wireless world

NOVEMBER 1980 60p

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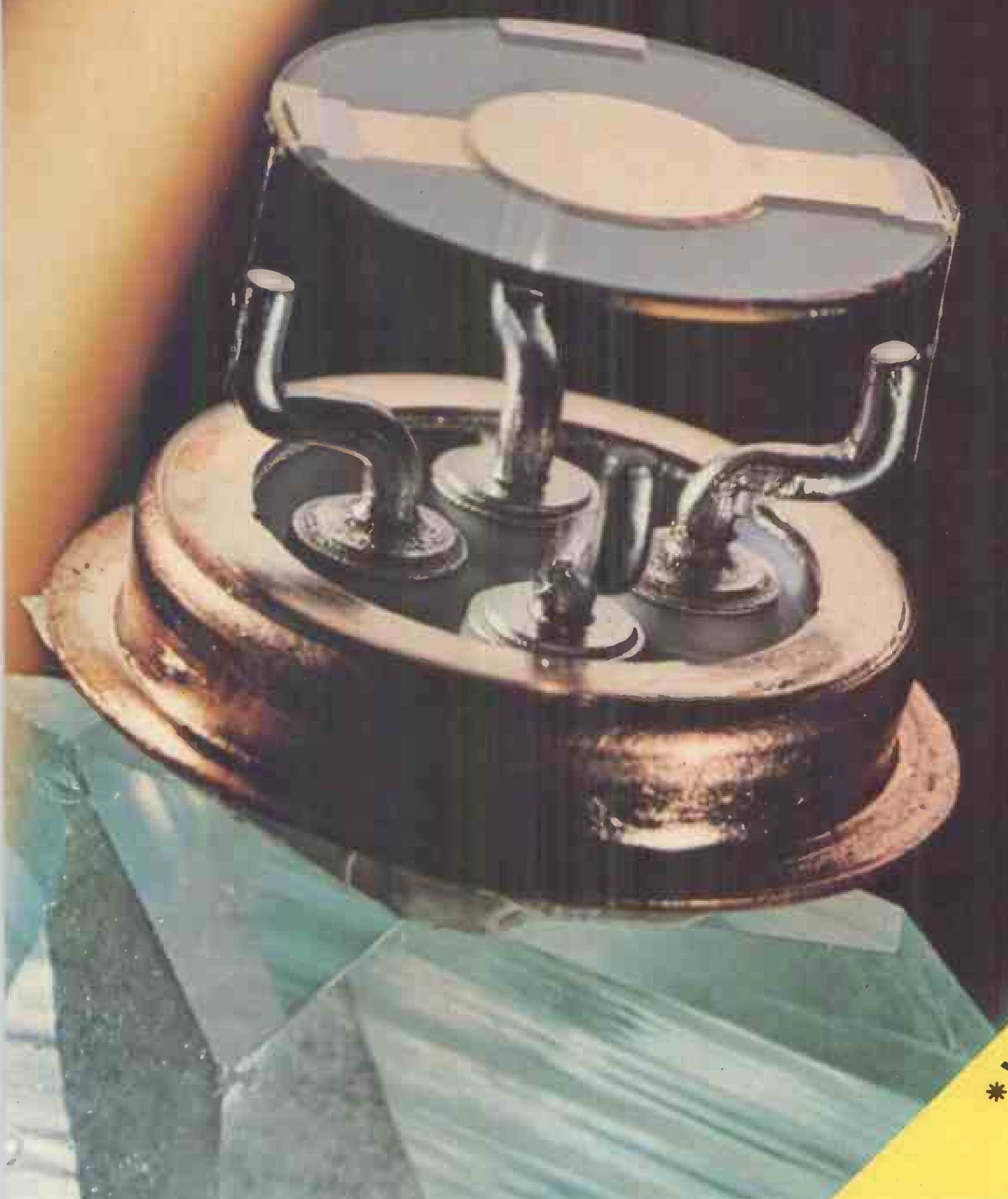

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page 19

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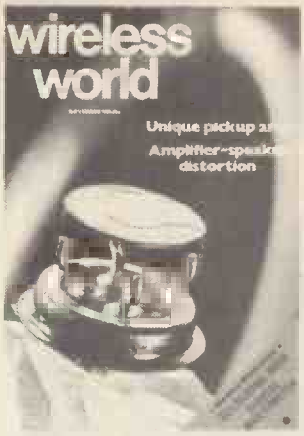

Front cover shows a quartz crystal made by Hewlett-Packard for a new oscillator. A plano-convex finish is used to achieve high stability.

IN OUR NEXT ISSUE

Darkroom exposure and enlarger timer **measures required exposure for a black-and-white print, giving a digital readout in seconds and tenths. It then times this exposure.**

Christmas electronics quiz, **set by polytechnic lecturer Bryan Hart and colleague. Prizes are offered.**

Programmable power supply **provides 0 to 40V at 2A, controlled via the IEEE General Purpose Interface Bus.**

More details page 47.

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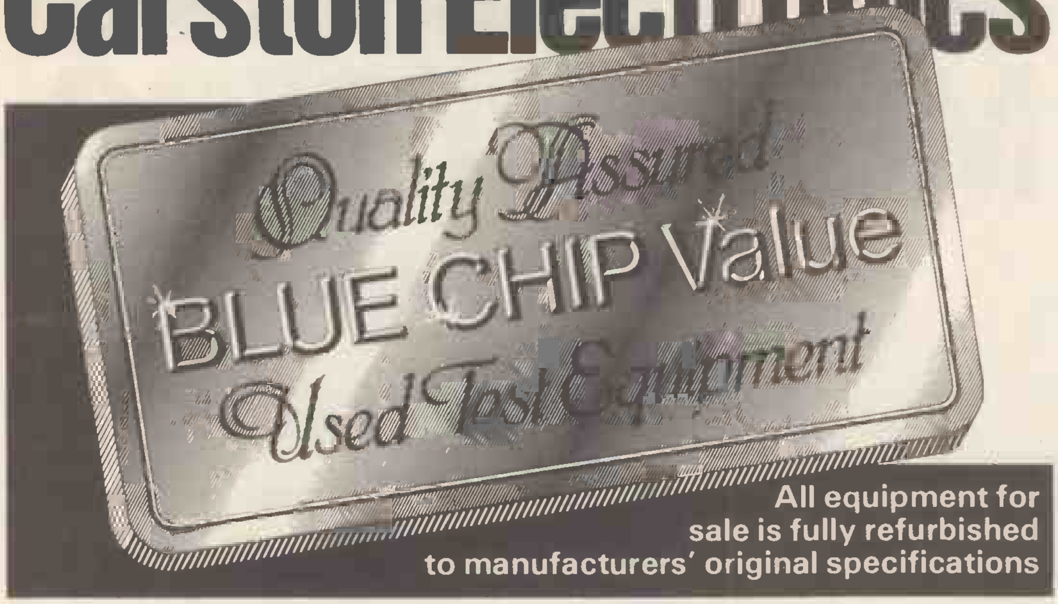
wireless world

ELECTRONICS/TELEVISION/RADIO/AUDIO

NOVEMBER 1980 Vol 86 No 1538

Carston Electronics



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- B601 RF LCR Bridge (Detector and Oscillator not incl). — 125
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- 74261A Psophometer CCITT — 475

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- 5303B DC-520 MHz. (Plug-on) 125mV sens. 50Ω — 120
- 5308A 0-75 MHz. Universal Module. 50mV sens. 1MΩ — 100
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- 5345 DC-500 MHz Time Int. Ave. Burst Total Ratio — 1225
- 10590A Adaptor converts 5245 Plug-ins to 5345 — 225

RACAL
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- 9024 10 Hz-600 MHz 7+1 digits — 250
- 9835 6 Digit DC-20 MHz 10mV — 100
- 9837 DC-80 MHz 6 digits — 130

SYSTRON DONNER
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- 6054A/04 11 Digit 20 kHz-18 GHz BCD O/P — [illegible]

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TEKTRONIX
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DRANETZ
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GAY
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- 1A4 four trace Plug-in DC-50 MHz — 375
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- 7A18 Dual Trace DC-75 MHz 5mV/div — 370
- 7A22 High gain diff. amp. 0.1 Hz-1 MHz 10µV — 450
- 7A26 Dual Trace DC-150 MHz 5mV-5V/div. — 525
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DCR 300-2.5 0-300V 2.5A DC Stab.	375
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DB ELECTRONICS	
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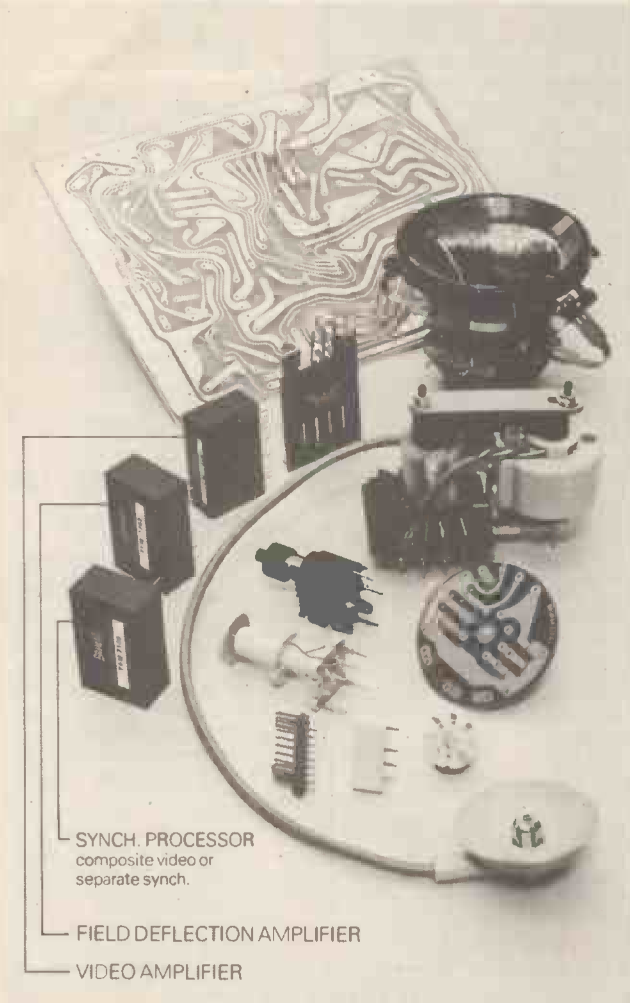

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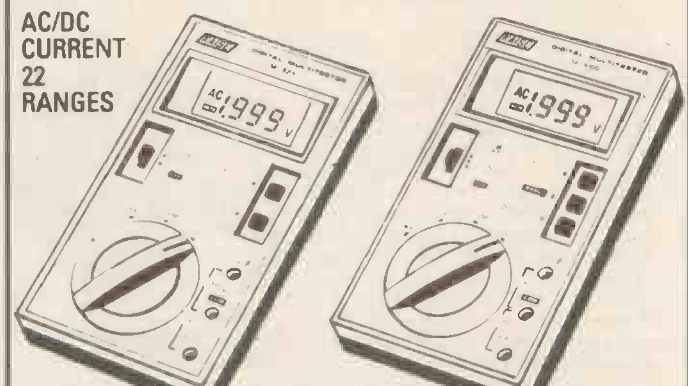

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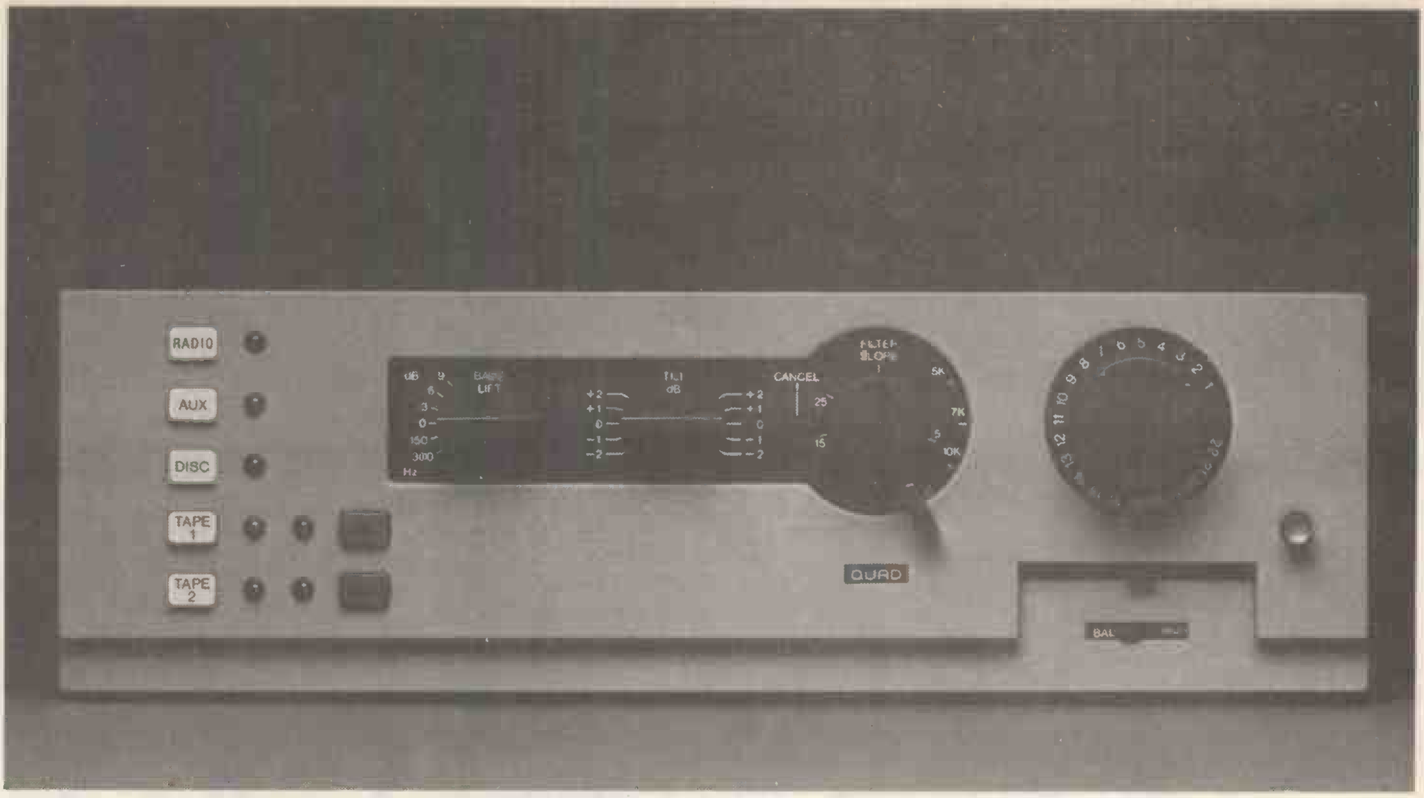

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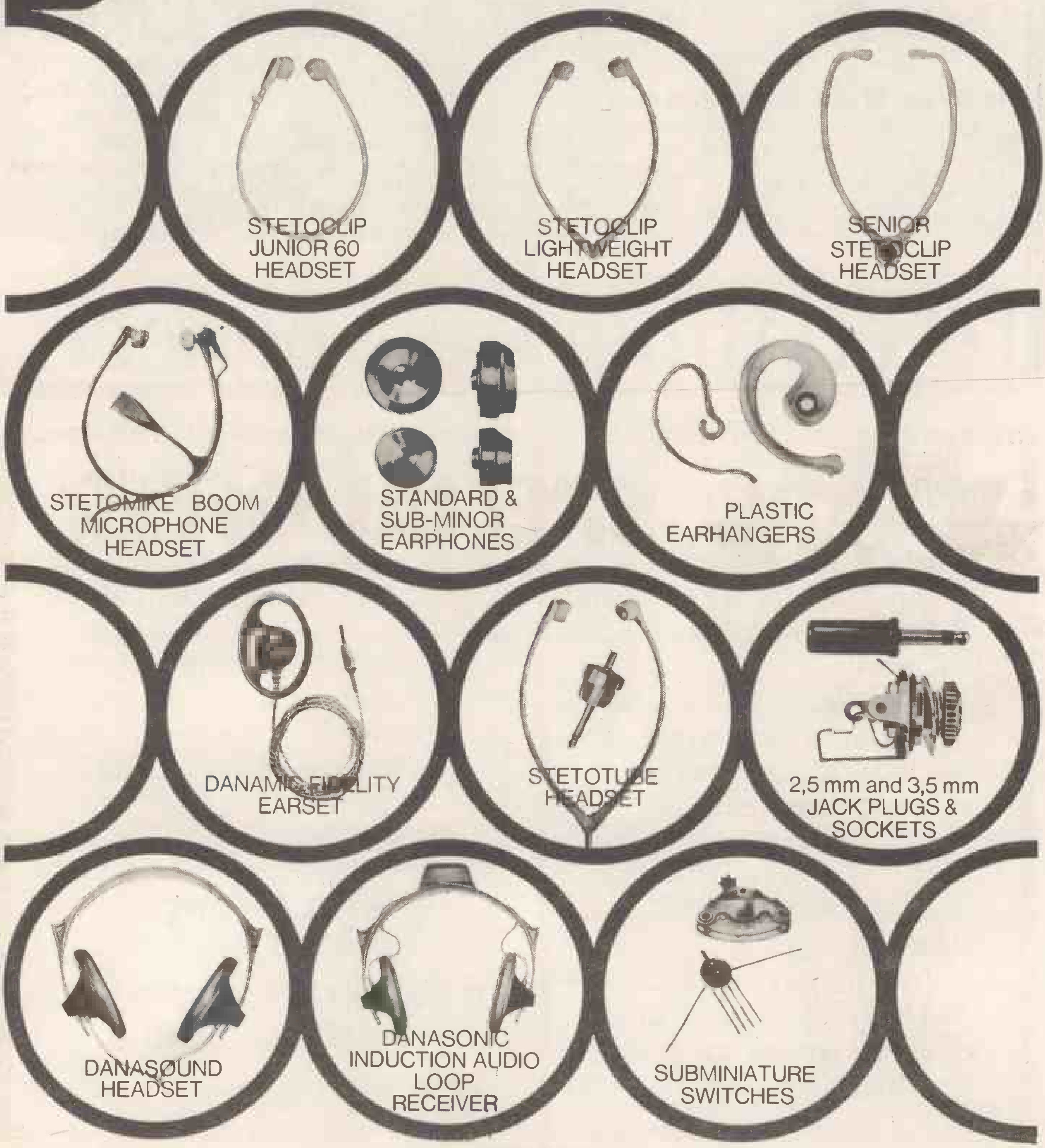

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		4072	17p
		4073	17p
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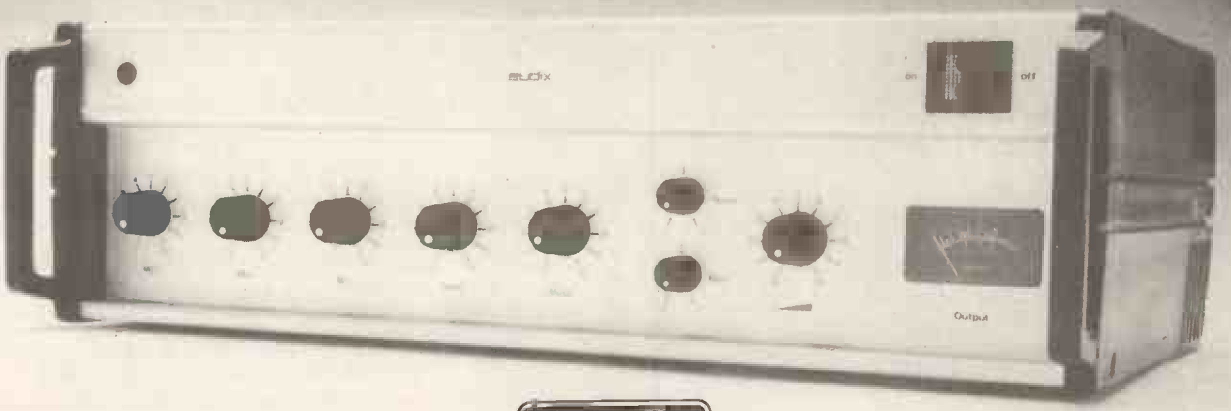

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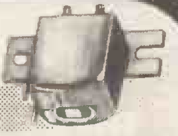

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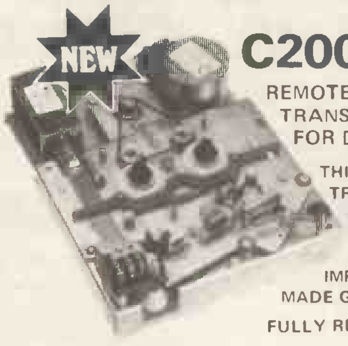

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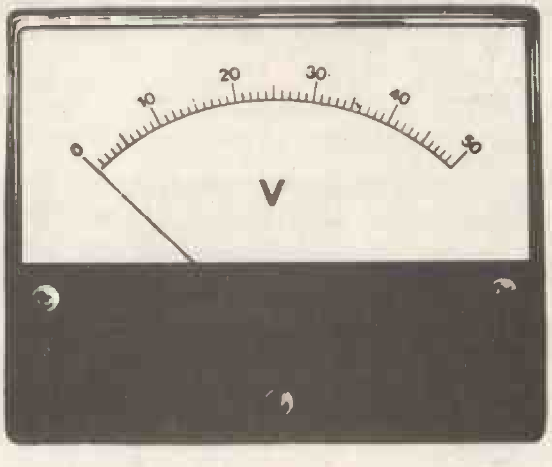
METER PROBLEMS?



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WW — 054 FOR FURTHER DETAILS

AND THERE'S MORE WHERE THIS CAME FROM

It's a long time since one of our adverts was presented in 'list' form - but simply because we do not try to squeeze this lot in every time doesn't mean that it's not available. Our new style price list (now some 40 pages long) includes all this and more, including quantity prices and a brief description. The kits, modules and specialized RF components - such as TOKO coils, filters etc. are covered in the general price list - so send now for a free copy (with an SAE please). Part 4 of the catalogue is due out now (incorporating a revised version of pt.1).

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KB4423	2.30
KB4424	1.65
KB4431	1.95
KB4432	1.95
KB4433	1.52
KB4436	2.53
KB4437	1.75
KB4438	2.22
KB4441	1.35
KB4445	1.29
KB4446	2.75
KB4448	1.65
NE5044N	2.26
NE5532N	1.85
SD6000	3.75
SL6270	2.03
SL6310	2.03
SL6600	3.75
SL6640	2.75
SL6690	3.20
SL6700	2.35
ICL8038CC	4.50
MSL9362	1.75
MSL9363	1.75
HA11211	1.95
HA11223	2.15
HA11225	1.45
HA12002	1.45
HA12017	0.80
HA12402	1.95
HA12411	1.20
HA12412	1.55
LF13741	0.33
SN76660N	0.80

FREQUENCY DISPLAY & SYNTHESISER ICs

SAA1056	3.75
SAA1058	3.35
SAA1059	3.35
11C90DC	14.00
LN1232	19.00
LN1242	19.00
MSL2318	3.84
MSM5523	11.30
MSM5524	11.30
MSM5525	7.85
MSM5526	7.85
MSM5527	9.75
MSM55271	9.75
ICM7106CP	9.55
ICM7107CP	9.55
ICM7216B	19.25
ICM7217A	9.50
SP8629	3.85
SP8647	6.00
95H90PC	6.00
HD10551	2.45
HD44015	4.45
HD12009	6.00
HD44752	8.00

CMOS 4000 SERIES

4001	0.17
4000	0.17
4002	0.23
4008	0.80
4009	0.58
4010B	0.58
4011AE	0.20
4011B	0.20
4012	0.55
4013	0.55
4015	0.95
4016	0.52
4017	0.80
4019	0.60
4020B	0.93
4021	0.82
4022	0.90
4023	0.17
4024	0.76
4025	0.17
4026	1.80
4028	0.72
4029	1.00
4030	0.58
4035	1.20
4040	0.83
4042	0.85
4043	0.85
4044	0.80
4046	1.30
4047	0.99
4049	0.52
4050	0.55
4051	0.65
4052	0.65
4053	0.65
4063	1.09
4066	0.56
4068	0.25
4069	0.20
4070	0.20
4071	0.20
4072	0.20
4073	0.20
4075	0.20
4076	0.90
4077	0.20
4078	0.20
4082	0.20
4093	0.78
4175	0.95
4503	0.69
4506	0.51
4510	0.99
4511	1.49
4512	0.98
4514	2.55
4518	1.03
4520	1.09
4521	2.36
4522	1.49
4529	1.41
4539	1.10
4549	3.50
4554	1.53
4560	2.18
4566	1.59
4568	2.18
4569	3.03
4572	0.30
4585	1.10

TTL N and LSN

7400N	0.13
74LS00	0.20
7401N	0.13
74LS01	0.20
7402N	0.14
74LS02	0.20
7403N	0.14
74LS03	0.20
7404N	0.14
74LS04	0.24
7405N	0.18
74LS05	0.26
7406N	0.28
7407N	0.38
7408N	0.17
74LS08	0.24
7409N	0.17
74LS09	0.24
7410N	0.15
74LS10	0.24
7411N	0.20
74LS11	0.24
7412N	0.17
7413N	0.30
7414N	0.51
74LS15	0.24
7416N	0.30
7417N	0.30
7420N	0.16
74LS20	0.24
7421N	0.29
74LS21	0.24
7423N	0.27
7425N	0.27
7427N	0.27
74LS27	0.44
7428N	0.35
74LS28	0.32
7430N	0.17
74LS30	0.24
7432N	0.25
74LS32	0.24
7437N	0.40
7438N	0.33
74LS38	0.24
7440N	0.17
74LS40	0.24
7441N	0.74
7442N	0.70
74LS42	0.99
7443N	1.15
7444N	1.12
7445N	0.94
7446N	0.94
74LS47	0.89
7448N	0.56
74LS48	0.99
74LS49	0.99
7451N	0.17
74LS51	0.24
7453N	0.17
7454N	0.17
74LS54	0.24
74LS55	0.24
7460N	0.17
74LS63	1.24
7470N	0.28
7472N	0.28
7473N	0.32
74LS73	0.38
7474N	0.27
74LS74	0.28
7475N	0.38
7476N	0.37
74LS76	0.38
74LS78	0.38
7480N	0.48
7481N	0.86
7482N	0.69
7485N	1.04
74LS85	0.99
74LS86	0.40
7489N	2.05
7490N	0.33
74LS90	0.90
7491N	0.76
74LS91	1.10
7492N	0.38
74LS92	0.78
7493N	0.32
74LS93	0.99
7494N	0.78
7495N	0.65
74LS95	1.14
7496N	0.58
74LS96	1.20
7497N	1.85
74LS107	0.38
74109N	0.63
74LS109	0.70
74110N	0.54
74111N	0.68
74LS112	0.38
74LS113	0.38
74LS114	0.38
74118N	0.83
74120N	1.15
74121N	0.42
74122N	0.46
74123N	0.73
74LS124	1.75
74125N	0.38
74LS125	0.44
74126N	0.57
74LS126	0.44
74128N	0.74
74132N	0.73
74LS132	0.78
74LS136	0.40
74LS138	0.60
74141N	0.56
74142N	2.65
74143N	3.12
74144N	3.12
74LS145	0.97
74147N	1.75
74148N	1.09
74LS148	1.19
74150N	0.99
74151N	0.55
74LS151	0.84
74153N	0.64
74LS153	0.54
74154N	0.96
74155N	0.54
74LS155	1.10
74156N	0.80
74157N	0.67
74LS157	0.55
74LS158	0.60
74159N	2.10
74160N	0.82
74LS160	1.30
74161N	0.92
74LS161	0.78
74LS162	1.30
74163N	0.92
74LS163	0.78
74164N	1.04
74LS164	1.30
74165N	1.05
74LS165	1.04
74167N	2.50
74LS169	2.00
74170N	2.30
74LS170	2.00
74LS174	1.20
74175N	0.87
74LS175	1.10
74176N	0.75
74177N	0.78
74181N	1.65
74LS181	3.50
74LS183	2.10
74184N	1.35
74185N	1.34
74LS190	0.92
74192N	1.05
74LS192	1.80
74193N	1.05
74LS193	1.80
74194N	1.05
74196N	0.99
74LS196	1.10
74LS197	1.10
74198N	1.50
74199N	1.60
74LS247	0.93
74LS257	1.08
74LS260	1.53
74LS279	0.52
74LS283	1.20
74LS293	0.95
74LS365	0.49
74LS366	0.49
74LS367	0.43
74LS368	0.49
74LS374	1.80
74LS377	1.95
74LS379	1.30
74LS393	1.40

VOLTAGE REGULATORS

78series	0.95
79series	1.00
78Mseries	0.65
78Lseries	0.35
79L05	0.85
78MGT2C	1.75
79MGT2C	1.75
723CN	0.65
L200	1.95
TDA1412	0.75
NE5553N	1.25
LM317MP	1.48
LM337MP	1.48

MICROMARKET

8080A/2	7.50
8212	2.30
8214	3.50
8216	1.95
8224	3.50
8251	6.25
8255	5.40
6800P	7.50
6810	5.95
6820	7.45
6850	4.90
6852	4.85
MC2708	7.50
2114	6.50
4027	5.78
2102	1.70
2112	3.40
2513	7.54
HM4716	4.50
81LS97	1.25

VARICAP TUNING DIODES

BA102	0.30
BA121	0.30
ITT210	0.30
BB204B	0.36
BB105B	0.36
BB109	0.27
MVM125	1.05
BB212	1.95
KV1210	2.45
KV1211	1.75
KV1226	1.95
KV1225	2.75
KV1215	2.55
KV1225	2.75

SWITCHING AND PIN DIODES
SHOTTKY DIODES

1N6263	0.62
BA182	0.19
BA244	0.17
BA379	0.35
TDA1061	0.95

SIGNAL DIODES & RECTIFIERS

1N4148	0.06
1N4001	0.06
1N4002	0.07
1N5402	0.15
OA91	0.07
AA112	0.25
BRIDGES:	
1A/50V	0.35
6A/200V	0.75

TRANSISTORS AUDIO DEVICES

BC237	0.08
BC238	0.08
BC239	0.08
BC307	0.08
BC308	0.08
BC309	0.08
BC413	0.10
BC414	0.11
BC415	0.07
BC416	0.08
BC546	0.12
BC556	0.12
BC550	0.12
BC560	0.12
BC639	0.22
BC640	0.23
2SC1775	0.18
2SA872A	0.14
2SD666A	0.30
2SB646A	0.30
2SD668A	0.40
2SB648A	0.40
2SD760	0.45
2SB720	0.45
2SC2546	0.19
2SA1084	0.20
2SC2547	0.19
2SA1085	0.20

AUDIO POWER DEVICES

2SB753	2.34
2SB723	2.34
2SK133	3.00
2SJ 48	3.00
2SK134	3.10
2SK135	3.75
2SJ 50	3.75
BD535	0.52
BD536	0.52
BD377	0.33
BD378	0.33
BD165	0.30
BD166	0.31

SMALL SIGNAL RF DEVICES

BF194	0.18
BF195	0.18
BF224	0.22
BF241	0.18
BF274	0.18
BF440	0.21
BF441	0.21
BF362	0.49
BF395	0.18
BF479	0.66
BF679S	0.55
BFR91	1.33
BFW92	0.60
BFT95	0.99
BFY90	0.90
40238	0.85

RF POWER DEVICES

VN66AF	0.95
2N3866	0.85

SMALL SIGNAL RF FET/MOSFET

BF256	0.38
2SK55	0.28
2SK168	0.35
J310	0.69
J176	0.65
40823	0.65
40673	3SK51
3SK45	0.49
3SK51	0.54
3SK60	0.58
MEM680	0.75
BF961	0.70
BF960	1.24
3SK48	1.64

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LF/HF FIXED INDUCTORS —FULL E12 RANGE

7BA series 1uH-1mH	0.16
8RB series 100uH-33mH	0.19
10RB series 33mH-120mH	0.33
10RBH series 120mH-1.5H	0.55
PIEZO SOUNDER PB2720	0.44

CRYSTAL FILTER PRODUCTS

10.7MHZ 2 POLE TYPES:

10M15A 15KHZ BW	2.49

10.7MHZ 8 POLE TYPES:

10M4B1 15kHz BW	14.50
H4402 7.5KHZ BW	15.50
10M22D 2.4KHZ SSB	17.20

HF FIRST FILTER:

B34F8A 34.5MHz HF	32.00

RADIO CONTROL CRYSTALS

(No splits available)

AM TX:-

3rd OT 30pF HC25U	1.65

AM/FM RX:-

3rd OT 30pF HC25U	1.65

FM TX :-

Fund 20pF HC25U	1.85
Pairs FM	3.25
Pairs AM	3.10

CRYSTALS

32.768 kHz	2.70
100kHZ	3.85
455kHZ	5.00
1.0MHz	3.00
3.2768MHz	2.70
4.000MHz	2.00
4.19439MHz	2.30
6.5536MHz	2.10
10.0MHz	2.50
10.6985MHz	2.50
10.7015MHz	2.50
10.245MHz	2.50
10.7MHz	3.00
11.52MHz	2.50
100MHz	3.00

LEDs

5MM RED	0.12
3MM RED CLEAR	0.15
3MM RED	0.15
2.5 X 5MM RED	0.17
5MM GREEN	0.15
3MM GN CLEAR	0.16
3MM GREEN	0.16
2.5 X 5MM GN	0.20
5MM YELLOW	0.15
3MM YELLOW CL	0.16
3MM YELLOW	0.18
2.5 X 5MM YE	0.20
5MM ORANGERED	0.20
5MM ORA CL	0.29
3MM ORANGERED	0.19
2.5 X 5MM ORA	0.24
5MM INFRA RED	0.56
BPW41 IR DET	1.51
IR OPT CPLR	1.44
5MM CLIP	0.04

LCDs

3.5 digit	9.45
4 digit	8.95
5 digit	8.95

SCHOTTKY DIODE BAL MIXERS (SBL1=MD108)

SBL1 1-500MHz	4.25
SBL1-8 .1-200MHz	4.55
SBL1-X 10-1000MHZ	5.75
SRA1 .5-500MHz	8.45
SRA1-1 .1-500MHz	9.25
SRA1H .5-500MHz	13.35
SRA3 .025-200MHz	10.25

LCD Module

CM161.
Miniature clock, 12/24 hr., alarm, day, date, backlight.
All for......9.95

CAPACITORS

All 5mm or less spacing

CERAMIC 50v
2P2,3P3,4P7,6P8
8P2,10P,15P,18P..0.04
22P,27P,33P,47P
56P,68P,82P,100P.0.05
150P,220P,270P
330P,390P,470P...0.055
1N0,2N2,3N3,4N7..0.06
10N (0.01uF)....0.05
22N,47N..........0.06
100N,220N........0.09
MONOLITHIC CERAMIC
10N,100N.........0.16

FEEDTHRU
1N0 SOLDER IN....0.09

POLYESTER (SIEMENS)
10mm LEAD SPACING
10N,22N,33N......0.17
47N,68N,100N.....0.19
220N,470N........0.22
1uF..............0.29

POLYESTER (GENERAL)
10mm LEAD SPACING
10N,15N,22N,33N..0.06
47N,68N,100N.....0.08
220N.............0.11
20mm LEAD SPACING
220N,330N,470N...0.18

MYLAR
5mm LEAD SPACING
1N0,10N,22N,33N..0.08
100N.............0.09
20mm LEAD SPACING
220N,470N....... 0.17

POLYSTYRENE
10P,15P,18P,22P,
27P,47P,56P,68P..0.08
100P,180P,220P,
270P,330P,390P...0.09
470P,680P,820P...0.10
1N0,1N2,1N5,1N8..0.11
2N2,2N7,3N3,3N9..0.12
4N7,5N6,6N8,10N..0.13

TANTALUM BEAD CAPS
16v: 0.22,0.33,
0.68,1.0.........0.18
16v: 2.2,4.7,10..0.19
6v3: 22,47.......0.30
10v: 22,100......0.35

ALUMIN ELECTROLYTICS RADIAL (VERT. MOUNT)

(uF/voltage)
1/63,2.2/50,4.7/35
10/16,15/16,22/10
33/6.3...........0.08
22/16,33/10,
47/10............0.09
10/63,22/50,33/50,
47/16,100/16.....0.10
47/63,100/25,220/16
470/6.3..........0.12
100/63,470/16,
1000/10..........0.18
1000/16,470/63...0.23
1000/63,2200/16..0.30
3300/25..........0.69
1000/100.........0.88
10000/70.........3.00

AXIAL (HORIZ. MOUNT)
1/25,4.7/16,6.4/25
10/16............0.08
4.7/63,22/10,22/16
33/16............0.09
47/25,100/16.....0.10
100/25...........0.11
1000/16..........0.25
2200/16,1000/25..0.36
1000/35,4700/16..0.45
1000/50..........0.58

RESISTORS

0.25W, 5% E12 CARBON
1ohm-10M.........0.02
0.25W 1% E12 METAL FILM
1.1ohm-1M........0.05

HORIZ CARBON PRESETS
10mm TYPE
100ohms-2M5......0.12
HORIZ CERMET PRESETS
1k, 10k..........0.27

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Vero Systems have developed two new British made wire wrapping tools for the electronics industry.

The 'Hobby' is designed to offer the newcomer wire wrapping at a reasonable price. Complete with wire wrapping bit suitable for 30AWG wire and any mini-wrap terminal. Ideal for low volume users.

The 'Verowrap' is fitted with a chuck which will accept any wrapping bits and sleeves, making it adaptable for different terminal sizes where 30AWG and 26AWG wire is in use.

Both tools incorporate a power unwrap facility operated by the flick of a switch.

The high capacity nickel cadmium batteries are charged in situ by use of a plug-in charger.

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WW — 072 FOR FURTHER DETAILS

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British Patents applied for

No other cleaner has all these advantages:—

1. Only 100% pure, natural diamond grains are utilised.
2. Blades are treated with hard chrome to reinforce the setting of the diamond grains, to obviate loosening or breakaway during use. This process also prevents clogging of the diamonded surface by residues resulting from use.
3. All diamonded blades are rectified to ensure an absolutely smooth surface by eliminating diamond grains which may rise above the surface. This eliminates all excessive scratching during use.
4. All diamond grains are rigidly calibrated to ensure a perfectly uniform grain size of either 200, 300 or 400.
5. The chrome gives a very weak co-efficient of friction and the rigidity of the nylon handle is calculated to permit proper utilisation and yet pliant enough to avoid undue pressures on highly delicate relays.

- Grain size 200., thickness 55/100 mm., both faces diamonded. For quick cleaning of industrial relays and switching equipment, etc.
- Grain size 300, thickness 55/100mm., both faces diamonded. For smaller equipments, like telephone relays, computer relays, etc.
- Grain size 400, thickness 25/100 mm., one face diamonded. For sensitive relays and tiny contacts. Two close contacts facing each other can be individually cleaned, because only one face of the spatula is abrasive.

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930	55p
935	65p
937	55p
944	65p
946	55p
957	55p
962	55p
9099	90p

7400

7400	11p
7401	12p
7402	12p
7403	13p
7404	17p
7409	18p
74[illegible]	16p
7412	18p
7413	28p
7420	16p
7430	18p
7432	25p
7440	16p
7442	68p
7448	75p
7473	32p
7474	32p
7475	40p
7476	40p
7490	35p
7492	50p
7493	50p
7496	45p
74121	35p
74123	45p
74154	90p
74157	55p
74122	45p
74125	50p
74195	100p
74196	100p
74283	140p
74290	120p
74365	90p
74366	90p

74LS

74LS00	18p
74LS01	12p
74LS04	15p
74LS08	20p
74LS10	19p
74LS11	30p
74LS12	30p
74LS14	60p
74LS15	38p
74LS20	19p
74LS30	19p
74LS32	25p
74LS40	26p
74LS42	56p
74LS47	78p
74LS48	85p
74LS49	99p
74LS73	30p
74LS74	30p
74LS75	39p
74LS86	39p
74LS90	40p
74LS107	40p
74LS123	69p
74LS125	50p
74LS132	79p
74LS138	69p
74LS151	75p
74LS153	75p
74LS155	65p
74LS161	78p
74LS163	90p
74LS164	90p
74LS168	190p
74LS174	99p
74LS175	99p
74LS195	87p
74LS221	110p
74LS244	175p
74LS245	325p
74LS251	120p
74LS257	110p
75LS290	95p
74LS293	120p
74LS366	57p
74LS373	170p
74LS374	170p
74LS375	140p
74LS377	188p
74LS393	135p
74LS490	140p
74LS670	260p

CMOS

[illegible]	19p
[illegible]	19p
4006	75p
4007	19p
4008	80p
4009	35p
4010	45p
4011	20p
4012	24p
4013	38p
4014	70p
4015	75p
4016	35p
4017	60p
4018	76p
4019	42p
4020	88p
4021	100p
4022	88p
4023	22p
4024	50p
4025	20p
4026	130p
4027	45p
4028	75p
4029	80p
4030	50p
4031	195p
4033	145p
4035	104p
4036	290p
4037	105p
4038	110p
4039	290p
4040	99p
4041	75p
4042	73p
4043	86p
4044	88p
4045	160p
4047	99p
4048	56p
4049	38p
4050	40p
405[illegible]	[illegible]9p
[illegible]	[illegible]
4053	73p
4054	111p
4055	121p
4056	121p
4059	560p
4060	112p
4063	112p
4066	56p
4067	422p
4068	19p
4069	19p
4070	28p
4071	25p
4072	25p
4075	20p
4076	88p
4077	23p
40[illegible]	29p
4081	23p
4082	25p
4085	86p
4086	68p
4089	130p
4093	68p
4094	225p
4095	99p
4096	325p
4098	110p
4099	180p
4501	25p
4502	112p
4503	68p
4507	52p
4508	288p
4510	76p
4511	125p
4512	75p
4514	250p
4515	290p
4516	109p
4518	99p
4520	99p
4521	230p
4526	105p
4527	130p
4528	99p
4529	140p
4531	150p
4532	125p
4538	150p
4543	160p
4556	70p
4560	225p
4569	240p
4572	46p
4584	79p
4585	125p

74C

74C20	30p
74C76	60p
74C85	145p
74C97	125p
74C98	125p
74C107	100p
74C16D	110p
74C161	145p
74C162	145p
74C163	145p
74C192	175p
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LM339	45p
LM380	65p
LM1496	65p
LM1871	550p
LM1872	550p
LM3900	50p
LM3914	225p
LM3915	225p
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FD1797 B D/D True Bus. side select	5995p

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6850	425p
6852	425p
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8214	450p
8216	395p
8224	395p
8228	395p
8251	495p
8253	1125p
8255	495p
8257	1050p
8259	1325p
MC14412VL	797p
Z80 PIO	595p
Z80 CTC	595p
Z80A PIO	695p
Z80A CTC	695p
Z80 DMA	1995p
Z80A DMA	2495p
Z80 SIO/0	2995p
Z80A SIO/0	3495p
Z8D SIO/1	2995p
Z80A SIO/1	3495p
Z80 SIO/2	2995p
Z80A SIO/2	3495p

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MC1488	90p
MC1489	90p
DM8123	125p
75150	125p
75154	125p
75182	195p
75322	250p
75324	325p
75325	325p
75361	350p
75365	295p
75451	50p
75491/2	75p
8T26	175p
8T28	175p
8T95	175p
8T97	175p

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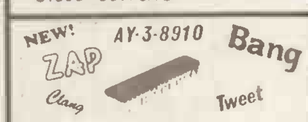

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FEATURES

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- Automatic switch off signal at end of tune for power saving
- Envelope control to give organ or piano quality
- Sequential tune mode
- 4 door capability when used as door chime
- Operation with tunes in external PROM if required (2708)
- Single supply (+5V) operation
- Tunes include: STAR WARS, BEETHOVEN'S 9TH and 5TH, JINGLE BELLS, YANKEE DOODLE, STAR SPANGLED BANNER, CLEMENTINE, GOD SAVE THE QUEEN, O SOLE MIO, WESTMINSTER CHIMES, and DESCENDING OCTAVE CHIME PLUS MANY MORE! With detailed specs and instructions

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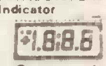

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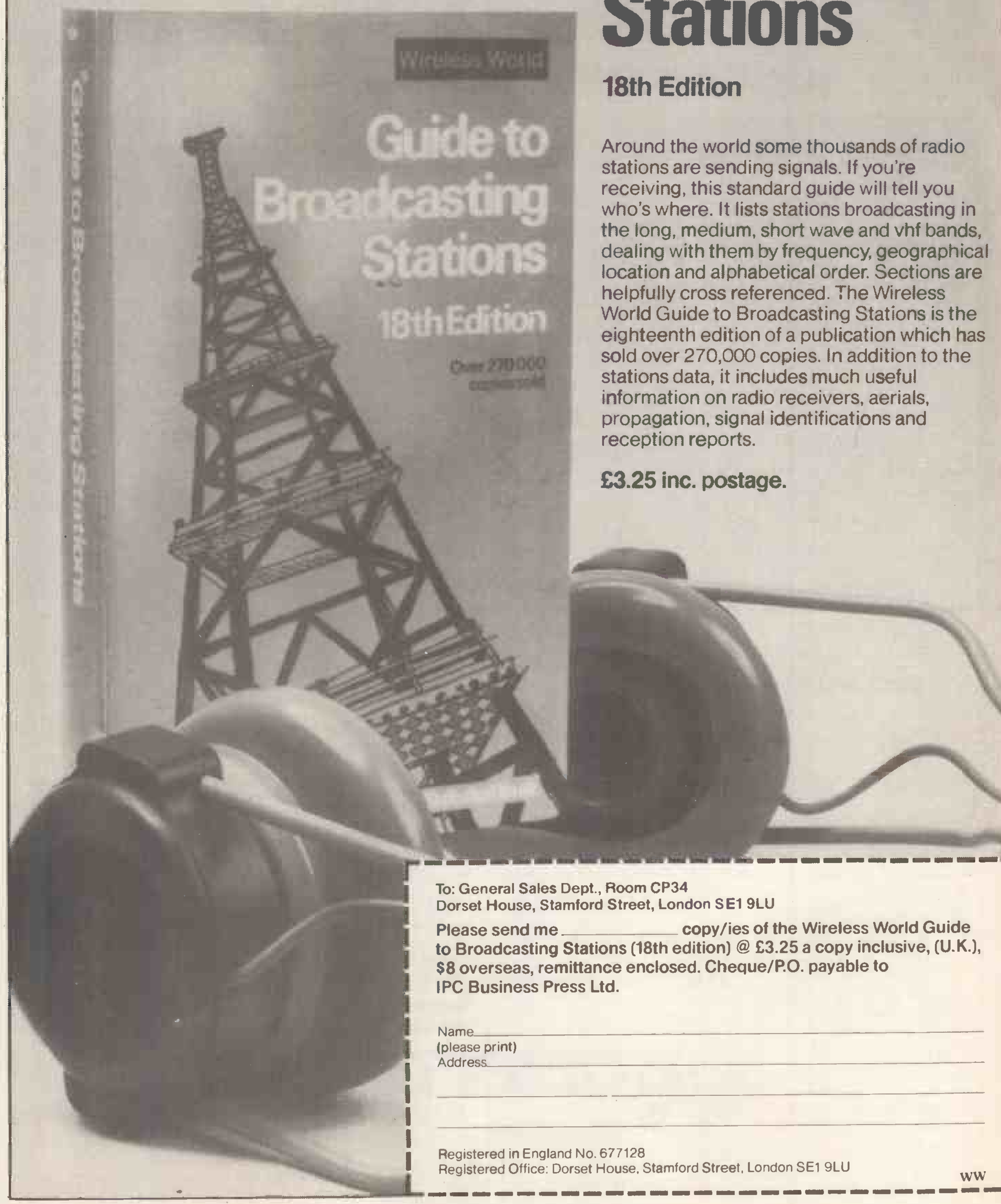

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Microchips and megadeaths

"Then I was shocked by the feeling that the skin of my face had come off. Then, the hands and arms, too. Starting from the elbow to the fingertips, all the skin of my right hand came off and hung down grotesquely. The skin of my left hand, all five fingers, all came off. . . . Hundreds of people were squirming in the stream. I couldn't tell if they were men or women. They all looked alike. Their faces were swollen and grey, their hair standing up. Holding their hands high, groaning, people were rushing to the river. . . . Under the bridge were floating, like dead dogs or cats, many corpses, barely covered by tattered clothes. In the shallow water near the bank, a woman was lying face upward, her breasts were torn away and blood spurting. . . . By my side many junior high school students were squirming in agony. They were crying insanely 'Mother! Mother!' They were so severely burned and bloodstained that one could scarcely dare to look at them. I could do nothing for them but watch them die one by one, seeking their mothers in vain." *(Eyewitness account, Hiroshima, 6 August 1945.)*

Engineers played their part in the making of these events. Thirty-five years later their role has become central, for the technology of delivering death has been greatly improved. We no longer have to rely on manned aircraft to drop atomic bombs but send them as the warheads of self-guided missiles. This is where electronic engineering makes its particular contribution to slaughter, in the design of the guidance system. Consider, for example, the Trident and the Tomahawk, the two nuclear missiles which the UK Government, without benefit of open Parliamentary debate, has swung on a reluctant nation. Both of these have guidance systems which rely on advanced digital microelectronics to update an inertial navigator. In the Trident, a submarine-launched ballistic missile intended as Britain's independent nuclear weapon, the electronic system receives reference information from the optical pattern of the stars. The Tomahawk, part of a NATO arsenal that will be owned and operated by US military forces, is a cruise missile; here the electronic system receives reference information on the geographic contours of the desired route from a magnetic-core memory and information on the actual contours over which it is travelling from a radar altimeter. And such is technical progress that as we get more and more devices on a single silicon chip so we are able to kill more and more people with a single missile.

Through work on such weapons electronics engineers in the East and the West have put themselves in the service of politicians, generals and industrialists who have become monomaniacs; who seem to see no way out of the self-perpetuating system of threat and counter-threat into which they have locked themselves and, like drug-addicts, desperately go on with it. The only thing likely to drag them out of their dementia is a threat from another direction – a concerted threat of rebellion from the trapped populations. It becomes increasingly clear, as our distinguished American contemporary *Science* has said, "that deterrence cannot ultimately be stable, and that the civilian populations of the world are no longer defended by the armed forces for which their taxes pay, but are merely hostages to them."

None of us can be proud to serve a technology which is being used in the name of "defence" as a means to attain immense human suffering. Because we know what this technology can do we should be among the leaders of dissent.

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Simple pick-up arm design

Separating vertical and horizontal pivots allows use of longer arm

By David Read, B.Sc. Hons (Elec. Eng.)

Costing between £5 and £10 to make, this arm gives improved tracking performance compared with conventional arms. Increased effective arm length is achieved by positioning the horizontal pivot at the extremity of the arm. Separation of the pivots also makes for easier construction.

Few people can afford either the money or the room for a hi-fi system which is tailor-made by experts with nothing but the excellence of performance in mind. The limits of cost and space, therefore, largely determine the type of equipment to be found in an installation. But even within these limits, it is no more than economic sense to arrange that the assembly contains units each with much the same standard of performance; it is also good engineering practice.

Home construction, properly carried out, obviously offers the best chance of achieving the highest standard of performance for a given outlay. Electronic equipment is well suited to this approach, especially using today's highly-developed solid-state technology. But the mechanical parts of a system are rarely given the do-it-yourself treatment. The average resources – in engineering know-how and availability of precision tools – are generally thought to be inadequate for this sort of work. I believe otherwise: given a suitable design, any limitations in skill and machinery can be overcome without much difficulty.

One of the items of hi-fi equipment which particularly lends itself to amateur construction is the pick-up arm. Provided that the design is right, only a normal complement of tools handled with average care is needed to produce a mechanism which will match the performance of a top-quality, high-compliance cartridge costing up to ten times as much in outlay.

The pick-up arm to be described is designed with the above thoughts in mind; it would cost between £5 and £10 to make. It mainly differs from commercial arms of conventional design in that the vertical and horizontal pivots are not positioned at the same point along the arm. As the photographs show, the pivot which allows movement in the vertical plane is mounted forward of the one giving horizontal movement. In this way, the horizontal pivot can be placed at the maximum distance from the turntable centre for a given plinth size because it is not then necessary to allow for traverse of the counterbalance weight behind what is normally the common pivot point. Thus there is room for a longer arm, giving improved tracking, and the staggering of the pivots means that, being separate, they are of simpler form and therefore easier to make.

Simple construction of pick-up arm separates vertical and horizontal pivots to allow increased tracking radius. Vertical pivot is situated halfway along arm.

The description deals first with the fundamentals of pick-up arm operation, showing what the requirements are and the ways in which these requirements may be met. The degree of development which could be applied to the basic concept depends on the personal taste, enthusiasm, ingenuity and ability of the builder and, to some extent, on the depth of pocket. As an example of what can be done a mk 2 model, built by the author and in regular use, is discussed to show some of the improvements affecting the appearance and ease of operation rather than performance which may be achieved.

Pick-up arm design is a matter of satisfying a number of conflicting needs and avoiding a few pitfalls. There has been much discussion, in these pages and elsewhere, on the subject of arm operation. It would not serve any useful purpose to go over the ground again in detail, although it is worthwhile listing the main requirements of a fixed-pivot arm of the type to be described, as opposed to the expensive, parallel-tracking mechanisms which so delight the servo-control enthusiasts.

The fixed pivot arm has to be designed for compromise. Ideally, it should carry the cartridge in such a way that this behaves as though it were effectively floating in space. For this to happen, the arm would need to be of zero mass and move without friction. There would also need to be a gradual change in the relative positions of arm and cartridge to match the geometry of the modulated groove being tracked. It is because these are not practical possibilities that compromises must be made to compensate as far as possible for the discrepancies between ideal and real operation.

The main requirements are that

- in the horizontal plane, it occupies the correct position relative to the disc centre
- the end carrying the cartridge moves as freely as possible at a constant distance above the disc surface
- it holds the cartridge so that the stylus is maintained in contact with the groove walls and with the optimum force on both walls
- it maintains the cartridge in its correct position relative to the groove with the minimum variation – random or periodic.

The requirement of small random change means, mainly, that the arm should be

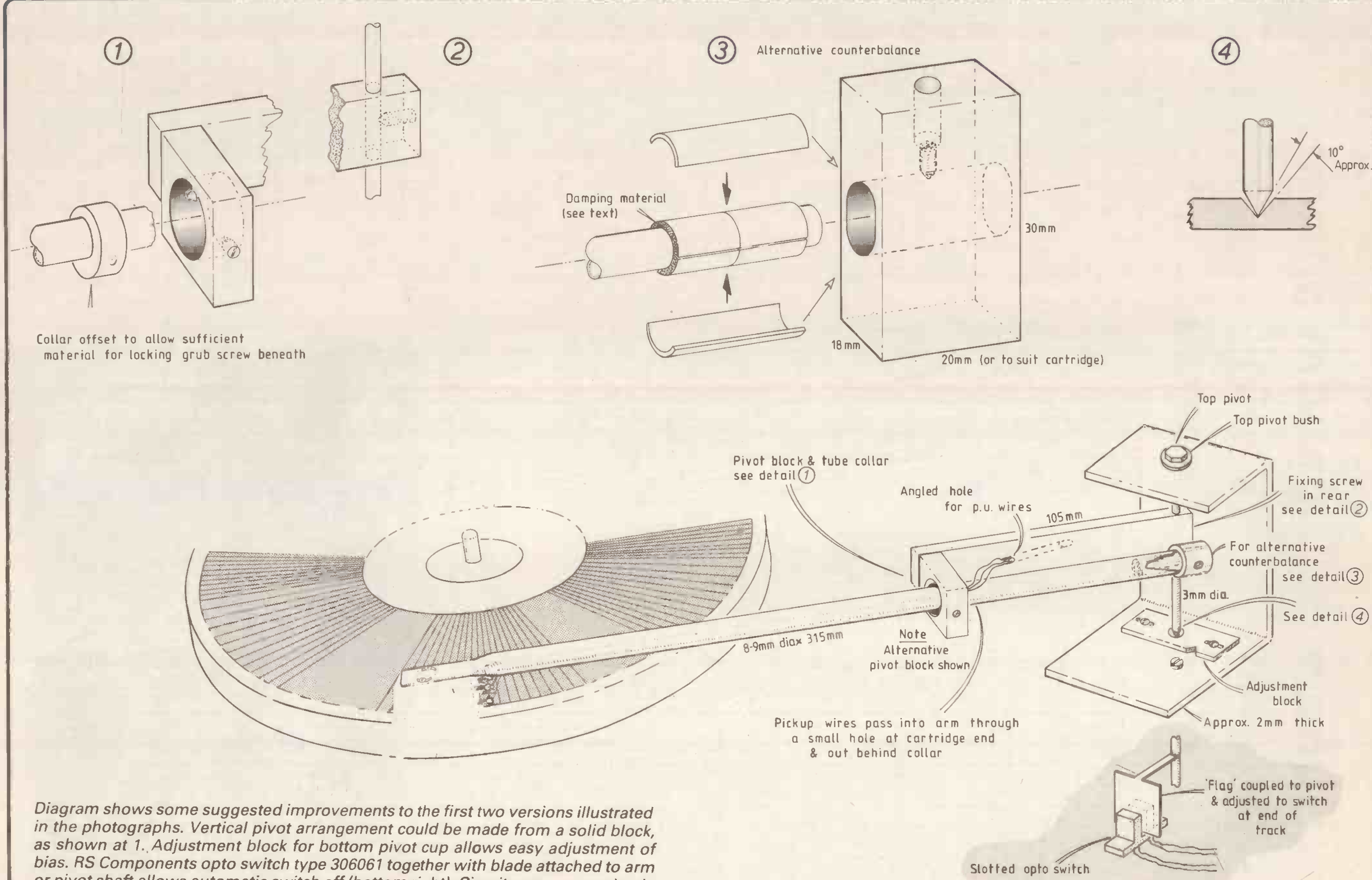


Diagram shows some suggested improvements to the first two versions illustrated in the photographs. Vertical pivot arrangement could be made from a solid block, as shown at 1. Adjustment block for bottom pivot cup allows easy adjustment of bias. RS Components opto switch type 306061 together with blade attached to arm or pivot shaft allows automatic switch off (bottom right). Circuitry can conveniently be fed from 18 volt supply within direct drive turntable unit.

tolerant of external vibration. Small periodic change requires that the arm should not be prone to mechanical resonance at any frequency in the audio band, and of moderate amplitude outside the band.

Turning from the general to the particular the illustrations show that the arm is effectively constructed in three sections
- the vertical pivot assembly, formed of a U-frame and a shaft which supports the horizontal-pivot carrier bar, allowing this to traverse in the horizontal plane
- the horizontal pivot assembly, incorporating the carrier bar and the horizontal-pivot block
- the arm itself, with adjustable counterbalance weight and cartridge-mounting platform.

The principle component of the vertical pivot is a silver-steel shaft of about 3mm diameter (not a critical dimension), tapered at both ends. When the shaft is fitted, each tapered end rests in a dimple seating to form a low-friction pivot of the type often used to suspend the revolving rings of a gimbal assembly (hence such pivots are often loosely called gimbals).

The top of the shaft mates with a simple seating formed in a brass boss and screwed into a tapped bush in the centre of the upper angle plate of the U-frame. The dimple seating holding the lower end of the shaft is drilled in a solid brass block or platform held in position on the U-frame base plate by screws passing through elongated holes. When the vertical pivot shaft is in position, the boss is screwed down into the bush until the shaft tips are located in the centres of the dimple seatings. The shaft is thus held so that there is no sideways movement at either end, but it is free to rotate about its axis.

The function of the block platform is to enable the lower dimple seating to be moved, when the securing screws are released, a small distance either side of a point vertically below the upper seating. Movement is possible to the extent of the elongated screw holes along a horizontal line parallel with the back plate of the U-frame. By this means, the shaft may be tilted through a small angle so as to provide anti-skating bias.

The diagram shows that the block has a V-groove cut into one edge immediately opposite a raised-head screw let into the U-frame base. The purpose of the groove and screw is to enable easy adjustment of the amount of bias, in a way similar to that employed in car distributors for setting the contact-breaker gap. The vertical offset is achieved with the two back screws rocking the dimpled base plates on the hardwood motorboard.

The drawing shows a method of securing the horizontal carrier bar to the pivot shaft. A hole drilled about 8mm from one end of the bar through which the vertical pivot shaft is passed provides an interference fit. One or two tapped holes (metric size M2.5 or 6BA) lead horizontally from the rear end-face of the carrier bar into the shaft hole. Slotted grub screws are fitted into the threaded holes so that when tightened the bar is securely fixed to the shaft. In this way the vertical position of the carrier above the bottom plate of the U-frame (and hence above the turntable) may be adjusted to set the angle between the stylus cantilever and disc at the recommended (standard) value of 15 degrees, the cartridge then being parallel to the disc surface.

At the other end of the carrier bar, the horizontal-pivot block is fixed in position by means of screws, not visible in the photograph, leading through the bar into tapped holes in the block. The tubular-section arm passes through an elongated hole in this block, being held there by a pivot arrangement described below.

The block is shown in enlarged detail in the drawing. Two tapped holes lead into the pick-up arm aperture from opposite sides of the block to form a line along a diameter of the arm when positioned centrally in the aperture. Slot-headed screws, with tapered ends to form pivot points, are threaded into these holes, one from each vertical side face of the pivot block.

Second version of arm has vertical pivot situated at ⅔ along arm with the aim of reducing longitudinal arm vibration.

A brass collar, of about 5mm thickness by 15mm o.d., is fitted to the pick-up arm tube at the point where it passes through the pivot-block aperture, being fixed in position roughly two-thirds of the length of the arm from the end carrying the cartridge by a grub screw threaded through it and bearing onto the tube. This collar has two dimple seatings located centrally on the outside face at opposite ends of a diameter, and clear of the securing-screw hole. When the arm, with its fitted collar, is positioned correctly in the aperture the two pivot screws are tightened so that their tapered ends locate in the dimple seatings. This assembly thus forms a second gimbal mounting and allows the arm to move freely in the vertical plane.

The pick-up arm is simply a maleable aluminium-alloy tube, not hard duraluminium, with one end pinched into a flat spade shape for about 25mm with two slotted holes cut into it for securing the cartridge. The slots provide for limited adjustment of the angle between arm and cartridge. At the other end of the arm (in the prototype design), a lead slug is fitted into the tube and held there by a common paperclip. This slug forms the major part of the weight required to counterbalance the combined mass of that part of the arm which is on the opposite side of the horizontal pivot and the cartridge itself. A brass collar passed over the pick-up tube at this end as a sliding fit and held in position by a grub screw is set to give the recommended playing weight.

An alternative counterbalancing arrangement is illustrated in detail 3 which offers some advantages in ease of operation and adjustment, but at the expense of a slight increase in difficulty of construction.

In this modification, the counterbalance weight is a single rectangular block of brass measuring about 30 by 18 by 20mm. As the drawing shows, a hole of 15mm diameter runs between two of the block faces and connects at right angles to a second, smaller hole leading from the centre of the upper face. The lower part of the connecting hole is tapped to take a screw to secure the balance weight in position on the arm. The upper part is counterbored to take the screw head and allow for screwdriver access.

On the end of the pick-up arm adjacent to the vertical pivot, one or two layers of a special self-adhesive flexible foam plastic are wrapped round the tube, over a length of about 20mm. Two thin shells of semicircular section – made of, say, ½mm material – are fitted round this plastic sleeve to provide mechanical decoupling. The main hole drilled through the counterbalance weight is of suitable diameter to slide over the shell/sleeve assembly so that, with the weight positioned on it, the plastics material is slightly compressed. The weight can then be moved along the sleeve to an appropriate position to give the recommended playing pressure for the chosen cartridge. Having achieved this, the counterweight securing screw is tightened, care being taken that the weight has its longer axis exactly parallel to the vertical pivot shaft so that it does not touch either this or the carrier bar.

The principal advantage of this alternative counterbalancing arrangement is that the plastic sleeve mechanically separates the arm and the weight and so adds resistance to the mass and compliance of the arm/cartridge assembly and reduces the Q of the natural resonance of the combination. A reduction of about 5dB in the amount of vibration at the resonance frequency is aimed at. Measurements are being taken for a mk 3 arm after experiments with different materials, including Sorbothane (Permali, Plasticell division), Inseal (Dickinson Robinson group), and Eccorsorb (Emmerson & Cumming). The emphasis is on plasticity, not elasticity, as elastic material could aid resonances.

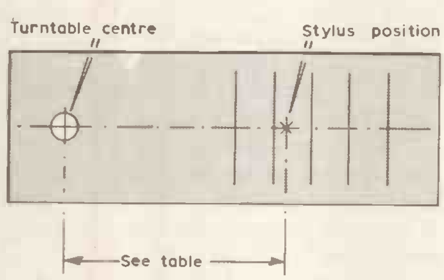
The arms are of very light construction, an advantage from the point of view of stability of the gimbal bearing and reduced chances of damage in transit. But it does mean the arms are only suitable for high compliance pick-up cartridges, typically 20×10^{-6} cm/dyne or better.

Best results are obtained if the pick-up arm is suitably positioned in relation to the turntable (see items 1 and 2, below), has the cartridge properly fitted (item 3) and is correctly adjusted in respect of two other settings affecting the arm itself (items 4 and 5). These five parameters of operation and the necessary adjustments for optimum performance are as follows.

1. **The rake angle,** otherwise called the vertical tracking angle, is the angle between the cantilever carrying the stylus tip and the surface of the disc being replayed, standardized at 15 degrees for most cartridges. It is the angle set between the cantilever arm and the top face of the cartridge body. This face is held flush with the flattened end of the pick-up arm and if this flattened end has surfaces parallel to the axis of the arm, the vertical tracking angle will be correct when the arm is set parallel to the surface of the turntable. Thus, the only adjustment necessary in the arm mounting is to arrange for the appropriate height of the carrier bar on the vertical pivot shaft.

2. **Overhang** is the amount by which the effective length of the pick-up arm – the length from the vertical pivot to the stylus tip – exceeds the distance from the vertical pivot to the spindle of the turntable. Overhang is measured as the horizontal distance between the centre of the turntable and the stylus when the stylus, spindle and vertical pivot are all in the same straight line. With record and turntable placed at the front left corner of the plinth and the arm base at the far back right, you can then arrive at arm length and overhang using the table.

3. **Offset angle** is the angle between the axis of the pick-up arm and the longitudinal axis of the cartridge which can be considered as a datum at 90° to the line of correct normal lateral displacement of the stylus. For a reproducing stylus to trace the recorded groove without distortion, the longitudinal axis of the cartridge must be maintained at a tangent to the recorded groove. As the pick-up arm sweeps round a fixed pivot, i.e. does not act as a parallel-tracking mechanism, this ideal condition cannot be met. However, as a combined effect of optimum setting of both offset angle and overhang, tangential tracking can be made to occur at two points along the curve swept by the stylus, i.e. at two values of groove radius. The extent of the tracking error can thus be reduced to an acceptable value on either side of these two points. The optimum value of offset angle (obtained by calculation but summarized in the Table) is set by means of a simple protractor which is usually drawn on a piece of strong card and has the following general form



As the figures in the Table show, the magnitude of the tracking error becomes less as the effective length of the pick-arm increases. The vertical pivot in this design is located at a distance from the turntable which is the maximum for a given plinth size, so the effective length of the arm is virtually equal to its overall length.

4. **Playing weight** is the force exerted by the stylus tip on the disc surface. In this arm, the amount of force is mainly controlled by the weight of the counterbalance slug in the basic form or by the position of the rectangular block in the modified arrangement. Fine adjustment to suit the cartridge installed is obtained by moving the sliding collar to an appropriate position which can easily be determined by measuring the weight at the stylus using one of the small calibrated balance mechanisms readily available for this purpose. The same means of setting adjustment can be used for the modified counterbalance system.

5. **Anti-skating bias.** As the stylus traces the modulated groove it experiences a side thrust – a component of frictional force acting along a tangent to the curve swept by the stylus round the vertical pivot – which causes it to bear more heavily on one side of the groove than on the other. This can result in a difference in performance between the two channels of a stereo recording; in particular, it can cause the onset of distortion at a lower modulation level in one channel than in the other.

This unwanted side thrust can be counteracted by an opposing rotational bias acting at the vertical pivot of the arm. Such a bias is easily provided here by inclining the pivot shaft at a small angle, so slight as to be unnoticeable. This is done by releasing screws in the adjustment block and sliding the block an appropriate distance (to the left as viewed in the illustration, i.e. toward the turntable). A screwdriver blade, suitably angled between the slot in the side of the block and the nearby screw head makes precise adjustment easier.

continued on page 62

Table taken from Pickup-arm design techniques, by T. S. Randhawa *Wireless World*, March 1978.

Pivot to stylus length (inches)	Optimum overhang (inches)	Optimum offset angle (degrees)	% 2nd harmonic distortion due to tracking error	Zero tracking error points in inches from record centre First	Second	Maximum tracking error (degrees)
7.5	0.76	27.62	0.91	2.34	4.61	2.93
8.0	0.69	25.56	0.85	2.31	4.60	2.77
8.5	0.65	24.00	0.79	2.33	4.58	2.58
9.0	0.62	22.70	0.74	2.32	4.62	2.33
9.5	0.58	21.33	0.70	2.30	4.60	2.23
10.0	0.55	20.19	0.66	2.34	4.56	2.15
10.5	0.52	19.24	0.61	2.33	4.59	2.00
11.0	0.50	18.38	0.58	2.33	4.61	1.87
11.5	0.48	17.59	0.56	2.33	4.62	1.76
12.0	0.45	16.67	0.54	2.31	4.58	1.75
12.5	0.43	16.01	0.51	2.31	4.58	1.66
13.0	0.41	15.40	0.50	2.31	4.60	1.58

Column 4 is for a recorded velocity of 10cm/s r.m.s. The last column is for an arm having the optimum offset angle and optimum overhang.

FARNBOROUGH 1980

International radar and avionics development since 1978

Heading picture: AEW Nimrod, showing nose and tail radomes which contain look-down radar.
Wing-tip pods contain equipment for monitoring of radio and radar emissions.

Electronic systems in light aircraft and some of the smaller business types are still recognizably concerned with communications and navigation, with perhaps a weather radar and landing aid in the more opulent. The electronics are aids: without them, the aircraft will fly perfectly well, but may tend to fly into "stuffed clouds" and to use more fuel than they should.

Airliners of the more statuesque variety and even some of the smaller ones rely to a far greater extent on electronic assistance for automatic flight control (a.f.c.), fuel management, automatic landing and navigation. Aerodynamically exotic aeroplanes, like the Harrier and the Super Mirage 4000, for example, simply will not stay in the air at low speeds without electronics, being control-configured or, to put it another way, unstable.

Most weapon-carrying military aeroplanes are weighed down with highly complicated locating, aiming, firing and avoiding electronics in an obviously vain attempt to demonstrate to a potential foe that he stands little chance of success in any bellicose adventure. Since, for each bloc, this is only intermittently true, the exercise is ultimately futile, and is of benefit only in the impetus to engineering development it provides. In the absence of civil aviation, Farnborough would be a depressing experience.

Automatic control

Smiths Industries have been involved in engine controls and indicators for many years. Recently, they received a £6 million order from Boeing for autothrottles for the 727 and 737, to be fitted on both new and existing aircraft. The STS 10 ensures, by means of a digital performance-data computer, that the engines are run at the most fuel-efficient speeds to give the required flight pattern. General Electric (US) have their thrust-management system for the new Boeing 757 and 767 airliners, Marconi provide supervisory electronics for the RB211, Delco equipment (not shown) is being installed in Pan Am's 747s (saving 1.5%, or 7.5 million gallons of fuel a year) and a number of companies make completely automatic control systems for both flying controls and thrust management.

The term 'fly-by-wire' has gained currency in recent years, being taken to mean full-authority analogue or digital control of all functions in an aircraft. One loop maintains stability, another responding to pilot's demands for control movements, and enhancing control characteristics. Marconi, for example, make a complete fly-by-wire system for the Tornado and Jaguar, where all attitude and engine controls, flaps and slats are under the supervision of computers.

Marconi are also in the lead with fibre-optic data highways for avionic computers. Multiple, redundant data channels are used, which require the transfer of data between channels for voting to avoid differences between channels and to determine fault conditions. Crosslane data feeds are vulnerable to interference, and fibre-optic links are used to give complete isolation and freedom from electromagnetic transients.

This limited use of optical data highways has been referred to as 'fly-by-light', but one feels that the expression ought really to be reserved for fully optical transmission, as is now being developed by Marconi, and as is used by Bell in a Jet-Ranger helicopter. In the Bell system, movement of the pilot's controls causes a transparent encoder disc to move between a light source and photodiodes, producing 18 Gray-coded bits of information as a position code. The data is latched into a parallel-to-serial data store, from which it is read out serially into fibre-optic cables to a receiver at the servo to be controlled. Two monostable flip-flops are clocked and produce wide pulses for a 1 and narrow ones for a 0, the result being converted back to analogue form for servo operation.

Displays

Both civil airliner pilots and close-support fighter pilots experience moments of concentrated activity when their attention cannot, with safety, be divided between the instrument panel and the view ahead. It is therefore standard practice now to provide the quicker aircraft with either head-up display (HUD) or head-down display (HDD). They ought, perhaps, to be called 'head-in-one-place displays' (HIOPD), since the intention of these devices is to provide the pilot with all the information he needs to fly the aeroplane, including the main instrument readings and the view ahead, in one place – either at the screen or on the panel. The technique is not new

(*WW* first reported it nineteen years ago), but it is continuously refined and varied.

In the HUD category, Marconi have their new diffractive unit, which affords a much wider field of view than was previously possible. The principle of a HUD is that a c.r.t. screen in the instrument panel which displays the more vital instrument readings is reflected from a half-silvered mirror in the pilot's forward view, so that he can see both the view forward and the instrument readings without moving his head and without refocusing his eyes, since the reflected image is collimated. The angle over which the c.r.t. display is visible is fairly narrow.

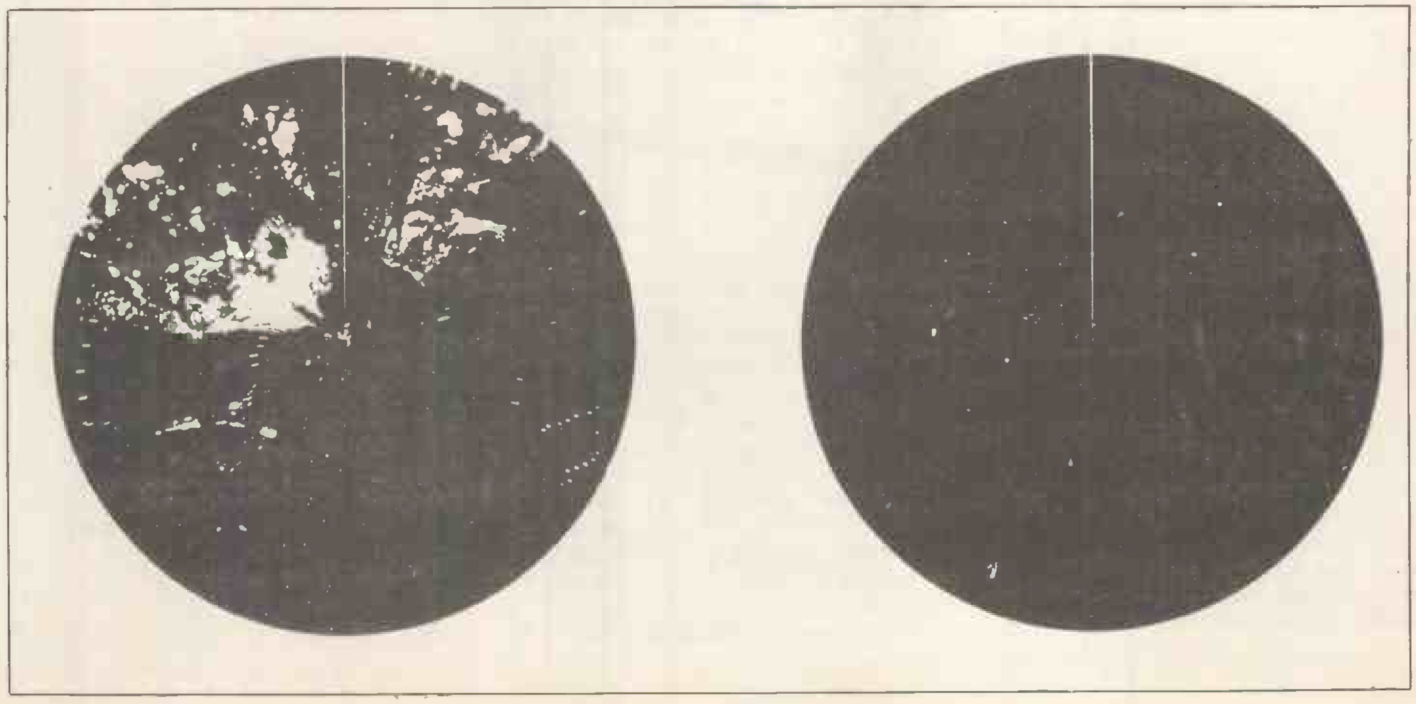
In the new HUD, convex glass components are combined to form several reflective surfaces, made from special coatings which reflect light only at the wavelength of the c.r.t. phosphor. The shape of the reflective paths and the single-wavelength characteristic combine to provide a wide-angle, bright display, since all light but that from the c.r.t. display is transmitted, this being reflected. For night use, the c.r.t. will display a television forward view, obtained by means of an infra-red camera, and the instrument information. The i.r. camera is part of the American LANTIRN programme, which is to provide Low-Altitude Navigation, Targeting Infrared for Night in the A 10 and F-16.

A similar night-vision display, also from Marconi, is intended for the Sea King helicopter. This uses an Intensified Isocon television camera mounted on a stabilized platform under the nose, which can also carry a number of thermal imaging modules developed by Marconi, Rank Taylor Hobson and EMI in the UK's Thermal Imaging Common Modules programme. The extraordinary feature of the equipment is that the camera follows the direction in which the pilot is looking, its display being projected into the pilot's view by a HUD-type system in his helmet visor. Effectively, therefore, he sees the view he would normally see, in whatever direction he looks, but in the dark as well.

Civil aircraft now use c.r.t. displays to an increasing extent in place of the familiar rows of 'clocks'. Colour tubes increase the amount of information possible in one display: the Penetron, a tube which emits a colour depending on the depth of penetration of the phosphor by the electron beam, is used by C.S.F. and Marconi, and several companies make special shadowmask tubes for this application. It is not possible to obtain a blue colour in the Penetron, and C.S.F. are now developing high-resolution shadowmask tubes with in-line guns and slotted masks. The difficulty here is

Marconi infrared camera for night vision, mounted under the nose of a Sea King helicopter. Camera aligns itself with pilot's line of sight, and display is mounted on his helmet.

Radar displays show the effect of Plessey's AMTI clutter suppression. On the left is an unprocessed picture, with aircraft returns lost in clutter. The processed display shows a complete absence of static returns, only aircraft echoes remaining. The system is being evaluated at Farnborough on a Plessey ACR 430 airfield control radar.



that stroke-formed letters and symbols are not easy for a conventional deflection yoke to generate when an in-line gun is used. C.S.F. say they can now do this.

Radar

Secondary-surveillance radar (s.s.r.) was originally very much an afterthought, used during the war to distinguish friends (who had transponders on board) from foes (who hadn't). It is now the chief tool used in air traffic control and is still being developed by, for example, Cossor. The UK's ADSEL (Address-selective) programme has been under way since 1971, in co-operation with the US DABS (Discrete Approach Beacon System). Both work on a common principle of first 'acquiring' all s.s.r.-equipped aircraft and subsequently addressing the required aircraft directly at a lower interrogation rate. This does improve the interference problem, where aircraft respond to the wrong interrogation or to the right interrogation but to the wrong ground station ('garbling' and 'fruit'), but it requires a much narrower beam, so that position information can be obtained from each reply. The narrow beam is achieved by combining the signal from two halves of the aerial in and out of phase to give a sum and difference pattern. The difference has a sharp phase change null in the boresight direction which, when taken in conjunction with the peaky sum pattern, gives effectively a very narrow beam, reducing uncertainty. It is possible to measure the position of an aircraft to within 5 minutes of arc in this way.

The problem of clutter continues to occupy radar designers. There have been many techniques put forward over the years to reject permanent, non-informative returns, based on the fact that the landscape is stationary, while targets are not. One problem has been that, if an aircraft is flying tangentially to the radar pattern, there is no movement in the range dimension and the echo is suppressed, along with the clutter. Plessey's Area Moving Target Indicator (AMTI) uses storage and data-processing methods in the video stages to avoid the problem. The search pattern is divided into a great number of small areas, bounded by pulse-length and bearing, the average level of video in each cell over a number of scans being digitized and stored. Any incoming signal which, on comparison, is found to exceed the stored level is assumed to be worthy of display and is passed, anything below this level being rejected. The storage level is continually up-dated to take account of variations in precipitation, etc.

One of the more depressing sights at Farnborough was the appearance over the Black Sheds of the Airborne Early Warning (AEW) Nimrod, a grotesque derivative of that most beautiful of all aeroplanes, the Comet. This aircraft, a modification of the marine reconnaissance Nimrod, is intended for look-down surveillance of the approaches to the UK so that low-flying intruders will not be able to slink in unnoticed. A Marconi-Elliott S-band, pulse-Doppler, primary radar feeds synchronized scanners in radomes fore and aft, the returns being presented on six synthetic displays, which are controlled by microprocessors to provide all the information on a particular return. A secondary radar (i.f.f.) is also carried, the whole package being under the management of a main computer, which analyses the radar data and compiles messages to base. The communications system to support all this is suitably complex, using high-speed digital data links at h.f. and u.h.f.

Navigation

Honeywell are to fit ring-laser strapdown gyros for inertial navigation to the AV-8B, McDonnell's developed version of the Harrier. The systems are already specified for the Boeing 757/767 airliners and have also been selected for the Airbus A310. The absence of moving parts means a huge increase in reliability —Honeywell claim m.t.b.fs of over 60,000 hours.

The principle is the Doppler effect, in which a laser sends two beams round a path in which they are reflected to intersect at a detector. When stationary, both wavelengths are the same at the detector, but when the ring turns about an axis normal to the ring, the beam in one direction will appear to increase in wavelength, the other apparently decreasing. The difference is measured digitally and fed, in conjunction with the results of measurements in two other axes to the navigation computer, which continuously integrates the measurements to determine position. □

New look in multimeters

American companies have, in recent years, almost completely dominated the low-cost, laboratory-quality multimeter market. Their close liaison with integrated-circuit manufacturers has enabled them not only to learn of new chip developments early enough to gain a lead over European makers, but also, in many cases, to influence the design of the chips to suit their own ideas. One result has been the evolution of the complete converter-plus-logic modules now in use. While this is, no doubt, of great benefit to users, in that it confers greater reliability than the use of many components to perform the same function, and also makes for a lower price, it means that a European manufacturer who bases his instrument on these chips is adding scarcely any value and cannot charge an economic price.

Thurlby Electronics, a British firm which began trading in 1979, has decided to attack this market by offering much better performance than is obtainable from single-chip designs and to reap the benefit of EEC membership by selling at a lower price than American makers are able to, since they must allow for import duty and higher support costs.

The Thurlby 1503 uses a single i.c. for

logic and display functions, but a greatly improved analogue-to-digital converter. It is more genuinely a 'multi' meter, since not only does it measure alternating and direct voltage and current, resistance and diode characteristics, but frequency up to 4MHz. Measurements are resolved to 15 bits on d.c. measurements and resistance, to form what is termed a '4¾-digit' display – a full-house reading would be 3200.0mV, for example. Scale length on alternating voltage is 14 bits and on current 13. Error varies between 0.055% and 0.3%, with a maximum error of 2.5% at 10A.

A crystal is used to determine integration time, which confers a high degree of immunity to mains-frequency interference, and which is also used as time-base generator in the frequency-measurement mode.

Thurlby claim that their a-to-d converter outperforms, with respect to accuracy, drift and noise, anything currently available in i.c. form. They also point out that the use of low-power circuitry not only makes for less heat and, consequently, lower drift than is usual, but enables internal batteries to power the instrument for 200 hours. The instrument costs £139 and is made by Thurlby Electronics Ltd, Coach Mews, St. Ives, Huntingdon, Cambs.

Correction

Graphical communication with microcomputers

To those readers who find Fig. 26 of this article (September issue, p.76) difficult to take in, we have to apologize and admit that it is not an *xy* tablet. The *xy* tablet picture had to be left out for space reasons and the captions were mixed. The device shown is a Quest Automation Micropad, which recognizes hand printing, transmitting the characters to a computer.

Intermodulation at the amplifier-loudspeaker interface

Part 1: Analysis of one source of audible difference between amplifiers

by Matti Otala* and Jorma Lammasniemi, Technical Research Centre of Finland

Intermodulation occurs between an amplfied signal and a delayed version returned from a loudspeaker through a feedback loop, when open-loop output impedance is high compared to speaker impedance. Part one of this article analyses this and a second part describes a measurement method with results of tests on different types of amplifier circuit and suggestions for avoiding the effect.

The sound quality at the low-frequency end of the audio reproduction chain has often been discussed in such subjective terms as firm, soft, dry and mellow. As far as loudspeakers are concerned, the change in sound impression may be explained as a result of different technical characteristics of the drivers, filters and cabinets. Amplifiers present a more serious problem because the level of harmonic distortion at these frequencies is usually low, the frequency response is relatively flat, and output damping is almost always adequate.

An intriguing question sometimes encountered in practice is why the sound may perceivably change at the low end of the frequency spectrum when the same listening environment and the same loudspeaker system is used and only the power amplifier is changed. It is our experience that certain power amplifier circuit topologies sound different to others, although no directly explainable difference is noted in the electrical performance of the circuits when tested with resistive load. The following analysis shows that, under certain conditions, the loudspeaker reaction to the drive signal can propagate in the feedback loop of a power amplifier and intermodulate with the drive signal itself. This may partly answer the question.

The dynamic loudspeaker provides a complex load to the amplifier. As much has been written about its behaviour (see, for instance, references 1), it is sufficient here only to present a short list of some of the most important factors affecting the interface between the loudspeaker and the amplifier.

The total compliance of the cone suspension and the loudspeaker cabinet, and the cone mass, form a damped mechanical resonance, typically in the frequency range of 30 to 80Hz for the woofer and at correspondingly higher frequencies for the squawker and tweeter. Other mechanical resonances are created by the different moving parts of the cone, excited by the voice coil, but not necessarily rigidly coupled to it. All these mechanical resonances behave like parallel tuned circuits in series with the voice coil resistance and inductance. The crossover filters also exhibit complex reactive behaviour, especially around the crossover frequencies. Figs 1 & 2 show the impedance of two popular loudspeaker systems manifesting both cone and crossover filter resonances.

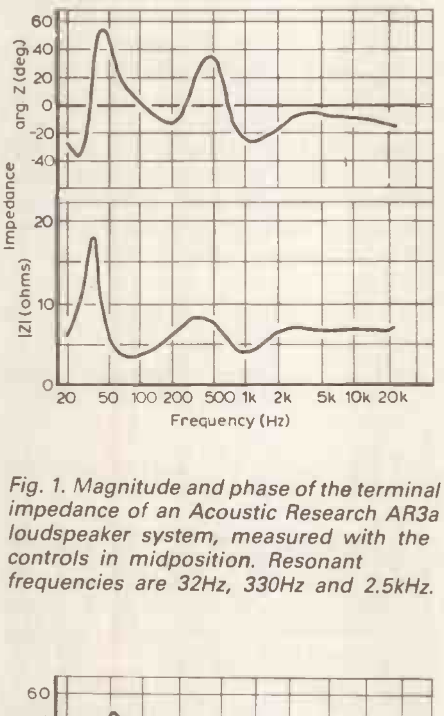


Fig. 1. Magnitude and phase of the terminal impedance of an Acoustic Research AR3a loudspeaker system, measured with the controls in midposition. Resonant frequencies are 32Hz, 330Hz and 2.5kHz.

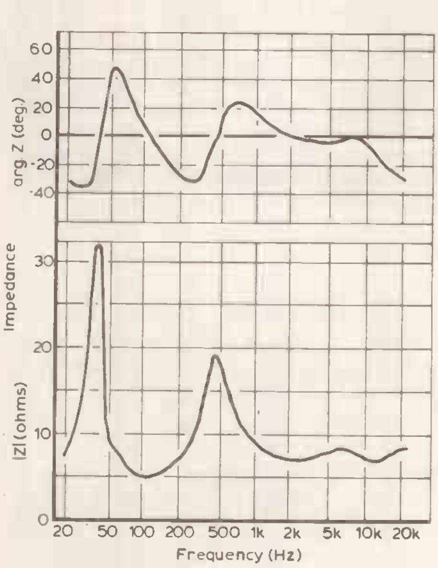


Fig. 2. Magnitude and phase of the terminal impedance of a Yamaha NS-1000 Monitor loudspeaker system, measured with the controls in midposition. Resonant frequencies are 38Hz, 410Hz, and 5.5kHz.

Energy is stored in all these reactances, especially in the resonances. Because a reactance cannot dissipate energy, and the internal dissipation in the loudspeaker is low at these resonances, most of the stored energy returns to the amplifier and is dissipated in it. In addition, the loudspeaker terminal impedance is non-linear, and cone break-up, delayed responses and acoustical reflections create generator effects in the loudspeaker. Fig. 3 shows a greatly simplified equivalent circuit of a loudspeaker, taking into account only few of the effects discussed.

Now analyse a feedback amplifier having two different loads, as shown in Fig. 4. A pure resistance R is used when measuring the characteristics of the amplifier. A loudspeaker, represented by the grossly simplified equivalent circuit of Fig. 3, is the true load. It is assumed to have a linear resistance R and negligible voice coil inductance L_v to facilitate the analysis. The circuit is far from perfect, but this analysis is to illustrate the basic mechanism of distortion only, not to calculate it to a high degree of accuracy. Similarly, the amplifier is assumed to have an infinite input impedance, and no frequency compensation. All these approximations do not affect the result of the analysis. Note that a new parameter, the open-loop output impedance Z, has been incorporated in the circuit in contrast to prior analyses.

The input signal V_1 is taken to be a step function $V(t)$, so that its Laplace transform

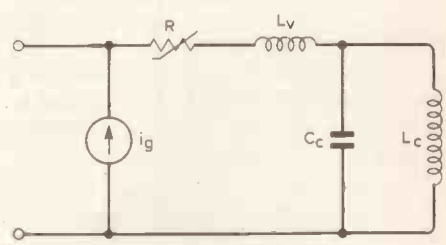


Fig. 3. Simplified loudspeaker equivalent circuit. L_C and C_C are cone dynamic mass and suspension compliance, respectively, L_V the voice coil inductance, R the voice coil resistance, including the radiation resistance, and i_g the generator effect current source.

* Submitted by Professor Otala whilst on leave of absence with Harman Kardon Inc.

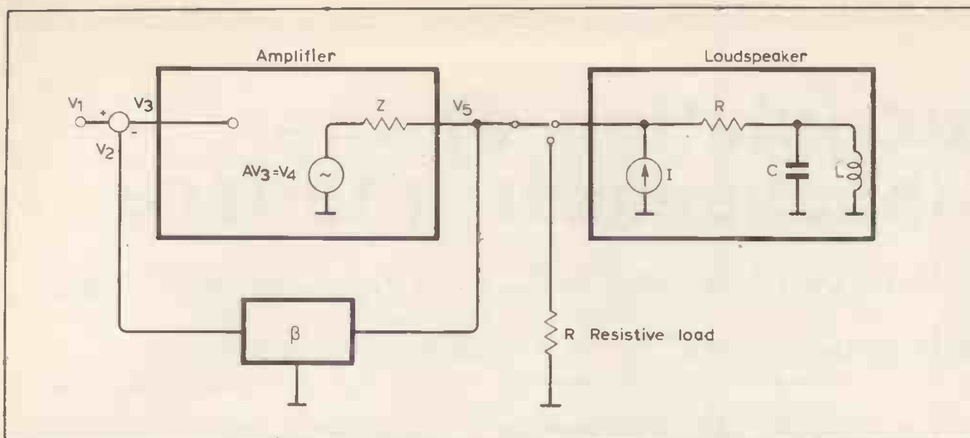


Fig. 4. Equivalent circuit of the amplifier-loudspeaker combination used in the analysis. Amplifier has resistive feedback network β, gain of A and open-loop output impedance Z. No frequency-dependent effects are incorporated in the amplifier circuit. The loudspeaker is assumed to have negligible voice coil inductance and is considered to be perfectly linear.

is $L[V_1]=v_1/s$. The analysis is based on linear theory.

For the resistive load R, the transforms of voltages V_4 and V_5 are

$$V_4(s)=\frac{A(1+Z/R)}{s(1+Z/R+\beta A)}v_1$$

and

$$V_5(s)=\frac{A}{s(1+Z/R+\beta A)}V_1 \qquad 1$$

The inverse transforms are both perfect step functions and the only difference to standard feedback equations is the term Z/R. An adequate damping factor necessitates that the closed-loop output impedance of the amplifier be much smaller than the loudspeaker impedance, i.e.

$$R \gg Z/(1+\beta A)$$

which yields a further simplification. Taking the inverse Laplace transform, the voltages are found in time domain

$$V_4(t)=\frac{A(1+Z/R)}{(1+\beta A)}v_1\, U(t) \qquad 3$$

and

$$V_5(t)=\frac{A}{(1+\beta A)}v_1\, U(t).$$

If now the loudspeaker is substituted for the load, the situation changes markedly. Assuming the damping to be adequate, as by equation 2, equations 1 take the form

$$V_4(s)=\frac{A}{1+\beta A}\Big|-\beta Z I(s)+ \frac{v_1}{s}(1+\frac{Z}{R})\frac{s^2LC+sL/(R+Z)+1}{s^2LC+sL/R+1}\Big| \qquad 4$$

and

$$V_5(s)=\frac{A}{s(1+\beta A)}v_1.$$

No change has occurred in the transformed output voltage V_5 of the amplifier. This is to be expected, as the feedback effectively controls the output voltage. However, the internal drive voltage of equation 4 now contains complex terms consisting of the parameters in the loudspeaker equivalent circuit. To study the behaviour of this voltage in time domain, the inverse Laplace transform of equation 4 yields

$$V_4(t)=\frac{A}{1+\beta A}\left[-\beta Z I(t)+v_1(1+\frac{Z}{R})\left\{1-\frac{Z}{(R+Z)}\frac{1}{Q}\exp\left(-\frac{\omega_1 t}{2Q}\right)\sin\omega t\right\}\right] \qquad 5$$

where $\omega_1=(1/LC-1/4R^2C^2)^{1/2}$, the resonant frequency of the loudspeaker cone, terminals short-circuited, and $Q=\omega_1 RC$, the approximate quality factor at resonance.

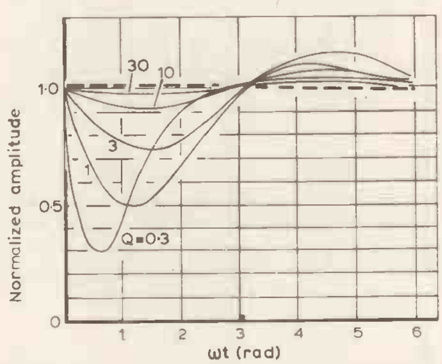


Fig. 5. Typical waveforms from equation 7 as functions of normalized time, with the resonant quality factor Q as parameter. The loudspeaker-generated oscillation is very large, especially for low values of Q. Corresponding waveform for resistive load is shown with a dashed line.

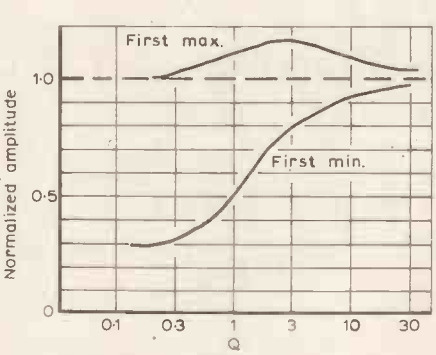


Fig. 6. Values of the first minimum and the first maximum of equation 7 as a function of quality factor Q.

The first term corresponds to the effect of any current generated in the voice coil of the loudspeaker by the vibration of the cone. Assuming that the feedback is large, $1+BA \gg 1$, say greater than 30dB, the first term becomes

$$V_4(t)=-ZI(t)$$

showing that the amplifier internal drive voltage necessary to serve as a sink for the loudspeaker generator current is directly proportional to the open-loop output impedance Z. Dividing this equation by the nominal signal level of equation 3 the ratio of the loudspeaker-generated signal to the driver signal can be found

$$\frac{V_4(t)_{generator}}{V_4(t)_{signal}}=\frac{Z}{R+Z}\frac{I(t)_{generator}}{I(t)_{signal}}$$

Similarly, the last term of equation 5 can be divided by the signal level, equation 3 which yields the ratio of the resonant oscillation in V_4 to the signal in V_4

$$\frac{V_4(t)_{oscillation}}{V_4(t)_{signal}}=$$

$$1-\frac{Z}{R+Z}\frac{1}{Q}\exp(-\frac{\omega_1 t}{2Q})\sin\omega t. \qquad 7$$

This represents a damped oscillation at the cone resonance frequency. There are negative minima and positive maxima at

$$T=\frac{1}{\omega_1}(\arctan 2Q+n\pi)$$

where n is an integer, with values

$$V_4(T)=1-\frac{Z}{R+Z}\frac{2}{(1+4Q^2)^{1/2}}\exp(-\frac{\arctan 2Q+n\pi}{2Q}).$$

Assuming $Z \gg R$, some typical waveforms of equation 7 are plotted in Fig. 5, and the values of the first minima and maxima are plotted in Fig.6 as functions of Q. The amplitude of oscillation increases with decreasing Q. The reason for this apparently strange behaviour is that, when the Q of the resonant circuit is lowered, the circuit absorbs more energy from a broadband signal spectrum.

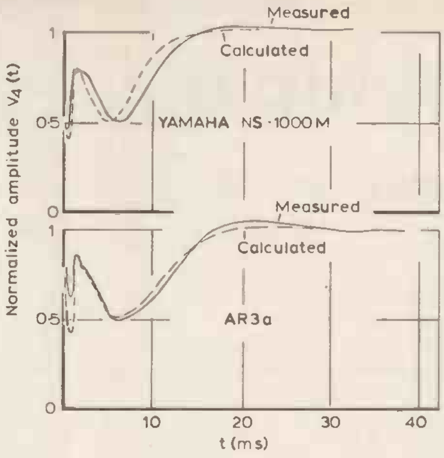


Fig. 7. Measured responses $V_4(t)$ and calculated responses for the AR3a and NS-1000M loudspeaker systems. Only the two first resonances around 35Hz and 400Hz were taken into account in the calculated values. The good match of the responses show that the theoretical model used is satisfactory.

To check the validity of the approximations made, the calculated measured responses $V_4(t)$ are shown in Fig.7 for the two loudspeaker systems of Figs 1 & 2. The calculated results are very close to the measured ones, which is surprising considering the complexity of the real three-way loudspeaker systems. This proves that the simple equivalent circuit of Fig. 3 is satisfactory for this analysis.

To be continued

References 1

Berman, J. M. and Fincham, L. R., Application of digital techniques to the measurement of loudsperakers. *J. of the Audio Eng. Soc.*, vol.25, 1977, pp. 370-84.

Fryer, P., Loudspeaker distortions, can we hear them? *Hi-Fi News*, July 1977, pp. 51-7.

Heyser, R., Loudspeaker reviews in various issues of *Audio*. For review of the Yamaha NS-1000, see *Audio*, January 1979, pp.82-90.

Johnson, J. H., Power amplifiers and the loudspeaker load. *Audio*, August 1977, pp.32-40.

King, G., Interface 1, amplifier to loudspeaker. *Hi-Fi News*, December 1976, pp.87-91.

Pramanik, S. K., Specifying the loudspeaker-amplifier interface. 53rd AES Convention, Zurich, 1976.

BOOKS

A well-established author, Graham Beech, has a new publication to add to his list, called **Successful Software For Small Computers**, which is based on Basic language and emphasizes the technique of "structured programming". It is said that when used correctly, this technique enables programs to be made that work first time.

Each of the five sections in the book, Structured programming, Mathematics, Data structures, Data processing and Simulation, is illustrated by complete programs, both as designs and as complete Basic listings which are claimed to be fully tested on a TRS 80 computer. The style of writing used is easily understandable and the information offered will probably be found useful by all kinds of small computer users, especially those who have a knowledge of Basic and want to know how to design programs. In floppy-back form, the book costs £5.50 and is published by Sigma Technical Press, 5 Alton Rd, Wilmslow, SK9 5DY.

Applied Electronic Communication, by Robert Kellejian, is an extensive text or reference book with three main subdivisions, Circuits, Systems and Transmission, which cover virtually all aspects of the subject, from the roots of the theory to the practical applications and formulae involved. After an introductory section in each chapter, learning objectives are given. This rather interesting approach enables the reader to visualize, at a glance, the contents of the chapter, the order in which different subjects will appear, and the level of understanding which can be achieved by reading the text which is to come.

Each chapter is concluded with a set of problems aimed at verifying the understanding gained and providing direct experience with procedures typical of engineering practice. Anyone wishing to use this work as a text book should, however, note that American standards are used. The price of the book in hardback form is £16.05. It is actually published in the USA and information on how to get it is available from Science Research Associates Ltd, Newton Rd, Henley on Thames, Oxford RG9 1EW.

IN OUR NEXT ISSUE

Darkroom exposure meter and enlarger timer

A constructional project for photographers, this unit will measure the required exposure for a black-and-white print, giving a digital readout in seconds and tenths. It will then time this exposure. It may also be used as a ten-minute process timer to count minutes and seconds. Cost: about £30.

Christmas quiz

Keep your brain alert and resist the torpor that comes from too much food and drink! Our electronics quiz, set by polytechnic lecturer Bryan Hart and colleague, will be a welcome break from compulsory enjoyment and will keep you mentally in trim to face 1981. Prizes too!

Programmable power supply

A professional design which provides 0 to 40V at 2A, controlled via the IEEE General Purpose Interface Bus. The instrument operates as a listener/talker (using an l.s.i. chip) and can be modified to provide other voltages and currents. Additional features include manual operation and an overload detection circuit which signals the controller.

On sale 19 November

Designing inductors carrying d.c.

Simple procedure for comparing cores and choosing the optimum

by D. H. Thomas M.I.E.E.

The initial selection of a suitable size of iron or ferrite core for an inductor or transformer with windings carrying direct current is difficult. The author describes a simple procedure which not only enables different cores to be compared for a given application but also enables a basic design to be completed using the optimum core.

The design of transformers and inductors which carry a current with only an a.c. component is relatively straightforward and is based on the well known equation:–

$$E = 4.44\,B\,N\,a\,f \quad (1)$$

However, transformers and inductors whose windings carry a current with a direct component require a different design procedure. This is because the d.c. component can cause the core to saturate, giving a very low incremental inductance. A possible solution is to introduce a gap of non-magnetic material into the core. This gap reduces the effective permeability of the core. Thus with an optimum gap the core can be run somewhere below saturation flux density. Calculating the optimum gap can be a tedious process and also introduces another variable into the choice of the optimum core. The optimum gap chiefly depends on the required inductance, the d.c. and a.c. components of current, the maximum flux density allowable in the core and the core area.

A long while ago C.R. Hanna[1] devised an elegant system to enable the optimum gap to be easily found. Graphs are available for a number of ferrite and iron cores based on Hanna's technique. A representative graph for a medium size ferrite core is given in Fig. 1. The vertical axis is graduated in units of LI^2 and the horizontal axis in units of NI. Both L and I (the total of the d.c. and the peak a.c. components of current) are known and thus a point on the curve can be found. The curve is graduated directly in gap thickness, giving the optimum gap directly and, referring to the horizontal scale, we find a corresponding value of NI and hence the number of turns N. This is an excellent basis for a design as, once the number of turns is known, the necessary gauge of wire and hence the winding resistance can be determined. Hanna curves, however, are only available for some cores.

A more general approach is really required to enable the most suitable core

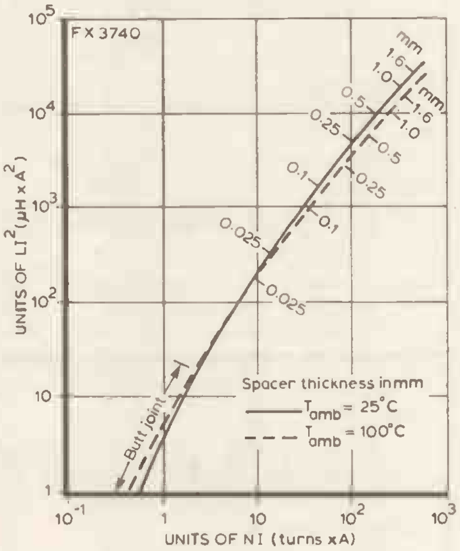


Fig. 1. Representative graph for a medium-sized ferrite core as used in Hanna's technique for finding the optimum gap.

to be rapidly selected. Frequently the final design will be done by transformer specialists but in the early stages of equipment design engineers find it desirable to rapidly compare a range of cores to see if the design is feasible within the available space. A simple design procedure is derived below and outlined at the end of the article.

Inductance can be defined as flux linkages per amp.

$$L = N\frac{d\Phi}{dI} \quad (2)$$

If no saturation occurs Φ is proportional to I and if remanent flux is small,

$$L = N\frac{\Phi}{I} \quad (3)$$

hence

$$N = \frac{LI}{\Phi}$$

$$= \frac{LI}{Ba} \quad (4)$$

where a is the cross-sectional area of the core. (All dimensions are in metres.)

Equation 4 could have been written as

$$N = \frac{L\hat{I}}{\hat{B}a} \quad (5)$$

where $\hat{I}$ is the sum of the d.c. and peak a.c. components and $\hat{B}$ is the flux density corresponding to the peak current.

Now $\hat{B}$ is available from the manufacturer's data for the core material, a is available from the core data (or can be easily measured) and L and $\hat{I}$ are the required parameters. Hence the number of turns, N, is known directly. For ferrite cores a parameter, inductance for 1 turn (A_L) is defined. Now, for the inductor being considered,

$$A_L = \frac{L}{N^2} \quad (6)$$

If this value is greater than the value of A_L given in the core data, we need more turns calculated from the core maker's value of A_L

$$N = \frac{1}{A_L}\sqrt{L} \quad (7)$$

In this case no core saturation will occur. A more likely case is that the value of A_L calculated in equation 6 will be less than the value given in the core data in which case a gap will be required in the core. In this case the number of turns will be that calculated in equation 5. This equation is very useful as it allows different cores to be directly compared in terms of N.

If the value of A_L calculated in equation 6 is significanty lower than the value given in the data sheet, then most of the available m.m.f. will be dropped across the two air gaps, each of thickness g. The approximate gap can be calculated as follows:

$$B = \mu_0 H$$

$$= \mu_0\frac{IN}{2g}$$

$$g = \mu_0\frac{\hat{I}N}{2\hat{B}} \approx \frac{10^{-6}\hat{I}N}{\hat{B}} \quad (8)$$

Generally manufacturers provide two types of ferrite core, namely transformer and inductor cores. Transformer cores are ground to fit each other as perfectly as possible, giving high values of A_L, but the actual value of A_L varies from batch to batch as the permeability of the core material varies. Inductor cores are ground so that the middle limb is shorter than the outside limbs, giving an integral air gap. This gap is ground so that the inductance factor, A_L, is constant for a given type of core even if the properties of the core material vary. Thus for certain cores it may be possible to choose a member of the family with the required value of A_L. In this case no additional gap is required and if necessary N can be changed slightly to suit the actual value of A_L quoted in the data sheet. If this is not practical, a transformer core may be gapped with a suitable thickness of cardboard or mica of thickness g. (It should be noted that the same thickness of spacer should be fitted to the centre and outer limbs of the core to ensure equal spacing and to prevent the cores breaking when clamped.)

The actual choice of peak flux density will depend on the maximum ambient temperature. Some ferrite core materials, unlike steel, have saturation flux densities which depend on core temperature to a considerable degree. For the core material whose characteristics are given in Fig. 2 a suitable peak flux density at 100°C would be 150mT. However if the maximum core temperature was 70°C a suitable peak flux density would be 220mT. In any case the saturation flux density varies widely with core material whether ferrite or steel.

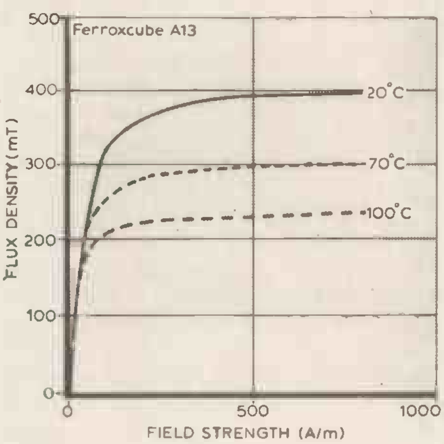


Fig. 2. Curves of flux density against field strength for Ferroxcube A13 ferrite core material, at temperatures of 20°C, 70°C and 100°C.

Basic Design Procedure

1. Calculate the required inductance, value of the peak magnetising current, the maximum allowable winding resistance and the maximum ambient temperature.
2. Select a core and list the following parameters:

Core flux area	a
Core winding area	A
Core winding diameter	D

Peak flux density at the maximum core temperature $\hat{B}$ (assume core temperature rises 10°C above ambient temp.)

3. Calculate the number of turns N from equation 5:

$$N=\frac{L\hat{I}}{\hat{B}a}$$

4. Calculate the inductance factor from equation 6:

$$A_L=\frac{L}{N^2}$$

and see if a gap is required. If a gap is not required re-calculate N from equation 7:

$$N=\frac{1}{A_L}\sqrt{L}$$

5. Calculate the winding resistance from equation 9:

$$R=\frac{D}{A}\times N^2\times 10^{-7}\Omega$$

for an inductor and twice that value for a transformer.

6. See if the resistance estimated in step 5 is similar to the requirement given in step 1. If similar proceed to step 7; if not repeat the above procedure using a larger or smaller size of core.
7. From the value of N calculated in steps 3 and 4 and using wire tables, choose an optimum gauge of wire which comfortably fits in the bobbin, allowing sufficient space for other windings and insulation if required. Also calculate the gap if required as given in equation 8:

$$g=\frac{\hat{I}N}{2\hat{B}}\times 10^{-6}$$

or use an inherently gapped inductor core.

The resistance of the winding is probably the most important parameter and, knowing N, can be calculated from the following equation:

$$R=\frac{\text{diameter of winding}}{\text{area of winding}}\times N^2\times 10^{-7}\Omega \qquad (9)$$

This extremely useful equation is based on the resistance of copper and typical percentage filling of the winding area with copper, allowing space for the former and insulation and applies for an inductor. For a transformer the resistance will be double.

Substituting the value of N given by equation 5 in equation 9 gives another extremely useful result.

$$R=\frac{\text{diameter of winding}}{\text{area of winding}}\times\frac{L^2\hat{I}^2}{\hat{B}^2\,\text{core area}^2}\times 10^{-7} \qquad (10)$$

Again the resistance of a transformer would be twice as great. Provided that there is a substantial d.c. component (which makes a gap necessary), equation 10 allows an immediate estimation of winding resistance for a given core and has been found to work well for ferrite and iron cored inductors.

Inductor flux falls to zero during each cycle

Single-ended forward converters work in this manner and are a special case of the cases described above. Forward converters require the magnetising current to be as small as possible to reduce the energy that is fed back to the supply during each cycle. To achieve the small magnetising current, no gaps are introduced into the core in the general case.

If V = voltage across primary of transformer, t = on time of transistor switch,

$$V=N\frac{d\Phi}{dt}$$

and as the flux starts from zero

$$V=\frac{N\Phi}{t}$$

hence

$$N=\frac{Vt}{\hat{B}a} \qquad (11)$$

and winding resistance is

$$R=2\times\frac{\text{diameter of winding}}{\text{area of winding}}\times N^2\times 10^{-7}\Omega \qquad (12)$$

or

$$R=2\times\frac{\text{diameter of winding}}{\text{area of winding}}\times\frac{V^2t^2}{\hat{B}^2a^2} \qquad (13)$$

where a is the area of the core.

In equations 12 and 13, the factor of 2 for a transformer is included as forward converters always use a transformer.

The magnetising current should be calculated from either the core permeability or from the value of A_L given for the core.

$$L = N^2 A_L \quad (14)$$

$$= \frac{V^2 t^2 A_L}{\hat{B}^2 \times a^2} \quad (15)$$

and the peak magnetising current is

$$\hat{I} = \frac{\hat{B}^2 a^2}{Vt A_L} \quad (16)$$

Useful formulae for transformers not carrying d.c. and smoothing chokes are given by T. Roddam in ref. 2.

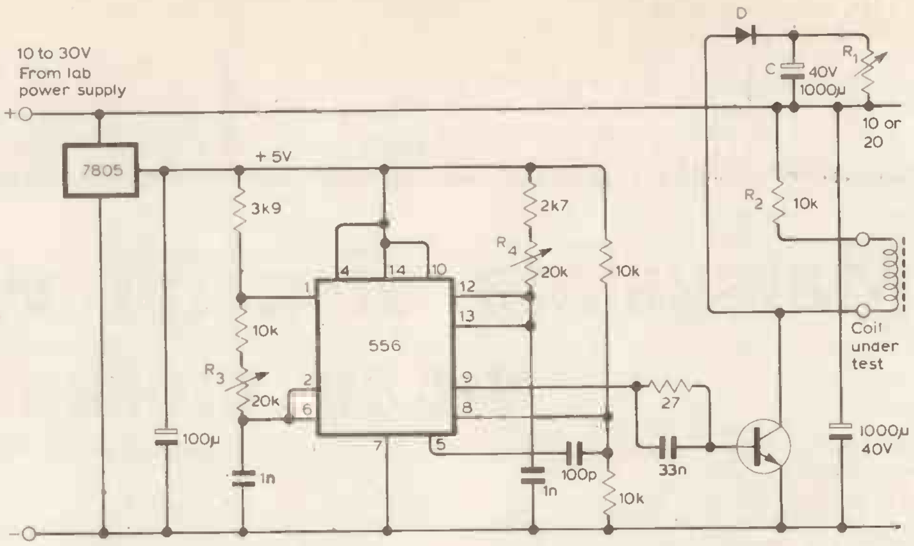


Fig. 3. Test rig to determine the peak flux that a high frequency core can accept.

Evaluation of core characteristics

If the peak flux that a core can accept is unknown, a simple test can be carried out to measure it. A high frequency core can be measured using a test rig similar to that shown in Fig. 3. (A low frequency core could be tested using a similar rig running at a much lower frequency.) The transistor acts as a switch connecting the supply voltage from an adjustable output lab power supply to the winding and D, R_1 and C act as a load. R_3 and R_4 set the frequency and duty ratio of the transistor "on" time and together with the supply voltage and R_1 set the current in the core. The core current can be monitored across R_2. Provided the voltage across R_2 is triangular, there is no core saturation but if the waveform of the voltage is curved, core saturation is occurring. The peak current can then be varied as explained above and a condition found where no saturation occurs. The core can then be placed in an oven set to the highest anticipated ambient temperature and the corresponding value of peak current for no core saturation found. The inductance of the winding can then be calculated from the supply voltage and rate of rise of current. Thus the number of turns N, peak current $\hat{I}$ and inductance L are known and the core area can be substituted into equation 5 to determine the peak flux density $\hat{B}$.

This technique gives a rapid procedure for an initial design. Such an initial design could be tried before the design is optimised by a specialist designer who will modify the design somewhat to allow for ease of winding, insulation, leakage inductance and core loss.

It should be noted that if it is known from the start that a gap will be required, a direct comparison of cores may be made in terms of resistance using equation 10.

$$R = \frac{D}{A} \times \frac{L^2 \hat{I}^2}{\hat{B}^2 a^2} \times 10^{-7} \Omega$$

I would like to thank the Directors of Cossor Electronics Ltd for permission to publish this article and Mullard Ltd for permission to reproduce Figs. 1 and 2.

References

1. Design of reactances and transformers which carry direct current, C. R. Hanna, *A.I.E.E. Trans.*, Vol. 46, pages 155-158, February 1927. Also: The design of iron cored chokes, M. G. Scroggie, *Wireless World*, Vol. 30, pages 558-561, 1 June 1932.
2. Some thoughts on transformers, T. Roddam, *Wireless World*, December 1973.

Literature received

Tape Recorder Spares Ltd have sent us a copy of their Audio Packs catalogue, which contains details and prices of a vast range of audio leads, plugs, adaptors and spares. It can be had from TRS at 206-210 Ilderton Road, London, SE15 1NS on payment of £1.25.

Applications for the NOVO range of logic circuits which are all provided with a non-volatile memory on the chip are set out by Plessey in a new booklet. Data sheets are provided. Obtainable from the Publicity Office, Plessey Semiconductors, Kembrey Street, Crowdy's Hill Estate, Swindon, SN2 613A. WW401

Soldering equipment and small tools, including the Oryx soldering-iron range, the Iso-Tip quick-change iron and several integrated-circuit handling tools, are described in an information pack from Greenwood Electronics, Portman Road, Reading, Berks, RG3 1NE. WW402

Students, teachers and lecturers meeting new topics in physics for the first time may like to know that Unilab produce a series of booklets in their "Notes for Use" series. They have sent us three, entitled Student oscilloscope, Microwaves and Analogue computing – an introduction. They are published at £1.50 each for the first two, £2.00 for the one on computing, and are obtainable from Unilab Ltd, Clarendon Road, Blackburn, BB1 9TA.

Equipment enclsoures from Sorel are the subject of a large catalogue, recently received. In addition to enclosures of many sizes and types, there is also information on metal-working tools, small cabinet-fittings, and wiring aids. The catalogue can be obtained from Sorel Electric Ltd, Cosgrove Way, Luton, Beds. WW403

We have received from Quarndon a full catalogue and price list of an enormous range of **semi-conductor** discrete and integrated devices and **microcomputers**, copies of which can be obtained, free of charge, from Quarndon Electronics Ltd, Slack Lane, Derby. WW404

A leaflet on **waveform processing**, using a transient recorder, tape storage and computer controller is available from Data Laboratories Ltd, 28 Water Way, Mitcham, Surrey, CR4 4HR. WW405

Home Radio's new catalogue is published, containing a vast array of all the **components** the average home constructor needs, complete with price list. Semiconductors are in a supplement, which we didn't receive. Catalogue costs £1.30 from Home Radio (Components) Ltd., 269A Haydons Road, London SW19.

Hewlett-Packard have a leaflet, AN 191-6, on the **measurement** of length, dielectric constant and delay matching of transmission lines, using a time-interval counter and time-interval probe. It can be obtained from from H-P at 308-314 Kings Road, Reading, Berks. WW406

We have received from Raindirk a brochure on the Status 250W Audio Power **Amplifier** and control unit. They are intended for professional or public address work and are housed in 19 inch rack-mounting enclosures. Information from Raindirk Ltd., Downham Market, Norfolk. WW407

A programmable sequence **controller** from Tempatron is fully described in an informative brochure, which can be obtained from Tempatron Ltd., at 6 Portman Road, Battle Farm Estate, Reading, RG3 1JQ. WW408

A complete list of books for the amateur electronics enthusiast is published by Bernard Babani (Publishing) Ltd., The Grampians, Shepherd's Bush Road, London W6 7NF. WW409

NEWS OF THE MONTH

Matsushita disc for world-wide video market?

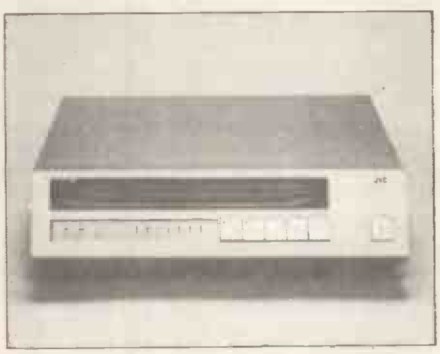
Thorn-EMI are setting up a joint venture with General Electric (USA) to support the introduction of the VHD video disc sytem in the USA. Three new companies consist of an equipment manufacturing company owned jointly by Matsushita Electric Industrial Co, its subsidiary Victor Company of Japan, and General Electric, a programme management company and a disc manufacturing company, both jointly owned by Thorn-EMI, Matsushita and GE. Plan is to introduce the video disc system by the end of 1981 with 200 programme titles, mainly films but with some original material, followed by introductions in France and Germany at "perhaps six-month intervals". (General Electric is in third place in the US television market with a share of 7.5%, after RCA and Zenith both of whom are already committed to a video disc system.)

The news followed the April announcement of Thorn-EMI and the Victor Company agreeing to "co-operate on a world-wide basis in all aspects of the promotion of the vhd system", suggesting that a software link was needed before GE would commit themselves to VHD. Disc mastering and pressing plants are planned for Europe, Japan and the USA, though locations are not finalized. Neither apparently is the ownership, because a European plant could either be a Thorn-EMI company or a jointly owned company, according to a spokesman. Thorn-EMI say they plan to manufacture equipment here on a progressive basis, but no timescale is given. (They said this about VHS equipment but have not yet manufactured it.) Thorn clearly look on their VHS collaboration with JVC as very successful, and have undoubtedly been a major factor in helping video recording to reach 2% market penetration in a year less than it took in the USA.

Prices of equipment will be close to the $500 of the RCA video disc player planned for launch early in 1981. $530 to 550 is suggested for the USA and £250 to 280 in the UK, with a separate random access unit at $150. Magnavox – who recently stepped up their initially modest marketing – and now Pioneer have optical players prices at $700 to 775.

The add-on random access unit recently demonstrated offered still play, normal play, fast visual search, quick play of two, three, four or five times normal speed, slow motion of half, quarter, eighth, and sixteenth time for selected addresses and times, sequential play of differing functions, and interrupted mode changes and programme skip. Some of these functions are integrated with a player in one prototype but in the interests of low player cost the specialized functions will be offered separately. But with an NTSC player speed of 900 rev/min and two picture frames per revolution, showing (two) still pictures normally leads to unacceptable picture quality, unless special steps are taken. One possibility is to encode two identical frames next to each other, but done throughout a record this would cut playing time in half. Another is to make use of a memory to delay a frame's worth of picture – as done at the demonstration – but the size and cost of this solution is still prohibitive for consumer use.

The demonstration showed better picture quality than that from video recorders, but a muffled sound quality indicated restricted h.f. response. As the preliminary brochure claimed an audio bandwidth of 20kHz, this left one wondering about the validity of the remaining meagre information. Thorn/JVC would not directly compare it with a broadcast picture but claimed instead that it was "competitive" with a Philips-system picture, and making it clear that Philips themselves claim compatibility with a broadcast picture.



Three NTSC versions of the JVC capacitance electro-guidance video disc player. Latest prototype player, right, is claimed to be simpler and cheaper than Philips-type optical player and to have versatility associated with servo-assisted pickup, though freeze-frame is still a problem.

Another add-on unit will be a p.c.m. demodulator – which will follow VHD by 6-8 months Thorn say – for use with sound-only records and dubbed AHD (audio high density). A 16-bit linear code and 47.25kHz sampling rate now supersedes the earlier proposal of 14-bits and 44kHz sampling. Another change since VHD was first announced two years ago is a reduction in disc size from 30 to 26cm, aimed at easing manufacturing problems, together with acceptance of the need for a disc case for dust, scratch and fingerprint protection.

Both JVC and Thorn-EMI are still secretive about technical aspects of VHD, in sharp contrast to their rivals RCA and Philips, and only scant details have been issued. The gist of this is that in recording a VHD disc, a rotating glass master coated with photosensitive material is irradiated by a laser beam modulated simultaneously with both tracking and programme signals to produce a spiral of pits. This is used to prepare a metallic master by "the conventional audio process". The conductive p.v.c. pressings made from this are said to require no further processing: obviously the basis for JVC's claim of "highly competitive" disc manufacturing cost. But with around 50,000 turns to a spiral and a pitch of 1.35μm – 40 times smaller than an audio disc – one wonders what the rejection rate will be?

Playback relies on a capacitance effect between the conductive disc and an electrode coating on the stylus, much as in the RCA disc system. In the RCA player the stylus is mechanically guided and rests in one spiral turn, whereas in the JVC disc it rests over ten spiral turns (JVC claim 2000 hours stylus life) and is electrically guided. The stylus assembly is servo-controlled by marker pulses on either side of signal information, both laterally to ensure proper tracking and longitudinally to give time base correction. The modulation scheme uses the usual f.m. video carrier, with pedestal at 6.7MHz and a deviation of 1.4MHz (according to the brochure) or 1.8MHz (according to the press data), described as "single carrier composite" – not the "colour-under" approach they stress – but more than that JVC won't say. Which presumably means that it hasn't yet been finalized.

● RCA responded to the Thorn/JVC/GE announcement by claiming theirs was "a unified operation ranging from research and development of manufacture, marketing and programming – not an alliance among individual companies which are diverse both in geography and marketing concepts". Scheduled for US introduction in the first quarter of 1981 with a programme catalogue of 300 titles, the RCA capacitance electronic disc system, CED, is also expected to be made by CBS and Zenith. RCA say they expect to sell 200,000 players alone next year.

Micro-based marine d.f. set for a fast "fix"

High-speed processing, leading to a rapid "fix" and safety at sea, are the two points which receive greatest emphasis in the technical literature accompanying the Syma Offshore Navigation System (the ONS 4000). This equipment has been developed and manufactured by Sysmaster Ltd, of Farnborough, Hants (an offshoot of System Designers of Camberley) in collaboration with the National Research Development Corporation.

The equipment, which is basically a microprocessor-controlled d.f. radio receiver, combines digital, analogue and radio techniques to achieve automatic operation. The unit synchronizes with the six-minute radio beacon cycle, automatically fixing and memorizing up to six compass bearings derived from the built-in electronic compass – this is a gimballed fluxgate unit which senses the earth's horizontal magnetic field.

Bearings remain in memory until the navigator is ready to "lay them off" onto a standard chart, with frequency, time and bearing indicated digitally on a l.c.d. panel. A small loudspeaker provides positive morse code identification of each beacon. A motor-driven ferrite rod aerial acts as the scanning sensor, housed in a weather-proof casting with a stainless steel sense aerial mounted on top.

Programming of the unit is carried out by the navigator to preset frequency and programme times of a chosen set of coastal m.f. beacons. A fix can be taken without any intervention by the navigator. Station tuning in the radio unit is by frequency synthesis and beacon bearings are derived from a statistically averaged series of measurements, giving accuracy without the need for high signal strength from each beacon, which may be difficult to achieve in bad weather or poor propagation conditions. This technique,

The control unit of the Sysmaster ONS 4000 navigation set.

the makers say, enables the navigator to get "the best possible fix at the worst possible time."

The complete unit costs £1,675 excluding v.a.t. and further information can be obtained from Sysmaster Ltd, 30 Invincible Rd, Farnborough, Hants, who can also supply a list of approved Syma agents in the UK.

NEW BBC TRANSMITTERS

Three BBC transmitters began operation on 29 August covering the remote villages of Armathwaite and Lazonby in Cumbria, Newton Abbot in Devon and Ashford in the Water, Derbyshire. All transmissions from these relay stations are vertically polarised. Further information can be obtained from the Engineering Information Dept., Broadcasting House, London W1A 1AA.

System X now in service

Britain's first all-electronic telephone exchange has been operating in London for over three months. It is the first example of a piece of hardware in British Telecom's System X family to go into full service, and is what is known as a junction tandem unit, switching telephone calls between some 40 local exchanges in the capital. Other types of System X units are local exchanges and trunk exchanges. Installed in Baynard House, a new British Telecom building in Queen Victoria Street, the tandem exchange has switched over 2.5 million calls from July 1 to the time of going to press. Housed in 50 racks, each 7ft high by 3ft wide, it can handle 150,000 calls per hour. An electro-mechanical cross-bar exchange would require about 400 such racks to do the same job. The failure rate so far has been 1 or 2 failures in 4000 calls, but British Telecom expect this to be reduced. Main contractor for the exchange was Plessey Telecommunications.

System X differs from earlier electronic exchanges installed in the UK which use reed relays for the final switching of lines and are therefore not fully electronic. It uses digital semiconductor devices throughout, ranging from discrete transistors, through integrated circuits up to l.s.i. devices. In the Baynard House tandem exchange low power Schottky t.t.l. devices are used widely and there are also m.o.s. devices. Because of the modular design of all System X sub-assemblies, it will be possible to introduce newer devices such as c.m.o.s. logic and magnetic-bubble memories at later stages as the technology develops. All the operations in the Baynard House exchange are controlled by a stored program. Calls are set up, faults are identified and the whole system is managed by computer-like processes. The equipment also uses what is called common channel signalling, a technique in which the signals controlling calls and managing the network are passed between System X exchanges as data transmission.

The transmission and switching functions in the exchange are brought together into a common digital mode of operation. For example, incoming calls from the 40 or so conventional London exchanges first of all have the analogue speech waveform separated from the signalling pulses. Then the speech waveform is converted into 30-channel p.c.m. form and the signalling pulses are transformed into suitable digital information for insertion into a particular time-slot of the p.c.m. system. The combined time-division multiplexed information is then passed at a rate of 2.048 Mbit/s into the main part of the exchange. A converse process takes place, of course, with calls going out from the System X tandem to the conventional local exchanges.

The first all-electronic local exchange in the System X scheme will be installed next year at Woodbridge, Suffolk.

The display terminal and keyboard of the Box Office Computer System (BOCS), shortly to be launched by a development company with a science-fiction ring to its title – Space-Time Systems Ltd. The system plans and displays, for example, the sold, unsold and reserved status of up to 2,000 seats at a time and Space-Time Systems foresees its eventual adaptation to other box office systems including ticket sales for football matches, etc.

News in brief

Agreement has been reached between Philips of Canada and the Bendix Corporation of Baltimore, Maryland, USA, giving Philips exclusive rights to the Canadian manufacture and sales of Bendix's microwave landing systems, known as MLS.

British Telecom's optical fibre network construction has had another leg completed with the installation of the first 140 Mbit/s section from London to Reading. The eight-fibre cable, which carries data equivalent to 1,920 telephone channels, has been carried out by Telephone Cables Ltd, a subsidiary company of GEC.

The second US/Southeast Asia Telecommunications Conference and Exhibition is scheduled for December 3 and 4 at the Mandarin Hotel in Singapore. Detailed information may be obtained from John Sodolski, Electronic Industries Association, 2001 Eye Street, NW Washington DC 20006, USA.

Electronica 80 is being held at the Munich Fair Grounds from 6 to 12 November 1980 and constitutes the ninth international trade fair for components and assemblies in electronics under this title.

Hitachi is to set up a television components manufacturing company in Selangor, Malaysia. This new arm of the company, to be known as Hitachi Consumer Products (Malaysia), will rest upon the joint investment of Selangor and Hitachi and will make the standard range of tv components such as deflection yokes, line output transformers and tuner units. Operation is scheduled to begin in June 1981.

Greenpar Engineering Ltd, Harlow-based manufacturers of coaxial connectors and r.f. components, have changed the name of the company to Greenpar Connectors, Ltd.

The gold used as plating for contact surfaces in British Telecom's electronic telephone exchanges is to be reduced from its present thickness of 5 microns to only 2½ microns. British Telecom, the telecommunications part of the Post Office, hopes by this action to save about £2 million after the changes, which began in October.

In spite of £450,000 lost on a turnover of £1 million in its second year of trading, Compeda, the company set up by the National Research Development Corporation to market British computer-aided design expertise, has succeeded in selling a £250,000 system chip design system to General Electric of the US. Compeda's managing director said that the projected turnover for 1981/82 was about £3 million and the company should be making a profit by next summer.

IPAT '81, the International Conference on Ion and Plasma Assisted Techniques, is to be held in Amsterdam from 30 June to 2 July 1981. The conference will include information of the latest developments in ion plating, ion implantation, ion beam processes, molecular beam epitaxy, plasma deposition, plasma enhanced c.v.d., sputtering, reactive techniques, plasma etching, plasma processing and testing of coatings and coating equipment. Papers are welcomed on the themes outlined and authors should submit abstracts of 200-300 words immediately, the deadline being 11 November 1980. Address entries to the Secretariat, IPAT '81 International Conference, 26 Albany St, Edinburgh EH1 3QH.

Times change

BBC2's clock, seen in some links between television programmes, is now generated electronically instead of optically. There is no mechanical clock and no camera or slide scanner. The new display is of a clock face, with hour, minute and second 'hands', and a pattern to indicate the channel, different techniques being used to generate the two.

The channel number display uses a process known as run-length encoding, in which data is stored in a programmable, read-only memory in a form which greatly reduces the amount of memory needed. Each change of colour and width of symbol requires only one byte of data, instead of one byte for every element of the display (the memory-mapped technique). In this way, fixed patterns, such as the Open University logo, which also uses the new technique, are produced with a smaller memory than would otherwise be needed, although movement can be obtained by using a microprocessor to change the data in a random-access memory in real time. The data is then taken directly from the r.a.m.

Two types of storage are needed for the clock. The hour markings and clock face are kept in p.r.o.m., being read out in synchronism with the television line waveform. Only one quadrant need be stored, since the other three are obtained by symmetry.

Data for the 'hands', however, is in r.a.m. An erasable p.r.o.m. controls a microprocessor, which determines the time and calculates the angle of the hands. Break-up of almost-horizontal edges is reduced by varying the output waveform to take account of the television line structure.

The BBC expect to generate the BBC1 clock in a similar way next year.

BBC engineers with the new television clock. Richard Russell, whom readers will remember for his work on the Wireless World teletext decoder, and who designed the clock system, is on the left. The run-length data for the logo was produced by John Mitchell, second from left, and the Open University symbol data was the work of Ewen McLaine and Robin Vinson.

Inmarsat to lease satellites

With a world-wide satellite communications system as its objective, the International Maritime Satellite Organisation (Inmarsat) is to consider supply contracts from satellite organisations, with plans to expand coverage by putting three additional geostationary satellites into orbit, one for each of the world's oceans. Two spare craft, supplementing these three at 65°E, 175°E and 335°E respectively, will also be put into orbit.

Although the programme is still under discussion, the choice is likely to include the European Space Agency's Marecs, Intelsat V and Marisat. Marecs has a capacity of 46 voice channels* and is a dedicated satellite, i.e. as it is used exclusively for maritime channels there is no danger of interference with other signal traffic, although such satellites are comparatively expensive.

Part of the leasing programme, which will begin in 1982, will include offers of short-term use of one of its existing satellites with a 7 voice-channel capacity. While existing Marisats were launched in 1976 with a 5-year design life, they are now expected to last for another two years.

Oluf Lundberg, of Inmarsat in London, says that at present maritime satellites are relatively under-used, even though use per ship is quite high. On the other hand, he estimates that there will be around 2,500 ship users by 1986. He also contrasted the normally slow rates of information processing through conventional maritime radio communication with the speed of computer-controlled services on land, notably in the case of oil companies, who need fast communication from sea rigs to shore bases. He says that this problem can be solved by the communications power of satellite telephone, telex and facsimile operation and companies will not be slow to recognise the advantages of the system.

*Capacity of one voice channel is equivalent to 22 telex channels.

Monitor device regulates heart-beat

One of the latest medical spin-offs from the NASA space programme is an implantable heart-assist device, developed by Michael Mirowski, MD, of Sinai Hospital Baltimore, to aid sufferers with a condition known as ventricular fibrillation.

The device is about 7cm square, is encased in titanium and weighs 255g (9oz). It is programmed to continuously monitor the heart, and to recognize life-threatening arrhythmias. If these occur it provides an electric shock through electrodes directly in contact with the heart so as to restore its normal rhythm. The first shock pulse occurs 15 seconds after the fibrillation begins, giving the heart a chance to correct itself. If the first shock has no effect, three more are delivered until a normal rhythm is established, with the last two shocks being increased in intensity. The unit is powered by lithium batteries with a life span of three years or 100 shocks.

NASA and the Applied Physics Laboratory have developed a monitoring and recording device for the unit which can be worn by the patient and which stores electrocardiographic data, the number of fibrillating episodes, pulse applications and the long-term performance of the implanted device.

The *New England Journal of Medicine* reported on the implant device in a pilot study by a team of scientists from Sinai Hospital of Baltimore, the John Hopkins Medical Institutions and the John Hopkins Applied Physics laboratory, although the automatic defibrillator (its commercial name is AID) is being manufactured by Medrad/Intec Systems of Pittsburgh, Pennsylvania in its evaluative stage. The units are not yet available commercially.

Radio Nottingham now stereo

BBC Radio Nottingham became in September the first BBC local radio station to start a regular service of stereophonic broadcasting. New studios using stereo sound desk equipment have been built in some old offices at the station. Considerable reconstruction was done while the station was actually on the air. Quite apart from the installation of the new equipment, the offices needed acoustic treatment to convert them into studios.

Listeners will find the stereo service on Radio Nottingham's v.h.f. frequency of 95.4MHz, broadcast from the Colwick Park transmitter. The BBC say that most listeners with stereo tuners or music centres should have no problem in receiving the service, and that listeners with mono sets listening on v.h.f. or medium-wave will not notice any change. Aerials set up for the national radio services in stereo may need some adjustment to make the best of the Radio Nottingham stereo service.

Digital television demonstration

Now that much more studio equipment in television broadcasting is going digital, broadcasters throughout the world are trying to establish a common standard for digital information transfer by which this equipment can be interfaced and made compatible. In Europe the EBU is working towards an interface standard for the 625-line system and in the USA the SMPTE is doing likewise for the 525-line system. Both of these organisations are also working together to try to achieve a truly international standard. One problem is what to encode digitally, the composite video signal or its separate luminance and chrominance components.

To help interested engineers understand what is going on the IEE has organised a demonstration and colloquium on "Digital television" on 31st October, in the IEE building, Savoy Place, London WC2R OBL, starting at 10.30am. You have to register beforehand by getting a registration form from the IEE (tel: 01-240 1871).

"Radar-invisible" aircraft? Back to the drawing board!

Fighter planes known as "stealthy aircraft," built and tested by Lockheed Aircraft Corporation for the US Defence Department and claimed to be "virtually invisible" to radar, appear to be less than successful at the basic business of remaining in the air – all three prototype machines have crashed because of their peculiar shape.

The Guardian (22 August 1980) reported that many observers have been excited at the prospect of penetrating Russian air space unnoticed and other accounts suggest that the technique being employed in the aircraft is a combination of "rounding off corners" (sharp features produce maximum radar reflections) and that of coating the aircraft with "radar-absorbent" material, which in reality disperses the returning radar signal.

This is not the first time such material has been tried. During the Second World War German U-boats were coated with a compound called Sumpf, which was fairly effective until it was washed away by sea water.

Prestel grows, but slowly

"Prestel is now a reality in most of the major cities and regions of the UK," according to Richard Hooper, the director of this British Telecom viewdata service. To understand this claim you have to interpret what he means by "a reality". Although the Prestel service will be available to approximately 10 million UK telephone users by the end of 1980, the number of people who are actually connected as subscribers is pitifully small. At the time of going to press it was 5260. At the present rate of growth (about 500 per month) this could become 8,000 or so by the end of the year. Of the total of 5,260, only 588 were private households, indicating that the principal growth of the service has been among business and professional users. This must be seen as a disappointing start, particularly after the publicity campaign put on earlier this year and the fact that British Telecom forecast 27,000 users by the end of 1980. Prestel has now been operating for about a year (see December 1979 issue, p.55).

Clearly Mr Hooper's reality means the availability of the service to UK citizens who have telephones. This is certainly good. At the beginning of 1980 Prestel was available only in London, Edinburgh, Glasgow, Birmingham and Nottingham. By the early autumn Leeds, Brighton, Reading and Sevenoaks had been added. In the coming few months the service will be extended to other important towns including Cardiff, Belfast, Norwich, Bournemouth, Chelmsford and Luton.

It seems likely that the slow growth of the Prestel market, relative to the British Telecom forecast, is due to the present high cost of being a subscriber (details of installation and running charges were given in our December 1979 report).

This cost will go even higher with the new telephone tariffs recently announced by British Telecom. A related problem here is that the price a user is prepared to pay will depend on the amount of information he can get out of the service, but already the information providers are becoming restive because of the small number of users whom they can reach to sell their information to. There is clearly a chicken-and-egg problem in the growth of the market.

However, Mr Hooper may well be committed to the idea of getting the charges down, for last year, before he became director of the service, he wrote "Prestel set prices must come down first to ensure a large residential market . . . someone somewhere has got to make a heavy capital commitment to volume production for the costs to come down."

M.Sc. courses in chip design

The Science Research Council has announced that it will be funding three new courses in i.c. design, to be undertaken at Edinburgh University, Manchester University and Brunel and Southampton University. They will consist of one-year courses run in close collaboration with the microelectronics industry and will include substantial practical work, giving students the opportunity to oversee the production of an i.c. from design to fabrication.

Funds are also being provided by the council for necessary equipment and access to computer-aided design and electron beam lithography facilities at its Rutherford and Appleton laboratories and to the SRC-supported silicon processing factories at Edinburgh and Southampton Universities.

An intake of about 16 students per year at each centre is expected, with as many as possible being supported by industry.

UKADGE work – but when?

Command, control and communications for radar defence of Britain are to be up-dated by a group of companies who have one-third shares in UKSL, which is UK Air Defence Ground Environment Systems Limited. The companies, who announced at Farnborough their victory in a two-way M.o.D. competition to secure the contract are Plessey, GEC-Marconi and the US company Hughes Aircraft, with the French Thomson-CSF taking a sub-contracting role. ICL, Westinghouse, Signaol of Holland and SINTRA of France comprised the losing group.

UKSL are confident that the work, which is said to be worth £100 million, will escape the moratorium on defence spending recently announced by the Secretary of State for Defence, which is to run for three months or longer. This has not yet been confirmed.

Spark gaps

Transient protection in high voltage, medium current applications

by **J. Dearden**, B.Sc., C.Chem., F.R.I.C., Welwyn Electric Ltd.

Because many electronic circuits are subjected to voltage transients which can destroy delicate components, some form of protection should be provided. A simple and effective method of protection is to use a spark-gap device which reacts more quickly to a high-voltage transient than an electro-mechanical or solid state component. This article outlines the problems and parameters which must be considered when using a spark gap.

Spark gaps vary in style and construction. For low voltage and current applications, the simplest type consists of two wire electrodes moulded into an open plastic frame as shown in Fig. 1. However, more elaborate design is required if high voltage and current are combined with a high spark repetition rate. This type is usually constructed with a ceramic case filled with an inert gas, and high temperature alloy electrodes as shown in Fig. 2.

In a two-electrode spark-gap the insulation is very good at low voltages, and no leakage current exists. As the voltage increases, the few electrons present in the gap, due to cosmic radiation and other ionising effects, are accelerated until they are able to ionise atoms of gas in the vicinity of the electrodes. This causes an avalanche effect as the additional electrons produce further ionisation, and as the current increases the voltage falls as shown in Fig.3. A further increase in current causes heating of the cathode by ion bombardment, and this creates emission sites and a transitory glow discharge. The increased current eventually produces an arc discharge, or spark, with a peak current determined by the external circuit. After the spark has discharged, ionisation of the gas decays until the gap has returned to its original condition.

In some tv receivers the focusing circuit for the c.r.t. can, under certain fault conditions, expose the focusing electrode to the full 25kV from the e.h.t. supply. Therefore, to protect the c.r.t. from possible damage, the spark-gap must fire and divert the 25kV source before the pulse height reaches a dangerous level, but must also remain in a stable unfired state at the maximum focusing voltage. These two limits are used to determine the breakdown requirements for the spark-gap, and popular breakdown bands are 7 to 9kV, 8 to 10kV and 10 to 12kV.

The breakdown across a gap is determined by a complex and interacting set of parameters such as electrode shape, gap size, gas pressure, composition of the gas and the type of external circuit. To obtain a precise breakdown voltage, the ideal shape for the electrodes is two large spheres, which produces a high degree of field uniformity where the spheres are closest. Therefore, when the voltage is increased, the change from the Townsend or "dark" discharge to the avalanche breakdown occurs quickly across the whole width of the field. If, for example, electrodes with sharp edges are used, a non-uniform field is produced and as the voltage increases, the transition from a "dark" discharge to a total breakdown can be pre-empted by a corona or brush discharge. Although this is a self-sustained discharge, it does not represent a failure of the entire gap and the rest of the gap will continue to carry a "dark" current. A further increase in voltage causes the corona to spread across the whole field and complete breakdown then occurs. For this reason, when wire electrodes are used, care must be taken to form the wire into a smooth curve to avoid pre-breakdown corona. It is also important to use a wire which is free from surface damage, and to ensure that the free end of the electrode is either embedded in the insulating case material or bent away from the gap as shown in Fig. 4.

Unfortunately, simple rules cannot be applied when calculating the gap size required for a given breakdown voltage across wire electrodes. The electrode shape is not ideal, the breakdown will vary with wire diameter, and the field will be modified by the case dielectric. However, it is easy to achieve the required breakdown voltage by trial, and then repeat it by maintaining the electrode geometry and gap size.

For a given electrode geometry, the spark breakdown voltage also varies with pressure. The normal range of pressure variation in the UK is from 728 to 773mmHg (970 to 1030 millibars) which, with a 5mm gap, is equivalent to a change in breakdown voltage of 700V as illustrated in Fig. 5. Therefore, if the spark gap is not totally sealed, and subjected to normal atmospheric pressure variations, it will stay within about 500V of the specified value. In the case of a sealed unit, significant pressure variations will be caused by changes in the ambient temperature. In a tv receiver a 40°C

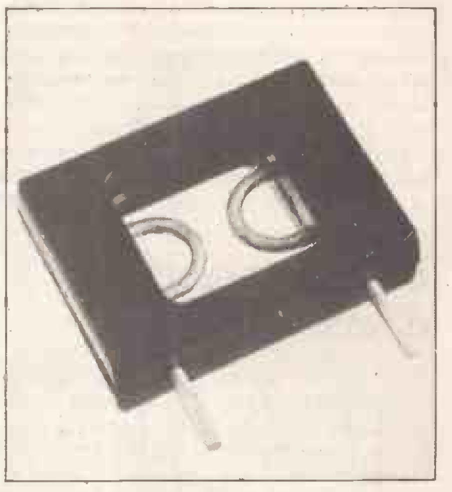


Fig. 1. Open construction spark-gap.

Fig. 2. Ceramic spark-gap.

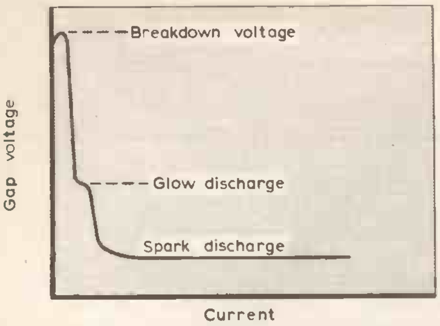


Fig. 3. Voltage – current characteristic of a two-electrode spark-gap.

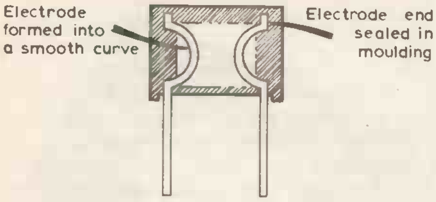


Fig. 4. Electrode arrangement.

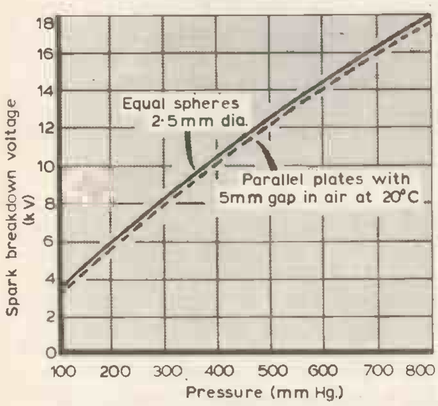


Fig. 5. Effect of pressure variation on spark breakdown voltage.

change is not uncommon and represents a pressure change of 110mmHg, which is equivalent to a 2.3kV change in breakdown voltage. From this example it is clear that a sealed unit is not suitable for applications with large temperature changes.

If the spark gap is not sealed, composition variations of the atmosphere can cause large changes in the breakdown voltage as illustrated in Fig. 6. For this reason it is important that the air in an unsealed unit does not become contaminated, and the use of a thermoplastic for the case is recommended because it does not emit vapour when subjected to modest heat. Thermosetting resins, however, usually contain reactive hardeners which can cause atmospheric contamination, particularly in small enclosures. If a low quality plastic casing is used, water vapour can be absorbed to create surface leakage currents which can modify the mode of breakdown. This type of leakage can be eliminated by treating the surface of the plastic with a hydrophobic material such as a silicone resin, which prevents the formation of a continuous moisture film.

Contrary to popular belief, contamination of the spark-gap atmosphere with moisture has little effect on the breakdown voltage. Changing the relative humidity from 0 to 100% causes the breakdown voltage to rise by only 3.5%[1] and is independent of electrode shape and gap.

A knowledge of the external circuit is necessary before a realistic test procedure can be defined. Three important facts, essential to optimise the component design and carry out the tests, are the amount of energy to be discharged across the gap, the rate at which this energy is dissipated, dictated by the maximum discharge current, and the expected discharge repetition rate. The test circuit shown in Fig. 7 simulates the conditions in a tv receiver where a 25kV e.h.t. supply charges a 5000pF capacitor through the 40MΩ resistor. The capacitor can be discharged across the spark gap by an igniter which is set to fire at any pre-determined rate. Resistor RL limits the discharge current to around 1000A.

When the energy from the capacitor is discharged across the electrodes, it causes intense surface heating which coats the internal walls of an enclosed device with metal and causes leakage currents. The extent of this effect depends on the volatility of the electrodes and the peak level of energy being dissipated. Because the energy of the discharge is proportional to the square of the voltage, the problem is most significant in high voltage devices. With a 1000A limit on the discharge

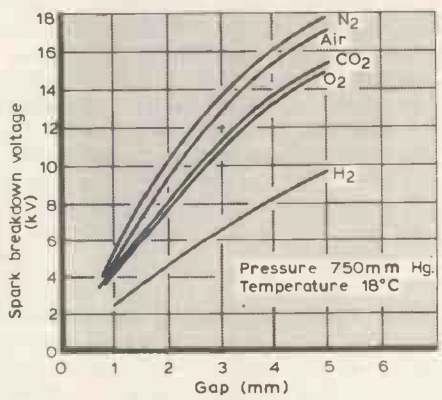


Fig. 6. Breakdown voltage between two 2.5mm dia. spheres in various atmospheres[1].

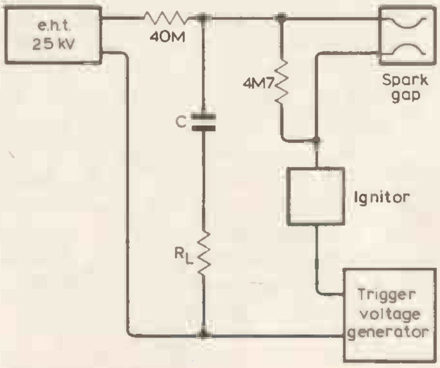


Fig. 7. Spark-gap test circuit.

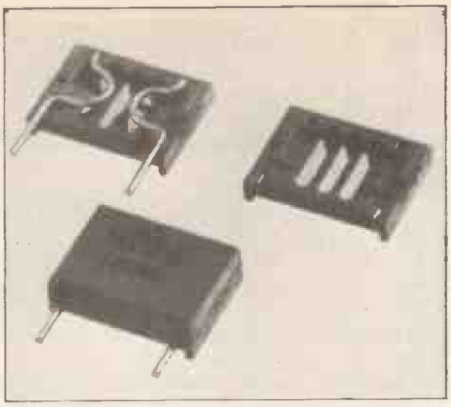


Fig. 8. Internal construction of a sealed spark-gap.

current, brass electrodes will give intolerable leakage effects after a few tens of discharges. At the other extreme, costly tungsten or platinum electrodes can withstand almost unlimited discharges with no current limitation and without any change in the insulation resistance. A good compromise is a copper-nickel alloy, which is sufficiently hard and of low density to retain the electrode shape once it has been bent, the terminal sections are rigid and allow easy location into a printed circuit board, it can withstand several thousand discharges at 12kV with a 1000A limit, and it is easily tinned by dip soldering.

Fig. 8 shows an internal view of a spark-gap. The walls of the cavity are corrugated to increase tracking distance between electrodes, and so reduce surface leakage.

Reference

1. Cobine, J. D., Gaseous Conductors, *Theory & Engineering Applications*, p.164, 167 and 182.

Aerial design book

Articles on aerial design, aerial theory and wave propagation, published originally in *Practical Wireless*, have been collected together in a book, entitled Out of Thin Air. The aerials described are mainly for amateur use, although there is a m.w./l.w. loop. Additional articles include a survey of propagation modes, a piece on the influence of the sun on propagation, and a discussion of v.s.w.r. at v.h.f., together with a v.s.w.r. meter design. The book is well presented, with large diagrams where necessary, and a useful feature is a directory of aerial suppliers. It costs £1.25 from bookshops or £1.50 by post from Post Sales Dept., IPC Magazines Ltd., Lavington House, Lavington Street, London, SE1 0PF.

LETTERS TO THE EDITOR

PICKABACK SPARKS

I have recently uncovered an electrical effect which may be new to your readers. I myself have not seen anything of it before in my almost 50 years in a physics laboratory.

I had been thinking of possible means for enhancing the ignition spark in cars when it occurred to me that it might be possible to play a weak high voltage spark across the leads of a charged low voltage, high capacitance, capacitor, hopefully to provide a discharge path. I did not have an ignition coil by me, but I did have a Tesla coil. A 'Tesla' is used in high vacuum work and gives a high frequency oscillatory discharge with sparks up to an inch in length.

I charged up a 1μF capacitor to 1kV, earthed one lead and approached the other lead with the Tesla. Momentarily there was one long vigorous discharge and it was apparent that I had emptied my half joule into a long spark. The ordinary car ignition spark is roughly a hundredth of that. I tried the same thing later using a car ignition coil but could not get the effect. It seems that a single stroke is not sufficient – it is the second or subsequent sparks which provide the low impedance path.

I suppose that this effect is highly significant when considering the mechanics of lightning. I think, too, that I can just start to imagine a whorl of energy in the form of a plasma consisting of interchanging r.f. and ionic currents which might go some way towards explaining the phenomenon of fireballs. Has anyone detected r.f. interference from such balls?

A short while ago I was working a Van der Graaf generator on a bench in my room: the earthing got a little bit out of hand and so did the sparks. The main 40-amp fuse blew. I found the fault; a practically unused mains socket some eight feet away had burnt out and the presence of craters on the pins indicated that a gigantic arc had occurred.

Perhaps the effect is better known than I had thought?

John T. Lloyd
Department of Natural Philosophy
University of Glasgow

DIGITAL ELECTRONICS AND 'DEFENCE'

Some crucial factors have been missed out of the discussions in your journal on military electronics and on the status of engineers.

The only thing that separates a good electronics engineer from a cowboy is that the former has the ability to develop products which work.

Digital electronics represents overwhelmingly the major part of the electronics engineer's trade. Even though this has been the case for many years now, colleges and faculties still refuse to teach even the rudiments of the subject. Digital electronics is different from its antecedents in that one little flaw causes catastrophic failure. The result is that even well-motivated, well-intentioned electronics engineers today produce products which do not work, with the exception of trivial ones. Today a trained electronics engineer is indistinguishable from a cowboy, except that he will be more methodical about the way he goes about developing non-working products.

At a seminar held in Hull University to discuss college electronics syllabuses recently, I gave a paper in which I challenged any company with a multi-million pound project in development with significant digital electronic content to take me on board, and if within three months I did not find fatal flaws in their product which meant it would never be viable, I would pay a heavy financial penalty. There were no takers, although the challenge was published widely.

In view of the non-existence of training or education in digital electronics, only a foolhardy company will today embark on a large digital electronics project unless the final product does not need to work. The recent retrenchment of the Inland Revenue from a large system to lots of little systems represents a recognition of my thesis. When a large civilian project is abandoned, the company responsible hushes it up shamfacedly because it assumes that other (military) projects are successful. This is where military electronics comes in to save the 'profession' and give continued employment to people like me. When a major weapons system fails to work, the record is falsified 'for reasons of security'. The Ministry of Defence (themselves terribly ignorant of digital electronics for the same reasons), will pay anyway.

I see the military budget in electronics as a useful device to allow the colleges and faculties to continue to refuse to teach the rudiments of digital electronic design, by which I do *not* mean the programming of microprocessors or other trivial surrogate activities. The lecturers and professors do not teach the fundamentals of digital electronics because they do not know them. However, they will not let experienced, knowledgeable people into their faculties to teach the stuff. I have been trying to get such a job for more than ten years, but real experience and knowledge of digital electronic design appears to be a bar to employment in academia. (This was already true years before the recent Tory recession.) So long as this situation continues, we shall continue to have a useless industry funded by government largesse, the so-called defence budget. Of course, since they will never work, the military products will never in fact contribute to our defence. Today we have no defences; to work in the 'defence' industry is a polite way of being on the dole.

The government is happy to fund the 'defence' industry because it masks our true unemployment level. The trades unions like it for the same reason. Industry, the third supporting pillar of this massive fraud being perpetrated on the taxpayer, also supports it because it is a no-risk, guaranteed profit industry. Britain will disintegrate before we can overcome such a powerful triumvirate.

What distinguishes our 'defence' industry from that of other countries, for instance the USA and the USSR, is that it seems invulnerable to economic forces. During recession the expenditure, or more accurately the massive waste, increases. It is a very inefficient way of creating jobs to mask unemployment, but it is the only ideologically acceptable way. We are very like a dictatorship in that we can cut any other expenditure because of lack of government funds, but not 'defence'.

Some eight years ago an investigator of the 'defence' scandal said that "this country was being cheated of the talents of many of its finest scientists." This is much more true today.

In the electronics industry the norm is for a technically ignorant and careless customer to accept useless equipment from a technically ignorant manufacturer. The so-called 'trials' are rigged. Corruption is not generally involved; only stupidity and misplaced loyalty to their opposite numbers in the manufacturing company on the part of the treacherous representatives of the long-suffering taxpayer.

If we are to stop this gigantic financial drain on the country, which by the way incites our enemies to arm themselves as one result of our pretended state of military strength, we must have technical auditing on a par with financial auditing. At present no sanctions similar to those in case of fraud in the transfer of money are applied against those who connive in fraud over the transfer of military hardware.

It has been pointed out to me that such an auditing authority is very likely to be subverted; it may merely give credibility to the discreditable racket of charging the taxpayer hundreds of millions of pounds for useless weaponry. However, the present situation is so scandalous that a change could not be for the worse.

My proposal is that professional bodies – the I.E.E., etc. – audit trials involving equipment where their speciality is relevant. As with cash movements, fraud should come within the province of the criminal law. An obvious sanction is that someone who has taken part, either as representative of the supplier or as 'representative' of the long-suffering taxpayer, in a fraudulent 'trials' or 'acceptance test', should be banned from practising that technical skill for a period of ten years. Ignoring the ban would be treated as contempt of court.

Ivor Catt
St Albans Herts

DISPLACEMENT CURRENT

Following Professor Bell's article "No radio without displacement current" (August 1979 issue), I wrote a letter which appeared under the title "Displacement current" (November letters). A reply by Professor Bell to my letter was published in the same issue. I felt that this reply revealed misunderstandings of a fundamental nature regarding the points I was trying to make and I could not see how any useful purpose would be served by my responding to it. Since, however, Professor Bell has restated his arguments in the August 1980 letters it seems that I must reply.

My original letter contains the following two paragraphs:

"I understand that Aristotelians believed that a force was necessary to keep bodies in motion and that, in the absence of this force, the motion would cease. This theory led them into certain difficulties. For instance a spear once thrown, appeared to continue to move without a force being present. The philosophers rose to this challenge magnificently with a theory that air, displaced from ahead of the spear, rushed to the rear and generated the requisite force – the theory was saved. Unfortunately they missed the simple point first noted by Newton, that it is in the nature of a moving body to continue to move.

"In the same way I fear that Maxwell invented a complex explanation for a very simple phenomenon, i.e. that electromagnetic radiation, or energy current, moves at the speed of light – and that's all, because that is what energy current does. No mechanism invoking E producing H and H, in return, producing E is required."

I would have thought my intention was quite clear – it was to show, by analogy, how a faulty set of primitives can lead to problems in a theory which necessitate the introduction of ad hoc causality relations. In a similar way I believe that the causality relations alleged to reside in Maxwell's equations (i.e. changing magnetic field producing electric field and changing electric field producing magnetic field) are spurious. A moving body continues to move because that is what moving bodies do; an electromagnetic disturbance or energy current, of whatever distribution, continues to move because this is what energy currents do. In other words the statement "energy current travels at the velocity of light" is a primitive assumption in my theoretical framework which requires no further explanation. In my framework the moving energy current is the simple situation and 'static' electric and magnetic fields are composite.

Before I leave this point I must make two other observations. Firstly Professor Bell not only seems to misunderstand my argument but to compound this by not even having an adequate grasp of his original article, for he states in both the November 1979 and August 1980 replies that "I mentioned early speculation about the planets because Newton's theory of gravitation ...." My problem is that I can find no such mention of the planets in Professor Bell's article. True, he mentions Jupiter in the context of the propagation of radio waves from the vicinity of this planet, but nothing else.

Secondly, the relevance of Hobbes's *The Leviathan* seems a little dubious. I will admit that my statement that the principle of inertia was first noted by Newton is open to question – I would suggest that it was probably first noted by Galileo and enunciated by Newton – although it seems a little beside the point. Incidentally, I cannot locate the passage in *The Leviathan* which Professor Bell is referring to and wonder whether he in fact means some other work by Hobbes, possibly *De Corpore*. I would in any case be obliged if he could let me have a full reference. Since *The Leviathan* is a work of political philosophy it would be a strange place to make the kind of comments quoted by Bell – but who can tell with philosophers!

Several other points are raised by Professor Bell's letter. Before Maxwell's theory can be "faulted on experimental evidence" we require a definitive statement of that theory. Where is this to be found? Certainly not in Maxwell's *Treatise* since this involves views regarding the aether which would not be acceptable to modern physicists. Perhaps if someone could supply a definitive statement of Maxwell's theory I might be able to suggest some experimental tests.

Professor Bell states that he does not know what the energy current concept is or how it relates to the Poynting vector, yet this is set out in the article by Catt (see "The Heaviside signal," *W.W.* July 1979). It surprises me that, having stated his lack of understanding of the concept, and apparently not having seen the above-mentioned article, he still tries to apply it to loop antennas, etc.

It is extremely unfortunate that the displacement current debate has been cluttered by so many side issues. I feel great sympathy for the impartial reader of this correspondence who is attempting to decide which side of the debate has the greater insight into the subject. I am more or less resigned to the fact that it is impossible to debate the central issues of electromagnetic theory because of the high 'noise level' which is generated by those who defend the established view. Where do we go from here? As Professor Bell says, "Everyone tends to believe what he wants to believe" or, to quote from T. S. Kuhn, ("The structure of scientific revolutions," University of Chicago):

"Max Planck, surveying his own career in his *Scientific Autobiography*, sadly remarked that 'a new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it'.

"These facts and others like them are too commonly known to need further emphasis. But they do need re-evaluation. In the past they have most often been taken to indicate that scientists, being only human, cannot always admit their errors, even when confronted with strict proof. I would argue, rather, that in these matters neither proof nor error is at issue. The transfer of allegiance from paradigm to paradigm is a conversion experience that cannot be forced. Lifelong resistance, particularly from those whose productive careers have committed them to an older tradition of normal science, is not a violation of scientific standards but an index to the nature of scientific research itself. The source of resistance is the assurance that the older paradigm will ultimately solve all its problems, that nature can be shoved into the box the paradigm provides. Inevitably, at times of revolution, that assurance seems stubborn and pig-headed as indeed it sometimes becomes."

Do we really have to wait for a new generation to grow up before we can countenance changes in the accepted theoretical structure? This is the real problem, not electromagnetism, relativity or mechanics, but how to create a forum in which proper discussion of fundamentals can take place.

D.S. Walton
CAM Consultants

Perhaps Professor Bell (August letters) really should have completed his application of the two "disciplines" of science to both the Maxwell and the Catt, Davidson, Walton theories. CDW's theory certainly has fewer hypotheses than Maxwell's (they only need to define what they mean by energy current). From their theory one can deduce Maxwell's equations (yes, and the famous dD/dt term, which is a mathematical quantity, not a "physical current") as well as Faraday's and Maxwell's laws of electromagnetic induction.

I don't believe Catt, Davidson and Walton have ever attempted to suggest that Maxwell's equations are incorrect, merely that they are at best mathematical devices exceedingly useful for setting university examination questions. They may or may not be correct on this point, but that, of course, isn't what everyone's supposed to be discussing (see the editorial in the May issue).

L. J. Higgins
Swindon
Wilts.

SATELLITE TV

As someone with a keen interest in the possibilities offered by satellite tv, I was pleased to find an article on the subject in your September issue. This, I hoped, would add to the information provided by Chriet Titulaer in his book entitled "Televisiesatellieten", which I discovered during a recent visit to Holland (but which is not mentioned in your bibliography). This contains an extract from the famous article by Arthur C. Clarke which appeared in your journal in 1945.

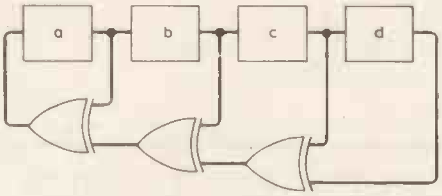
Unfortunately, S. J. Birkill's article proved to be disappointing. My interest lies in the early availability of a terminal to which a conventional television receiver can be connected with a minimum of intermediate equipment and which will afford a choice of foreign broadcasts, preferably from Western Europe. Having experienced the benefits of a cable relay system affording 10 channels from five countries, it is impossible to be satisfied with the insular, parochial, bland diet of news and opinions which is served up in the UK. The Americans, it would seem, already have the choice (admittedly at a price) of 36 channels, and home terminals are already on the market in Japan. Why, then, are these not available here? Your article shows clearly that there is no need to wait three or four years until European tv satellites are in operation: there are already plenty of surprises for the enthusiastic DX-er.

D. S. Jordan
Canterbury
Kent.

There is no direct satellite broadcasting in Western Europe yet. –Ed.

FEEDBACK FOR P.R.B.S. GENERATORS

Mr Wood's method of determining feedback connections which give maximum length sequences (September Letters) is interesting in that it avoids most of the algebra with which the problem is usually tackled, but unfortunately, although it is certain that the circuits it eliminates won't give maximum length sequences, it doesn't follow that those which are left will. For example, it is well known in the trade that if $a+b$ is a multiple of 8 there are no values of a and b which will give a maximum length sequence. Such sequences can be obtained however by using the more complicated circuit shown below, with appropriate values of a, b, c and d.



The problem of finding the appropriate connections is the subject of an extensive literature. A convenient starting point is "Shift Register Sequences" by S. W. Golomb (Holden-Day, 1967). Most of us find in this book a convenient finishing point, too. It contains a table of values of Mr Wood's a and b for values of $a+b$ up to 36.

For those who do not have access to a microprocessor system, or who have but still haven't learnt to use it, much can be done with a programmable calculator. You need to know that the output of a two-input exclusive-OR gate, usually designated $a+b$ is also given by $(a-b)^2$ where subtraction and multiplication are conventional. Shift, if not specifically available, may be obtained by repeated use of the memory exchange facility. The number of memories, rather than the number of program steps, will usually limit the number of stages which can be simulated. Readers can check Mr Wood's table, up to the limit of their memories and patience. They can also investigate the circuit given here, for eight stages. The values of *a*, *b*, *c* and *d* which give maximum length sequences, taken from Golomb, are:

a	*b*	*c*	*d*
1	1	5	1
1	2	2	3
1	4	1	2
2	1	1	4
2	1	2	3
2	1	3	2
d	c	b	a

K. S. Hall
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The letter from K. Wood on pseudo-random-binary sequence generators in the September issue made me wonder what problem *he* had cracked by simulating a shift register with feedback on Z80. My own problem a couple of years back arose from the need to construct a pink noise generator for electroacoustic work. Having bought a c.m.o.s. 4006 shift register I then had to discover suitable feedback connections in order to get a maximal-length pulse train. The 4006 has 18 stages so the pulse train should be $2^{18}-1=262143$ bits in length. Only 6 of the 18 stages come out to pins, and the four independent sections of the register may be interconnected in six different ways.

I had no mind to read through *all* the literature on the subject, but I must comment that I found that tables of irreducible polynomials were of absolutely no help to me whatsoever, apart from a little practice in decoding octal. Is this also K. Wood's experience, I wonder? It would have been possible to rig some simple hardware that would have taken the 4006 through all possible combinations of interest, and the task was offered as a student project. However, by the end of the session no student had shown interest in such a mundane exercise. So I turned to the ICL1900 series computer and wrote a BASIC program that turned this giant into an 18-stage shift register. This may well rank as the world's least efficient computer program (if booby prizes are being offered I am interested), for it takes a computer an unconscionable time to perform over a quarter of a million shifts from a high level program. The situation was only slightly improved by reprogramming in ALGOL.

Clearly the time had come to rewrite the slowest part of the program, the shifting loop, into machine code. The snag here was that although the PLAN code was well documented, actually learning to use it efficiently requires some weeks of study under expert tuition. Luckily my colleague Tim Fuller took pity on me and wrote and tested a suitable PLAN segment (a matter of 16 instructions) for incorporation into my ALGOL program. I was then at the point which Mr Wood seems to have reached more effortlessly with his Z80 routine, and I proceeded to output sequence lengths for all feasible arrangements of connections, with the register starting from all stages set to 'true'. For the benefit of posterity I hope the editor will allow me to record here the only six arrangements which gave maximal-length sequences. Numbering the stage output connections from 1 to 18, there was only a single set of 6 feedback connections, namely 4, 8, 9, 13, 17 and 18.

With four feedback connections there were five alternative sets:

4	5	10	18
4	5	13	18
4	13	17	18
5	13	14	18
8	13	14	18

Naturally enough, the output from stage 18 is used in every case. It is more convenient to use one of these five sets, as the four feedback connections can be combined using only three quarters of a 4030 quad gate i.c., leaving the fourth gate available for use as a clocking oscillator. If any readers have constructed the p.r.b.s. generator shown on page 43 of *Electronics Today International* for March 1974, they should find that it does not give a maximal length sequence, but one which is 262140 bits in length. It is not impossible that this might stick (on start-up) in the four-bit sequence 0011001100110011, etc. as far as I can deduce. Can any reader confirm (or refute) this asseveration?

Desmond Thackeray
Department of Music
University of Surrey
Guildford

GENERATING THREE PHASES

Your correspondent, E. V. Hurran (August, Letters) recommends one of the Van der Pol oscillators for producing a good sinusoidal output, particularly at very low frequencies. While agreeing that the virtues of some older circuits should not be overlooked, it is our experience that for many practical applications an oscillator with a properly engineered method of amplitude control is needed. Without such control there must be either constant attention to manual control of loop gain, or reliance on some degree of saturation in the amplifier or amplifiers. Van der Pol assumed a 3rd-order non-linear characteristic.

As we have shown (*Electronic Engineering*, April and May 1957, pp. 164 to 169 and 210 to 213; and *Wireless World*, March 1970, pp. 134-139) a satisfactory sine-wave oscillator for very low frequencies is obtained by using a two-integrator loop as a selective circuit and adding a feedback path containing a limiter. This produces a two-phase oscillator; but from two phases, three or any number may be obtained by vector addition and subtraction. The distortion introduced by the limiter is readily calculable and can be made small. When variable tuning is required it can usually be obtained more conveniently than with a three-phase oscillator.

F. E. J. Girling
Malvern
E. F. Good
Darlington.

TECHNICIANS OF SCIENCE

In reference to your editorial "Producers before Products" in the June/July issue, I must say it is rare in these times to read such an article in a technical magazine. Well done! But although you take a wide and simple view, the fact is that many of us can't go along with it, or even understand its importance – perhaps because of the very insanity of the society in which we live.

Engineers and technicians must become more aware of what they're actually doing, and not just remain content to satisfy the demands created by people who see everything in terms of money and power. There *are* alternative ways, and to find them we need open minds. True science and engineering involve more than technical knowledge. Those people who stay at the level of technical knowledge are the technicians of science, no matter what academic qualifications they may have – there are no institutions to give higher degrees than those they have anyway. If only we could obtain a clear view of the whole system, from the small details up to philosophical questions about our existence, there would be a better chance that each of us, in his own job, would be doing the right thing at the right time to abolish aggression, harmful ambition and competition and the other injuries to humanity of which you write.

As a relatively young computer engineer, working to develop electronic systems for agriculture, I try to use techniques which make the processes more accurate – but not automatic unless this is necessary because they consume too much energy or cannot be done manually. I'm not working in mass production now, but since I've studied and worked in Britain and have also seen the same problems here in Israel, it's quite clear to me that we are all engulfed in the industrial system you describe.

There are not many articles published about electronic techniques in agriculture. If any *Wireless World* readers are involved in agriculture I will be glad to let them know about my current work.

Yehiel Livnat
Kibbutz Neer-Oz
Doar-Na Hanegev
Israel.

VARIABLE PHASE ALL-PASS FILTER

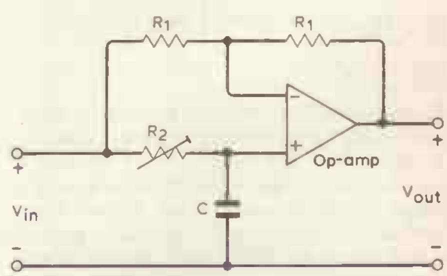
Further to the article on page 77 of the May issue by T. G. Izatt and E. Bell describing a variable phase all-pass filter, the circuit performance described is readily obtained using a simple operational amplifier circuit (below) which, due to the higher open loop gain, will give a more precisely defined transfer function (subject to sufficient bandwidth obtainable from the operational amplifier).

The transfer function

$$\frac{V_{out}}{V_{in}} = T_{(s)} = \frac{1 - sCR_2}{1 + sCR_2}$$

or $T_{(\omega)} = e^{-j2\phi}$
where $\phi = \tan^{-1}(\omega CR_2)$

Two or more such circuits may be cascaded to provide a wider range of phase variation.



F. J. Lidgey
Department of Engineering
Oxford Polytechnic
and
E. A. Worpe
Department of Physics
University of Surrey

COMPUTER CHAOS

I write to express discontent with the general confusion of the world of computing and programming. Different mainframe manufacturers think fit to evolve similar systems, or systems for similar ends, that work in entirely different ways. When they use the same interface there is sure to be some minute difference making them incompatible.

Under the unpleasant political systems, of course, computer structure and software would be rigidly restrained. As it is, the working individual is expected to carry the burden of different systems and system variants which were originally created in the hope of producing profits which he does not see, and indeed they may well fail to materialise.

Anyone in the top ranks of computer engineers can only hope to become really affluent by starting a microcomputer firm which, even if it does not collapse in a few years, will only add to the Tower-of-Babel chaos surrounding us.

Coming now to the home computer, I am still shuddering from an advertisement for a printer containing many complex special l.s.i. circuits "untested, ungauranteed – what more could you want?" Making a note not to fit a printer, and stealing the family tv set to cut costs, one still needs a microcomputer with high reliability, a correspondingly low cost maintenance service, with easily expandable memory and interfacing. BASIC alone is not going to launch anyone on a computing career and there is a case for having PL/M resident in memory, which raises the question of whether amateurs should not be allowed the use of standard programmes legitimately acquired at small cost. This seems an obvious case for state intervention, involving a package deal for amateurs across the country. Your correspondent Russell Gad (June/July issue has had to write his own dissembler/editor for his (bought) microcomputer and this underlines the need for several programs to be provided to run the system properly. Even writing machine code is done efficiently by using high level language(s) and an assembler.

The amateur computer will simulate the operations of more complex computers, running at uncommercial speeds in complex work, and the best amateurs will need access to large, copyrighted programs. Since the computer industry can only profit from their activities it is up to them to make programs freely available. It is not for me to suggest that in default of this programs will be passed around illegally; there should be no incentive for this if proprietary programs are licensed to amateurs at fees reflecting the amount of use they will get.

Bernard Jones
London W1

RADIO AND FREE SPEECH

In relation to the eternal prevarication over citizens' band, we should be quite clear that ours is a representational democracy where free speech does not need to be limited by law, because it can be limited without it. When electrical communication systems were invented, governments became terrified that at last anyone who could make a transmitter could be heard without editorial filtering. The government therefore siezed the air waves much as it had siezed that other means of mass communication, the theatre in Elizabethan times. The method was the same: licensing. Pressure from radio enthusiasts caused the government to permit amateur transmission. The mere achievement of communication over vast distances with watts of power was scientific research. In the long term, however, human communication is about what is communicated and most forms of communication were taboo under the terms of licensing. Certainly the two areas where mutual understanding are most in need, religion and politics, are taboo.

One of the most fascinating aspects of professional radio is listening to foreign correspondents assessing the situation in a country. How vastly more interesting to hear a national of that country give his own assessment. Most of it would be government organised but if the right frequencies were kept open, illicit transmitters could be cheap and easy to construct, difficult to pinpoint. Once it became impossible to clamp down on these most governments would let them exist. Our country has been as repressive in this field as the Soviet Union and for no valid reason except the desire to keep free speech as a hollow sham.

Even more vital than communication of political, scientific and philosophical views is the ending of the isolation of the car driver. Here the need is for short-range radio communication and the need is to make it compulsory. Civilised behaviour is a phenomenon dependent on communication, which is why the car driver is the most uncivilised human being and behaves in a totally egocentric manner.

It seems to me that the laws on radio waves should be concerned with more than protecting commercial and military communication from interference and should not be used to prevent people from communicating. With the ending of the monopoly powers of the Post Office on connecting things to telephone lines it is high time that the silly ban on competing with the Post Office in family communication was ended. Ordinary families just do not spend hundreds of pounds 'phoning each other long distance. Even the Queen has been held to be bound by this silly rule.

Fred Allen
Cambridge

AUDIO KITS

I thoroughly agree with the opinions of your correspondent of many months ago on the variable quality of the current flood of kit-form hi-fi – variable meaning bad to worse – that is with the exception of a certain company who sell kits with pre-assembled p.c.bs. Generally, kit-form hi-fi is best avoided.

Some months ago I paid £100 plus v.a.t. for a high powered (one quarter of the claimed output would be quite sufficient in my humble home – even with highly inefficient speakers) integrated stereo amplifier. I estimated no more than forty hours' work. The job absorbed no less than eighty hours, and another fifteen hours sorting out problems. The latter included a special modification that only a highly qualified engineer could have worked out. Oh yes, the supplier described the kit as "easy to build" and "entirely suited to the novice."

In this day and age one-hundred hours equates to £200 after tax, so one could say that this appalling piece of equipment cost some £300+. True, sixty per cent of kit buyers are not very fussy people, but I am sure that at least forty per cent do consider returning the kits for a refund; however, they rarely do because they believe that a very high standard of assembly work will compensate for the flimsy mechanical design. This seldom works out, and in the end all one can show for the monotonous labours of kit construction is a typical trash item – and more often than not a non-working one to boot. Building a relatively simple device can prove to be highly enjoyable, but a stereo amplifier . . .

So before you rush out to buy that hi-fi kit with undaunted enthusiasm, think about it very seriously, and never, never buy a kit without first listening to a built-up example and also having a chat with someone who has built one up – even if the latter involves an advertisement in the electronics press.

Be warned – sixty per cent of kit buyers probably end up with a non-working item, and around ninety-five are probably dissatisfied.

I firmly believe that all kit suppliers should be involved, that is, the time taken by a reasonably experienced enthusiast without previous knowledge of the kit in question.

Should all audio kits carry a Government health warning?

M. J. Evans
Worcester

WHEN BOMBING PROLONGED A WAR

The recent commemoration of the 35th anniversary of the second world war's ending coupled with the second printing of Max Hasting's outstanding book, *Bomber Command*, makes it appropriate to record the following failure in vital communication between branches of the central intelligence command.

Hasting's book describes how the bombing of Coventry on the night of November 14, 1940 is supposed to have been avenged by inviting Royal Air Force personnel to choose their own targets, and how a certain Bob Dodd volunteered to bomb Eindhoven in Holland although the main option appears to have been Hamburg. It is to be hoped Dodd's navigational skills on this occasion were no better than when (as the book relates) he bombed Epinay in Vichy France in the belief he was bombing Mannheim!

Early in 1941 I was summoned to the London headquarters of the organisation subsequently known as Special Operations Executive, and interrogated by Lt Col E. Schroeter. I joined a few months later and learned the import of this hyper-secret body charged with co-ordinating European Resistance and supplying its peculiar needs.

Following evacuation of Dunkirk by the British, the factories of Eindhoven had gradually developed a major technique in helping to sabotage the Nazi war machine. The communications equipment plants had devised methods of producing programmed short-life thermionic radio valves and other components on which the German High Command relied. There was also a clandestine plant devoted to the invention and production of simple gadgets guaranteed to immobilise German tyre and track vehicles, such as personnel carriers and tanks. If Dodd's preference for bombing Eindhoven rather than Hamburg had the effect of smashing the former town's communications equipment production, the Germans undoubtedly transferred their orders to manufactories far less likely to be under surveillance of saboteurs one half as efficient as those of Eindhoven. In fact, by 1945, the Dutch Resistance engineers had so much perfected guaranteed fail-early electronic components that I and others were being offered contracts to go to Holland, to re-establish techniques of standard equipment production. I opted for somewhat similar duties in Denmark.

"Col. Soejoe"
(Name and address supplied)

Intentional logic diagrams

Improving the intelligibility of logic circuits

by Tony Cassera

In a logic circuit, the designer's intention may be to use a gate in a way other than that described by its name. A Norgate can be used to Nand inputs and the author contends that the *intention* of the circuit designer should be indicated on the diagram.

As the cost of servicing electronic equipment rises, manufacturers are paying more attention to improving the serviceability of their products. There are many ways in which the repair of faulty electronic equipment can be facilitated. Readily accessible circuit boards, good component layout and numbering, and built-in test points are typical areas where great improvements have been made and which make life easier for the hard-pressed service engineer.

Improvements have also been made in the presentation of technical manuals, but there is still much inadequate documentation being produced. One area where there is room for improvement is in the presentation of logic diagrams for digital circuits. There are many drawings that one can only follow with a great deal of effort, involving the following sort of mental monologue; "when that's high and that's low then that will be high and that low; no, that will be high. Or low? Let's start again. When that's low . . .". But in the service workshop or at the customer's site, speed of repair is all-important and logic diagrams should do everything possible to show the user exactly what the designer's intention was at every gate in the circuit. Such drawings may be called intentional logic drawings.

Look at the example taken from an engineering manual in Fig. 1. Can you say quickly what conditions are needed to allow a pulse to appear at the output? As it is drawn, it appears that the two X inputs are Anded and the $\overline{\text{ENABLE}}$ signal is being Ored and POS.X-COUNT. If you look at the manufacturer's catalogue for the devices you will see that the symbols for the 7400 and the 7402 are given there in the same form. Where has the drawing gone wrong?

The sense of such logic can be made clearer by recognizing that when we use inverted logic in which the low level is the true or asserted state, the logic symbols do a swap and And gates become Or gates and vice-versa. The equivalent symbols for the common logical gates with conventional and inverted logic representation are given in Fig. 2. If you don't see this at first write out the truth table for a familiar device, say a two-input Nand gate:

A	B	o/p
0	0	1
0	1	1
1	0	1
1	1	0

Now invert the logic by writing a 1 where there was a 0 and a 0 where there was a 1 to give:

A	B	o/p
1	1	0
1	0	0
0	1	0
0	0	1

which is the truth table of a Nor gate in conventional logic. The convention used is that when we are looking for an assertion of a "low is true" signal we put a bubble on that input line. The mnemonic for the low signal should either carry a bar over its name or, easier to print, be followed by L. When possible, signals that end on a bubble should begin on a bubble. Fig. 1 is redrawn using this intentional symbolism in Fig. 3, where the designer's intention becomes clear. When either X1 or X2 is low and the ENABLE signal is low then the pulse train POS.COUNT PULSE should appear at the output. When logic diagrams are drawn out in this way they are more intelligible than when the gates are represented only by the conventional "manufacturer's" symbols. Let us look at another example. The conventional representation of a flip-flop made from two Nand gates has been redrawn using intentional symbolism in Fig. 4. The second drawing makes it clear that the device is normally in the reset state waiting for a low input on pin A to set it.

Of course, there are ambiguities in the intentional symbolism. When we want to use a signal both in its high and in its low state how should we represent it? Mnemonics should be chosen to

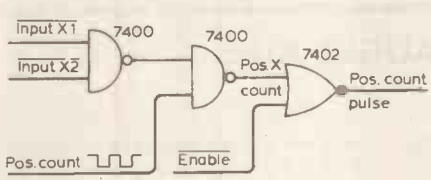


Fig. 1. Conventional logic diagram, in which gates are used for different purposes than their symbols indicate.

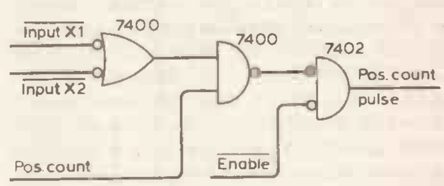


Fig. 3. Circuit of Fig. 1 drawn in 'intentional' symbols.

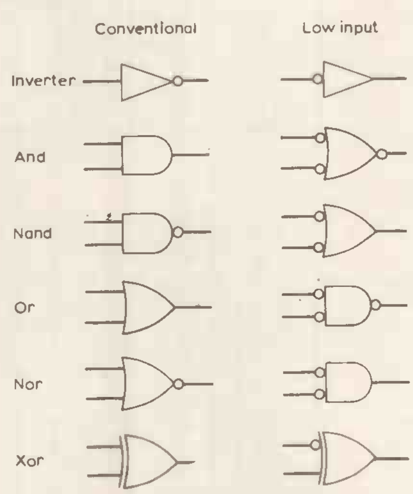


Fig. 2. Conventional symbols and their equivalents when low-level logic is used.

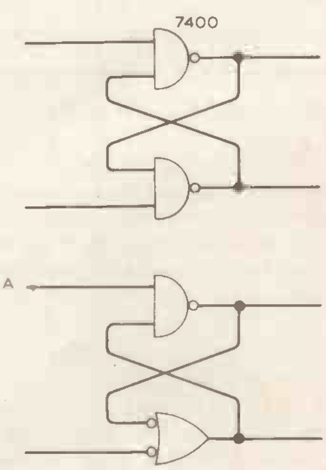


Fig. 4. Flip-flop circuit drawn in the conventional way (top) and in 'intentional' symbols.

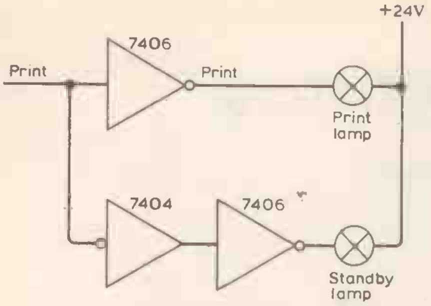


Fig. 5. Printer circuit, showing that ambiguities can appear.

represent some positive action. Thus in a computer printer the signal that sets it printing is best called PRINT rather than NOT STANDBY. But what if we want to light signal lamps to show when the printer is printing and when the printer is in standby? The circuit that might be used is shown in Fig. 5 which breaks the rule that signals that begin on a bubble end on a bubble. Such a situation is unavoidable: all one can do is to make the logic diagram represent some certain state, for example the printer printing, and draw the desired levels for that state. The naming of signals gives more trouble when we have two equally valid functions represented by the high and low on a signal line. For example, in an automatic weighing machine we might have a switch to select pounds or kilograms. A high on the line would make it weigh in pounds, a low in kilos. Should we call the line POUNDS H or KILOS L? It is really a matter of choice but having made the choice the designer might state in his table of signals that POUNDS L = KILOS L.

There is another small ambiguity in the representation of set and reset inputs to devices, for example flip-flops. Such devices are typically set and reset by low signals and the inputs are marked with bubbles as a reminder of this fact. Yet the presence of a reset condition is often a rare event, perhaps only at the power-on time. It must be remembered that the bubble is telling the reader that to achieve reset or set there must be a low going signal, not that he normally expects to find a low there.

A possible criticism of this notation is that the same physical device, say a 7400 quad Nand gate may appear in two different shapes on the same drawing and thus add to confusion. But it is inescapable that in many logic circuits devices described as Nand gates are being used to Or low signals and Nor gates are being used to And low signals. In summary any digital diagram that seeks to show more than the connexions between circuit elements may well involve some inconsistencies. However more sense is better than less sense and adoption of the above guidelines does make logic diagrams more understandable and allows the troubleshooter to check logic levels with his oscilloscope quickly. □

Simple pick-up arm design

continued from page 41

The amount of bias to be applied is best determined using a test record which provides a stereo signal having equal high modulation on each channel. If this signal is reproduced through amplifiers capable of carrying large amplitudes without distortion and the resulting waveforms displayed on a dual-trace oscillocope, the two outputs may be simultaneously inspected. The correct amount of bias is then established by varying the inclination of the vertical pivot until the two output waveforms are equally free of distortion. In practice, there will be a range of adjustment over which there is no discernible change in waveform shape. It is therefore necessary to find two positions of the block at which the onset of distortion can be seen, first in one channel and then in the other. Having located these points, the best setting is one midway between them.

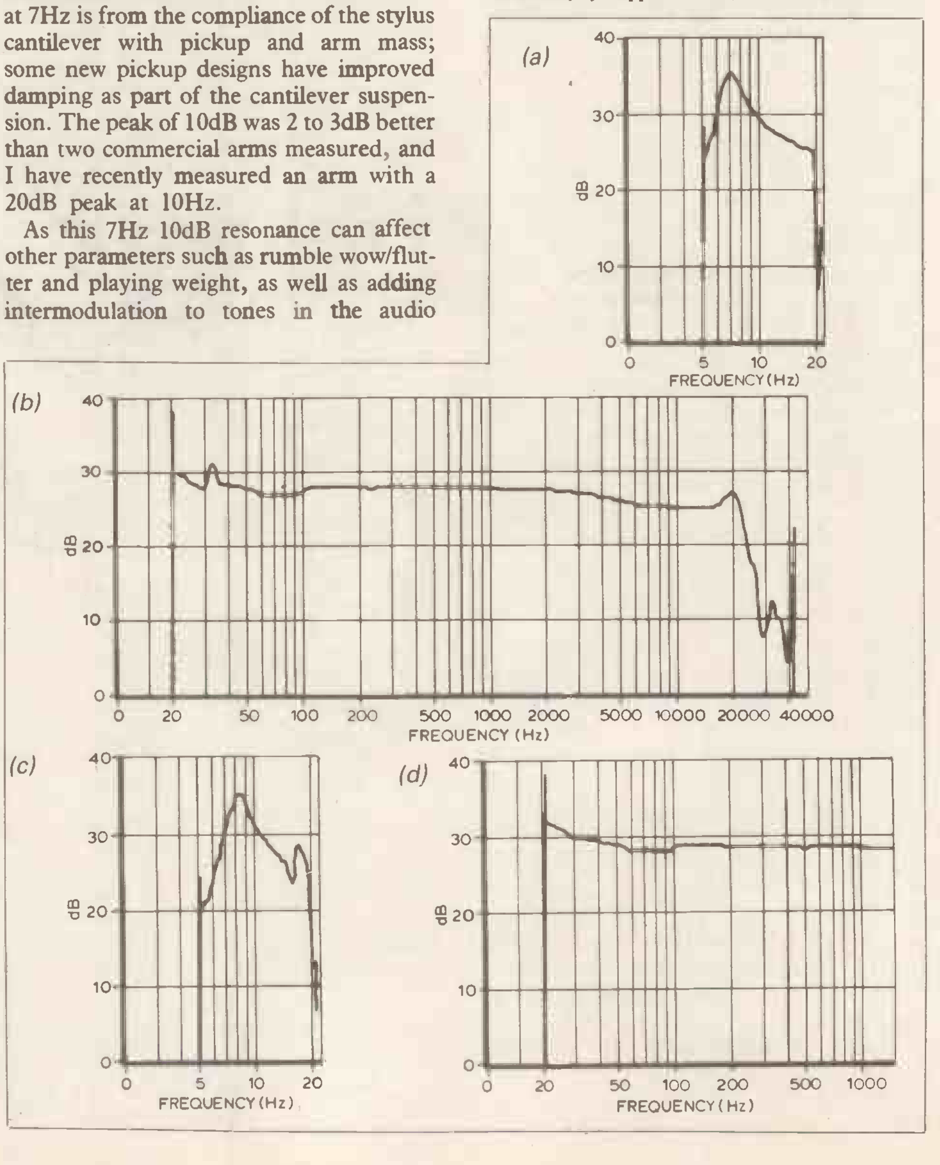
The two photographed versions were tested for arm resonances using the B & K test record QR2010, band 15. The l.f. arm resonance for the first arm, Fig. (a), is certainly in a suitable position as there is minimum energy from the record near 7Hz and it is clear of the lower recorded modulation limit of 20Hz*. The resonance at 7Hz is from the compliance of the stylus cantilever with pickup and arm mass; some new pickup designs have improved damping as part of the cantilever suspension. The peak of 10dB was 2 to 3dB better than two commercial arms measured, and I have recently measured an arm with a 20dB peak at 10Hz.

As this 7Hz 10dB resonance can affect other parameters such as rumble wow/flutter and playing weight, as well as adding intermodulation to tones in the audio band, the resonance can also make the problem of groove jumping from vibrations greater, especially walking and traffic. Modifications were considered but as other arm resonances can occur in the audio band a 20Hz to 20kHz sweep was made, Fig. (b). Similar tests were made on the second arm, Figs (c) and (d).

Close inspection of the first arm showed oscillation about the horizontal pivot, with the two ends as antinodes. I had hoped that moving the horizontal pivot to a ⅔:⅓ position instead of half way would reduce the oscillation and result in nodes at both the pickup and pivot. The second arm, built on this basis, did not show an improvement as far as the main arm resonance is concerned; however the small resonance at 33Hz disappeared.

Although it is hoped to halve the 7Hz resonance on the mk 3 arm, some increase in output toward the 20Hz end can be justified as the IEC recording/playback characteristic specifies a 3dB reduction in amplitude at 20Hz. A slight up-turn from arm resonance could therefore help to keep overall response flat to 20Hz. □

★As shown by Record warps and system playback performance, by Happ & Karlov, AES Convention 1973.



Satellite broadcasting in the eighties

2 – European satellite projects

by G. J. Phillips, M.A., Ph.D., B.Sc., BBC Research Department

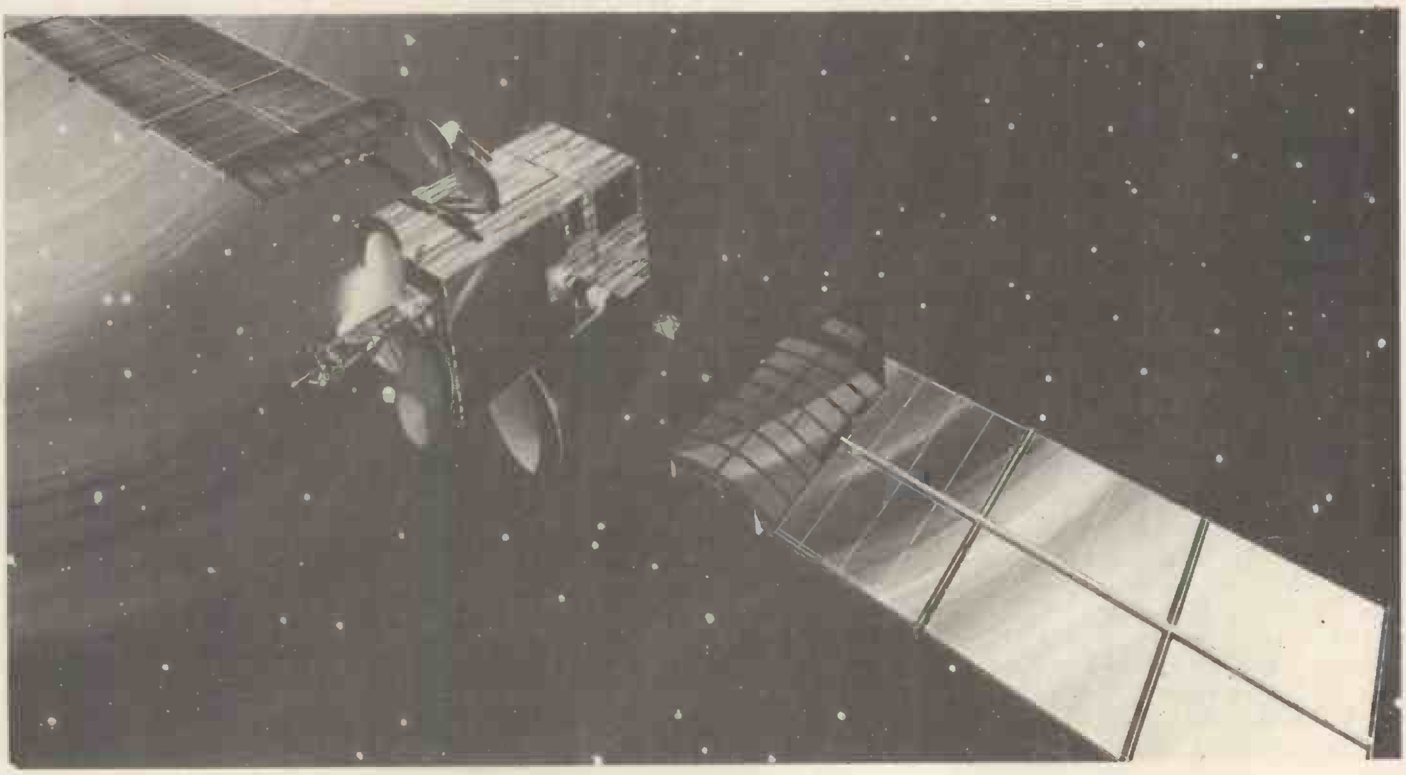
There are a number of satellite broadcasting projects under discussion in Europe. An outline of present proposals is given here but details may, of course, be modified in the course of development.

European Space Agency L-SAT. This project is for a large satellite, to be launched by Ariane-3 in the first quarter of 1984, to carry transponders for a number of different applications including two for pre-operational use in satellite broadcasting.[3] Other transponders will permit trials on business-system communications (up-link in 14 to 14.5GHz band, down-link in 12.5 to 12.75GHz band) as well as propagation and wide-band data-link studies in the 30GHz (up-link) and 20GHz (down-link) bands. The precise details for the two 12GHz braodcasting beams are still to be settled but one beam is likely to be elliptical (approximately 1 by 2.4 degrees), carrying channel 24 with left-hand polarisation to correspond with one of the Italian assignments, and the other a circular beam (1.6 degrees wide) which may carry channel 20 or 28, probably with the opposite polarisation. The intention for the first three years at least is to take advantage of the fact that either beam can be independently steered to cover any European country, so that satellite broadcasting demonstrations and pre-operational experience can be obtained on a time-sharing basis. Most of the experiments are likely to take place with the satellite at the 19° West orbit position. Consideration is being given, however, to operation for extended periods at 31° West and 5° East as may be required to provide pre-operational test transmissions to match plans in the UK, Spain and Scandinavia for operating their own satellite broadcasting satellites in the second half of the decade. The use of the satellite towards the end of its seven-year life is uncertain but Italy has made a strong bid to use it as a starting satellite for its service on two channels until replaced by a purpose-built operational satellite.

The UK has made the largest single contribution so far to the L-SAT project in terms of money and corresponding contracts. At least seven other countries are giving support, notably Italy and the Netherlands. British Aerospace has been selected as principal contractor. The decision in implementing L-SAT will be taken at the end of 1980 following completion of the definition/design stages now in progress.

French and German satellites. France and Germany withdrew their support for L-SAT in 1979 and agreed that they would co-operate in building two satellites, one for each country, each capable of transmitting on three channels. The satellites themselves would be built by Messerschmitt-Bolkow-Bohm in Germany in co-operation with Aerospatiale in France; they are intended to be launched by the Ariane launcher, which is largely a French development, though carried out within the framework of the ESA. Present plans are working towards a launch of the German satellite in December 1983 and the French one in June 1984. The German satellite will operate on channels 6, 10 and 14, and the intention is that two channels

Artist's impression of L-SAT from British Aerospace, the principal contractor. The BBC has proposed to the Home Office that after two years' operation in the 19°W orbit position the satellite should be moved to the UK's orbit position of 31°W and made available to the BBC for a subscription tv direct broadcasting experiment. If, however, L-SAT has to remain at 19°W it might be possible to change the second transponder to a frequency and polarization suitable for the UK, or to fund an additional broadcast transponder for UK use. Two L-SATS would be built, one to be held as a spare.



will carry television and the third a multiplex of sound programmes using digital modulation. The details for France are not yet settled.

NORDSAT project. As indicated earlier, the four Nordic countries are in the privileged position of having secured eight channels in the 1977 plan within a beam whose coverage embraces Norway, Sweden, Denmark and Finland. NORDSAT is the joint body set up both to exploit this beam and to include transmissions for Iceland, Faroes and Greenland, the project being based on the use of a satellite at 5° East. The intention is to relay the various national television programmes throughout the whole group of countries. For the four major countries eight programmes could be relayed and for the Icelandic beam the assignments permit five.

The participants wish to include sound programmes but are reluctant to forgo one television channel by dedicating one channel for a sound multiplex (as proposed in Germany). They wish to develop suitable means for adding several sound channels to the television channel to cater for a stereo pair for television extra language channels connected with the television programme, and additional channels for sound programmes not associated with the television programme. While this is considered feasible, considerable experimentation and international discussion will be needed before the most practical and economic solution can be achieved, preferably with a common standard with other European countries at least for the method of sending the main sound component of the television programme. Experiments with OTS have already shown that a digital sub-carrier for 2, 4 or 6 audio channels may be one way of contributing to the needs and, as already mentioned, there is interest in Europe generally in improving and extending television sound transmission methods. Another avenue to be explored is a digital signal in the video waveform within the line-blanking period (a development of the principle used in the sound-in-syncs system on video links in the UK and for Eurovision) but the system would be dependent upon a practical decoder for domestic receivers.

Other countries. The only other European country that has been reported as actively investigating satellite broadcasting is Luxembourg. This would clearly have a sizeable audience for commercial French, Dutch and German programmes in the area of good individual (domestic) reception extending some 200 to 300km around Luxembourg. Transmissions from French and German satellites from the same assigned orbit position of 19° West would ensure the installation of suitable receivers. Table 1 (last month) shows that those equipped for the French satellite would already have the correct polarisation and half-band for Luxembourg's channels. The limited size of the Luxembourg beam makes direct broadcasting to any part of the UK impractical in terms of individual reception; even in the extreme south-east of England a 2 to 3m diameter aerial would be required for reception, so a commercial audience is unlikely, unless re-distribution of programmes by cable becomes legally and economically acceptable.

Finally, in addition to the US/Canadian CTS experiments mentioned earlier, a demonstration of satellite broadcasting outside Europe has also been successfully accomplished in Japan with a 100W transponder in the 12GHz band.[4]

Current investigations

One serious concern has been possible interference. For example the image frequency or i.f. may correspond to radar or air radionavigation systems of significant power, and second thoughts may be needed on the preferred i.f. and whether to have the local oscillator frequency above or below the signal frequency. A more difficult problem may be harmonic radiation from microwave ovens since, by the end of the decade, both these and satellite receivers are likely to be in close proximity in residential areas. The fifth harmonic of ovens nominally on 2.45GHz may be the main concern and could affect reception in the upper half of the 11.7 to 12.5GHz band. Of course, all the interference mechanisms mentioned have been studied theoretically but, as in many interference problems, practical experience will be necessary to see whether the assumptions are valid. First examination suggests careful design of the receiving system will be needed to avoid problems with the known levels of signals from potential interfering sources.

Satellite television signals are required to have added to their video waveform an "energy dispersal" signal such as a 25-Hz triangular (symmetrical) sawtooth, corresponding to 600kHz peak-to-peak deviation. The dispersal waveform helps in controlling interference to terrestial systems carrying multichannel telephony and operating in the same band. Its removal from television signals will require additional clamp circuits to avoid picture flicker. The current satellite broadcasting standard for 625-line signals calls for CCIR pre-emphasis, a.c. coupling and the polarity convention used in terrestrial microwave links and satellite point-to-point vision links, but the f.m. deviation is about 14MHz – a value higher than terrestial link practice but below present satellite link video-deviation standards. Some aspects of these standards (e.g. the video pre-emphasis curve) may be revised to meet any difficulty in applying them to receivers in the home, although present opinion is that they are already close to the optimum.

For sound transmission it has been proposed for the French and German satellites that, besides an analogue sub-carrier at 5.5MHz for the main sound signal, a second analogue subcarrier at 5.746MHz should be used, either for a second language or to provide a stereo difference signal. To ensure adequate sound quality there are proposals that each subcarrier should deviate the main carrier as much as 5.6MHz peak-to-peak and that the f.m. sound deviation should be increased above the present ±50kHz value to ±65kHz or even ultimately to ±100kHz. Some engineers are concerned about the requirements for i.f. group delay accuracy, video linearity and the careful filtering of the video band that are called for in the domestic receiver to prevent any noticeable degradation (by patterning etc.) of the picture by the presence of the two analogue subcarriers at the proposed level. As a result there is a case for considering a digital sound system of some kind – a single digital subcarrier carrying two audio channels for example – to provide the sound for television from the start of satellite broadcasting. Those preferring this solution feel that, with a lower level of subcarrier, problems of sound or picture quality are more easily resolved and that large-scale-integration (l.s.i.) circuits should ensure that digital demodulation will be cheap and will avoid analogue-circuit alignment problems.

Some journalists and enthusiasts have pictured satellites as a means for anyone to "drop in" and receive television programmes from other countries at will, so that when the 1977 plan did not appear to provide for this, scorn or indignation was expressed at the apparent narrow-mindedness of the planners.[5] What must be understood, however, is that there is nowhere near enough frequency spectrum to plan for interference-free direct reception of the 50 or 100 programmes implied. Furthermore there would be political, legal, copyright and advertising problems in widespread international coverage. Within the scope of the 1977 plan there is nothing to stop shared programmes or joint productions and pressure from the public should ensure that the broadcasting authorities provide them with what they want. The plan is perhaps open to criticism because it is a compromise which allows a considerable degree of inevitable overspill between adjoining countries. Perhaps in the next band at 40.5 to 42.5GHz (apart from thinking of higher definition, digital video and maybe stereoscopy) we should use large apertures and make sure that beams are tailored to fit each country or part of a country more precisely. This in turn would reduce interference to others, lead to more efficient use of the spectrum, and give more channels for each country.

Acknowledgement. The author wishes to thank the Director of Engineering of the BBC for permission to publish this article.

References

3. Herdan, B. L. European multipurpose telecommunication satellite: development plans. paper submitted to AIAA 8th Communication Satellite Systems Conference, Orlando, April, 1980.

4. Ishida et al. Present situation of Japanese satellite broadcasting for experimental purposes. *IEEE Trans.* BC25 No. 4, p. 105, December 1979.

5. See for example editorial in *Nature* Vol. 267, 5 May 1977.

Coherent audio filters for c.w. reception

Novel filter helps separate Morse signals from interference

by **F. Charman** G6CJ

The problem of extracting information from a noisy environment has been with us ever since wireless communication began, and over the years many noise-reducing systems have been invented. Today the radio astronomer separates 'informative noise' from a background which may exceed it by 30 dB or more. The author discusses the problem as it affects the radio amateur using Morse-code signalling, and introduces a novel type of filter which uses coherent addition to help separate steady-state signals from interference, and noise man-made or natural. It uses the tapped delay line principle to provide a non-ringing filter which, as well as lifting the signal from its environment, also has a narrow passband with desirably steep sides.

If all the radio amateurs in the world using the h.f. band could be heard together, one operator's share would be about 3 Hz. Fortunately, the possibility is remote but, nevertheless, the packing density is a severe and ever growing problem, particularly since the most interesting signals are often down in the noise or buried in the 'fourth layer' of interference.

It has often been said that c.w., as it is misnamed, is a dying art. Most professional communication is now carried out by machine systems which are faster and more reliable, though they seldom approach the Shannon ideal as closely as the Morse code: the cost of reliability seems to be very expensive in bandwidth. The argument for keeping Morse alive, given long ago, still holds[1]. The possession of a large body of radio operators is an important national asset, as it was to us during the last world war. In times of emergency, when sophisticated means may fail, the human operator can still carry on some sort of communication with the absolute minimum of gear. One therefore feels justified in continuing to search for ways of improving c.w. communication

C.w. communication

In hand operating, selectivity takes place in two stages: in the receiver and in the operator's head. After the atmosphere and the external noise have done their worst the receiver does its best, and then the operator does a great deal more. He attunes his brain to the signal and its particular rhythm, and uses his knowledge of the redundancy of the language and maybe his knowledge of the operator at the other end of the circuit. This 'subjective selectivity' can be greatly helped by converting the receiver audio output to a stereo image, particularly in searching, when one needs to be alert to the signal environment[2]. The operator is quite as important as the machine and there is plenty of scope yet for improving the coupling between man and machine. However, the following work is largely on the side of the machine.

Filters and noise

Noise in the present context includes white and transient noise, as well as unwanted signals. The author was encouraged to undertake the present investigation after moving to a location abounding in 11kV power distribution lines, which often produce enough somewhat 'coloured' noise to bury any but the most resolute signals.

The first attempt was a highly selective filter of conventional type, but this was quite useless. The noise particles grew into great blobs in the passband,

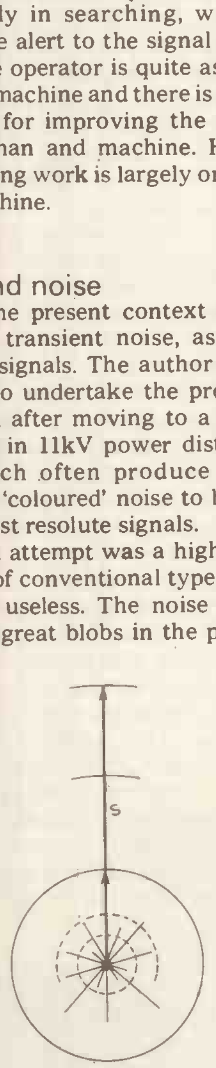


Fig. 1. Illustrating coherence. The vector S represents the signal whilst the noise is a number of random vectors in the centre. The area of the circles represents the power in the signal and the noise. Addition of N signal vectors in phase increases the signal power N^2 times. The noise can only be added as power, so N samples gives only N times noise power, a signal/noise power gain of N.

whilst the weak signals, already modulated by noise in the receiver, actually lost power because they now had a wider spectrum. It became clear that in such a situation it was best to use the widest passband that interfering signals would allow. The transients kicked the narrow-band filter transients into damped oscillations which lasted for at least Q cycles. To prevent this, it would be essential to use heavily damped, non-ringing circuits, but this would normally require a great number of non-interacting sections to produce a narrow-band result.

Some method was sought of securing coherent build up of the wanted signal and it seemed that a delay line several cycles long could provide samples at every half-cycle of the wanted audio frequency, which could be added in phase to enhance the signal at the expense of the incoherent noise, as in Fig. 1. Since the phase must vary with frequency, coherence would degenerate as the frequency moved away from the half-cycle value, and a narrow band might more easily be obtained. This turned out to be the case.

Transversal filters

The tapped delay line, or transversal filter, of Fig. 2 is normally used in the time domain, for generating or recognizing coded pulse trains or shapes, in, for example, secure communication systems or high-resolution radar. The delay line may comprise lumped networks or may be cable or waveguide. In this case it is going to work in the time domain for noise and in the frequency domain for c.w. signals.

For audio applications, network sections are necessary. Several sections are needed to obtain good coherent advantage and they must have low Q in order to prevent ringing. It turns out that all-pass sections make a very good filter and with quite low Q rapidly produce a narrow passband. Second-order sections are required to produce a phase shift of 180° at the mid frequency.

Perhaps one should explain what is meant by the Q of an all-pass filter. In a bandpass filter, of course, Q conventionally determines the rate of fall of amplitude away from centre frequency. An all-pass filter has uniform transmission at all frequencies, but the rate at which the phase changes about the mid frequency is under control; in a lumped, LC allpass, this is determined by the L/C ratios in relation to the terminating impedance, the loaded Q of the network. In dealing with filters it is more convenient to use the damping factor, m, which is the inverse of Q.

Design

In a T-filter of N stages, the adder sums $N+1$ samples in progressive phase. It is quite easy to reduce the sum to a compact formula (see Appendix). For design, since one is working in phase rather than frequency, the first step is to produce a generalized chart of output amplitude versus phase for various values of N, as shown in Fig. 3 (a). The second step is a chart, seen in Fig. 3(b), to convert these responses to frequency scale in terms of the damping factor. Thus m can be chosen to control bandwidth.

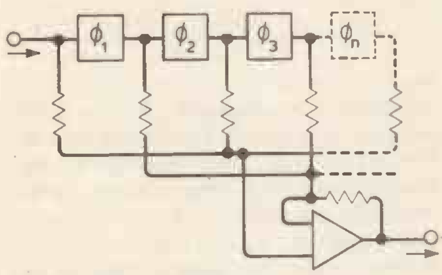


Fig. 2 Transversal filter. The tapped outputs along the delay line are added in alternate phases. At the section mid-frequency where $\phi = 180°$ all samples are fully coherent. Away from this phase position coherence declines, and a bandpass filter results.

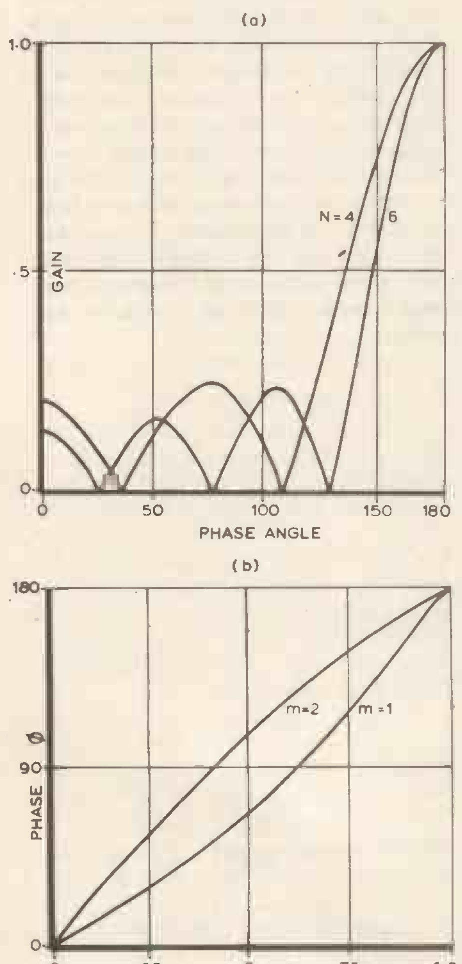


Fig. 3 Design charts for the filters. (a) the basic response in terms of phase per section. (b) conversion of response to frequency scale in terms of damping factor m.

The responses are characterized by steep sides to the passband, followed by sidelobes, as in a conventional m-derived filter or a linear aerial array. These sidelobes are too large for a noisy signal environment, and various means are discussed later for reducing them.

Theory of performance

When a resonant wave enters the filter, each tap in turn delivers one half cycle of oscillation and the output builds up in $N-1$ steps to $N+1$ times the input amplitude; it decays likewise when the signal stops, as in Fig. 4. Of course, this makes the signal sound a little 'woofy' as would a conventional filter, but the rise is linear and quick. Up to eight stages have been used without the effect becoming too unpleasant. At the resonant audio frequency used this slope represents a small fraction of a typical morse dot.

A pulse may in general be treated as a step function or a combination of two or more. Analytically, the output of an ideal allpass to an ideal step is rather alarming – a sharp spike where the components of its frequency spectrum come into phase, followed by a broad pulse representing the intermediate spectrum. But this is not a real situation. The filter sections never pass zero or infinite frequency. The pulses are topped and tailed naturally in propagation through space and through the receiver. What the filter receives is a single, rounded pulse, maybe with some overswing. This propagates down the chain with very little change if the damping is high and the result is no coherence, but a kind of oscillation lasting $N+1$ half cycles. Thus, a c.w. signal is extended in amplitude whilst a transient is extended in time and one can expect the improvement due to coherence of the signal. Similarly, band-limited white noise delivers samples belonging to different epochs, and again there is no coherence.

Filter sections

The use of active networks brings several advantages apart from the avoidance of physical inductors. Modern integrated-circuit amplifiers can provide filter sections with high input and very low output impedances. Thus, there are no interactions between sections; they are unilateral, and reflections cannot run up and down the chain, as they can in passive filters, to produce long-delay echoes on transients. The damping required for frequency response is automatically incorporated in each section of an active filter.

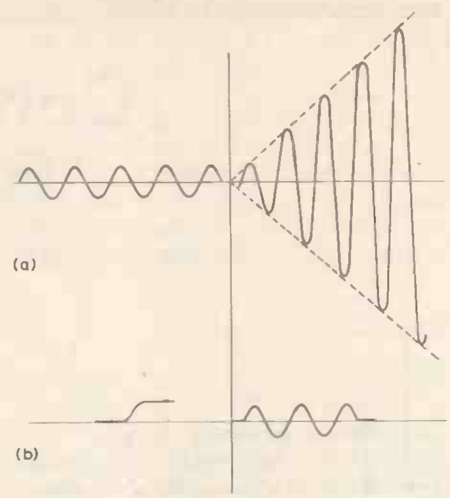


Fig. 4 Response of the T-filter to (a) resonant a.c. signal and (b) band-limited step function. The signal is extended in amplitude and the transient in time.

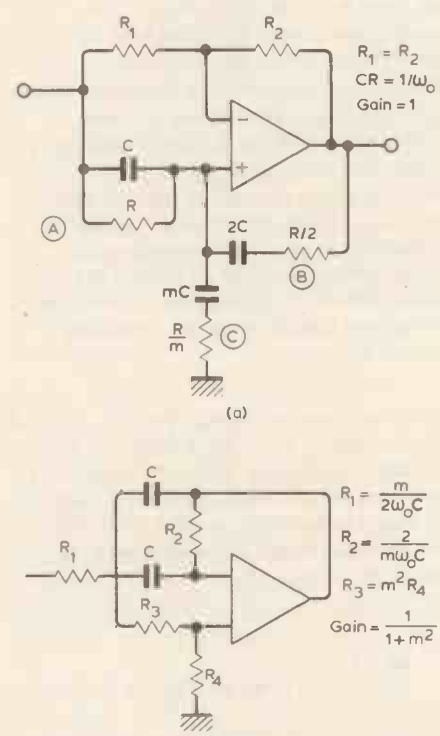


Fig. 5 Two active, all-pass circuits which can be made to give any value of damping factor. The Holt and Gray circuit (a) looks more complex but is easier to implement, since circuit (b) requires special R-values and an extra amplifier to recover unity gain.

Two active circuits are known which provide complete freedom of choice of damping coefficient[3], and their basic forms are shown in Fig. 5. In the Holt and Gray circuit, A is the main arm, controlling the mid-frequency. Arm B has twice the admittance value of arm A and provides a cancellation in the algebra of the response function, whilst arm C with admittances mA determines the damping factor. Resistors R_1 and R_2 fix the gain at unity, as is essential for our T-filter.

The most critical components are the gain control pair. Because of the positive feedback arm B, the circuit can become unstable if R_2 exceeds R_1 by more than a few percent, and oscillation may occur at about 10 kHz, where amplifier limitations brings the phase round to 360° too soon. Arm B is next in order of importance and will upset the gain and phase response if too far out of adjustment. Nevertheless, using 2% resistors and 2½% capacitors, many sections have been made without difficulty.

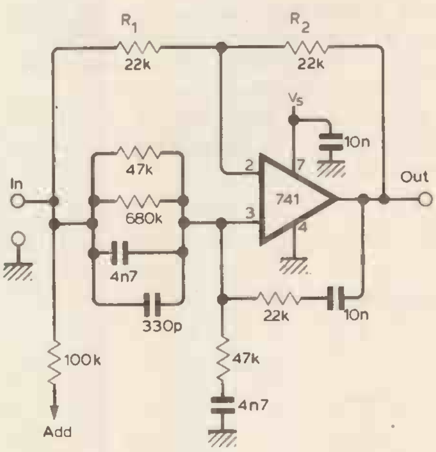


Fig. 6 All-pass section with f_o = 725Hz and m0.94. All resistors except the 680k are of 2% tolerance and all capacitors except the bypass and the 330pF are 2½% polystyrene. The actual vale of R_1 and R_2 is not important but they should be a well matched pair.

The circuit of Fig. 5(b) looks simpler, but requires difficult resistor values, needing parallel pairs or a stable variable resistor, and therefore much trouble in setting up. Also its gain is $1/(1+m^2)$ which must be brought up to unity with a second amplifier.

The centre frequency of the Holt and Gray filter chosen has been set at 725 Hz. This is a comfortable listening frequency and is also in the most selective region of the hearing mechanism. In addition, the *CR* product in the networks can be based on 22kΩ× 10nF, and since the E-series component values are approximately logarithmic, other pairs can be found for various *m*-values. Figure 6 shows the detailed circuit.

Sidelobe reduction

As noted above, the sidelobe level, about −12 dB, is too high. Some 'leak' of the outside world is useful, but it must not let in too much of the noise spectrum, or overload signals; 30 dB is a desirable target. Various schemes have been considered, such as the use of an over-riding bandpass filter or mixed *m*-values along the chain. Another is to go back to the aerial designer, and use a tapered distribution by weighting the taps to the adder. The first two only give about −20 dB, the taper about −24 dB. A taper much used is the familiar 'cosine-on-pedestal' and together with a quite low-Q input bandpass filter can be made to give −30 dB sidelobes. A Tchebysheff taper could no doubt be made but would require very close tolerances to give the −30 dB, but the input filter has another advantage in that it removes much of the transient energy and thereby improves performance. So the head filter has been used as part of the complete design. (Note that the T-filter passes on in some way all the energy which enters whilst the more conventional filter rejects energy outside its passband).

Four-stage linear-array model

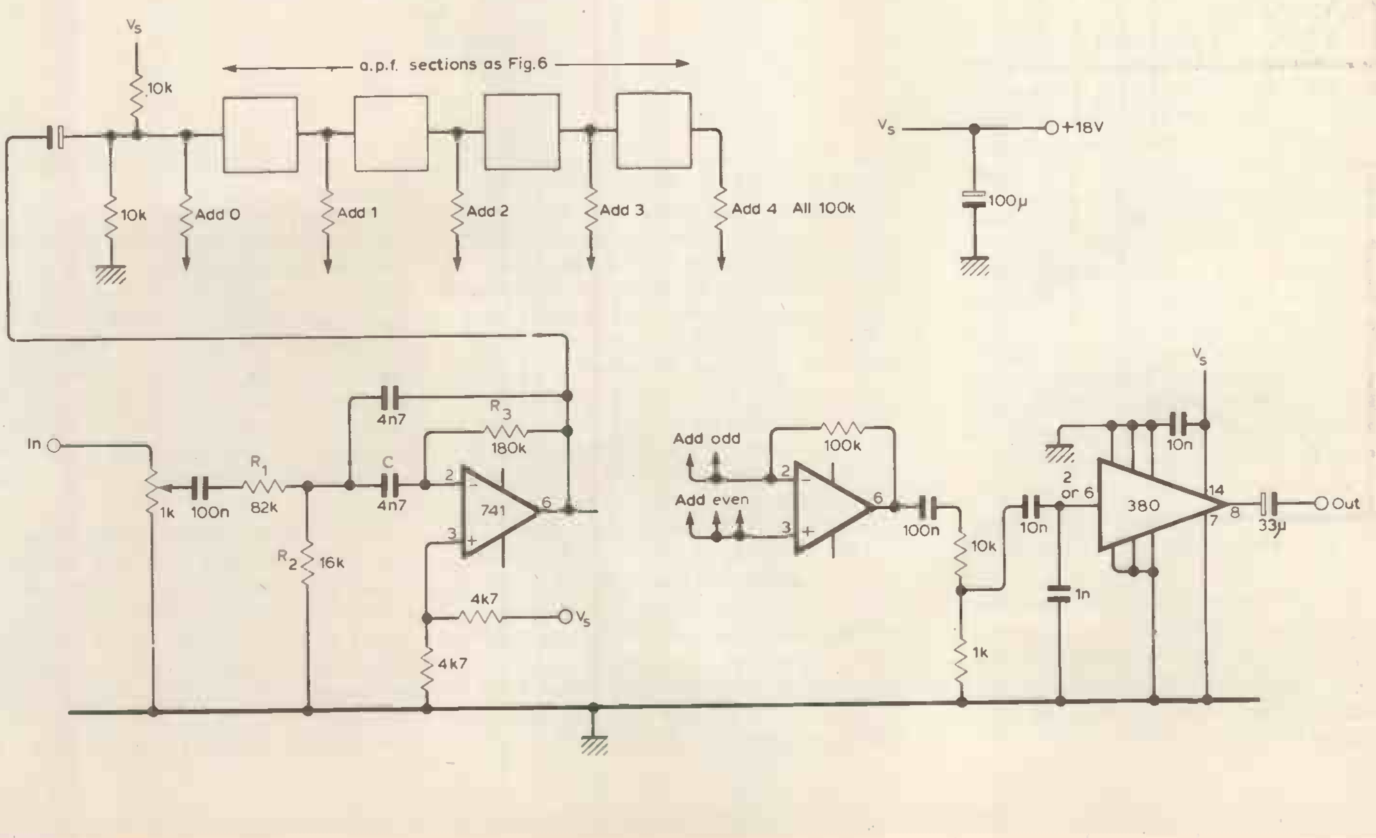
Figure 7 gives details of a four-stage T-filter, using the all-pass sections shown in Fig. 6. A feature is that the operational amplifiers are biassed up to ½V_s, so that a single, earthed power supply can be used. Type 741 amplifiers are used throughout; other types such as the 709 need an external compensating capacitor.

The input bandpass filter is a well known type in which the bandwidth is constant ($B=1/\pi CR_3$) whilst it can be tuned by varying the input shunt resistor R_2. The resonant frequency is given by $1/(2\pi C\sqrt{R_{12}R_3})$ where R_{12} is the parallel value of R_1 and R_2. The gain at resonance is $R_3/2R_1$. It should be tuned to peak at 725 Hz or to balance the two sidelobes of the complete filter. The bias for this stage clamps the non-inverting input to ½V_s.

The delay line uses sections as detailed in Fig. 6, the main properties of which have already been given. One adder tap is taken from each input and one from the final output. Bias is applied at the first input, and the amplifiers are good enough to hold this closely all down the chain, though the models made used two stages per board, based on the 747 chip (two 741 in one unit) and each board was provided with one bias and blocking capacitor. The latter should be 1 μF; this already shifts the phase a few degrees and if any less is used the peak frequency of the filter will move.

To test the allpass sections it is

Fig. 7 Complete four-stage T-filter with input sidelobe filter, using allpass sections as in Fig. 6. Apart from the delay line sections and the adder, no close tolerance components are needed. Note the bias arrangements for the delay line and the input filter. The adder takes its bias from the delay line.



necessary to check that the output terminals (pin 6) are at about ½V_s, and that the phase shift per section is 180° at 725 Hz. The latter test can be made by connecting both input and output taps of one section to the inverting input of the adder; the output of the adder should zero at the 180° frequency. If these tests are satisfied then all is probably well, though it is advisable to use an oscilloscope to test for self oscillation.

The adder is conventional, and takes its bias from the filter chain. The gain is unity for each input but, since there are five, the a.c. output will be five times that of the input to the main filter, so this is the overload point of the system. With a supply of 18 volts to the amplifiers, the system will handle sufficient level for headphone use. If the adder is to be tested separately it must be provided with bias.

The output of the adder will drive a high-impedance headset direct, but for more general use, an output stage has been added, based on the LM380, which will drive any headphones, or a small speaker of almost any impedance. Its input is tapped down to give an overall gain of about 2 or 3. Input blocking is necessary and the 1000pF shunt is protection against strong r.f. fields.

The LM380 is internally protected against output short circuits, but if less than 12 volts supply is used it may lock out and play possum. It is a lively megahertz bandwidth amplifier, and both the 0.47μF and 0.01μF decouplings are essential: if it does oscillate it may draw enough current to do damage. The main earth and heatsink on pins 3, 4, 5 and 10, 11, 12 should connect at least two square inches of circuit board copper, and for speaker use extra heatsink should be added.

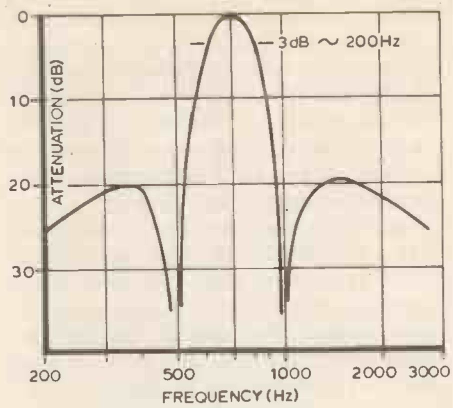
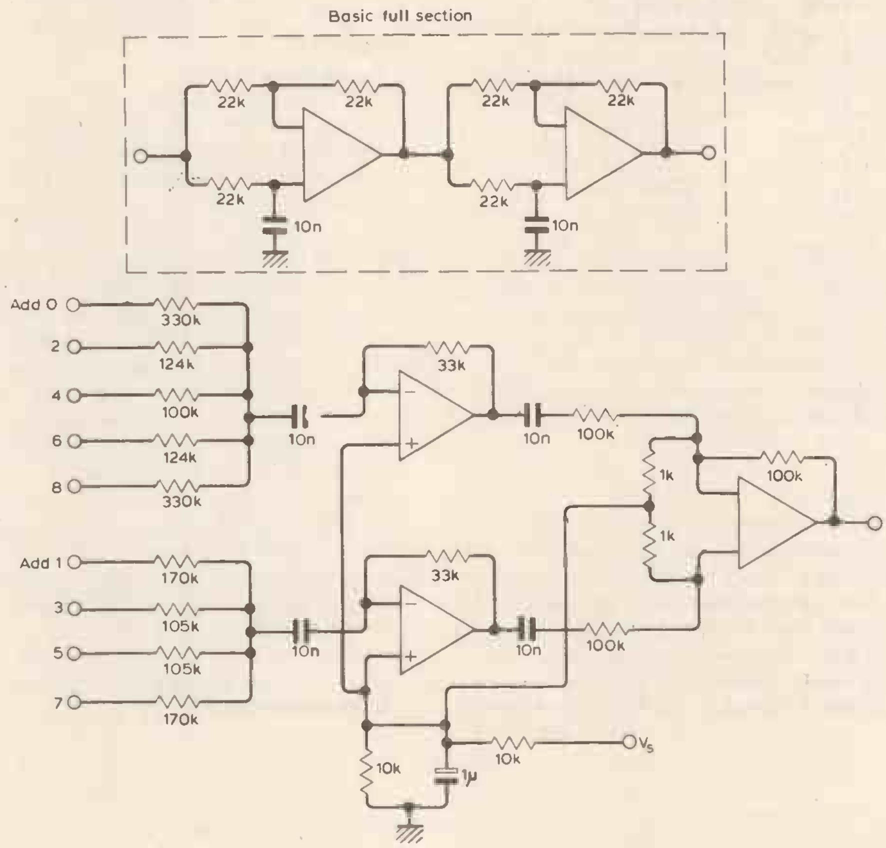


Fig. 8 Frequency response of the linear filter of Fig. 7.

Fig. 9 Basic delay line sections and adder for an eight-stage cosine-on-edestal model. The 2nd order section is replaced by two first order sections for an equivalent m = 2 and the adder redesigned for weighted addition and division.



Performance

The overall frequency response (Fig. 8) is characterised by nulls at about 500 and 1000 Hz, i.e. about 2½ bandwidths apart. (if these are not correct, check the adder and the overall flat frequency response of the delay line). With close-tolerance components these notches may be 40 dB or more below peak level, and one can, in fact, tune out a c.w. signal and listen to its spectrum puffing on either side of the notch. Also the transient rejection is sufficient to reduce the apparent strength of signals with a bad spectrum. However, strong, hash-type noise tends to whistle near the peak frequency, and reducing this effect led to further development.

Cosine-on-pedestal model

The natural frequency of a second-order filter, at which the transports of the transients abound, is $\omega_0\sqrt{1-m^2/4}$. With $m=1$ as in the model above, this quite close to ω_0, and the obvious step is to move toward critical damping with m approaching 2 and thus push the noise energy towards zero frequency. However, more sections are then needed to retain the 200 Hz bandwidth, which increases cost but gives extra coherent gain. A good arrangement would be six stages with m about 1.7, but the cosine-on-pedestal with its low sidelobes was attractive and this model was made.

For the taper distribution the shape and ratio of curve to pedestal is not critical, and $1 + 2\cos x$ is a good shape. But, as with the aerial, the cost of sidelobe reduction is an increased bandwidth and correspondingly reduced gain. Eight stages with $m=2$ gives a 200Hz bandwidth and a gain of about 6.

The essential differences from the previous design are shown in Fig. 9. One advantage of using $m=2$ is that a second-order filter section can be made using two first-order networks in a much simpler circuit. This doubles the number of amplifiers but the cost is about the same, since an 8-pin 741 now costs no more than two polystyrene capacitors.

The taper distribution is arranged by varying the resistors feeding the adder. Since fractional addition cannot easily be carried out on the positive amplifier input, two adders are needed, one for each phase, with a third to bring them together. The first pair are also arranged to divide as well as add, to reduce signal level, by using low value feedback resistors. (The gain is the sum of the eight ordinates of the taper curve).

The frequency response is shown in Fig. 10. In use this filter is noticeably better than the four-stage model, particularly in noise performance. The ability to perceive the signal environment when necessary may be arranged by fitting a switch to cut out the input bandpass filter. In all these filters it is advisable to protect against strong r.f.

fields by screening and filtering both input and output.

Further outlook

It may be considered better to try to apply this filter system earlier in the receiver than the audio stage, before the receiver becomes overloaded by extraneous signals or before the detector has added its contribution of trouble. To do it at i.f. would require a large number of high-Q sections, probably quartz, to produce the narrow bandwidth.* It should be possible however, at an i.f. of say 50 kHz, to use analogue shift registers to give the required delays. However, the devices are expensive, and one would need one with taps at, say, 64-section intervals.

Against this it may be noted that most good receivers have a "CW" filter of about 600 Hz bandwidth in their i.f. amplifier which can deal with much of the overload problem. Also, with recent developments in high linearity detectors and modulators, there is now a better argument in favour of audio filtering[4].

*In regard to transient performance, the demodulator converts the i.f Q to the equivalent audio value.

Addendum

Measurements of transient performance confirmed the pulse response of Fig. 4, though with some irregularity due to the small overswings 'aliasing' into the next epoch. However, the 3kHz band-limited white-noise behaviour disappointing; it seemed that the residual noise energy in the sidelobes doubled the effective noise bandwidth of the narrow passband.

This led to the idea of using low-Q resonant filters instead of allpass sections. Since this paper was prepared, such filters have been made, using sections like the bandpass filter shown in Fig. 7, with a Q of unity. (No tap was taken from the input line since this would produce a wideband signal level of $1/N$).

The expected noise improvement was obtained, and the shape factor was good; the nulls have of course been lost, but the sides pull down much faster than those of a single-stage filter of the same 3dB bandwidth.

The circuits are much simpler and four stages can easily be built round one LM324 amplifier chip. Also there is no need for close-tolerance components or critical stage-gain control, though the overall gain should not be much greater than unity, or the transients will grow. On a cost basis, there is probably no great advantage, since the phase rate is only half of that of an a.p.f. section, and more stages are required for the same selectivity. The optimum arrangement for a 200 Hz bandwidth is probably $N=6$, $Q=1.25$, or better, $N=8$, $Q=1.0$.

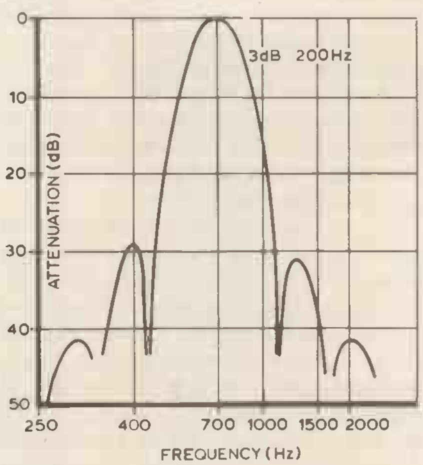


Fig. 10 Frequency response of the eight-stage cosine-on-pedestal model.

Appendix

For the linear filter:

$$\text{sum of output taps} = \sum_{r=0}^{N}(-1)^r e^{-jr\phi}.$$

This is a geometrical series with a progression ratio $(-e^{-j\phi})$ and, using the g.p. sum formula, with Euler's equivalence $e^{jx} = \cos x - j\sin x$, and algebraic and trigonometric manipulation, it can be reduced to

$$\text{SUM} = \frac{\begin{smallmatrix}\sin\\ \cos\end{smallmatrix}(N+1)\phi/2}{\cos\phi/2} \qquad \begin{matrix}\sin\text{: } N \text{ odd}\\ \cos\text{: } N \text{ even}\end{matrix}$$

When $\phi = 180°$, this is indeterminate, but by taking limits the sum is found to be $(N+1)$.

$$\text{Zeros occur when } \phi = \frac{k\pi}{N+1}$$

$$k = 1, 3, 5 ...... N \text{ even}$$
$$= 0, 2, 4 ...... N \text{ odd.}$$

$$\text{The 3dB bandwidth } \phi \approx \frac{1.4m}{N+1} \text{ (empirical)}$$

For the cosine-on-pedestal:
$(1 + K\cos x)$ with $x = 0$ to π over series.

$$\text{SUM} = \sum_{r=0}^{N}(-1)^r e^{-jr\phi}(1 + K\cos r\pi/N)$$

Reduction proceeds as before, but is tedious, giving

$$\text{SUM} = +\frac{K}{2}\,\frac{\begin{smallmatrix}\cos\\ \sin\end{smallmatrix}[(N+1)\phi/2 - \pi/2N]}{\cos(\phi/2 - \pi/2N)}$$

$$-\frac{K}{2}\,\frac{\begin{smallmatrix}\cos\\ \sin\end{smallmatrix}[(N+1)\phi/2 + \pi/2N]}{\cos(\phi/2 + \pi/2N)}$$

Analytically, the method given for a.p.f. sections leads to hyperbolic functions, but for a hand computer one can use $\Sigma = z(z^n - 1)/(z-1)$ where $1/z = 1 + jQ(x - 1/x)$ and $x = \omega/\omega_0$, using the rectangular/polar conversion for the complex z operations.

References

1 Editorial; *QST* August 1964.
2 Charman. F. and Harris. R. "Subjective selectivity and stereocode" *Radio Communication*, Sept 1975.
3 Holt and Gray. *Proc. I.E.E.*, Dec. 1967 p.1871.
4 Tong. D. A. BSc PhD. "Audio filters as an aid to reception" *Radio Communication*, Feb. 1978.

Party electronics

Over a quarter of a million pounds was donated to the Conservative Party and its supporting organizations in the year 1979/80 by companies prominent in electronics, according to a Labour Party information sheet. Among the largest donations in all the companies listed were those of GEC (£50,000), Lucas (£20,000), Plessey (£48,000), Rank (£53,000) and Thorn (£20,000).

Smaller contributions included £13,700 from BICC and a variety of sums below this from Chloride, Chubb, Comet, Decca, EMI, Morgan Crucible, Smiths Industries and Telefusion.

The Labour Party document comments that the total donations made directly to the Tory Party were 104% up on those for the previous year, and that the "obvious reason" for this massive increase was that the General Election of May 1979 inspired a larger number of companies than before to dig deep into their resources in order to support the Conservative cause.

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An acoustically small loudspeaker

2 – Construction of speaker enclosures and active crossovers

by R.I. Harcourt B.Sc., M.I.E.E.

The bass enclosure uses a Dalesford D30-110 5in unit and is 3 litres in volume, giving a 3dB point of 100Hz and a Q of 0.7 (measured values). The KEF B110, which is a rather similar drive unit, could also be used, but has not been tried. The enclosure is constructed of 18mm timber (in order of preference hardwood, plywood and chipboard) to ensure a low level of unwanted sound. The author used chipboard and, using the method outlined in part 1, was unable to measure any panel resonances or other sound transmission through the walls owing to their low levels (at least 30dB down). Dimensions are shown in Fig. 6. The bracing member is used to eliminate one of the two resonances arising from the square dimension, but was also found to remove a chassis resonance of the drive unit which coupled to the box at 320Hz, by bracing the magnet. The member is deliberately made slightly larger than the available space so that when the front panel is fitted the drive unit and rear panel are stressed. The enclosure is filled with 4oz long-fibre wool.

Sub-woofer

The sub-woofer required for adequate bass extension (below 100Hz) has a fourth-order, band-pass characteristic arising from the second-order, high-pass function of the closed-box enclosure system and a second-order boost filter. The 3dB frequency of the sub-woofer enclosure is made the same as that of the 5in bass unit, which is 100Hz. For analysis, the network functions for the band-pass sub-woofer and for the bass enclosure system were combined to produce a bi-quartic function to determine the Q and gain required from the components for a satisfactory 3dB point and low ripple. Normal analytical techniques were found inadequate for the case of the bi-quartic function, and the magnitude function was taken and explicitly solved using a home computer. These functions are shown in the Appendix.

The ideal Q for the enclosures was found to be 0.5, but this low figure was not practicable for the small enclosures used. The figure of 0.7 was taken for the Q and the method of Small[7] was used for the enclosure design. The higher Q implies some ripple in the response, but the computer prediction is that this ripple amounts to only 1.6dB, which is hardly audible, particularly since it is at 113Hz, where room eigentones are likely to give rise to much larger ripples. The frequency response predictions are shown in Fig. 7.

The design procedure for the sub-woofer enclosure was similar to that for the bass unit, but using the Son-Audax WFR 15S. The theoretical Q for the enclosure system was 0.7: however, when the enclosure had been built the Q was measured as 1, and stuffing the enclosure with long-fibre wool did not significantly reduce it. The effect of the higher Q is to introduce about 3dB of ripple into the response. To lower the Q, the old technique of feedback Q correction was used. If the output resistance of the amplifier is made negative by the introduction of positive feedback, then part of the voice-coil resistance is effectively cancelled, giving a lower Q. A theoretical treatment is found in the Appendix. Figure 8 shows the circuit of this arrangement for the case of the Crimson Elektrik ΩE608 amplifier module. The 47k negative-feedback resistor R_7 is part of the CE608 module, and the module must be modified in the following manner. Remove R_6 (1.5k) and C_4 (100μF, 10V) from the CE608 board. Replace R_6 by a 1k2 resistor. Take a screened lead from R_6 to the 100μF, 10V capacitor on the filter board. The 1N4148 back-to-back diodes are an insurance against mains transients, which can otherwise destroy the amplifier when it is used in this manner.

The summing amplifier, which combines the two channels, and the second-order filter circuits are also shown in Fig. 8. The filter is a conventional Sallen and Key type with an f_0 of 28Hz and a Q of 1. The summing amplifier provides the gain necessity for the bass boost of the below-resonance enclosure. Two 27k resistors combine the left and right bass channels within the metalwork housing the active crossovers and amplifiers. A screened lead takes this signal to the summing amplifier, which can be remotely sited. (In the author's installation, the two metalwork kits containing the crossovers and amplifiers are shelf mounted with the loudspeakers remote.) The screened lead takes the combined bass signal to the sub-woofer enclosure, where the filter p.c.b., CE608 amplifier and power supply are sited, enclosed in a Crimson Elektrik metalwork kit.

The WFR15S unit used for the sub-woofer has a high efficiency, which to some extent offsets the amount of bass-boost necessary for the below-resonance design. However, the limiting factor for all loudspeakers at the bass end, whether sub-resonant or not, is the cone excursion capacity, and not the power handling capacity as it sometimes supposed. Since the maximum s.p.l. available from a closed-box enclosure is determined by the area of the cone and the cone excursion, it is possible to increase the s.p.l. by increasing the number of drive units. The WFR15S has a cone-excursion-limited maximum s.p.l. of 86dB at 35Hz, the worst case considered here, since this limit increases at 12dB/octave. This may be compared with 88dB s.p.l. available from two KEF B139 units in a closed box, and with approximately 95dB s.p.l. from the full symphony orchestra. The author has considered using two WFR15S units in two closed-box enclosures placed adjacently, which would produce about 6dB more, i.e. 92dB s.p.l. at 35Hz, but space considerations led to the use of a single unit placed in a corner of the room, which gives a 9dB gain when compared with the free-space radiation figure, at no extra cost.

Clay enclosure

The mid-high frequency enclosure is made of modelling clay (Das) which has the property of setting rock hard without the use of firing. Plastic-wrapped 980g packs are available, and four packs were used for a pair of enclosures. However, the sides were found to be rather thin and six packs would be preferable. The clay is rolled flat with a rolling pin to the required dimensions and moulded round a cylinder of fine-mesh chicken wire. The cylinder is 20cm high and 40cm circumference. Cut a 60mm square hole in the chicken wire for the Jordan 50mm unit, and an appropriate round hole for the tweeter used. (The author has used both the Son-Audax tweeter (available as a smaller-faceplate version, the HD 9×8 D25) and the Scan-Speak 2008 pictured in Fig. 4.) The clay can be worked by those with no previous experience in the art, provided that it is remembered that a little moisture is required for smoothing down and for jointing. Avoid too much water.

Use two packs of Das for the cylinder and one for the base and dome. There will be some left over for patching holes and for surrounding the drive units with a fillet to provide a smooth profile. The wet clay will join to dry clay successfully when a little moisture is used, so it is not essential to obtain a perfect finish first time. The base and dome are made by rolling out one pack of Das to about 50cm square and cutting out two circles. One circle is made into the dome by placing the cylinder vertically in a

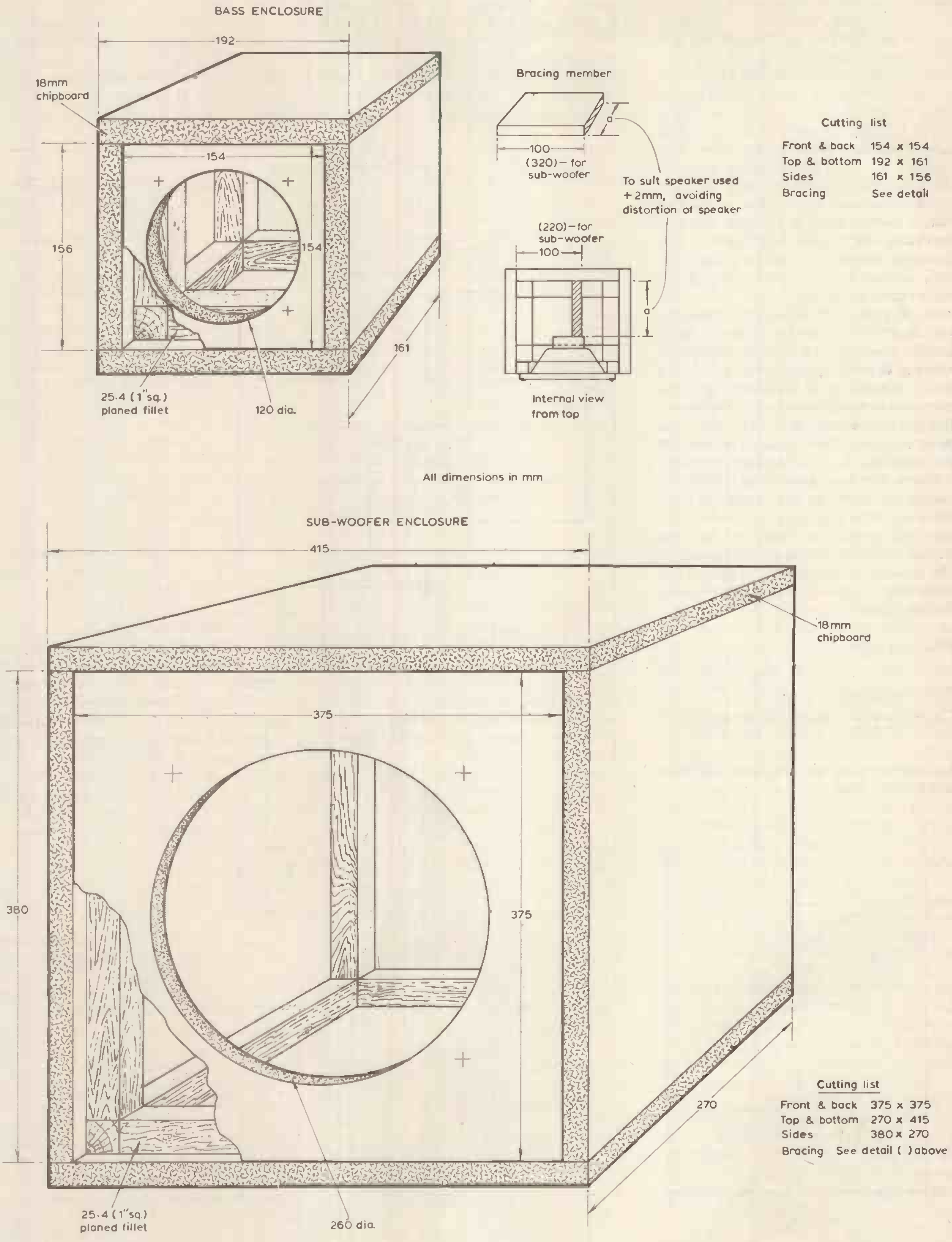


Fig. 6. Construction of the bass and sub-woofer enclosures.

mixing bowl and moulding the circle into the bowl, joining the edges with the end of the cylinder. The moulding is then placed upon the other circle and joined to this, forming the base. It may be found desirable to support the dome from the inside of the enclosure while it is drying to prevent sag. The clay takes about two days to set in an airing cupboard, and when set the drive units are fixed using silicone rubber (bath sealant). Holes are drilled for the wires to exit the back of the enclosure. About 4oz long-fibre wool is used as filling material, before the units are fixed. The adhesive takes 1-2 hours to set, and the spare clay (which should be kept in a plastic bag to prevent drying) can be used to form a smooth fillet around the edges of the units to reduce diffraction. For finishing, Declon acoustically transparent foam is formed into a cylinder and has a circle fixed to the top.

The cylinder of foam is overlapped by 0.5in and stapled together, and the circle for the top is stapled to the top edge of the cylinder. When this arrangement is turned inside out the join is concealed, and the sleeve can be fitted over the clay enclosure. The clay can be sprayed black to match the drive units, and the foam can be sprayed any desired colour, using aerosol paint.

The author has experimented with the positioning of the satellite units, and has found that stereo imaging is best when the units are placed on stands so that the tweeter is the height of the seated listeners' ears, and the units are 0.5-1m away from the walls. This requires stands about 470mm high.

Electronics

The Crimson Elektrik modules for the bass, mid-range and treble units are mounted in two Crimson Elektrik metalwork kits, with interconnecting socketry, as shown in Fig. 9. The kits are stacked on top of each other. One contains a normal two-channel amplifier with power supply, and the stabilized supply for the active crossover modules. The second kit contains four power amplifier modules and the active crossovers. If it is desire to omit the dome tweeters, as recommended by Jordan, then two amplifiers can be omitted also. Full instructions are supplied by Crimson Elektrik for the construction, but the filter p.c.b. for the sub-woofer is not supplied by them. Those wishing to make their own crossovers are referred to reference 2 where Linkwitz gives the circuit and design formulae. The crossover frequencies are 500Hz and 4kHz.

The sub-woofer electronics are housed in a suitable chassis together with a power supply. The author used a Crimson Elektrik metalwork kit and power supply, arranged as shown in Fig. 10. Because there is a positive feedback loop connected

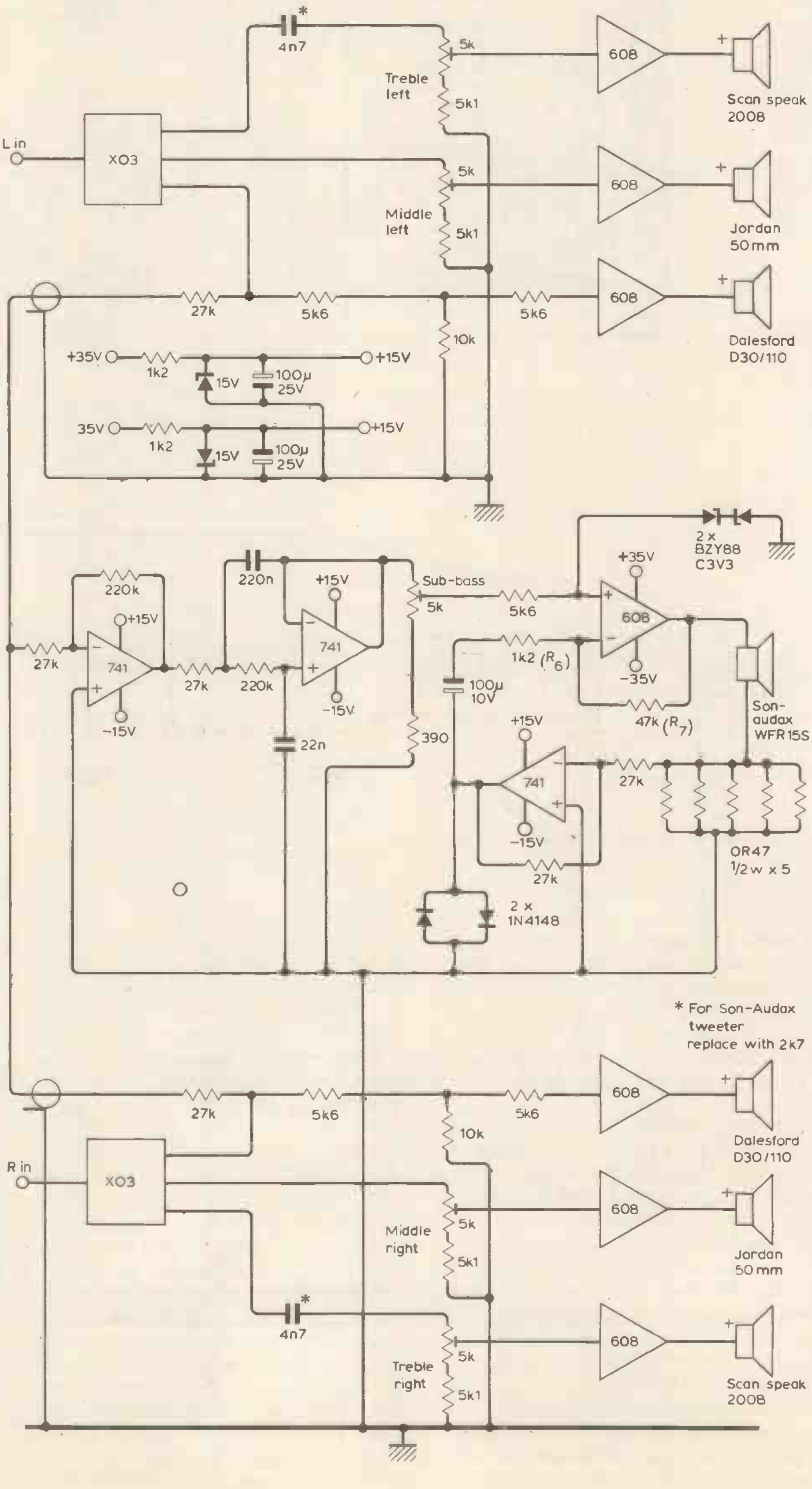


Fig. 8. Summing amplifier and filters for sub-woofer drive.

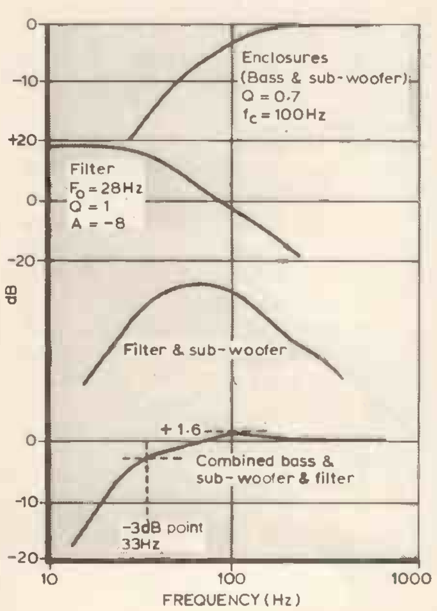
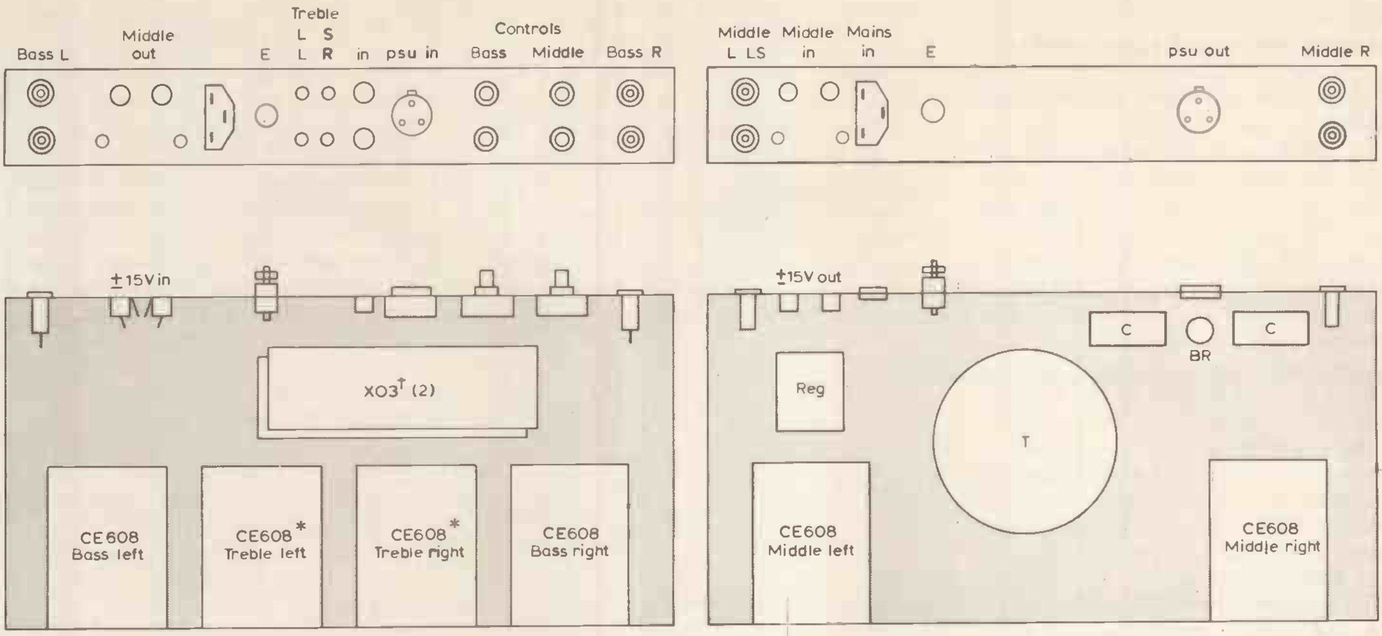


Fig. 7. Computer-predicted curve (bottom) for combined bass and sub-woofer responses.



* Omit for 2-way system
† XO2 for 2-way system

Fig. 9. Suggested layout of amplifiers and filters.

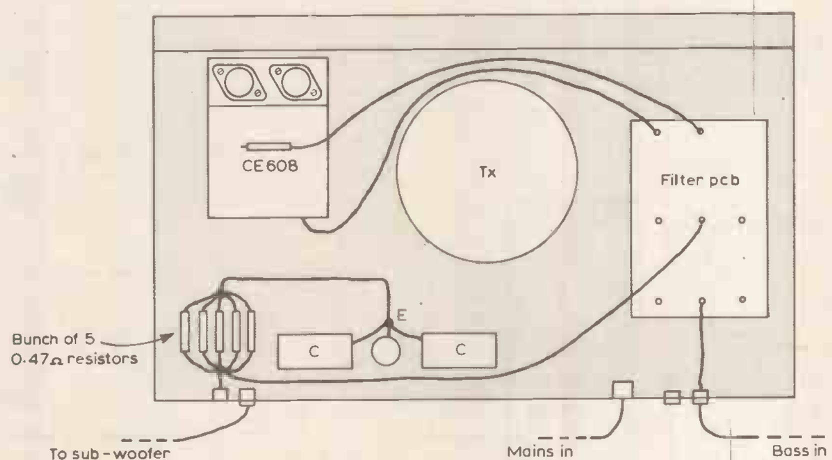


Fig. 10. Layout of sub-woofer amplifier and filter.

between two p.c.bs with screened cable, it is possible that mains harmonics may give rise to hum. To reduce this, use the thinnest screened cable obtainable, and route the cables well away from the mains transformer. The author has found that the screened cables are best positioned by experiment to give the lowest hum.

Listening tests

In each case, the audience was composed of electronics engineers. The first comparison was with the *Hi-Fi For Pleasure* Compact Monitor, a three-way system made from a kit, with much larger enclosures than those of the A.S.L. There was a large difference between the systems and the audience of three were unanimous in preferring the active system. The most noticeable difference was a gain in transient-attack on such instruments as guitar, piano and drums, when using the A.S.L.

The second comparison was with Spendor BC1s. In this case, the audience of two could just detect a difference, but were unable to tell which was in use. There was slightly more colouration or 'warmth' in the lower mid-range (about 500Hz) of the A.S.L. On some material, the greater bass extension of the active system could be heard. Direct comparison of stereo imaging was not found valuable, since the co-sited speakers interfered with each other's sound field.

Other considerations than sonic ones then become important. The larger size of a passive speaker may be a consideration, though price is not since, considering the cost of amplifiers and speakers, the two systems are comparable.

It should be mentioned that high-quality equipment (amplifier, deck, arm and cartridge) was used in the tests, in which analogue, digital and direct-cut records were played. The author is unable to measure or explain the slight 500Hz colouration, and intends to try the effect of lowering the crossover frequency.

Addresses

Crimson Elektrik: 1(a) Stamford Street, Leicester LE1 6NL

Sonaudax Loudspeakers Ltd: Main distributor is Falcon Acoustics, Tabor House, Norwich Road, Mulbarton, Norwich, Norfolk NR14 8JT

Dalesford: A.C. Farnell Ltd, Kenyon Street, Sheffield S1 4BD.

E.J. Jordan Ltd: Stonyway, Bovingdon Green, Marlow-on-Thames, Bucks SL7 2JH

K.E.F. Electronics Ltd: Tovil, Maidstone, Kent ME15 6QP

Scanspeak: Crimson Elektrik

Das is available from larger branches of W.H. Smith

Long-fibre wool can be obtained from Wilmslow Audio, Swan Works, Bank Square, Wilmslow, Cheshire, who also stock Dalesford, K.E.F. and Jordan drive units

Badger Sound Services, 46 Wood Street, Lytham St. Annes, Lancs FY8 1QG, stock most components, including Crimson Elektrik and wool, and are looking into the possibility of producing the sub-woofer electronics as a kit.

References

7. Small, R.H. "Closed Box Loudspeaker Systems" part 1 and part 2, *J. Audio Eng. Soc* 20 No. 10 and 21 No. 1, 1972 & 1973.

Appendix: sub-woofer characteristics

A closed box enclosure has network function

$$GH2(s_n) = \frac{s_n^2}{s_n^2 + s_n/Q_o + 1}$$

$$\text{where } s_n = s/\omega_o$$
$$s = \sigma + j\omega$$

The second-order, low-pass with gain A is

$$GL2(s_n) = \frac{A}{s_n^2/h^2 + s_n/hQ_1 + 1}$$

$$\text{where } h = \omega_f/\omega_o$$

The two functions above in cascade give the fourth-order, bandpass

$$GB4(s_n) = \frac{As_n^2}{(s_n^2 + s_n/Q_o + 1)(s_n^2/h^2 + s_n/hQ_1 + 1)}$$

Summing this with the response of the bass enclosure (1 channel only)

$$GH4(s_n) = \frac{As_n^2 + s_n^2(s_n^2/h^2 + s_n/hQ_1 + 1)}{(s_n^2 + s_n/Q_o + 1)(s_n^2/h^2 + s_n/hQ_1 + 1)}$$

The magnitude function, which is too long to reproduce here, is then taken and programmed into a home computer. The result of evaluating this function is that, for a filter Q_1 of 1, an enclosure Q of 0.7 and an enclosure f_0 of 100 Hz, the gain required is $A = -8$, the 3dB-down requency of the system is 33Hz and ripple is 1.6dB at 113Hz. Note that the gain is negative, as is usual with second-order crossovers, when the drive unit is connected out of phase to achieve this. In the case of this design, the negative gain is achieved by the summing amplifier, and the driver is connected in phase.

For the D30/110 an enclosure volume of 3 litres was found to give the necessary Q and f_0. For the WFR15S an enclosure volume of 33 litres gave an f_0 of 100Hz, but the Q was too high. To reduce the Q the following expressions are considered from Small[7].

$$Q_{ts} = Q_{es}Q_{ms}/(Q_{es} + Q_{ms}) \qquad 1$$

$$Q_{es} = \omega_s C_{mec}(R_e + R_g) \qquad 2$$

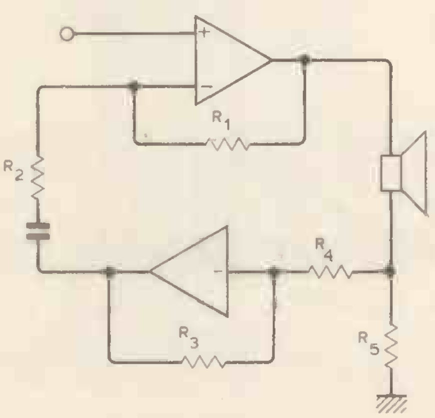
R_g is the output resistance of the amplifier and, by making it negative, Q_{ts} can be reduced to the desired value. The required Q'_{ts} is given by:

$$Q_c/Q'_{ts} = f_c/f_s$$

f_s = 31 Hz, f_c = 100 Hz, Q_c = 0.7. Therefore,

$$Q'_{ts} = 0.22$$

since $Q_{ms} = 4.19$, $Q'_{es} = 0.23$ from eqn. 1.



We know that with $R_g = 0$, $Q_{es} = 0.46$ and that $R_e = 7.3$, so from eqn. 2,

$$\omega_s C_{mec} = 0.063$$

and the required R_g is -3.7Ω.

The amplifier is given a negative resistance by the circuit shown.

By inspection:

$$R_g = \frac{-R_1R_3R_5}{R_2R_4}$$

For the CE608, R_1 = 47k. Choose R_5 = 0.1Ω, $R_3 = R_4$ = 27k. Then R_2 = 1.2k.

List of symbols

c velocity of sound 345 m/s
C_{mec} electrical capacitance representing moving mass
f frequency
f_c resonant frequency of closed box system
f_s free air resonant frequency of drive unit
G(s) response function of s
Q_{es} Q of driver at f_s considering electrical resistances R_e and R_g only
Q_{ms} Q of driver at f_s considering driver non-electrical resistances only
Q_c total Q of system at f_c
Q_{ts} total Q of driver at f_s considering all driver resistances and R_g
R_e d.c. resistance of driver
R_g output resistance of amplifier
s complex frequency variable (jω=σ)
ω_s radian resonant frequency of driver in free air □

The Author

The author was born in London, and lived as a child in Nairobi, Kenya. He attended Ipswich school, and from there went on to Southampton University, where he obtained an Honours Degree in Electronic Engineering in 1967. Appointed as an Executive Engineer in the Post Office HQ, he spent some time carrying out organisation and methods studies, before moving on to the Experimental Packet Switching System (EPSS) for which he helped to produce a mini-computer-based tester. Currently he is with the Mechanization and Building department of Postal Headquarters, where he is developing a traffic recording system for parcel sorting.

Personal privacy of engineers

Mr F. W. Sharp of the Institution of Electronic and Radio Engineers writes to us as follows:

The suggestion was made in a BBC Radio 4 programme "Reel Evidence" broadcast on the evening of August 26th, that the membership lists of the chartered engineering institutions were freely available and could be used to compile unauthorized information about the work of individuals. As far as the IERE is concerned, this is not so: the Institution's membership list is maintained on a strictly confidential basis. By decision of the IERE Council a "list of members" is now no longer published.
F. W. Sharp

Audio gain controls

2 – Obtaining equal gains in the two channels of a stereo pair

by Peter Baxandall, B.Sc. (Eng.), F.I.E.E., F.I.E.R.E., M.A.E.S.

Continuing his survey of gain control problems and solutions, Peter Baxandall discusses tracking volume controls in stereo amplifiers, concluding with a proposal for an unusual design of control.

Stereo gain control tracking

Connected with the problem of obtaining a satisfactory scale-shape for the volume-control law in stereo control units, is that of achieving an accurately equal gain in the two channels at all knob settings. Preferably, the channel gains, if adjusted to be equal at one volume control setting, by means of the balance control or otherwise, should remain within ±1dB of equality at all other settings of operational significance. This is quite likely not to be the case if cheap types of carbon-track, ganged log. pots. are used.

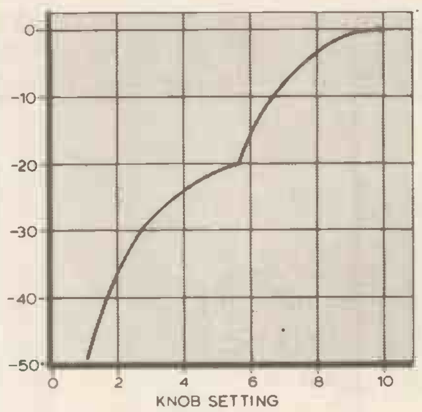


Fig. 20. Approximation to log. law obtained by changing resistivity of halves of carbon-track pot.

Figure 20 shows the measured gain-variation law on one channel of a very high quality, commercial control unit, having a simple, passive volume-control circuit, using the above type of pot. The very rough approximation to a logarithmic (linear-in-dB) law is obtained by making the two parts of the pot. element of different surface resistivities, the resistivity changing suddenly from one value to another at half-rotation of the knob. At the point of change, there is a severalfold change in slope, which is a quite undesirable feature. Though some quite cheap commercial pots. give a better approximation to a logarithmic law than that of Fig. 20, there is clearly much to be said for employing a type of gain control circuit which inherently gives a smooth and nearly logarithmic law without needing pots. with a non-linear resistance law. It ought to be easier to make ganged linear pots. with accurate matching between sections than to make ones with non-linear laws and equally good matching, though unfortunately, limited experience in measuring the departure from linearity of cheap so-called linear carbon-slider pots. has shown that undesirably large errors often occur.

One solution to the problem of obtaining a good scale shape and accurate tracking is, of course, to employ ganged, stud-type volume controls. These should give not more than 2dB per stud, at the most, and should have a click mechanism to make sure they are never left in an unsatisfactory half-way state between one stud and the next. Then, provided their internal resistors are accurate and stable, very accurate tracking will be obtained.

Careful measurements have been made of the resistance versus knob-position relationship for eight specimens of R.S. Components 10kΩ linear "slide tandem" pots, and Fig. 21 shows the results for three of these. It will be seen that:

(a) none of the specimens has a truly linear law;

(b) the departure from linearity, though of somewhat different nature for the three specimens, is nevertheless of fairly accurately the same shape for the two halves of each specimen, and this is the case also for the other five specimens;

(c) there are considerable differences between the absolute total resistance values of the specimens, and, in the case of specimen number 3 particularly, between the two resistance elements in one specimen.

For normal audio control-unit applications, minor departures from the nominal volume-control law are unimportant, provided they are equal for the two channels. Differences in the absolute resistance values for the two elements in a stereo pot. may or may not cause gain mistracking, dependent on the nature of the associated circuit.

Consider first the circuit of Fig. 22(a), which gives a range of gain well suited to most control-unit applications. (The circuits of Figs. 12 and 14 are better suited to microphone-amplifier applications, where the higher maximum gain given is advantageous.) It is necessary in practice to insert a resistor R_1 in series with the input end of the pot. to limit the maximum value of k obtainable to, say, 0.9 or 0.95, otherwise – see Fig. 8(a) – the characteristic becomes too steep at the high-gain end. Note that k is defined as

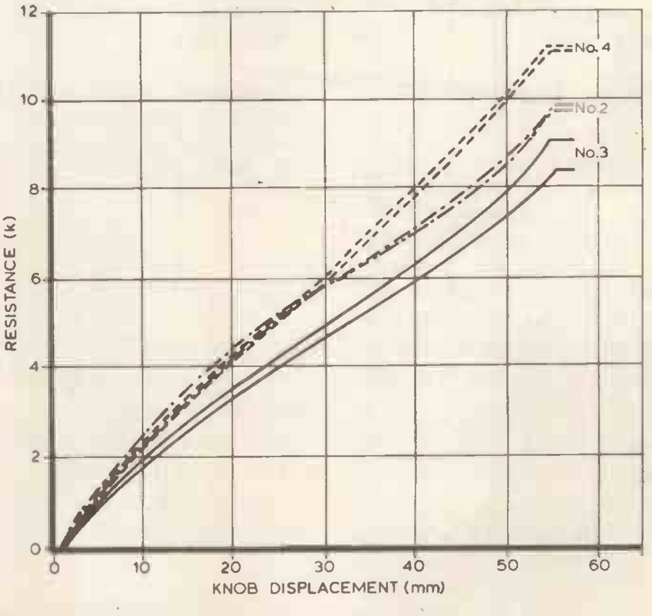


Fig. 21. Samples of characteristics of dual linear pots.

shown in Fig. 9, and is not the same as k' in Fig. 22. The reason for introducing k' is that it enables a more straightforward comparison to be made between the behaviour of the (a) and (b) circuits in Fig. 22 – k' is a measure purely of the knob position, whereas, as shown in Fig. 9, k involves also the value of the fixed series resistor.

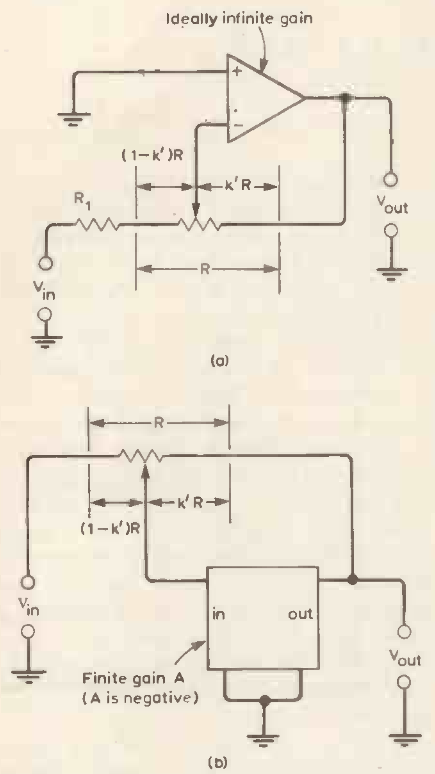


Fig. 22. In circuit (a) the total resistance of R compared with R_1 varies the control curve, whereas the circuit at (b) is independent of track resistance.

The gain of the Fig. 22(a) circuit is given by:–

$$\frac{V_{out}}{V_{in}} = -\frac{k'R}{(1-k')R+R_1}$$

$$= -\frac{k'}{1-k' + R_1/R} \qquad (5)$$

The gain of the Fig. 22(b) circuit is given by:–

$$\frac{V_{out}}{V_{in}} = -\frac{k'}{1-k' - 1/A} \qquad (6)$$

It will be seen that equations (5) and (6) are of exactly the same form, A being a negative number to represent the fact that the amplifier is a phase inverting one. Thus if A is made equal to R/R_1, the two circuits will have identical graphs relating overall gain to knob position.

Circuit (b) has an advantage over (a), however, in that the control characteristic is quite independent of variations in the absolute resistance R of the pot. element, whereas in (a) an increase in R requires a proportionate increase in R_1 to return to the same control characteristic. Thus, using a pair of circuits of the (b) type in a stereo system, differences in the element resistances in the two halves of the ganged pot., which, as already mentioned, are found to occur in practice, will not affect the accuracy of tracking between the channels, whereas in (a) an increasing discrepancy will occur as the gain setting is increased. It has been assumed that the amplifier input impedance in circuit (b) is very high, so that there is no significant loading on the pot. slider.

To carry out the Fig. 22(b) scheme in practice, an economical recipe is required for a phase-inverting amplifier of high input impedance and feedback-stabilized gain. The simple arrangement shown in Fig. 23(a) is not very good, for to avoid significant loading of the slider, the resistors R_a and R_b must be made very high in value, which then seriously degrades the noise performance. This problem may be satisfactorily solved by inserting a unity-gain follower between the slider and R_a, R_a and R_b now being made of very much lower values. This arrangement is shown in Fig. 23(b).

Amplifier A in Fig. 23(b) has to handle only quite small voltage excursions, even though V_{in} and/or V_{out} may sometimes reach levels of several volts. There is no need to use an op. amp. for A, better economy, with little degradation in performance, resulting if a simple emitter-follower is used. A satisfactory practical design is given in Fig. 24. Over a range of gain adjustment of approximately 30dB, the departure from the ideal straight-line graph is no more than ±1dB. The unity-gain op. amp. follower at the left has been included so that the complete circuit presents a high input impedance to the source of V_{in} at all gain settings – this source may be the tape and radio inputs to a control unit, for example. Without this follower, the input impedance at maximum gain setting falls to 1.09kΩ.

Because the gain of the Fig. 24 circuit is independent of the total resistance of the pot. element, being dependent only on the slider tapping ratio, the tracking error between stereo channels can probably be held within ±1dB limits in production, over a 30dB range of gain, using low-cost carbon pots.

Alternative technique. An alternative technique, which, like the previous one, avoids the necessity to put fixed resistance in series with the pot. to limit the

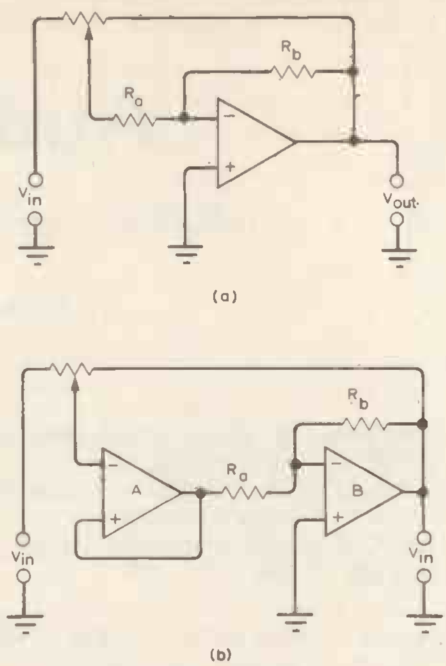
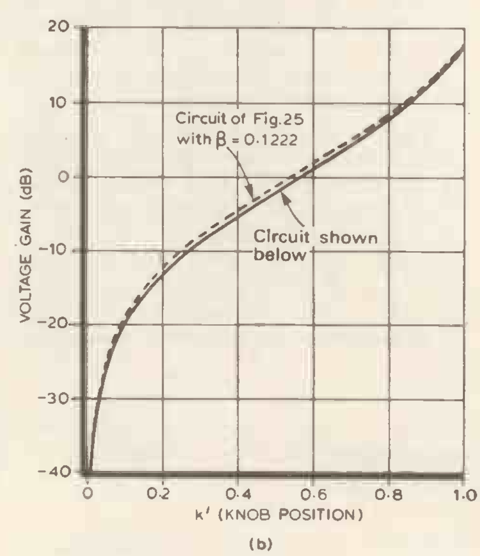
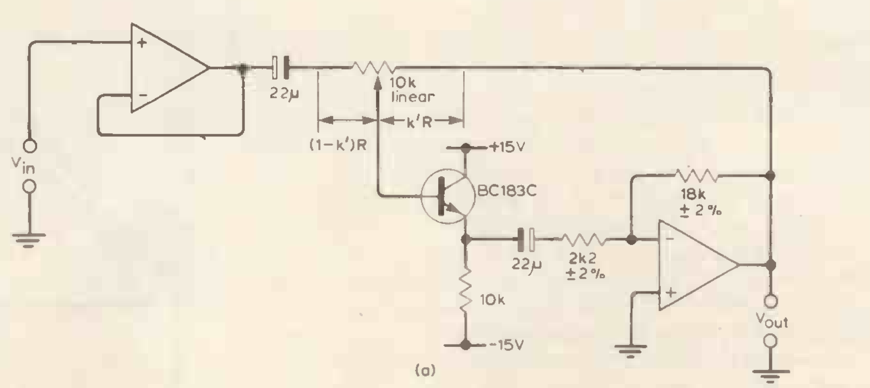


Fig. 23. Two circuits embodying the Fig. 22(b) idea. Circuit (b) uses voltage follower to avoid need for high-value resistors R_a and R_b.

Fig. 24. Practical version of Fig. 23(b) is shown at (a), with its control characteristic at (b) (lower curve).





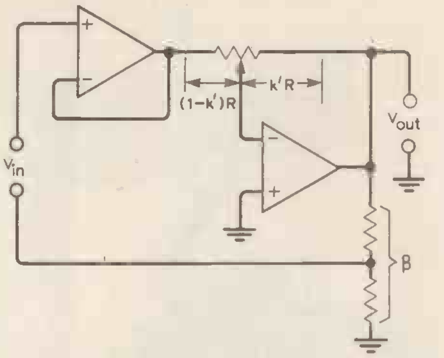


Fig. 25. Feedback amplifier limits maximum gain without use of fixed resistor in series with pot. Characteristic is upper curve in Fig. 24(b).

maximum gain, is shown in Fig. 25 in its simplest form.

Here a fraction β of V_{out} is fed back as overall negative feedback in series with V_{in}. The forward gain, A, of this feedback system is $-k'/(1-k')$, so that applying the usual feedback formula gives:

$$\frac{V_{out}}{V_{in}} = \frac{A}{1-A\beta} = \frac{-k'/(1-k')}{1-[-k'/(1-k')]\beta}$$

from which

$$\frac{V_{out}}{V_{in}} = -\frac{k'}{1-k'+k'\beta} \qquad (7)$$

Comparing equation (7) with (5) and (6), it will be seen to be not quite of the same form, for the third term in the denominator of (7) involves k', whereas this is not the case in (5) and (6). Suppose we choose β in the Fig. 25 circuit so that equation (7) gives the same maximum gain, i.e. gain at $k' = 1$, as that given by the Fig. 24(a) circuit in accordance with equation (6). This requires $\beta = 0.1222$, and equation (7) then yields the broken-line curve shown in Fig. 24(b). Looking at these two curves, it is very tempting to conclude that the circuits of Figs. 24 and 25 inherently give slightly different shapes of characteristic, but more careful thought shows that this is actually not the case.

Referring to equation (7), this may be written:

$$\frac{V_{out}}{V_{in}} = -\frac{k'}{1-(1-\beta)k'}$$

$$= -\frac{1}{1-\beta} \times \frac{(1-\beta)k'}{1-(1-\beta)k'}$$

$$= -\frac{1}{1-\beta} \times \frac{k'}{\frac{1}{1-\beta} - k'} \qquad (8)$$

Equation (6) may be written:

$$\frac{V_{out}}{V_{in}} = -\frac{k'}{1-1/A-k'} \qquad (9)$$

Comparing (8) and (9), it will be seen that if A and β are so chosen that $(1 - 1/A) = 1/(1 - \beta)$, then the only difference between the equations is that the right-hand side of (8) is multiplied by the constant factor $1/(1 - \beta)$. This means that the curves for the two circuits are exactly the same in size and shape, but that represented by equation (8) is displaced upwards relative to the equation (9) curve by $20 \log 1/(1 - \beta)$ decibels.

Thus, the real difference in behaviour between the circuits of Figs. 24 and 25 is that when designed to give identical shapes of control characteristic, the Fig. 25 circuit, at all knob settings, gives a slightly higher gain than does that of Fig. 24.

Passive control using linear pots.

A single linear pot. used as shown in Fig. 1 or Fig. 2 gives a control law which is quite intolerable for normal audio purposes. It is well known that by shunting a load resistor from the slider to earth, a characteristic approximating more closely to the ideal uniform decibel spacing may be obtained, though unfortunately only over a range of some 20dB or thereabouts. Fig. 26, based on calculations I did while a student in 1942, shows what happens as the loading is varied.

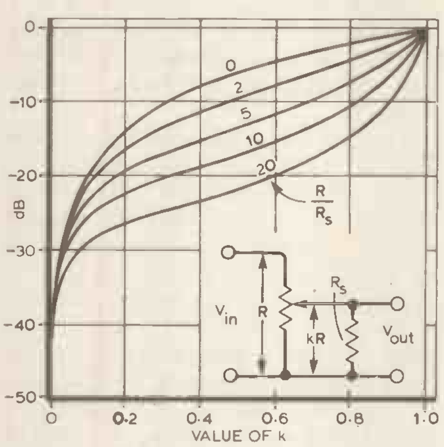


Fig. 26. Family of curves obtained from shunted linear pot. slider.

Very much better results than the above can be obtained with passive circuits using linear pots. if one or more fixed tapping points are provided, and the simplest such scheme is that shown in Fig. 27(a). If the resistors R_a and R_b are made of very much lower value than the pot. resistance, the attenuation with the slider at the tapping position is determined almost entirely by the values of R_a and R_b, and is virtually unaffected by any non-linearity in the law of the pot. element itself. There is, however, a sudden change in slope as the slider passes the tapping point, and a typical characteristic is shown in Fig. 27(b).

By adding a loading resistor between the slider and earth, a much better characteristic can be obtained, and it is possible to choose the value of this resistor so that there is no discontinuity in slope as the tapping point is passed. Fig. 28 shows a practical design employing a centre-tapped linear pot. with the slider output suitably loaded, together with the characteristic obtained. Over a control range of about 35dB, the departure from the ideal straight line is not much more than ±1dB. By having two tapping points on the pot. element – and low-cost slider pots. can be obtained with this feature – the nearly-linear control range can be extended to about 50dB if required, satisfying the most exacting needs.

For instrumentation purposes, the above technique can be extended much

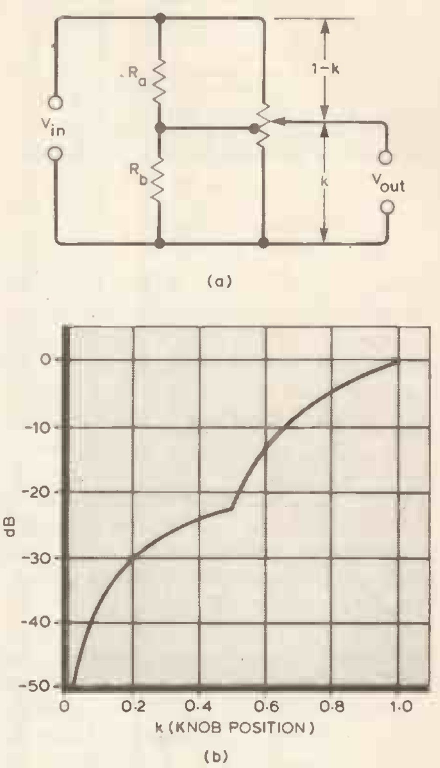


Fig. 27. Tapped linear pot. (a) gives approx. log. characteristic, shown at (b). With R_a and R_b low, gain at mid position is almost independent of track linearity or resistance.

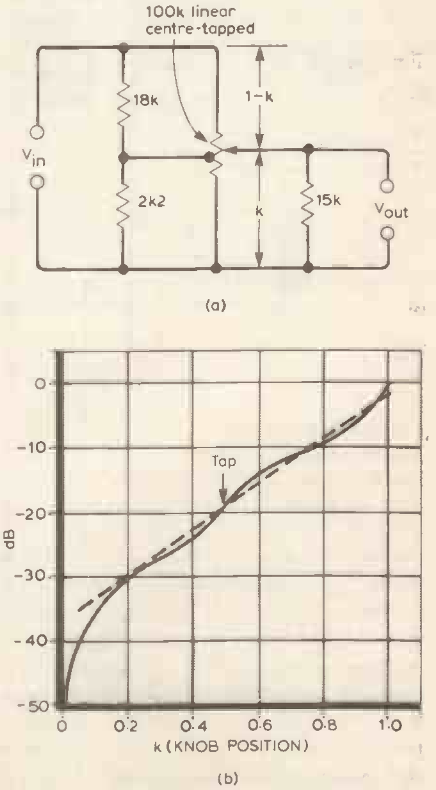


Fig. 28. Practical version of Fig. 27.

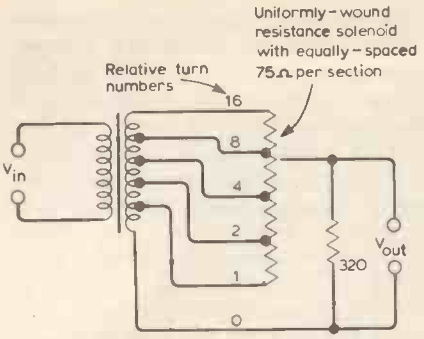


Fig. 29. Multiple-tap linear pot. with transformer-fed taps for precise voltages.

further, providing attenuators of extremely high precision and stability. An interesting example from a different field occurs in the Wayne Kerr B5009 Logarithmic LCR Bridge, in which readings are taken from an approximately 25cm long "slide-rule", which has a logarithmic scale covering a 16 : 1 ratio. The circuit associated with this device is shown in Fig. 29. The use of a tapped transformer winding to energize the tappings on the resistance element ensures extreme precision in the ratios of the voltages at these points, since they are determined almost purely by the turn numbers on the transformer. As the slider is moved down from the top, the attenuation at each tapping position increases by successive factors of 2, or 6.02dB. In the absence of the loading resistor on the slider, V_{out} varies linearly with slider position between tapping points, whereas, for a perfectly logarithmic scale, it is the log of V_{out} that is required to vary linearly. The error amounts to approximately 0.5dB midway between tappings. By adding the right value of loading resistor as shown, this error is reduced to less than ±0.05dB.

By using a transformer, the attenuation characteristic is made almost perfectly independent of production variations or non-uniformity in the resistance element, provided only that the physical positions of the tappings are accurately maintained. With the Fig. 28(a) type of arrangement, variations in pot. resistance do have some effect, but it may be kept small by making the resistance of the resistor-chain connected to the tapping(s) much less than the resistance of the pot. itself.

For high-grade audio control-unit applications, where the use of slider-type controls is considered appropriate, there would seem to be a strong case for using the Fig. 28 arrangement but with two tappings. By using ±2% resistors to feed the tappings, excellent stereo tracking should be obtained with a most desirable shape of control characteristic.

BBC log. attenuator

An interesting and very neat solution to the problem of providing a wide-range gain control having uniformly-spaced decibel scaling was devised in 1946 by C. G. Mayo and R. H. Tanner of the BBC Research Department. It was used in a portable microphone amplifier made by the BBC for acoustic measurements[5], but was unfortunately not taken up commercially.

The principle is given in Fig. 30, and Fig. 31 shows the actual construction. These illustrations are taken from reference 5. A is a block of resistive material, of which the underside is covered by a conductive electrode B. The input is applied between B and another electrode C, the output being taken between B and a slider D. The various series and shunt paths through the resistive material may be regarded as approximately equivalent to the ladder network shown, the output of each successive section of the ladder being a constant fraction of that of the previous section, giving a scaling with uniformly-spaced decibel divisions. The useful range of the model illustrated was about 70dB.

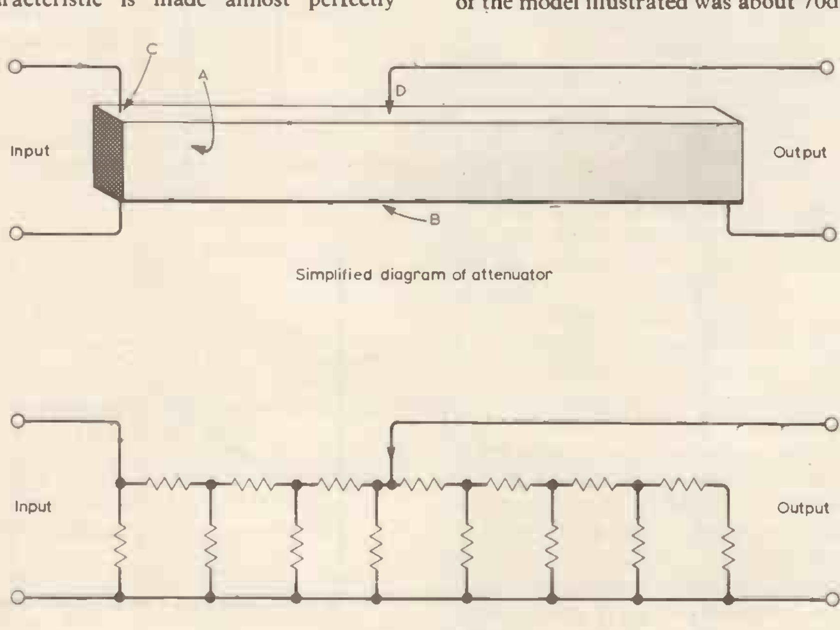


Fig. 30. BBC gain control principle at (a) is 'distributed' equivalent to attenuator network at (b).

Fig. 31. Attenuator whose principle is shown in Fig. 30. Note screen round output. Photograph by courtesy of Electronic Engineering

It is pointed out that the output impedance of this type of attenuator does not become low when the attenuation is large, so that it is very important to avoid appreciable stray-capacitance coupling between input and output. The output connexion is therefore brought out coaxially, with a screening plate as shown in the photograph.

It has occurred to me that there is no essential need to employ a thick block of resistive material, and that an attenuator based on the same broad principle could be made using carbon-coated s.r.b.p. sheet material of the type commonly used in ordinary carbon pots. To test this idea, a quick experiment was done with the set-up shown in Fig. 32, and yielded the rather impressive result shown in Fig. 33. The very first graph obtained was somewhat inferior, apparently because of unsatisfactory contact between the steel vice jaw and the carbon coating. This was overcome by interposing a strip of polished copper foil between the carbon coating and the vice jaw.

Though an attenuator having a very extended range of operation as in Fig. 33 may fulfil some requirements, it is not ideal for use in control units etc., for the range of control needed in practice covers far less than 100dB, except that an "off" position coming soon after the position giving 40 or 50dB attenuation is really desirable. The Fig. 32 type of construction could readily be modified to provide such a characteristic, by shaping the conductive electrode, or metallic coating, somewhat as shown in Fig. 34. Halving the width of the carbon track, for example, would double the slope of the graph.

It is relevant to consider the suitability of attenuators based on the above principle for stereo purposes, i.e. whether sufficiently accurate tracking would be readily obtainable. Since the slope of the attenuation characteristic depends, to a first order at least, on nothing but the width of the resistive track, it would be important, for stereo use, to adopt a form of construction in which production variations in this width are minimized. The Fig. 34 construction does not appear to be ideal, for it relies on cutting the edge of the carbon material accurately in relation to the position of the metallized coating. The arrangement shown in Fig. 35 would seem much preferable, since accuracy of cutting is no longer involved and the metallized coating could be deposited by some form of printing technique with a very high degree of consistency.

The lower impedances usually used in transistor equipment, compared with earlier valve equipment, ease the problem of keeping the input-to-output stray capacitance sufficiently small, but it is still important to adopt a constructional arrangement which aims to minimize such capacitance. Working at 1kΩ impedance, with a control giving up to 100dB attenuation, the stray capacitance must be kept to less than 0.1pF. The connexion "rail" on which the slider moves must therefore be positioned away from the carbon surface and screened from this and the input connexion by an earthed screening plate.

Another advantage of the Fig. 35 arrangement is that, because of its symmetry, unwanted slight lateral movements of the slider during its traversal would be expected to have less effect on the attenuation than with the Fig. 34 form of construction – though it has been found that even with the latter, movements of about 1mm at right-angles to the direction of traversal produce only a small fraction of 1dB change in output provided the slider contacts the carbon track within 2 or 3mm of its edge.

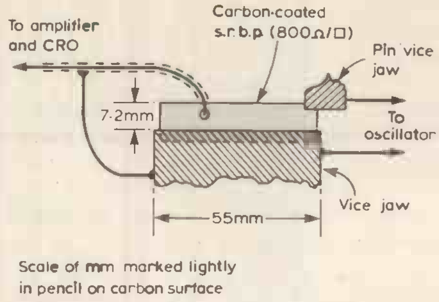


Fig. 32. Experiment using sheet instead of block in Fig. 30.

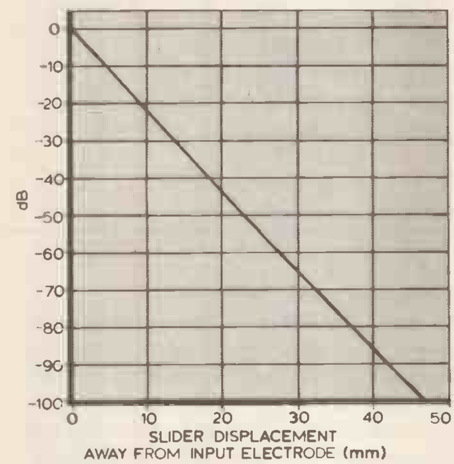


Fig. 33. Measured result obtained with Fig. 32 arrangement.

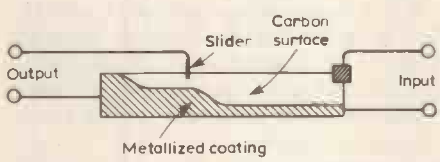


Fig. 34. Suggested form of control using Fig. 32 principle. Characteristic steeper at low-gain settings.

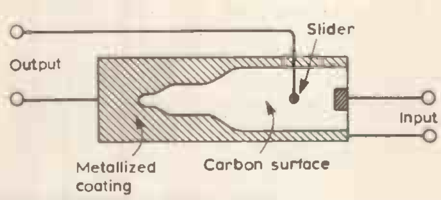


Fig. 35. Symmetrical version of Fig. 34 for improved consistency of performance.

Other methods of log. control and stereo tracking

● Perfect tracking of stereo channel gains at all settings, without the need for precision gain-control circuits, may be obtained by first producing, from the incoming L and R signals (L + R) and (L − R) signals. If the (L + R) signal is fed to one half of a ganged gain-control circuit, multiplying it by a factor α, and the (L−R) signal is fed to the other half of the gain-control circuit, which multiplies it by a factor β, then the sum of the gain-control circuit outputs is given by:

$$\text{sum} = (\alpha+\beta)L+(\alpha-\beta)R \qquad (10)$$

and the difference of their outputs is given by:–

$$\text{difference} = (\alpha+\beta)R+(\alpha-\beta)L \qquad (11)$$

Thus, though the balance as such is perfect, it is obtained at the price of introducing some cross-talk when α is not quite equal to β. The effects of stereo cross-talk are discussed in detail in reference 6.

● Perfect tracking without the introduction of crosstalk can be produced if a single gain-control circuit is used to control both channels. This can be done, for example, by first making the L and R audio signals modulate two different r.f. carrier frequencies, the two amplitude-modulated carriers being fed to the same gain-control circuit and being subsequently demodulated in phase-sensitive detector circuits. Though this technique could give virtually perfect results, it would not seem to be very attractive economically.

● Various simple gain-control circuits give a nearly linear relationship between attenuation in decibels and control position over a range of several dB. If a sufficient number of such circuits are put in cascade, and the controls are ganged, an approximately linear relationship may be obtained over any required range. While this technique is not usually very attractive when carried out literally with mechanically-ganged pots., it would appear to be worth bearing in mind as a possible technique for providing electronic gain control with a logarithmic characteristic. The idea is quite old.

● At the present time the most satisfactory technique for wide-range electronic gain control is that which exploits the fact that silicon planar transistors follow with high accuracy the relationship:–

$$I_c = I_o e^{qV_{be}/kT} \qquad (12)$$

where I_c is the collector current and V_{be} is the base-to-emitter voltage. (The other quantities are constants.)

Circuits can be designed in which the gain in decibels is linearly related to the control voltage over a range of about 100dB, and by using the "log-antilog" or predistortion technique, a performance sufficiently good, with respect to distortion and signal-to-noise ratio, to justify the use of such circuits in very high-quality audio systems, can be obtained. A very sound and clear treatment is given in reference 7.

This type of circuit is at the heart of compander systems of the dbx type. It could be used to provide gain control in audio control units, a single pot. varying the control voltage to a pair of such circuits in the two audio channels. The distortion and noise performance, though good, is not quite up to the highest standards sometimes demanded, maybe unnecessarily, in expensive control units, but some further refinement of i.c. versions of these gain-control circuits, including the reduction of residual even-harmonic distortion by the use of more fully balanced arrangements, may take place.

● In a fully digital audio system, gain control with perfect stereo tracking and any desired control law may be carried out on a purely numerical basis.

References

5. Shorter, D. E. L. and Beadle, D. G., "Equipment for Acoustic Measurements", *Electronic Engineering*, Vol. 33 No. 283, pp. 326-331 (September 1951).

6. Harwood, H. D. and Shorter, D. E. L., "Stereophony: the effect of cross-talk between left and right channels", BBC Eng. Mono. No. 52 (March 1964).

7. Curtis, D. R., "A Monolithic Voltage-Controlled Amplifier Employing Log-Antilog Techniques", *J.A.E.S.*, Vol. 24, No. 2, pp93-102 (March 1976).

8. McKenzie, A. A., "Philips and the MIC/DIN problem", *Hi-Fi News*, Vol. 24, No. 9, p. 65 (September 1979). □

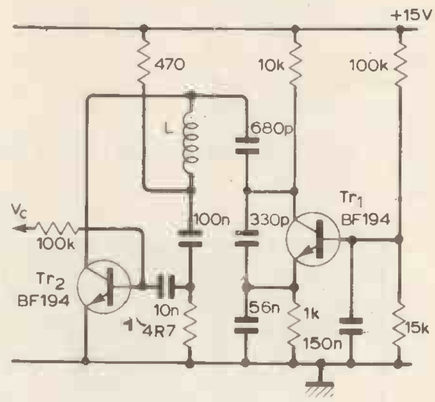
CIRCUIT IDEAS

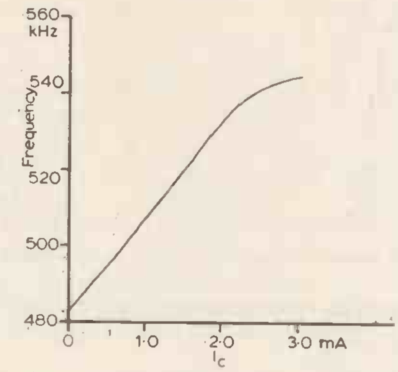
Reactance circuit

Reactance circuits are not very popular because it is difficult to design a phase-shift network which will work into a low and varying base impedance. This circuit overcomes the problem and gives a greater and more linear frequency swing than common variable capacitance diodes. The 90° phase shift is produced by a resistor in series with the inductor, which produces a voltage in phase with the inductor current and consequently almost in quadrature to the e.m.f. across the resonant circuit. The collector current of Tr_2 is in phase with the inductor current and therefore produces the effect of an inductance in parallel with the resonant circuit, which raises the operating frequency. The resistance is chosen to give about 100mV pk-to-pk because there is little advantage in a larger signal at the base of the reactance transistor.

The oscillator is designed to give an amplitude of around 100mV pk-to-pk at the base of Tr_1, which is controlled by effective mutual conductance variation. The amplitude changes by only 10% from 480 to 530kHz. If the oscillator level is controlled by collector "bottoming", a much larger frequency swing is possible with little amplitude variation, at the expense of some waveform distortion. The susceptance introduced in parallel by this circuit is $B_e = g_m RB_L$ where B_L is the susceptance of the inductor and g_m' is the effective mutual conductance, which is about half the mutual conductance with an average collector current if the amplitude is 100mV pk-to-pk.

R. G. T. Bennett
Christchurch, New Zealand



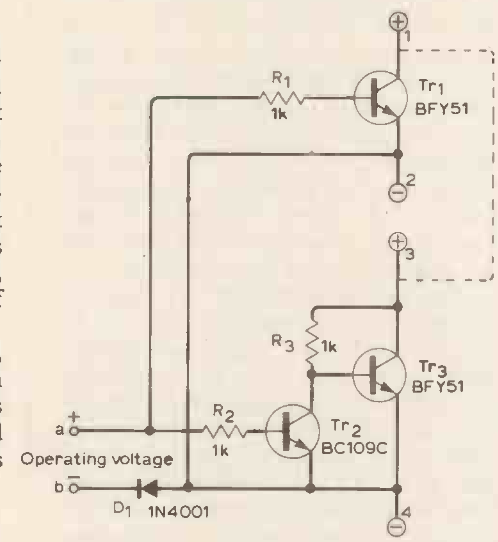


Solid-state relay

In radio control applications this solid-state relay can replace a conventional electromagnetic type to save space, weight and provide a faster switching response. The circuit comprises one make and one break contact, but a changeover configuration can be obtained by connecting contact points 1 and 3 together. The relay operates when a voltage is applied to inputs a and b, and D_1 prevents damage to Tr_1 and Tr_2 if the wrong polarity is connected.

When no operating voltage is present, Tr_1 is turned off and acts as an open contact. Tr_2 is also turned off, but Tr_3 is turned on via R_3 and acts as a closed contact. Current rating of Tr_1 and Tr_3 is 750mA at 20V.

B. Lowery
Lincoln

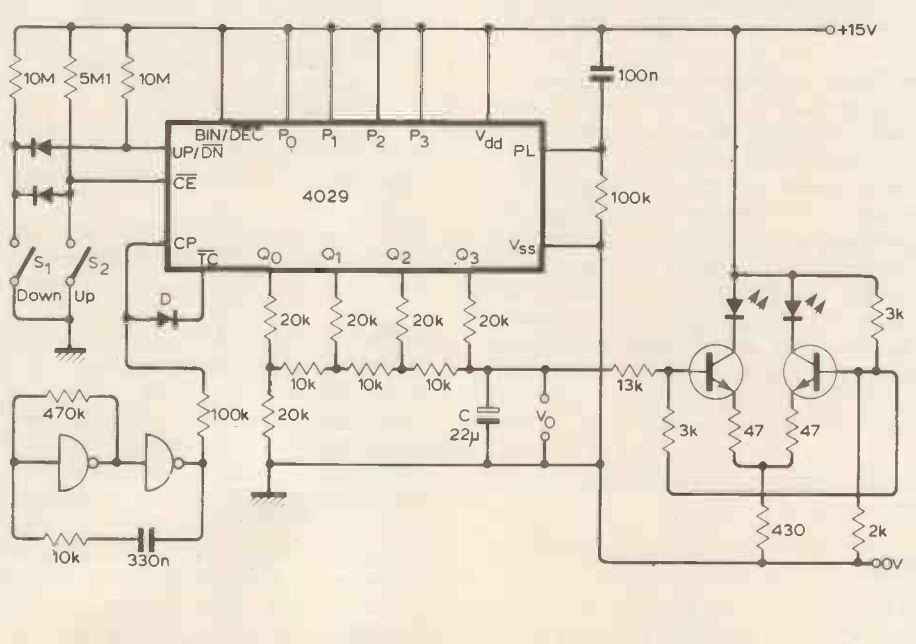


Touch control

One c.m.o.s. counter can be used to provide touch-controlled voltages for the TCA730 or similar circuits. The state of the counter is converted to an analogue voltage by a resistance ladder, and smoothed by a capacitor. When the terminal count in either direction is reached, the clock input is inhibited. Two l.e.ds, driven by a differential amplifier, show the position of the counter and the control voltage. Output voltage swing is 2-10V with a supply of 15V.

Two cascaded counters provide a suitable resolution for volume control applications. At switch on, the counter is preset to a position set by the parallel load inputs.

N. Istvan
Budapest
Hungary



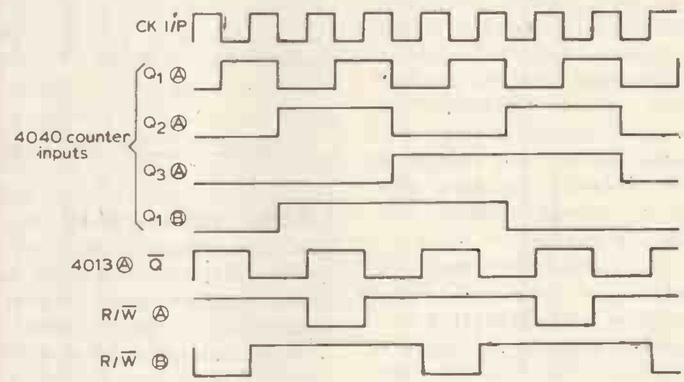
Digital delay

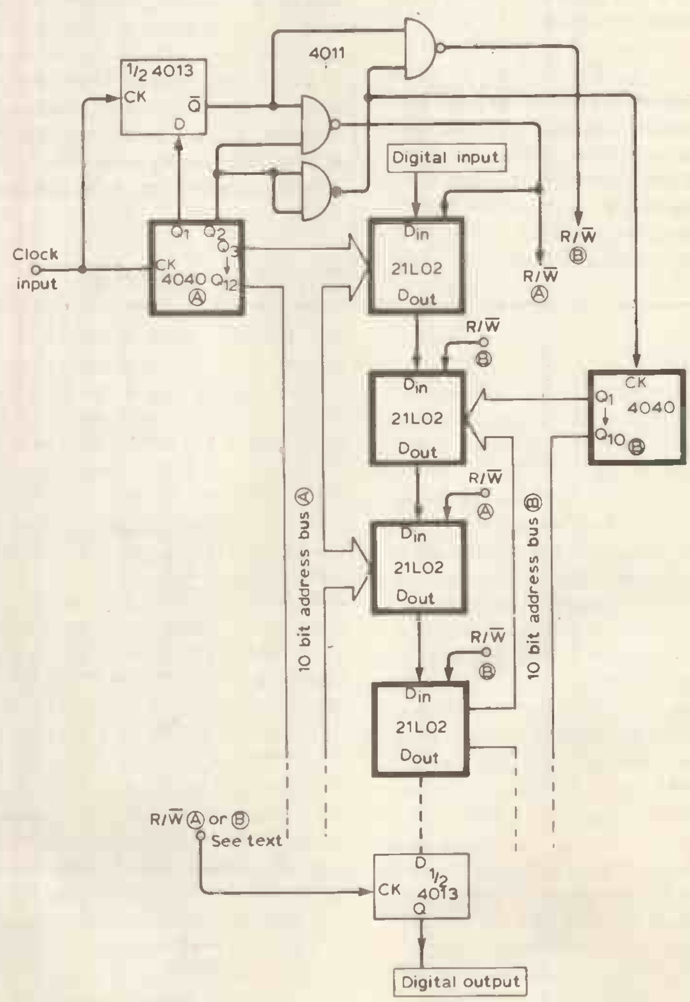
This circuit was designed to give a relatively long delay in a single-bit stream adaptive delta modulation system. The conventional method uses shift registers, but these are quite expensive and become less economical as the bit requirement increases. A more attractive method is to use the popular and inexpensive 21L02 1024-bit r.a.m. which only requires one +5V supply. The memory is sequentially addressed so that data is initially read from, and new data subsequently written into each successive cell. Data read out in this manner is identical to the input but delayed by 1024 address change periods. To cascade several memories, the write cycles must be progressively shorter for each device, and this ultimately limits the system.

However, this problem can be eliminated by connecting the memories serially and addressing alternate devices by a 10-bit incremental address signal. A second 10-bit address, which is incremented in quadrature to the first, is applied to the remaining memories. Symmetrical read/write signals can now be used to transfer data from one memory to the next in the appropriate manner due to the overlapping address signals.

Numerous memories can be used as long as loading constraints are observed. Delayed data is extracted from the system by clocking the D_{out} of the last 21L02 through the remaining half of the 4013 flip-flop with either r./$\overline{\text{w}}$.Ⓐ, if the number of memories is even, or r./$\overline{\text{w}}$.Ⓑ if it is odd. It is unnecessary for the address wiring for each memory to be coherent because a unique address is only required for each cell.

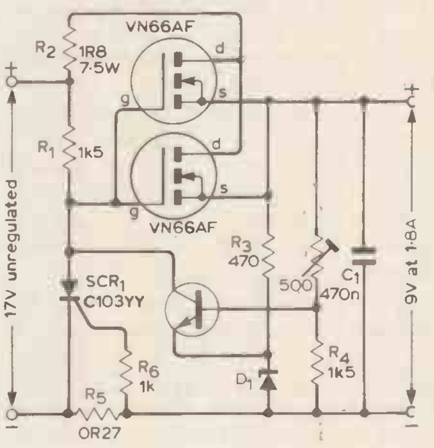
P. Gladdish
Holbrook
Derbyshire





Power f.e.t. voltage regulator

Power f.e.ts can be used as the control element in a relatively simple linear regulator. The V.m.o.s. f.e.t. has a high value of g_m, a high impedance, and can pass a reasonably high drain current. Another advantage, shown in this example, is



parallel operation where the positive temperature coefficient of V_{ds} tends to produce equal current sharing. Operation is similar to a conventional regulator except that the f.e.ts require virtually no gate current. An error amplifier provides gate drive to both f.e.ts, which then conduct. Output voltage can be adjusted by the variable resistor. The voltage at the gate is about 11V for a load current of 100mA, and increases to approximately 16V with a current of 1.8A. A foldback current limit protects the regulator against overload by triggering a thyristor at about 2A to switch both f.e.ts off. The circuit has an output resistance of 60mΩ and provides +9V with loads up to 1.8A. Performance depends on the gain of the error amplifier, and further improvements can be obtained by replacing the transistor with a high-gain op-amp. Larger currents can be provided by increasing the number of parallel f.e.ts, which must be mounted on heatsinks.

G. Loveday
Tonbridge
Kent

WORLD OF AMATEUR RADIO

DX records broken

What is thought to have been the longest distance two-way 144MHz tropospheric contact ever to have been made in IARU Region 1 (Europe and Africa) took place on August 6. R. V. Thorn, G3CHN in south Devon made contact with EA8XS in the Canary Islands, off the African coast, a distance of over 2600km. At the time anticylonic weather conditions extended from south-west England southwards to the Canary Islands and westwards almost to Florida, possibly a near miss for the first translantic 144MHz contact by means of ducting, though again suggesting that some day this may be achieved. Sea ducting between California and the Hawaiian Islands has, on very rare occasions, provided American amateurs with 144 and 432MHz tropo contacts over distances exceeding 4000km.

Many British amateurs made their first 144MHz contacts with Andorra during an intensive spell of operation by C31RN.

On the 10GHz microwave amateurs, Italian enthusiasts have bettered their previous world record distance of 633km when, during July, I0SNY/7 made contacts with IW3EHQ/3 and I3SOY/3, raising the record to 757km.

More museum stations

Some 300 members of the 1000-strong Royal Naval Amateur Radio Society (RNARS), formed in the UK in 1960, live overseas, including 114 in Australia where a national branch was formed in October 1979. As a result of the successful restoration by RNARS of the bridge wireless office of *HMS Belfast* (GB2RN) in the Pool of London, the Maritime Trust of Australia has accepted an offer by RNARS Australia to restore the W/T office of *HMAS Castlemaine* and to permit the installation of a modern amateur radio station with the callsign VK3RAN. Most of the original W/T equipment has been located and is now being restored. VK3RAN has regular schedules with RNARS stations in the UK including GB2RN. A similar project is also being undertaken for *HMAS Diamantinia* which is to form a naval museum at Brisbane.

Special calls held by RNARS in the UK include GB3RN at *HMS Mercury* (shore station) where the callsign G3BZU is also used (except on open days at Portsmouth Naval Dockyard); also GB2FAA at the Yeovil Naval Air Station ("Fleet Air Arm").

The London Science Museum has recently put on a display two off-line rotor-type cryptographic machines of World War II vintage: a three-rotor German Enigma (Geheim Chiffriermachine) based on the work of Arthur Scherbius, and the British Type X Mark III machine developed in the 1930s by Air Commodore Oswyn with the help of the RAF Workshops. This typewriter-like machine could be used in the field to provide a ciphered tape at up to 20w.p.m. while "powered" by turning a handle with the other hand.

Amateur tv news

John Wood, G3YQC is to edit *CQ-TV*, the journal of the British Amateur Television Club. A recent listing of amateur tv stations in South East England includes 24 stations in south London and along both sides of the Thames estuary. Atv transmissions across the English Channel to France, Holland and Belgium are reported, although activity in Manchester and the north-west has dropped in recent years. In the current issue of *CQ-TV* Grant Dixon, G8CGK describes his work with computer-based (Triton) slow scan television. Digital processing can include the insertion of a reduced-size image into a quarter of the transmitted picture: for example it is possible to store a photograph of the operator in the computer memory and then, whenever required, to insert this into the top right-hand quarter of the transmission. An article by Tom O'Hara, W6ORG, reproduced from the American atv journal *A5* describes an arrangement to interface a home computer (TRS-80) with a television camera to enable two non-synchronous pictures to be readily mixed.

On the bands

Swansea Amateur Radio Society has won the RSGB's 1980 National Field Day trophy with the Bristol Trophy (single station entry) going to the Teesside Contest Group. Band leaders were: 1.8MHz Farnborough; 3.5MHz Harlow; 7MHz Mansfield; 14MHz Southgate; 21MHz Guernsey; and 28MHz East Nottingham. The Gravesend Trophy was won by Guildford; the Scottish NFD trophy by Glenrothes; and the Frank Hoosen Memorial trophy by Southgate.

Amateur licences in the USA at mid-1980 had risen to 385,625 with the FCC issuing 12,583 new licences in the first half of 1980, compared with 6119 during the full year of 1979. Pass rate in the FCC examinations has risen markedly although this has been ascribed by *Ham Radio* more to memorization of the "question-and-answer" guides that have recently become available rather than better understanding of the theory by candidates: examination syllabus has recently been changed.

The New Zealand amateur Fred Johnson, ZL2AMJ, in commenting upon the long-standing controversy on the international requirement for morse code proficiency to obtain a licence for amateur bands below 50MHz, has identified and listed 75 factors that have been put forward in support of or against a compulsory code requirement. The overwhelming majority appear to be favourable to the c.w. mode which it is noted "shows no sign of a diminishing use from observation on the bands". ZL2AMJ notes that the critics of the code requirements "are overwhelmingly drawn from those who have not experienced the use of the code on the h.f.bands and hence cannot be expected to understand the position that the code has in the amateur radio world" although "the reason for them not seeing any necessity for it can be appreciated". Among his many factors he notes that this is a skill which is not difficult to learn as is sometimes claimed and that it takes about 40 hours of effort to go from zero to about 12 words per minute proficiency. Criticism of the code requirement can be traced back through amateur radio publications "to when phone operation first commenced and there is no evidence to show that the level of criticism is any more today than in earlier days". Examination of the QSL cards passing through the New Zealand bureau "reveals a surprisingly high use of c.w." and the number of articles in c.w.-related topics appears to be increasing.

The potential health hazard posed by the use of polychlorinated biphenyls (p.c.b.) as transformer-oil in 'dummy loads' etc. has recently attracted increased attention in amateur circles. However Tom Ruynon, VE5UK points out that the main hazard arises when the non bio-degradable substance gets into the food chain rather than from skin contact. Similarly it is recognised that the fumes from melting polyurethane-coated wire, used for experimental prototype wiring, contain the toxic substance di-isocyanate which can result in severe asthmatic attacks, particularly to people who have become sensitised.

In brief

Despite the recent fire, it is expected that the 1981 RSGB National Amateur Radio Exhibition will be held in the temporary building which is being erected at Alexandra Palace, although dates have not yet been announced .... Among 1000 search volunteers for two-year-old Elizabeth Peck in West Sussex were 34 members of Raynet, the radio amateurs' national emergency network. All ended happily when the little girl was discovered alive and well 41 hours after wandering off from her family .... Approximately 2500 of those who sat the UK Radio Amateurs' Examination last May passed.

PAT HAWKER, G3VA

Colour tv receiver design

4 – The switched-mode power supply

by **R. Wilkinson**, B.Sc.(Hons), M.I.E.E., Decca Radio & Television Ltd

A switched-mode power supply operating at television line frequency was chosen for the 70 series because of its inherently low power loss; its ease of obtaining any voltages required; and the possibility of making the chassis isolated from the mains. The alternative approach of a thyristor supply (used successfully for several years in the 80 and 100 series chassis) does not readily lend itself to these requirements. Whilst it can be made to work efficiently, bulky iron-cored chokes are required and these are expensive, heavy and could produce mains frequency fields which could affect the c.r.t.

The 70 series s.m.p.s.u. is a flyback type of convertor (Fig. 16). Tr_1 switches the transformer primary across the rectified mains and energy builds up in it in the form of a magnetic field. When Tr_1 switches off, its collector voltage rises and so (by transformer action) does the secondary. D_1 conducts and feeds all the energy stored in the transformer into the load. Hence the load is only supplied when the transistor is off.

Stabilisation of the output voltage, against mains and load variations, is achieved by taking a sample of voltage from a winding on the transformer and comparing it with a fixed reference voltage. The resulting error voltage is used to correct the drive waveform fed to the output device.

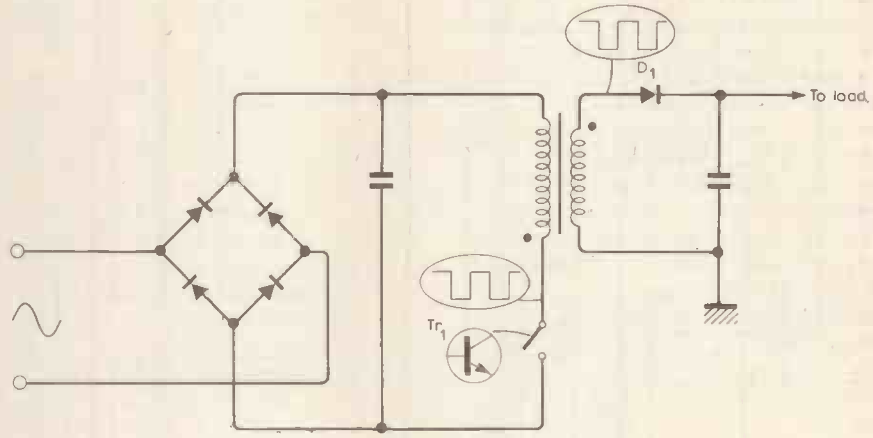


Fig. 16. Principle of the switched-mode power supply.

Fig. 17 shows a block diagram of the s.m.p.s.u. circuit. The control unit contains an oscillator to ensure that the output stage remains switching whether it is synchronised or not. There is an input of line drive from the sync processor. This, you may remember, has been synchronised to the line sync pulses on the received video waveform. The other input is a line flyback pulse and is used in a phase discriminator as a phase reference for the oscillator drive pulses which will eventually be used to provide base drive for the line output transistor. This phase reference is adjustable and can be used as a line shift control.

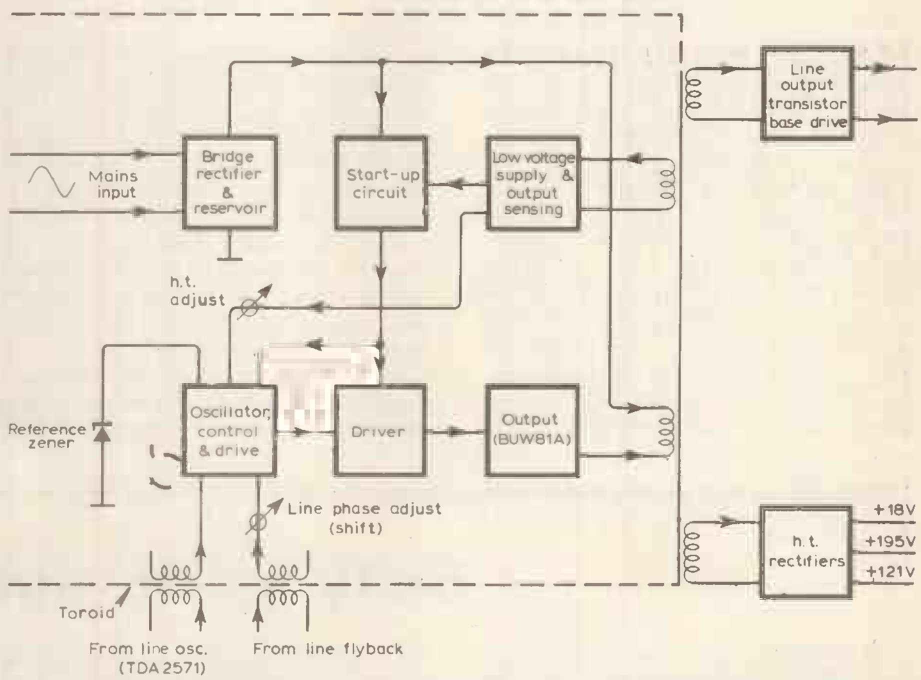


Fig. 17. Block diagram of the switched mode power supply circuit.

Both these inputs cross the isolation barrier and, consequently, must use double-insulated components: the line drive input uses a small toroidal transformer and the line flyback phase reference is from a small isolated winding on one limb of the line output transformer.

During normal operation the control circuits are supplied from the s.m.p.s.u. t.f. and so, when the set is first switched on, some power must be supplied to the oscillator to start switching the output stage. The start-up circuit supplies this power and then switches off once the voltage from the t.f. has built up sufficiently to drive the control circuits. Fig. 18 shows a simplified version of the complete s.m.p.s.u. circuit and the start-up circuit operation can be seen from this. At switch-on Tr_1 is turned hard on by base current through R_1. Current flows through R_2 and Tr_1 to supply the control i.c. TDA2581 and the driver stage Tr_3 and Tr_4.

As the oscillator commences switching the driver stage, and hence the output stage, the voltage at C_1 steadily builds up until D_1 turns on. Then Tr_2 turns on, pulling down the base of Tr_1 which switches off. From then on the power to the control i.c. and the driver stage is

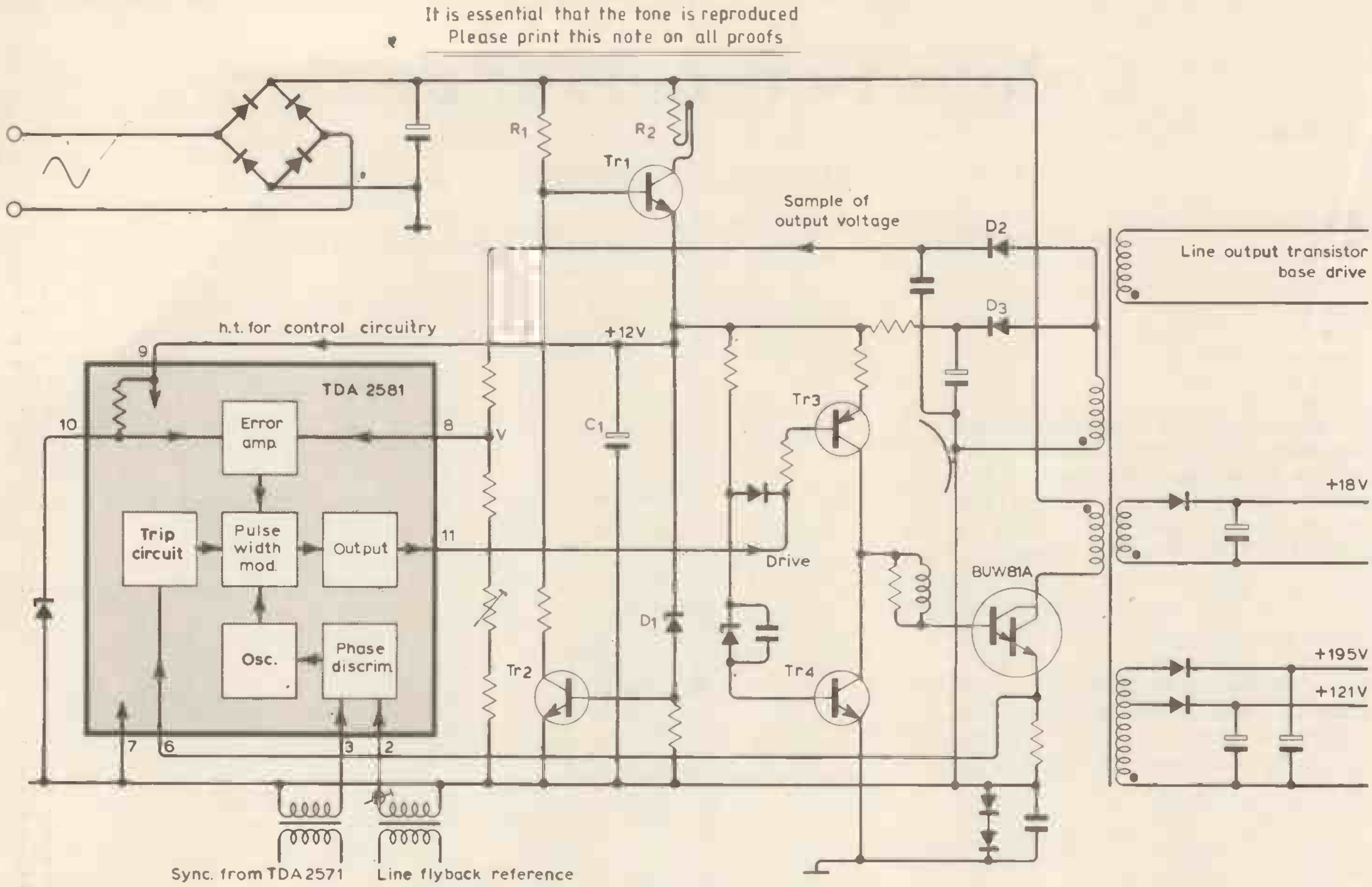


Fig. 18. Simplified version of complete power supply circuit.

supplied through D_3. Thus R_2 does not need to be on all the time and another source of power wastage is removed.

The heart of the control circuitry is the pulse width modulator. This determines the mark/space ratio of the output waveform and hence the output voltage.

The error amplifier controls the pulse width modulator according to the difference between the adjustable sample of the fed back transformer voltage V and the stable reference voltage across D_1. A trip circuit senses the current in the output device and cuts off the output pulses if the current rises above a pre-determined value. It then waits for a short while and then releases the pulses again. If the excessive load or fault still remains then the trip cuts off the output again. After this cycle has repeated about ten times the output pulses are cut off "permanently" and the supply can only be restarted by switching off the mains, waiting a few seconds and switching on again (assuming the fault or overload has cleared or been corrected).

The i.c. contains other protection circuits, which operate the trip if the fed back sample voltage goes high or if the control i.c. supply goes low or if the reference voltage at D_1 goes open-circuit.

The driver stage has two transistors in a push-pull configuration. It will be noticed that the output device is a Darlington transistor. This device is used in preference to an ordinary transistor because it removes the need for a driver transformer.

Reliability

As has been shown, the factors influencing the design of a television receiver are many and varied and often conflict with each other. The solving of the problems thus presented has produced, at least in the 70 series, a receiver which gives an excellent and reliable performance. One of the aims of the design team was to improve on the already good reliability figures achieved by the 80 and 100 series. The low failure rates that were monitored during the 24 hour soak test in the factory indicated that this was achieved with a good margin. □

Sixty years ago

Until shortly before 1920 communication between submarines and shore or other vessels was only possible while transmitting or receiving above the waves, due, of course, to the attenuation of electromagnetic waves by water. An article called "The Submarine's Wireless" in the November 27th, 1920 edition described newly found techniques which enabled practical communication while the vessel was under water. The techniques in question involved the development of extremely sensitive receiving and amplifying apparatus, and more efficient aerial systems, to make possible the bridging of distances of up to three miles while the vessel was submerged under nine feet of water. An aerial current of six amps was required for this feat, but there is no mention of the frequencies used, although long-waves are suggested as they were found to be able to penetrate the water better than short-waves.

In the same issue, a small feature also appeared on a wireless telephone pack-set which was used by RAF officers as far back as the autumn of 1918. Two photos show the set "mounted" on an officer who stands, supported by his bicycle, with a wooden frame aerial projecting from the top of his head. As wireless sets, especially of this type, were not all that common at that time he probably gave some of the locals quite a start.

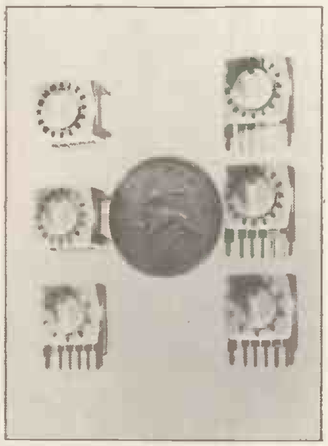
The need for ships to pass out of unlit harbours during wartime was the necessity that gave birth to the invention of the "radio cable", which was discussed in the "Notes and News" section also in this issue. This guidance cable, through which an alternating current was passed, was laid in the harbour waterways. Ships using the cable were fitted with two detection coils, probably one on either side of the deck, which intercepted the electromagnetic waves coming from the cable. By noting the relative strength of the waves reaching each coil, it was possible for the ship's navigator to determine his position in relation to the cable. The US Navy laid one such cable which was sixteen miles in length, in the main waterway approaching the port of New York.

NEW PRODUCTS

Microcomputer instructor

A flexible prototyping system, designed to cut the cost of microprocessor evaluation and development, has been introduced by Philips Test and Measuring Instruments. The PM 4300 microcomputer instructor, which is marketed by Pye Unicam, uses interchangeable modules to adapt the system to different 8 or 16-bit processors. Types which can at present be accommodated are the M68000, 8086, Z8002, Z80, 8048, M6801, 8088 and the M6809, and additions to the range are expected in the near future. PM 4300 is claimed to be more powerful than a manufacturer's evaluation board, and allows writing/debugging of programs, checking operation of peripherals, exercising input/output ports and implementing interrupt routines. A hexadecimal keyboard, an 18-function keyboard, switch/l.e.d. i/o displays and a 16-digit alphanumeric display are features of the desktop microcomputer instructor. Use of the function keys enables automatic i/o reading and writing, single stepping, setting hardware breakpoints, timing and memory manipulation to be carried out, and the user has complete control over system operations, including communication with i/o devices and generation of interrupts manually or using the real-time system clock. The RS-232 serial interface allows direct linking to existing development systems and the PM 4300 is compatible with the Philips PM 4421 PDMS microcomputer development system. Pye Unicam Ltd, York St, Cambridge CB1 2PX.
WW 301

WW 301



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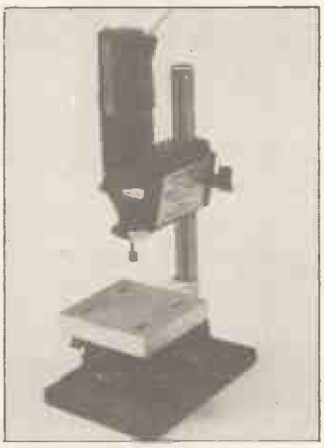


WW 303

WW 304

Switches and pots

Miniature switches for programming via b.c.d. or b.c.hex., at low cost, are introduced by Ambit International in a new range designated the SRQ series. Uses of the switches include 'on-card' programming of frequency synthesizers, cash registers, timing devices, coin operated machines and computer games. Both horizontal and vertical mounting variations are available at a price of 99p per unit or 64p per unit in 100 off quantities.

Also introduced by the same firm are potentiometers, the K16A20 series, which are basically standard 16mm types with 300° of rotation, but featuring an integral epicyclic drive. This feature enables improved resolution control as it gives a 5:1 turns reduction ratio of spindle rotation, for applications such as varicap tuning elements and instrument controls. E12 series values ranging from 100Ω to 1MΩ are available, but Ambit are stocking a restricted range at present, at a 100 off price of 82p. Ambit International, 200 North Service Rd, Brentwood, Essex CM14 4SG.
WW 302

P.c.b. drill

Unlike most mini-drills, the USA manufactured Dremel Moto-Tool, introduced by Microflame Ltd, is suitable for operation at mains voltage, can supply considerable torque, and has a maximum free-running speed of 27000 r.p.m. Four collet sizes, of 1/8in, 3/32in, 1/16in and 1/32in diameter, and a range of over 100 accessories for drilling, grinding, deburring, engraving etc., make the drill suitable for a wide range of applications other than just the drilling of p.c.bs. The basic drill with one collet costs £33.60, or it can be bought complete with a set of accessories at a price of £40.35. A drill-stand and a compatible vice are also available at prices of £18.80 and £11.39 respectively. Microflame (UK) Ltd, Vinces Rd, Diss, Norfolk IP22 3HQ.
WW 303

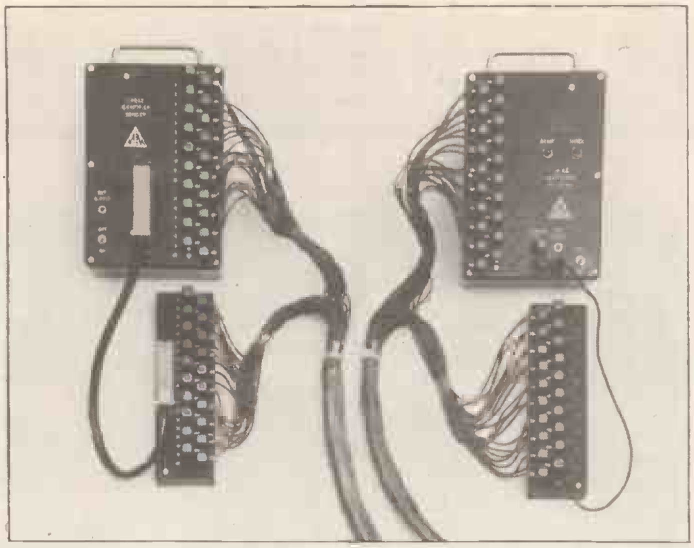
"Pocket" computer

Battery powered, fully portable, 1.9Kbytes r.a.m. and a total of 11Kbytes r.o.m., are all features of the Tandy TRS 80 Pocket Computer, due to be released in October, for which eight different software packages will be available to cover varying requirements from civil engineering to computer games. By using a cassette interface, which is not included in the price of £119, programs can be loaded into the computer, one after the other, without the previous program being erased. TRS 80 makes use of a digital-display and a 57 key alphanumeric keyboard, and measures only 175 × 70 × 15mm. Prices of the software will range from £8.95 to £13.95, and the cassette interface will cost £17.95. Tandy Corporation, Bilston Rd, Wednesbury, West Midlands WS10 7JN.
WW 304

Cable identifier

Electricians faced with the problem of finding the beginnings and ends of conductors of identical appearance in a cable group should find this product of interest. The Cable

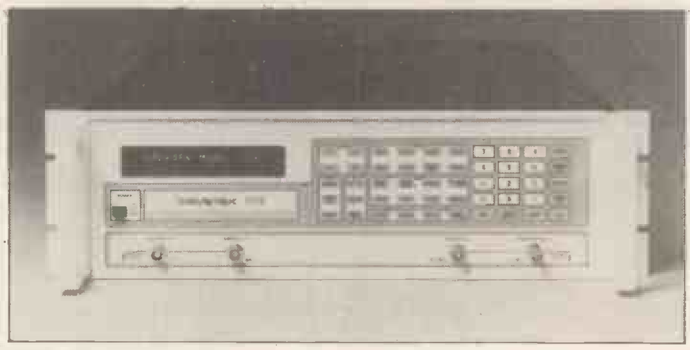
Identifier System, developed by Mason and Morton Ltd, consists basically of two units, a sender and a receiver, to which the cable group to be identified is connected. When switched on, the cables connected to points one and two on the sender are identified at the receiver and indicated by red and green l.e.ds respectively. Once identified, these two cables are simply connected to special points on the receiver to enable the two units to communicate with each other, after which the other cable points can be identified directly one by one. Open or short circuited cables are also shown up by the system. The basic model can accommodate up to 20 cables, and extensions are available to enable a maximum of forty cables to be identified. The Mason and Morton Group, M&M House, Frogmore Rd, Hemel Hempstead, Herts HP3 9RW.
WW 305



WW 305

Waveform synthesizer

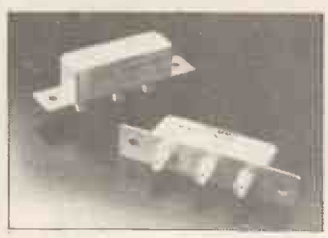
One of four new instruments recently introduced by Wavetech Electronics Ltd, is a programmable waveform synthesizer, for use either as a bench-top unit, or in conjunction with a.t.e. Model 178, as it is called, can be used as a function, signal or sweep generator. Among the types of waveform in its range are sine, offset sine, square, triangle and ramp, at programmable output voltages of up to 20V p.p. into 50 ohms, with frequencies of up to 50MHz. The design techniques incorporated enable synthesized triggering, gating, frequency sweep, burst counts, and combinations of these modes to make it a flexible instrument which can be used for a wide range of applications, and its dual-microprocessors enable input data to be accepted in any order or form for optimal resolution and performance. Additional features include stored settings, a.m. and φ.m., variphase operation, frequency markers, and advantages such as 'learn mode', made possible through the use of a general purpose interface bus. D.c. offset, d.c. output and fixed t.t.l./t.t.l. output are also standard features. Wavetech Electronics Ltd, 115 Crockhamwell Rd, Woodley, Reading, Berks RG5 3JP.
WW 306



WW 306

Double-balanced mixer

Considering the 1 to 4.2GHz bandwidth of this double-balanced mixer, the Summit model 1307, distributed by March Microwave Ltd, the performance is unusually high. Conversion loss and noise figures are both less than 6dB, and lo to r.f. isolation is greater than 40dB. During assembly, hot carrier diodes are selected for the quad using a computerized technique to enable good matching and optimum noise performance. The unit, housed in stainless-steel and designed to work under rugged conditions, will probably find its use in such fields as commercial satellite communications. March Microwave Ltd, 112 South Street, Braintree, Essex.
WW 307



WW 307

Midget capacitors

Suitability for assembly into thin and thick-film circuits, is one of the features of a new range of solid-electrolyte tantalum chip capacitors, type 194D Midget, which is available through Hy-Comp Ltd and manufactured by Sprague Electric. Capacitance values range from 0.1μF to 100μF, with working voltages of up to 50V d.c. for values under 4.7μF. Working voltages for values above 4.7μF fall gradually to a maximum of 4V d.c. for 100μF. The unpackaged devices, which have epoxy encapsulated bodies, are available in eight different sizes, ranging from 1.27 x 2.54mm to 3.8 x 7.2mm, and are compatible with modern hybrid assembly techniques, including soft-soldering, epoxy bonding and thermal compression bonding. Standard operating temperature range is from -55°C to +125°C, and capacitance tolerances of either 20% or 10% are obtainable (also 5% to special order). Hy-Comp Ltd, 7 Shield Rd, Ashford Industrial Estate, Ashford, Middx. TW15 1AV.
WW 308

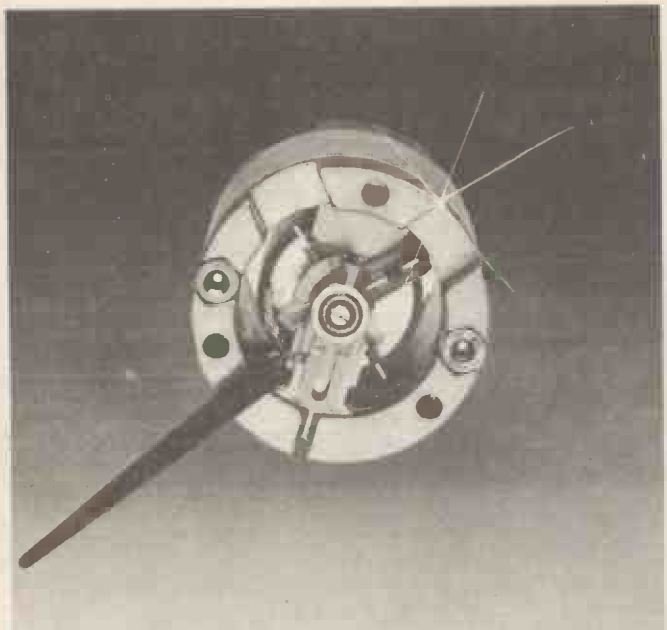
WW 308

Software for micros

A series of products called Component Software, introduced by Texas Instruments Ltd, support the TMS9900 family of 16-bit microprocessors and TM990 microcomputer modules. They complement TI's Microprocessor Pascal products to enable a reduction in the number of software statements and allow designers to add modular software capability to their applications. Component Software products rely on a standard software interface, analogous to the hardware interface in v.l.s.i. components or microcomputer modules, to communicate with language-support and custom software routines. Initial products in the series are the TMSW330R Realtime Executive and the TMSW340F File Manager, at £950 and £923 respectively, both available either for use on TI's floppy-disc based microprocessor development system or the hard-disc based AMPL system. The Realtime Executive has 6K bytes of software routines that perform the necessary executive functions for a real-time, multi-masking application program. These functions include system initialization, concurrent process synchronization, inter-process communication, interrupt linkage, memory management and priority scheduling. The File Manager provides device-independent file management capability from assembly language and/or microprocessor Pascal application programs, and can interface at several different levels to the Realtime Executive, depending on the input/output generality and software 'overhead' the designer wishes to include in his application. Texas Instruments Ltd, Manton Lane, Bedford MK41 7PA.
WW 309

E.e.p.r.o.m.

With a memory capacity of 16Kbit, this e.e.p.r.o.m., the HN 48016 by Hitachi Ltd, is claimed to be the first of its kind in the world. Dialogue Marketing Ltd say that it is now available through them for sample deliveries, with large-order capacity expected by the end of the year. Memory organization of the device is 2048-word × 8-bit, the same as for the 2716 e.p.r.o.m. family, but its access time is only 350ns, and also the number of program/erase cycles possible is greater, at a maximum of 1000 times. Compatibility with existing e.p.r.o.ms, suitability for use with 2MHz microcomputers, and an ability to retain data for longer than 10 years at 85°C, are among the other features of this product. Dialogue Marketing (Electronics) Ltd, Unit 11G, Rose Industrial Estate, Bourne End, Bucks FL8 5AS.
WW 310



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MPA 200 100 WATT (rms into 8Ω) MIXER/AMPLIFIER

Featured as a constructional article in ETI, the MPA 200 is an exceptionally low priced — but professionally finished — general purpose high power amplifier. It features an adaptable input mixer which accepts a wide range of sources such as a microphone, guitar, etc. There are wide range tone controls and a master volume control. Mechanically the MPA 200 is simplicity itself with minimal wiring needed making construction very straightforward.
The kit includes fully finished metalwork, fibreglass PCBs, controls, wire, etc. — complete down to the last nut and bolt.

Panel size 19.0" × 3.5". Depth 7.3"

COMPLETE KIT ONLY £49.90 + VAT!

MATCHES THE CHROMATHEQUE 5000 PERFECTLY!

CHROMATHEQUE 5000 5 CHANNEL LIGHTING EFFECTS SYSTEM

This versatile system featured as a constructional article in ELECTRONICS TODAY INTERNATIONAL has 5 frequency channels with individual level controls on each channel. Control of the lights is comprehensive to say the least. You can run the unit as a straightforward sound-to-light or have it strobe all the lights at a speed dependent upon music level or front panel control or use the internal digital circuitry which produces some superb random and sequencing effects. Each channel handles up to 500W and as the kit is a single board design wiring is minimal and construction very straightforward.

Kit includes fully finished metalwork, fibreglass PCB controls, wire, etc. — Complete right down to the last nut and bolt!

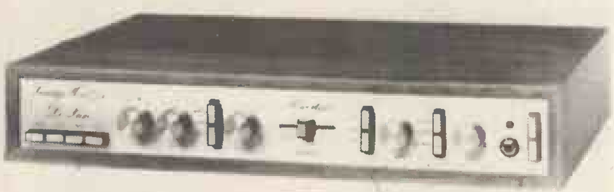
COMPLETE KIT ONLY £49.50 + VAT!

Panel size 19.0" × 3.5". Depth 7.3"

POWERTRAN

SYNTHESIZER KITS ON PAGE 93. MORE KITS AND ORDERING INFORMATION ON PAGE 91.

All kits also available as separate packs (e.g. PCB, component sets, hardware sets, etc.). Prices in our FREE CATALOGUE.



DE LUXE EASY TO BUILD LINSLEY HOOD 75W STEREO AMPLIFIER £85.00 + VAT

This easy to build version of our world-wide acclaimed 75W amplifier kit based upon circuit boards interconnected with gold plated contacts resulting in minimal wiring and construction delightfully straightforward. The design was published in Hi-Fi News and Record Review and features include rumble filter, variable scratch filter, versatile tone controls and tape monitoring while distortion is less than 0.01%.

T20 + 20 20W STEREO AMPLIFIER £33.10 + VAT

This kit, based upon a design published in Practical Wireless, uses a single printed circuit board and offers at very low cost, ease of construction and all the normal facilities found on quality amplifiers. A 30 watt version of this kit (T30 + 30) is also available for £38.40 + VAT. MATCHING TUNERS — See our FREE CATALOGUE!

Above 2 kits are supplied with fully finished metalwork, ready assembled high quality teak veneer cabinet, cable, nuts, bolts, etc. and full instructions — in fact everything!

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MUSIC EFFECTS DEVICE — AS FEATURED IN ELECTRONICS TODAY INTERNATIONAL!

The BLACK HOLE designed by Tim Orr, is a powerful new musical effects device for processing both natural and electronic instruments, offering genuine VIBRATO (pitch modulation) and a CHORUS mode which gives a "spacey" feel to the sound achieved by delaying the input signal and mixing it back with the original. Notches (HOLES), introduced in the frequency response, move up and down as the time delay is modulated by the chorus sweep generator. An optional double chorus mode allows exciting antiphase effects to be added. The device is floor standing with foot switch controls, LED effect selection indicators, has variable sensitivity, has high signal/noise ratio obtained by an audio compander and is mains powered — no batteries to change! Like all our kits everything is provided including a highly superior, rugged steel, beautifully finished enclosure.

COMPLETE KIT ONLY £49.80 + VAT (single delay line system)

De Luxe version (dual delay line system) also available for £59.80 + VAT

Cabinet size 10.0" x 8.5" x 2.5" (rear) 1.8" (front)

TRIO TEST INSTRUMENTS

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NEW

THE CS1830 30 MHz + Sweep Delay

The CS1830 is a completely new 30 MHz dual trace oscilloscope employing a square format, internal graticle, PDA tube for accurate bright display. A new feature is the inclusion of calibrated sweep delay with a range of 1μS-100 mS and trace bright up to show the delay position. As you can see from close study of the photograph, the CS1830 has all the facilities you could require in a high performance instrument but for more detail, simply ask us for a comprehensive leaflet.

Brief specification

Rectangular PDA tube 120 × 96 mm. P31 phosphor.

Bandwidth DC—30 MHz	Overshoot less than 3%
Sensitivity 5mV/cm (30 MHz)	Sweep time 200nS/cm-0.5 S/cm
2mV/cm (20 MHz)	Linearity better than 3%
Input R.C. 1 M /23 pF	Trig. bandwidth DC—30 MHz
Risetime 11.7 nS	Sweep delay 1μS-100 mS

CS1830 only **£455** + VAT includes 2 probes

NEW

THE C51572 30 MHz for the VTR Lab.
If you are in Video, **you need the CS1572**

The CS1572 is a dual trace 30 MHz oscilloscope designed for the video tape recorder engineer. Video delayed sweep facilities are provided to allow magnification and analysis of any point in a single video frame together with separation of video odd and even fields. A truly unique tool for anyone concerned with video measurements as well as a top specification dual trace wide band oscilloscope for general lab use. The complete range of video facilities is too great to explain in a small advertisement so why not call us and ask for the full story on the CS1572.

Brief Specification

As for CS1830 except that the sweep delay feature is replaced by comprehensive video sweep delay facilities which allow complete analysis of video wave forms and VTR alignment.

CS1572 only **£425** + VAT, includes 2 probes

ESTABLISHED

THE CS1577 30 MHz at 2mV + Signal Delay
The most popular scope in the range.

The CS1577 is, without doubt, our most popular oscilloscope and hundreds of satisfied users in all sections of the electronics industry will confirm this. The CS1577 combines a wide bandwidth DC-30 MHz performance with extremely wide trigger bandwidth (DC-40 MHz) and 2 mV sensitivity over the full bandwidth.

Fixed signal delay is provided by a helix delay line which allows viewing of the leading adges of fast pulses for accurate rise time measurement, and the 130 mm PDA tube gives a bright, stable trace even at the highest sweep speeds (20 nS/cm using × 5 expansion). Good triggering, even at low levels has always been an outstanding feature of Trio oscilloscopes and the CS1577 demonstrates this to perfection. Triggering, as in the other 30 MHz instruments can be from CH1 or CH2 or can be alternated with the beam switching so that input signals of differing frequency will provide stable displays.

Truly an oscilloscope masterpiece. CS1577.

CS1577 only **£410** + VAT, includes 2 probes.

ESTABLISHED

THE CS1575, unique dual trace 4 function Audio Scope

The CS1575 is a unique tool for the audio engineer. It features the normal facility of dual trace display with sensitivity to 1 mV/cm but not only can it display the input signal on two channels, it can **simultaneously** display the phase angle between them. and measure the phase angle referenced to a zero phase calibration display. In addition to these unique features, you also have independent triggering from each channel to give stable displays even with widely differing input frequencies.

Absolutely indispensable to the professional audio engineer, the CS1575 is now in use all over the world. See it in action or send for complete details.

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Model	Output Power RMS	Distortion Typical at 1KHz	Slew Rate	Rise Time	Signal/Noise Ratio DIN AUDIO	Price & VAT
MOS120	60W into 4-8Ω	0.005%	20V/μs	3μs	100dB	£25.88 + £3.88
MOS200	120W into 4-8Ω	0.005%	20V/μs	3μs	100dB	£33.46 + £5.02

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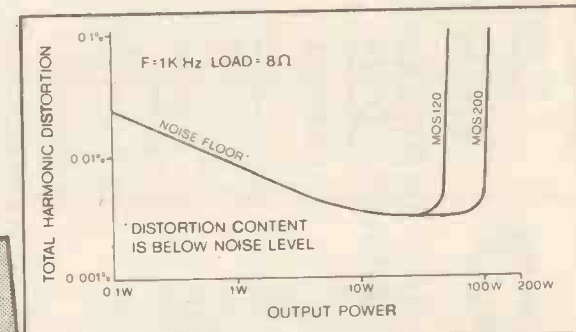
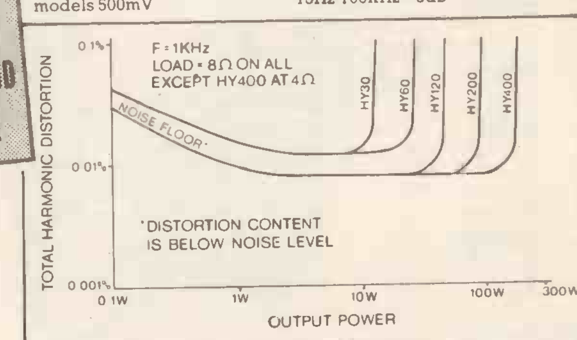
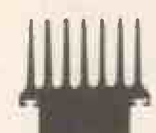
Model	Output Power RMS	Distortion Typical at 1KHz	Slew Rate	Rise Time	Signal/Noise Ratio DIN AUDIO	Price & VAT
HY30	15W into 4-8Ω	0.015%	15V/μs	5μs	100dB	£6.34 + 95p
HY60	30W into 4-8Ω	0.015%	15V/μs	5μs	100dB	£7.24 + £1.09
HY120	60W into 4-8Ω	0.01%	15V/μs	5μs	100dB	£15.20 + £2.28
HY200	120W into 4-8Ω	0.01%	15V/μs	5μs	100dB	£18.44 + £2.77
HY400	240W into	0.01%	15V/μs	5μs	100dB	£27.68 + £4.15



Load impedance both models 4Ω – ∞ Input sensitivity both models 500mV Input impedance both models 100KΩ Frequency response both models 15Hz-100KHz – 3dB



Load impedance all models 4Ω – ∞ Input sensitivity all models 500mV Input impedance all models 100KΩ Frequency response all models 15Hz-50KHz – 3dB



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7437	35p
7438	35p
7440	17p
7441	70p
7442A	60p
7443	112p
7444	112p
7445	100p
7446A	93p
7447A	75p
7448	80p
7450	17p
7451	17p
7453	17p
7454	17p
7460	17p
7470	36p
7472	30p
7473	34p
7474	30p
7475	38p
7476	32p
7480	50p
7481	100p
7482	84p
7483a	90p
7484	100p
7485	110p
7486	34p
7489	210p
7490A	30p
7491	80p
7492A	46p
7493A	36p
7494	84p
7495A	70p
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74128	75p
74132	75p
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74141	50p
74142	200p
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74147	190p
74148	150p
74150	130p
74151A	70p
74153	70p
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74155	90p
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74161	100p
74162	100p
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74167	200p
74170	240p
74172	450p
74173	120p
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74175	85p
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74181	160p
74182	90p
74184A	150p
74185	150p
74186	500p
74188	325p
74190	120p
74191	120p
74192	100p
74193	100p
74194	120p
74195	95p
74196	95p
74197	80p
74198	150p
74199	150p
74221	160p
74251	140p
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74LS273	170p
74LS279	90p
74LS283	90p
74LS298	160p
74LS323	400p
74LS324	200p
74LS348	200p
74LS365	48p
74LS367	70p
74LS368	100p
74LS373	150p
74LS374	150p
74LS375	120p
74LS377	160p
74LS378	140p
74LS390	120p
74LS393	120p
74LS445	140p
74LS668	100p
74LS670	400p

4000 SERIES

4000	15p
4001	22p
4002	20p
4006	95p
4007	20p
4008	80p
4009	40p
4010	50p
4011	20p
4012	25p
4013	50p
4014	84p
4015	84p
4016	45p
4017	70p
4018	89p
4019	45p
4020	100p
4021	110p
4022	100p
4023	27p
4024	50p
4025	20p
4026	130p
4027	50p
4028	84p
4029	100p
4030	55p
4031	200p
4034	200p
4035	110p
4036	295p
4039	295p
4040	100p
4041	80p
4042	80p
4043	90p
4044	90p
4046	110p
4047	100p
4048	55p
4049	45p
4050	45p
4051	80p
4052	80p
4053	80p
4054	150p
4055	125p
4056	135p
4059	600p
4060	115p
4063	120p
4066	50p
4067	450p
4068	27p
4069	20p
4070	30p
4071	25p
4072	25p
4073	25p
4075	25p
4076	107p
4081	27p
4082	27p
4086	72p
4089	150p
4093	70p
4094	250p
4095	95p
4096	95p
4097	340p
4098	120p
4099	200p
40100	220p
40101	132p
40102	180p
40103	180p
40104	99p
40105	120p
40106	90p
40107	60p
40108	470p
40109	100p
40110	300p
40114	250p
4502	120p
4503	70p
4507	55p
4508	290p
4510	99p
4511	120p
4512	80p
4514	250p
4515	300p
4516	110p
4518	100p
4520	100p
4521	250p
4526	108p
4527	150p
4528	100p
4532	140p
4534	550p
4536	375p
4538	120p
4543	180p
4553	320p
4556	72p
4560	200p
4569	250p
4572	40p
4583	110p
4584	90p
4585	150p
4724	250p
40097	90p
14411	1100p
14412	1100p
14433	1100p
14500	700p
14599	290p

INTERFACE ICs

AD536A	130p
AD561J	1400p
AD7524	600p
DM8123	175p
DM8131	375p
DP8304	450p
DS8835	250p
DS8836	150p
DS8838	225p
MC1488	75p
MC1489	75p
25S10	350p
75107	160p
75110	325p
75150	175p
75154	175p
75182	230p
75322	300p
75324	375p
75325	375p
75361	300p
75363	400p
75365	200p
75451/2	72p
75491/2	70p
8T26	160p
8T28	250p
8T95	200p
8T97	160p
81LS95	120p
81LS96	140p
81LS97	120p
81LS98	140p
9601	110p

93 SERIES

9301	160p
9302	175p
9308	316p
9310	275p
9311	275p
9312	160p
9314	165p
9316	225p
9321	225p
9322	150p
9334	360p
9368	250p
9370	300p
9374	200p

74S SERIES

74S00	60p
74S04	60p
74S05	75p
74S08	75p
74S10	60p
74S20	60p
74S30	60p
74S32	90p
74S37	90p
74S64	60p
74S74	90p
74S85	300p
74S86	180p
74S112	120p
74S114	120p
74S124	300p
74S132	160p
74S133	75p
74S138	225p
74S139	225p
74S157	250p
74S174	250p
74S175	320p
74S194	350p
74S241	450p
74S260	70p
74S373	500p
74S374	500p

LINEAR I.Cs

AY1-0212	600p
AY1-1313	668p
AY1-1320	320p
AY1-5050	140p
AY3-1270	840p
AY3-8912	650p
AY5-1224A	240p
AY5-1315	600p
AY5-1317A	775p
AY5-4007D	520p
CA3019	80p
CA3046	70p
CA3048	225p
CA3080E	72p
CA3086	48p
CA3089E	225p
CA3090AQ	375p
CA3130E	90p
CA3140E	50p
CA3160E	100p
CA3161E	140p
CA3162E	450p
CA3189E	300p
CA3280	160p
DAC1408-8	200p
FX209	750p
ICL7106	850p
ICL8038	300p
ICM7555	80p
LF13331	310p
LF351	48p
LF356P	95p
LM10C	425p
LM301A	27p
LM311	70p
LM318	200p
LM319	225p
LM324	45p
LM339	75p
LM348	95p
LM377	175p
LM380	75p
LM381AN	180p
LM386	95p
LM393	100p
LM709	36p
LM710	50p
LM725	350p
LM733	100p
LM741	18p
LM747	70p
LM748	35p
LM2917	250p
LM3900	70p
LM3909	70p
LM3911	130p
LM3914	225p
LM3915	225p
LM4136	120p
LM13600	125p
MC1310P	150p
MC1458	48p
MC1495L	350p
MC1496	70p
MC3340P	120p
MK50398	750p
ML920	775p
MM57160	620p
NE531	150p
NE555	20p
NE556	70p
NE562B	425p
NE564	420p
NE565	130p
NE566	155p
NE567	140p
NE571	425p
NE5534A	250p
S566B	270p
SAD1024A	1250p
SFF96364	1100p
SL490	400p
SN76003N	280p
SN76013N	140p
SN76013ND	120p
SN76023N	140p
SN76477	175p
SP8515	750p
TAA621	275p
TBA641B11	225p
TBA651	200p
TBA800	90p
TBA810	100p
TBA820	90p
TBA950	300p
TCA210	250p
TCA220	350p
TCA940	175p
TDA1004	300p
TDA1008	320p
TDA1010	225p
TDA1022	570p
TDA1024	120p
TDA1034B	250p
TDA1170	300p
TDA2002V	325p
TDA2020	320p
TL071/81	45p
TL072/82	75p
TL074	130p
TL084	110p
TL170	50p
UAA170	175p
UDN6118	320p
UDN6184	320p
ULN2003	100p
XR2206	300p
XR2207	400p
ZN414	90p
ZN419C	225p
ZN424E	135p
ZN425E	400p
ZN427E	750p

VOLTAGE REGULATORS

Fixed Plastic TO-220

1A	+ve		-ve	
5V	7805	65p	7905	65p
12V	7812	60p	7912	65p
15V	7815	60p	7915	70p
18V	7818	60p	7918	70p
24V	7824	60p	7924	70p
100mA	TO-92			
5V	78L05	30p	79L05	70p
12V	78L12	30p	79L12	70p
15V	78L15	30p	79L15	70p

OTHER REGULATORS

LM309K	135p	78HGKC	600p
LM317T	200p	78H05KC	550p
LM323K	500p	78MGT2C	135p
LM723	37p	79HGKC	600p
		TL497	300p

OPTO-ELECTRONICS

2N5777	45p	ORP60	120p
OCP71	90p	ORP61	120p
ORP12	120p	TIL78	55p

OPTO-ISOLATORS

ILD74	130p	TIL111	90p
MCT26	100p	TIL112	90p
MCS2400	190p	TIL116	90p

LEDS

0.125"		0.2"	
TIL32	55p	TIL220 Red	16p
TIL209 Red	13p	TIL222 Gr	18p
TIL211 Gr	20p	TIL228 Red	22p
TIL212 Ye	25p	Rectangular LEDs (R, G, Y)	30p
TIL216 Red	18p		

0.2"			
TIL220 Red	16p	NSB5881	570p
TIL222 Gr	18p	TIL311	600p
TIL228 Red	22p	TIL312/3	110p
Rectangular LEDS (R G Y)	30p	TIL321/2	130p
		TIL330	140p
		7750/60	200p

DISPLAYS

		DRIVERS	
3015F	200p	9368	250p
DL704	140p	9370	300p
DL707 Red	140p	UDN6118	320p
		UDN6184	320p

TRANSISTORS

AC126	25p
AC127/8	20p
AC176	25p
AC187/8	25p
AF116	50p
AD149	70p
AD161/2	45p
AU107	200p
BC107/8	11p
BC109	11p
BC117	20p
BC147/8	9p
BC149	10p
BC157/8	10p
BC159	11p
BC169C	12p
BC172	12p
BC177/8	17p
BC179	18p
BC182/3	10p
BC184	11p
BC187	30p
BC212/3	11p
BC214	12p
BC237	15p
BC327	16p
BC337	16p
BC338	16p
BC461	36p
BC477/8	30p
BC516/7	40p
BC547B	16p
BC548C	9p
BC549C	18p
BC557B	16p
BC559C	18p
BCY70	18p
BCY71/2	22p
BD131/2	54p
BD135/6	54p
BD139	56p
BD140	60p
BD189	60p
BD232	95p
BD233	75p
BD235	85p
BD241	70p
BD242	70p
BDY56	200p
BF200	32p
BF244B	35p
BF256B	70p
BF257/8	32p
BF259	36p
BFR39	25p
BFR40	25p
BFR41	25p
BFR79	25p
BFR80	25p
BFR81	25p
BFX29	40p
BFX30	34p
BFX84/5	40p
BFX86/7	30p
BFX88	30p
BFW10	90p
BFY50	30p
BFY51/2	30p
BFY56	33p
BFY90	90p
BRY39	45p
BSX19/20	20p
BU104	225p
BU105	190p
BU108	250p
BU109	225p
BU180A	120p
BU205	200p
BU208	200p
BU406	145p
E300	50p
E308	50p
E310	50p
MJ2501	225p
MJ2955	90p
MJ3001	225p
MJE340	50p
MJE2955	100p
MJE3055	70p
MPF102	45p
MPF103/4	40p
MPF105/6	40p
MPS6531	50p
MPS6534	50p
MPSA06	30p
MPSA12	50p
MPSA13	50p
MPSA20	50p
MPSA42	50p
MPSA43	50p
MPSA56	32p
MPSA70	50p
MPSU06	63p
MPSU07	60p
MPSU45	90p
MPSU65	78p
OC28	130p
OC35	130p
TIP29A	40p
TIP29C	55p
TIP30A	48p
TIP30C	60p
TIP31A	58p
TIP31C	62p
TIP32A	68p
TIP32C	82p
TIP33A	90p
TIP33C	114p
TIP34A	115p
TIP34C	160p
TIP35A	225p
TIP35C	290p
TIP36A	270p
TIP36C	340p
TIP41A	65p
TIP41C	78p
TIP42A	70p
TIP42C	82p
TIP54	160p
TIP120	120p
TIP122	130p
TIP142	130p
TIP147	130p
TIP2955	78p
TIP4055	70p
TIS43	45p
TIS93	30p
ZTX108	12p
ZTX300	13p
ZTX500	15p
ZTX502	18p
ZTX504	30p
2N457A	250p
2N696	35p
2N697	25p
2N698	45p
2N706A	30p
2N708	30p
2N918	45p
2N930	18p
2N1131/2	36p
2N1613	25p
2N1711	25p
2N2102	70p
2N2160	350p
2N2219A	30p
2N2222A	30p
2N2369A	25p
2N2484	30p
2N2646	45p
2N2904/5	30p
2N2906A	30p
2N2907A	30p
2N2926	9p
2N3053	30p
2N3054	65p
2N3055	48p
2N3442	140p
2N3553	240p
2N3565	30p
2N3584	250p
2N3643/4	48p
2N3702/3	12p
2N3704/5	12p
2N3706/7	14p
2N3708/9	12p
2N3773	300p
2N3819	25p
2N3820	50p
2N3823	70p
2N3866	90p
2N3902	700p
2N3903/4	18p
2N3905/6	20p
2N4037	65p
2N4058/9	12p
2N4060	12p
2N4061/2	18p
2N4123/4	27p
2N4125/6	27p
2N4401/3	27p
2N4427	90p
2N4871	60p
2N5087	27p
2N5089	27p
2N5172	27p
2N5179	90p
2N5191	90p
2N5194	90p
2N5245	40p
2N5296	55p
2N5401	50p
2N5457/8	40p
2N5459	40p
2N5460	60p
2N5485	44p
2N5875	250p
2N6027	48p
2N6041	160p
2N6044	160p
2N6052	300p
2N6059	325p
2N6107	65p
2N6247	190p
2N6254	130p
2N6290	65p
2N6292	65p
2SC1172	150p
3N128	120p
3N140	120p
3N141	110p
3N201	110p
3N204	120p
40290	250p
40360	40p
40361/2	75p
40364	120p
40408	90p
40409	100p
40410	100p
40411	300p
40594	120p
40595	120p
40673	75p
40841	90p
40871/2	100p

DIODES

BY127	12p
BYX36-300	20p
OA47	9p
OA81	15p
OA85	15p
OA90	9p
OA91	9p
OA95	9p
OA200	9p
OA202	10p
1N914	4p
1N916	7p
1N4148	4p
1N4001/2	5p
1N4003/4	6p
1N4005	6p
1N4006/7	7p
1N5401/3	14p
1N5404/7	19p
IS920	9p

HEAT SINKS

For TO220 Voltage Regs and Transistors	22p
For TO5	12p

BRIDGE RECTIFIERS

1A	50V	19p
1A	100V	20p
1A	400V	25p
1A	600V	30p
2A	50V	30p
2A	100V	35p
2A	400V	45p
3A	200V	60p
3A	600V	72p
4A	100V	95p
4A	400V	100p
6A	50V	80p
6A	100V	100p
6A	400V	120p
10A	400V	200p
25A	400V	400p

ZENERS

2.7V-33V

400mW	9p
1W	15p

TRIACS PLASTIC

3A	400V	60p
6A	400V	70p
6A	500V	88p
8A	400V	75p
8A	500V	95p
12A	400V	85p
12A	500V	105p
16A	400V	110p
16A	500V	130p
T2800D		130p

THYRISTORS

1A	50V	70p
1A	400V	90p
3A	400V	100p
8A	600V	140p
12A	400V	160p
16A	100V	160p
16A	400V	180p
BT106		110p
C106D		45p
MCR101		36p
TIC44		27p
2N3525		130p
2N4444		140p
2N5060		34p
2N5064		40p

LOUDSPEAKERS

Size		
2½"	64R	80p
2½"	8R	80p
2"	8R	90p
1½"	8R	100p

MEMORIES

2101-4L	400p
2102-2L	120p
2107B	500p
2111-4	400p
2112-4	300p
2114	225p
2114-2L	450p
4027-3	375p
4044	900p
4116	350p
5101	510p
6810	325p
74S201	350p
82S16	325p

ROM/PROMs

71301	700p
74S188	225p
74S387	350p
74S470	650p
74S471	650p
74S571	650p

CPUs

1600	1200p
1802CE	750p
2650A	2000p
6502	700p
6800	650p
6802	950p
6809	2500p
8080A	450p
8085A	1100p
INS8060	1000p
Z80	750p
Z80A	950p

EPROMS

1702A	500p
2708	450p
2716 (+5V)	£7

SUPPORT DEVICES

3242	800p
3245	450p
6522	700p
6532	900p
6820	375p
6821	340p
6845	£25
6850	300p
6852	370p
8155	1100p
8205	320p
8212	225p
8216	225p
8224	275p
8226	250p
8228	525p
8251	475p
8253	1000p
8255	450p
8257	900p
8259	950p
Z80PIO	600p
Z80APIO	700p
Z80CTC	600p
Z80SIO-1	£24
Z80ACTC	700p
Z80-SIO-1	£24
mc14411	1100p

UART

AY-3-1015P	500p
AY-5-1013A	400p
IM6402	500p
TMS6011NC	400p

CHARACTER GENERATORS

3257ADC	990p
RO-3-2513 U.C.	600p
RO-3-2513 L.C.	700p
SN74S262AN	£10

KEYBOARD ENCODER

AY-5-2376	700p

CRYSTALS

32.768KHz	250p
100KHz	300p
200KHz	370p
1.0MHz	320p
1.008MHz	350p
1.8432MHz	325p
2.00MHz	325p
2.45760MHz	325p
3.276MHz	300p
3.579MHz	150p
4.00MHz	290p
4.194MHz	POA
4.43MHz	125p
5.0MHz	325p
6.0MHz	300p
6.144MHz	300p
7.0MHz	300p
7.168MHz	300p
8.00MHz	300p
8.867MHz	300p
10.00MHz	310p
10.7MHz	300p
12.0MHz	350p
16.00MHz	350p
18.00MHz	300p
18.432	350p
19.968MHz	390p
26.690MHz	350p
27.145MHz	325p
38.6667MHz	350p
48.0MHz	300p
55.5MHz	400p
116.0MHz	350p

LOW PROFILE DIL SOCKETS BY TEXAS

8 pin	9p	18 pin	16p	24 pin	24p
14 pin	10p	20 pin	20p	28 pin	30p
16 pin	11p	22 pin	22p	40 pin	40p

WIRE WRAP SOCKETS BY TEXAS

8 pin	25p	18 pin	50p	24 pin	70p
14 pin	35p	20 pin	60p	28 pin	80p
16 pin	40p	22 pin	65p	40 pin	100p

SUBMINIATURE SWITCHES

Toggle	
SPST	60p
SPDT	65p
DPDT	70p
DPDT (centre off)	85p
Push to make	15p
Break	25p
Push latching SPCO	60p
SLIDE DPDT	18p
ROCKER SPST	28p
WAFER	
1P/12W	45p
3P/4W	45p
4P/3W	45p
2P/6W	45p

TRANSFORMERS

(prim 220/240V)

6-0-6 100mA	90p
9-0-9 75mA	95p
9-0-9 1Amp	330p
0-12V 2A	410p
15-0-15 1A	325p
0-12-15 20-24-30 1A	400p

ANTEX SOLDERING IRONS

C-15W	415p
CX-17W	425p
CCN-15W	425p
X25	440p
SPARE BITS	
C/CX/CCN	50p
X25	50p
SPARE ELEMENTS	
C/CX/X25	180p
CCN	200p
ADCOLA IRONS	
K1000	550p
K2000	550p

VEROBOARDS

DIP Breadboard 4.15 × 6.15 (Suitable for 20 × 14 pin or 16 × 16 pin DIL ICs) 325p

DIP Breadboard as above with tracks for 31 way connector 375p

V-Q Boards for ICs (No track cutting) 130p

CONNECTOR PLUGS

31 way Plug	120p
31 way Socket	120p
S-100 Busboar	1500p

EDGEBOARD CONNECTORS 0.156" PITCH

2 x 10 way	85p	2 x 22 way	135p
2 x 15 way	100p	2 x 25 way	160p
2 x 18 way	120p		

COUNTERS

74C925	550p
74C928	600p
ICM7216B	2000p
ICM7217A	850p
ZN1040E	700p

TTL & ECL

MC4024	325p
MC4044	325p
10116	70p
10231	350p

★ SPECIAL OFFERS ★

2114L (450ns)	£2.25	7805/7812	£5/10
2708 (450ns)	£4.00	7905/7912	£6/10
2708 (650ns)	£3.25	(Above prices for one value)	
2716 (+5V)	£7.00	P&P and VAT extra	
4116 (200ns)	£2.75		

Programming service for 2716 available by appointment or by mail.

BREADBOARDS

EXP350 3.6 x 2.1 (Up to 3 x 14 pin ICs)	£3.15
EXP650 3.6 x 2.4 (Up to 1 x 40 pin IC)	£3.60
EXP300 6 x 2.1 (Up to 6 x 14 pin ICs)	£5.75
EXP600 6 x 2.4 (Up to 1 x 40 pin DCs)	£6.30

PROTOBOARD (R) SOLDERLESS BREADBOARDS

Socket Strips/Bus Strips/Binding Posts mounted on sturdy base plate.

PB6 6 x 14 DIL ICs	£9.20
PB100 10 x 14 DIL ICs	£11.80
PB102 12 x 14 DIL ICs	£22.95
PB103 24 x 14 DIL ICs	£34.45
PB104 32 x 14 DIL ICs	£45.95

16 KEY KEYPAD (Reed Switches)	450p
UHF Modulator 6MHz	£3.75
UHF Modulator 8MHz	450p
LOGIC PROBE	£18.00
MICROTEST 80R	£17.00
TMK500	£22.00
Pocket multimeter	£4.75

VEROBOARDS

0.1 (copper clad)

2.5×3.75"	65p	Pkt of 100 pins	50p
2.5×5"	75p	Spot face cutter	120p
3.75×3.75"	75p	Pin insertion tool	118p
3.75×5"	80p	Vero Wiring Pen + 2 wire spools + combs	370p
3.75×17"	340p		
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Our new improved performance model of the Linsley Hood Cassette Recorder incorporates our VFL 910 vertical front mechanism and circuit modifications to increase dynamic range. Board layouts have been altered and improved but retain the outstandingly successful mother and daughter arrangement used on our Linsley Hood Cassette Recorder 1.

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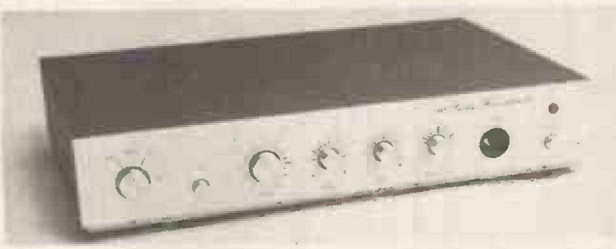
LINSLEY-HOOD 30 WATT AMPLIFIER



The very latest amplifier design to be published and in our opinion the best yet. The concept was to produce an amplifier that sounded as good as the authors 75 watt design but which was cheaper and simple to build for applications where the higher power is not needed. This new kit is designed to match the Linsley-Hood Cassette Recorder 2 and a tuner will be available later to make a complete stackable system. A very advanced assembly system has been devised by us to make construction ultra simple and anyone who can solder components in a printed circuit board will find it great fun. Conventional wiring is at an irreducible minimum, only being needed to connect the mains transformer and pilot light. For an amplifier of this quality this kit represents incredible value for money.

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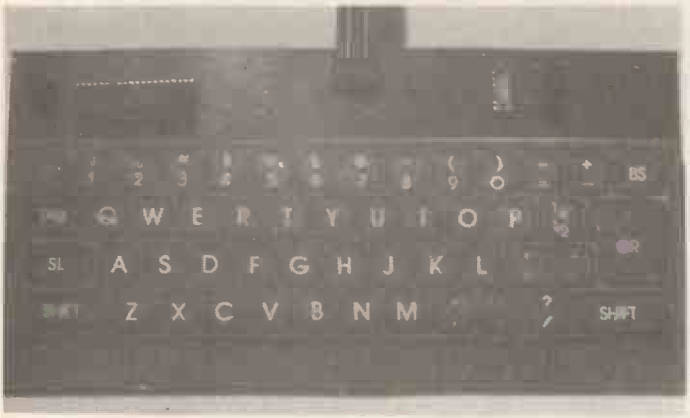

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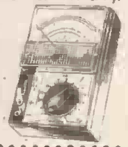

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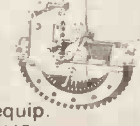

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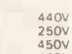

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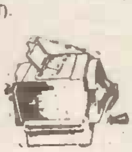

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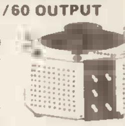

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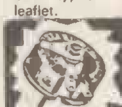

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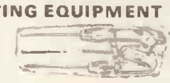

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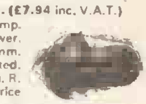

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6.5 mfd.	280V AC	£1.00
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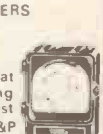

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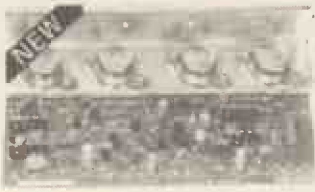

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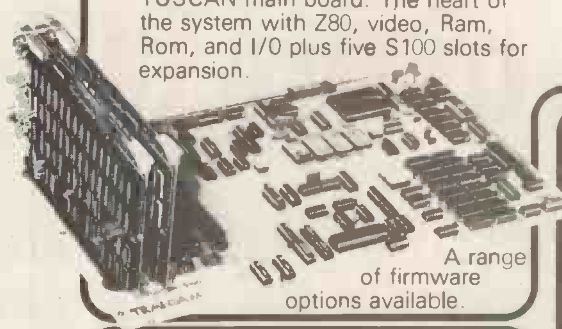

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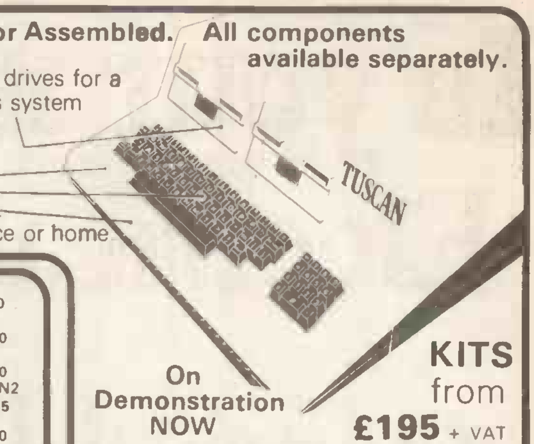

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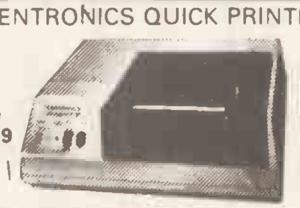

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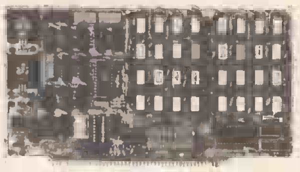

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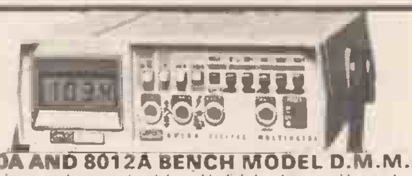

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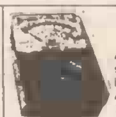

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213	1.0	.0.5	2.90	0.90
71	2	1	3.86	0.90
18	4	2	4.46	1.10
85	.0.5	2.5	6.16	1.10
70	6	3	6.99	1.10
108	8	4	8.16	1.31
72	10	5	8.93	1.31
116	12	6	9.89	1.52
17	16	8	11.79	1.52
115	20	10	15.38	2.39
187	30	15	19.72	2.39
·226	60	30	40.41	O.A.

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Sec Voltages available 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30V or 12V-0-12V or 15V-0-15V

Ref.	30V	Price	P&P
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79	1	3.93	1.10
3	2	6.35	1.10
20	3	6.82	1.31
21	4	8.79	1.31
51	5	10.86	1.52
117	6	12.29	1.67
88	8	16.45	1.89
89	10	18.98	1.89
90	12	21.09	2.24
91	15	24.18	2.39
92	20	32.40	O.A.

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1K	30.67	2.65	84W
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Sec Voltages available 5, 7, 8, 10, 13, 15, 17, 20, 33, 40 or 20V-0-20V or 25V-0-25V.

Ref.	25V	50V	Price	P&P
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103	2	1	4.57	1.10
104	4	2	7.88	1.31
105	6	3	9.42	1.52
106	8	4	12.82	1.73
107	12	6	16.37	1.89
118	16	8	22.29	2.39
119	20	10	27.48	O.A.
109	24	12	32.88	O.A.

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Voltages available 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 or 24V-0-24V or 30V-0-30V

Ref	30V	60V	Price	P&P
124	1	.5	4.27	1.10
126	2	1	6.50	1.10
127	4	2	8.36	1.31
125	6	3	12.10	1.31
123	8	4	13.77	2.12
40	10	5	17.42	1.89
120	12	6	19.87	2.12
121	16	8	27.92	O.A.
122	20	10	32.51	O.A.
189	24	12		

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Ref.	mA	Volts	£	P&P
238	200	3-0-3	2.83	0.63
212	1A, 1A	0-6, 0-6	3.14	0 90
13	100	9-0-9	2.35	0.44
235	330 330	0-9, 0-9	2.19	0.44
207	500 500	0-8-9, 0-8-9	3.05	0 85
208	1A, 1A	0-8-9, 0-8-9	3.88	0.90
236	200 200	0-15, 0-15	2.19	0.44
214	300 300	0-20, 0-20	3.08	0 90
221	700 (DC)	20-12-0-12-20	3.75	0.90
206	1A 1A	0-15-20-0-15-20	5.09	1.10
203	.5 .5	0-15-27-0-15-27	4.39	1.10
204	1A 1A	0-15-27-0-15-27	6.64	1.10
239	50	12-0-12	2.88	0 37

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Ref.	VA	Price	P&P
'07	20	4.84	0.91
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151	200	12.28	1.31
152	250	14.61	1.73
153	350	18.07	2.12
154	500	22.52	2.47
155	750	32.03	O.A
156	1000	40.92	O.A.
157	1500	56.52	O.A.
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Ref	VA (Watts)	£	P&P
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64	75	4.41	1 10
4	150	5.89	1.10
67	500	12.09	1 91
84	1000	20.64	2.39
93	1500	25.61	OA
95	2000	38.31	OA
73	3000	65.13	OA
80S	4000	84.55	OA
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For further information on either Mikro 1000 system, please contact:

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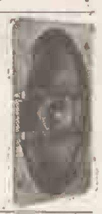

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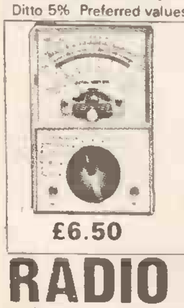
Suitable for cassettes, and all sizes of tape reels. AC mains 200/250V. Hand held size with switch and lead. Will also demagnetise small tools **£7.50** Post 50p
Head Demagnetiser only £5

RELAYS. 12V DC **95p.** 6V DC **85p.**
BLANK ALUMINIUM CHASSIS. 6 x 4—**95p;** 8 x 6—**£1.40;** 10 x 7—**£1.55;** 12 x 8—**£1.70;** 14 x 9—**£1.90;** 16 x 6—**£1.85;** 16 x 10—**£2.20.** **ANGLE ALI.** 6 x ¾ x ¾in—**25p.**
ALUMINIUM PANELS. 6 x 4—**24p;** 8 x 6—**38p;** 14 x 3—**40p;** 10 x 7—**54p;** 12 x 8—**70p;** 12 x 5—**44p;** 16 x 6—**70p;** 14 x 9—**94p;** 12 x 12—**£1;** 16 x 10—**£1.16.**
PLASTIC AND ALI BOXES IN STOCK. MANY SIZES
ALUMINIUM BOXES. 4 x 4 x 1½ **£1.** 4 x 2 x 2 **£1.** 3 x 2 x 1 **80p.** 6 x 4 x 2 **£1.30.** 7 x 5 x 2½ **£1.45.** 8 x 6 x 3 **£2.20.** 10 x 7 x 3 **£2.50.** 12 x 5 x 3 **£2.30.** 12 x 8 x 3 3.
BRIDGE RECTIFIER 200V PIV 4 amp **£1.50.** 8 amp **£2.50.**
TOGGLE SWITCHES SP **30p.** DPST **40p.** DPDT **50p.**
PICK-UP CARTRIDGES ACOS, GP91 **£2.00.** GP94 **£2.50.**
SONOTONE 9TAHC Diamond **£3.75.** V100 Magnetic **£6.50.**
RESISTORS. 10Ω to 10M. ¼W, ½W, 1W, **1p;** 2W **10p.**
HIGH STABILITY. ½W 2% 10 ohms to 1 meg. **8p.**
Ditto 5% Preferred values, 10 ohms to 10 meg. **3p.**

MINI-MULTI TESTER



Deluxe pocket size precision moving coil instrument, jewelled bearings — 2000 o.p.v. Battery included
11 instant ranges measure:
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Continuity and resistance 0-1 meg ohms in two ranges.
Complete with Test Prods and instruction book showing how to measure capacity and inductance.
£6.50

HIGH QUALITY

JVC DECK
£28.50
Post £2

J.V.C. BELT DRIVE STEREO DECK
Detachable head, adjustable counter balance weight, hydraulic damped cueing platform, automatic pick-up arm return, 2 speeds, 33 and 45 rpm, suppression circuit to start stop switch. 240V AC motor, dynamic pendulous bias compensator. Teak veneered base. 19in. x 14½in **£9.** Plastic cover **£6,** post £2.
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RCS SOUND TO LIGHT KIT Mk. 2

Kit of parts to build a 3 channel sound to light unit 1,000 watts per channel. Suitable for home or disco. Easy to build. Full instructions supplied. Cabinet **£4.50** extra. Will operate from 200MV to 100 watt signal. **£18** Post 50p
200 Watt Rear Reflecting White Light Bulbs. Ideal for Disco Lights, Edison Screw. 6 for **£4,** or 12 for **£7.50.** Post 50p.

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This kit is suitable for record players, guitars, tape playback, electronic instruments or small PA systems. Two versions available: Mono, **£12.50;** Stereo, **£20.** Post 45p. Specification 10W per channel; input 100mV; size 9½ x 3 x 2in. approx. SAE details. Full instructions supplied. AC mains powered. Input can be modified to suit guitar.

RCS STEREO PRE-AMP KIT. All parts to build this pre-amp. Inputs for high, medium or low imp per channel, with volume control and PC Board **£2.95**
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6-12 volt 4 amp	£6.50	6-12 volt 4 amp	£2.00

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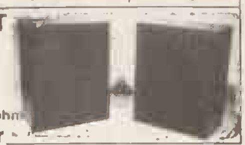

FLUTED WOOD FRONTS
TEAK VENEERED CABINET
11 × 8½ × 7in
50 to 14,000 cps 15 watts 8 ohm
Post £2 **£20 pair**

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2500mF 50V **70p;** 3000mF 50V **65p;** 2000mF 100V **£1.**
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5000mF 35V **85p.**

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8/350V	35p	8+8/500V	95p	50+50/300V	50p
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50/500V	£1.20	32+32/350V	50p	150+200/275V	70p
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SHORT WAVE 100pf air spaced gangable tuner, **95p.**
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Post £1.50 ea.

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DELUXE MK II	12	8-16	15	HI-FI	£14
SUPERB	12	8-16	30	HI-FI	£20
AUDITORIUM	12	8-16	45	HI-FI	£20
AUDITORIUM	15	8-16	60	HI-FI	£29
GROUP 35	12	4-8-16	40	PA	£12
GROUP 45	12	4-8-16	45	PA	£15
GROUP 50	12	4-8-16	60	PA	£20
GROUP 75	12	4-8-16	75	PA	£22
GROUP 100	12	8-16	100	PA	£26
GROUP 100	15	8-16	100	PA	£29
DISCO 100	12	8-16	100	DISCO	£26
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£69 Post £2.00
Ideal for Halls/PA systems, Discos and Groups. Two inputs. Mixer, Volume Controls, Master Bass, Treble and Gain Controls. 50 watts r.m.s. Three loudspeaker outlets 4, 8, 16 ohms.

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Professional 4 inputs with volume controls. Will mix mics, decks, musical instruments, etc. **£89**
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MAKE	MODEL	SIZE	WATTS	OHMS	PRICE
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GOODMANS	TWEETER	3½in	25	8	£4.00
AUDAX	TWEETER	3¾in	60	8	£10.50
SEAS	MID-RANGE	4in	50	8	£7.50
SEAS	MID-RANGE	5in	80	8	£10.50
SEAS	MID-RANGE	4½in	100	8	£12.50
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GOODMANS	FULL-RANGE	8in	20	8	£5.50
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Stabilised output, 9 volt 400 m.a. UK made in plastic case with screw terminals. Safety overload cut out. Size. 5 × 3¼ × 2½in. Transformer Rectifier Unit. Double insulated. Suitable Radios, Cassettes, models. **£4.50**

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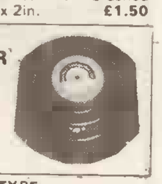
For 13x8in. or 8in. speaker **£9.50** Post 99p
For 6½in. speaker and tweeter **£8.50** Post 99p
Many other cabinets in stock. Phone your requirements.
SPEAKER COVERING MATERIALS. Samples Large S.A.E.
LOUDSPEAKER CABINET WADDING 18in wide **25p** ft.

GOODMANS TWIN AXIOM 8 inch dual cone loudspeaker. 8 ohm. 15 watt hi-fi unit **£10.50.** Ditto 15 ohm **£8.** Post £1.
CROSSOVERS. TWO-WAY 3000 c/s 3 or 8 or 15 ohm **£1.90.** 3-way 950 cps/3000 cps. **£2.20.**
LOUDSPEAKERS PM 3 ohm 7x4in. **£1.50;** 6½in., **£3.00;** 8x5in., **£3.00;** 8in., **£3.50.**
SPECIAL OFFER: 64 ohm, 2¾in., **35** ohm, 3in., 25 ohm, 3in., 5x3in., 7x4in., 8 ohm, 2in., 2¾in., 3in., 3½in., 5in., **15** ohm, 3½in. dia, 6x4in., 7x4in., 5x3in., 3 ohm, 4in., 5in., 7x4in., **120 ohm,** 3¼in. dia. **£1.50 each.**
FAMOUS MAKE TWIN CONE LOUDSPEAKERS
8in. diameter 4W **£3.50.** 10in. diameter 5W **£3.50;** 12in. diameter 6W **£4.50.** 3/8 or 15 ohms, please state.
MOTOROLA PIEZO ELECTRIC HORN TWEETER **£6.50**
Handles up to 100 watts. No crossover required.
BLACK PLASTIC CONSTRUCTION BOX with brushed aluminium facia. Sturdy job. Size 6¼ x 4¾ x 2in. **£1.50**

GOODMANS RUBBER SURROUND BASS WOOFER



Standard 12in. diameter fixing with cut sides 12" x 10". 14,000 Gauss magnet. 20 watts RMS 4 ohm imp.
Bass resonance = 30 c.p.s.
Frequency response 20-8000 c.p.s.
BARGAIN, £8.50. Post £2

ALUMINIUM HEAT SINKS. FINNED TYPE.
Sizes 5"×4"×1" **95p.** 6½"×2"×2¼" **45p.**
JACK PLUGS Mono Plastic 25p; Metal 30p.
JACK PLUGS Stereo Plastic 30p; Metal 35p.
JACK SOCKETS. Mono Open 20p; Closed 25p.
JACK SOCKETS Stereo Open 25p; Closed 30p.
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Values = 5, 7, 10, 20, 50, 100, 200, 250, 470, 2000 ohms.

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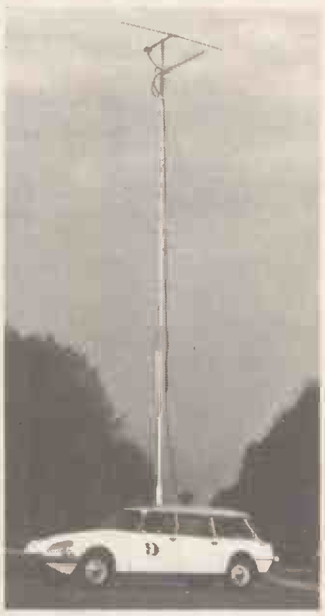

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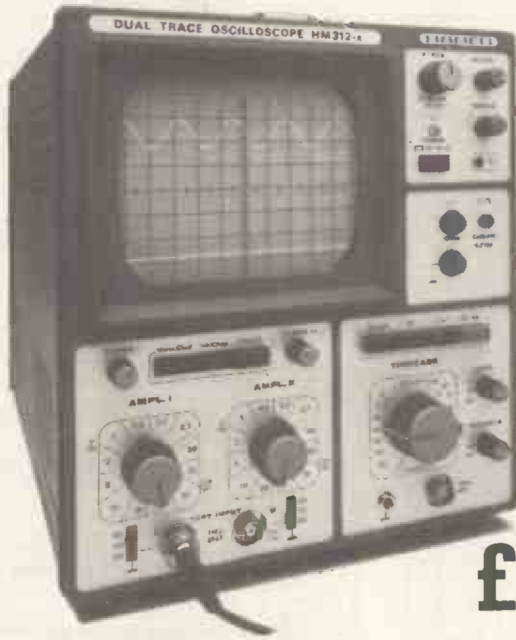
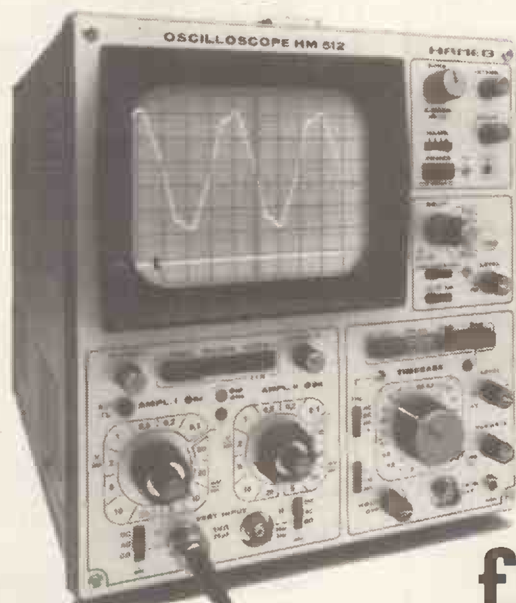


HM312 Dual Trace Oscilloscope. DC-20MHz. Sensitivity 5mV-20V/cm Time base range 0.5uS-0.2S/cm with x 5 horiz mag to 100nS/cm. CRT screen 8x10cm. Full XY using chII as X input. Bandwidth 2.3 MHz. TV trigger.

£250



HM512 Dual Trace Oscilloscope with delayed sweep. DC-50MHz. Sensitivity 5mV-20V/cm Time base range 0.1uS-2.0S/cm with x5 horiz mag to 20nS/cm. Delay ranges 7 decade steps 100ns-1S with fine control CRT screen 8 x 10cm. Full XY using ch II as x input, bandwidth 4 MHz. Z input. Delay line allows viewing of leading edge. Vertical overscan indicated by 2 LED's.

£580

Other models available.
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TEKTRONIX 465B PORTABLE OSCILLOSCOPE

100MHz Dual Trace Delayed and Mixed Sweep Trigger View supplied with all Standard Accessories +

1 YEAR WARRANTY

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5½ digit. AC/DC volts. 1µv resolution on DC. Autoranging. Variable display time. Resistance down to 1mΩ

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Variable Phase, Sine and Signal Generator 203A £495
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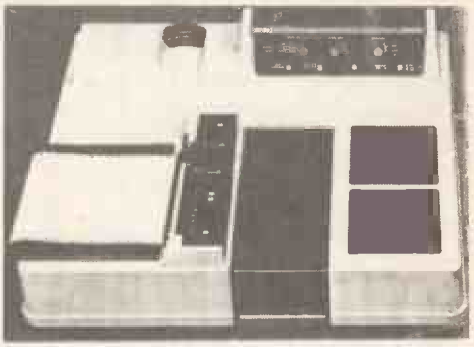

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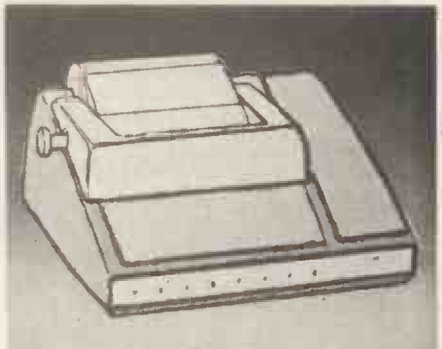

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SCREEN SIZE — 12″ diagonal.
SCREEN CAPACITY — 960 characters; 80 per line x 12 lines.
CHARACTERS — 5 x 7 Dot Matrix; 625-line raster.
CHARACTER SET — 64 ASCII alphanumerics and symbols.
KEYBOARD — TTY format.
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Specification

SCREEN — 12″ diagonal. 1998 characters: 74 per line x 27 lines.
CHARACTERS — 5 x 7 Dot Matrix; 625 lines raster.
CHARACTER SET — 64 alphanumerics and symbols. 32 ASCII control codes.
KEYBOARD — Detachable, solid state. TTY design. 10-key numeric cluster plus editing and cursor control keys.
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OPERATING MODES — Switch-selectable, full duplex, half-duplex or batch.
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STANDARD INTERFACE — CC ITT V-24 (EIA RS-232 B/C).
REMOTE COMMANDS — Insert/delete Line, Clear Screen, Clear Foreground Data Only, Home Cursor, Address Cursor, Set Background intensity. Set Foreground Intensity, Carriage Return, Backspace, Ring Bell, Transmit, Print.
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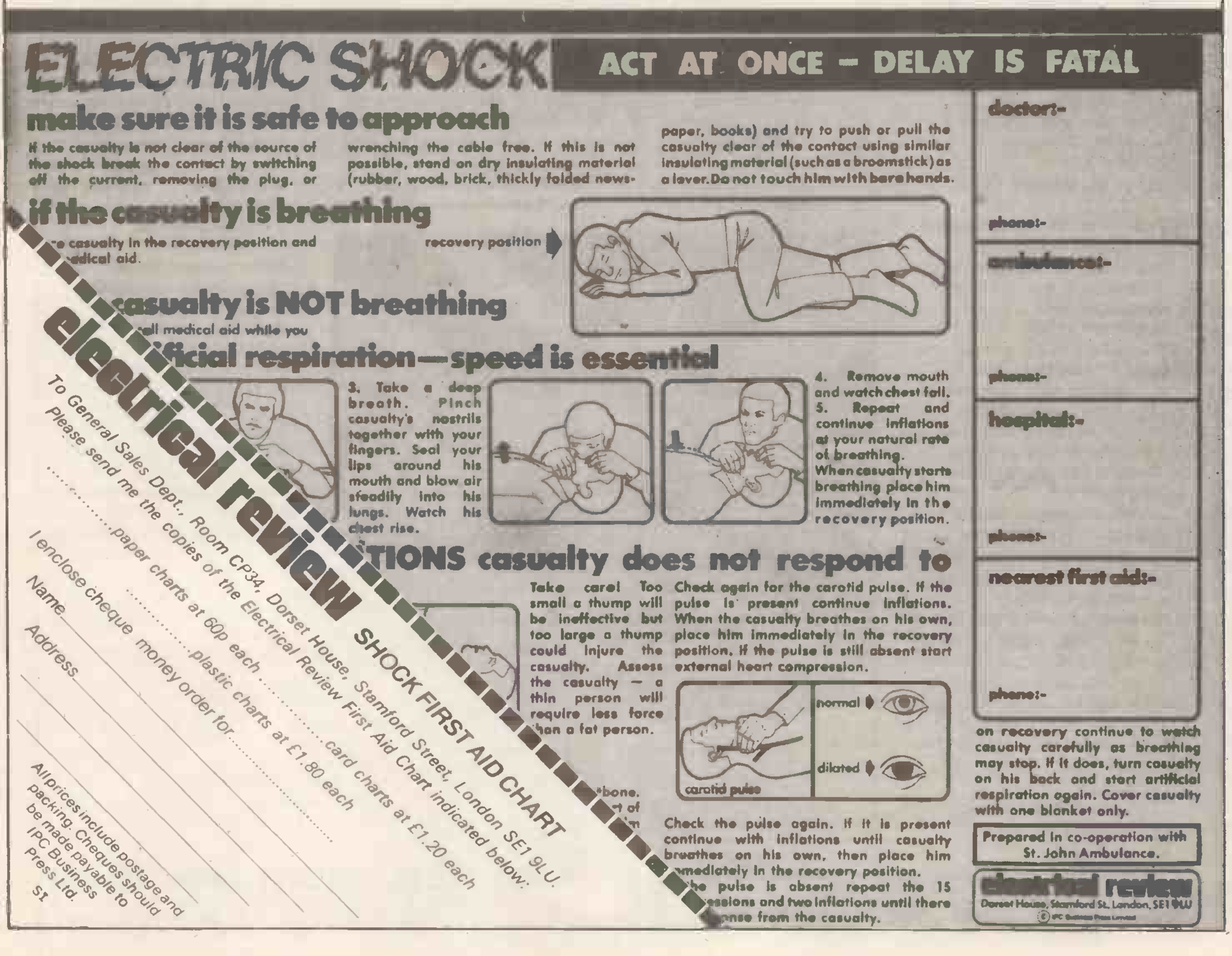

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Advertisements accepted up to 12 noon Monday, November 3rd, for December issue, subject to space being available.

DISPLAYED APPOINTMENTS VACANT: £12.00 per single col. centimetre (min. 3cm).
LINE advertisements (run on): £2.00 per line, minimum three lines.
BOX NUMBERS: £1 extra. (Replies should be addressed to the Box Number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London SE1 9LU).
PHONE: Eddie Farrell, 01-261 8508.
Classified Advertisement Rates are currently zero rated for the purpose of V.A.T.

WE'RE MOVING

NOTICE TO CLASSIFIED ADVERTISERS RE: CHANGE OF ADDRESS

With effect from November 7, 1980, Wireless World will be moving to Sutton, Surrey. From this date, classified advertisers should send their material to the following address:

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WIRELESS WORLD
Quadrant House, The Quadrant
Sutton, Surrey SM2 5AS

TELEPHONE: 01-661 3500
TELEX: 892084 BISPRS G

wireless world

(747)

Advanced Broadcasting Equipment

Increased home and export orders for our broadcast TV products mean that we are looking widely to recruit staff to fill new vacancies and others created by promotion of engineers who have been with us some time.

SYSTEMS ENGINEERS — TELEVISION

Experienced engineers are needed to work on design and project management of Outside Broadcast vehicles and television studios. This is an opportunity for engineers to become involved in projects from their initial design concept, through manufacturing to delivery and installation.

Our custom built systems require a high degree of customer contact at engineering level, from the initial design stage to the necessary training of operational staff on completion of the contract, both within the UK and overseas.

You should have a knowledge of TV studio engineering gained from experience in this type of work or from experience in the operational side of television.

DESIGN AND DEVELOPMENT ENGINEERS — VIDEO

An experienced engineer who will be involved in the design of studio products, including a new range of colour cameras, using the very latest analogue and digital techniques. You will have the opportunity to see your designs made in volume production, fulfilling the high technology requirements of the '80s.

We are looking for engineers who are qualified to degree or HND level and who have at least four years' experience in the design of electronic equipment, with some knowledge of video engineering and microprocessor techniques.

DESIGN AND DEVELOPMENT ENGINEER — AUDIO

A senior audio design engineer responsible for the design of custom made studio talkback systems to specifications agreed with customers, for use in television mobiles and studios.

You need to be professionally qualified, and have a background to enable you rapidly to take over the full responsibilities of this product area.

TEST ENGINEERS

We require engineers at intermediate level to assist in the manufacture of our new range of products for the Broadcast studio television market.

You need to have an up-to-date knowledge of digital and linear circuit techniques gained from experience working on broadcast television, or similar sophisticated products, and be capable of faultfinding down to component level.

We are a young, successful Company, well known in international television circles, operating from our modern purpose-built factory in Andover. Salaries offered are very competitive, and supplemented by generous holidays, free life and health insurance, pension scheme, subsidised meals and relocation expenses.

PLEASE WRITE GIVING FULL DETAILS OR PHONE JEAN SMITH AT THE ADDRESS BELOW FOR AN APPLICATION FORM.

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ELECTRONICS

Link Electronics Limited,
North Way, Andover,
Hants, SP10 5AJ.
Telephone: (0264) 61345

(735)

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Starting salary up to £6,737 (under review).
Please apply for an application form to the Recruitment Officer (Dept. WW9)
H.M. Government Communications Centre, Hanslope Park, Milton Keynes MK19 7BH.

(589)

R & D Engineers

required to work on digital circuits for micro-processor based industrial and commercial systems.

The candidate should have a working knowledge of TTL and CMOS logic and have experience of programming at assembler language level for micro-processor systems.

Engineers should hold a degree/HNC or equivalent qualifications. Salary will be commensurate with qualifications, age and experience.

If you are seeking an enjoyable position involving both hardware and software development, write giving your career to date or telephone

Dr. G. O. Towler
(New Product Development Manager)
British Relay Electronics Ltd.
32 Biggin Way
Upper Norwood
London, SE19
Tel. 01-764 0931

(172)

British Relay Electronics

ENGINEERING OPPORTUNITIES

Telemotive uk Ltd is a Company in association with a major U.S.A. manufacturer with world leadership in the radio control of industrial machines, systems and processes, in collision prevention, and in other industrial electronics activities.

Our principal products are founded on the Near Field Induction Effect and on other inductive techniques in the 300kHz band. No other U.K. company has a comparable product line and our business therefore offers engineering experience of unusual interest. Training in our techniques is provided.

COMMISSIONING ENGINEER

We currently require an engineer with the ability to work independently, commissioning, servicing and testing systems on customer's sites. In addition, the engineer would at times work on systems requiring service at base (Hersham).

The position involves travelling within the U.K. and will take the engineer into a wide variety of industries. A company car is provided.

ELECTRONICS TECHNICIAN

We also require a technician whose duties would include assembly, wiring and test of complete equipment as well as testing small batches of PCBs. He or she would work with a small team of engineers but must be able to work unsupervised.

Previous experience of wiring is essential, preferably to military standards. Previous production testing experience would be an advantage.

Telemotive is a good employer. We look only for above average personnel, and this is reflected in the conditions of employment offered.

Please apply in writing, giving details of previous experience and training, to:—

765

telemotive uk ltd

Riverdene Industrial Estate, Molesey Road, Hersham, Walton-on-Thames, Surrey
Telephone Walton-on-Thames (09322) 47511

NORTH WEST THAMES REGIONAL HEALTH AUTHORITY

SENIOR ELECTRONICS TECHNICIAN

for THE REGIONAL AUDIOLOGY CALIBRATION AND REPAIR SERVICE

This post was created to help improve audiology (hearing testing) services in the area covered by the North West Thames Regional Health Authority. The technician will be providing a Regional Service but will be based in a laboratory in the Department of Medical Physics, Charing Cross Hospital and working under the supervision of the Audiological Scientist.

The work includes routine calibration and repair of equipment in audiology centres in the Region. Additionally the technician will assist in the equipment advisory service and in some development work in the Audiometry Department at Charing Cross Hospital. Excellent workshop facilities are available.

Applicants should have an interest in audio-engineering and good organising abilities. The travelling necessary to provide this service will require the technician to use his/her private car for which allowances will be made in accordance with D.H.S.S. regulations. The post is Medical Physics Technician III grade with a salary scale of £5003-£6350 inc.

Further details and an application form available from: **District Personnel Department, Brandenburgh House, 116 Fulham Palace Road, London W6. Tel: 01-748 2040 x 2992.**

(723)

UNIVERSITY OF NOTTINGHAM
Department of Psychology
A vacancy exists in the Psychology Department for a Grade 6

COMPUTER TECHNICIAN

(Male or female). Duties include the design/development of sophisticated on-line equipment for laboratory control plus routine maintenance of the Department's computer laboratory complex. The laboratory is based on a PDP 11-34 master computer with DEC GT40 and LSI 11 slave machines. Expansion of the system, including microprocessor based developments, is in progress.

Design experience with CMOS/TTL devices is essential and previous computer experience desirable.

Suitable qualifications include HNC (or quivalent) in a relevant subject or ONC with appropriate computer experience.

Salary is in the range of £5,478-£6,543 per annum.

Application forms can be obtained from the **Head of Technical Services, Department of Psychology, University of Nottingham, University Park, Nottingham NG7 2RD. Telephone: Nottingham 56101 Extn. 3174.**

(719)

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(8994)

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Take a look at Kodak

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We are expecting a high standard from you. You will need a sound knowledge of practical electronics coupled with mechanical skills, preferably having had previous servicing experience. In return we can offer the rewards and promotion prospects expected when you join a large international company and potential earnings in the range £7,000 – £8,000 p.a. (under review) including some overtime, allowances and company bonus plus plenty of attractive employee benefits.

We are looking for men or women aged 21 and over to join our teams of service engineers strategically placed around the U.K. to meet the service needs of our customers.

Full training on our equipment will be provided and on completion of training a Company vehicle is provided where it is needed to cover the territory.

Please write to Mr. C. Long, Personnel Department, A1t, Kodak Limited, P.O. Box 66, Station Road, Hemel Hempstead, Herts. HP1 1JU, giving details of education, experience and personal information.

Kodak

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(756)

MANAGEMENT & EXECUTIVE SELECTION

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Join a successful, progressive company and reap the benefits. Engineers with 1-6 years computer maintenance experience are required in many UK regions. Salaries £7K – £12K + car. Interested?
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(631)

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REQUIRED (AGE 25 TO 40)

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Application with curriculum vitae in English should be addressed to:

CIBA-GEIGY LIMITED
Agro-Projects AG 8.13/Attn H. Wenk
4024, Basel, SWITZERLAND
For further particulars ring: 010/4161/377192

(718)

NATIONAL BROADCASTING SCHOOL

We are looking for a

BROADCAST ENGINEER

with experience in Local Radio.

The job will involve teaching radio operations and maintenance, and will include maintenance of the School's studios and facilities. Some travel will be required.

The successful applicant will be responsible to the Chief Engineeer and will have had significant experience in broadcasting, preferably with a background in maintenance. Some experience of teaching and of digital technology would also be advantageous.

Excellent staff benefits including 5 weeks' holiday a year. Salary negotiable.

Please apply with CV and other relevant details to: Chief Engineer, National Broadcasting School, 14 Greek Street, London W.1.

(738)

WESTWARD TV

TV BROADCAST ENGINEERS —PLYMOUTH

Westward TV seeks several additional experienced Electronic Broadcast Engineers for their Studios at Plymouth. One vacancy involves the operation and maintenance of Telecine and VTR equipment, including quadruplex 1" helical scan and high band Umatic equipment, together with Rank Cintel telecines.

Additionally, two vacancies are anticipated in the Electronic Maintenance Department, one of which will be a more senior appointment and involve maintenance duties within the Master Transmission Control area. We offer attractive locality and conditions of service including five weeks' annual holiday (from next year), free life insurance and salaries of up to £9,950 (Senior Engineer), including supplements.

Telephone the Personnel Manager for further details on 0752 69311 or write to Westward Television Limited, Derry's Cross, Plymouth PL1 2SP.

(725)

SENIOR AUDIO TEST ENGINEER

Opportunity to join a London based company producing high quality sound mixing consoles for live media, professional recording and broadcast applications.

The individual most suitable for this responsible and interesting situation would be aged 28+ with HND (or similar) qualification and several years post-qualification experience in fault diagnosis with audio products designed to a high-reliability specification.

Ability to formulate test procedures, to appraise quality standards and coordinate an enthusiastic team of test engineers and technicians is essential.

In return we offer excellent remuneration, good conditions and an opportunity to gain managerial experience in this field.

Telephone Jim Cousins on 01-388 7060 or 01-387 7679 for an application form and further information, or write to him giving resumé of career to date.

MIDAS Audio Systems Ltd.
54-56 Stanhope St., London NW1 3EX

(724)

PHILIP DRAKE ELECTRONICS LTD.

Manufacture Audio equipment for the Broadcast Industry and have vacancies for the following staff:

PROJECT ENGINEER

To work in the Project Department. The job includes Project discussion with customers, the detail design of systems, test supervision, and the compilation of system handbooks.

TEST ENGINEER (as PROJECT ENGINEER)

To test primarily the custom-built products, mainly Communications systems, along with supervision of other staff and Test department load management and planning. Some experience in the design and test of audio and digital circuits is essential.

DESIGN ENGINEER

To work under supervision of the present Design Engineer, to undertake detail circuit design and product development. Experience in the design of audio and digital circuits is essential, and an understanding of product design for manufacture is desirable.

DRAUGHTSPERSON/TRACER (as PROJECT ENGINEER)

To work primarily in the Project Department, to prepare handbook drawings and design system metalwork, and also to prepare circuit diagrams and standard products. Experience in control panel layouts and Broadcast audio requirements is desirable.

The company offers a 37½-hour week with 17 days' holiday minimum. Experience in the Broadcast Industry and/or suitable qualifications are desirable for all positions. Salary negotiable dependent on experience. Apply by telephone or writing to:

Alan Brill, Philip Drake Electronics Ltd.
23 Redan Place, London W2 4SA. Tel. 01-221 1476

(752)

Radio Communications

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To join our expanding R&D Laboratories covering a wide range of R.F. spectrum, from L.F. to V.H.F. Equipments include transmitters and receivers for marine- and land-based use, radio navaids and radio monitoring remote computer-controlled systems.

Electronics Engineers should have experience in transmitter or receiver design, analogue or digital circuit design, microprocessor applications. Software Designers should be experienced Programmers with an interest in control, signal processing or navigational software.

Attractive salaries are complemented by excellent prospects and generous benefits.

Contact: **David Bird, Redifon Telecommunications Limited, Broomhill Road, Wandsworth, London, S.W.18. Phone: 01-874 7281** (reverse charges).

(9938)

UNIVERISTY OF SURREY

ELECTRONICS TECHNICIAN ENGINEERS

The Electronics Services Unit in the Department of Electronic & Electrical Engineering seek a Grade 6 Technician to assist with the design, development, production and maintenance of a wide range of electronic equipment. Current projects include control and measurement modules for the UOSAT satellite to be launched in 1981, underground communication systems, instrumentation for ion implantation research and various applied microprocessor systems. Applicants should have broad based practical experience and HNC equivalent qualification.

The University offers good working conditions and environment, and facilities for a wide range of sports and social activities. Salary in on a scale £5478 to £6543. For further details or to arrange a visit contact Dennis Pollard (Guildford 71281 Ext 392).

The University has four other vacancies for experienced Electronic Technician Engineers at salaries between £4776 and £6543 in the Departments of Chemistry, Electronic and Electrical Engineering, Psychology, and the Computing Unit. Contact **Karina Bruley (Guildford 71281 Ext 776)** or write to **The Staff Officer, University of Surrey, Guildford GU2 5XH.**

(712)

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We offer a Technician the chance of working on the design and construction of specialised electronic equipment which will be used in both research and clinical applications. This is an excellent opportunity for a man or woman who holds a City and Guilds Final Technological Certificate (or equivalent) in appropriate subjects and ideally has some experience in the use of analogue and digital circuit techniques.

You will be working with four other technicians and apart from your design work, you will carry out maintenance on a wide range of commercial apparatus within our purpose built and well-equipped workshop.

Please phone Mr. A. Charles, Senior Electronics Engineer, on (01) 794 0500 Ext. 3198, to arrange an informal visit.

Application form and Job Description available from the Personnel Department, Royal Free Hospital, Pond Street, London NW3 2QG. Tel. (01) 794 0500 Ext. 4286. Please quote ref. 0761. Closing date 30th October, 1980.

Camden and Islington Area Health Authority (T)

(727)

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01-502 1589/01-464 7714. EXT. 502 (321)

Going Places?

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We have immediate vacancies for suitably qualified men and women to train in the operation and maintenance of broadcast transmitters and to serve in various parts of the country. Even if you have no previous experience in RF transmission work it may be worth your while to apply since full training will be given. Transmitter work is challenging and involves knowing about colour television techniques, stereo radio transmission, digital communication, logic and microprocessors, wave propagation, aerials and transmission lines as well as heavy power equipment. In the future opportunities may arise for work overseas or on mobile maintenance teams.

The minimum qualification required for an Engineer appointment is an appropriate HNC/HND, a C & G, F.T.C. (Telecommunications) or a T.E.C. Higher Certificate or Diploma in Electronics or Telecommunications.

Applicants must have normal colour vision and hearing.

Starting salary is in the range £5425 to £5945 depending upon experience plus extra payment for shift working.

For further information and an application form, write to:- **The Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA,** or leave your address by telephone on 01-408 0052 at any time, quoting Reference No. 80.E.4052/WW.

BBC

(700)

CHIEF ELECTRONICS TECHNICIAN

The Department of Physical Metallurgy and Science of Materials to take charge of Departmental Electronics Workshop. Responsibilities to include maintenance and repair of electronics equipment, supervision of trainee technicians, design and construction of electronic and electrical equipment. Experience in electrical and electronic maintenance of electron microscopes would be an advantage, but not essential. It would also be necessary for the technician to be on call after hours for maintenance duties in connection with the electron microscope. A special inconvenience allowance would be paid for these duties. Salary scale £6378-£7164 per annum. Ref. 109/d/258.

Application form available from:

Assistant Secretary
Personnel Office
University of Birmingham
P.O. Box 363
Birmingham B15 2TT (742)

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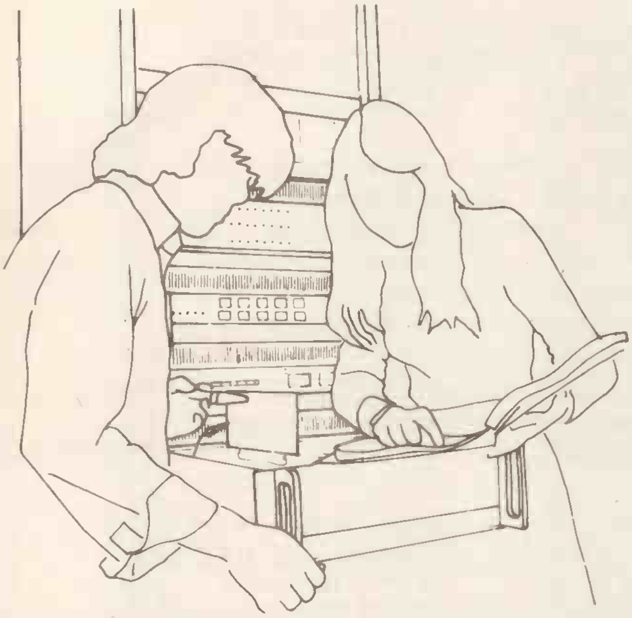

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If you are interested to hear more, please fill in the following details:-

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(9200)

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NORTHERN REGIONAL HEALTH AUTHORITY

ELECTRONICS TECHNICAL ASSISTANT

Electronics Technicians of high calibre are required for the Regional Engineer's Department, which is based at Walkergate, Newcastle-upon-Tyne.
The appointment will be at Technical Assistant Grade I, on the salary scale £5850-£6900 (currently under review).
These posts offer technologically interesting and varied work, with excellent working conditions, and well-equipped laboratories. They involve visits to hospitals throughout the Region, for which financial reimbursement is made.
Applicants must have had considerable and broad experience with modern electronic equipment.
Minimum qualifications: Higher National Certificate or City and Guilds Full Technological Certificate in Electronic Engineering, or equivalent.
Application form and job description available from the **Regional Personnel Officer, Northern Regional Health Authority, Benfield Road, Newcastle-upon-Tyne NE6 4PY.**
Closing date for applications: 27th October, 1980. (721)

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Please send detailed curriculum vitae to:
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POSTBUS 75, 6190 AB BEEK (L), THE NETHERLANDS**

(701)

ELECTROSONIC

PRODUCT DESIGN ENGINEER

Electrosonic Ltd., a world leader in the fields of audio visual, lighting and control systems, require a Product Design Engineer with professional qualifications, in one or more of the following disciplines:

Audio recording — reproduction, analogue, or digital control circuit design.

The applicant should have a minimum of two years' proven experience for this senior post. The ability to undertake all aspects of a design and development from product conception through to production, including initial design, prototype development and A.T.E. programming is essential.

The right applicant will enjoy an excellent salary and working conditions at our recently-opened design offices in Swanley.

Please write or telephone for an application form to:

Peter Smith—Design Manager—Unit Products
Electronics Ltd.
Warwick House
Azalea Drive, Swanley, Kent
Telephone Swanley 60321

1978

USE YOUR IMAGINATION

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Minim Audio

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Age should be over 25; an excellent salary negotiable with expanding company in leisure field.

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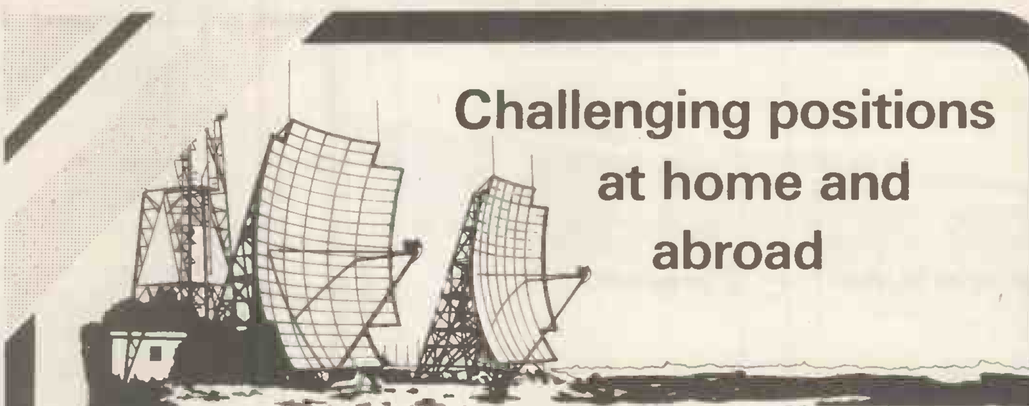

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Please apply, with details of your career to date, to: Personnel Manager, Plessey EAE Limited, Dept WW, Offshore House, 284/285 Southtown Road, Gt. Yarmouth, Norfolk NR31 0JB Telephone 0493 58541

(530)

PLESSEY EAE

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COMPUTING LABORATORY

MICROPROCESSOR COMPUTING OFFICER

The University Computing Microprocessor Laboratory provide advice and help to the University research community in the use of microprocessors. Cross assemblers and other tools are supported by the University PRIME configuration.

The post will involve the design and development of microprocessor based systems. Familiarity with microprocessor architecture over a broad range is desirable.

Applicants should have a degree in a relevant discipline and experience in the microprocessor field.

Salary or Other Related 1A Scale £5505-£9595 USS Superannuation.

Further particulars and application forms are available from **The Registrar, University of Salford, Salford M5 4WT** to whom completed forms should be returned by 14 November 1980, quoting reference CL/79/WW. (722)

Electronic Engineers – What you want, where you want!

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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.

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TJB

Please send me a TJB Appointments Registration form:

Name . . . .

Address . . . .

. . . .

(9238)

UNIVERSITY OF LIVERPOOL
DEPARTMENT OF BIOCHEMISTRY

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For servicing and repairing scientific equipment. Applicants should have at least ONC or equivalent qualification in electrical/electronic engineering. Experience desirable but not essential. Salary Grade 3 (£3918-£4590) or Grade 4 (£4431-£5097) according to qualifications and experience.

Application forms from the Registrar, The University, P.O. Box 147, Liverpool, L69 3BX. Quote ref. RV/580/WW. (740)

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Application form and further details from Group Personnel Department, 01-405 9200, extension 228. (751)

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(768)

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Write for application form to: **The Secretary, Department of Clinical Measurement, Westminster Hospital, 65 Romney Street, London, S.W.1, or Telephone 828 9811, Ext. 2640.**

(750)

UNIVERSITY OF ABERDEEN

TECHNICIAN (GRADE 3)

required for the Department of Bio-Medical Physics and Bio-Engineering for 3-year appointment working as a member of a team developing apparatus for medical imaging; the research project has reached the stage of producing images of sections of the body. Applicants should hold an ONC (or equivalent qualification) and have had about 4 years' experience in electronics. Previous experience in imaging is not necessary, as the successful applicant will acquire skill in this and allied fields.

For suitably-qualified candidate, salary will be on scale £3,919-£4,590.

Persons interested in being considered for the post and in obtaining further information on the work are invited to contact D. J. M. S. Hutchison, Department of Bio-Medical Physics, Aberdeen AB9 2ZD (Tel. 0224-681818, Extension 3220).

(741)

CBC 221

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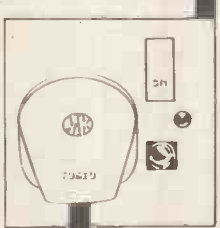

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(761)

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GCHQ

Inner London Education Authority
LEARNING MATERIALS SERVICE
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London SW8

HEAD OF SOUND (ST4)

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Applicants should have suitable theoretical qualifications with *significant* relevant experience at senior level. A good working knowledge of all sound operations associated with television and film is essential.

Salary is within the scale £8756.64 to £9593.64.

Further information and application forms available from the Education Officer (EO/Estab. IC), Room 365, I.L.E.A. The County Hall, London SE1 7PB. Telephone 01-633 7456.

(734)

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(720)

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(650)

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(Ref. 150/2)

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Application forms, quoting reference number, from the Administrative Services Officer, Leeds Polytechnic, Calverley Street, Leeds LS1 3HE.

(681)

SITUATIONS VACANT

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Television Centre, Thackery Road, London, SW8

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Salary is within the scale £5,072 to £7,631. Progression up the scale to £6,818 is by annual increments subject to satisfactory performance. Progression beyond that point is dependent on a positive assessment.

Further information and application forms available from the **Education Officer (EO/Estab. 1C), Room 365, I.L.E.A., The County Hall, London SE1 7PB. Telephone 01-633 7456.**

(729)

QUEEN MARY COLLEGE
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ELECTRICAL & ELECTRONIC ENGINEERING DEPARTMENT

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(744)

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DEPARTMENT OF BIOCHEMISTRY

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(739)

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EDUCATION DEPARTMENT
Grade 4

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(743)

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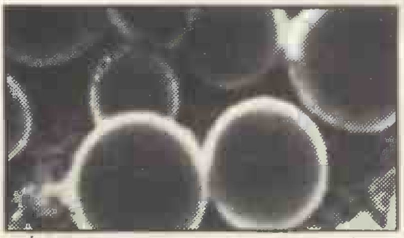

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