear,

Branch if interrupt pin low, BIL, allows the interrupt input to be used as an extra input line if the interrupt mask is set, when the instruction causes a branch if the interrupt signal is logical 0.

Branch if interrupt pin high, BIH, causes a branch if the signal at the interrupt input is logical 1.

Remaining branch instructions cause a branch depending on the condition of just one of the condition-code register bits. The half-carry bit is set as a result of a carry from bit three to bit four in the accumulator with instructions ADD or ADC, and is used in decimal arithmetic described later.

BCC Branch if carry clear, which may also be referred to as branch if higher or same, BHS.

BCS Branch if carry set, which may also be referred to as branch if lower, BLO.

BNE Branch if not equal to zero, i.e. when the Z bit is clear.

BEQ Branch if equal to zero, i.e. when the Z bit is set.

BHCC Branch if half carry clear.

BHCS Branch if half carry set.

BPL Branch if plus, i.e. if N bit is clear.

BMI Branch if minus, i.e. if N bit is set.

BMC Branch if interrupt mask, bit I, is clear.

BMS Branch if interrupt mask is set.

Bit manipulation

The final section of the instruction set covers bit-manipulation instructions for the 6805. Although the Z80 has similar instructions, 6800, 6802 and 6809 type microprocessors do not. Bit-manipulation instructions fall into two categories – bit set/clear and bit-test and branch. They are intended for manipulating i/o port data for setting or clearing a single output port line which may for instance drive a relay, or for testing the status of an input line which may be connected to say a switch causing a branch depending on its state. As these instructions are intended for i/o control only direct addressing is allowed, which means that they can only be used to operate on addresses in the range 00 to FF.

Bit set/clear. Any bit in any byte in address locations between 00 and FF may be set to a one or cleared to zero using these instructions. They are two-byte instructions consisting of the op-code and a direct address and their mnemonics are BSET and BCLR. Two arguments are required in the operand field, the number of the bit to be operated on, between zero and seven, and the direct address of the byte which contains the bit. BSET 3,$32 will cause bit 3 of address location 32 to be set.

When assembling, the bit number modifies the bit-set instruction op-code and 32 goes into the second byte of the instruction. From the instruction-set table (*WW* April 1983, page 64) the op-code is calculated using 10+2n where n is the bit number (working in hexadecimal). For bit three, n is three which gives 10+6 so the assembled version of the above instruction is

```
1632    BSET    3,$32
```

and it can be tried out using this example

```
040   3F32   CLR    $32
042   1632   BSET   3,$32
044   83     SWI
```

When the program finishes, check the contents of address location 32 using the memory-open key (mo); it should hold eight because the address was cleared before bit three was set.

bit number		7	6	5	4	3	2	1	0
contents of location	32	0	0	0	0	1	0	0	0

Bit test and branch. Instructions BRCLR and BRSET cause a branch when the specified bit in a byte in address range 00 to FF is clear or set respectively. These are three byte instructions. The first two bytes are the op-code modified by the bit number and the direct address of the byte, as with bit set/clear. Byte three holds the twos complement branch offset. Three arguments are required in the operand field, the bit number, the direct address and the branch label/address, e.g.

```
040 0E00FD LOOP BRSET 7,$00,LOOP
043 203B        BRA   $80
```

The op-code for BRSET is 2n and in this case n is seven which gives a hexadecimal result of 0E. Provided that bit seven of address 00 is set to one, this program branches to the label loop, i.e. back to the start of the same instruction, and repeatedly executes the same instruction until the branch condition is not met.

Address 00 is the eight-bit i/o port on the 68705. In Picotutor, this port is connected to the eight-way dual-in-line switch with bit seven connected to the left-most switch. At switch on this port is automatically set as eight input lines and if the switch for bit seven is open a pull-up resistor in the processor makes this bit appear as a 1 (set) when address 00 is read. When the switch is closed, the associated processor input pin is connected to 0V so bit seven appears as a 0 (clear) when address 00 is read.

If the program is run with the switch open, the branch-if-bit-set instruction is repeatedly executed and the display blanks as the monitor program is no longer operating it. With the switch closed the branch-if-bit-set condition is no longer true as bit seven is clear so the loop is broken and the next instruction executed. This also causes a branch, but to the monitor re-entry point so the Picotutor dash prompt is displayed.

Branch offsets may be calculated on the Picotutor even though the function was designed for two-byte numbers and not three. For three-byte bit-test-and-branch instructions the result from the calculator must be decremented by one, as in the following key sequence

Key	Display
bc	S
040	d
040	FE

where the offset minus one is FD. Having to calculate op-codes for bit manipulation instructions can be tiresome; the table lists all combinations of these instructions and equivalent op-codes.

Programming techniques are the subject of the next article.

*Picotutor is an assembly-language programming aid described in *Wireless World* Dec. 1982 and Jan. 1983.

Op-codes for bit-manipulation instructions

Op-code	Mnemonic	Op-code	Mnemonic
00	BRSET 0	10	BSET 0
01	BRCLR 0	11	BCLR 0
02	BRSET 1	12	BSET 1
03	BRCLR 1	13	BCLR 1
04	BRSET 2	14	BSET 2
05	BRCLR 2	15	BCLR 2
06	BRSET 3	16	BSET 3
07	BRCLR 3	17	BCLR 3
08	BRSET 4	18	BSET 4
09	BRCLR 4	19	BCLR 4
0A	BRSET 5	1A	BSET 5
0B	BRCLR 5	1B	BCLR 5
0C	BRSET 6	1C	BSET 6
0D	BRCLR 6	1D	BCLR 6
0E	BRSET 7	1E	BSET 7
0F	BRCLR 7	1F	BCLR 7

In brief . . .

Paisley College are to receive a £63,000 grant from the Science and Engineering Research Council for research into ferrite-loaded microwave i.cs operating at frequencies between 20 and 100GHz. Several i.cs have already been built by research student David Sillers who will "spend some time at Philips and BT research laboratories, who are both collaborating in this work."

Four carrots for the Berlin International Audio and Video Fair 1983, 2 to 11 September – the world's smallest studio-quality u.h.f. pocket transmitter from Senheiser, a professional mobile video recorder from Grundig for teaching, research work, information services and advertising, Hitachi's VHS recorder giving 8h of uninterrupted film from a standard 4h tape and Sony's Beta camera/recorder weighing 2.5kg and giving three recording hours from a standard cassette.

Two-metre transceiver

Besides helping one understand operation of the transceiver, this description of software – which completes the multi-mode transceiver design – will aid software modification.

by T. Forrester, G8GIW

Transceiver software consists of a main control program which calls various subroutines in sequence, as shown in flow-chart form in the March issue, page 39. Conveniently, this technique allows certain routines to be bypassed by simply removing reference to them from the control program. Removing a subroutine during program development was simply a matter of taking out three or four bytes in the main control program, which is useful if one is not sure where a program error lies.

Repeater subroutine. When the main program calls repeater mode, the repeater subroutine sets the peripheral interface adapter A-port for data input and sets the controls-enable signal, pin 36 of IC_{804}, to one. Machine code for setting the p.i.a. A-port for input and activating controls-enable is located between addresses 188B and 1995. This code, used each time controls are tested, stores the status of the controls in the accumulator. If bit zero is clear, repeater mode is bypassed but if bit zero is set the processor tests for receive by looking at bit one of the p.i.a. A-port. A 'one' on this line tells the program that the transmitter is to receive and that no shift is required so repeater mode is left.

Bit zero being at 'one' indicates that transmitting and a negative 600kHz shift (JSR NVE) are required. On return from the negative-shift subroutine, JSR NVE, the program loops, testing bit one of the A-port until a 'one' is detected to indicate that receiving is required. At this point the program jumps to the positive-shifting subroutine, JSR PVE, adds 600kHz then leaves the repeater subroutine.

Software detects whether the transceiver is set for transmit or receive by addressing IC_{803} (see March issue, page 41) which passes the status of press-to-talk, up-frequency, down-frequency, squelch-open and power-on controls. Machine code between locations 1880 and 188A enables IC_{803} through pin 33 of the processor and loads the buffered switch signals into the accumulator. This code is used every time the status of up/down, transmit/receive squelch and power-on controls is required. Repeater routine is between memory location 1831 and 1844.

Reverse repeater subroutine. This subroutine is more complex than the previous one because the receiver is operating at 600kHz below its original frequency in repeater mode, so when reverse repeater mode is entered the frequency has to be restored to its original value. While receiving in reverse repeater mode, the subroutine has to call all the routines normally needed for simplex mode, including tuning up/down, scan and erase, to allow the band to be tuned.

On entering the reverse repeater routine, software tests for transmit or receive. If receive is detected, the program jumps to the negative-shift subroutine, JSR NVE, used in repeater mode to subtract 600kHz. Detection of a transmit condition causes the program to jump to the simplex routine, JSR SIMP, and loop so long as the transmit condition exists; this disables the rest of the controls. Simplex routine is located between 1879 and 187F and uses the subroutine between 1880 and 188A to test the p.t.t. line. When the transceiver is set up to receive and has just shifted – 600kHz, another loop is entered to test for receive and reverse repeater mode (see flow chart).

Scan subroutine. On entering this subroutine from the main program, the first operation tests to see if scan has been selected and if not, returns to the main programme. When scan mode is selected the software looks at the squelch status signal entering pin 6 of IC_{803}; squelch open, i.e. signal present, is represented by a one on the line. If a signal is present the test routine is carried out to see whether the next frequency to be monitored is to be skipped over or not. If the frequency is to be skipped, the synthesizer is moved to the next channel and control is passed back to the scan routine.

Now the program again checks for the presence of a signal and if it is still there, 12 is loaded into the accumulator and then stored in the first temporary location (TEMP1) at address 002F. The value 12 loaded into temporary-location one determines how long the transceiver monitors each channel, and is gradually decremented. Delay value 12, currently held in location 195B may be changed to increase or decrease the delay as desired.

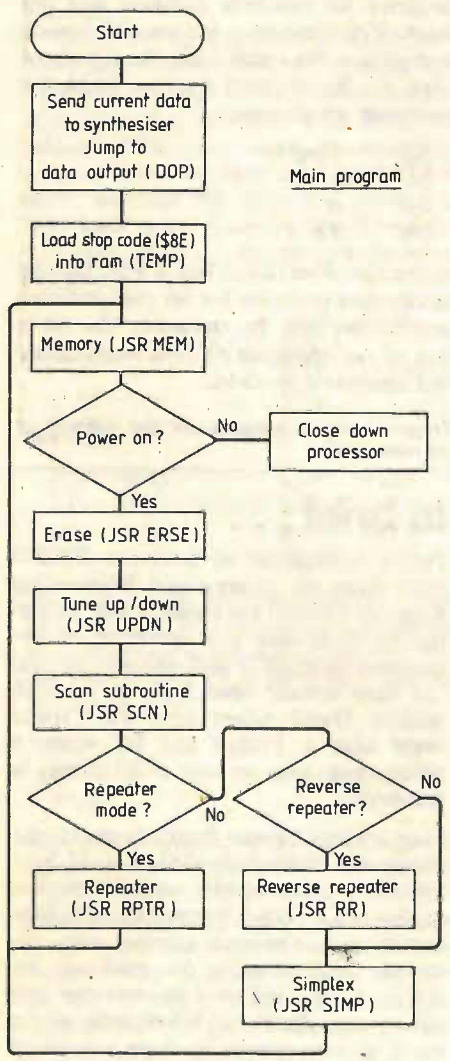
Pressing the skip button while monitoring a frequency in scan mode results in the frequency being included in the skip look-up table by means of the frequency-add subroutine, FADD. Next time the synthesizer stops at this frequency the test subroutine will cause it to be bypassed. Not pressing the skip button while monitoring a frequency causes the program to jump to a delay loop (JSR WT2) after temporary location TEMP1 is decremented. Delay loop WT2, located between 1913 and 1936, decrements ram location 0015 from 00FF to zero and is carried out 15 times.

While in the WT2 loop, the program monitors the power line and on detection of the set being switched off causes 8E to be loaded into ram location 0014: this operation puts the processor in its stop mode. After leaving the WT2 delay loop the program tests whether scan mode is still required and if so tests the temporary location at 002F for zero. When the TEMP1 test for zero is true, program jumps to the scan-up subroutine, JSR SCNU, located between 1980 and 19A2. Scan-up routine increments the synthesizer in scan mode and sets top and bottom frequency limits for scan mode. Location 1991 currently holds E4 to set the highest frequency of a scan to 145.9999MHz. An increase of one unit represents an increase in the top frequency of 10kHz. Similarly location 1995 holds 1C representing the lowest frequency of 144MHz.

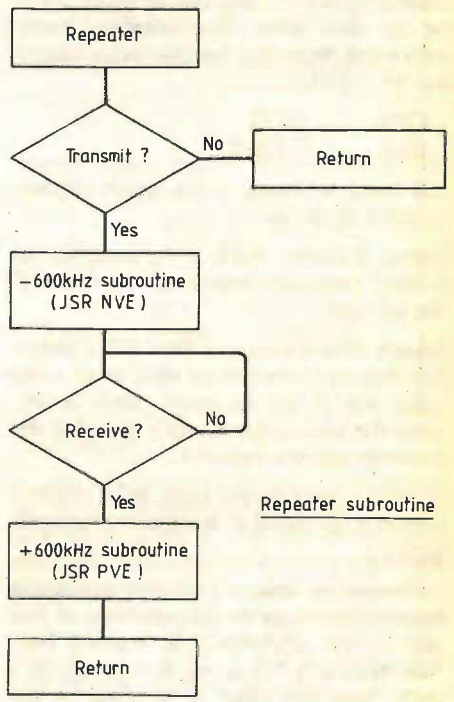
With present hardware the maximum and minimum frequencies are 146.270 and 143.700MHz. To widen these limits, wiring of $IC_{800,801}$ shown on page 39 of the March issue would have to be modified.

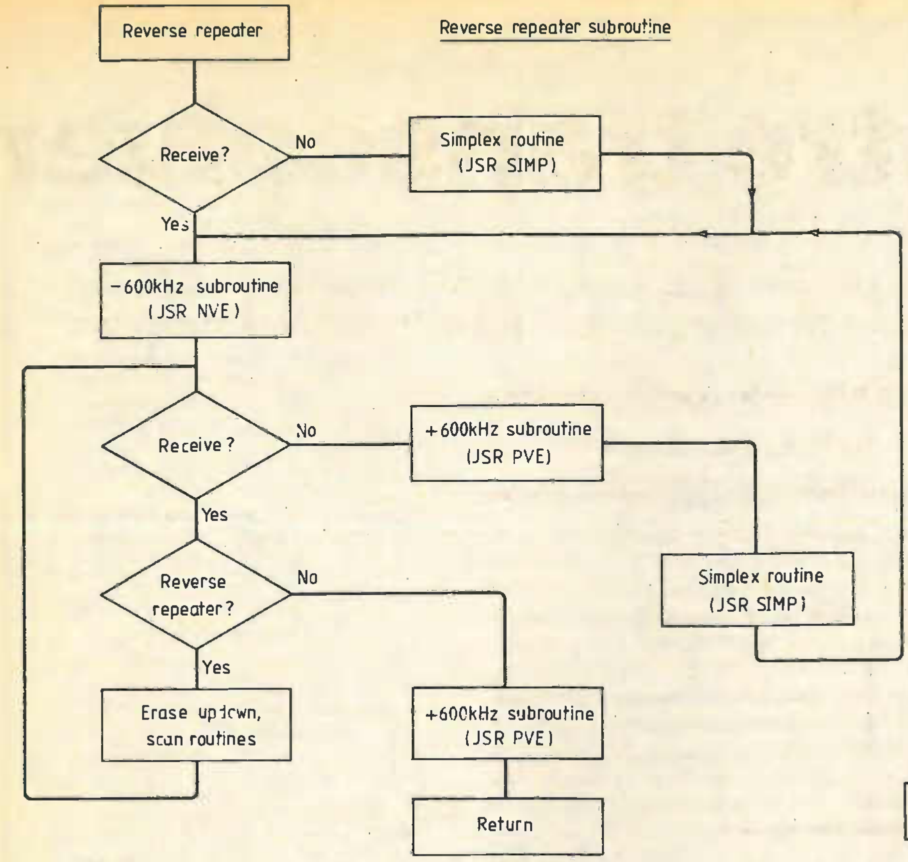
Memory subroutine. This subroutine is the most complex, encompassing all of the other subroutines except those for reverse repeater and skip modes which do not operate in the memory mode. Memory subroutine is best dealt with by breaking it down into units each providing a function.

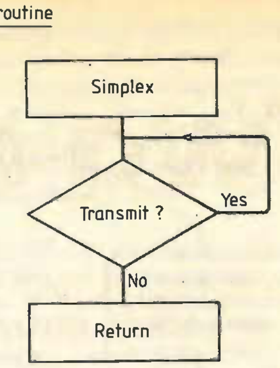
Unit one is a memory scan, which takes frequency data from memory-frequency ram locations between 1D and 32 in sequence. Two bytes are used for each frequency – one byte controls the 100Hz steps while the other controls the voltage-

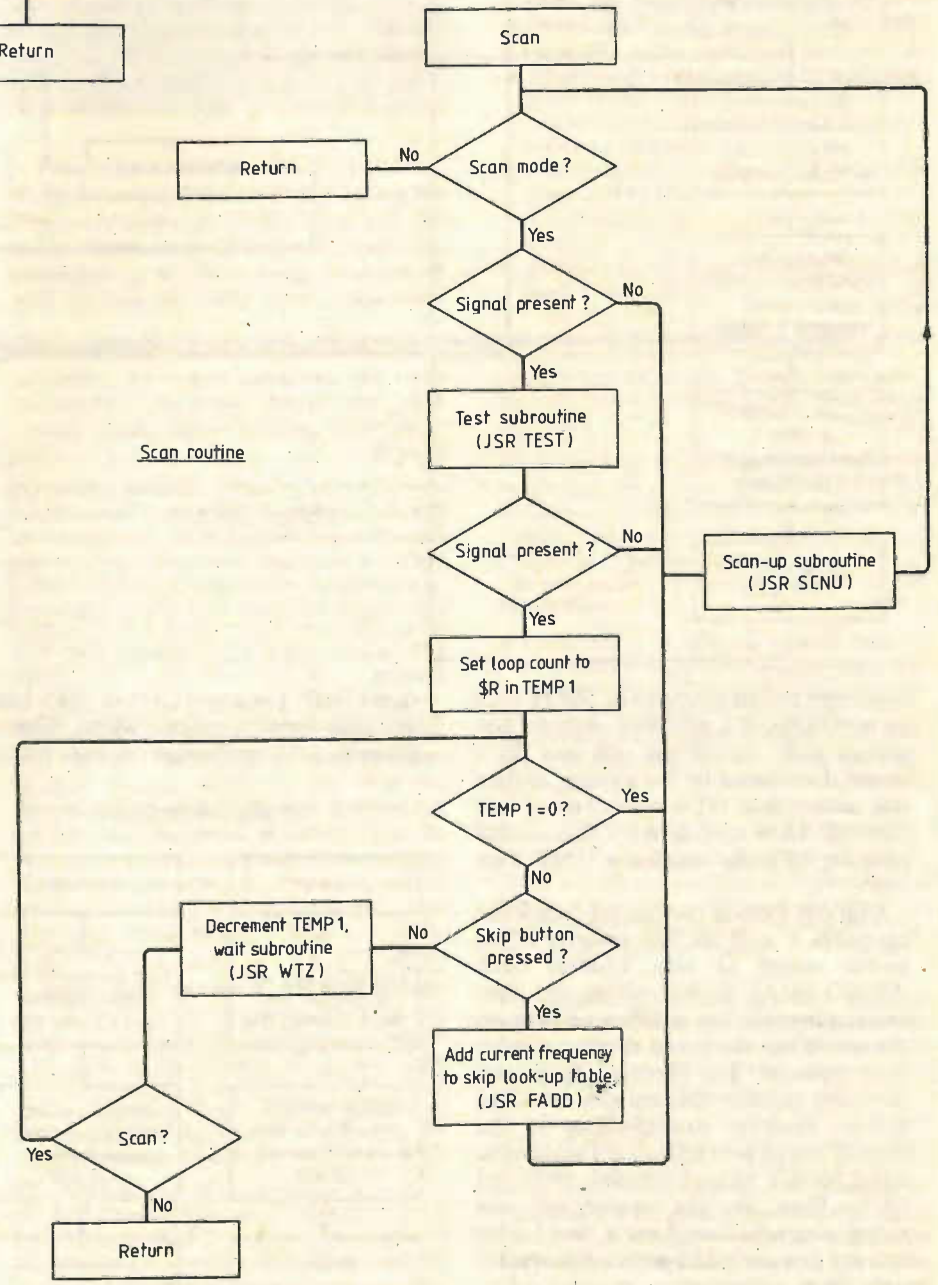


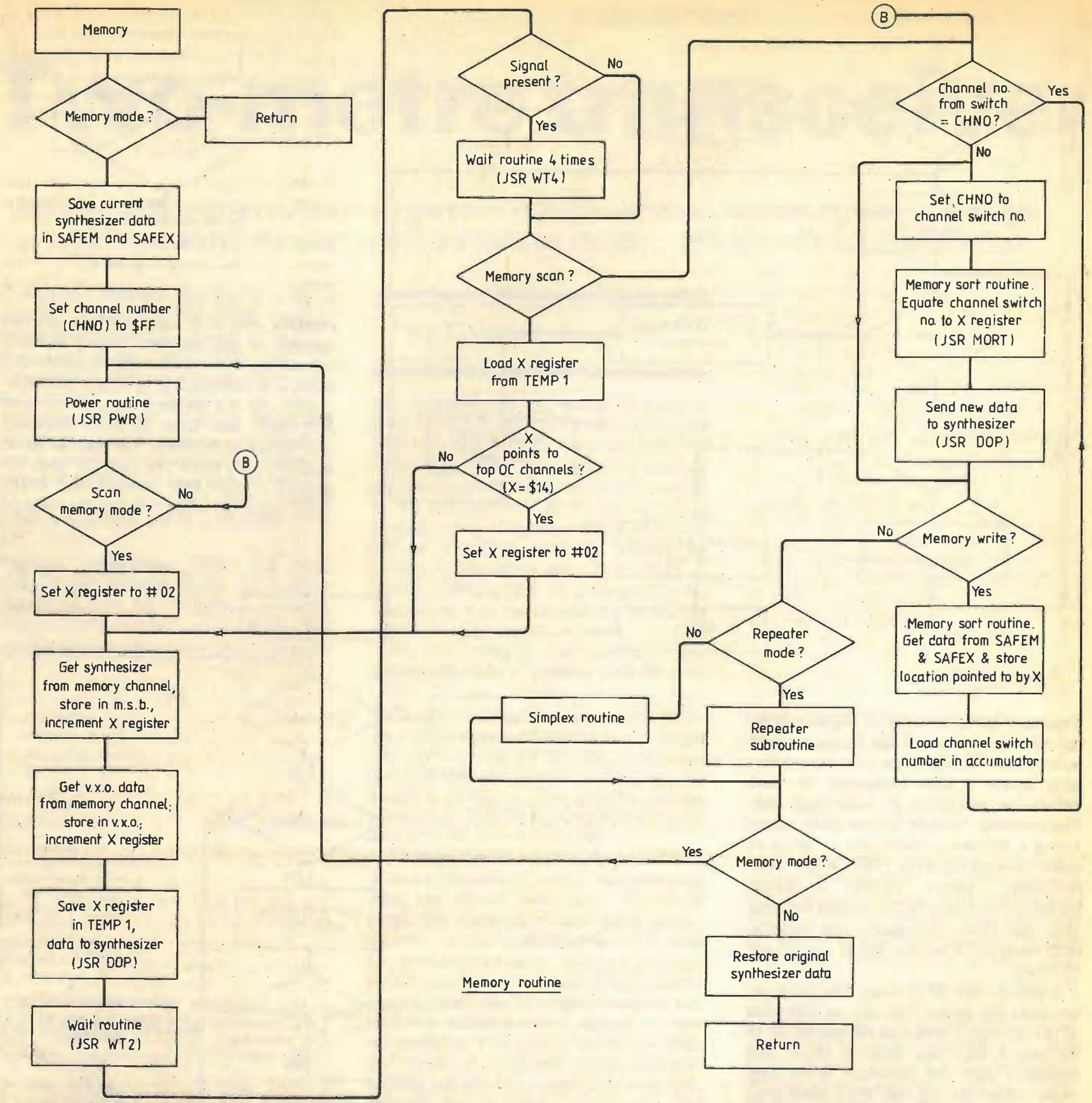
Eprom starts at 1800 hexadecimal and software breaks down into these main routines. Erase and up/down routines were covered in the April issue









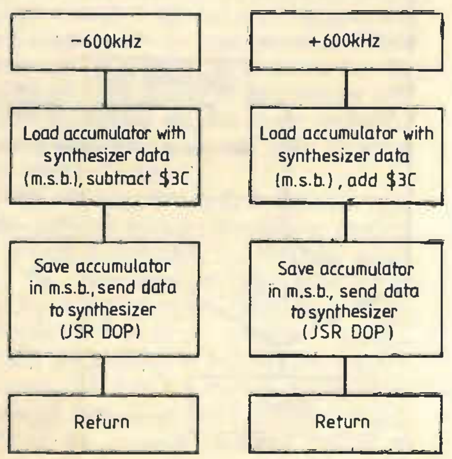


Memory routine

controlled crystal oscillator in 100Hz steps up to 9.9kHz. If a particular memory frequency is in use the set will wait for a period determined by the number of time that the outine at 191D is called using code between 1A94 and 1AA2. The current program calls the routine at 191D four times.

Unit two looks at the channel switch and compares it with the last position of the switch stored in ram location 001A (CHNO 001A). If the two are the same nothing happens but a difference between the two causes the stored channel number to be updated. The processor then loads the index register with the content of the memory location corresponding to the channel-switch position using a subroutine called MORT located between 1B07 and 1B16. Data for the synthesizer and voltage-controlled oscillator is then loaded into the processor and sent to the synthesizer using a data-output routine, abbreviated DOP. Locations 1B71 to 1BE2 hold the data-output routine, which besides controlling the synthesizer converts binary

± 600kHz subroutines



to condensed multiplexed b.c.d. to drive the display. Every time the frequency is changed in any mode, the data-output subroutine is used.

Unit three takes the frequency in use before memory mode was entered and places it in the memory locations pointed to by the channel switch then the program jumps back to unit two to send the data to the synthesizer. Unit four allows repeater mode to be used while in memory mode and provides the way out of memory mode, restoring the original operating frequency. When the program is in memory mode, the original operating frequency is stored in ram locations 0012 and 0013 for synthesizer and voltage-controlled oscillator data respectively.

±600kHz subroutines. Postive shift, PVE and negative-shift, NVE routines reside in locations 18AB to 18B5 and 18A1 to 18A7 respectively and add or subtract

Specification

Frequency coverage	144 to 146MHz	Power	16.5W f.m. and 14.0W p.e.p. s.s.b. with 13.8V supply
Frequency steps	100Hz or 25kHz	Spurious outputs	−70dB at 16.5W
Frequency display	7-digit l.e.d. with 100Hz resolution	Harmonics	−45dB at 288MHz −50dB at 432MHz
Tuning method	up/down buttons on microphone or channel switch (select memory channel)	Carrier suppression	50dB (s.s.b)
Memory	9 memories programmed by push button – may be scanned with six second hold	Squelch threshold	0.1µV (s.s.b. and f.m.)
Scanning	scan memory channels or scan band (144 to 146MHz) with provision to skip up to 40 channels	Bandwidths	2.4kHz s.s.b. 12.5kHz f.m.
Modes	l.s.b., u.s.b., f.m. simplex, repeater and reverse repeater	Sensitivity	0.26µV p.d. for 12dB quieting (f.m.) 0.13µV p.d. for 12dB s/n ratio (s.s.b.)
		Receiver image response	−76dB
		Third-order intercept point (receiver)	−1dBm
		Size	205 by 250 by 65mm
		Antenna impedance	50Ω nominal

600kHz from synthesizer data stored in 0010. Hexadecimal value 3C is the equivalent of 600kHz in this case. Both of these routines use the data-output routine, DOP, to modify the synthesizer and display.

Four lesser routines remain. The first, located between 18B6 and 18CD, takes the frequency down in 25kHz steps and the second between 18CE and 18E7 takes the frequency up in 25kHz steps. Two similar routines causing 100Hz steps up and down are in locations 18E8 to 18FA and 18FB to 180D respectively. These routines may be modified to make the set operate with any channel spacing. Readers considering modifying the software will find the Motorola MC146805E2L microprocessor applications manual helpful.

Photocopies of p.c.b. track diagram and component positions can be obtained by sending a large s.a.e. to Wireless World Transceiver, Room L303, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS. Programmed eproms at £8 and software listing at £1.50 including UK postage and vat are available from T. Forrester, 125 Seven Way, Bletchley, Bucks.

Modules

1 Receiver converter, 144MHz to 9MHz November 1982. pp.35-38
2 Transmit converter, 9MHz to 144MHz December 1982. pp.61-63
3 Transmit power amplifier and power regulators -December 1982 pp.61-63 January 1983 pp.42-45
4 Discriminator, squelch, noise blanker, a.f. power amp January 1983 pp.42-45
5 Synthesizer logic January/February 1983 pp.42-45
6 Synthesizer voltage-controlled oscillator, power change over February 1983 pp.38-41
7 9MHz s.s.b. transceiver, 9MHz f.m. exciter February 1983 pp.38-41
8 Microprocessor control and interfaces March 1983 pp.39-42
9 Frequency-display driver March 1983 pp.39-42
10 1750Hz tone-burst and receive a.f. pre-amp April 1983 pp.69-71

WW

LITERATURE RECEIVED

A comprehensive 64-page catalogue of radio-frequency **interference filters** for mains power and other uses has been published. It lists 120 filters from a plug-and-socket model to keep noise out of home computers or hi-fi to a 800A power filter or a 32-line filter for data transmission which can handle 9.6Kbit/s. Belling Lee Intech Ltd, 240 Great Cambridge Road, Enfield EN1 3QW. **WW407**

The first issue of the **Electronics for Peace Journal** reports on the first national conference of the Electronics for Peace movement and includes articles on the reliabikoty of digitally-controlled weapons, the dangers of Ada, the computer language designed for use by the US Department of Defence, which could be error-prone. On the positive, and peaceful, side there is an article on information networks at the domestic level. Membership of Electronics for Peace, including a free subscription to the Journal, is £5 (£3 for the unwaged) to Steve Holmes, 151 Courthouse Road, Maidenhead, Berks SL6 6HY. **WW408**

Stepping motors and suitable drives and some useful design features explained in a four-page brochure . Evershed and Vignoles Ltd, Acton Lane, London W4 5HJ. **WW409**

Television and audio spare parts, especially for the Rank Bush/Murphy equipment forms the core of the Mastercare catalogue, which also has service aids and tools, instrument and test equipment and various accessories and other components. Mastercare Components, 653 London Road, High Wycombe, Bucks HP11 1PH. **WW410**

Microwave products including ferrite devices, valves, noise generators, noise standards and power units are fully illustrated in a product guide. There are precise descriptions of five different types of waveguide circulators/isolators, together with information on transitions/i-soducers, and a design service. Nore Microwave Ltd, 36 Towerfield Road, Shoeburyness, SS3 9SH. **WW411**

Training schemes for schools, college and apprentice use are described fully in a booklet from Taran. Blackboard-sized **breadboards** illustrate circuits which can be built and demonstrated to a class or group. Students can get hands-on experience of circuits from the very simple to advanced studies in microwaves, digital electronics, control and automation, and communications. Taran International Ltd, Raynham Road, Bishop's Stortford, Herts CM23 5PG. **WW412**

A 'budget range' of **toroidal transformers** with dual secondary windings rated at 9 to 240V and single 110, 220 or 240V primaries, or a double 120V primary are available off-the-shelf from the manufacturers who have also published a leaflet describing them. Cotwold Electronics Ltd, Kingville Road, Kingsditch Trading Estate, Cheltenham, Glos GL51 9NX. **WW413**

The Bi-Pack semiconductor catalogue costs £1 (including postage) but does include some useful information such as pin-outs for a number of devices. Despite the title, there are a number of other components and tools, test gear, audio modules and data books. Bi-Pack Semiconductors, PO Box 6,6A High Street, Ware, Herts SG12 9AG. **WW414**

The Zehntel **p.c.b.-handling robot** can identify boards and can position them at an automatic test station or a repair bench to within 0.5mm. Motion is six axes is claimed to be unique. Details in a brochure from Zehntel Ltd, 62 Tanners Drive, Blakelands, Milton Keynes MK14 5BP. **WW415**

A folder-full of 34 different sections make up the Verospeed catalogue which offers over 5,000 components from 120 manufacturers. New sections are cable accessories, data books, computer accessories and opto-electronics. Verospeed, Stanstead Road, Boyatt Wood, Eastleigh, Hants SO5 4ZY. **WW416**

Automated design and production facilities are available to designers of electronic equipment. These and the test facilities, all claimed to be at highly competitive prices, are described in a brochure from Tasbian Ltd, 2 Burrington Way, Plymaouth, Devon PL5 3LS. **WW417**

The preliminary product brief for the Zilog Z800 family of **microprocessor units** specifies 8/16-bit devices with many added instructions including signed and unsigned multiplying and division, on-chip counter/timers, two versions also have on-chip u.a.r.t. and direct memory access channels. All versions include paged memory management to address 512Kbytes while two of them can cope with 16Mbytes. Also from Zilog is a user's manual for the Z8000 floating-point emulation package. Zilog (UK) Ltd, 43 Moorbridge Road, Maidenhead, Berks SL6 8PL. **WW418**

NEW PRODUCTS

Audio oscillator with ultra-low distortion

Less than 0.0005% distortion is claimed for the Bang & Olufsen TG8 audio oscillator. Intended for circuit testing, test-gear calibration, and production-line product testing, its typical distortion is 0.00015% (harmonic) over the audio range 20Hz to 20kHz. The instrument is also a signal generator for 1Hz to 100kHz and has a wide range of facilities. Voltage output is from 3mV to 10V checked against a built-in voltmeter. David Bisset Ltd, 52 Luton Lane, Redbourne, Herts AL3 7PY.
WW301

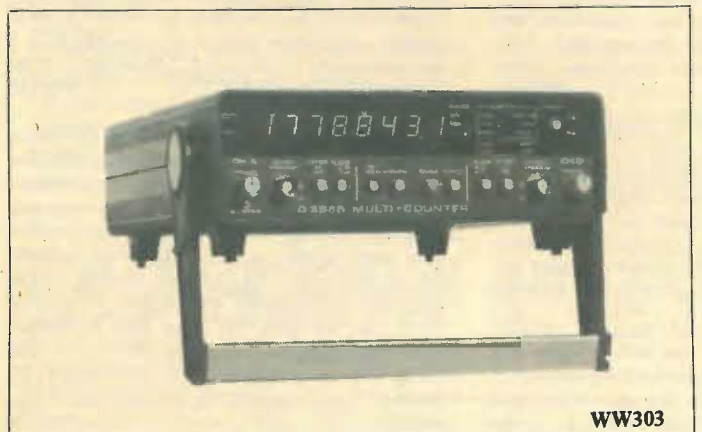

WW301

Autodial modem

Any computer that uses the S-100 bus can be fitted with the Modem-100 which provides a complete autodial viewdata modem and display driver on a single card. It gives full colour display output. The card includes an 8749 microprocessor, on-board ram and rom and a calendar clock which allows for timed autodialling. Modem-100 costs £695 but a cheaper (£495) alternative is Prattle (Programmable receive and transmit telephone line equipment) built around a Z80 processor, with rom and ram programs modem buffering, autodial and answering etc, using single byte commands. Prattle also interfaces with the S-100 bus. High Technology Electronics Ltd, 303 Portswood Road, Southampton SO2 1LD.
WW302

Multi-counter

A dual-channel facility on the Norma D3655 counter enables frequency ratios and time intervals to be measured. The measuring periods of 10ms, 1ms, 1s and 10s allow frequency measurement up to 120MHz and event counting in the range 10Hz to 10MHz. A self-test facility checks on the internal oscillator. D3655 is available with an IEEE 488 or an IEC 655 interface and so can be linked in with a data processing system. Cropico Ltd, Hampton Road, Croydon, Surrey CR9 2RU.
WW303


WW303

Controlled soldering

A temperature range of 216 to 426°C may be regulated to within 5°C using a slim, lightweight, micro-tipped soldering iron along with the Ungar 9000 control unit that incorporates a led bar-graph temperature display and the ability to calibrate it at the work station. Model 9000 has a fast heat-up time and temperature recovery and the iron is supplied with a variety of interchangeable, iron-clad, chrome plated tips. HB Electronics Ltd, Lever Street, Bolton, Lancs.
WW304

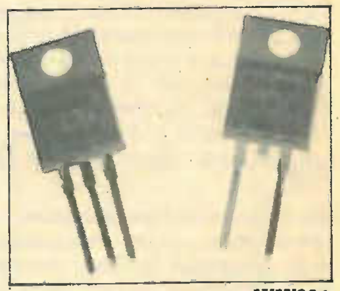

WW304

Speech synthesized to order

Inflexion, tone and clarity of synthetic speech can be easily adjusted when using the TI Portable Speech Lab, according to the distributors. Phrases for industrial control, alarm systems, measuring equipment, remote monitoring, aids for the handicapped and childrens' games can be recorded and then edited to change pitch, emphasis or other parameters, and the edited version then programmed into an eprom for use in a product. The package can also be used in an 'immediate' mode, being used as a peripheral processor to a host computer which can store the speech produced. Each stored phrase can be up to 10 seconds in length with sampling rates of 8 or 10kHz. The distributors are also offering a message programming service using the Speech Lab. VSI Microsystems, Roydonbury Industrial Park, Horsecroft Road, Harlow, Essex CM19 5BY.
WW305

High-speed rectifiers

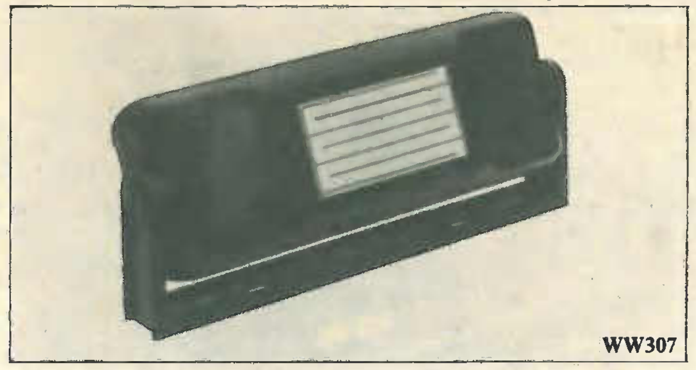
For use as output rectifiers and flywheel diodes in high frequency p.w.m. and switching regulator applications, the RUR series of low-cost epitaxial silicon rectifiers offer high reverse voltage capability. Several advantages are claimed for the diodes including low spikes, low electromagnetic interference requiring little or no RC damping, and low dissipation when compared with Schottky devices. The RUR-810 series are single rectifiers while the RUR-D810 are double i.cs with a common cathode. Rated for a forward current of 8A with a maximum forward voltage drop of 0.89V, the maximum reverse voltage is 200V. Voltage ratings vary for different diodes in the series from 100 to 200V r.m.s. Reverse recovery time is less than 35ns. VSI Electronics (UK) Ltd, Roydonbury Industrial Park, Horsecroft Road, Harlow, Essex CM19 5BY.
WW306


WW306

Very nice dear, but what's it for?

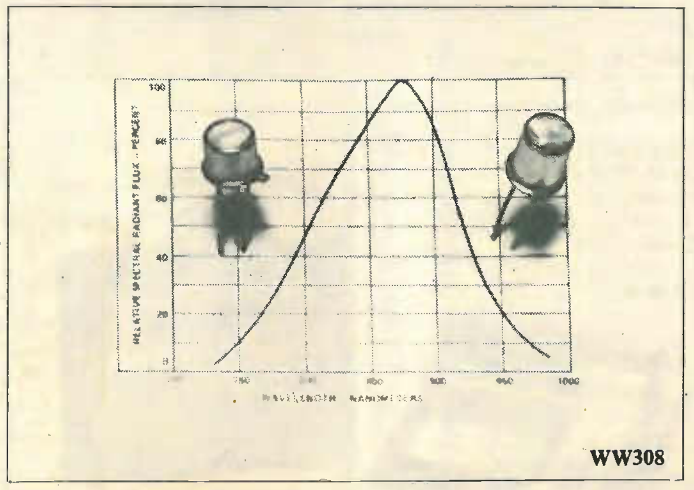
A company with a problem is Regisbrook of Reading who have samples of a very sensitive humidity sensor – so sensitive, they say, that it will detect the moisture in exhaled breath at a distance of 0.6m. It is battery powered and pocket sized with an adjustable mounting bracket. The sensing grid consists of interleaved gold filaments on a ceramic substrate. There is an integral alarm bleeper which is not triggered if the gold elements are shorted together. The alarm stops when the sensing grid is wiped dry.

The problem is: what can be done with it? A first prize of champagne, with ten runners up to get the sensor itself, for the best suggestions, serious or imaginative, which should be sent to Regisbrook Ltd, Studio House, 215 Kings Road, Reading, Berks RG1 4LS.
WW307


WW307

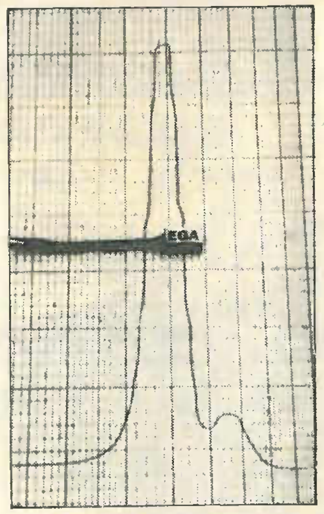
Infrared emitters

Two gallium-aluminium arsenide i.r. diodes emit radiant flux at a wavelength of 880nm. They are designed to have better coupling efficiency with silicon photodiodes and to be particularly suitable for use in pulsed applications. Output in pulsed operation is 100mW, and for continuous operation 10mW. The C86038E has a glass lens to produce a narrow beam, while the C86038E/F has a flat glass window and no lens. The devices may be used in high-speed sorting and counting, intrusion alarms, edge indicators, collision protection, optical coupling and isolation, data transmission and in photoelectric smoke detection. RCA Solid State, Lincoln Way, Windmill Road, Sunbury on Thames, Middlesex TW16 7HW.
WW308


WW308

Accelerometer withstands 10000 g

A miniature transducer for the measurement of acceleration vibration and shock, the EGAX-125 weighs less than half a gram. The active semiconductor strain-gauge bridge gives a full scale output of 250mV. Built-in over-range stops and damping provide the ability to cope with high g. Static and dynamic measurement is available in various ranges from 5 to 5000 g, with a temperature range of −5 to 120°C. Its ability to operate at 10000 g overrange makes it suitable for automotive crash and barrier testing, rocket launching and monitoring, vibration testing and control, and basic laboratory experiments. Entran Ltd, 8 The Mall, London W5 2PJ.
WW309



Driver for stepper motors

Specifically designed to drive small to medium-sized permanent magnet stepper motors, the UCN4202A i.c. uses a full-step double pulse driver that optimizes the efficiency of the motor torque. Input/output circuitry is t.t.l. compatible and a minimum of external components are needed, to provide 600mA outputs suitable for 15V motors. Higher current ratings or bipolar operation is possible by using the device to drive power transistors or other motor drivers. Semiconductor Specialists (UK) Ltd, 159 High Street, Yiewsley, West Drayton, Middlesex UB7 7XB.
WW310

Switchmode kit

To demonstrate the capabilities of their m.o.s. power transistors and pulse-width modulators, Siliconix have brought out a 38-piece kit which assembles into a dc-to-dc converter able to output 5V, 10A from a 24V input. Operating at a frequency of 400kHz, the completed circuit is claimed to have better than 1% accuracy in regulation and less than 60mV output ripple. In addition to demonstrating the operation of such a circuit, the kit also shows its small size and low cost measuring 80 by 110mm and weighing 140g. £29.95 from Siliconix Ltd, Morriston, Swansea SA6 6NE.
WW311

Game of logic

A board game that teaches Boolean algebra, digital logic, the Karaugh map and Venn diagrams is based on a game invented by Lewis Carroll. The beginners' pack, while said to be fun to play, teaches the elements of the workings of computers, hence the title of the game – Computer. Additional packs increase the number of 'memory bits' and variables up to a 'professional' level. Computer is made in cut-out cardboard. Beginners' pack is £1 from N. Darwood Ltd, Halfacre, Stroud, Petersfield, Hants.
WW312

Connections verified

When a p.c.b. has been wire-wrapped there follows a tedious system of checking the interconnections to make sure that all is correct before populating the board with expensive i.cs. A way of overcoming this is to use interconnect verifiers which are made in d.i.l. i.c. packages and incorporate arrays of l.e.ds with one to indicate the status of each pin, from eight to 48. By grounding one pin all the l.e.ds on one node are lit; incorrect connections will also be lit and points not connected, which should be, are not lit. Dim displays would indicate poor connections. This technique would not be suitable for mass production where a test rig would be set up, but offers a low-cost alternative for board development and for small batches. Track Equipment Corporation, PO Box 3181, Nashua, New Hampshire 03061, USA.
WW 313

If you would like more information on any of the items featured here, enter the appropriate WW reference number(s) on the mauve reply-paid card bound in this issue. Overseas cards require a stamp.

MICRO PRODUCTS

Local processor

The problem of waiting for main-frame computer time for computation can be overcome by the use of the AP500 array processor from Analogic. The unit incorporates the MC68000 16/32-bit processor and uses 32-bit floating point arithmetic. This gives it a very high speed: the manufacturers quote its ability to invert a 100 by 100 matrix in 649ms. Using a technique of distributed control of memory, input/output and arithmetic, the central processing section can run high-level language or assembly language programs. 128Kbytes of program memory are available in the basic version, expandable up to 256K. Data memory provided is 16K by 32-bits which can be expanded to 912K 32-bit words.

The processor may be used for radar data processing, seismic research, body-scan tomography, nuclear magnetic resonance spectroscopy, image processing, speech analysis, and testing and control procedures. It need only interrupt the host computer if a certain pattern is detected among the incoming data or when a report has been compiled.

Interfaces enable it to be used as a peripheral device, as a co-processor, or to be linked through a local-area network. For many applications it could be used as a stand-alone computer. Analogic Ltd, The Centre, 68 High Street, Weybridge, Surrey.
WW314


WW314


WW315

Eprom programmer

A microprocessor-controlled eprom emulator/ programmer has been designed to work with all popular m.o.s. eproms. The EP8000 includes all the necessary 'personality' differences between the various eproms in software and the instrument adapts itself automatically for emulating or programming a specific device. It provides a video output so that the user can examine the contents, which may also be displayed a line-at-a-time on the eight-character led display built in. Serial and/or parallel i/o buses are provided. Data can be loaded from a pre-programmed rom, through the serial or parallel ports or from an audio cassette. GP Industrial Electronics Ltd, Unit E, Huxley Close, Newnham Industrial Estate, Plymouth PL7 4JN.
WW315

Modular computers with BBC Basic

A series of microcomputer modules constitute the Cube range which, despite their title, are not cube shaped but built on Eurocards. Intended for industrial and control applications, the core of the system is Eurocube, a 2MHz single card microcomputer based around a 6502 or a 6809 processor. Included on the board are four memory sockets which can hold, for example, an operating system, a Basic or other language interpreter in rom, and ram which can retain its contents with the help of a back-up battery mounted on the board and which can also maintain an on-board calendar clock. The computer cards plug into a rack which can also accommodate a wide range of input/output control modules and interfaces, including black and white or colour video output, cassette and disc controllers, keyboard inputs, and additional memory.

Control Universal have an agreement with Acorn Computers to use their firmware including the BBC Basic interpreter. This means that a control computer incorporating BBC Basic can be put together at a lower cost than buying the Acorn/BBC computer. To get all the facilities of the BBC it would indeed cost more using this modular approach, but for industrial use it is probable that many of those facilities are not needed, as all extensions are compatible with each other, and with the Acorn BBC micro.

An extension board called Beebex which plugs into the 1MHz-bus port on the BBC has slots for many of the Cube range of modules. Up to 1Mbyte of memory may be added with battery back-up to provide what the makers call a 'silicon disc'. Control Universal Ltd, Unit 2, Andersons Court, Newnham Road, Cambridge CB3 9EZ. (This address may be temporary as the company is looking for more area to expand into.)
WW 316

Daisywheel Interface

Those who are unable or unwilling to tackle the RS232C interface for an Olivetti Praxis typewriter, featured on page 24, might be interested in another already built. Designed with the Acorn/BBC computer in mind, it is suitable for any computer with an RS232C/423 outlet operating at 300 Baud. Full handshake and busy signalling is incorporated and the printing speed is 10 to 12 characters/s. The slim unit may be unobtrusively fitted to the side of the machine and there is no interference with normal operation as a typewriter. Inclusive price with easy-to-follow fitting instructions is £69, from Timtom Micro, 9 Ilton Road, Penylan,
WW317

Logical design

Developed at Brunel University and implemented by the same designers at Cirrus Computers, Hilo-2 features gate-level and function-level logic design simulation and timing verification. It is a high-speed universal logic design simulator and is a powerful tool for integrated circuit design, according to GenRad who market it. Tests may be simulated and validated and all functions modelled by using the menu-driven interface. The system runs on 32-bit virtual memory computers. Reduction in i.c. design and development time is claimed for Hilo-2 which may be used in conjunction with the GenRad v.l.s.i. test system. Included in the software is hazard spike analysis, 'worst case' modelling, interactive design analysis and hierarchical simulation for managing the complexity of a design. Implementations are available for Vax 780, Vax 730 and other computers. GenRad Ltd, Norreys Drive, Maidenhead, Berks.
WW318

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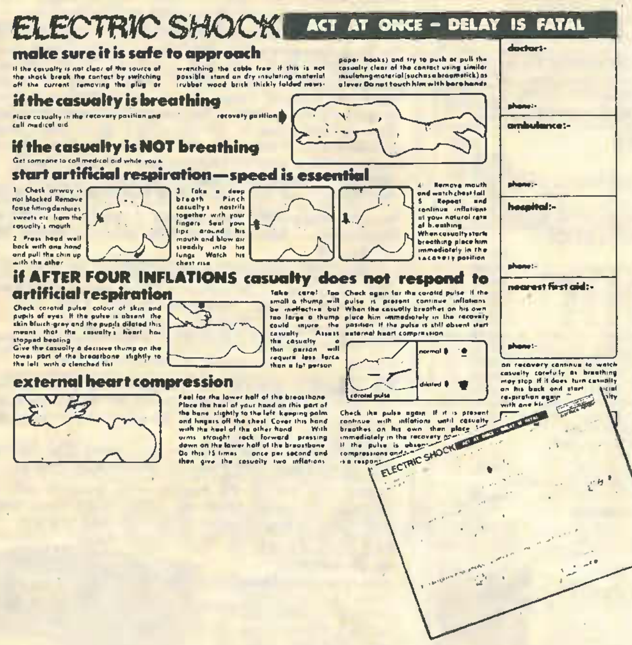

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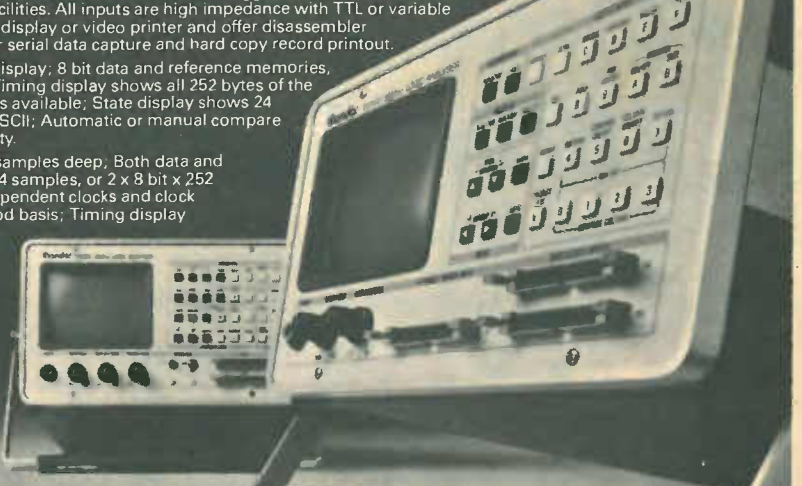

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100	16	14p
100	25	16p
100	40	22p
100	63	25p
100	100	30p
220	10	16p
220	16	17p
220	25	22p
220	40	25p
220	63	30p
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2N2906	25p
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2N2907	25p
2N2907A	26p
2N2920	3.47
2N2923	25p
2N2924	15p
2N2925	15p
2N2926	10p
2N3053	27p
2N3054	56p
2N3055	60p
2N3055H	120p
2N3250	36p
2N3251	36p
2N3439	98p
2N3440	80p
2N3441	1.25
2N3442	1.35
2N3442RCA	1.85
2N3445	4.80
2N3446	6.09
2N3447	5.72
2N3448	6.56
2N3468	1.00
2N3512	1.06
2N3553	2.65
2N3638	55p
2N3638A	70p
2N3702	10p
2N3703	10p
2N3704	10p
2N3705	10p
2N3706	10p
2N3707	10p
2N3708	10p
2N3709	10p
2N3710	10p
2N3711	10p
2N3712	2.00
2N3713	1.38
2N3714	2.98
2N3715	3.31
2N3716	3.60
2N3773	1.99
2N3819	36p
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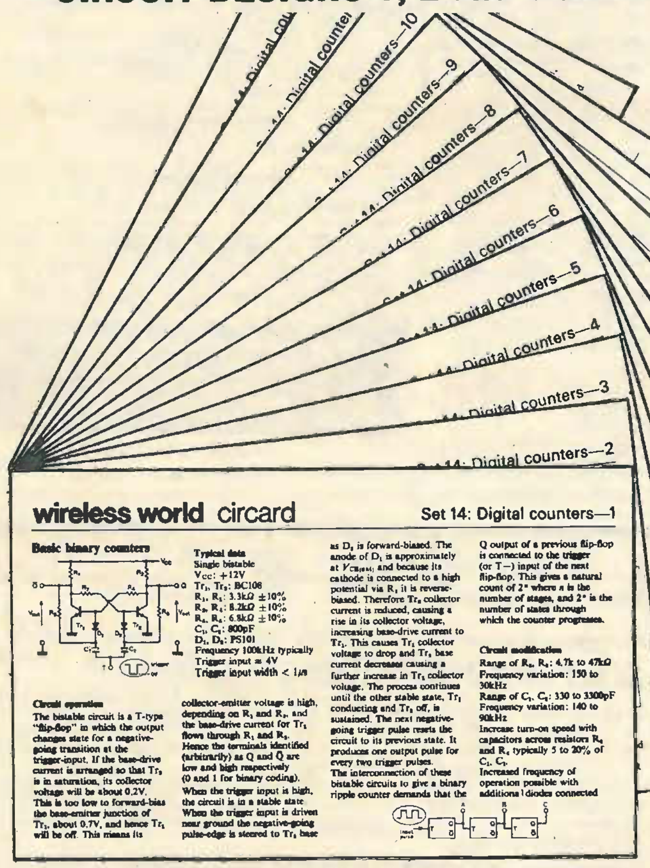

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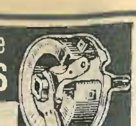

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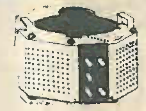

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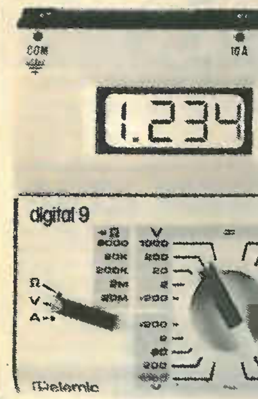

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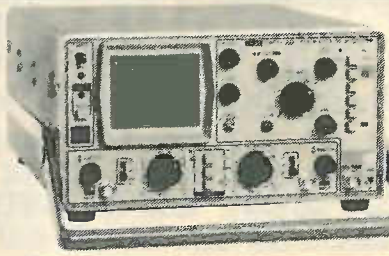

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(1926)

Metropolitan Police Office

Telecommunication Officer

The Command and Control Computer System provides the Metropolitan Police with a message switching system and is used for the efficient handling of emergency calls and the use of Police resources.

The successful candidate will control and co-ordinate the activities of the shift computer and network operation personnel; control and direct the operations shift support officer with particular regard to recovery and back-up procedures and services to the Force Training School at Hendon; correlate system performance data and prepare computer systems performance reports, including recommendation for action to improve system performance.

Candidates must have TEC Higher or SCOTEC Higher Certificate in Electronics, Telecommunications or similar discipline; OR C&G Full Technological Technicians Certificates Parts I, II and III in Telecommunications; OR HNC in Electrical/Electronic Engineering; OR an equivalent or higher acceptable qualification. All candidates must have had appropriate training and should normally have 10 years experience of computer operations and telecommunications. Knowledge of Sperry Univac 1100 series machines advantageous. Senior ex-service personnel with TEC/SCOTEC/C&G recognised exemptions will also be considered.

Starting salary £9340 rising to £10800. In addition this post attracts £1250 Inner London Weighting. Promotion prospects.

RELOCATION ASSISTANCE MAY BE AVAILABLE.

For further details and an application form (to be returned by 12 August 1983) write to Civil Service Commission, Alencon Link, Basingstoke, Hants, RG21 1JB, or telephone Basingstoke (0256) 68551 (answering service operates outside office hours). **Please quote ref: T/6012.**

SEVERN TRENT WATER AUTHORITY

Senior Communications Engineer

£9,033-£9,999 p.a.

Communications Engineer

£8,154-£9,033 p.a.

The Authority is currently installing a regional network of microwave radio links to connect principal offices throughout its area. The network, which consists primarily of 1.5 GHz links, is used for both speech and data and is due for completion in August of this year.

The successful candidates should be qualified to HND/HNC level in Electronics/Electrical and are required to maintain and enhance radio, multiplex and other ancillary and terminal equipment associated with the system. Experience in the installation, commissioning and maintenance of a broad variety of electronic and electrical equipment is necessary. Both post holders will be required to undertake certain emergency repair duties outside normal office hours.

While the two posts are based in Finham on the southern outskirts of Coventry in the Avon Division both engineers will however, in the course of their duties, be required to travel extensively throughout the Authority's Region.

Application forms are available from the Personnel Office, Severn Trent Water Authority, Avon Division, Avon House, De-Montfort Way, Cannon Park, Coventry CV4 7EJ. Telephone: Coventry (0203) 416510.

Closing date for the return of application forms: 3 August, 1983.

(2199

SEVERN TRENT WATER

Electronic Test Engineers/Technicians

Racal Radar Defence Systems part of the Racal Electronics Group is undergoing a period of rapid growth. To meet our increasing production demands, we need to recruit a number of Test Technicians and Test Engineers at the following locations in Surrey – New Malden, Chessington and Hersham, and at Leicester.

The Company manufactures a wide range of products aimed principally at the Defence Industry including radar early warning and guidance systems, military displays and ECM and ESM systems.

The Test Department is responsible for the test and diagnostic functions on a wide range of complex radar equipment using high quality manual and automatic test equipment.

Applicants should be educated to HNC/HTC standard and have practical knowledge or experience of radar and/or microwave systems.

Conditions of employment are excellent including a competitive salary, five weeks holiday, and company pension and life assurance scheme.

Interested? Then phone me on: 01-397 5281 or alternatively write with brief details of qualification experience and current salary to:

Mr P N Willis,
Senior Personnel Officer,
Racal Radar Defence Systems Ltd.,
Davis Road, Chessington, Surrey.

Racal's people are Racal's success

RACAL

(2188)

FIELD SERVICE ENGINEER

LKB Instruments Limited, the UK subsidiary of a major international scientific instrument company is further expanding its range of products for the diagnostic clinical chemistry market and as a result a vacancy exists for a Field Service Engineer within their Customer Service Department.

Applicants should have a sound knowledge of digital and analogue electronics, and field service experience in clinical or medical instrumental diagnostics would be a distinct advantage.

The work involves the repair and maintenance of instrumentation situated mainly in Hospitals and University Laboratories. Preference will be given to applicants living in the London area.

Conditions of employment are excellent and in addition to a good basic salary and company car, the company has a profit-sharing scheme, BUPA particpation and four weeks' annual holiday.

Contact Mrs. D. Duff, for Application Form

LKB

LKB INSTRUMENTS LIMITED
232 Addington Road, Selsdon
South Croydon, Surrey CR2 8YD

Tel: 01-651 5313

(2184)

RF SERVICE ENGINEER

We are responsible for all aspects of sales, service and warranty in Europe for the Plasma Therm range of RF generators, plasma processing equipment and inductively coupled plasma systems throughout UK, Europe and Scandinavia. The Plasma Therm product range is a market leader in its field and has an enviable track record of profitable growth and product innovation.

THE JOB. RF service engineer based in London to provide RF service and technical support throughout UK, Europe and Scandinavia. The candidate should be a self starter, willing and able to work on his own, and be able to trouble-shoot and solve problems in the field.

REMUNERATION. The right candidate will be offered an attractive financial package to include a performance-related bonus scheme, pension and a company car.

Applications and cvs should be addressed to:

Mr J. F. Stackhouse
PLASMA THERM LTD.
Kangley Bridge Road, Sydenham
London SE26 5AR

(2156)

CUT THIS OUT!

Clip this advert and you can stop hunting for your next appointment. We have a wide selection of the best appointments in Digital, Analogue, RF, Microwave, Microprocessor, Computer, Data Comms and Medical Electronics and we're here to serve *your* interests.

Call us now for posts in Design, Sales, Applications or Field Service, at all levels from £6,000-£16,000.

Technomark
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11 Westbourne Grove, London W2. Tel: 01-229 9239.

1935

Akai (UK) Limited, a leading name in the consumer electronic market, specialising in hi-fi and video products, now have the following vacancies at their Heathrow headquarters:

VIDEO TECHNICIAN

As one of the leaders in the video market we are seeking a Video Technician, aged 25+ who is a fully qualified, experienced Television Engineer. Applicants will have some experience of repairing video recorders as this opportunity is in our busy in-house Servicing Department.

We work to high standards and need someone who will maintain them, as well as being self-motivated with the ability to handle technical queries both by telephone and letter.

SENIOR AUDIO TECHNICIAN

The successful candidate will be fully qualified with some years experience in the servicing and repair of high quality hi-fi equipment. This will suit someone who is looking for a more supervisory position where duties will include the control of a small workshop, answering technical queries and dealing with the public, in addition to normal servicing work.

Communication skills both written and oral are necessary, as is the ability to cope with the pressure in this highly active department.

AUDIO TECHNICIAN

Due to our ever increasing growth we now need another Audio Technician to join our servicing team. Applicants will be fully qualified and have some experience in the servicing and the repairing of high quality hi-fi equipment.

The above positions offer competitive, negotiable salaries on the basis of age and experience, an attractive benefits package and the opportunity of joining a Company that is progressive in its outlook.

Men and women interested should write or telephone for an application form to: (no agencies).

(2208)

Pat Mann, AKAI (UK) Ltd., Haslemere Heathrow Estate, Parkway, Hounslow, Middlesex TW4 6NF. Telephone: 01-897 6388.

AKAI
Hi-Fi/Video

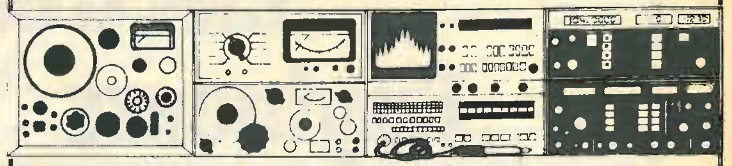
E.L.A.C.
REQUIRE AN
ACOUSTIC ENGINEER

Electro Acoustic Industries Limited, a progressive and expanding Company, require an enthusiastic Engineer to assist in the development of loudspeakers for all purposes, covering a range from specialist telecomm. applications HiFi, M.O.D. Marine to 'In Car' entertainment.
The successful candidate will be aged between 25 and 35 years and have had some practical experience in the design and application of test equipment. Experience in the use of Bruel & Kjaer frequency measuring equipment is particularly relevant.

Write including a C.V. to:
**MR. R. N. WALTON
TECHNICAL DIRECTOR
ELECTRO ACOUSTIC INDUSTRIES LTD
STAMFORD WORKS
TOTTENHAM
N15 4QU**

(2181)

Test & Calibration Engineers



Having introduced an extended new product range, many of which are microprocessor based, Marconi Instruments has once again confirmed itself as Europe's leading manufacturer of sophisticated test and measurement systems. Our products are selling throughout the world and we are naturally developing further new and innovative designs.

A key role in our organisation is that of our Luton based Service Division, where a group of Technicians satisfy a very wide range of customer needs in the repair and calibration of test equipment.

When you join our team you will quickly become individually responsible for work assignments involving many different kinds of propriety products.

Prospects are excellent. The Division is part of a large company with its main Instrument Design/Manufacturing Base at St. Albans, a Microwave Plant at Stevenage and a further substantial Design Manufacturing Group at Donibristle in Scotland. The Company is proud of its policy of promoting men and women from within, as future Salesmen, Managers and Engineers.

Salaries, which are dependent upon experience and ability are excellent and regular overtime is normally available. Progress for competent engineers and technicians can be rapid. Relocation assistance is available in approved cases. Special consideration is given to 'ex-forces' personnel.

Whatever your level of experience we would like to hear from you. Cut out the coupon and send it to John Prodger, Recruitment Manager, Marconi Instruments Limited, FREEPOST, St. Albans AL4 0BR. Tel: (0727) 59292.

Name Age
Address

Tel. No.
Years Experience

Present Salary:	£6,000	£7,000	£8,000	Over
	£7,000	£8,000	£9,000	£9,000

Qualifications

Present Job

(2143)

marconi instruments

CHELSEA COLLEGE
University of London

Applications are invited for the post of

TECHNICIAN GRADE 5

to join an Electronic/Development Workshop working with the departments of basic medical sciences. The work undertaken consists of the design, development and construction of analog and digital equipment for use in the life sciences. The successful applicant will have a good knowledge of electronics and an interest in or experience of the application of these techniques to solving biological problems.

Salary scale: £6279 – £7332 pa plus £1220 London Allowance.

Application forms from the Personnel Office, Chelsea College, 552 King's Road, London SW10 0UA. Closing date: 3rd August 1983.

(2192)

CHIEF ELECTRONICS TECHNICIAN

DARTFORD and GRAVESHAM HEALTH AUTHORITY based at JOYCE GREEN HOSPITAL, DARTFORD, KENT

Qualifications – ONC, HNC preferred.
Salary Scale – £7,386 to £9,212 Medical Physics Technician II This is a newly established post offering an exceptional opportunity for the establishment of a section responsible for the maintenance of electronic and bio-medical equipment.
Candidates, male or female, should possess broad experience of electronics together with an understanding of the safety aspects of equipment.
In addition to a sound technical background applicants should possess the managerial qualities required to organise and supervise both subordinate staff and contracted work and be capable of developing and sustaining successful working relationships with all levels and disciplines of hospital staff.
For job description and application form write to: District Personnel Dept., Darenth Park Hospital, Dartford, Kent.
PREVIOUS APPLICANTS FOR THIS POST WILL BE CONSIDERED AND NEED NOT RE-APPLY.

(2195)

**LEEDS WESTERN HEALTH AUTHORITY
THE GENERAL INFIRMARY AT LEEDS**

MEDICAL PHYSICS TECHNICIAN
GRADE III or IV (Electronics)

Electronics Technician required in the Medical Physics Department. Duties of the post include the development, commissioning, testing, maintenance and repair of a variety of electro-medical and computing equipment. The post becomes available on 1st November, 1983.

Experience in electronics is essential and the appointment will be made in Grade III or IV depending on the qualifications and experience of the successful candidate. Salary will be in the range £6132 to £7926 (Grade III) or £5171 to £6798 (Grade IV).

Application forms and job descriptions are obtainable from The Personnel Officer, Leeds General Infirmary, Great George Street, Leeds LS1 3EX.

Closing date: 29th July, 1983. (2209)

LOGEX ELECTRONICS RECRUITMENT

Specialists in Field & Customer Engineering appointments, all locations and disciplines.

**Logex House, Burleigh, Stroud
Gloucestershire GL5 2PW**

0453 883264 & 01-290 0267

(24 hours)

R & D OPPORTUNITIES. Senior level vacancies for Communications Hardware and Software Engineers, based in West Sussex. Competitive salaries offered. Please ring David Bird at Rediffusion Radio Systems on 01-874 7281. (1162

RF ENGINEER

TO CARE ABOUT A PRODUCT THAT CARES FOR THE USER

YORKSHIRE **c£11,000**

Our client, Tunstall Telecom, designs and manufactures the UK's most used emergency communications system for the elderly or infirm.

The increasing demand for greater flexibility and mobility of use has created the need for a further RF Engineer.

The work will be on varied low power RF frequency projects and will involve significant theoretical and practical design.

You will work in co-operation with other areas of R & D and part of the task will be to liaise with the Home Office.

The position will suit someone with proven design experience from a commercial background, a degree and most of all a mature approach to cost effective and 'producible' design work.

Apart from an excellent negotiable salary and benefits package (with relocation assistance where necessary) this is an opportunity to make a very personal 'stamp' on a product that will have a very beneficial effect on the elderly and infirm within the country.

To discuss this position in greater detail telephone or write to Paul Hecquet on Lewes (07916) 71271.

(2174)

Electronic Engineers –
What you want, where you want!

TJB Electrotechnical Personnel Services is a specialised appointments service for electrical and electronic engineers. We have clients throughout the UK who urgently need technical staff at all levels from Junior Technician to Senior Management. Vacancies exist in all branches of electronics and allied disciplines - right through from design to marketing - at salary levels from around £5000-£15000

If you wish to make the most of your qualifications and experience and move another rung or two up the ladder we will be pleased to help you.

All applications are treated in strict confidence and there is no danger of your present employer (or other companies you specify) being made aware of your application.

TJB ELECTROTECHNICAL PERSONNEL SERVICES,
12 Mount Ephraim,
Tunbridge Wells,
Kent. TN4 8AS.

Tel: 0892 39388

Please send me a TJB Appointments Registration form:

Name ....

Address ....

....

(861)

Premier international electronics companies – very secure and expanding in London and the south of England – require professional senior staff (including departmental heads). Relocation allowance up to £3,000.

ELECTRONIC ENGINEERS

Electronic engineers required with degree – H.N.C. – tech. cert. – O.N.C. Almost any background required but software and hardware experience will bring salary of absolute minimum of £6,500 p.a. and could be up to £11,000 p.a.

ELECTRONIC DESIGN/DEVELOPMENT

Engineers required with experience of circuit or component design or development for microwave equipment or digital logic or computer peripherals or electronic packaging or film technology or telecommunications. Also above for updating in modern techniques. Salaries up to £15,000.

SOFTWARE PROGRAMMERS & ENGINEERS

Engineers or mathematicians required for development of commissioning and design proving programmes from assistant to team leader level. Salaries up to £12,000 p.a.

Please contact by telephone, or letter, to discuss companies and possibilities. Watford 49456 anytime.

(2146)

GORE MANAGEMENT SERVICES LTD

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218 St Albans Road, Watford, Herts.
Tel: Watford 49456

B&W

LOUDSPEAKER ENGINEER

Rare opportunity to join the R&D team at B&W Loudspeakers in Sussex

The successful candidate will be involved with the design and development of both loudspeaker drive units and complete high-fidelity speaker systems, using our in-house computer and laser interferometer.

Applicants should be educated to at least HNC standard and preferably have experience of electronics and acoustics. A thorough understanding of the operation of a loudspeaker system is essential.

The salary is negotiable. Please apply in writing to Stephen Roe.

B&W LOUDSPEAKERS LTD
Elm Grove Lane, Steyning, West Sussex (2207)

Royal Marsden Hospital,
Fullham Road, London SW3

Medical Physics Technician

MPT2

required in the Physics and Radiotherapy Departments. The appointed person will be responsible for the supervision of a pleasantly situated, well-equipped electronics workshop and the maintenance and service of an interesting variety of radiotherapy equipment.

The Department has 3 cobalt treatment machines, 150kv and 300kv X-ray units, a Philips 10mv linear accelerator and a simulator. Current developments include the installation of a Philips 5mv linear accelerator and caesium Selectron unit.

Applicants should hold ONC, HNC or similar qualification in electrical engineering or (preferably) in electronics, and have relevant technical experience particularly with Philips linear accelerators. To be appointed on to the MPT2 scale applicants should have served at least 2 years as MPT3 or equivalent. Salary scale £8,383-£10,209 per annum.

Application form and job description available from the Personnel Department, Royal Marsden Hospital, at the above address. Tel: 01-352 8171 Ext. 446/447.

(2197)

UNIVERSITY OF
SURREY

Department of Electronic and Electrical Engineering

RESEARCH OFFICER
for the "UOSAT Spacecraft project"

Applications are invited from engineers with proven experience in RF and/or digital techniques for the post of Research Officer on the UOSAT spacecraft project.

The work will involve the initiation, implementation and operation of spacecraft ground support hardware/software and the design and fabrication of future spacecraft systems.

The UOSAT spacecraft, built in the Department of Electronic & Electrical Engineering at the University of Surrey, supported by UK Industry (AMSAT-UK and the RSGB), and launched by NASA in October 1981, is controlled from a command station located within the Department. The spacecraft currently supports a number of engineering, scientific, educational and amateur radio experiments and is expected to continue operating for several years.

The appointment will be for 12 months on Research and Analogous Scales up to a maximum of £8530 per annum.

Applications in the form of a curriculum vitae (3 copies) including the names and addresses of two referees should be sent to the Deputy Secretary (Personnel), University of Surrey, Guildford, Surrey, GU2 5XH, by 22 August 1983 quoting reference 170/WW.

(2173)

CAMBRIDGE HEALTH AUTHORITY
Physics Department
Addenbrooke's Hospital, Hills Road, Cambridge

Medical Physics Technician Grade II

(£7,386-£9,212)

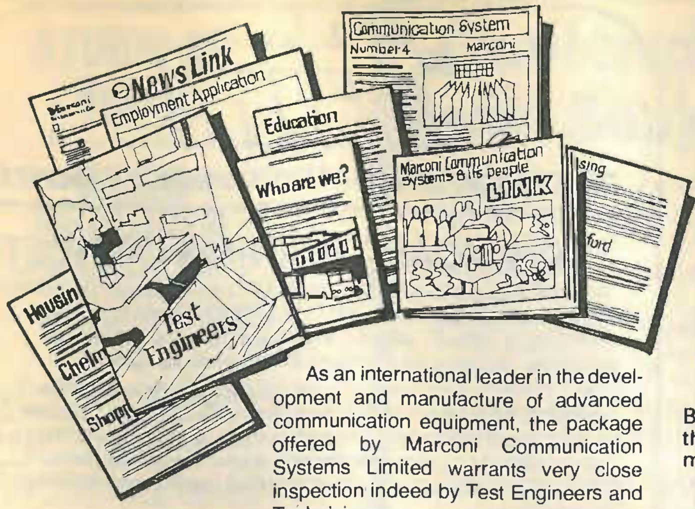
An electronics technician is required to provide maintenance and support services to the CT Head Scanner at Addenbrooke's Hospital and to electro-medical equipment in the Thoracic Surgical Unit, Papworth Hospital.

Applicants should hold an appropriate HNC or equivalent qualification and have several years' experience in the field of electronics (mini computer experience advantageous).

For further details contact Mr P. E. Ward, Principal Physics Technician, at the above address. Tel: (0223) 245151 ext. 471.

Application form and job description from the Personnel Department ext. 7511.

(2177)



Test Engineers/ Technicians here's a package worth looking into

As an international leader in the development and manufacture of advanced communication equipment, the package offered by Marconi Communication Systems Limited warrants very close inspection indeed by Test Engineers and Technicians.

When you're thinking about a move, you've got to be sure that both your career and lifestyle are going to benefit. And we believe we have a lot to offer on both accounts.

Right now we are seeking men or women to join our Space and Microwave, Digital Communications and Defence Departments to work on a wide range of equipment including satellite and tropo systems, data modems, PCM and associated ATE such as Graduate.

Of our reputation in advanced electonics there can be little doubt. Current projects, like Triffid, ICS3 and Modems for British Telecomms new data distribution service are among the most advanced of their kind, designed to meet the needs of military and civil communications for a generation to come.

In Chelmsford we're very conveniently located for London, the Essex countryside and coast. A modern town with good facilities and a variety of reasonably priced housing.

Applicants should preferably be qualified to HNC in Electronics although practical experience in a test or field services environment is equally important.

Vacancies cover a wide range of seniority and responsibility with salaries between £5,000 – £8,000 p.a. Our information package will tell you more so telephone now for your copy or write with full C/V to Gordon Short at Marconi Communication Systems Limited, New Street, Chelmsford, Essex, CM1 1PL. Tel. Chelmsford (0245) 353221, extension 592.

Marconi
Communication Systems

Marconi

VHF/Radio Engineer

Middle East

Our client, involved in several major projects overseas, require a Telecommunications Engineer immediately to advise and monitor an important harbour system. Emphasis is on VHF radio links, operational control and port safety services.

Candidates should be graduates in an appropriate discipline, preferably with membership of a professional institution, and have relevant experience in VHF radio field. In addition to professional background, applicants must be skilled in liaison and consultancy practices, preferably gained overseas and be available for immediate interview and posting.

The post attracts an excellent tax-free salary package of c.£24,000 together with usual overseas benefits, including free furnished accommodation, company car and medical cover. Candidates, aged 30-45, must hold relevant degree to qualify for interview.

Please write initially with full career details to Confidential Reply Service, Ref. DSV 8760, Austin Knight Limited, London, W1A 1DS.

Applications are forwarded to the client concerned, therefore companies in which you are not interested should be listed in a covering letter to the Confidential Reply Supervisor.

Austin Knight Advertising

BORED ?

Then change your job!

1) Film-TV Equipment
Installation and maintenance of studio and TV equipment. UK and abroad.

2) Satellite Communications
Test Engineers required with experience of digital circuitry. £7,700. Surrey.

3) Microcomputers and Peripherals
Service Engineers required £8-£10,000 Camberley.

4) Data Communications
Service of microprocessor-based equipment. £8,000 + car. Reading.

5) Service Personnel
(RAF, RN, Army)
We have many clients interested in employing ex-service fitters and technicians at sites throughout the UK. Phone for details.

6) £500 per week
We are paying very high rates for contract design and test engineers who have a background in RF, MICROWAVE, DIGITAL, ANALOGUE or SOFTWARE, at sites throughout the UK.

Hundreds of other Electronic and Computer Vacancies to £12,500

Phone or write:
Roger Howard, C.Eng., M.I.E.E., M.I.E.R.E.
CLIVEDEN CONSULTANTS
87 St. Leonard's Road, Windsor, Berks.
Windsor (07535) 58022 (5 lines)

(1640)

CLIVEDEN

BOX NOs.

Box number replies should be addressed to:

Box No. ....
c/o Wireless World
Quadrant House
The Quadrant
Sutton, Surrey, SM2 5AS

PIONEER

require

A SAFETY/TECHNICAL CO-ORDINATOR

Pioneer High Fidelity (GB) Limited is a very successful and expanding company in the electronic consumer industry. We market a wide range of Hi Fi, Car Audio and Video products.
A vacancy now exists in our Technical Department for a Safety/Technical Co-ordinator at our new premises in Greenford, Middlesex.
The job entails the submission of new products to B.E.A.B. for approval, liasing with our factories in Japan and with the United Kingdom Safety Authorities and the writing of technical service bulletins for our dealers and authorised service centres.
The successful applicant should be fully conversant with BS-415 safety standards, applicable to domestic electrical equipment, and should have had at least two years' experience in this field.
He/she should be qualified to H.N.C. or equivalent standard in electronics and preferably with at least three years' experience in domestic HiFi and/or Video equipment. Some experience in technical writing is also essential.
Benefits include competitive salary, four weeks' holiday, subsidised restaurant, contributory pension scheme and private health cover.

For further information or an application form, please contact:
Mrs C. A. Burridge, Pioneer High Fidelity (GB) Limited
Field Way, Greenford, Middx. UB6 8UZ. Tel: 01-575 5757

(2196)

tam

TELEVISION AUDIO MAINTENANCE LIMITED

TECHNICAL TRAINING OFFICER

Television Audio Maintenance (TAM) is an expanding national Division of the Telefusion Plc Group (£80 million turnover) providing a Video/TV/Audio after sales service to leading electrical retailers, all of whom are household names.

This interesting and challenging new appointment will be of interest to engineers of City and Guilds Technician Education or equivalent who wish to broaden their experience across a wide range of modern merchandise and manufacturers. Applicants should preferably have had teaching or training experience.

The work involves conducting Central and Regional Courses, preparing material to be used by our national network of Local Trainers, providing technical servicing advice to our 50 Service Departments and liaising with manufacturers. The position is based at Blackpool. Considerable travelling is involved.

Salary is negotiable. Company car plus other fringe benefits. Reply with full details to:

Mr. R. M. Beaton, Group Personnel Manager, Telefusion Plc, Telefusion House, Preston New Road, Blackpool, Lancs.

(2198)

ELECTRONICS ENGINEER

Rediffusion Music require an Electronics Engineer with a minimum of five years' experience in the professional audio field, covering real time and high speed magnetic tape duplicating systems.
The successful candidate will be involved with the design, development and technical back-up of studio and factory production equipment. Should be qualified to degree or HND level, and will be expected to have proven supervisory and communication skills.

For application form please contact:

Mrs Joanne Jarvis
Personnel Officer
Rediffusion Business Electronics Ltd.
Music Division
Cray Avenue
Orpington
Kent
Tel: Orpington 32121

(2193)

THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY
DEPARTMENT OF ELECTRICAL AND COMMUNICATIONS ENGINEERING

PROFESSOR AND ASSOCIATE PROFESSOR (2 VACANCIES)

Applications are invited from suitably qualified candidates to fill the above posts. The Holder of the Chair of Electrical and Communications Engineering would be expected to assume leadership of the Department. The discipline of the Associate Professor would be chosen to complement that of the Professor.

The Department of Electrical and Communications Engineering has a current academic staff of 16, and a total student enrolment of 190. The Department is responsible for courses leading to a Bachelor's Degree with specialisation in either communication or power engineering, and to a Diploma or Graduate Diploma leading to a Master's Degree after further study, has recently been introduced. There is scope for developing related courses within the Department.

The applicants should have appropriate qualifications and extensive teaching and administrative experience in higher education, special expertise in some branch of electrical and communication engineering, and a recognition of some of the problems facing technological education in a developing country. He/she will be required to stimulate and pursue research and maintain and develop strong links with engineering employers and the profession.

The language of instruction is English.

SALARY:	Professor	K22,840
	Associate Professor	K21,720
	(K1=£0.7591)	

Initial contract period is for three years. Other benefits include gratuity of 24% taxed at 2%, appointment and repatriation fares for the staff member and family after 18 months of service, settling-in and settling-out allowances, six weeks paid leave per year, education fares and assistance towards school fees, free housing. Salary continuation and medical schemes are available.

Detailed applications with curriculum vitae together with names and addresses of three referees and telephone contact should be received by: The Registrar, PNG University of Technology, Private Mail Bag, Lae, Papua New Guinea by 31st August, 1983.

(2186)

INNER LONDON EDUCATION AUTHORITY
Learning Resources Branch
Television Centre
Thackeray Road
Battersea SW8 3TB

ENGINEER – ELECTRONIC MAINTENANCE

Salary range: (ST2) £7,035 to £7,974 plus £1,284 London Weighting Allowance.

The ILEA's Television Centre produces a wide range of educational programmes on video and audio cassettes.
The Maintenance section numbers four persons and a vacancy has arisen for an engineer with a sound knowledge of the principles of colour television, and preferably a working experience of maintaining broadcast type TV equipment. Applicants must wish to specialise on the video side (cameras, vision mixers, telecine, etc.), and will receive appropriate training.
An engineering degree, TEC or other equivalent qualifications are desirable.

Application forms from the Education Officer (EO/Estab. 1B), Room 365, The County Hall, London SE1 7PB. Please enclose a stamped and addressed foolscap envelope. Completed forms to be returned by May 4, 1983.
ILEA is an equal opportunities employer.

(2201)

SALFORD COLLEGE OF TECHNOLOGY
DEPARTMENT OF ENGINEERING

LECTURER IN ELECTRONICS (AUDIO/MUSIC RECORDING)

Lecturer required from 1 September, 1983, to assist in the development of new three year full-time Diploma course in Music Recording Technology.
Candidates must have a degree in Electronics or Physics and should have practical experience of analogue and digital equipment. An ability and/or interest in music is essential.
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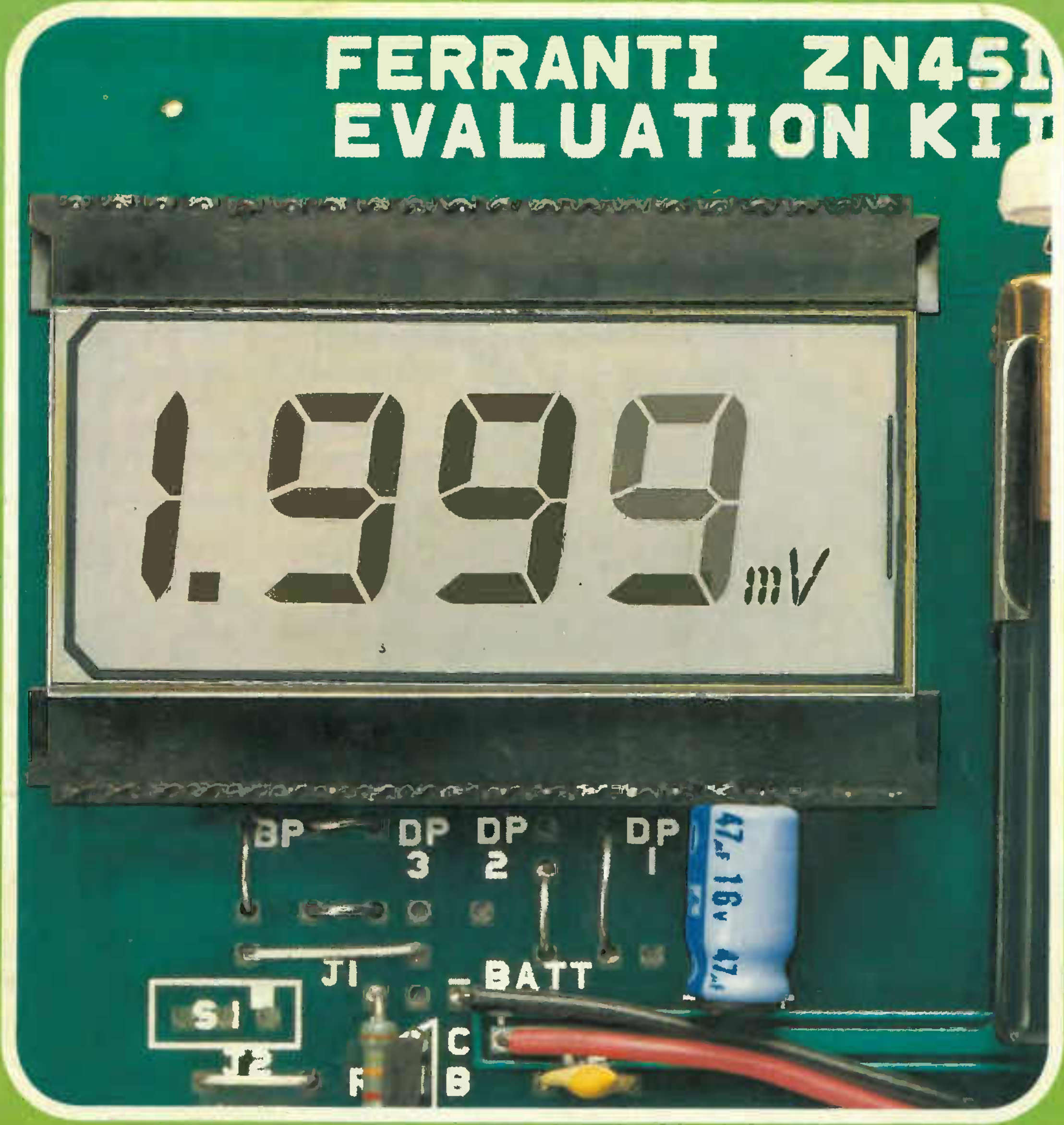

Better by design

If you're the sensitive type, check out the new ZN451 DVM.

Measuring microvolt signal levels is easy with the new ZN451 DVM IC. It's the first DVM that auto-zeroes external signal conditioning circuits to give full-scale readings as low as ± 1.999 mV with no zero adjustment.

Two logic outputs are provided to control external analogue switches, allowing op-amps and other circuits to be put inside the auto-zero loop and have their offsets cancelled by the ZN451's digital auto-zero system.

Use the ZN451 with pressure transducers, thermocouples, strain gauges or any low output transducer.

To make it even easier there's the ZN451 Evaluation Kit, which contains everything* you need to make a 2mV DVM, available from your Ferranti distributor price £29.50 inc. VAT.

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