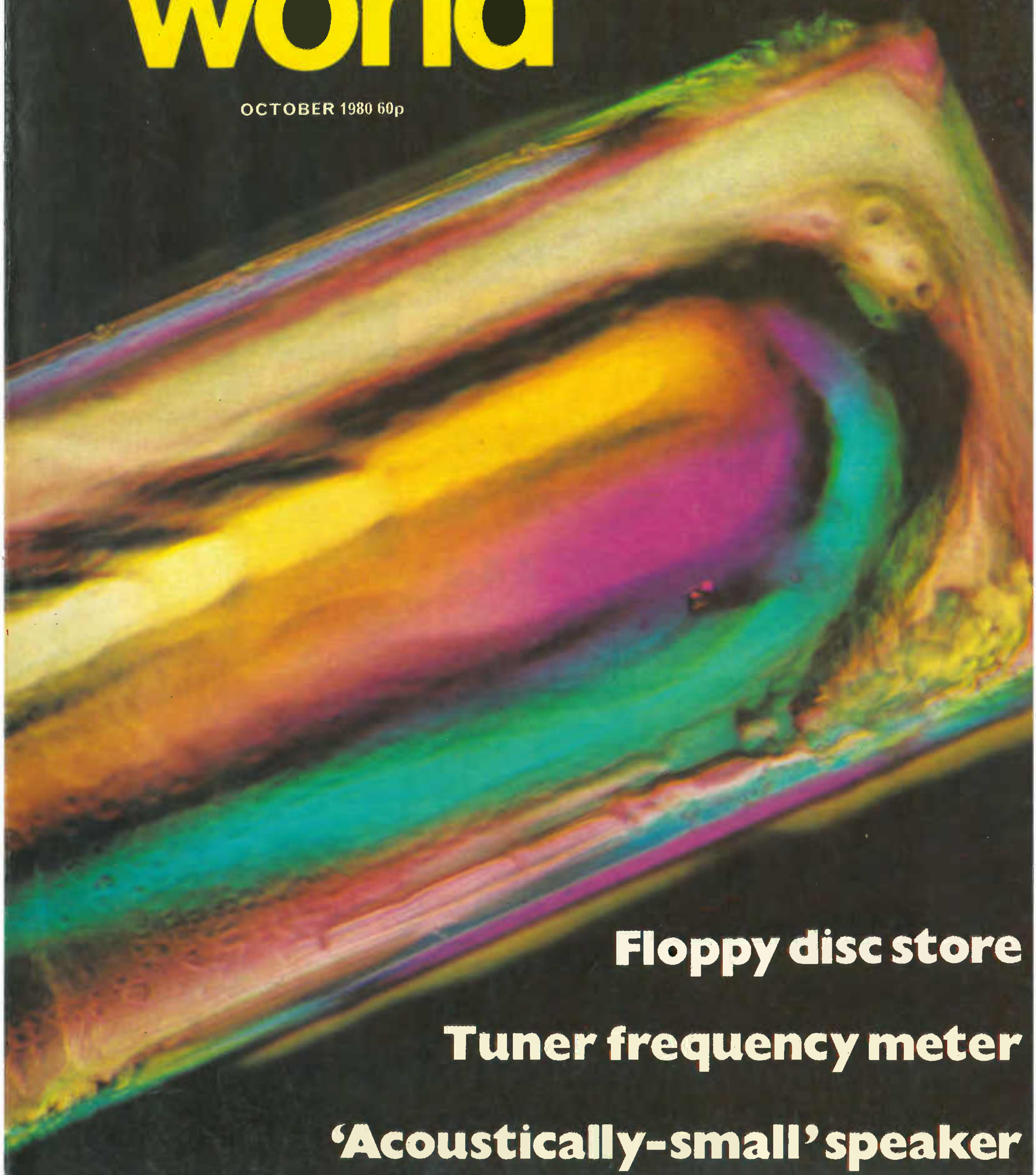
wireless world

OCTOBER 1980 60p



Floppy disc store

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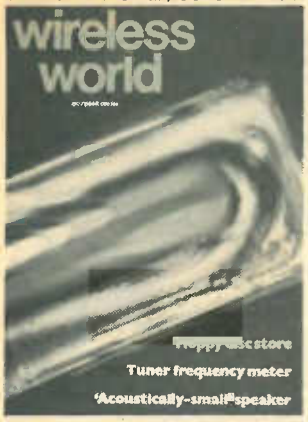
'Acoustically-small' speaker



Front cover shows a single Rochelle salt piezo-electric crystal, as seen in polarized light. Photo by Paul Brierley

IN OUR NEXT ISSUE

Unique pickup arm **Constructional design in which horizontal and vertical pivots are displaced to increase arm radius and so reduce tracking distortion.**

Amplifier-loudspeaker interface distortion **examines intermodulation between the signal and a delayed, frequency transformed version generated by the loudspeaker and propagated in the feedback loop.**

Designing inductors carrying d.c. **Simple procedure allows different cores to be compared and the optimum one chosen for a particular design.**

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ELECTRONICS/TELEVISION/RADIO/AUDIO

OCTOBER 1980 Vol 86 No 1537


Haltron

TRIO TEST INSTRUMENTS

THE RANGE HAS INCREASED — THE PRICES ARE DOWN

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) 2mV/cm (20 MHz)	Sweep time 200nS/cm-0.5 S/cm
	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.

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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.

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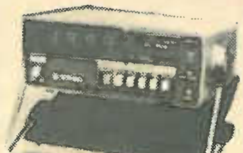
AC to 1000V
Ω to 20MΩ
I to .2A

Semi Auto Ranging



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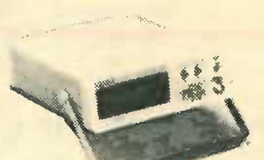
FC756 500 MHz COUNTER

10 Hz-500 MHz
50mV

Superb instrument



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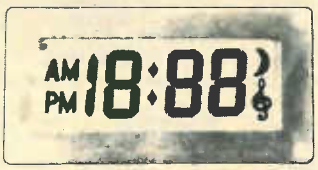

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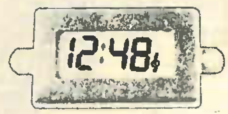

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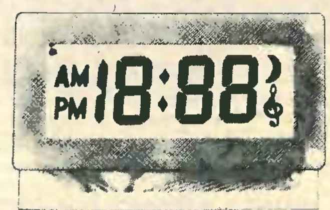

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Temp drift typ 80ppm/C

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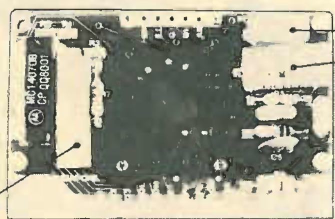
1pA typical input current
Decimal point selection with on board EX–OR integrated circuit



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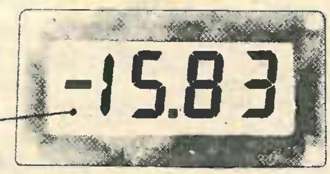
Polypropylene integrating capacitor for minimal roll – over error

Large easy to read 0.5 inch LCD



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BS314 4 channel 1mV-10V 16 speeds — 1650
BS316 6 channel 1mV-10V 16 speeds — 2350
29300 X-Y Single pen A4 0.25mV-10V/cm 0.1s-50s/cm — 545

HEWLETT PACKARD
680M. 5 inch. Stripchart Single Pen 5mV-120V I/P 20cm/min 2.5 cm/Hr — 275
7046A Two pen A3 0.25mV-5V/cm — 995

KUDELSKI
Nagra 4.2 LSP Professional Audio Recorder (Batt optd) — 1215

NAGRA
Mains Unit for 4.2 LSP — 95

PHILIPS
PM 8251 Single pen 10in chart 10mV-50V FS — 450

RACAL
Store 4. Uses D/4 inch magnetic tape. Will record 4 F.M. channels. Operates at 7 different speeds. — 1950

S E LABORATORIES
6150/6151 12 channel UV 1250 mm/s-25 mm/min 6 in chart — 1400
994 6 Channel Pre-Amp ± 1% ± 1V o/p — 450
6008 25 Channel μV 8 in 4m/sec to 25mm/min — 895

SMITHS INDUSTRIES
RE541.20 Single Pen. 0.5mV-100V FSD. 3-60cm/min and hour — 350

YOKOGAWA
3046. 10 inch Chart Single Pen. 0.5 mV-100 VI/P2.60cm/min and/hr — 350
3047. 2 Pen Version of 3046 — 425

Signal Sources and Generators

BOONTON
102B 4.3-520 MHz Int/Ext FM/AM 0.1μV-1V 50Ω — 1725

DYMAR
1525 100 kHz-184 MHz Int/Ext AM/FM Batt/Mains — 525

GOULD ADVANCE
SG70 5 Hz-125 kHz 600Ω 4w — 85

HEWLETT PACKARD
204D 5 Hz-1.2 MHz. 600Ω. 80dB att. O/P 5V RMS — 150
204D/001 As for 204D (Battery operated) — 175
608E. 10-480 MHz AM — 410
620B 7-11 GHz 50Ω FM/PM 1mw — 1100
8614A 800 MHz-2.4 GHz + 10dBm to −127 dBm 50Ω AM/FM — 1950
8616A 1.8-4.5 GHz Ext AM/FM/PM 10 mw — 925

MARCONI
TF144 H/4S HF Generator 10 kHz-72 MHz AM — 550
TF791. FM Deviation Meter 4-1024 MHz — 95
TF801/D1. 10-470 MHz AM. FM. — 255
TF995A/2. 1.5-220 MHz AM. FM. — 350
TF2171 Digital Synchroniser for TF2015 — 525
TF2002/AS 10 kHz-72 MHz FM/AM 0.1-1V o/p — 625
TF2012 UHF, FM 400-520 MHz, 0.03μV. Counter o/p — 650

RACAL
9081 5-520 MHz LED Display O/P — 130dBm AM/FM — 1875

ROHDE & SCHWARZ
SWOB 11 0.5-1200 MHz. 50Ω — 850

SCHAFFNER
NSG101 Mains Interference Simulator. Superimposes Pulses on mains for testing immunity of equipment to interference. Pulse amplitude. ±800V. Rise Time 0.25μs Width 50 & 200μs — 300
NSG330 Ignition Interference Attachment — 150
NSG200B Mains Interference Simulator (Mainframe) — 250

STC
74216 Noise Generator 20 Hz-4 kHz Flat/CCITT Wtg — 315

TEXSCAN
9900. 10-300 MHz. Sweep generator with CRT display — 525
TV Markers set of 5: 31.5, 32.5, 35, 39.5 & 41.5 MHz — 195

Spectrum Analysers

HEWLETT PACKARD
8443A Tracking Gene/counter 100 kHz-110 MHz — 850
8445A Automatic pre-selector 10 MHz-18 GHz — 1300
8555A RF Plug-in 10 MHz-18 GHz 1 kHz Res — 3000
8558B For 180 Mainframe 100 kHz-1.5 GHz 1 kHz-res — 1750
3580A/001/002 Digital Storage 5 Hz-50 kHz. X-Y o/p — 1400

NELSON ROSS
011. DC-20 kHz. 80dB dynamic range. Dispersion: 100 Hz-6 kHz — 350
022. DC-100 kHz. Dynamic range 60dB fits into various 500 series CRO's — 350

TEKTRONIX
3L5. Plug-in unit fits into various 500B series CRO's. 50 Hz-1 MHz. Greater than 60dB dynamic range — 475

Sweep Generators

HEWLETT PACKARD
8690B Mainframe. Int/Ext AM. Ext FM — 600
8693B/100 3.7-8.3 GHz.5mW. PIN levelled 'N' connectors — 600
8699B/100 0.1-4 GHz.6mW. (20mW to 2 GHz). PIN levelled. 'N' connectors — 1200

TEXSCAN
9900 Sweep Generator 10-30 MHz CRT Display — 525
VS60 Sweep Generator 5-100 MHz Rate 60 Hz — 950
LN40A Log Amplifier — 105

T.V. Test Equipment

PHILIPS
PM5508B Pattern Generator. 625 lines PAL. UK Systems — 225

Voltmeters-Analogue

AVO
8 Mk IV — 70

BOONTON
92AD/01/09 10 kHz-1.2 GHz 1999 FSD 10μV Res — 525
92C 10 kHz-1.2 GHz 500μV-3V. 1% of FS — 350

BRADLEY
CT471C. AC/DC/Ω, current multimeter and RF — 75

HEWLETT PACKARD
400E Millivoltmeter 10 Hz-10 MHz B/W 1mV FSS — 99
427A. AC DC/Ω multimeter — 275
3406A. 10 kHz 1.2 GHz — 345
8405A Vector Voltmeter 1-1000 MHz B/W Auto Phase Lock — 850
3400A 10 Hz-10 MHz 1mV-300V True RMS — 350

KEITHLEY
610C Electrometer DC 1mV-100V, Amps 10^{-14} Recorder o/p — 350

LEVELL
TM3B 5μV-500VAC 1 Hz-3 MHz + 50 to 100 dB — 80

LINSTEAD
M2B DC AC 10 Hz 500 kHz — 25

MARCONI
TF2603. AC voltmeter to 1.5 GHz — 300

PHILIPS
PM2454B 1mV 300V. 10 Hz 12 MHz Z in 19MΩ. DC O P — 300

RACAL
9301 RMS Millivoltmeter 10 kHz-1.5 GHz with carry case — 475

Voltmeters-Digital

ADVANCE
DMM 7A/01 1999 FSD AC/DC/Ω/Current — 115

FARNELL
DM131B. 1999 FSD AC DC Ω Current Temperature — 85

FLUKE
8000A 1999 FSD. AC/DC/OHMS/Current — 115

HEWLETT PACKARD
34740A/34702A 9999 FSD.AC/DC/OHMS — 180

SOLARTRON
LM1420.2. 2300 FSD DC only 0.05% — 75
LM1420.2BA. 2300 FSD AC True RMS/DC — 110
A200.19999 FSD DC only — 160
A203.19999 FSD AC/DC/Ω. Sensitivity: (1μV DC, 10μV AC, 100mΩ resistance) — 300
A205.19999 FSD AC/DC/Ω — 300
A243. 119999 FSD AC/DC/Ω. Sensitivity: (1μV DC, 10μV AC, 10mΩ resistance) — 325
7050.99999 Auto AC/DC/Ω — 350

Voltmeters Vector/Phase

DRANETZ
305B 9999 FSD Mainframe for PA 3001 module — 575

HEWLETT PACKARD
3490A 100000 FSD 1μV-1000V DC 0.01% 10μV-1000V AC & Ω — 625

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TEKTRONIX 465 DC-100 MHz Dual Trace 5mV-5V/Div 0.05μs-0.5s/Div Delayed T/B XY DC 4 MHz — £1250
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CROWCON
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YELLOW SPRINGS INST.
57 Dissolved Oxygen Meter — 405

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ROTHEROE & MITCHELL
L2SK Personal Air Sampling Kit — 195

Data Comms. & Cable Test Equipment

MARCONI
TF2333 Transmission Test Set 30 Hz-550 kHz — 685

WANDEL & GOLTERMANN
PS3 Selective Level Osc. 300 Hz-612 kHz — 425
SPM3 Selective Level Meter 300 Hz-612 kHz — 475

Temperature Measuring Equipment

COMARK
1601 BLS Analogue Thermometer for Type A thermocouples. 4 ranges −87 to +1000°C — 75
1604 BLS As 1601 except ranges −60 to +170°C in 23 steps — 82
1625 BLS Type T thermocouples −100° to +300°C in 40 steps Batt/optd — 90
1642 BLS Type J Thermocouples −120° to 800°C in 9 steps Batt/optd. — 75

Radio Telephones & Test Equipment

DYMAR
BC282 4 Port Battery Charger 50 Hz-240V AC — 115
883 0.5W VHF R/T. 3 Freq. Selector Hand Held — 385

Phase Meters

DRANETZ
PA3001 Phase module 2 Hz-700 kHz ± 0.1 to 0.25° — 225
301A 5 Hz-500 kHz Z in 100kΩ ± 1°-2° — 400

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Carston

Carston Electronics Limited
Shirley House, 27 Camden Road, London NW1 9NR. Telex 23920

Contact Brian Hollingsworth or Noel Jennings **01-267 5311/2**

WW — 033 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).

LINEAR ICs - NUMERIC LISTINGS

TBA120S	1.00
L200	1.95
U237B	1.28
U247B	1.28
U257B	1.28
U267B	1.28
LM301H	0.67
LM301N	0.30
LM308H	0.96
LM308N	0.65
LM339N	0.66
LM348N	1.86
LF351N	0.38
LF353N	0.76
LM374N	3.75
LM380N-14	1.00
LM380N-8	1.00
LM381N	1.81
ZN419CE	1.95
NE544N	1.80
NE555N	0.30
NE556N	0.50
NE560N	3.50
NE562N	4.05
NE564N	4.29
NE565N	1.00
NE566N	1.60
NE570N	3.85
SL624	3.28
TBA651	1.81
uA709HC	0.64
uA709PC	0.36
uA710HC	0.65
uA710PC	0.59
uA741CH	0.66
uA741CN	0.27
uA747CN	0.70
uA748CN	0.36
uA753	2.44
uA758	2.35
TBA810AS	1.09
TBA820M	0.75
TCA940E	1.80
TDA1028	2.11
TDA1029	2.11
TDA1054	1.45
TDA1062	1.95
TDA1072	2.69
TDA1074A	5.04
TDA1083	1.95
TDA1090	3.05
HA1137	1.20
HA1196	2.00
HA1197	1.00
TDA1220	1.40
LM1303	0.99
LM1307	1.55
MC1310P	1.90
MC1330	1.20
MC1350	1.20
HA1370	1.90
HA1388	2.75
TDA1490	1.86
MC1496P	1.25
SL1610P	1.60
SL1611P	1.60
SL1612P	1.60
SL1613P	1.89
SL1620P	2.17
SL1621P	2.17
SL1623P	2.24
SL624C	3.28
SL1625P	2.17
SL1626P	2.44
SL1630P	1.62
SL1640P	1.89
SL1641P	1.89
TDA2002	1.25
TDA2020	3.00
ULN2242A	3.05
ULN2283B	1.00
CA3080E	0.70
CA3089E	1.84
CA3090AQ	3.35
CA3123E	1.40
CA3130E	0.80
CA3130T	0.90
CA3140E	0.46
CA3189E	2.20
MC3357P	2.35
LM3900N	0.60
LM3909N	0.68
LM3914N	2.80
LM3915N	2.80
KB4400	0.80
KB4406	0.60
KB4412	1.95
KB4413	1.95
KB4417	1.80
TDA4420	2.25
KB4420B	1.09
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
LM1232	19.00
LM1242	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

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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

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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
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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

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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

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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

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2N3866	0.85

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2SK168	0.35
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J176	0.65
40823	0.65
40673	3SK51
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3SK60	0.58
MEM680	0.75
BF961	0.70
BF960	1.24
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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
1N0,1N5,1N8..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

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10mm TYPE
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BC147B	6p
BC149	7p
BC149C	7p
BC159	9p
BC160	35p
BC167A	10p
BC178	12p
BC179	12p
BC182	8p
BC182L	9p
BC183	9p
BC183L	9p
BC184L	9p
BC186	20p
BC212	9p
BC212L	9p
BC213B	9p
BC327	13p
BC328	13p
BC337	16p
BC338	11p
BC440	32p
BC547	9p
BC548	9p
BC550	14p
BC558	12p
BCY33	99p
BCY34	99p
BCY39	229p
BCY58	16p
BCY70	12p
BCY71	12p
BCY72	12p
BF179	25p
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BFX30	32p
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2N2368	15p
2N2369	14p
2N2894A	20p
2N2904	15p
2N2904A	15p
2N2905	15p
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7412	17p
7413	25p
7414	45p
7416	25p
7417	25p
7420	14p
7427	28p
7430	14p
7432	22p
7438	26p
7442	48p
7447	50p
7450	15p
7451	15p
7470	30p
7472	25p
7474	20p
7475	27p
7480	40p
7482	60p
7486	25p
7491	63p
7492	35p
7493	28p
7494	63p
7495	63p
74100	110p
74107	30p
74121	25p
74122	36p
74123	44p
74145	72p
74154	80p
74157	60p
74161	85p
74175	63p
74180	84p
74181	151p
74191	80p
74192	80p
74193	80p
74194	80p
74LS00	11p
74LS01	11p
74LS02	12p
74LS03	12p
74LS04	12p
74LS10	19p
74LS11	20p
74LS20	18p
74LS30	18p
74LS32	24p
74LS42	89p
74LS51	24p
74LS55	28p
74LS74	39p
74LS75	46p
74LS76	39p
74LS85	99p
74LS90	36p
74LS93	79p
74LS114	49p
74LS122	65p
74LS123	65p
74LS124	115p
74LS132	89p
74LS139	79p
74LS151	89p
74LS155	91p
74LS156	89p
74LS157	69p
74LS165	69p
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4021	83p
4022	79p
4023	16p
4024	49p
4025	17p
4026	129p
4027	39p
4028	59p
4029	89p
4030	49p
4034	189p
4035	99p
4042	69p
4043	86p
4044	83p
4046	109p
4049	45p
4050	63p
4051	69p
4052	69p
4053	69p
4066	49p
4069	17p
4070	17p
4071	17p
4072	17p
4073	17p
4075	19p
4076	75p
4077	35p
4081	19p
4082	17p
4160	105p
4161	105p
4162	105p
4163	105p
4402	36p
4404	110p
4412	86p
4445	174p
4446	148p
4502	99p
4511	89p
4512	89p
4514	229p
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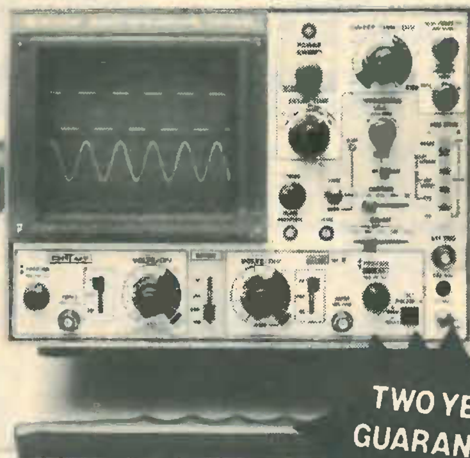
say hi! to the CS-1830

...and 'goodbye' mediocrity.



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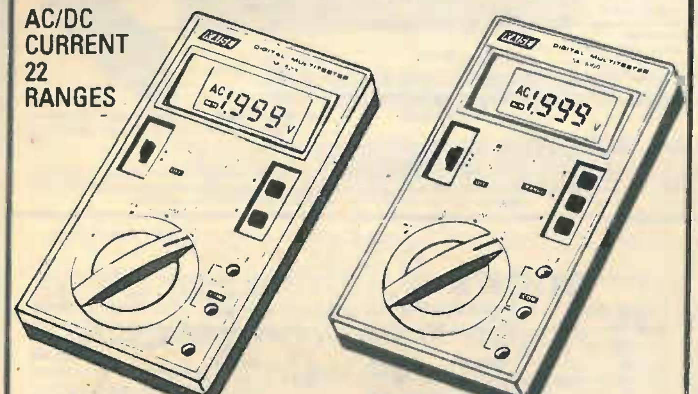

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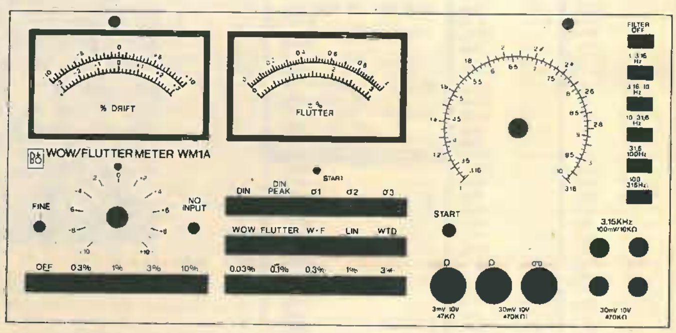
WOW/ FLUTTER

driftmeter WM1A



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Available from selected stockists

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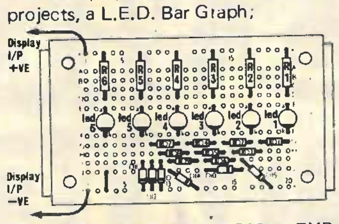

You will need; One EXP 300 or EXP 350 breadboard, 15 silicon diodes, 6 resistors, 6 Light Emitting Diodes.

Just look at the diagram, Select R1, plug it into the lettered and numbered holes on the EXPERIMENTOR BREADBOARD, do the same with all the other components, connect to the battery, and your project's finished. All you have to do is follow the large, clear layouts on the 'Electronics by Numbers' leaflets, and ANYBODY can build a perfect working project.

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No soldering modular breadboards, simply plug components in and out of letter number identified nickel-silver contact holes. Start small and simply snap-lock boards together to build a breadboard of any size.

All EXP Breadboards have two bus-bars as an integral part of the board, if you need more than 2 buses simply snap on 4 more bus-bars with the aid of an EXP 4B.

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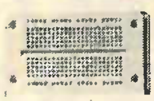
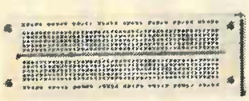
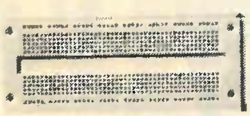
EXP 350 £3.15 Specially designed for working with up to 40 pin ICs perfect for 3 & 14 pin ICs. Has 270 contact points including two 20 point bus-bars.



EXP 300 £5.75 The most widely bought bread-board in the UK. With 550 contact points, two 40 point bus-bars, the EXP 300 will accept any size IC and up to 6 x 14 pin DIPS. Use this breadboard with Adventures in Microelectronics.

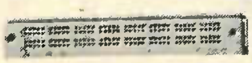


EXP 600 £6.30 Most MICROPROCESSOR projects in magazines and educational books are built on the EXP 600.



EXP 650 £3.60 Has ·6" centre spacing so is perfect for MICROPROCESSOR applications.

EXP 4B £2.30 Four more bus-bars in "snap-on" unit.



The above prices are exclusive of P&P and 15% VAT.

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PB6 Kit, 630 contacts, four 5-way binding posts accepts up to six 14-pin Dips.

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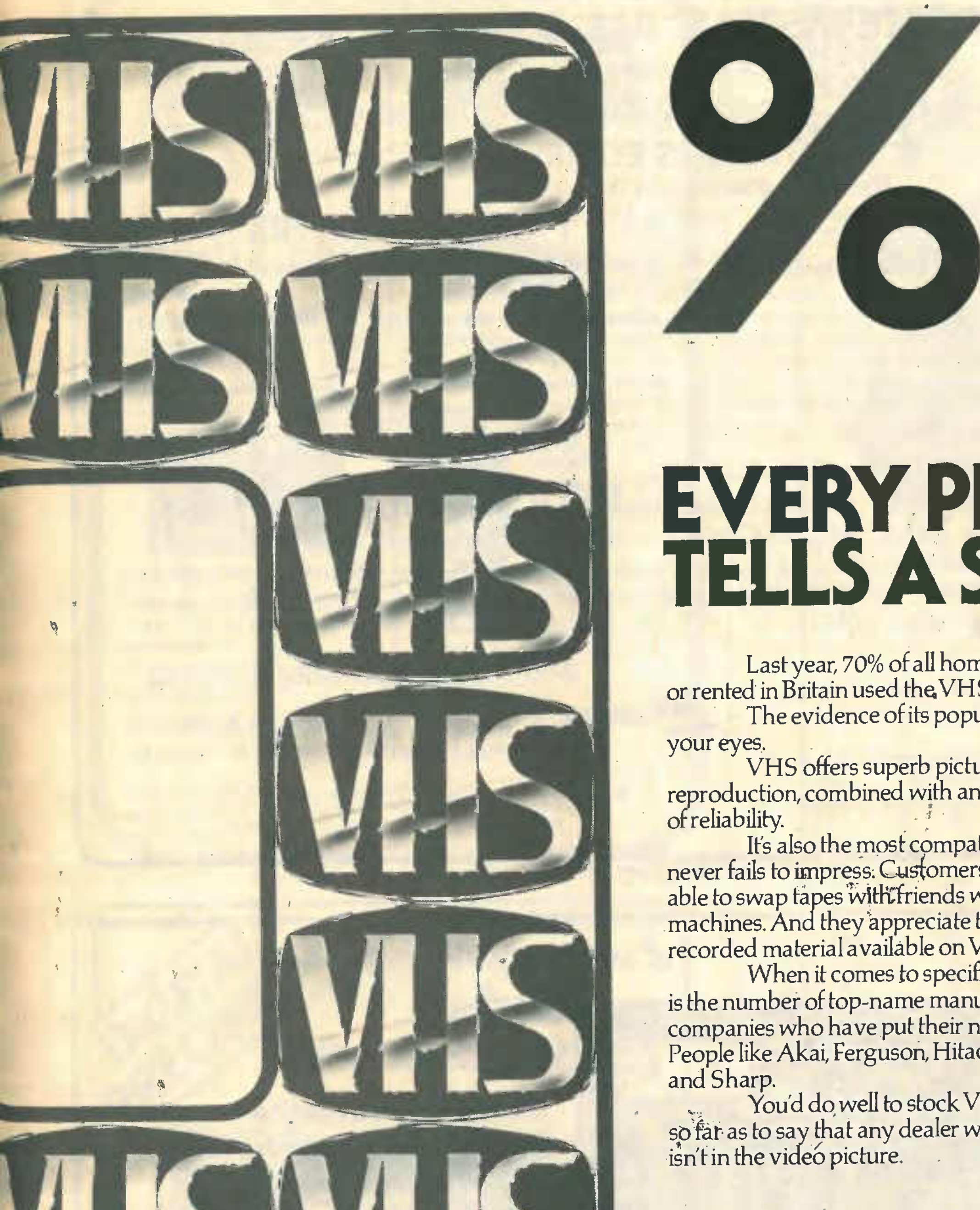

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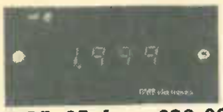

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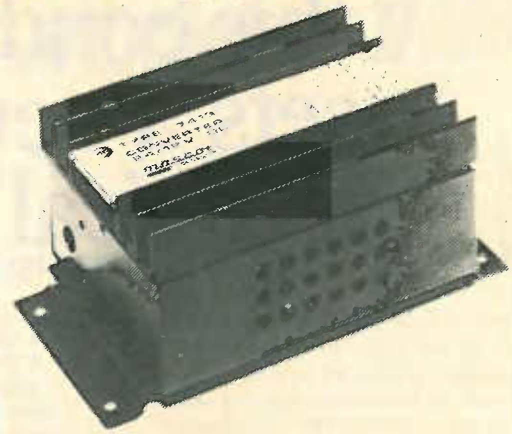

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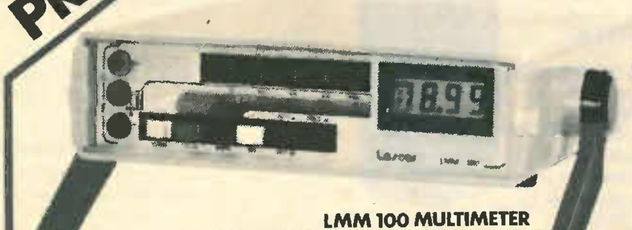

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Personal hygiene or public health?

The director of the CCIR, Richard Kirby, made a good point recently when he said, in opening an IEE conference in London, that studies of spectrum utilization should be better recognized as a legitimate and challenging discipline of communication science (News, September issue). In spite of the fact that the welfare of peoples had "become intricately dependent on a great array of radio techniques and services" all sharing the common resource of the electromagnetic spectrum, only a few specialists were fully aware of "the precarious balance that is this matter of spectrum utilization and of its increasingly critical and complex character." This came well from the head of an international body. And the content of the IEE conference itself, on spectrum conservation, strongly reinforced his argument. No doubt from necessity rather than choice it had plenty of papers on particular techniques — bandwidth efficiency, frequency re-use, station siting, reducing spurious emissions etc. — but not a single "overview" paper that tackled spectrum conservation as a general socio-economic requirement and analysed comparatively the different radio services' information handling needs. We had detailed results from specialists who are working away in separate compartments but not speaking to each other. Everyone is diligently practising personal hygiene in this field but nobody is concerned about public health.

The central fact that an "overview" paper would have brought out, of course, is that spectrum conservation is much more than the business of reducing frequency bandwidth to a minimum. Efficient use of the spectrum also depends on sharing frequencies in time or in geographic space — and also, less commonly, by different polarizations of wave propagation. This was at least implicit in the IEE conference. As one of our contributors, Leslie Berry, has pointed out, we should not be talking about spectrum pure and simple but what he called "spectrum space" with the three dimensions of frequency bandwidth, time and physical space as area or volume (see "Measuring spectrum use", December 1978). And in his article Mr Berry proposed a measure for determining the efficiency with which radio systems use this quantity — a ratio of communications output to spectrum-space input. Some such quantity (cf. Shannon's formula for the maximum capacity of a communications channel) should surely be the starting point for all studies in spectrum utilization.

How far should communication science go in pursuing fundamentals? It depends on what you understand by communication. Those of us who think that engineering should concern itself with the human communicators as well as the hardware will claim that spectrum conservation should study both the demands and the real needs of the users of spectrum space. Any user who demands more space than he really needs is clearly planning to use the spectrum inefficiently. At present the goods are carved up arbitrarily and irrationally by authorities whose decisions are little more than passive responses to the demanders. He who shouts loudest gets most. Those with the loudest voices are the political and economic interests that determine the established order in any place. Because they benefit from maintaining the status quo these people do not want any other system of spectrum apportionment and least of all a system based on a rational assessment of human needs. They have a direct interest in continuing the piecemeal, divisive approach to spectrum studies and keeping engineers and scientists where they belong. This is why there is so little money available, as Richard Kirby noted, to support the fundamental study of this resource — a natural resource which, an international commission has rightly claimed (News, May issue), should be more equitably shared as the common property of mankind.

Radio tuner frequency counter

Digital frequency display for a receiver or for general use

by J. L. Linsley Hood

The addition of a numerical display of the tuned frequency can make a useful improvement to the ease of use of a radio receiver, especially in the case of broadcast reception on the short-wave bands, and a circuit is given for such a display designed for use with a Yaesu FRG 7 communications receiver. However, the circuit techniques employed for this purpose may be adapted with little difficulty to other applications ranging from I.f. frequency measurement to f.m. tuner station identification.

One of the most attractive of the facilities offered by digital circuit components is the simple numerical display of voltage or frequency, with a substantial reduction in the ambiguities in the reading of either of these variables.

A particular area where the numerical display of frequency is of substantial value is in the display of the tuned frequency of a short-wave radio receiver, since the crowding of transmitters in the broadcast bands demands a degree of adjacent channel selectivity which makes an analogue tuning dial very difficult to interpret. The instrument described below was intended for use in the display of the frequency of the second, tuned, i.f. in a Yaesu Musen FRG 7 communications receiver, but the design was deliberately chosen so that it could be used equally well in other frequency counter applications with appropriate small modifications to the arrangement of the circuit.

Since it is the belief of the author that there is a wide, and growing, divergence between the areas of understanding of those electronic engineers whose interests and experience lie in 'linear' or 'analogue' electronics, such as amplifiers and radio systems, and those whose experience is mainly confined to 'digital' circuitry, as in numerical display systems and microprocessors, it is thought that any description of digital circuitry which is accessible to the former will appear very ingenuous to the latter. Apologies are therefore offered in advance on this score, to those whom it may offend.

Circuit arrangement

The method employed in frequency counting is shown in the block diagram of Fig. 1, and consists basically of five parts. The first of these is a circuit designed to define an accurately determined time interval, during which some form of 'gate' will be opened to allow the frequency to be measured to pass through to a counter. This interval generating circuit is almost invariably quartz crystal controlled, and usually consists of a crystal oscillator, followed by an appropriate number of frequency divider stages. The 'gate' can be one of a number of logic elements, but an And or a Nand is usually the most convenient.

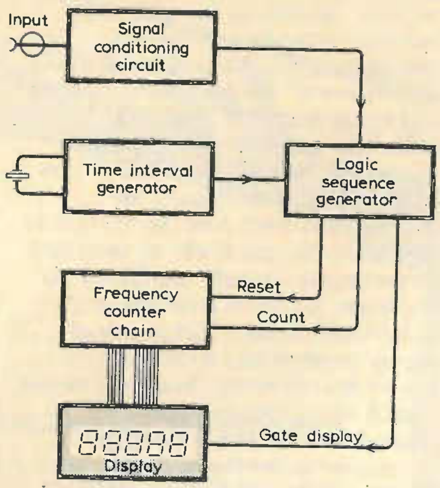


Fig. 1. General arrangement of frequency meter.

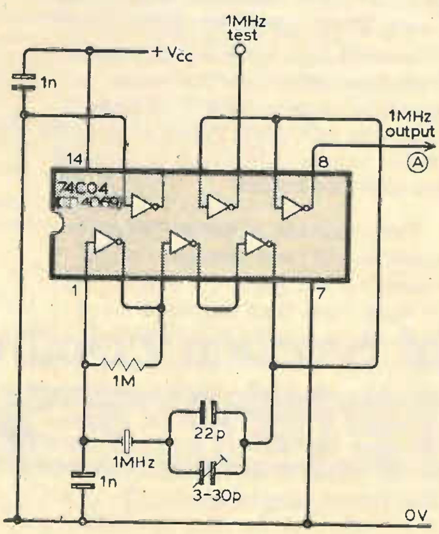


Fig. 2. Crystal oscillator, with test point output.

The second necessary part is some form of signal conditioning circuit, which will convert the probably small amplitude sinusoidal input signal at a high impedance into a well-defined square wave of adequate amplitude to swing cleanly between the '0' and '1' levels of the logic and counter elements.

The third essential section of the counter is a suitable logic-sequence generator which will perform the operations of resetting the counter, either to zero or to some predetermined number, opening the gate, and operating the display at the conclusion of the counting operation.

The two remaining stages are the frequency counter chain, which will normally have an output in binary coded decimal (b.c.d.), and the display section, which can be a b.c.d.-to-seven-segment decoder, some form of latch or display gating, and a seven-segment, light-emitting-diode, vacuum-fluorescent or liquid-crystal numerical indicator.

By far the most cost-effective way of providing a numerical display of this type, is to use one of the many large-scale integrated-circuit 'single chip' counters — available from Ferranti, National Semiconductor, Intersil, Oki and many other makers. The only drawback to this approach is that there is often very little scope for a change of intention once the integrated circuit has been acquired, and the choice of display, offset frequency, or operating range may be fairly circumscribed. Indeed, in using a single-i.c. frequency counter, there is little point in going to the trouble of building the counter for oneself, rather than buying a complete ready-built circuit, so long as the desired specification is available — but this necessarily precludes the possibility of a versatile unit.

For these, and other, reasons it was decided to put a frequency counter together from standard digital i.c. building blocks, while retaining as many options within the structure for other uses as appeared practicable.

For reasons of practical convenience, adaptability to supply voltages, and low power consumption within the counter circuitry, it was decided to use c.m.o.s. logic elements, of the 74C... series, which offer pin-for-pin interchangeability with the equivalent 74... (t.t.l.), 74S... and 74LS...

transistor-transistor, Schottky, and low-power Schottky 5V logic families. This would allow a subsequent increase in operating speed, if required, without the need for major redesign, by the simple replacement of some of the leading counter i.c.s and a reduction of the supply voltage.

Experience with the National Semiconductors 74C... c.m.o.s. logic elements, in the unbuffered types, has shown that at 12V supply-line levels, an operating frequency in excess of 7MHz can be assured, with 10MHz being typical. Also, in common with other c.m.o.s. logic circuits, the very high input impedance of the gates allows various quasi-linear operating modes to be employed, which are very useful in signal level translation.

Crystal-controlled oscillator. The circuit of this is shown in Fig. 2, and employs a 1MHz parallel-resonant, AT-cut quartz crystal, of the type intended for use with a 30 pF load capacitance. The first element of the 74C04 hex. inverter is self biassed with a shunt 1M0 resistor, and a high-gain, phase inverted feedback signal is derived from the third of the series-connected stages.

A 1 nF capacitor from input to ground prevents spurious overtone modes. Two further stages act as buffers to the counter and test points respectively. The unused input is grounded to prevent uncontrolled action, a practice which should be observed, where appropriate, with all c.m.o.s. gates. A small, preferably ceramic, capacitor — in the range 1 to 100nF — is connected from the h.t. line to the ground line as close as convenient to the supply to the i.c. to prevent spurious triggering of these or other stages.

The output from this circuit is a clean square wave at 1MHz frequency, and of about 0.8 V_{cc} amplitude, peak to peak. Precise frequency adjustment may be made by alteration of the 3-30pF trimmer capacitor.

Divider chain. The circuit of this is shown in Fig. 3, and consists of a chain of four 74C90 decade counters. These i.c.s are internally organized as a divide-by-five and a divide-by-two counter, connected in such a manner that the output is taken from the divide-by-two stage, which has an equal mark-to-space ratio squarewave output. Since the input is fed by a 1MHz signal, the output of the first i.c. in the divider chain, at pin 11, is a 200kHz signal. The crystal may be tuned to approximately 1MHz by adjusting for zero beat note between this and the 200kHz carrier from the Droitwich Radio 4 transmitter, or more accurately if a double-beam oscilloscope is available on which these two signals may be displayed simultaneously.

Signal conditioner. This circuit is shown in Fig. 4. The input stage is an f.e.t. amplifier with a gain of 6-10 in the range 1-10MHz, and capable of operating down to very low frequencies if the coupling capacitors are increased in value. Half of the six inverter stages of the 74C04 are used as a three-stage cascaded amplifier, with the input stage self-biassed to sit at a potential suitable for linear amplification.

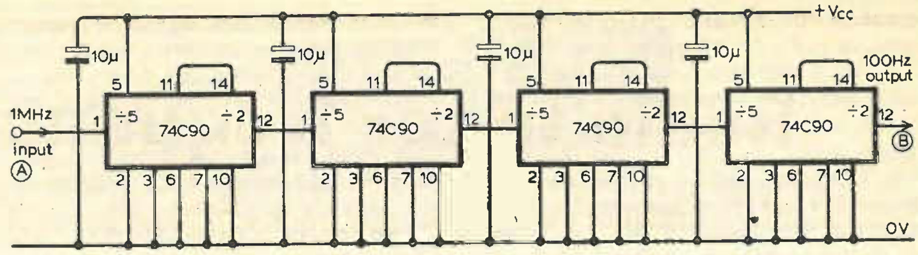


Fig. 3. Divider chain provides 100Hz for gate control.

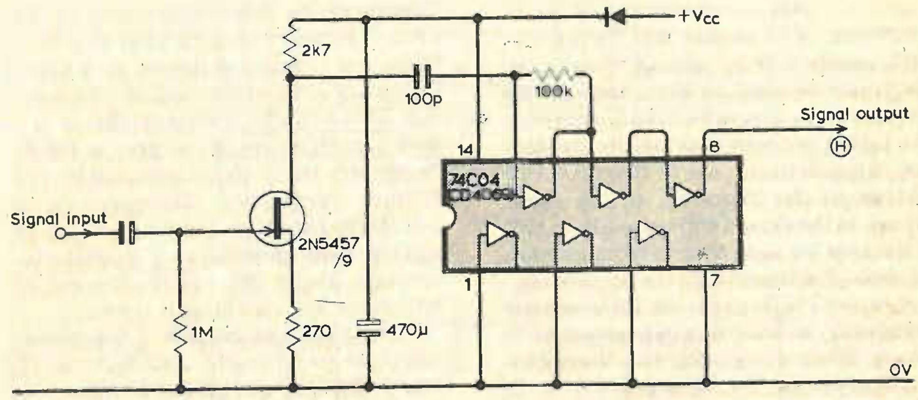


Fig. 4. Unknown-frequency input amplifier and signal conditioner.

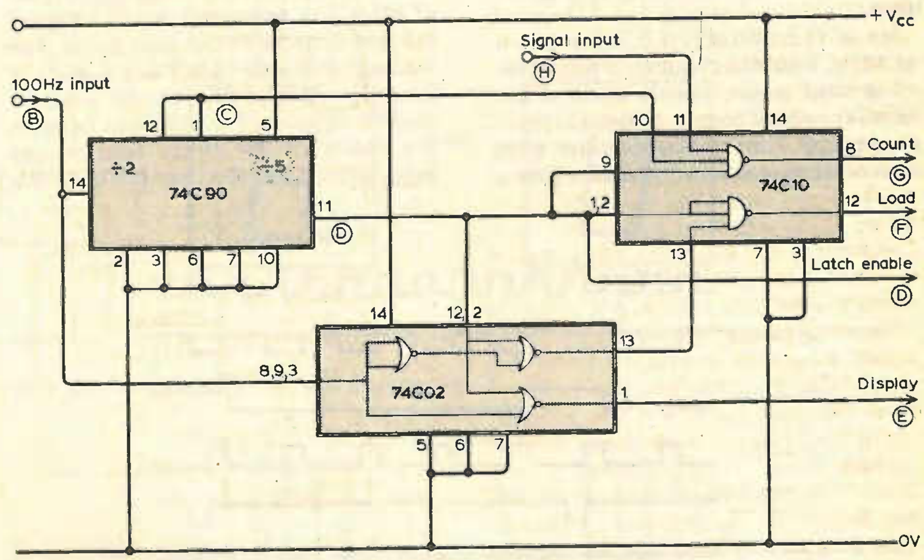


Fig. 5. Logic circuit to control gate and display.

Since the operation of this stage at high frequencies can be embarrassed by h.t.-line ripple being amplified by the cascaded stages, the input coupling capacitor is made small deliberately, and the h.t. supply to this i.c. is decoupled through a diode 'hook' and a large value electrolytic. The source of this problem is described later. The input sensitivity of the conditioner stage is better than 10mV at up to 5MHz.

Counter logic circuit. The design of this stage is of considerable importance in the operation of the counter, and a number of variations of possible circuitry have been published, having varying degrees of complexity. The basic task is, however, a simple one. In order of required performance, an appropriate pulse must be provided to reset the counter, the gate must be opened to allow the signal to be routed to the counter, and after the count has been completed, the final count must be displayed; either by means of a pulse which turns on the display, or by a pulse which allows a 'latch' to transmit an input signal to its output, and then hold this signal until the next 'latch-enable' pulse is received.

In the particular application for which this unit was designed, that of displaying a 3-2MHz signal with a 100Hz accuracy, a gate open time of 10 milliseconds was required. This was achieved by dividing the 100Hz output signal of the counter chain by two, using part of a 74C90, giving waveform C in Fig. 6, and this is used to control one input of a 3-input Nand gate, as shown in the logic circuit diagram of Fig. 5.

A fundamental problem in all frequency counters is that posed by the statistical fluctuation of the count by ±1 digit due to the random sampling of the count during the gate open period. This causes an irritating flicker in the display of the last digit. A partial solution to this problem, normally employed, is to sample less frequently, and usually a free-running, slow, multivibrator is used to limit the sample frequency to one which will minimize the flicker without making the counter too sluggish in its rate of response to a change in the frequency of the input signal. In the design shown in Fig. 5, this reduction in sampling rate is accomplished by using the divide-by-five output of the 74C90 to give a 10Hz sample frequency, as shown in waveform D in Fig. 6. When combined with the signal input at H and the 10ms pulse from C, the result is a negative-going count waveform train as shown at G, having a 10ms duration but occurring only every 100ms.

Since the counter i.c. chosen, a 74C192 (CD40192), requires a negative-going reset pulse, which must occur before the count begins, two gates from a quadruple 2-input Nor gate are used to combine waveforms B and C to give a suitably timed 5ms duration pulse, which is gated by another 3-input Nand to give a negative-going 5ms pulse at 100ms intervals, as shown in waveform F. This is used to reset the 74C192 to a predetermined count number, in a binary-coded decimal form. This operation is described as 'load'.

Two options are available in the display of the count, which require different operating waveforms D and E. This choice is described later.

Counter chain. The circuit layout of the FRG 7 receiver is such that the first frequency changer is driven by a high-frequency oscillator, used in conjunction with a quartz crystal oscillator in a drift-cancelling mode, to give a 1MHz bandwidth 1st i.f. signal, reduced by the second frequency changer to a 3.455MHz-2.455MHz bandwidth slab of signals, corresponding to a 0-1MHz increment above the 1MHz interval to which the first oscillator is tuned.

The task of the frequency counter is therefore to represent 3.455MHz as '0' and 2.455MHz as '1000kHz', which is accomplished by the use of a 74C192 synchronous up/down counter in the 'down' mode, with the initial count level of 455.0 (the presumed 3rd i.f.) loaded into the counter by the load pulse. The loading table is given in Table 1, and the general organization of the counter chain is shown in Fig. 7. As can be seen, the choice of 'up' (from zero or any other chosen number) or 'down' counting is made by the selection of either the pin 5 or the pin 4 inputs to this i.c. The unwanted input is taken to the positive 'V_{cc}' rail.

	A	B	C	D
0	L	L	L	L
1	H	L	L	L
2	L	H	L	L
3	H	H	L	L
4	L	L	H	L
5	H	L	H	L
6	L	H	H	L
7	H	H	H	L
8	L	L	L	H
9	H	L	L	H

Table 1. Preloading.

Any number of counter stages may be cascaded in this fashion but, in the example shown, four are used with the signal input being taken to the least significant digit counter — which, in this case, will display the 100Hz number since the gating period is 10 milliseconds. Although a number of counts between 34,550 and 24,550 will be received during this period, the first digit is not of interest and is therefore not displayed. An input frequency of 3,455 kHz will therefore be represented simply as '000.0' and 3,355 kHz as '100.0', ascending to '999.9' as the input frequency decreases to 2.4551 MHz, which is the required condition.

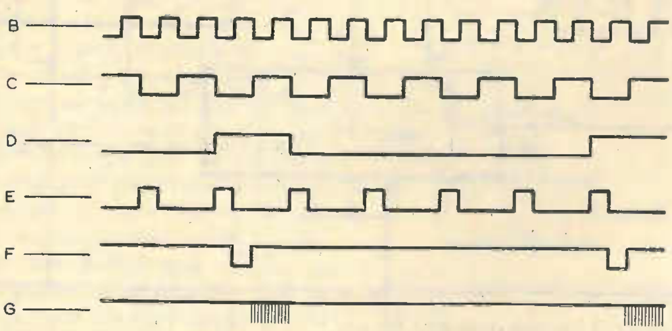
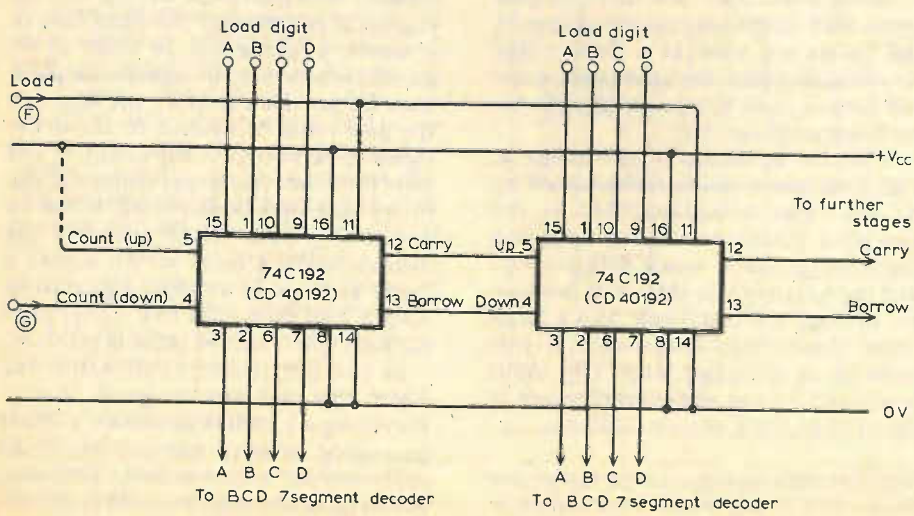


Fig. 6. Waveforms in logic circuit of Fig. 5.

Fig. 7. Part of four-stage down counter.



Display. Two possible display modes are feasible, depending on whether leading-zero suppression is needed, based on the 74C48 b.c.d. to seven segment decoder — which permits leading zero suppression but not input latching — or the CD4511, which incorporates a latch but not leading-zero suppression. If both of these facilities are required, the 74C48 should be used with a separate quad or octal latch interposed between counter chain and decoders. An example of this using the 74C373 octal latch is shown in the Appendix.

The first of these two options is shown in the diagram of Fig. 8, using the 74C48 coupled to common-cathode l.e.d. seven-segment displays, via 180-ohm, current-limiting resistors. The decimal point is permanently illuminated via a 1k2 resistor to the rail, at a position to the left of the least significant digit. Pin 4 on this i.c. performs the dual function of blanking input or leading zero suppression output, so that if pin 4 is always connected to the pin 5 of the next, less-significant digit, no leading zeros will be shown when the input pin 5 of the most significant digit is connected to the 0V line. Connecting this to the positive line will allow leading zero indication.

If pin 4 on these i.cs is taken to the 0V line, the display is suppressed, and this is used to prevent display during the count or reset periods by connecting these pins through small-signal silicon diodes to the display pulse output E of the logic circuit. This causes the display to be illuminated at a 50Hz frequency on a 1:4 duty cycle. Persistence of vision prevents visible flicker.

The major snag with this arrangement is that a mean current of some 50mA for each seven-segment l.e.d. display is necessary for adequate daytime brightness, which means 200mA in total for four digits. Since this current is pulsed on a 1:4 duty cycle, the peak display current can be 0.8 amps at a 50Hz pulse frequency. This inevitably causes some h.t.-line ripple, and argues both the need for a separate power supply and some decoupling of sensitive portions of the circuit such as the signal conditioner stages, to prevent h.t.-line-borne interference with their operation. Nevertheless, with these precautions, this option is a satisfactory one.

As mentioned above, one of the inherent problems of any counter system is the inherent statistical uncertainty of the input count, which can cause a ±1 digit flicker in reading. An amelioration of this problem which is possible with c.m.o.s. logic elements, because of their very high input impedance, is to put an RC input filter in the b.c.d. signal lines feeding the decoder, and this arrangement is shown in Fig. 8.* The only snag with this is that on changing frequency, the last digit (in this case the 100Hz one) tends to lag behind the others in its response. Since this digit is the least significant one, this is only a small penalty.

Fig. 10. Counter in use with communications receiver.

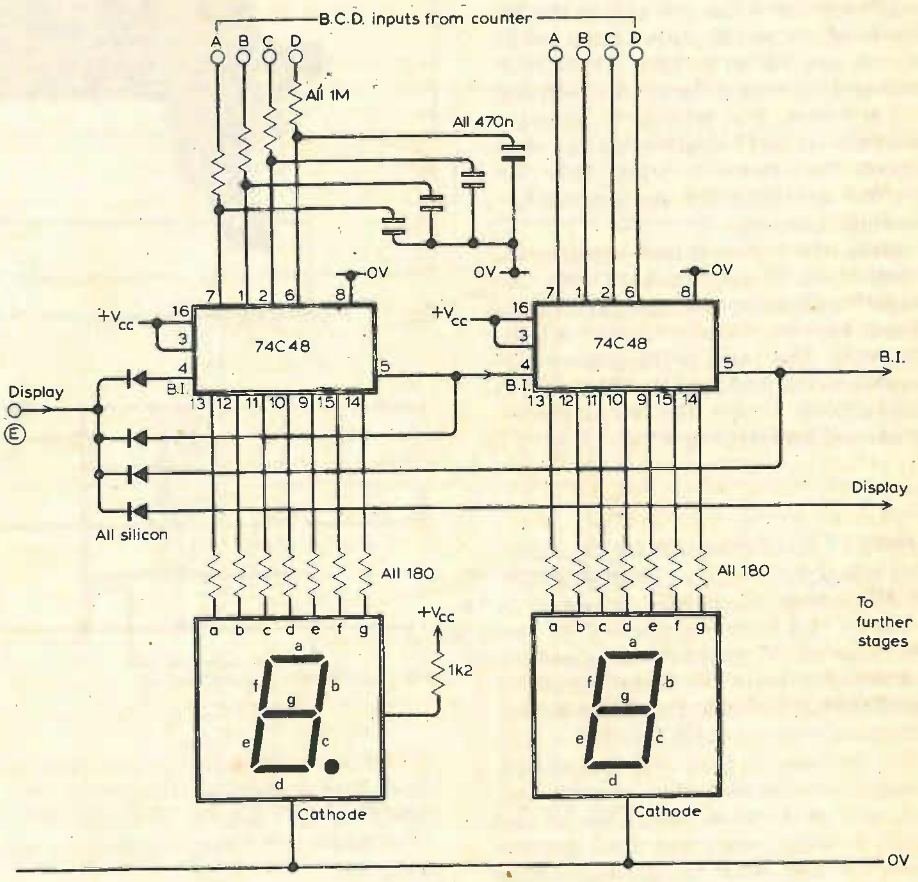


Fig. 8. Two sections of count and display circuit.

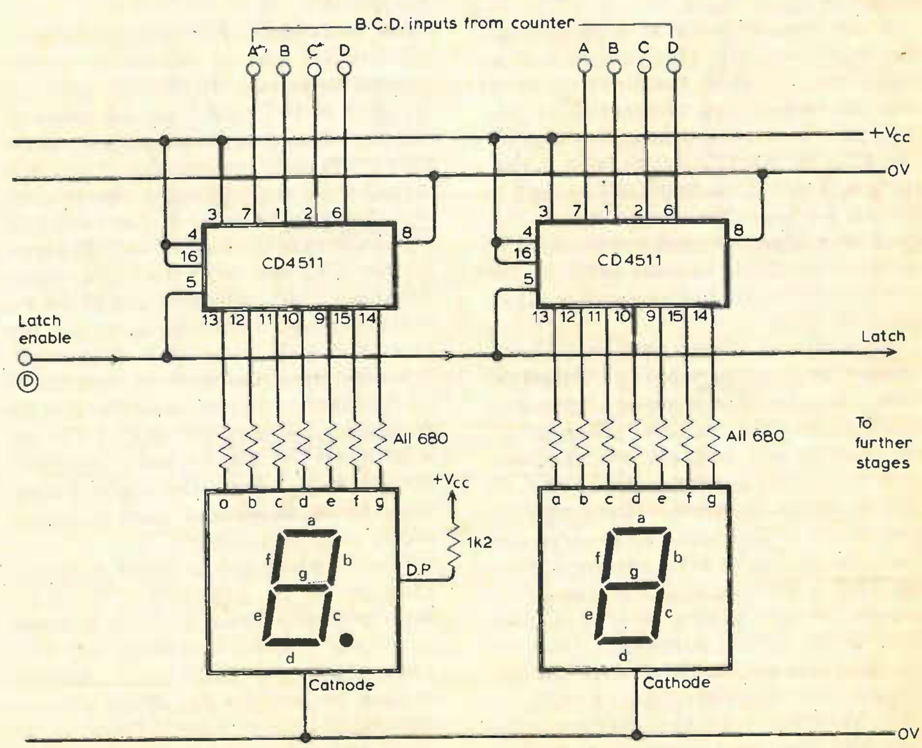


Fig. 9. Decoder and display using CD4511 latched decoder i.c.

*The use of analogue averaging techniques with digitally encoded signals poses a number of interesting intellectual problems, in deciding whether such a system would work at all, or, if it did, whether the results would be spurious or would lead to non-numerical characters, which is presumably why this technique is not known. However, having inwardly debated this point for some time, and having carried out a number of (admittedly simple) statistical analyses of the likely outcome of a 2- or 3-digit jitter, based on the b.c.d. encoding sequence shown in Table 1, the matter remained in doubt, and was resolved empirically by a parallel operation of a damped and an undamped input decoder stage.

What was found in this trial was that occasionally the 'damped average' was biassed in one direction or another, by comparison with the visual estimate of the digit jitter, and that, very occasionally, unexpected numbers — i.e., more than one digit away from the central number — could appear briefly in the display. However, the visual comfort of a stable indication was thought, in this instance, to be of greater benefit than a possible ±1 digit averaging error. No non-numerical digits have been seen.

Presumably, the result is predictable statistically if a Gaussian distribution is used to determined the weighting of the individual 'H's and 'L', and if the gate is assumed to behave in an ideal manner in which any input $>V_{cc}/2$ is an 'H' and any input $<V_{cc}/2$ is an 'L'.

CD 4511 option. This type of b.c.d.-to-seven-segment decoder has a built-in latch circuit, which allows it to store the input b.c.d.-coded signal until such time as a refresh instruction is received.

The operation of this latch is such that no information can be transferred to the output while the input to pin 5 is high (i.e. at V_{cc} line level). In this condition, the decoded output refers only to the last instruction received on its inputs while pin 5 was low (i.e. at the 0V line level). Since the output from pin 11 of the last 74C90 divider (D) is high during the whole of the reset (load) and count cycles, this waveform makes a convenient latch-enable signal, and causes the display to show only the number attained when the counter has finished counting.

Since this display is then continuous, there is no display flicker, with the important feature that the current demand from the decoder/display is non-pulsating. The value of the series resistors should be amended (to 680 ohms) to take account of this. The circuit connexions are shown in Fig. 9.

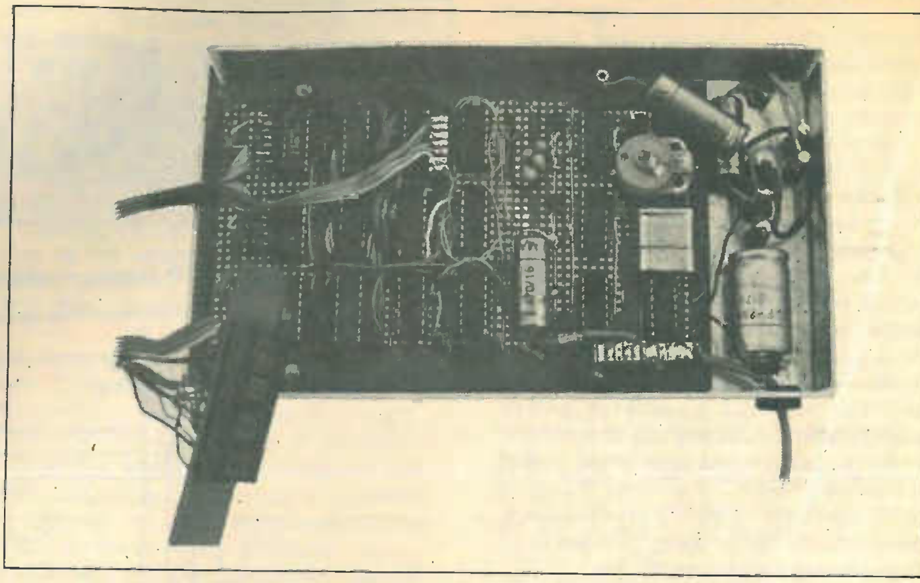


Fig. 11. Inside view of instrument.

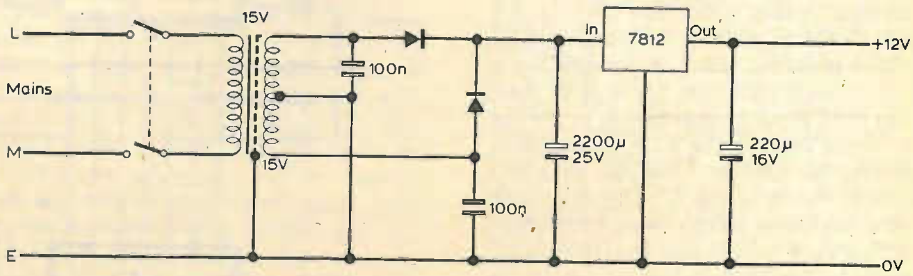


Fig. 12. Power supply circuit.

Use as FRG7 frequency counter

The complete circuit, as used, is shown in the photographs of Figs. 10 and 11. In view of the high sensitivity of the receiver — if properly aligned in accordance with the manufacturer's instructions, the background sensitivity threshold is below 0.1 microvolt — it is very necessary that the frequency counter should be well screened, and enclosed in a metal case. One of the Vero G range cases was used for the author's unit, with an internal mains transformer having an electrostatic screen, and with a coaxial socket input for the i.f. signal input.

A small modification is necessary to the receiver itself. This consists of a mains outlet cable, terminating in a suitable free socket, connected to the internal transformer primary — so that the display extinguishes when the receiver itself is switched off — and a coaxial socket outlet on the rear of the receiver, connected with a short length of low-capacitance coaxial cable to the second oscillator buffer output (test point TP 404).

Since it was anticipated that there would be some unwanted radiation from the counter, in spite of all precautions, an on/off switch was included on the counter unit. In the event, this was only receivable at the 25, 27, 28 and 29 MHz frequencies, where it heterodyned with the small amount of stray radiation from the internal 1 MHz crystal within the FRG 7. By adjusting the frequency counter crystal tuning to give a zero beat on the 29MHz harmonic, it can be brought into concordance with the internal crystal to better than a few Hertz in 1,000,000. With this heterodyne removed, the total spurious radiation level on the prototype is so low that the additional on/off switch is only used to check that occasional whistles on the tuning scale are not due to the counter.

A suitable power supply unit is shown in Fig. 12.

Appendix

Other applications. As shown in Table 1, the counter can be preloaded to any desired frequency offset. This can be 0, if inputs A, B, C and D are all taken to the 0V rail, so that the frequency read is that of the input. In this case, it will be a straightforward frequency meter, and will normally be used in the count-up mode. (Pin 4 of the leading 74C192 taken to the $+V_{cc}$ rail, with the input signal fed to pin 5.) If a sampling rate of 100 Hz will give adequate display accuracy, the circuit can be used as it stands. If, however, the circuit is to be used for an l.f. frequency counter, with the sample frequency reduced to, say, 1 Hz, by additional 74C90s in the frequency divider chain of Fig. 3, the display flicker with the 74C48 decoder, used as shown, would be unacceptable.

Since leading zeros would normally require to be blanked (the least significant one never is, since it would cause the display to extinguish on a count of 0 — so if leading zero blanking is used, pin 5 of the RH 74C48 must be connected to $+V_{cc}$) the CD4511 is unlikely to be suitable. A separate latch will then be necessary. A convenient system is shown in Fig. 13, using the 74C373 octal latch. Since the latch-enable signal with this is high, the switching waveform from D requires to be inverted. The remaining Nor gate of the 74C02 in Fig. 6 is used for this purpose.

The remaining useful application of this circuit is in the display of the tuned frequency of an f.m. tuner, in the range 86-108 MHz. Since the oscillator frequency of the f.m. tuner head will be above the tuned frequency by 10.7 MHz, the counter will be used in the count-up mode, with a preloaded number equivalent to the 9's complement of 10.7 (89.2). If a 100kHz indication accuracy is adequate, a 4-digit counter will again be used, with the decimal point wired in ahead of the least significant digit.

Since leading-zero blanking will be needed, at least for the first digit, pin 5 on this 74C48 should be connected to the 0V rail.

As mentioned earlier, the upper reliable frequency limit of the c.m.o.s. counters is about 7-8 MHz on a 12 volt supply. The input frequency from the f.m. tuner oscillator will be well above this, and the most convenient way of solving this problem is by using an input divide-by-100 i.c., such as the RS 8629. This should be mounted with a transistor emitter-follower input, as close as practicable to the tuner head. The output frequency from this, in the range 1.187MHz to 0.967MHz, can then be

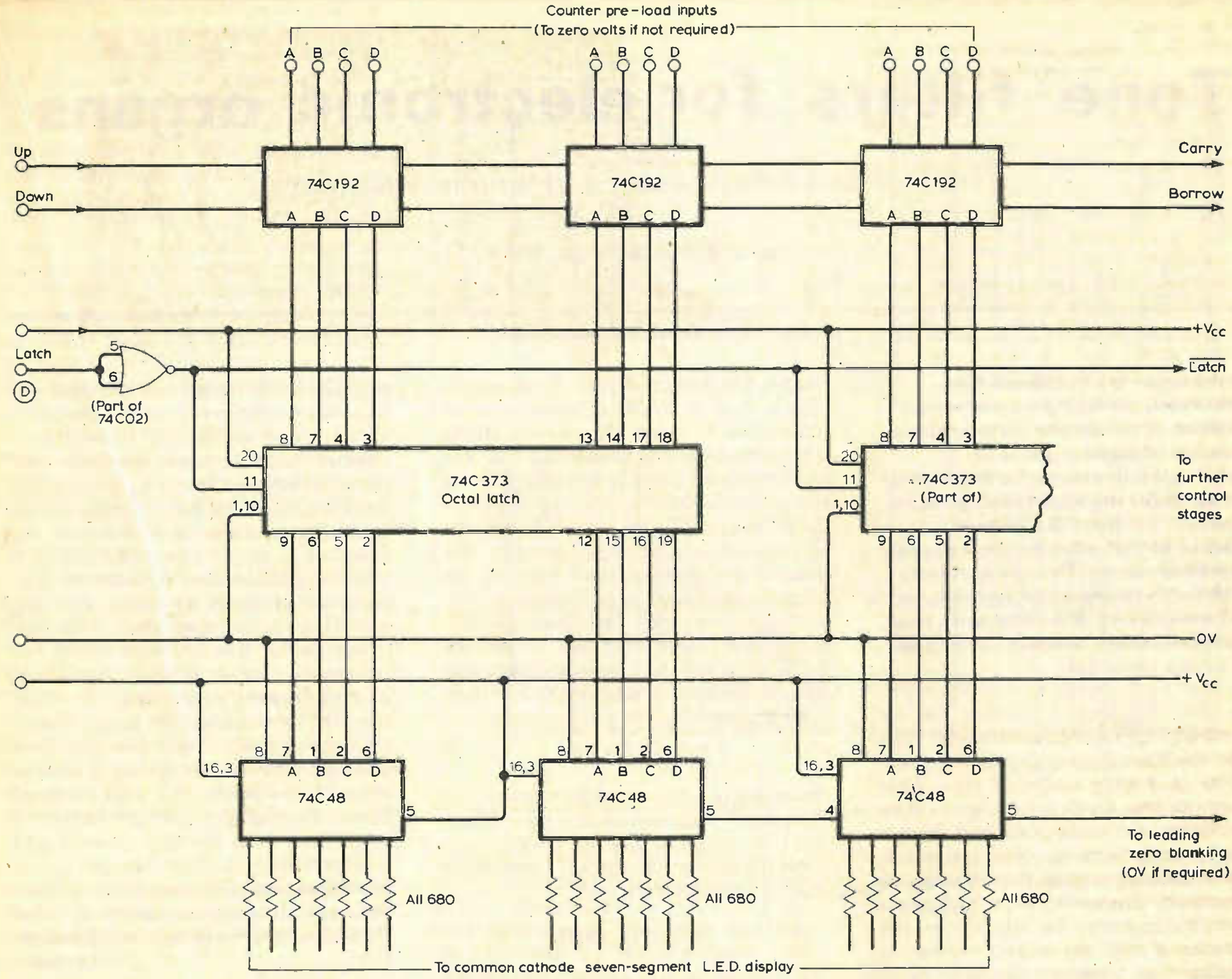


Fig. 13. Modification for use as low-frequency counter, using external latch.

taken to the counter by a screened cable. The count accuracy required will be 1kHz, and will allow a sample period of 1 millisecond. One fewer 74C90 in the divider chain of Fig. 3 will be required. Apart from the modified input signal interface, as shown in Fig. 14, this reduction in the length of the divider chain and the change in the count mode and offset of the 74C192s, the circuit form of Fig. 10 is as required. □

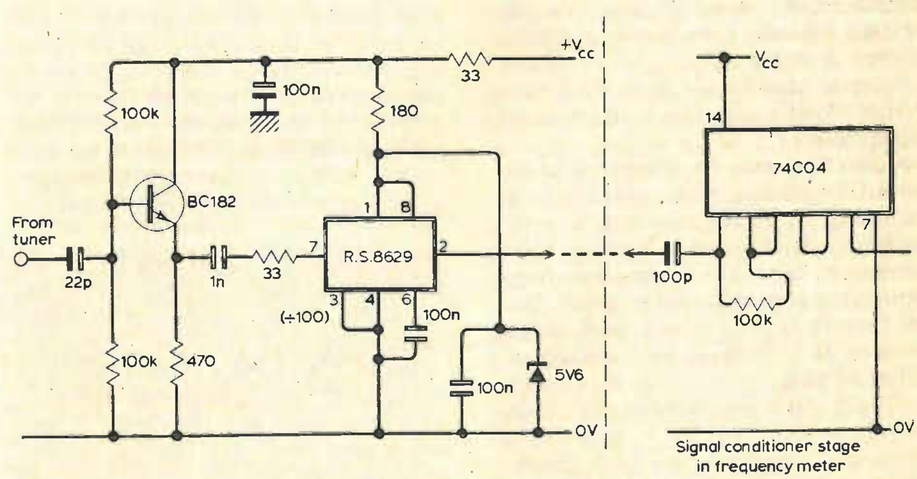


Fig. 14. Divide-by-100 prescaler for use with f.m. tuner.

Tone filters for electronic organs

Part 1: organ tone spectra and source waveforms

by C. E. Pykett, B.Sc., Ph.D.

As the organ is a sustained-tone instrument, achieving a satisfactory imitation of the steady-state acoustic emission of organ pipes is of paramount importance. In this respect the design of the tone-forming filters is crucial, yet there is a curious absence of definitive material dealing with filter design. This is apparently reflected in the range of commercial instruments on the market: with few exceptions their "voicing" seems to be mainly empirical.

To derive a simple expression for the frequency response of a tone filter consider the basic organ system, representative of a wide range of electronic instruments, shown in Fig. 1. The waveforms are initially derived from a continuously running tone generator. Waveforms at various frequencies are selected by depressing keys, and envelope shaping may be applied at the instants of key attack and release to simulate the transient phenomena of organ pipes. (Whilst of considerable importance, transients are not further discussed here). The signals are passed through various tone forming filters depending on the stops or tone colours selected and the output from the filters is then finally amplified and fed to loudspeakers.

A tone filter may be thought of as an amplifier whose gain varies with frequency. The gain can therefore be explicitly written as a function of frequency, $G(f)$. Similarly, each harmonically rich waveform from the generators is equivalent to a large number of individual sine waves of different frequencies, each sine wave having a different amplitude. This waveform can also be written as a function of frequency, say $H(f)$. Therefore the output from the tone filter, $F(f)$, is the product of the input voltage and the gain just as with any amplifier

$$F(f) = G(f).H(f)$$

In general the tone filter will also modify the phase as well as the amplitude of each frequency component in the input signal. As the ear is insensitive to relative phase for present purposes, this does not matter, which makes the design of tone filters much easier than it would otherwise be. It does mean, however, that the *waveform* emerging from the tone filter will not necessarily bear any resemblance to the waveform emitted by the organ pipe if both were to be viewed on an oscilloscope screen. It is only the *frequency spectra* that need to be matched as closely as possible.

If the frequency functions are expressed on a logarithmic amplitude scale then new functions are obtained that are related by addition rather than multiplication

$$P(f) = Q(f) + R(f)$$

Rearranging this equation gives the frequency response of the tone filter, $Q(f)$, in terms of the input spectrum from the tone generator, $R(f)$, and of the output spectrum $P(f)$

$$Q(f) = P(f) - R(f)$$

This simple equation shows that filter design involves three basic steps. First, the logarithmic spectrum of both the tone generator waveform and of the sound to be simulated must be available. Second, the frequency response of the required filter must be derived by subtracting one from the other. Third, the response so obtained has to be realised in hardware. Subsequent sections discuss each of these stages in detail.

Acoustic spectra of organ tones

Before a filter can be designed to imitate the sound of a particular type of organ pipe the spectrum of that sound must be obtained. Following a careful search of the scientific and engineering literature extending back into the 1930s, it was discovered that very few systematic investigations into the acoustic spectra of organ tones have been reported. As this information is vital to the design of an imitative electronic instrument, three of the most useful references are appended here [2,3,4]. Boner's article (1938) describes one of the first attempts to use electronic techniques to analyse the sound of an organ pipe radiating in a free field (that is away from the reverberant conditions of an auditorium) by mounting organ pipes atop a 24 foot tower out of doors. From the three references quoted, spectra corresponding to the four main classes of organ tone can be extracted, viz flutes, diapasons, strings and reeds, and this goes some way toward providing a framework for the design of a wide range of filters. To augment this information I made recordings of organ sounds and analysed them. A large amount of information was obtained from a four-manual instrument by Rushworth and Dreaper with some particularly fine solo stops.

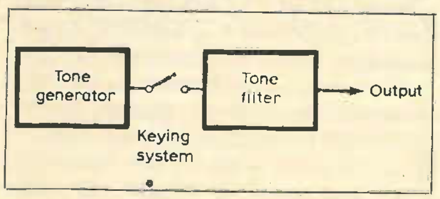


Fig. 1. Basic electronic organ system considered in this article is the subtractive kind in which an harmonically rich waveform is filtered.

Recordings were made of organ pipes in situ using omnidirectional capacitor microphones with a frequency response from below 20 Hz to about 20 kHz. Two microphones were used, feeding separate channels of a tape recorder with a frequency response from 35 Hz to 16 kHz (±2dB). The recordings were subsequently replayed monaurally into a high resolution spectrum analysis system with a dynamic range of 60dB. The reason for using two microphones and then summing their outputs on replay was to reduce distortion of the spectrum through reflections from the surfaces in the auditorium. Because they set up standing waves, such reflections can result in a significant increase or decrease in the intensity of sound of a particular frequency at the microphone location. By using two microphones there is a reduced likelihood of an identical distorting effect occurring at both simultaneously. (A better method for averaging out the effects of reverberation would have been to use averaging in the frequency domain after phase information had been removed.) Recordings were made of four octavely-related samples from each stop on the organ, and the whole exercise has resulted in a library of some hundreds of pipe spectra.

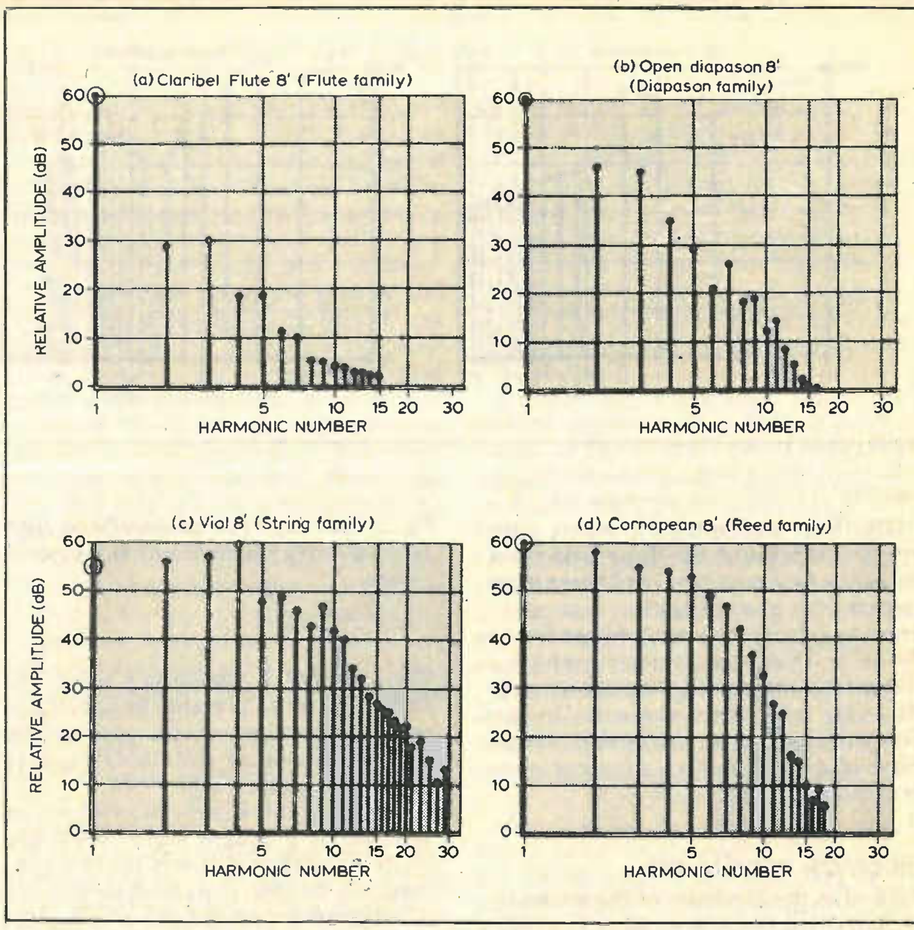


Fig. 2. Large number of harmonics in organ pipe spectra means high cost for additive instruments.

The steady state emission of a pipe is periodic at its fundamental frequency. This is the lowest frequency present in the spectrum in most cases and it defines the musical pitch of the pipe. Because the emitted waveform is periodic, the only other frequencies present in the spectrum are harmonics or integer multiples of the fundamental; there is virtually no acoustic energy lying between adjacent harmonics. Certain pipes, however, possess a significant noise component due to random fluctuations of the air. In other cases the amplitudes and phases of each harmonic fluctuate randomly to a significant degree. Both of these effects produce energy that is not confined to the harmonic frequencies in the spectrum. However assume for simplicity that the spectrum of an organ pipe consists only of equally spaced lines at the fundamental and harmonic frequencies.

This structure is shown in Fig. 2, with examples of spectra corresponding to each of the four classes of tone. These have been normalized to the frequency of the fundamental so that the abscissae represent harmonic numbers (on a logarithmic frequency scale). All of these spectra contain a large number of harmonics, at least 15, within the dynamic range of 60 dB. This is significant in that it clearly demonstrates that the flute is far from being a single sinewave as commonly stated. Nevertheless, as the amplitudes of the harmonics in this spectrum decrease rapidly with increasing harmonic number, it is possible to approximate to a reasonable flute tone using only a few harmonics. This is why additive sinewave instruments, which rarely have more than nine harmonics available, are able to provide good flutes whereas their performance at synthesizing almost any other type of tone leaves much to be desired. A glance at the remaining spectra in Fig. 2 shows why. For a subjectively satisfying imitation of these pipe tones, one should aim to embrace all harmonics within a dynamic range of about 60 dB. Therefore even the diapason requires about 15 harmonics and the other two spectra need more. Unless a very large number of harmonics is available in an additive instrument, the only cost-effective way to proceed is with the subtractive approach. (Whilst there are a very few additive instruments that have large numbers, perhaps in excess of one hundred, harmonics available for tonal synthesis, these are expensive experimental developments using advanced microprocessor technology and as yet they are scarcely suitable for amateur construction.)

Returning briefly to the imitation of an organ flute stop of the sort illustrated by the spectrum in Fig. 2(a), this type of tone is in some ways the most difficult to simulate in spite of the apparent simplicity of the spectrum. Merely designing a filter to produce the same overall spectral features often produces a tone that seems somewhat dull and lifeless compared to the original, especially on A-B comparison using tape recordings. Ladner[3] made the same point, and it seems that the role of the low-amplitude high-order harmonics is not well understood. Sumner[1] reports that physical features such as the "chimney" in the flute stop of that name are responsible for subtle formant bands in the spectrum, though he does not give further details.

Passing on to the other sounds, where imitation is much easier than for flutes, consider the diapason. The spectrum shows that the amplitude of the harmonics gradually falls off with increasing harmonic number. The viol, on the other hand, has harmonics that increase in amplitude up to the fourth, whereafter they fall. This is the result of a viol pipe being of smaller scale (narrower) than a diapason pipe of the same length.

Finally the cornopean has a spectrum in which the harmonic energy falls with frequency though the fall is not in excess of 6 dB until harmonics beyond the fifth are encountered. The relative smoothness of this curve compared to the previous three in which more scatter is apparent seems to be characteristic of many reed tones.

Table 1. Harmonic amplitudes of various pipe spectra in dB, corresponding to Fig. 2.

	organ stop name			
harmonic	**claribel flute**	**open diapason**	**viol**	**cornopean**
1	60	60	55	60
2	29	46	56	58
3	30	45	57	55
4	18	35	60	54
5	19	29	48	53
6	11	21	49	49
7	10	26	46	47
8	5	18	43	42
9	5	19	47	37
10	4	12	42	33
11	4	14	40	27
12	3	8	34	25
13	3	5	32	16
14	2	2	28	15
15	2	1	27	10
16	—	0	26	7
17	—	—	25	9
18	—	—	23	6
19	—	—	22	—
20	—	—	22	—
21	—	—	18	—
22	—	—	20	—
23	—	—	19	—
24	—	—	15	—
25	—	—	20	—
26	—	—	11	—
27	—	—	14	—
28	—	—	13	—
29	—	—	—	—
30	—	—	—	—

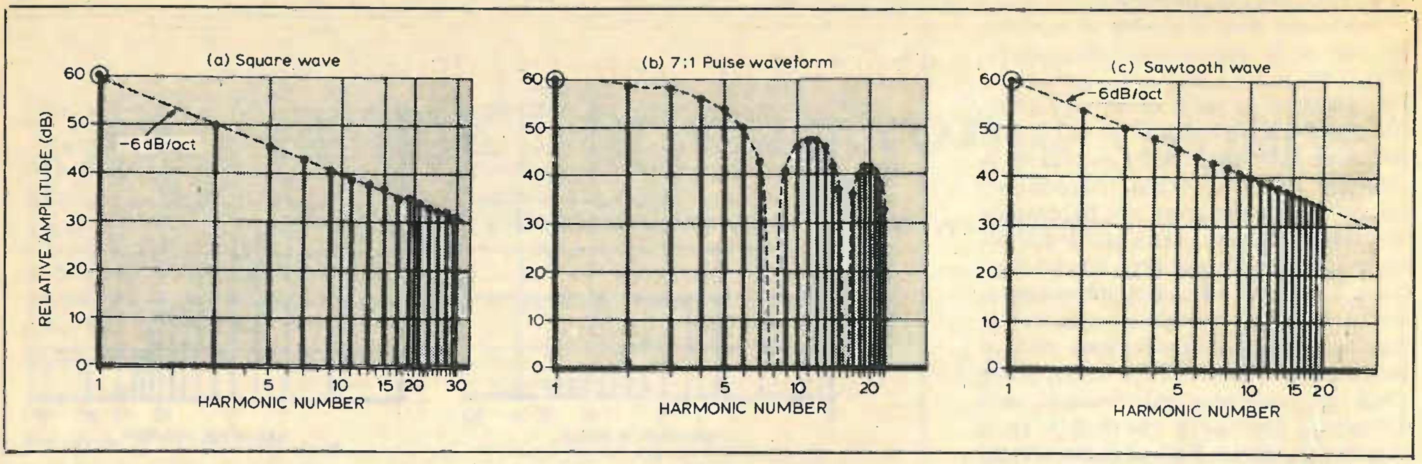


Fig. 3. Easy-keying pulse waveforms such as in (a) or (b) are defficient in harmonic content.

The four examples of organ pipe spectra represent the four principal categories of organ tone, and there is no reason why essentially the same spectrum should not be used to design filters for several footages, thereby producing a diapason chorus or a reed chorus, etc. Together with other examples in the references cited, a reasonably broad base of data is available for the construction of filters.

Electrical waveforms

As well as the spectrum of the sound to be simulated, we also need that of the source waveform from which the tone filters are fed. It would be a short and simple matter to present the spectra of commonly used waveforms at this point but several other practical aspects require discussion first.

Table 2. Harmonic amplitudes of various wavefoms in dB corresponding to Fig. 3.

harmonic	waveform		
	square	7:1 pulse	saw tooth
1	60	60	60
2	*	59	54
3	50	58	50
4	*	56	48
5	46	54	46
6	*	50	45
7	43	43	43
8	*	*	42
9	41	41	41
10	*	46	40
11	39	47	39
12	*	47	38
13	38	46	38
14	*	42	37
15	37	37	37
16	*	*	36
17	35	36	35
18	*	40	35
19	35	42	35
20	*	42	34
21	34	41	34
22	*	38	33
23	33	33	33
24	*	*	33
25	32	33	32
26	*	37	32
27	32	39	32
28	*	39	31
29	31	38	31
30	*	36	31

(*denotes the absence of a harmonic)

Probably the easiest waveform to generate is a square wave. With the ready availability of top-octave synthesizers, dividers and envelope shapers in integrated circuit form a complete generating system of, say, 84 frequencies (seven octaves) can be contained on one card. Unfortunately the square wave is far from ideal for tone forming, except in a few cases, because it contains only the odd-numbered harmonics, whose amplitudes decrease at 6 dB per octave, Fig. 3(a). A square wave cannot therefore be used to derive any of the spectra shown in Fig. 2 as these contain even harmonics. It is, however, suitable for use where tones such as a stopped diapason or a clarinet are required, in whose spectra the odd harmonics are much more prominent than the even ones.

In a square wave multi-frequency generating system it is relatively simple to generate pulse waveforms of different mark-space ratios. These possess, in general, both even and odd harmonics and the spectrum of a pulse waveform with a 7:1 mark-space ratio has been discussed by Ryder[5]; this special case is of particular interest to those readers who may be building his organ. The spectrum, Fig. 3(b), shows that certain harmonics are missing. This effect is always obtained with pulse waveforms, including the square wave just discussed. This is merely a "pulse" waveform with a 1:1 mark-space ratio, where the nulls happen to coincide with the even harmonics. Whilst pulse waveforms again have the desirable advantages of simple generation and keying (envelope shaping) one possible problem concerns the low average energy of a waveform consisting of short pulses. This could give rise to noise difficulties at the output of the tone filters which usually introduce considerable insertion loss.

The "classical" waveform that is often used when both odd and even harmonics are required is the sawtooth. This has a spectrum containing all harmonics, whose amplitudes decrease at 6 dB per octave as in Fig. 3(c). Unfortunately the sawtooth is not particularly economical to generate, and once generated it cannot be keyed by the simple non-linear envelope shapers commonly used for square or pulse waveforms without introducing distortion. One way to circumvent of pulse waveforms, and then combine them with appropriate weights so that a staircase waveform obtained. This is a good approximation to a sawtooth.

Another approach is to generate and key a single square wave and then convert it to a sawtooth using a discharger circuit of the type shown in Fig. 4. The square wave is first converted to a series of narrow pulses, for example by differentiation followed by rectification, which are then used to repeatedly discharge the capacitor C through the electronic switch S. Inbetween discharges the capacitor charges exponentially through R. A linear ramp is obtained if R is replaced by a constant-current source, though for musical purposes this would seldom be required. An exponential ramp produces little significant difference in the spectrum even at harmonics as high as the 30th. The source voltage V can be used to

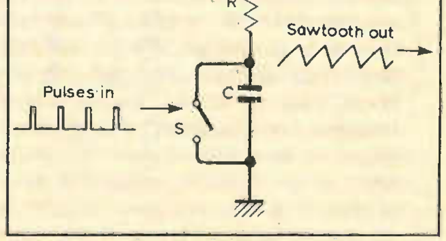


Fig. 4. It is easier to generate and key a rectangular wave and then convert it to a sawtooth than to operate on the sawtooth.

SOUND PRODUCTION IN THE PIPE ORGAN

Organ pipes emit sound when compressed air at a low pressure enters via a valve controlled from a keyboard. Various mechanical, electromechanical or pneumatic contrivances are used to control the valves. Each stop on an organ controls a whole rank of pipes, and has to be "on" before that rank will sound from the keyboard. In each rank there are as many pipes as notes on the keyboard (with a few important exceptions). Therefore even a very small organ will contain several hundred pipes, and a large one many thousands. It is this multiplicity of individually adjusted tone sources that gives the pipe organ its extraordinary richness of sound. (The origin of the term "stop" to denote a particular rank of pipes is of considerable antiquity, and is thought to derive from the great organs of the Gothic period which were originally built with no means of isolating one set of pipes from another. Not surprisingly, such means were soon introduced so that certain sections of the instrument could be "stopped" from sounding!)

Pipes fall into two categories known as flue pipes and reed pipes. Flue pipes are constructed in much the same way as a recorder or tin whistle in that the incoming wind is formed into a narrow sheet which then encounters a lip fashioned in the wall of the pipe. An oscillatory motion is imparted to the wind sheet whose frequency is controlled by the air column in the remainder of the pipe, acting as a close-coupled resonator. Thus the musical pitch is controlled by the length of the pipe. (This highly compressed description tends to hide the complexity of the physics of the flue pipe, a subject that cannot be adequately treated here). The tone quality of the sound is determined by the distribution of the energy in the frequency spectrum and for flue pipes this is to a large extent controlled by the relative proportion of length to breadth. This parameter is termed the scale of a pipe, and it gets numerically smaller as a pipe of constant length gets narrower. The smaller the scale, the greater the proportion of higher harmonics in the sound. You might think that the scale should remain constant across a rank of pipes if the tone quality is to remain constant. This is true, but in practice the scale is varied in a systematic manner so that the volume especially toward the top end can remain subjectively the same.

Another factor controlling the timbre of the pipes is whether they are open or closed at the top. An open pipe encourages the formation of harmonics, whereas a stopped one has a sound that is dominated by the odd harmonics only.

Flue pipes are generally made of wood or metal and can have a variety of cross sectional shapes. They are used to generate three of the traditional types of organ tone (flutes, diapasons and strings) and the front pipes in an organ case often form part of a diapason rank. The physical difference in tonal structure between these types of tone is discussed later.

Reed pipes form the fourth type of organ tone and generate sound by means of a metal tongue (the reed) alternatively opening and closing an aperture that communicates with the rest of the pipe. Again, this is a closely-coupled generator-resonator system whose detailed physics is even more obscure than those of the flue pipe. An important factor however is that the shape of the resonator tube controls the timbre to a large extent. Pipes that are flared reinforce all harmonics to a greater or lesser degree, whereas cylindrical bores emphasize only the odd harmonics. The names of reed stops, often fanciful, imply that they are attempting to imitate orchestral instruments such as the oboe, clarinet or trumpet. This imitation is usually in name only since the tone of organ reeds is unique and part of the tradition of organ building.

Perhaps the most artistic and subtle part of organ building resides in the hands of the voicer, who tunes and adjusts the tone quality and volume of each pipe individually, a process which is the result of centuries of skill and craftsmanship. By basing the design of tone filters on the harmonic structure of actual pipes one attempts to endow the electronic instrument with some of the artistic virtues of the real one.

The relationship between the fundamental frequency of a pipe and its length has resulted in widespread use of the "footage" nomenclature to indicate pitch. An eight foot stop, for example, means that the frequency of the note two octaves below middle C (usually the lowest note on the keyboard in a church organ) is the same as that which would be produced by an open pipe as used on a piano. Stops of 16 foot pitch therefore sound an octave below this, and a four foot pitch an octave above, etc. The ability to control many ranks of pipes at once from one keyboard, or a variety of tone colours and pitches depending on the stops selected, contrinutes to the tonal variety and brilliant ensemble that is characteristic of a first rate pipe organ.

A complete account of the physical and aesthetic design principles of the organ can be found in the book by the late Professor Sumner.[1]

achieve envelope shaping during key attack and release.

Several filters are discussed in the next article, all designed assuming the availability of a sawtooth wave to feed them with. This has been chosen for the following reasons:

- Its spectral structure is simple. Harmonic amplitudes decrease monotonically with increasing frequency rather than in the oscillatory fashion of a pulse spectrum. This results in a filter frequency response that is also much simpler than if a pulse waveform had been used. This is important because of the comparative ease with which an electrical implementation of the filter can be built.
- A square wave has already been rejected as being unsuitable for all but a few special tones (though in these cases it is essential).
- Sawtooth and square waves are available in the author's instrument. This meant that a subjective judgment could be made as to the effectiveness of a filter design and in particular it was possible to make A-B comparisons of the electronically generated sounds against tape recordings of the originals.

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2. Boner, C. P., Acoustic spectra of organ pipes, JASA, July 1938.
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Marconi Fellowship

The Marconi International Fellowship maintains the motto "to commission creative work in science, technology and humanism," and recognises such work with an annual award of $25,000. The general criteria for eligibility include the importance of the candidate's contributions to communications, science or technology, and the degree to which the candidate's life exemplifies commitment to applying communications science or technology to bettering the human condition. For information of the award, write to Dr. Walter Orr Roberts, Marconi International Fellowship Council, Aspen Institute for Humanistic Studies, 1229 University Avenue, Boulder, Colorado 80302 USA.

Floppy disc system for the scientific computer — 1

8in disc stores 400K bytes

by J. H. Adams, B.Sc. M.Sc.

Storage of data in small computer systems is often accomplished by a 300-baud cassette tape recording. With a transfer rate of only 2K-bytes per minute, this method makes locating and transferring long strings of data a rather slow process. The introduction, through the users' club[1], of a more advanced operating system for the computer[2], and the availability of memory expansion kits, has made a faster store very desirable. To solve this problem the author has developed a store based on an 8in flexible (floppy) disc, which can accommodate 400K-bytes of data and transfer 0.5K-bytes per second.

Recordings on disc are made by converting the data bytes into a serial stream of 1s and 0s at a rate of 250,000 bits per second, i.e. one bit every 4μs, truncating the 1s down to about 0.5μs pulses and then interleaving a regular stream of 0.5μs pulses from the system clock as shown in Fig. 1. These pulses are used to reverse the current in the recording head and, hence, the sign of the flux recorded onto the disc. Converting the parallel input data to a stream of pulses is most easily achieved by one of the controller i.cs which are, in essence, dedicated microprocessors combined with programmed logic arrays to feed control information between the controller, the disc-drive electronics and the computer. Recordings are made on concentric rings, or tracks, 77 on an 8in disc, and a drive unit with two motors rotates the disc and steps the combined record/read/erase head from track to track. Optical devices provide signals which indicate when the head is over the outermost track 0 and, using a small hole punched in the disc, an index pulse to indicate when the disc starts each revolution.

The electronics in the drive unit convert t.t.l. levels to switching currents in the head and vice versa, operate the stepping motor and provide erasing signals. Other functions may include door locking, motor-on indication, adjustment of recording current on inner tracks, separation of data, disabling the write operation on write-protected discs, and loading the head against the disc on read operations. This drive unit contains most of these features, although separation of data is achieved in the controller i.c.

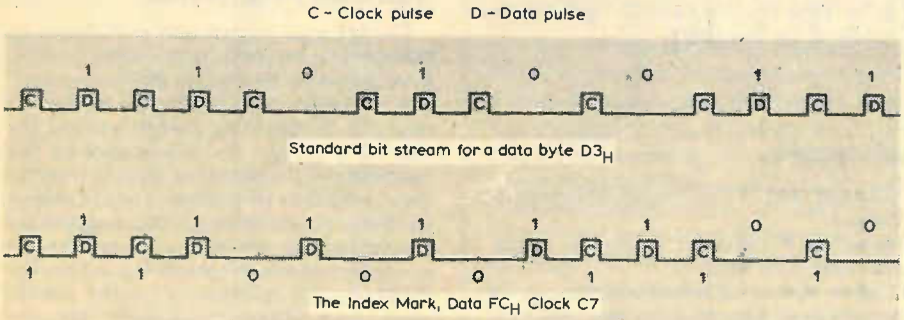


Fig. 1. Interleaved data and clock pulses.

Recording format

At 360 r.p.m. it is possible to record over 5000 bytes of data on each track of the disk. To allow the controller to identify recorded clock pulses from serial data pulses from the disc, the start of the decoding process is triggered by the index pulse, and the recording begins with a standard code which the controller can recognise and synchronize with. This code is often produced by repetitive recording of the byte 00, i.e. the clock pulses are recorded with no interleaved data pulses. The next task for the controller is recognition of the start of the first byte in the data stream. As all possible data bytes may start the stream, no single byte can be reserved for this purpose. Instead, a data byte with a few of the clock pulses missing is used and is known as a mark byte. Normal bytes can be thought of as data bytes interleaved with the clock byte FF, i.e. all eight pulses. A typical mark byte is data byte FC, interleaved by the clock byte C7. After this index mark, about 5000 bytes of data follow and the recording runs to the start of the next index pulse with a final code of bytes, usually 00s or FFs. The total number of code bytes is determined by the accuracy of the clock and drive motor.

Sectored tracks

If data transfers, which match the above, are all that is required of the disc, it is an efficient way of using the system in terms of bytes stored per disc. Usually, however, transfers are of variable length and, as it is not directly possible to access part of the way through a track, there is a limit of one recording per track, no matter how short the data block. To improve the potential disc capacity, each track is split into sectors which each require start and stop codes and identification marks. This leaves less space for data, but normally provides the most efficient mode. Such a format, now widely in use, is the IBM 3740 which fits 26 data sectors into each track, with 128 data bytes in each sector as illustrated in table 1.

In the present format, sectors consist of an identifying block followed by the data. Six 00s synchronize the clock/data separator, an address mark (data FE, clock C7) indicates the boundaries of the bytes, and, as previously explained, track and sector numbers are given. This is followed by a CRC, which is a two-byte cyclic recognition code used by the controller to check for errors when reading information. The sector then has a short code, immediately followed by six more 00s, a data mark (data FB, clock C7), the 128 bytes of data, a two byte CRC for the data, and a final code. Each track has 26 of these sectors end to end, prefixed by a large block of 00s, an index mark (data FC, clock C7), and trailed to the end of the track by a code. The copious supply of synchronizing bytes and CRC codes can, with suitable software in the computer, produce a very reliable system.

Formatting all of this information onto the disc is a complicated operation, IBM 3740 sector

6 bytes 00	Ident mark	Track no.	00	Sector no.	00	CRC 2 bytes	17 bytes 00	Data mark	Data 128 bytes	CRC 2 bytes	27 bytes FF
Ident field							Data field				

IBM 3740 track

40 bytes FF	6 bytes 00	Index mark	26 bytes FF	26 sectors	approx. 240 bytes FF

Table 1. Formatted disc arrangement.

and most discs are supplied formatted with dummy data (usually byte E5). Such discs are marked 128 bytes per sector or per record, soft sectored. The last mentioned term means that the start of the sectors is indicated by software recorded onto the disc, as opposed to permanent hard sectoring, achieved by punching index holes in the disc for each sector (sometimes called 33 hole media for this reason). One disadvantage of soft sectoring is that, if formatting information gets magnetically corrupted, the sectors affected become useless. For this reason, even unused discs should be treated with care. Fortunately, if this should happen, the controller can re-format tracks to this and a number of other formats.

Computer-controller interface

To the computer, the controller looks like four input and four output ports. However, to address the controller, the computer only needs to supply one line each from IC_2 and IC_3, (the computer's input and output-port decoders) along with address lines A_3 and A_4 as shown in Fig. 2. Because neither of the address lines go to the decoding i.cs, they take no part in decoding the 8-bit port addresses which the Z80 sends along the bottom eight address lines during I/O instructions. Therefore, I/O commands such as IN(05), IN(0D), IN(15) and IN(1D) will activate the same line from IC_2, the bottom three bits of each number being the same, 101, but each provides a different combination on A_3 and A_4. By connecting the IN line to the controller's $\overline{RE}$ (read enable) input, and the two address lines to the A_0 and A_1 inputs, all four controller registers may be read by the computer. In a similar fashion, one line from IC_3 drives the $\overline{WE}$ (write enable) line of the controller, which allows the computer to write information into any of the registers. For details of these see Table 2.

As well as the data bus into and out of the device, and the four control lines described above, there are two lines from the controller to the computer. One indicates that, either through natural completion or through a failure, the controller has finished an operation and wants servicing, $\overline{INTRQ}$, the other, $\overline{DRQ}$, indicates that the controller desires a data transfer either to or from it. This information is present in the status register but, because of the high rates of data transfer taking place, these lines must be used to enter the Z80, through the interrupt line, in preference to the much slower polling of the status register. The Z80 can therefore keep up with the steady demand for, or supply of data between it and the controller. For this reason, part of the interface consists of a simple but effective interrupt controller.

Controller disc-drive interface

Lines from the controller to the drive comprise step and direction signals for the head-position motor, data and gating signals for the write operation,

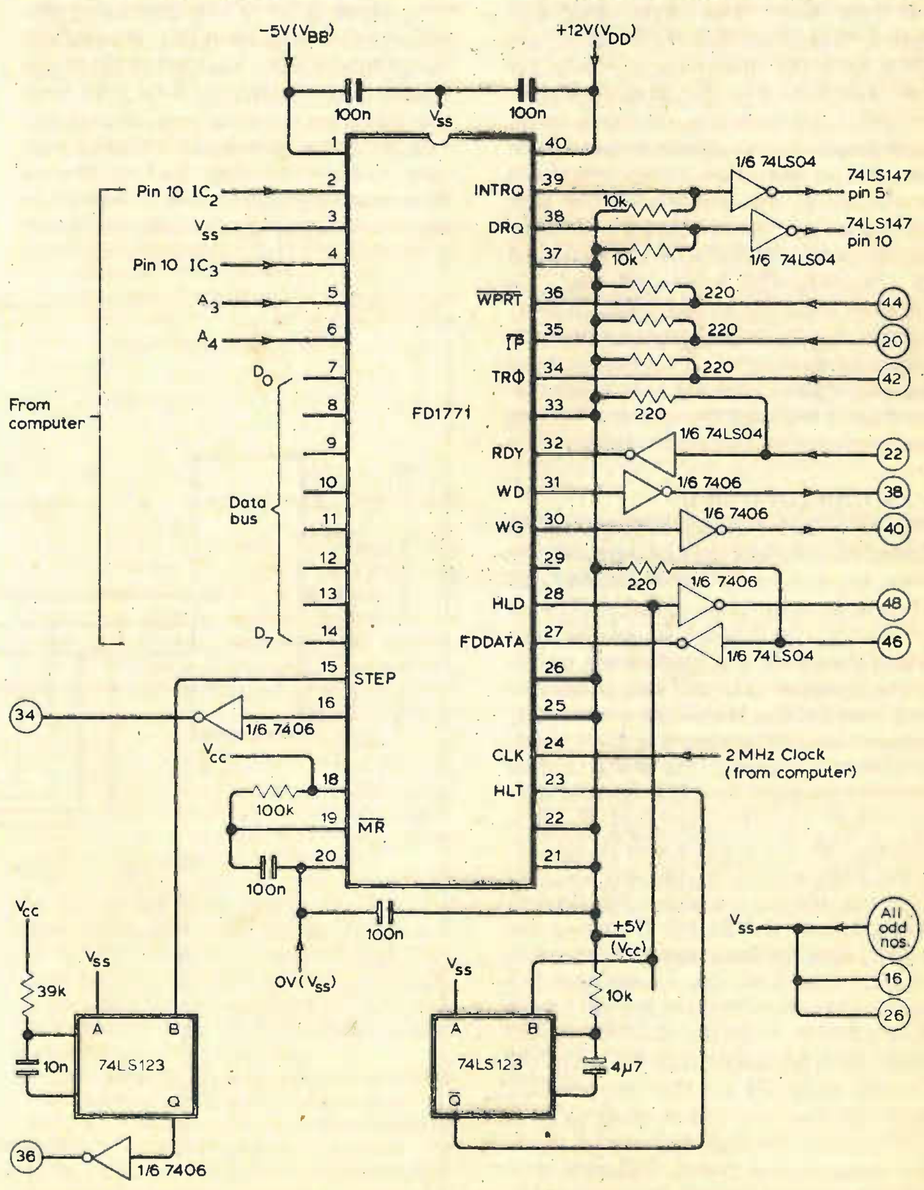


Fig. 2. Floppy-disc controller/formatter.

A3	A4	Register	Addressed as	Remarks
0	0	Status	IN A,(05)	Read on $\overline{INTRQ}$, checked for CRC error and record not found bits during Read, Write and Seek.
		Command	OUT (A0),A	Receives commands from the computer.
0	1	Track	IN A,(0D) OUT (A8),A	This register normally contains the current head position, 00 to 4C. It is reset to 00 on completion of the Restore command.
1	0	Sector	IN A,(15) OUT (B0),A	This register holds the desired sector number for use during Read and Write operations
1	1	Data	IN A,(1D) OUT (B8),A	Used during Read and Write operations as the source and destination of data bytes. During Seeks, it holds the desired track number, towards which the head and the track-register step.

Table 2. Register structure of the floppy-disc controller. Note that these details refer to the controller in this interface. More details are given in the data sheet[3].

and a head loading signal. In the opposite direction, the drive provides data in the form of interleaved clock and data pulses, the index pulse and signals to indicate that the head is over track zero, the disc drive is ready for use, and whether the disc is write-protected. Some drives provide a head-loaded signal, or can load the head onto the disc in the 10ms delay provided internally by the controller. As this drive does not, a monostable is used to provide a delay signal which is triggered by the outgoing headload line. To improve noise immunity when transferring signals to and from the electromechanical drive, the lines at both ends are pulled high via low value resistors, and high-current sinking buffers are used to drive signals to and fro.

Interrupt controller

Interrupts allow external hardware to divert the microprocessor temporarily from its stream of instructions, and accept instructions from, or more usually, to call a block of instructions which deal with the hardware's needs. In the computer, the $\overline{INT}$ line to the Z80 is driven by the MM57109 which only requires the Z80 to read (for Mk I and II systems) or transfer (for Mk III), data between the two. This is a fairly simple procedure and the interrupt mode is chosen, which causes a call to the address 0038 where, in the earlier two systems, there is a short routine to read the data. In the Mk III, there is a re-enable of the interrupt and return so that the interrupt line makes the Z80 pause until the MM57109 is ready for a data transfer. With the disc, faster and more complex responses are required because either of the two interrupting lines can become active separately or simultaneously and, depending upon the operation in hand, different responses may be required. To provide the extra flexibility without sacrificing speed, Mode 2 interrupts must be possible, and this is carried out by the interrupt controller in Fig. 3.

In Mode 2, after the Z80 has completed its existing operation, it responds to the interrupt by asking the interrupting device to supply an 8-bit byte onto the data lines which it uses, in conjunction with the previously loaded I register, to form the address of the first of two consecutive memory locations where it will find the starting address of a subroutine to be executed. With these two locations in the r/w.m., the disc operating system can make alterations to their contents and so alter the Z80's response to, in particular, a $\overline{DRQ}$ interrupt to cope with read, write and verify operations which are at the heart of a disc system.

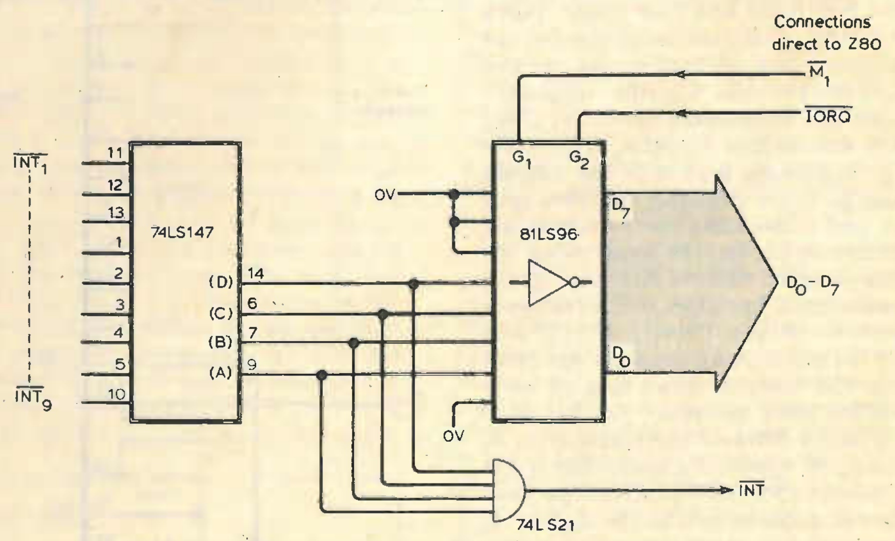
The circuit uses a 74LS147 priority encoder to generate a 4-bit code derived from the highest priority active input line. This code forms bits 1 to 4 of the byte which, when both $\overline{M1}$ and $\overline{IORQ}$ are active low, (a combination which only occurs during the Z80 interrupt acknowledge sequence) is gated onto the data lines. Direct connection to the Z80 is necessary because, during the interrupt response, both $\overline{RD}$ and $\overline{WR}$ are inactive and the bus transceiver isolates the Z80 from the main data bus.

The connection from the MM57109 to the $\overline{INT}$ pin of the Z80 must be broken and re-routed through one of the unused inputs to the interrupt controller. As the 57109 is now driving a low-power Schottky device, the pull-down resistor on this line must be changed to 10kΩ connected to the −5V supply.

Part 2 will describe the controller circuit and software.

References

1. Users' club, contact Mr P. L. Probetts, 50 Cromwell Road, Wimbledon, London SW19 8LZ.
2. Mk III monitor, contact the author at 5 The Close, Radlett, Hertfordshire WD7 8HA (Radlett 5723).
3. Data sheet, Western Digital FD 1771, Mar 77.



$\overline{INT}$ line active	Priority	Byte fed into the Z80 for a type 2 interrupt
1	lowest	E3
2		E5
3		E7
4		E9
5		EB
6		ED
7		EF
8		F1
9	highest	F3

Fig. 3. Interrupt controller.

LETTERS TO THE EDITOR

"CRANKY" VIEWS

In May's letters Mr Williamson made two statements. Firstly he said that the millibel is rubbish, and secondly he said that a magazine of *Wireless World*'s stature should not provide a platform for cranky views.

In respect of the former he may be right but in respect of the latter he is definitely not. Let us see what J. S. Mill has to say:

> "To refuse a hearing to an opinion because they are certain that it is false is to assume that *their* certainty is the same as *absolute* certainty. All silencing of discussion is an assumption of infallibility. Though the silenced opinion be an error, it may, and very commonly does, contain a portion of truth; and since the prevailing opinion on any subject is rarely or never the whole truth it is only by the collision of adverse opinions that the remainder of the truth has any chance of being supplied.
>
> Even if the received opinion be the whole truth, unless it is contested it will be held in the manner of a prejudice, with little comprehension of its rational grounds.
>
> If there are any persons who contest a received opinion let us thank them for it. In an imperfect state of the human mind the interests of truth require a diversity of opinion."
>
> (*On Liberty*, abridged)

And let W. E. Weyl end the subject with a flourish:

> "To every shade of thought, religious, scientific, political, economic, and social; to every craze, fad, dogma, heresy, and inspiration; there should be accorded a forum, a soap-box, a ton of type, and, subject to a subsequent responsibility for utterances, full liberty of speech and print."
>
> (*The New Democracy*, 1912)

Long live cranky views.

S. Frost
Edinburgh

VHF PROGRAMME LABELLING TESTS

I would be obliged if you could draw your readers' attention to the fact that the BBC are conducting experimental transmissions on their Radio 4 broadcasts from the Wrotham transmitter which can give rise to apparent interference when receiving stereo transmissions with some types of receiver, as the BBC seem to be keeping quiet about it.

Having experienced interference for the past few months which only affected Radio 4 and then only when a stereo broadcast was being received, which interference vanished when I disabled the stereo decoder, I rang the BBC's Engineering Information Department and was told that this trouble was caused by adjacent channel interference from a continental station, that I should fit an attenuator, and that there was definitely nothing wrong with their transmitted signal. I subsequently found out, quite by chance, that they are in fact making experimental transmissions from Wrotham, and on speaking to their Research Department was told that these were known to affect certain receivers, of which mine (an Alba UA800) was one. The noise on my receiver is somewhat like that of a distant diesel engine ticking over, which is quite noticeable during quiet passages in music or speech.

On ringing the BBC's Engineering Information Department a week or so later I was again told that my trouble was due to a foreign station. Only after I said that I knew that they were making experimental broadcasts which were affecting my receiver was the existence of these broadcasts admitted, and I was told that they would shortly be extended to Radio 2, as their Research Department had not had any complaints. Personally I cannot see how their Research Department could receive complaints when there has been apparently no publicity about these broadcasts, and it would appear that anyone making enquiries about interference is told that a foreign station is to blame, this despite the fact that the BBC's Research Department appear to know that problems will be experienced with certain receivers.

Some of my colleagues have reported noticing similar background noise with their receivers (various Philips and Ferguson models), but had attributed it to outside interference. It does not in any case make itself apparent very often due to the scarcity of stereo programmes on Radio 4. I would ask anyone who has noticed this effect and who has thought or been told that it is interference to contact the BBC.

I must say that I am somewhat puzzled by the BBC's approach. Although they have usually been quite open in the past about experimental transmissions, and requested feedback from the listeners, it seems that in this case feedback has been blocked for reasons best known to themselves.

R. Camp
Romford
Essex

The BBC replies:

May I fill in the background to the points in Mr Camp's letter?

As has been publicised in *Wireless World* and elsewhere, the BBC is investigating proposals for inclusion of data signals in radio broadcasts. If a suitable system can be established it could offer a number of facilities of considerable benefit to the listening public, including channel and programme identification; automatic receiver tuning and switch-on as pre-selected in advance by the listener; automatic receiver search for the type of programme desired (e.g. light music, news); and visual display at the receiver of simple text such as channel and programme title; clock time and news headlines.

Compatibility with existing receivers is clearly an important factor. BBC Research Department has carried out laboratory tests on a range of domestic receivers and these tests have been supplemented by broadcast trials wherein data signals on a 57kHz subcarrier have been included in Radio 4 v.h.f. transmissions from Wrotham.

The results of these broadcast trials have been assessed by means of questionnaires issued to selected listeners, including receiver manufacturers' representatives. The trials have not been generally publicised since to do so would inevitably mean that many unrelated interference or other difficulties would be ascribed to the data signals and the trials largely vitiated.

Although the trials were unpublicised it would have been quite wrong for us to have wished to deny their existence or to give misleading advice to listeners complaining of interference. I very much regret that this happened to Mr Camp and freely apologise to him. In fact there was no intentional cover-up, simply human failure in that Engineering Information Department engineers answering enquiries were insufficiently alerted to the possibility of interference from this source: that this was so is my responsibility and their suggestion of interference from other stations was reasonable since this is a common problem at this time of year.

The desirability of a system of data signalling on a subcarrier in v.h.f. transmissions has been recognised for some time in many countries. The international (CCIR) Recommendation for f.m. stereophonic broadcasting allows for the use of a 57kHz subcarrier in this way and receiver designs should be capable of handling signals according to this Recommendation: such a subcarrier is widely used in other countries. Some receivers, including Mr Camp's, are not so designed and some other older receivers may suffer some degree of interference unless their stereo multiplex decoders are very carefully aligned.

In September we shall assess very carefully the results of the current trials and Mr Camp's report on his experience will represent useful additional information in this context. We shall wish to be sure that no difficulty will be caused to receivers which are designed with the CCIR recommendation in mind, and to assess the degree of any problems experienced with older receivers.

D. P. Leggatt
Head of Engineering Information
BBC, London W1

MAXWELL'S EQUATIONS REVISITED

As mentioned in the May correspondence columns, we received a large number of letters commenting on Ivor Catt's article in the March issue. Our original intention was to present collectively the main points of all these letters. After discussions between the author and some of the correspondents, however, we finally decided to print one letter which was considered by an independent referee to be fairly representative. (This referee is a senior engineer in a large computer firm.) The letter chosen is followed by a direct reply and some general remarks by the author.

Regarding Mr Catt's latest article, "Maxwell's equations revisited" in the March issue, I feel that he should be relieved of some of his pseudo-mathematical delusions. For example, what exactly does he mean by the equation

$$\frac{\partial h}{\partial x} \cdot \frac{dx}{dt} = \frac{\partial h}{\partial t} \qquad (1)$$

One criticism is that dx/dt can only be used to represent the velocity of the train if x represents the x-co-ordinate of a *fixed point* on it. Mr Catt originally introduced x and t as independent variables to define a point in space-time, so dx/dt is a meaningless quantity.

Also, if Mr Catt had really performed a "careful analysis" he would have had great difficulty in deriving equation (1) in the first place, as anyone with even elementary knowledge of partial differential calculus could tell him. Equation (2)

$$\frac{\partial H}{\partial x}\cdot\frac{dx}{dt}=-\frac{\partial H}{\partial t} \qquad (2)$$

falls into the same category of fallacies. Small wonder it never appears in the textbooks!

Mr Catt then goes on to say that "almost anything" is a solution to the equations

$$\frac{\partial E}{\partial x}=-\frac{\partial B}{\partial t} \qquad (3)$$

$$\frac{\partial H}{\partial x}=-\frac{\partial D}{\partial t} \qquad (4)$$

This, to put it mildly, is a slight exaggeration of the facts. It is a fact that a sinewave, or a number of sinewaves, *is* the solution of the equations *given the correct boundary conditions.* Mr Catt's train is also a solution of the equations but since it obeys a different set of boundary conditions it does not appear as a sinewave. More rigorously, the train profile can be considered as a Fourier series comprising an infinite number of sinewaves with different frequencies and amplitudes, and possibly also some exponential terms.

Having demonstrated the non-existence of any justification for the "theoretical" part of the article, I would like to ask the author if he has any justification for the abuse he proceeds to hurl at mathematicians in general. Mathematics is a tool for the scientist or engineer to enable him to concisely describe physical phenomena. Insight, or a "feel" for the phenomena, is built into the equations and a competent engineer should be able to "look inside" the equations and visualise what they represent. Visualisation of abstract concepts is more difficult but simply because mathematics is used as an aid in describing them does not make the theory "ludicrous and false".

Waveguides, antennae and the like are designed using Maxwell's equations, not by hit-and-miss methods, and behave as predicted by the mathematics. Electromagnetic theory is mathematical by its very nature and if Mr Catt abandons the mathematics he will be left with very little of any practical use.

R. C. Hayes
University of Liverpool

The author replies:
Equation (1) relates three things:

(a) the slope of a surface,
(b) its forward velocity,
(c) the rate of rise of the surface.

If the slope is 1 in 4, the forward velocity 10 metres per second, then the rate of rise of the surface is 2½ metres per second. This kind of

relationship is the stuff of which science and engineering is composed of. I think Mr Hayes knows full well what (1) means, since he has studied A-level mechanics.

Equation (2) says that if an unchanging TEM wave moves forward at the speed of light, the gradient of H with forward distance is related to the gradient of H with time. If it is a fallacy, then what is the correct formula? Or are we not allowed to relate $\partial H/\partial x$ to $\partial H/\partial t$ for a TEM wave?

Let Mr Hayes tell mechanical engineers to convert their trains into a Fourier array of sinewaves, and see how they react! Thank God mechanical engineers are too practical to be sucked into the kind of quagmire that permeates electromagnetic theory! I do not want to travel in a train with some exponential terms designed into or out of it! Would Mr Hayes recommend that the passengers be positioned so as to minimize their harmonic content?

Waveguides, antennae and the like are emphatically *not* designed using Maxwell's equations, any more than a tribal dance wins the battle that follows.

My successful pioneering attempts to interconnect high speed (1 ns) logic in Motorola in 1964 forced me to abandon all the maths that had grown like weeds to choke electromagnetic theory. A logic step is emphatically *not* a Fourier array of sinewaves, and you will run into all sorts of nonsense if you kid yourself that it is. Also, you can only successfully decouple the 5-volt supply to sub-nanosecond logic because it is untrue that capacitors have stray series inductance. The regular abandonment, at vast cost, of high speed logic systems during development will only cease if we can infiltrate some common sense into electromagnetic theory, and it stops serving merely as a favourite stamping ground for physically ignorant, fancy maths obscurantists. We must take the blarney out of electromagnetic theory.

The author also makes the following general remarks on the whole of the correspondence:
All twenty-two correspondents ignored the physics and concentrated on the mathematics. It seemed that whether Maxwell's equations mapped meaningfully and usefully onto reality mattered not. All that mattered was that the maths should be internally correct, or at least respected. An engineer like myself, who has sometimes worked as if through a blizzard of irrelevant, convoluted maths, takes the opposite view.

Some of the replies thought the minus sign should be there; some said it should not be. None noticed or contradicted my point, that the minus sign had no physical significance. (In fact it is an outgrowth of partial differentiation. Full differentiation has no minus sign, being a completely different operation from partial differentiation, in which the sign appears regardless of the nature of that which is being differentiated).

Always at a point on a surface in a three dimensional graph, the three slopes are related by

$$\frac{\partial z}{\partial x}\cdot\frac{\partial y}{\partial z}\cdot\frac{\partial x}{\partial y}=-1$$

The minus sign has nothing to do with electromagnetic theory. This contrasts with

$$\frac{dx}{dy}\cdot\frac{dy}{dz}\cdot\frac{dz}{dx}=+1$$

which is always true of the gradients of lines in two-dimensional graphs.

I. Catt

IEEE 488 BUS

Mr Ellesfen's article in the June/July issue on the IEEE 488 bus standard is timely, but bitter experience convinces me that he has over-simplified things a little. The IEEE, IEC, GPIB and HP-IB systems are not all identical. Try interconnecting a 'strict' IEEE instrument (e.g. a Fluke 8502 d.v.m.) to a European GPIB bus instrument — lo and behold, the plugs are different. In fact Mr Ellesfen's Fig. 3 may show a typical GPIB rear panel but those aren't IEEE connectors. I do wish you engineers could agree on these things — it would make life a lot easier for us mere mortals!

John Hennessy
Department of Physics
University of Sheffield

IMPEDANCE MISMATCHING

The article "Impedance Mismatching" by Dr Lidgey in the March issue calls attention to an often overlooked point, because students fail to read the whole definition of equivalence in networks. For instance, one source says:[1]

> "If one network can be substituted for another without change in the currents and voltages at the ports, the two networks are externally indistinguishable and *are said to be equivalent at the ports. Nothing need be known of the internal network configuration.*"

An equivalent network is not identical internally but has only identical values of external voltages and currents at the terminals. Thus comes our practice of substitution of "black boxes" to replace whole complex networks.

It is desirable to point out, as is done in the article, that power systems are not matched in impedance as 50 per cent efficiency rather raises the generation costs! But in communications where microwatts of power are *very* expensive, it is desirable to get out all we can, and so we match.

J. D. Ryder
Ocala
Florida, USA

Reference

1. J. D. Ryder, Introduction to Circuit Analysis p.175. Prentice-Hall, Englewood Cliffs, NJ 1973.

DESIGNING WITH MICROPROCESSORS

I would be grateful if you would allow me to draw attention to an error in Fig. 3 of "Designing with microprocessors" by Zissos and Valan in the May issue. The 8228 status latch shown would not produce the signals shown, since it decodes the status information placed on the data bus during the status pulse, $\overline{\text{STSTB}}$, which is absent from the diagram. The outputs from the 8228 are much more akin to other processors, and comprise $\overline{\text{MEMR}}$, $\overline{\text{MEMW}}$, $\overline{\text{I/OR}}$, $\overline{\text{I/OW}}$, and $\overline{\text{INTA}}$.

The diagram as shown would be correct if the status latch was a simple eight-bit latch clocked by the $\overline{\text{STSTB}}$ line.

P. B. Hodgson
Grantham
Lincs

The authors' reply: We thank Mr Hodgson for pointing out the omission of the $\overline{\text{STSTB}}$ strobe pulse in Fig. 3. This was intentional, for the sake of clarity.

D. Zissos and L. Valan

DESIGNING WITH MICROPROCESSORS

In their current series of articles "Designing with microprocessors" Zissos and Valan opened in the May issue with some remarks with which I profoundly disagree. They may be right, or I may be right; but either way, the questions involved are of such fundamental importance that I think both sides of the question need to be put.

To summarize, the authors put forward two views: that inefficient, machine-independent approaches are no longer justified, and that an understanding of the functioning of microprocessors is needed by their users. Let us look at this second point first.

It is obviously an advantage to understand how something works if you want to use it. It may also be more satisfying to know, but that is not the point. The question is, can a designer of something which incorporates a microprocessor do a better job if he understands how microprocessors work? I am sure that the answer is that he will probably use the microprocessor more effectively, but not by any means that he can produce a better design overall.

The problem is that designers are already overloaded with things that they ought to understand. Adding in the understanding of microprocessors is not a simple plus: it almost certainly means forgoing the attempt to understand something else.

Take the case where a microprocessor-based device is used as a circuit component — say an 'intelligent' filter which can discriminate between signal and noise far better than any array of passive components. The things that a designer could usefully come to understand better are how that filter itself works, or what its effect on the circuit as a whole will be. Understanding the filter may open up new opportunities, or avoid mistakes. Understanding the effects on the circuit will involve seeing the effects of a fixed, rather than frequency-dependent, delay, and may likewise open up opportunities or avoid mistakes. If the designer has time to take both on board, all well and good. More likely, though, something has got to go. Which? Well, the suppliers of the micro-based filter can tell him the salient features of the device as a whole. But who can tell him the salient features of its impact on the circuit he is designing? Nobody. He must sort that out himself.

The situation gets even more acute where a micro is used as a systems component, say as part of office equipment. There the range of aspects that a designer needs to understand gets very wide indeed — including marketability, the psychology of the operator, safety legislation, and so on. The poor designer can hardly keep his head above water. Let's not load him even more.

What the designer needs to know is *what micros can do*, not how they do it. One day I really must learn how transistors work (I grew up on valves). Even so, I seem to be able to use transistors, because I can find documentation which tells me what the result is.

I am not objecting to the inclusion of articles describing how micros work – I, like most readers of *Wireless World* I suspect, am a person who likes to know how things work. But those articles should not contain the implication that such knowledge is the best way to approach their use.

That argument pales into insignificance beside the one of machine independence. It took the 'big computer' world a decade or two to learn the lesson of machine independence. Now the microprocessor world seems determined to repeat the mistakes, against an economic basis that is far less tolerant of such mistakes.

Several years ago a fair size mainframe might cost £1,000,000. The application programs which used the machine probably cost somewhat less, but not much less. Originally they were written to suit the characteristics of the machine. Provided that no major growth required intermediate change, replacement might be needed in, say, seven years. Then there was good news and bad news. The good news was that the replacement cost less (despite inflation) than the predecessor. The bad news was that modifying the software would cost far more, and would be such a major undertaking that the resources would not be available to make the change. Thus we see people buying ICL 2900s, which are something like a hundred times as fast as some machines they replace, but running programs *slower* than their predecessors, because the old programs have to be run, and when a 2900 pretends that it is an older machine it is very inefficient indeed.

This is actually rather a favourable example! As the 2900 is a replacement for earlier ICL machines, and as it is a major cost item, the incentive and the money to provide the software for it to pretend to be an earlier machine have been there. In other cases users have been left in a real mess.

How do micros compare? For a start, the cost of programs typically far outweighs the cost of the device itself. So replacing the hardware is almost trivial in cost terms. But if the software is tied to the hardware the resultant software change cost can be crippling. *Microprocessors are only cheap if they are cheap to use; if the way in which they are used brings crippling costs, they are extraordinarily expensive.*

The situation is made worse by the rate of change in microprocessors. With the mainframe instanced above, the effective life was the life of the machinery. When micros are used in products, so that it is the product manufacturer who develops the software, the life is from the time he starts buying one version to the time that that version is superseded. *Currently that timescale appears to be about nine months.*

Put it another way. If you develop a prototype of a product incorporating microprocessors, the chances are that by the time you go into production that particular version will be obsolete. Later, when an assembly fails in service and requires replacement, the production chip originally incorporated will no longer be available. If the software is linked to a particular chip, you've got problems, and pretty severe ones. Among them is the fact that the people who designed the original software (which will no longer work on the latest version of the micro) might no longer be around, so that the new designers have to start from scratch. By the time that they have finished their work, a new version of the micro will already be on its way.

The large computer users have already learnt that there are considerable risks associated with machine dependent designs. The factors which have forced them to start using inefficient approaches to avoid being trapped are far more potent in the micro world. Far better endure the 50%, 100% or even 200% overhead of machine-independent software than be trapped in a short time by the 10,000% overhead instanced above.

What it comes down to is this. If you want to use a microprocessor as an educational toy, then learn how it works, and write programs which exercise the individual capabilities of different chips. It is a fascinating pastime. But if you want micros as a serious tool, think again. If you have got some time to spare, use it on thinking how the tool can help you, how it will affect the system where you use it. And whatever happens, try to avoid getting so tied up with a particular version (which will probably be obsolescent by the time it comes on the market) that very shortly you will find yourself occupied full time in just keeping things working.

R. M. O'Connor
St Albans
Herts

The authors reply:

We must disagree with Mr O'Connor's contention that a better overall design cannot be produced by the understanding of how microprocessors work, as will be demonstrated in later articles. This understanding can be gained by first-year Computer Science or Electrical Engineering undergraduates in two to three 50-minute lectures.

Because of the methodology available today it is unnecessary for a designer to feel overloaded. Much of the stress experienced is normally caused by lack of knowledge of the idiosyncrasies of v.l.s.i. chips. Although this lack of knowledge may be tolerated in users, it should not be acceptable in doers.

The analogy drawn with computers of a few years ago is invalid, because we now have step-by-step procedures for designing and implementing digital systems that did not exist then.

A closer look at the 'new' microprocessors shows no fundamental changes in the basic structure, and therefore they can be easily accommodated in systematically designed systems. The figure of 10,000% overhead is simply unrealistic or a result of a bad design.

D. Zissos and L. Valan

TV SETS FOR THE HARD OF HEARING

My hearing is poor and over the years I have found that I can best listen to the radio or television via a pair of headphones. Radio is, of course, no problem. But when I wished to purchase a television set with an outlet for 'phones I was just met with blank stares!

I am retired, and was in no hurry, so I went around all the television retailers in my area just to see what there was. The young assistants just did not want to know. Apart from one helpful dealer the only other trader willing to help was a stockist of exclusively Japanese products. The Japanese tv sets mostly had outlets fitted as standard for tape recording the sound, and for headphones. On some, inserting the headphone plug cut out the loudspeaker, on others there was a choice of cutting out or not cutting out the loudspeaker.

I bought one! What would you do? A circuit diagram was included and looking at it I concluded that the additional cost of fitting the outlets would be around £5.

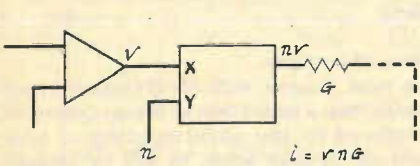
About ten per cent of the population have hearing problems, while five per cent have serious hearing problems requiring some form of assistance. On this basis it seems to me that someone is missing out on sales.

Fred Holloway
Essex League of the Hard of Hearing
Rayleigh, Essex

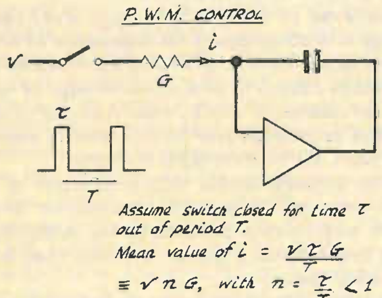
Pulse control of analogue functions

by Peter Williams, Ph.D. Paisley College of Technology

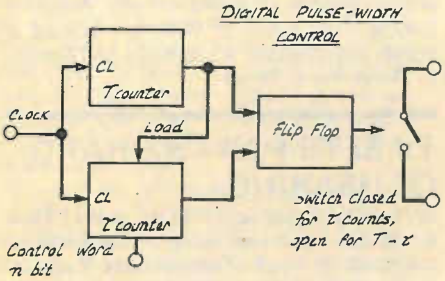
ANALOGUE MULTIPLIER CONTROL



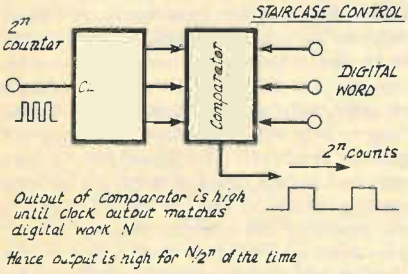
P.W.M. CONTROL



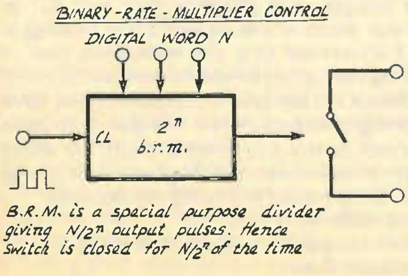
DIGITAL PULSE-WIDTH CONTROL



STAIRCASE CONTROL



BINARY-RATE-MULTIPLIER CONTROL



Any other device interposed between one integrator and the next, having a controlled transfer function, will vary the frequency of the oscillator/filter. Analogue multipliers are designed to have an output proportional to the product of a pair of inputs. Interposing a pair of such multipliers with one input of each fed from a control voltage results in linear control of the frequency. The multiplier is being used for the restricted function of a gain-controlled amplifier, other forms of which may be substituted. Only two-quadrant operation is required as the control voltage is unipolar. Variable transconductance circuits can also be used. In some cases the output is in the form of a current and the following drive resistor may be omitted. Overall stability may be affected by the additional lags introduced by the multipliers though with standard operational amplifiers, the dominant lags caused by internal compensating capacitors are likely to affect the response first.

A completely different approach is possible if the nature of the integrator is reconsidered. The voltage across the capacitor depends on the total charge and not on the manner in which that charge is acquired. This suggests that the current may be allowed to flow in short controlled bursts provided that the switching rate is high enough to minimize the ripple voltage that is inevitably superposed on the output. This is essentially pulse-width modulation, and n is replaced by τ/T, where τ is the pulse duration and T the pulse period. In the first configuration an analogue switch is assumed to be repetitively closed at a frequency of $1/T$ with τ being varied to control the mean current over the cycle. Typically, for an oscillator frequency f then $1/T > 10f$ would be preferable for minimum ripple. As analogue switches operating up to the MHz region are readily available this places little constraint on the usable signal frequencies. As before any number of sections can be used with the switches drive in synchronism from a common generator — the last consisting typically of a fixed frequency astable driving a variable period monostable.

The accuracy and resolution obtainable in the previous methods are restricted by the analogue sections of the circuit. Purely digital methods are possible for the control section which can increase the resolution without limit. One method is shown in which two interlinked counters are used to determine τ and T each as multiples of the period of a clock generator. The ratio τ/T is thus independent of any timing circuitry, being the ratio of two integers either one of which may be preset or controlled by an external digital control word. The T counter sets the flip flop and starts the τ counter. At the end of the τ counter duration, e.g. counting down to zero from the previously loaded control word, the flip flop is reset until the start of the next period. In this particular case the switch is closed for counts and open for $T - \tau$ counts, and any number of switches can in principle be driven from the given flip-flop.

As an illustration of the range of possibilities, consider the circuit shown, with a binary comparator driven from a 2^n binary counter. The output of the comparator is high until the counter output matches the control word N applied to the comparator. For the rest of the time the comparator output is driven low. Hence any switch activated by the counter will be on for $N/2^n$ of the time and the circuit would be capable of controlling a filter or oscillator such that $f \propto N$. A restriction on this and the previous form is the difficulty of filtering the switching waveform if the switching frequency becomes too low. It is desirable that $f_{clock}/2^n >> f$. Any other switching circuit that can close a switch for a controlled fraction of the time can be employed, and the method has been employed as a precision voltage divider for measurement applications.

One particular class of digital circuits seems particularly appropriate to this application — binary-rate multipliers and dividers. In the former a digital control word N directly sets the number of pulses that are transmitted during a complete cycle of operation of 2^n input pulses. Moreover these circuits can be combined to give output pulse rates that are complex functions of the input control numbers if required. Because the on and off states are distributed throughout the cycle the filtering problem is a little less severe, though they are not randomly distributed. The main advantage of these circuits is that no additional comparator or decoding action is required and the output can be applied directly to an analogue switch or switches. CMOS logic is the obvious family to use since analogue switches are readily available that are compatible with the b.r.ms. The restricted supply voltage range (typically ± 7.5V) restricts the associated analogue circuitry to the same value.

Pulse control of analogue functions

THEORY

● The first method strictly belongs to the previous section in that the analogue multiplier produces a continuous variation in the scaling factor by applying a control voltage to one of the inputs

$$\text{i.e.} \frac{i}{v} = nG$$

where n represents the control voltage on the Y input. The Y input may however receive a discontinuous voltage switching between zero and some maximum value but with a variable mark-space ratio: Provided the switching frequency is high the *mean* value of n is controlled by that mark-space ratio.

● If discontinuous control is adopted the analogue-multiplier can be omitted with the voltage applied to the integrator through a switch. Let the switch be closed for a time τ out of a period T.

$$\text{Mean } \frac{i}{v} = \frac{\tau}{T}.G = nG$$

$$\text{for } n = \frac{\tau}{T} < 1$$

The ripple voltage across the capacitor is minimized for $T << 1/f_L$ where $f_o = \omega_L/2\pi$. is the lowest sinusoidal frequency to be controlled and $f_l \propto \frac{\tau}{T}$.

● The second counter, a down-counter, is loaded with a control word when the first counter fills and sets the flip-flop. Until the second counter empties the switch is held closed for a time τ proportional to the control word. For the remaining time until the first counter fills the switch remains open because of the resetting action on the flip-flop by the second-counter.

Mark/space ratio is $\frac{\tau}{T-\tau}$

● A related method compares the output of a single 2^n counter with a control word N in a binary comparator such that the output is high for $N/2^n$ of the time. This is again available to control the on-off ratio of a set of switches.

● For the bit-rate multiplier the internal logic causes an output pulse rate

$$\propto \frac{\text{control word}}{2^n}$$

or mark-space ratio $N : (2^n - N)$.

EXAMPLES

1. A two-integrator loop has the resistors switched into and out of conduction periodically — the period of the switching waveform is T and the conduction-time per switching cycle is τ. Given R is 100kΩ and C 10nF, calculate the frequency of oscillation for $\tau = T$ and $\tau = 0.1T$ assuming that that frequency $f_o << 1/T$ i.e. that the ripple superimposed by the switching frequency on the sinusoidal oscillation is small.

The effective value of each conductance is $G' = \frac{G\tau}{T}$

$$\text{i.e. } R' = \frac{T}{\tau G} = \frac{TR}{\tau}$$

Therefore following the previous analysis, and assuming a unity gain inverter,

$$\omega_0 = \frac{1}{CR'} = \frac{\tau}{TCR}$$

$$\text{i.e. } \omega_0' = \frac{\tau}{T}\omega_0$$

$$\text{For } \tau = T \quad f = \frac{1}{2\pi.10.10^{-9}.10^5}$$

$\therefore f = 159\text{Hz}.$

For $\tau = 0.1T \quad f' = 0.1f = 15.9\text{Hz}$

2. In the previous question a switching frequency of 1.59kHz is used. Estimate the peak ripple as a fraction of the sinusoidal amplitude.

(i) $\tau = T$: the switch is closed permanently and there is no ripple due to the switching. If τ is finite but very close to T, then the switch is off for very brief periods and the capacitor voltages remain constant for that brief interval.

(ii) $\tau = 0.1T$: the effect is that of a rectangular wave at a frequency of 10kHz with an amplitude equal to the value of the slowly changing output of the previous integrator i.e. the output Vsinθ of one is applied discontinuously to the second whose output approximates to —Vcosθ. Hence the max. ripple on the output of the second occurs when sinθ = 1 i.e. when the second integrator output is passing through zero. Note that Vsinθ itself contains a small ripple but this error is ignored. The peak ripple is thus

$$\frac{V}{R}.\frac{\tau}{C} = V\tau\omega_0$$

or expressed as a fraction of the peak output, $V_\tau \omega_0/V = 0.1\,\omega_0 T$

$$\text{But } T = \frac{1}{10^4}\text{s}$$

$$\omega_0 = 10^3 \text{ rad/s}$$

$$\therefore \frac{\text{peak ripple}}{\text{sinusoidal amplitude}} \approx 0.01 = 1\%$$

The "twins" paradox of relativity

"What is long overdue is a general summing up of the whole matter, so that the source of the scandal can be located and removed without futile polemic."

by the late Herbert Dingle

In *Nature*, volume 269, page 284 (22 September 1977) I put a question to Dr Tom Wilkie concerning an often advanced suggestion he had repeated for disposing of the twin paradox of relativity. He did not reply, but added a note stating that he would be writing me "privately" on the matter. It was, of course, entirely proper that misunderstandings should be removed before the reply appeared, but although after considerable correspondence this seems to have been achieved, Dr Wilkie has not accepted my invitation to him now to publish his reply. It does not accord with recognised scientific practice that questions considered worthy of publication should remain without published answer, and it therefore become my duty to comment publicly myself on the implications of this incident.

But far more is involved here than the incident itself. The so-called "twin paradox" has been the centre of more or less continuous controversy for more than half a century, and still remains unsettled. Because of its peculiar — I believe unique – character it is no exaggeration, but a considered temperate statement, to call this a scandal, for reasons which I shall show, and what is long overdue is a general summing-up of the whole matter so that the source of the scandal may be located and removed without further futile polemic. This is attempted here and the uniqueness of the problem in scientific discussions made clear, but first it is desirable, notwithstanding its familiarity, to state what the "paradox" is in its simplest form. For brevity and clarity a particular extreme example – that given in my letter in *Nature* of 31 August 1973 – is chosen. There is no disagreement about the legitimacy and typicality of this example, and therefore no begging of the question in selecting it.

Peter and Paul are twins, of whom Paul travels at birth with uniform velocity v to a distant planet stationary with respect to the Earth, and immediately returns at the same velocity having aged by three days, to find his Earthbound twin, Peter, 30 years old. In the general case, any two identical forms of standard clock may be substituted for the twins, and if t is "Peter's" age when "Paul" returns, "Paul's" age at that event is $t\sqrt{1-v^2/c^2}$, where c is the velocity of light. It is evident that in this example v must be very slightly less than c.

Now the peculiar nature of this "paradox" lies in the fact that this has never been observed in any form: the result is wholly a deduction from a theory. In all the traditional controversies or paradoxes of science – the Ptolemaic and Copernican theories of celestial motions, the wave or particle nature of light, etc. – the problem has arisen from *observations*, and what has called for decision has been the correct theory for explaining them. Here the reverse is the case. The dispute is not about what theory best explains the observations (which do not exist), but about what observation – equal or unequal ages of the twins on reunion – is required by an independently accepted theory. And indeed there is an allied peculiarity in that if the observation were made, its result, whatever it might be, would still leave the problem unsolved: the question would still remain, what is wrong with the deduction from the theory of the opposite result? The problem, therefore, lies within the theory itself. Failure to understand the course of nature is excusable and observation of nature might be expected to bring enlightenment: failure to agree on the implications of our own constructed and accepted theories is not excusable. That is what makes the endless persistence of this controversy a scandal.

"Failure to agree on the implications of our own constructed and accepted theories is not excusable. This is what makes the endless persistence of this controversy a scandal."

Let us assume that the theory is true, and give the net results of the arguments for its requirement of symmetrical and asymmetrical ageing, respectively. The first can be stated very simply. The relativity theories, both special and general, require that it is equally true to regard Paul as moving with respect to a stationary Peter and planet, and Peter and planet as moving with respect to a stationary Paul. Therefore if, as the theories also require, the moving twin ages more slowly than

Herbert Dingle
2 August 1890 — 4 September 1978

Herbert Dingle was a distinguished scientist and philosopher who was Professor of History and Philosophy of Science at University College, London, from 1946 to 1955. Before that he was Professor of Natural Philosophy at Imperial College, from which he had graduated in 1918. His numerous scientific distinctions included the presidency of the Royal Astronomical Society (1951-53) and of the British Society for the History of Science (1955-57); he wrote several well-known books and an enormous number of scientific papers.

The early part of Professor Dingle's scientific career was a period of intense interest in relativity, and he became an expert on the subject. Although an admirer of the theory, he was sceptical about the well-known clock paradox or twin paradox, and did not agree with its generally-accepted resolution. After a prominent but inconclusive debate on the paradox, during the 1950s, he became convinced that the special theory, though mathematically impeccable, was physically impossible, and he spent much of his time and energy during the last 20 years of his life trying to persuade the scientific world that the theory was untenable. His criticisms of the theory, and his Socratic ability to ask questions that nobody else could answer, were not always well received; I have suggested elsewhere (*Canadian Electrical Engineering Journal*, April 1980) that his thesis has not been satisfactorily answered.

The accompanying paper is Professor Dingle's final summing-up of his views on the twin paradox. He sent me the manuscript a few months before his death, in the hope that I would be able to have it published, and I commend it to scientists in the hope that they will give it the serious attention that it deserves.

I am grateful to Mrs Pamela Dingle for giving her permission for this paper to be published, and to *Wireless World* for publishing it.
Ian McCausland
University of Toronto

the stationary one, a difference of ages on reunion would require Peter and Paul each to be the older at that event. This is impossible, so asymmetrical ageing cannot occur, and it is up to those who claim that it can to discover their error. (Though not among them I once thought I had done this[1], but later found that my argument failed, though not for the reasons alleged by my critics at the time[2]. That left me with no alternative to rejection of the theory. However, we are for the present regarding it as true.)

The arguments for asymmetrical ageing — by far the most favoured alternative – are legion but only one calls for serious attention, namely that given first by Einstein himself[3] and supported by Born[4], Tolman[5], Pauli[6], among others, and elaborated in detail by Moller[7] and Born & Biem[8]. No other has a weight of authority behind it comparable with this, or indeed when examined carries any conviction at all, while, granting the validity of the theories, every step in this argument is irresistible. I shall therefore consider it alone.

The essence of this argument is that, indeed, during the main part of the whole journey – that at constant velocity in both directions – the moving twin, whether he be regarded as Paul or Peter must be held to age more slowly than the stationary one, but if Paul is regarded as stationary, then the field of force* must be assumed to exist everywhere during the period of reversal of motion to keep Paul at rest, despite the impulse given him by the working of the engine of his vehicle, and also to bring Peter back to him although no such impulse is given to Peter. The effect of this force-field is to make Peter, during the period of reversal of motion, gain so much in age, and Paul to lose so much, as to far outweigh Paul's more rapid ageing during the uniform motions, and ultimately to give the same ages of the twins on reunion as those following from the assumption that Paul, and not Peter, is the one who moves. The calculation in this last case is simple. No force-field is required, since the engine suffices to reverse Paul's motion and Peter does not move, so Peter's gain during the periods of uniform motion is the sole effect. (Incidentally, when Peter moves similar force-fields are needed to accelerate him initially from rest to velocity v and to bring him to rest again at the end, and at these events Peter and Paul are virtually at the same place, and the general theory requires that in such circumstances the difference in the effects on ageing is negligible.)

Now let us apply this to our example. If Paul is the traveller he ages by 1.5 days during each of his outward and return journeys and by a negligible

*It is called a gravitational field, but this is misleading because it must be granted properties not found in natural gravitational fields.

Why *not* discuss relativity?

After the accompanying article by Herbert Dingle had been submitted for publication, there appeared an article in *New Scientist*[1], by Paul Davies, bearing the title "Why pick on Einstein?". This article defends relativity from its critics by presenting some of the evidence that is claimed to support the theory. As the only critic mentioned by name is Herbert Dingle, who is not able to answer back, I am briefly replying on his behalf. Because Professor Dingle has already presented the arguments in question himself, I shall not re-state them, but merely indicate the general nature of the arguments and cite appropriate references. I think the fact that Professor Davies does not even mention these arguments is evidence that they have not received enough attention from the scientific community.

Professor Davies mentions the Michelson-Morley experiment, stating that it consisted of comparing the times that light pulses travelling in perpendicular directions took to cross the same distance. But, as Dingle pointed out on various occasions[2, 3, 4], the experiment did *not* involve a direct measurement of time; the time comparison has been inferred from interference patterns. Of the possible interpretations of the experiment, one is that Newton's laws of motion are wrong, another is that Maxwell's electromagnetic theory is wrong; the usual interpretation of the experiment, in which the time difference is deduced using Maxwell's theory, eliminates in advance the interpretation that that theory is wrong. This illegitimate elimination of one of the possible interpretations of the experiment rules out that experiment as evidence in support of the special theory.

Dingle has also pointed out [3, 4] that, in experiments that involve elementary particles moving at very high speeds, the speeds of the particles are not measured directly but are inferred from certain observations by a process that involves the use of Maxwell's electromagnetic theory; this fact also rules out experiments of this kind as evidence in support of special relativity.

Professor Dingle[4] has also questioned observations of double stars as evidence supporting the special theory. Although one of his hypotheses – that light travels at constant velocity with respect to its own source, however the source may move – may seem rather difficult to accept, it is surely no more difficult to accept than some of the other phenomena that many physicists appear to believe in. The hypothesis is based on a suggestion already made by Faraday, and if it were true it would also, according to Moon and Spencer[5], allow clocks to be synchronised regardless of their state of motion. Dingle has also suggested that more attention should be devoted to the work of Ritz, whom he mentions in his article and whose work has recently been discussed by Waldron[6].

Furthermore, according to Dingle[4], all the experimental evidence that is taken to support the special theory could with equal validity be taken to support Lorentz's quite different theory if Einstein's special theory had never been conceived. In another *New Scientist* article, Roxburgh[7] appeared to agree with this when he stated that Einstein's thoery and Lorentz's were "observationally indistinguishable."

In his book *Space and time in the modern universe*, Professor Davies[8] makes the following statement in connection with two clock-carrying observers in uniform relative motion: "It is not that each observer merely *sees* the other clock running slow, it actually *is* running slow – a real physical effect." [Emphasis in the original]. This statement seems to me to provide strong support for Dingle's claim that, if there are two clocks in uniform relative motion, the special theory requires *each* clock to run (not merely *seem* to run) faster than the other.

The heading of the *New Scientist* article[1] uses the term "scientific malcontents" to refer to those who attack relativity. If being a relativist entails acceptance of all the mutually-contradictory arguments (some of which I have recently documented[9]) that have been published in defending special relativity against the criticism of Herbert Dingle, then I prefer to be a scientific malcontent, and I accept that designation with pride. I think every scientist should be a malcontent; after all, what is the value of trying to contribute new knowledge unless one is dissatisfied with the present state of knowledge?

I could write at length about my encounters with what Davies calls the "special provision" that most editors of science journals make for coping with papers of the type he describes, but this is not the time or the place. In any case, Dingle has described his own experiences so eloquently[4] that it is scarcely necessary to augment his description, but it is noteworthy that a supporter of relativity has now stated openly that most editors of scientific journals do make such special provision; it is not merely a figment of the critics' imaginations. Others who have encountered the "special provision" may tend to agree with me in thinking that the question in the heading of the *New Scientist* article should be amended to read: Why is criticism of relativity so resented?

Ian McCausland

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amount during the three periods of acceleration, while Peter ages regularly by 30 years during the complete process: hence, when they meet again, Peter's age is 30 years and Paul's three days. On the other hand, if Peter is the traveller he ages by 1.5 days during each of his outward and return journeys, and by almost 30 years during the change from recession to approach with respect to Paul, while the stationary Paul ages by 15 years during Peter's outward journey, changes during Peter's reversal to a state nearly 15 years before birth, and then ages by 15 years during Peter's return, somehow getting born shortly before Peter arrives. Consequently, when they meet, Peter's age is 30 years and Paul's three days – exactly as in the former case.

We can hardly suppose that Einstein, Born and the others believed that these processes were both actual occurrances, the one entitled to claim reality depending on our preference in choosing to whom to assign the motion, nor did they. What they supposed was that the only *observable* events in the whole process were the separation of Peter and Paul at the beginning and their reunion at the end. Everything that happened in between was regarded as being beyond possibility of observation and therefore demanding compatibility only with theory, not with experience, with which it had nothing to do. This is obviously so important that it is necessary to confirm it by quoting Einstein's own words (in translation), all that needs explanation being that the clock U_1 is Peter and U_2 Paul and that "the right and left hand columns" give the descriptions of the process, as I have described them, when Peter and Paul, respectively, are regarded as moving. Einstein writes[3]:

> "You must bear in mind that exactly the same process is described in the right and in the left hand columns, but the description on the left refers to the coordinate system K while that on the right refers to K'. According to both descriptions, at the end of the process the clock U_2 is retarded by a definite amount compared with U_1. With reference to K' this is explained as follows: it is true that during the stages 2 and 4, the clock U_1, moving with velocity v, works more slowly than U_2, which is at rest. But this retardation is over-compensated by the quicker working of U_1 during stage 3. For, according to the general theory of relativity, the clock works the faster the higher the gravitational potential at the place where it is situated, and during stage 3 U_1 is indeed situated in a region of higher gravitational potential than U_2. Calculation shows that the consequent advancement amounts to exactly twice as much as the retardation during stages 2 and 4. This completely clears up the paradox."

What Einstein means here by "the same process" is, of course, everything that is *observable*, while "the description", which differs in the two cases, is wholly a mental construction. The first is unique, for it must be the one thing that would actually occur; the last owes allegiance only to theory, not observation, and can vary within the limits allowed by the theory.

But it is clear, beyond possibility of question, that Einstein's "descriptions" relate to what is observable, and cannot therefore both be permissible; and furthermore, as the credentials of both are exactly the same, it is impossible to decide which must be rejected. Paul could be accompanied by a nurse, of such an age as to become 30 years younger without losing her power of intelligent observation, and she would report on return whether it was a baby or a teenage boy who arrived at the planet, and whether or not a baby was born during the return journey, even if she were unable to confirm the antenatal age of the being whom the planet left. The question I asked Dr Wilkie was, in effect, whether what the nurse would observe would admit of both of Einstein's "descriptions", or whether a theory that required it to do so must be abandoned. I am not surprised at his reluctance to commit himself to a choice; nevertheless, it is imperative that scientists shall make a choice if the ethical demands of science are not to be jettisoned.

". . . Mathematical consistency, though a necessary condition, is not a sufficient one for the truth of a physical theory."

What is the net result of all this? As I have said, it throws no light at all on what would happen if the experiment were made, for it is an analysis, not of a physical process that has never occurred, but of the requirements of a theory that purports to accord with physical processes, and I think it shows beyond doubt that the special relativity theory at least must be wrong. If the motion can be ascribed equally rightly to either twin, it cannot make them age at different rates; if it makes them age at different rates, there must be an absolute standard of rest to provide a criterion for distinguishing the faster from the slower developer. The special relativity theory requires different rates of ageing to result from motion which belongs no more to one twin than to the other: that is impossible.

It is impossible to exaggerate the importance of this result, for this theory is, by common consent, "taken for granted" in Max Born's words, in all modern atomic research, and it determines the course of practically all current developments in physical science, theoretical and experimental, whether concerned with the laboratory or with the universe. To continue to use the theory without discrimination, therefore, is not only to follow a false trail in the investigation of nature, but also to risk physical disaster on the unforeseeable scale, modern atomic experiments being what they are. It should therefore be a point of honour with those on whose authority atomic research is now being conducted to acknowledge at once the untenability of the theory, and to take without delay the necessary steps to discover where the theory falls.

That does not necessarily mean complete abandoning of its use, but it does demand the determination of the limits of its usefulness. It has already proved its effectiveness in many respects, and this has been mistaken by physicists for evidence of its truth. What the many successes of the Lorentz transformation equations have shown is that those equations are an effectual corrective of the imperfect classical electromagnetic equations within a limited range of experience. But it is now clear that the interpretation of those equations as constituting a basis for a new kinematics, displacing that of Galileo and Newton, which is the essence of the special relativity theory, leads inevitably to impossibilities and therefore cannot be true. Either there is an absolute standard of rest – call it the ether as with Maxwell, or the universe as with Mach, or absolute space as with Newton, or what you will — or else *all* motion, including that with the speed of light, is relative, as with Ritz. It remains to be determined, by a valid experimental determination of the true relation of the velocity of light to that of its source, which of these alternatives is the true one. In the meantime, the fiction of "space-time" as an objective element of nature, and the associated pseudo-concepts such as "time-dilation", that violate "saving common sense", should be discharged from physics and philosophy, and the fact realised that mathematical consistency, though a necessary condition, is not a sufficient one for the truth of a physical theory. Only thus can the scandal of more than half a century of confusion about the meaning of our own creations be ended.

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Audio gain controls

A survey of the methods used to achieve acceptable control of gain in audio amplifiers.

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

The design of gain controls is by no means as simple as it might appear. Peter Baxandall examines the difficulties in design and comments on many circuits which have appeared over the years, from very simple types in which compromises must be accepted, to those used in high-performance equipment.

An ideal audio amplifier with variable gain would have the following characteristics:
(i) noise output voltage = (source Johnson noise voltage) × (gain)
(ii) ability to deliver its full output voltage even at very low gain settings, which may be less than unity. The amplifier is therefore capable of handling very large input voltages at the lowest gain settings.

The simplest way to achieve (i) is that shown in Fig. 1(a), but this simple technique obviously fails lamentably with regard to (ii), for the maximum input voltage that can be handled without overloading is the same at all settings. The arrangement of Fig. 1(b), on the other hand, achieves (ii) perfectly, but fails with regard to (i).

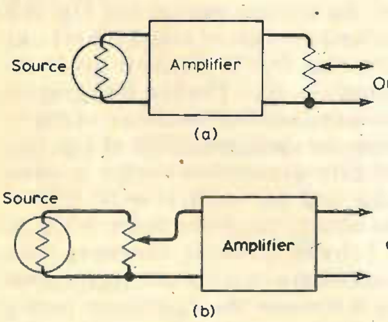

Fig. 1. Two small gain controls which do not fulfil both main requirements. Circuit (a) gives low noise, but will overload at low gain settings, while (b) introduces additional noise.

By using sufficiently subtle gain-control systems, it is possible to satisfy (i) and (ii) concurrently and almost perfectly, but the simple and widely used arrangement shown in Fig. 2 provides a compromise solution which is very satisfactory for many practical purposes.

An ideal amplifier would give a variation of output noise voltage with gain setting as shown by the full-line graph in Fig. 3, whereas the Fig. 2 scheme gives a characteristic as depicted by the broken line. Below a certain setting of P, the noise level from amplifier A at the output of P becomes less than the noise level of amplifier B referred to its input, so that the noise of amplifier B becomes the dominant contribution, establishing the level of the broken-line "plateau".

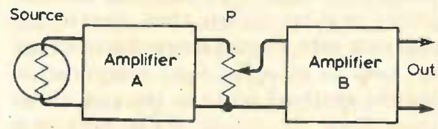

Fig. 2. This arrangement combines circuits of Fig. 1(a) and (b) to give compromise performance.

Now there is obviously no practical advantage in achieving an output noise level which is a long way below audibility at very low gain settings, so that a characteristic of the broken-line type is normally perfectly satisfactory, provided the level of the horizontal plateau is low enough. For a given overall maximum gain requirement, the product of the voltage gains of amplifiers A and B in Fig. 2 is fixed, but there is a choice with regard to the apportionment of this gain between the two amplifiers. The higher the gain of A is made, the lower is the position of the Fig. 3 plateau, but there is the disadvantage that the maximum signal input that can be handled without overloading amplifier A is reduced.

In domestic audio control units, the Fig. 2 arrangement is usually used. A suitable choice for the gain of amplifier B is normally such that full output level is delivered to the following power amplifier for an output level from the pot. slider of about 100mV r.m.s. If the wideband noise of amplifier B, with P set to zero, is equivalent to a noise input voltage to B of 0.5μV rms, which is fairly readily achievable, the zero-volume-setting noise output from B will then be 106dB below the full signal output level. (It may be added, however, that if the gain of B is made high enough to cope with the least sensitive of power amplifiers, which may require an input level of several volts, then the signal level at the pot. slider for full power output when used with a very-high-sensitivity power amplifier, will be much less than 100mV rms, and a figure much less than the 106dB mentioned above will then apply. Thus, for versatile use, it is desirable to provide a preset gain adjustment within amplifier B, or in the form of a simple passive attenuator after this amplifier.)

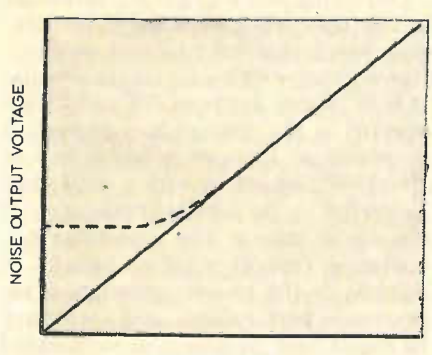

Fig. 3. Dotted line shows gain variation given by circuit of Fig. 2, where residual noise from amplifier B is predominant at low gain settings.

A closer approximation to concurrently satisfying conditions (i) and (ii) at the beginning of the article may be obtained, on the same principle as in Fig. 2, by employing three amplifiers with ganged gain-control pots. between them, but in general it is much better, instead, to employ schemes in which variable negative feedback provides much of the gain variation.

Variable-feedback gain control offers advantages both with regard to achievable performance (noise and signal-handling) and often with regard to economy of circuit design. Variable feedback alone cannot normally reduce the gain to zero; for 100% voltage feedback reduces the gain to unity rather than zero. Thus, it is usual to combine feedback variation with passive gain control, sometimes using a ganged pot. and sometimes using the parts of the track either side of the slider, in an ordinary single pot., to perform these functions. There are many possible schemes, of which some have been known for thirty years or more.

One of the simplest schemes is that shown in Fig. 4. The pot. resistance can be made quite low, e.g. 1kΩ, since it is driven by the op. amp., not the signal source. This results in a good noise performance at all settings. Disadvantages of the circuit are:

(a) the minimum gain is unity, not zero, and
(b) a floating signal source is required.

Disadvantage (b) is of little consequence when an input transformer is used, and (a) may be overcome by taking the signal output from the pot. slider. The latter change, of course, sacrifices the virtue of very low output impedance possessed by the Fig. 4 version.

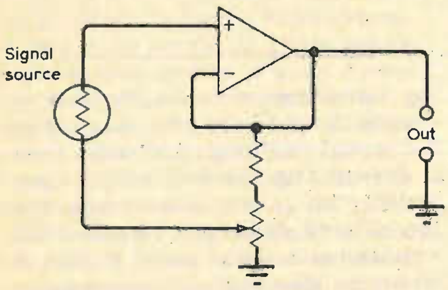

Fig. 4. Simple feedback gain control.

In assessing the pros and cons of various circuits, it is very helpful to appreciate the relationships between the circuits in the most vivid possible way, rather than relying purely on formal analysis. Very often the differences between circuits are much smaller than they appear to be, involving merely the choice of earthing point and/or the way of drawing the circuit diagram, rather than differences of more fundamental significance. Sometimes, in redrawing circuits employing op. amps. to facilitate better understanding of them, it is helpful to replace the op. amp. symbols by ordinary single-transistor symbols — an unfamiliar-looking circuit may then suddenly be recognised as an old friend! At other times, replacing a detailed transistor circuit by the op. amp. equivalent may reveal its true nature in the best way.

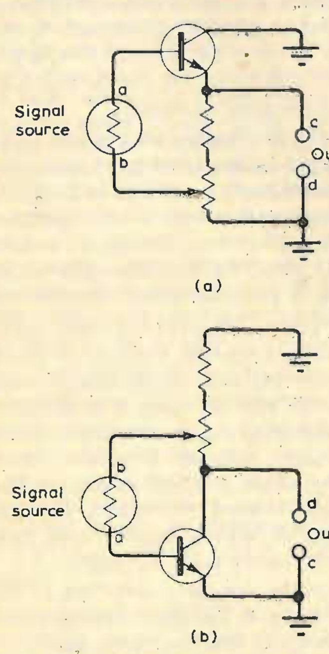

Fig. 5. Single transistor equivalent to Fig. 4, neglecting d.c. conditions. Rearrangement in (b) shows circuit to be easily recognizable.

On replacing the op. amp. in Fig. 4 by a transistor, the circuit of Fig. 5(a) is obtained. Though the collector would in practice be taken to a positive supply line, it is here shown as earthed, for in the present context we are concerned only with a.c. aspects and it is best to omit irrelevant details.

Shifting the earthing point to the emitter of the transistor, but making no other changes, leads to Fig. 5(b), which ios a simple common-emitter amplifying stage with adjustable feedback.

If the output in the Fig. 4 circuit is taken from the pot. slider instead of from the point shown, then the circuit, redrawn with a transistor in place of the op. amp., is as in Fig. 6(a). Merely shifting the earthing point to the pot. slider then yields the circuit of Fig. 6(b). It is now evident that moving the slider to the right has two separate effects — it increases the amount of resistance in the emitter lead, thereby increasing the amount of negative feedback, and it reduces the collector load resistance. Both these effects contribute to reducing the gain, which becomes zero with the slider fully to the right.

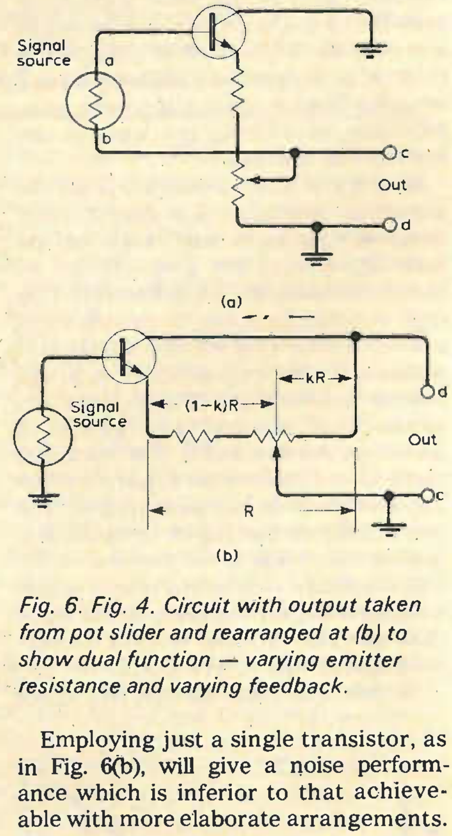

Fig. 6. Fig. 4. Circuit with output taken from pot slider and rearranged at (b) to show dual function — varying emitter resistance and varying feedback.

Employing just a single transistor, as in Fig. 6(b), will give a noise performance which is inferior to that achieveable with more elaborate arrangements. This is largely because the resistance inserted in the emitter lead is itself a generator of Johnson noise, which is effectively added in series with that generated in the internal resistance of the signal source. The transistor d.c. operating current must be chosen in relation to the source impedance, for good noise performance, and it will then be found that to obtain a substantial reduction of gain by inserting emitter resistance, the amount of resistance needed will give considerable degradation of the noise figure.

The above noise difficulty may be

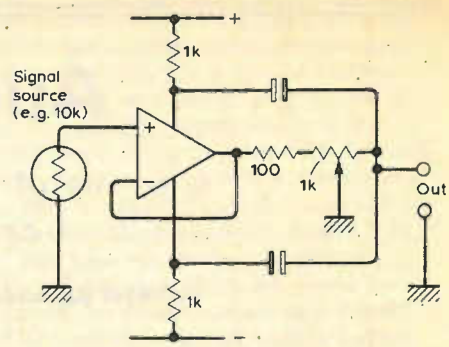

Fig. 7. Fig. 6(b) using an op. amp.

solved by replacing the single transistor by a suitable pair or triple, having a much higher mutual conductance than the single transistor but whose input stage operates at a similarly low current. The increased mutual conductance and output current permit the resistance values associated with the gain-control pot. to be made much lower, with a correspondingly reduced effect on the noise performance at low gain settings. The well-known configurations for pairs and triples as used in audio class 'B' output stages may be adapted to the present application, but an interesting alternative is that shown in Fig. 7. Here the supply connexions to the op. amp. are used as the equivalent of the transistor collector in the Fig. 6(b) circuit — a way of using an op. amp. which perhaps deserves to be more widely borne in mind.

Assuming infinite mutual conductance, the voltage gain of the Fig. 6(b) idealized circuit is simply $k/(1-k)$, Expressing this in decibels gives the graph of Fig. 8(a). The Fig. 8(b) graph is a measured one for the circuit of Fig. 7.

With the idealized circuit of Fig. 6(b), unity gain occurs when the pot. is set for $k=0.5$, and the curve is quite symmetrical about this centre point. With the Fig. 7 circuit, however, the curve is not symmetrical about the unity-gain point. This is because the right-hand part of the pot. is shunted by the parallel value of the two 1kΩ resistors going to the supply lines.

Another very simple feedback gain-control circuit is shown in Fig. 9. With high forward gain in the op. amp. itself, this circuit gives a gain, between the input and output terminal pairs shown, accurately equal to $k/(1-k)$. (This formula, as for the Fig. 6(b) case, may be prefixed by a minus sign if it is desired to allow for the fact that phase inversion occurs.)

The Fig. 9 circuit, unlike those previously discussed, has the feature that the current in the gain-control resistance chain is supplied by the signal source. This makes it impossible to achieve a good noise figure over a wide range of gain adjustment, no matter how the resistance values are chosen in relation to the signal-source impedance. That this must be so can best be understood as follows. Negative feedback as such never has any effect on the signal-

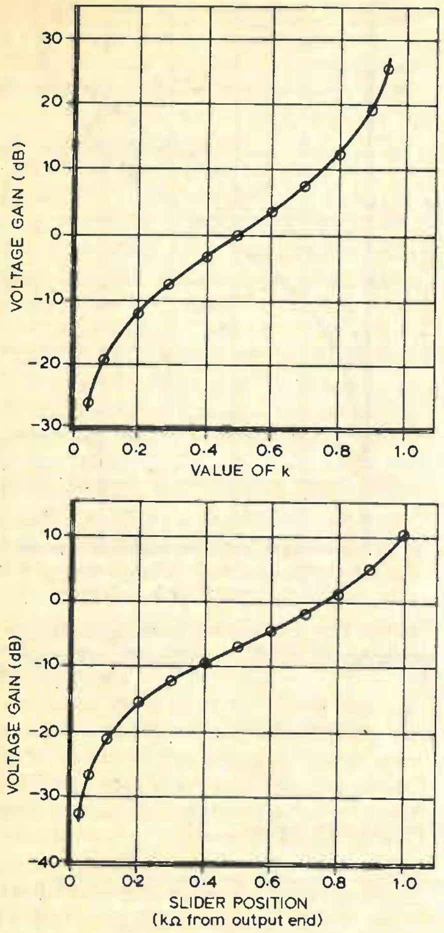

Fig. 8. Gain variation of Fig. 6(b) circuit is at (a). Measured performance of equivalent op. amp. circuit of Fig. 7 is shown at (b).

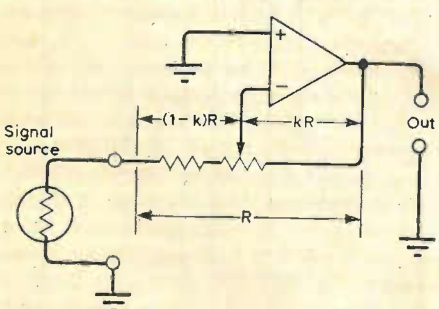

Fig. 9. Feedback gain-control circuit, which has disadvantage of source-fed resistor chain, giving poor noise figure over wide range.

to-noise ratio, at a given frequency, of an amplifier circuit to which it is applied, though the resistors introduced for the purpose of providing the feedback may do so. Thus the output signal-to-noise ratio of the Fig. 9 circuit is the same as that of the circuit shown in Fig. 10. If R is made low, say equal to the internal resistance of the signal source, it will degrade the signal-to-noise ratio at the source terminals*, whereas if R is made much higher, a

*When a resistive source of internal resistance R is shunted by a load resistance equal to R, the signal voltage is halved, but the Johnson noise voltage is reduced by a factor of only 2. The signal-to-Johnson-noise ratio is therefore worsened by 3dB.

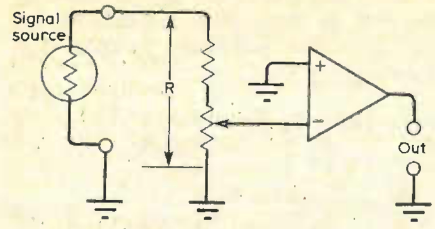

Fig. 10. Circuit of Fig. 9 gives same noise performance as circuit shown here.

large amount of resistance is introduced into the op. amp. input circuit at intermediate slider settings, with correspondingly large Johnson noise and maybe noise from the op. amp. equivalent current-noise generator.

Comparing Fig. 10 with Fig. 1(b) might suggest that the Fig. 9 circuit is no better than that of Fig. 1(b) as regards noise performance. This is not so, however, for to effect a given number of decibels reduction of gain below maximum, the slider in Fig. 9 has to be moved a smaller fraction of the way from the signal-source end of R than is necessary for the same gain reduction in the Fig. 1(b) circuit. The noise performance of Fig. 9 is better than that of Fig. 1(b), but is nevertheless not very good.

Another feature of the Fig. 9 circuit which makes it undesirable for some applications is that the loading of the signal source varies with the pot. setting. If the signal source has a complex internal impedance, the overall frequency response will vary with the gain setting.

This undesirable characteristic of the Fig. 9 circuit may, to a large extent, be overcome by inserting an emitter-follower (or op. amp. follower) between the signal-source and the left-hand end of the resistance chain. With a 50kΩ signal-source, for example, R could be made about 5kΩ, giving reduced Johnson noise from R but nevertheless subjecting the signal-source to negligible loading.

As already mentioned, the Fig. 9 circuit as it stands produces the gain-control characteristic shown in Fig. 8(a), which is symmetrical about the unity-gain point. Over a range of about 30dB, and using an ordinary linear pot., the scale shape obtained approximates fairly reasonably to the desirable one having uniformly-spaced decibel divisions, though for many applications a gain of more than unity would be preferred at the centre of this control range. The modification shown in Fig. 11 provides an increased gain at the point of inflexion of the control characteristic, but has the weakness that the gain cannot be reduced right down to zero. Provided R_a and R_b are made much lower in value than the pot. resistance, however, the minimum gain may be made sufficiently low for many purposes.

If a stud type pot. is used, and assuming there is complete freedom in the choice of its law and total resistance value, the Fig. 11 modificiation gives no advantage, the required performance being obtainable with better economy of components by adopting the Fig. 9 arrangement.

The circuit of Fig. 12 possesses a combination of several good features. It employs only one op. amp., has a high input impedance, the feedback network can be of low resistance for good noise performance, and the values of R_a and R_b can be chosen, in relation to R, to make the point of inflexion in the control characteristic occur at a gain of much greater than unity, as sometimes desired.

Analysis shows that the gain of the Fig. 12 circuit is given by:

$$\frac{V_{out}}{V_{in}}=\frac{R+\dfrac{R_b}{1-k}}{R+\dfrac{R_a}{k}} \qquad 1.$$

$$\text{or}\ \frac{V_{out}}{V_{in}}=\frac{k}{1-k}\times\frac{R(1-k)+R_b}{R_k+R_a} \qquad 2.$$

Thus, if R_a and R_b are each much greater than R, the gain is approximately proportional simply to $k/(1-k)$, and is approximately equal to R_b/R_a when $k=0.5$. Thus the control characteristic is fairly closely as in Fig. 8(a) but shifted upwards. For lower values of R_a and/or R_b the characteristic is of modified form, covering a smaller number of decibels with reasonable linearity.

The curve shown in Fig. 13 is the result of a measurement using the Fig. 12 circuit with the following values:

$$R=1k\Omega\ R_a=330\Omega\ R_b=3.3k\Omega$$

Comparison of this curve with Fig. 8(a) shows that it gives a poorer

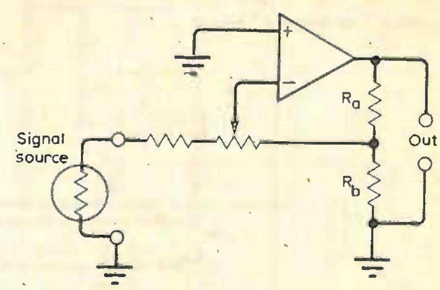

Fig. 11. Variation of Fig. 9, giving increased gain at halfway position of slider.

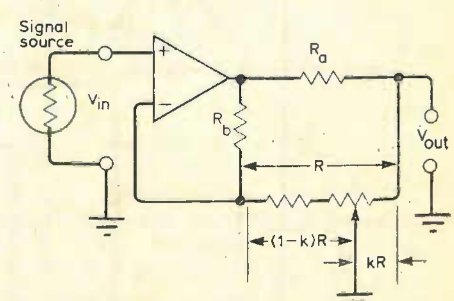

Fig. 12. Circuit featuring only one amplifier, high input impedance, low-resistance feedback chain for low noise and flexibility in choice of inflexion point.

approximation to the ideal linear shape for values of k above about 0.2. (The ideal curve would not, of course, remain linear down to $k=0$, for this would make it impossible to fade a programme down to zero volume. For most audio purposes, the ideal characteristic would cover about 40dB linearly, curving down to "minus infinity dB" below about $k=0.2$.)

Another circuit combining feedback and passive gain variation by means of a single linear pot. is shown in Fig. 14.

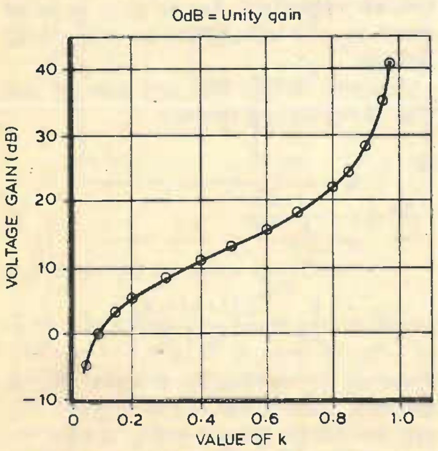

Fig. 13. Curve of circuit in Fig. 12.

This, in essence, is the circuit used by the BBC in their OBA9 outside broadcast amplifier, published in 1952. The gain is given by:–

$$\frac{V_{out}}{V_{in}}=\frac{kR+R_a}{R_a}\times\frac{R_b}{(1-k)R+R_b} \qquad 3.$$

$$\text{or } \frac{V_{out}}{V_{in}}=\frac{1+kR/R_a}{1+(1-k)R/R_b} \qquad 4.$$

The Fig. 14 circuit cannot give zero voltage gain, the gain with $k=0$ and

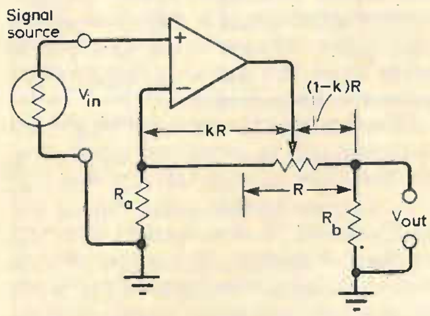

Fig. 14. Circuit providing feedback and passive control in one pot.

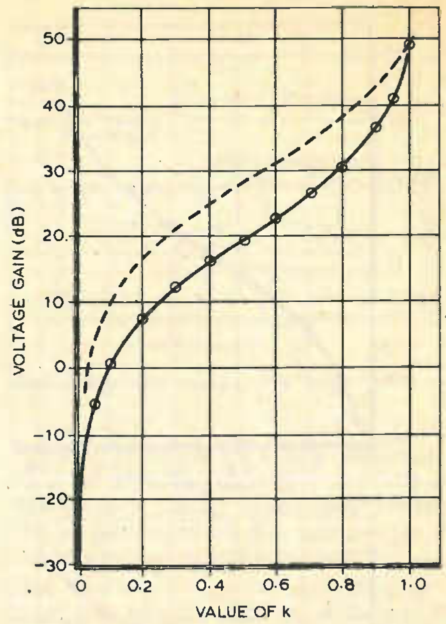

Fig. 15. Full-line curve shows calculated performance of Fig. 14 for two values of R_b.

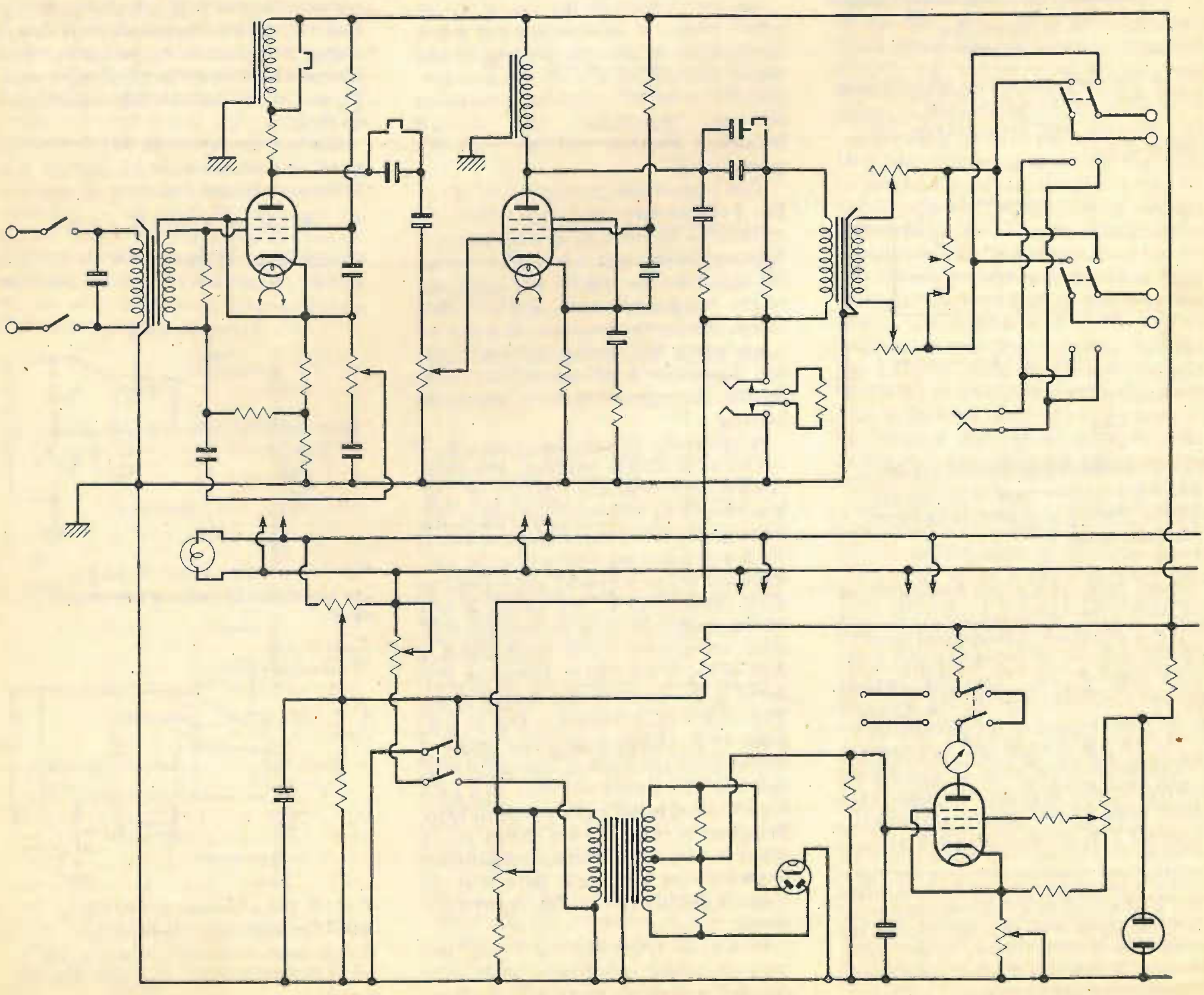

Fig. 16. BBC OBA8 circuit of 1939, with peak programme meter.

100% negative feedback being $R_b/(R + R_b)$. Though not an ideal feature, the minimum gain in the BBC design is nearly 90dB below the maximum gain, and is stated to be "effectively nil in normal conditions of use"[2].

The full-line curve in Fig. 15 is a calculated result for the Fig. 14 circuit, using the values $R = 100k\Omega$, $R_a = 330\Omega$ and $R_b = 3.3k\Omega$. For the broken-line curve, R_b was changed to $10k\Omega$. (The values in the BBC design were $R = 1M\Omega$, $R_a = 390\Omega$ and $R_b = 100k\Omega$.)

Figure 15 shows that with an ordinary, linear 100kΩ pot. in the Fig. 14 circuit, a control law not departing by more than 2dB from the ideal linear decibel scaling is obtained over an approximately 40dB range. In the BBC design[2], a stud type of 1MΩpot. was used, giving 38 steps of 2dB each and two larger steps at the low-gain end. Of course, if the luxury of stud pots. is allowed, any of the circuits here discussed may be given whatever control law is desired.

Though there is much to be said on grounds of economy, especially in stereo systems, for using a single pot. section to vary the feedback and effect passive attenuation, the use of ganged stud type pots. to perform these operations separately gives the designer greater freedom of choice in optimizing the design in all its aspects. This technique was used in the BBC OBA8 outside broadcast amplifier, designed well over forty years ago[1]. Starting at the maximum-gain setting, anticlockwise rotation of the knob first simply applied increasing negative feedback to the first stage, by raising the effective value of the feedback resistance in the cathode circuit. When this purely local feedback had been increased sufficiently to give a gain reduction of 16dB, further rotation of the knob maintained this first-stage feedback constant but proceeded to insert increasing passive attenuation between the first stage and the second (output) stage. In this way the two-valve amplifier was made capable of delivering full output level to line, at low distortion (abour 1%) for peak microphone input levels extending over a range of 56dB. (It is evident that the designers of this amplifier and the associated units gave high priority to keeping the number of valves used down to the absolute minimum necessary number. This is understandable enough, bearing in mind that the AC/SP3 television pentodes used were physically large and consumed four watts of heater power each. Now that high-gain devices are very small and cheap, and consume relatively tiny amounts of power, the designers of today are justified in adopting a very different outlook, often exploiting the plentifulness of gain to eliminate, or reduce the size of, transformers and also to achieve lower distortion levels in equipment of very much smaller size. Now that it has become fairly easy and cheap to obtain very low distortion levels, there is little argument for doing otherwise, whereas when the OBA8 was designed, lower distortion would have meant more valves, higher power consumption and shorter operating time on standby batteries. The designers were therefore justified in making the distortion just comfortably low enough, but no less, though they were doubtless quite capable at that time of achieving much lower distortion levels had this been thought desirable. In most circumstances of use, it is doubtful whether the subjective quality of the OBA8 could be distinguished from that of the best modern equipment. The weakest feature of the design is that the secondary of the input transformer,

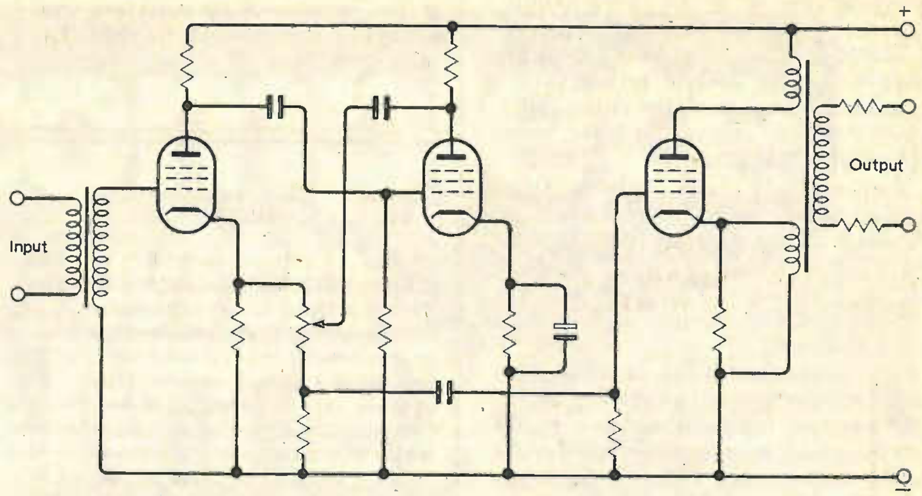

Fig. 17, BBC OBA9 circuit, designed in 1952.

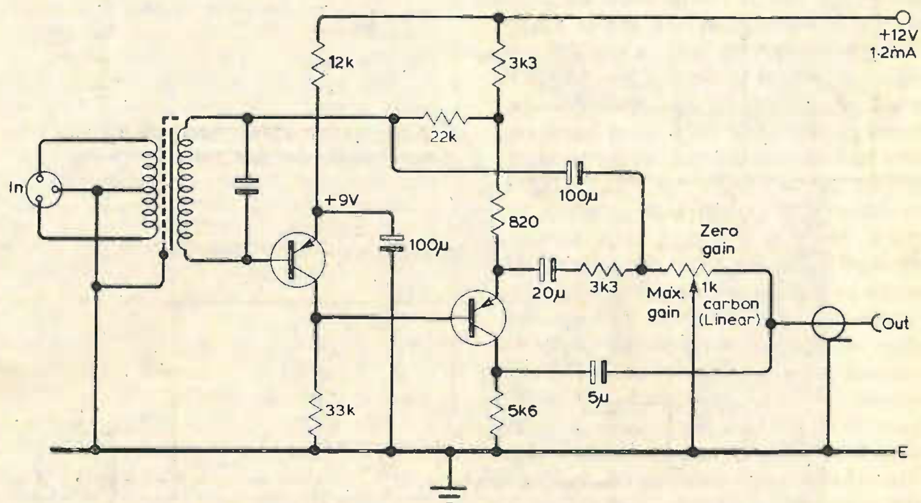

Fig. 18. Author's design of 1961.

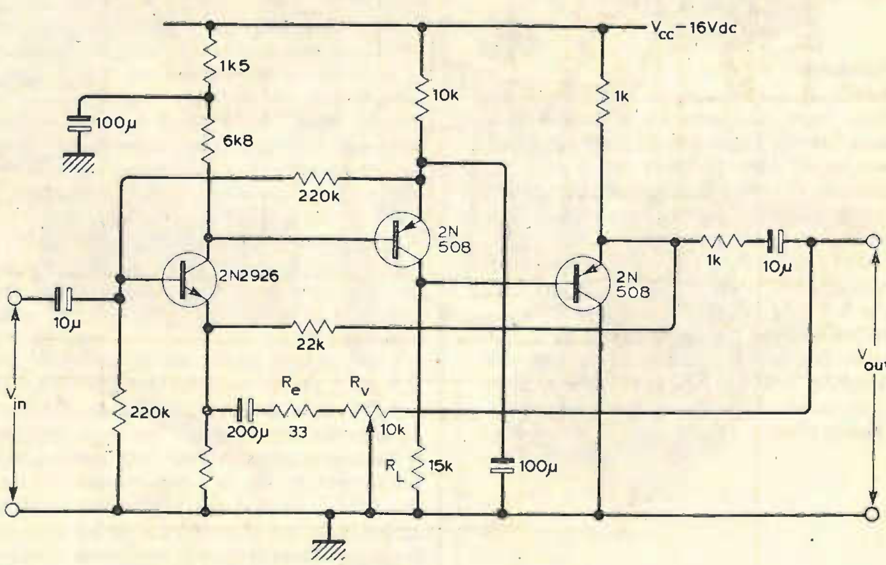

Fig. 19. Circuit by McWhorter of 1966.

which stepped up to the exceptionally high impedance of 300kΩ, is shunted by a 300kΩ resistor, thus sacrificing, in simple theory, 3dB of potentially-available signal-to-noise ratio. This point does not appear to have been appreciated at the time.)

Figures 16-19 show four practical amplifiers which use a combination of feedback and passive gain control. The McWhorter design[4] of Fig. 19 employs the basic circuit of Fig. 12, which has also re-surfaced recently in a Philips tape recorder[8].

My own circuit[3] of Fig. 18 is the same in broad principle, but unlike Fig. 12 has the negative feedback and the signal output taken from different electrodes of the output stage. This permits injection of the feedback voltage in series with the transformer secondary, thus obviating the introduction of local emitter feedback in the input stage. Though this circuit was in regular and very successful use for some years, a weak point in its design ultimately became evident, but only after hard service had caused the pot. slider to make erratic contact with the track. Unfortunately, if the slider fails to earth the track, there is a signal path straight through the track from the output collector to the input base. This is positive feedback and is of greater magnitude than the negative feedback from the output emitter. Violent oscillation therefore occurs during moments of poor slider contact, with accompanying very loud noises from the loudspeaker! The other circuits described do not have this weakness – a point worth bearing in mind.

To be continued

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□

BOOKS

A Users Guide to Copyright, by Michael F. Flint, is intended to make clearer the subject of copyright "to enable people whose jobs — or even hobbies — cover any copyright field, to acquire a general understanding". It is, however, only a reference book, and does not cover all the more complex legal aspects which may arise when dealing with this intricate subject. The book is laid out in a manner which will enable its reader to obtain the relevant piece of information quickly, and each chapter is sub-divided into well defined sections, each with a reference number and a bold sub-heading. Part 1, the first 14 chapters, is a general explanation of the copyright law, whilst the second part gives a more specified description of copyright in practice, with chapters directed at publishers and printers, advertising agencies, the music industry etc. The book is published by Butterworth Law Publishers Ltd, 88 Kingsway, London WC2B 6AB, and its price is £8.50 in limpback form.

Microcomputers are responsible for a great number of paperbacks, mainly from the USA, and the pace of publication does not appear to be slackening. Three such books have reached this office recently, among others too numerous to mention, each slanted in a different way.

The first is by a British author, Robin Bradbeer, and is entitled **The Personal Computer Book,** published by Input Two-Nine at £5.25 and distributed by MCB Publication, 198/200 Keighley Road, Bradford, West Yorks. BD9 4JQ. This one assumes no knowledge of computers — not even enough to know what computers will do — and, accordingly, the first two chapters are extremely basic. The rest of the book is an attractively written explanation of the more important aspects of computing techniques and of computers, a very useful feature being a survey of equipment currently on the market. Several appendices provide information which is quite difficult to find elsewhere in one place, such as bus standards, addresses of clubs, manufacturers and publications.

The second book, by E. A. Parr, is published by Bernard Babani (Publishing) Ltd., The Grampions, Shepherds Bush Road, London, W6 7NF at £1.75. This one is entitled **A Microprocessor Primer,** and approaches the subject by way of a hypothetical device, the DIM-1, so that the author can explain general features of microprocessors without being constrained by any particular design. Having gone through this process, he then sets out to study the Z-80. This is a small book (75 pages) but within its scope achieves its purpose.

Thirdly, there is **Introduction to Microcomputers for the Ham Shack,** by Harry L. Helms, Jr., published by Howard Sams and distributed by Prentice-Hall International, 66 Wood Lane End, Hemel Hempstead, Herts HPZ 4RG at £3.20. Also a small book, this is concerned with the application of micros to amateur radio. Three chapters are allocated to the basics of micro operation and programming, after which two chapters describe present and future operations using micros to send and receive Morse, to convert slow-scan tv to fast-scan for ordinary viewing, to store frequencies, in digital modulation, and in several other roles.

Early Radio Wave Detectors, by V. J. Phillips, gives a comprehensive account of various radio wave detectors used before the advent of the crystal and thermionic valve. Among the types described are spark-gap, electrolytic, magnetic, thin-film and capiliary detectors, as well as tickers, tone wheels, heterodynes and coherers, the type of detector which makes use of "a phenomenon which occurs in a poor electrical contact, the sort of contact which the engineers of today would call a 'dry joint' ".

Among the items described under the heading "Miscellaneous detectors," are the 'physiological' receiver, which made use of the electrical sensitivity of a frog's leg to displace a pointer on the smoked surface of a rotating drum, and the use of a human brain as a coherer, the description of which is supplemented by a photograph for which an advisory note is given for the benefit of "readers of delicate sensibilities". Be forwarned, however, the note appears at the bottom of the page, and the photo at the top!

The last chapter, entitled "And so to the modern era," covers the early crystal and thermionic valve type detectors and how they were used — an appropriate finale to an interesting and well-illustrated book. The publishers are Peter Peregrinus Ltd, Marketing Dept, Station House, Hitchin, Hertfordshire SG5 1RJ, and the price of the book in hardback form is £16.

Digital Techniques and Systems, by D. G. Green, is intended as a first course book for students with a basic knowledge of electronics and telecommunication transmission techniques, but the combined coverage of basic techniques used in modern digital circuits, and elementary principles of data communication, laid out in a logical sequence, make it useful for anyone wishing to gain insight into this field.

Chapter 1 gives a concise introductory description of a few of the uses of modern digital applications to which he may put the knowedge that he is about to learn. The second and third chapters cover the operation of electronic gates of all kinds and the remainder of the book, which includes chapters on digital modulation, data-links and pulse code modulation, is devoted to the subject of data transmission over telephone lines.

Worked examples are included in the text, and each chapter concludes with exercises, some of the questions of which have been taken from past C and G examination papers. Multiple-choice questions are also provided at the end of the book, which is priced at £4.95 and published by Pitman Books Ltd, 39 Parker St, London WC2B 5PB.

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An acoustically small loudspeaker

Unusual design gives low colouration and good off-axis response

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

This design for an active-crossover loudspeaker system is based on acoustic principles which are well established, and on psycho-acoustic criteria which are subjective in nature. As with all designs, trade-offs are possible. The acoustically small loudspeaker is designed to reduce colourations of the sound, below the limit of audibility where possible. This can be done at the expense of bass distortion, though since 40% second harmonic distortion is inaudible at 80 Hz[1], it is not considered important. In addition, a novel fourth-order, bandpass sub-woofer is described using an acousto-electronic crossover and feedback *Q* correction.

The basic aims of the design were low colouration and a uniform off-axis frequency response. A flat on-axis frequency response is the accepted criterion, but the off-axis response – often compromised in commercial designs – determines the stereo imaging qualities. Colouration and off-axis response depend upon both the drive unit and its enclosure, particularly in the mid-range, where the ear is most sensitive: it is between 1-4 kHz that most of the image is found. To avoid compromising this part of the spectrum, the Jordan 50mm aluminium-coned unit was used for its small size, low colouration, and good transient response – this was the only drive unit found for which the impulse response is published. It must be emphasized that it was not designed as a mid-range unit, and is specified to 22 kHz: the booklet advocates using the unit, together with a bass driver, to form a two-way system[3]. However, to the author's and a colleague's ears, an improvement was obtained with the use of a dome tweeter above 4 kHz, making a three-way system. Whichever way the unit is used, there are no crossovers in the critical range 500 Hz to 4 kHz to detract from the imaging quality by giving rise to an uneven polar response around the crossover frequency[2].

The design of a loudspeaker is often influenced by the ease, or otherwise, of its manufacture. For example, it is rare to find other than a cuboid of wooden construction used for the enclosure. But even ideal drive units are at a disadvantage in a wooden cuboid. The shape, size, materials and construction of an enclosure all have audible effects on the response. The great advantage of home construction is that one is freed from many of these constraints, and this advantage is exploited in the design. A mid/high frequency enclosure is made of modelling clay which does not require firing. Thus, the shape and materials of the enclosure are optimized.

Cavity resonance

Distortions in musical sounds take several forms, and the total harmonic distortion is often quoted. More recently, it has been found that this measurement does not correspond well with how a unit sounds: indeed, sometimes a valve amplifier with a high t.h.d. is preferred to a transistor design. It has become clear that steady-state measurements do not give a good indication of performance, and other measurements have been used. With pickup cartridges and loudspeakers, there is a large variation between units sometimes expressed as "detail" or "dynamics", perhaps due to the presence or absence of masking effects of one sound upon another. More complex effects have been found, which are time-dependent, such as the 1 millisecond forward inhibition of a sound upon a following one, and the 30-120 millisecond backward inhibition of a sound upon a preceding one[4]. These

could be stimulated by delayed resonances in transducers, which often have time-constants within these ranges. With this in mind, and the author having a particular dislike of the sound of delayed resonances, the design for the acoustically small loudspeaker sets out to minimize them.

The cavity resonances of an enclosure constitute an inharmonic series given by the solution to the wave equation for rectangular (or other) boundary conditions. The cuboid has resonances at

$$f_{\mathrm{nx,ny,nz}} = \frac{c}{2}\sqrt{(n_x/x)^2 + (n_y/y)^2 + (n_z/z)^2}$$

where c is the velocity of sound, n_x, n_y, n_z are integers chosen separately and x, y, z are the dimensions. These resonances can be heard because they present a widely varying acoustic load to the rear of the diaphragm and thus affect its motion. At high frequencies they can be damped using acoustic filling material, but this is not true at lower frequencies, nor necessarily for small enclosures; for both frequency and thickness of material affect the absorption. An acoustically small loudspeaker is of such a size that the lowest, and therefore all, the cavity resonances are outside the passband, and the loudspeaker is used below these frequencies. This applies, then, to a bass unit. Choosing $n_x = 1$, $n_y = 0$, $n_z = 0$ gives the lowest resonance at

$$f = c/2d$$

where d is the largest dimension of the enclosure, and this is the one-dimensional half-wave standing wave.

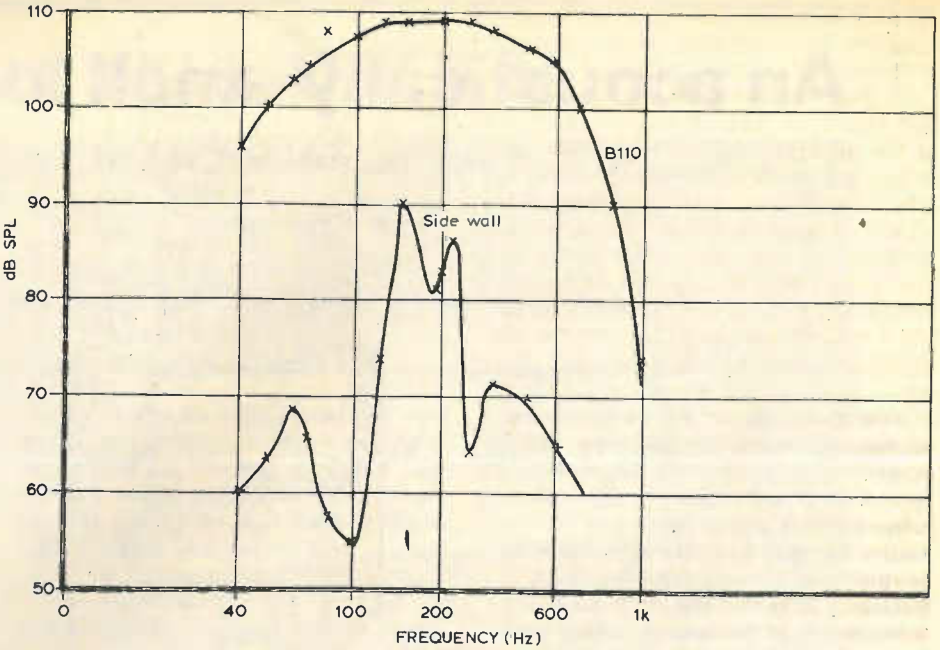


Fig. 1. Near-field transmission of cabinet side compared with that from B110.

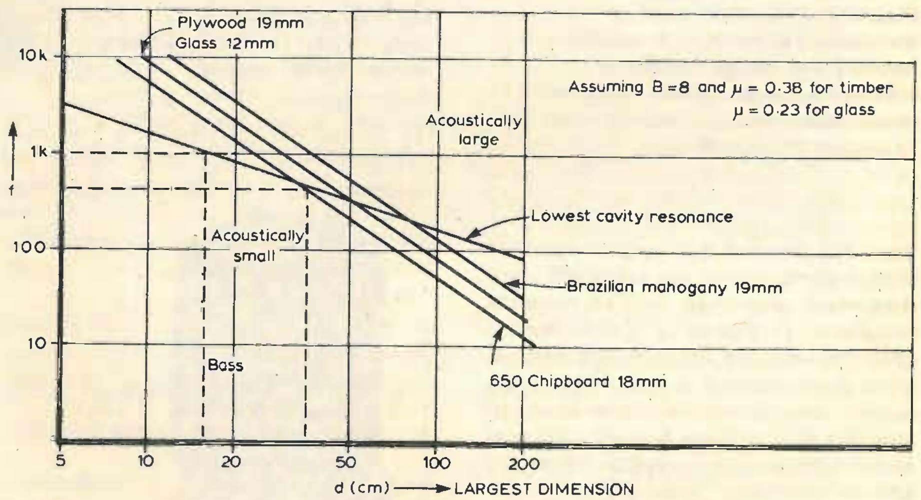


Fig. 2. Cavity and panel resonances for varying maximum dimension.

Panel resonance

Many loudspeakers have a "boxy" sound while reproducing male speech. The box can produce sounds in various ways, one of which is given above. Another way is by the panels of the box vibrating. It has been found[5] that at certain resonant frequencies, the output of the box is within a decibel or so of that of the loudspeaker. As an experiment, some enclosures were made after Linkwitz[2], constructed of 6mm plywood with a 10mm internal layer of roof-patching tar. The transmission of the cabinet side-panel was measured by placing two such units together, fed by sine-waves of equal amplitude but opposite phase, so as to null the sound from the loudspeaker. The microphone was placed 1cm from the side-panel so that the near-field response was measured. The results are shown in Fig 1. After correcting for the relative emitting area of the panel and allowing for two panels, the output from the box at 150 Hz was found to be about 8dB below that from the drive unit. Since the Q was measured to be 5, the box will continue to produce the sound after the drive unit has finished, which constitutes a delayed resonance. In this case the 40dB decay time will be $Q/0.7f = 48$ms.

A panel has a series of resonant frequencies, the lowest one of which is at

$$f = \frac{Bt}{2\pi a^2}\sqrt{\frac{E}{\rho(1-\mu^2)}}$$

where t is the panel thickness, a its dimension (for a square panel), E the Young's modulus of the material, ρ the density and μ the Poisson's ratio. B varies according to the construction, and is higher for a clamped panel than a freely supported one. For loudspeaker enclosures, B is taken as 8. An acoustically small loudspeaker can be made so that the lowest, and therefore all, the panel resonances are above the frequency of operation. The two resonance functions mentioned are plotted in Fig 2. From this can be determined the maximum dimension of an enclosure for it to be acoustically small. It can also be appreciated that most loudspeakers are acoustically large. The graph of the lowest cavity resonance coincides with a criterion for determining the maximum frequency at which to operate a drive unit to ensure wide dispersion, and the maximum enclosure width.

The sound emitted by an enclosure depends upon its dimension and the degree of its motion. For a circular piston, the emitted sound pressure level increases by 12dB for a doubling of its diameter, which implies that as a box is made smaller, so the sound radiated from it decreases. However, the internal pressure within the box increases as the volume is decreased, so that the deflecting force on the panel increases. This is compensated by a decrease in the actual deflection with reducing dimension, according to a square law. The combined effect of all this is a decrease of about 6dB in the emitted sound with a halving of the dimension. All the above factors represent a confluence of ideas pointing to acoustic size as being an important parameter. It is therefore no coincidence that listening tests have revealed a preference for small loudspeakers, provided that these are also well designed in other respects.

The panel transmission loss below the first resonance depends on the stiffness of the material used, not its mass or damping properties. The bass enclosure is best constructed of a thick material of high Young' Modulus. In this respect plywood is better than chipboard and hardwood better than plywood. Glass would seem to be an ideal material, for it has a Young's modulus 75 times that of chipboard, and an enclosure can be fabricated in the same way as an aquarium, using silicone rubber as an adhesive. This is a subject for further work.

Clay enclosure

Diffraction round an enclosure has been found[6, 2] to have a bearing on the frequency response and stereo imaging qualities of an enclosure, and Fig. 3 shows the frequency response of differently shaped enclosures, other things being equal. The sphere was found to give the smoothest response of the shapes tested, since there are no discontinuities in the surface to give rise to frequency-dependent effects. A novel enclosure is made as close to a sphere as practicable, and consists of a short vertical cylinder with domed top, as shown in Fig. 4. The shape is achieved by using modelling clay, which has a high density and large internal losses – it is acoustically "dead". The clay used is sold under the trade name of "Das", and does not require firing. It is not possible to include the bass unit in this enclosure, so only the mid/high-frequency unit or units are placed in it, and it is stacked on top of the bass enclosure. Because of the rounded shape, advantages are obtained in suppressing cavity resonances. The top-to-bottom, one-dimensional standing wave which normally occurs in a pipe is suppressed by the domed top, and similarly the axial one-dimensional standing waves are suppressed by the cylindrical walls. This leaves the two-dimensional waves, and the lowest is calculated to occur at 1.4 kHz, where the damping material used has a high absorption.

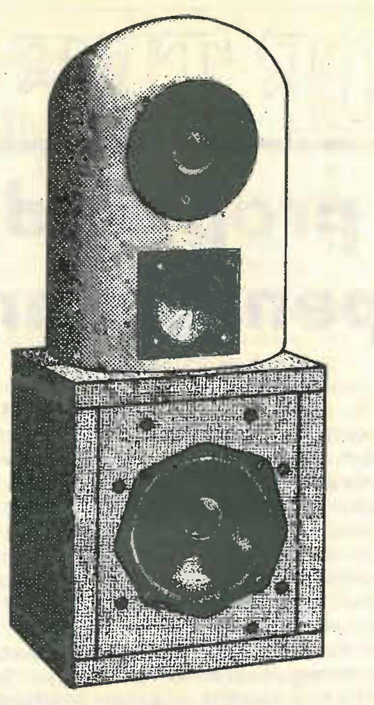


Fig. 4. Author's prototype. Clay enclosure on top contains mid and high-frequency units, while wooden bass enclosure is for B110. Single sub-woofer is not shown.

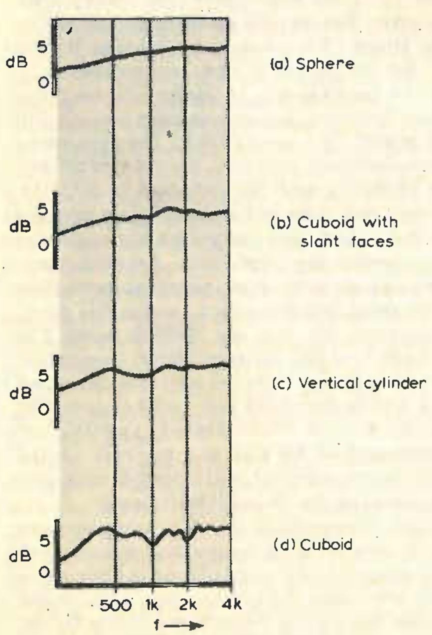


Fig. 3. Frequency response of four different cabinet shapes.

Bass enclosure

The simplest way of making an acoustically small bass enclosure is to make it physically small, and for operation up to 500 Hz the lowest resonance is placed higher, at 1 kHz, where the response is 20dB down. This, combined with the high absorption of the filling material and the internal losses of the enclosure material, will give only very small amounts of unwanted sound. The maximum dimension for the bass enclosure is found from Fig. 2 and is 16cm. The volume of a 16cm cube is 4 litres, and it is clear that this will give insufficient bass extension. A cube is to be avoided, since resonances coincide to give a higher Q, and the bass enclosure is best made with dimensions in the ratio 2.3:1.6:1, this being the ratio used for designing listening rooms. The maximum volume is around 1.1 litres, which is too small, and so a modification is called for. A 5in bass unit requires an enclosure dimension of 15cm on the front panel, and so the box is made square at 16cm: the other dimension is determined by the volume obtained from the design procedure for bass loading. The volume is divided internally by a partition placed to brace the magnet against the back panel, which also suppresses the offending double resonance caused by the square dimension.

An acoustically small loudspeaker does not have to be physically small, and this is achieved by a scheme of internal partitions, in which each sub-volume is acoustically small, but is connected to the adjacent one by a low resistance path. The partitions simultaneously brace the panels, effectively sub-dividing them into smaller ones which are acoustically small. The smallest dimension of the box is the width to ensure wide dispersion, and this is equal to or slightly greater than that required to house the drive unit.

Sub-woofer

The bass extension in this design is obtained by a novel sub-woofer, the aim being to achieve economy in space and expense. A 12in bass guitar speaker is capable of producing high levels of bass below 100 Hz, and is inexpensive. However, it has a rather high resonant frequency, which was utilized by placing it in an acoustically small enclosure and using it below resonance, with a second-order filter, to give the required amount of bass boost. The closed-box enclosure acts like a second-order high pass filter, and the flat part of the response above resonance is made to fall off at 12dB/octave using the filter. The portion of the response below resonance which was falling off at an ultimate slope of 12dB/octave is made flat with the same filter. The falling part of the new response is tailored to form half of a 12dB/octave crossover, the other half being the natural fall-off of the bass enclosure

continued on page 73

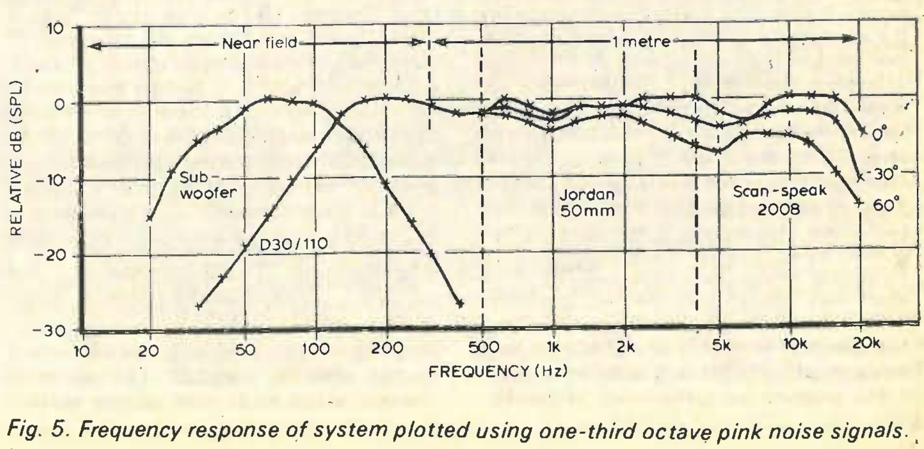


Fig. 5. Frequency response of system plotted using one-third octave pink noise signals.

NEWS OF THE MONTH

928 MHz proposed for UK's Open Channel

Concern about interference seems to be the main reason why the Home Office is proposing "just above 928 MHz" as a frequency for Britain's citizens' band service. The thinking behind this choice is published in a Green Paper discussion document entitled "Open Channel" — which is what the Government intends to call the UK service to disssociate it from the bad reputation of c.b. operation on 27MHz in some countries. By placing the service in this part of the u.h.f. band they would put it above all the television channels used in Britain and also above most of the communication and other systems — notably those of the police, the fire brigades and aircraft landing systems — where interference could have serious consequences. Because of likely interference they have rejected the National Electronics Council's proposal for a band somewhere between 100MHz and 500MHz (August 1978 issue, p.38). Having looked particularly closely in this region at suggested bands in the neighbourhood of 225MHz and 450MHz, the Home Office remarks in the Green Paper that here the interference "could be so severe and intractable as to lead to the dropping of certain television channels. This could not be contemplated in the context of European television planning, quite apart from the effect on the broadcasting authorities".

The choice of the particular figure of 928MHz, above which the Open Channel would be placed, is determined by several factors. First, several other countries, including the USA, Canada and some in Western Europe, are also considering setting up personal radio services in this part of the spectrum, notably in the new 900MHz mobile radio band (862-960MHz in Region 1) which was allocated by international agreement at the WARC in Geneva last year (February 1980 issue, p. 48). International standardisation would be a good thing, particularly to give manufacturers opportunities for economies of scale and larger markets in the design, production and sale of equipment. Secondly, in this respect, "just above 928 MHz" would avoid the ISM (Industrial, Scientific, Medical) band of 902MHz to 928MHz which is designated for use in ITU Region 2 (the Americas). Thirdly, there are the constraints of other, fixed communication services in this u.h.f. area which help to determine the figure of 928MHz. But the most important factor in fixing it is the possibility of image interference in television channel 68 resulting from frequencies immediately below 928MHz. The Green Paper in fact envisages a band 1MHz wide containing a maximum of 40 channels, each of 25kHz. This implies the possibility of frequency modulation, although the document does not say this directly. The Home Office's Radio Regulatory Department sees the question of choice of modulation as a commercial rather than a technical matter.

The proposal for a frequency of 928MHz raises the question of the likely range of Open Channel transceivers because of the relatively high absorption of r.f. energy by obstructions in this part of the spectrum. Of course, the Government doesn't want long-distance transmission in any case, and they consider a range of about 15km is enough. The Green Paper says that the frequency selected must enable this desired range of 15km "to be achieved in most environments without excessive transmitter power, thus minimising local interference, enabling frequency channels to be re-used and at the same time avoiding long range interference". After quoting some earlier studies of propagation at 900MHz and the ranges achieved, the document goes on to mention a limited series of tests done by the Home Office themselves in and near London to obtain additional data in this part of the spectrum: "From these tests it was estimated that with 25W e.r.p., a sensitive receiver and with aerial heights of 4 and 1.5m, the range in urban and suburban environments would be from 3 to 10km and that in open, flat country with no trees it might approach 20km."

To revert to the question of interference with other services, the Green Paper analyses what could happen with an Open Channel band near three different frequencies: 225MHz, 450MHz and 900MHz. Around 225MHz, the third harmonic of the transmitter "would come within the range 669-675MHz and reception of television channels 45 (662-670MHz) and 46 (670-678MHz) would be potentially affected." Up to 1.1 million television sets could be affected here by transmissions from equipment mounted in vehicles or from portable transceivers with integrated aerials. Below 450MHz, television reception of channels 64, 65, 66 and 67 would get interference from the second harmonic of the transmissions. Up to 1.7 million tv sets could be affected. Above 450MHz, the problem "is one of spurious responses in television receivers tuned to channels 23 and 24. It is estimated that 2.6 million installations receive a television field strength which is less than that necessary to protect them from the transmissions of fixed Open Channel equipment." At 900MHz, and up to 928MHz, Open Channel frequencies in this region "would potentially affect the reception of television channels 59-68 inclusive . . ." and it is estimated that ". . . up to 1.8 million tv installations receive a lower field strength from main stations than would be necessary to protect them from nearby Open Channel transmitters." Here, and in the band above 450MHz, the interference could be dealt with by filtering "but the scale of the possible problem is daunting."

On the question of regulatory control of Open Channel, the discussion paper says that the Government proposes "to combine the simplest possible licensing system with a limited technical control." The licensing system "would be flexible, simply authorising a named user, or a person acting with his permission, or a person to whom he had hired equipment, to use Open Channel." Licences would be renewed annually "and unlicensed transmissions would constitute, as now, an offence under the Wireless Telegraphy Act." Revoking licences would be a way of applying sanctions, short of prosecution, against deliberate illegal use. The licence fee would be set to pay for the administration of the service.

For technical control, only minimum standards for equipment would be set, and the Government's responsibility to users would be "confined to ensuring that a certain standard of service *can* be obtained rather than ensuring that it *is* obtained." There would be no formal specification system as with p.m.r. equipment. Regulations under the Wireless Telegraphy Act could set out technical requirements — on modulation, power, frequency stability, spurious radiation etc. — which equipment manufacturers would have to meet. These regulations "could make manufacturers liable to certify their products as conforming to those requirements; the onus would then be on the user to ensure that he used only certified equipment." In general the Green Paper makes it clear that the Government sees its responsibility as creating the technical conditions for a reasonable service but not in coping with abuses.

● Reactions to the Government's proposal have been mixed. The UK radio amateurs, for example, are quite pleased (for reasons explained in World of Amateur Radio this issue). So are those who concur with the Government's view of citizens' band as basically an amusement or hobby (Mr Timothy Raison, the minister concerned at the Home Office, has remarked that "it will be fun for people"). They see no reason to strive particularly to make life easy for manufacturers, dealers and users in what will be essentially a luxury trade. The equipment manufacturers, however, are predictably not at all happy with the proposal of 928MHz. They think there will be insufficient demand to make the design and production of sets for this frequency profitable. American experience suggests that the transceivers may cost about 20% more than comparable p.m.r. equipment for, say, the 200MHz band. The president of the Citizens' Band Association pressure group, James Bryant, has described the Green Paper as just another delaying tactic by the Government, and Walter Stevenson, of Air Call Ltd, has commented that many potential operators will now just go ahead on the illegal 27MHz band.

The Government is, of course, inviting such comments on its discussion paper and has asked all concerned to send in their views not later than 30th November, 1980 to the Radio Regulatory Department, Home Office, Waterloo Bridge House, Waterloo Road, London SE1 8UA.

Government begins erosion of Post Office monopoly

Referring to "a transitional period of three years," Sir Keith Joseph announced on July 21 that British Telecom's monopoly would be limited by government changes in the way terminal equipment is used as well as in the supply of services to third parties.

The new provisions, for which legislation will be introduced in the next parliamentary session, are expected to make it easier for privately supplied equipment to be connected to the Post Office network, assuming that the equipment meets the required technical standards. Similarly, more freedom will be extended to people who wish to use British Telecom's circuits to offer services to third parties which are not currently provided by the company, data processing facilites, for example.

In announcing these changes, Sir Keith also mentioned the possibility of "allowing the private sector to provide telecommunications transmission services such as satellite business systems." He said that he expected the main changes to lead to a significant growth in information, data transmission, educational and entertainment services provided over telephone circuits and to the emergence of new business. He said that he would be commissioning an independent economic assessment of the implications of allowing complete liberalisation for what are commonly referred to as "value added" network services. These include database services providing archives, advertising and entertainment services, electronic office facilities such as word processors, verbal message services, etc. as well as facilities for the interconnection of normally incompatible apparatus such as computers, facsimile machines and word processors. Monitoring and security alarm services also fall under this heading.

The first telephone and associated wiring connected to the main network will remain the responsibility of British Telecom, as will the maintenance of private branch exchanges (PABX) and associated wiring.

In theory, this should make available to the user a wider variety of equipment and sources and Sir Keith said that he is looking forward to seeing at an early stage approved extension telephones on sale in the shops, as well as greater competition in the installation and wiring of currently approved apparatus on business premises.

A spokesman of the Post Office Engineering Union, responding to the announcement, said that the changes would allow private operators to "cream off" the more profitable side of the business, leaving British Telecom to deal with the less profitable but necessary sector.

At the same time, Sir William Barlow, the Post Office chairman said that consumers' bills were likely to rise as a result of the changes.

IEC nuclear reactor standard published

The 70th standard produced by the International Electrotechnical Commission was issued late in July, and deals with periodic tests and monitoring of the protection systems of nuclear reactors. This standard, IEC publication 671, lays down principles for testing protection systems during both normal power operation and shutdown. Among details such as short interval or continuous surveillance checks the standard also considers the effect of test equipment failure on the reliability of reactor protection. The full publication can be obtained from the International Electrotechnical Commission, Central Office, Geneva, Switzerland, price 39 Swiss francs.

Pergamon Press makes first data deal with Russia

An investment of £10 million a year for the next ten years as part of a deal to provide western customers access (in English) to literature in Russian scientific and technical data stores, has been announced by Robert Maxwell, chairman of Pergamon Press.

The agreement made with Viniti, the Soviet Institute of Scientific and Technical Information, and Vaap (Soviet copywright) also includes the joint development of computerised information services. The *guardian* reports that these services would be immediately available on computer terminals, through the Infoline service, which was acquired recently by Pergamon and the agreement also includes the supply by the Russians of all documents in microfiche form.

The English language service is expected to begin in the first quarter of 1981 and will include material on information retrieval systems and the environment, with mathematics, energy and engineering following in 1982.

Phone charges up

Price increase proposals have recently been put by British Telecom, the telecommunications part of the Post Office, to the government and the Post Office Users National Council. The increases, which are expected to take effect from November 1, include a 0.5p increase in the telephone call unit fee to 4p accompanied by a reduction of time in the inland cheap rate period, although the IDD (International Direct Dialling) cheap rate will be extended to 8a.m. Foreign affairs will clearly be easier to arrange! Telephone rental charge increases to £16.75 per quarter for a business line and £12 per quarter for a residential line. Installation and extension charges will also rise. Further details can be obtained from British Telecom, Public Relations Department, 23 Howland St, London W1P 6HQ.

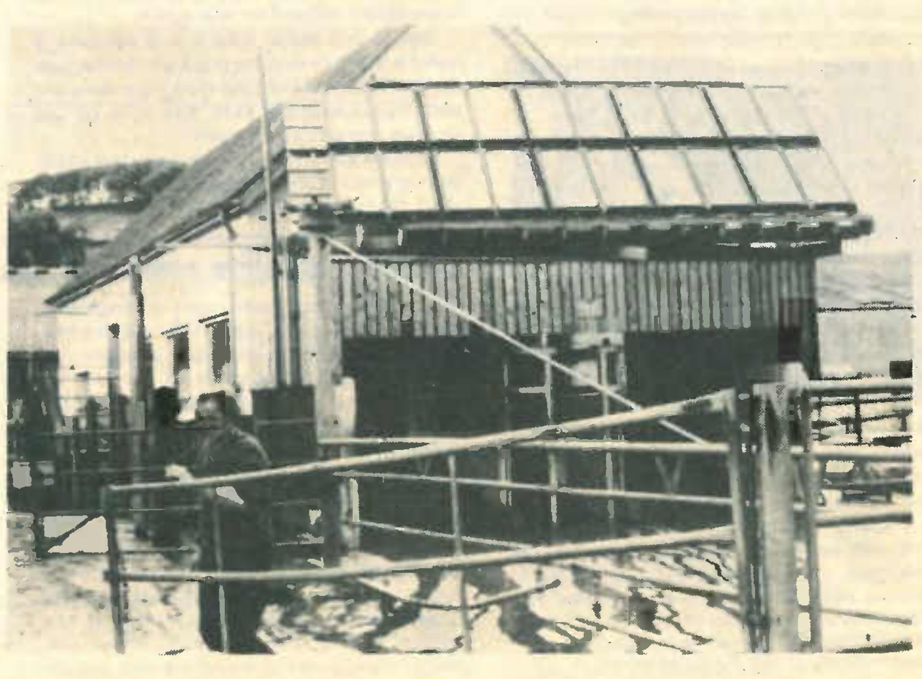
Data logger keeps an eye on the dairy

Two projects to determine economic use of energy are being run simultaneously at the Seale-Hayne College dairy unit in Newton Abbot, Devon, using a multi-channel data logging system, the Microdata M1600L.

One is aimed at energy conservation in the farm's milking parlour and associated dairy and involves a comprehensive study of energy input and consumption, while the other looks at the development of a solar energy system for use in the farm, this being linked to a study of dairy water requirements. More than 50 parameters are being monitored at regular intervals over several years involving the interfacing of a variety of transducers, both analogue and digital, with the data logger. This is achieved by the use of a separate plug-in signal conditioning module for each channel.

Where checking of fluid flow is concerned, turbine-type sensors deliver a pulse output with frequency proportional to flow rate and although this is an analogue signal, the data logger handles it digitally, with signal conditioning modules operating as tachometers to provide the pulse rate in digital form.

Recorded data is subsequently fed into the Plymouth Polytechnic Computer for analysis.



Government set to introduce cheap-rate engineering authority

The formation of a new body to govern the engineering profession, probably a 20-man committee with chartered status, is expected to be announced by Industry Secretary Sir Keith Joseph as we go to press. The new authority is likely to be only a small affair compared with the powerful engineering authority (which was to be directly responsible to government) envisaged by the Finniston Report of April 1980. This amounts to a compromise which could save the government about £8 million, reports the *Sunday Times*, and would also dispose of the present system of self-regulation by the institutions, through the CEI.

It is thought that the government will appoint members after recommendations made by engineering employers, unions and the institutions, with an initial expenditure level of £1 million to £2 million to get the new independent body started.

Most of the savings will be effected by "tapping into" the current Engineers' Registration Board and accreditation will probably depend at first upon the goodwill of existing institutions, once members reach the standards agreed by the new authority.

An alternative form could be a chartered body created by the Fellowship of Engineering (set up by the CEI in 1976), which would imply that membership would be decided entirely by the profession although the most likely authority is the former, partly because so many of the DOI's respondents to offer their views on the Finniston Report suggested that the impetus of an independent body was vital. This type of authority is also supported by the IEE (70,000 members) and the Engineering Employers Federation.

Landsat working again

NASA's five-year-old Landsat spacecraft is now back in service after a six month retirement caused by a malfunction preventing correct orientation in its orbit. The spacecraft developed problems on Nov. 5 1979 when the yaw attitude flywheel, part of the mechanism which kept it pointed towards earth ceased functioning, probably due to a lubrication breakdown.

University technicians get 12%, lecturers 17%

The standing commission's report on pay comparability, published at the end of July, recommends a salary increase of about 12% for university technicians, while university lecturers are expected to be awarded 17%, although the Association of university Teachers had originally made a provisional agreement for 19.6% with the university authorities.

The commission recommended that an additional lump sum should be paid to technicians, varying from £46 to £140 according to grade and the increases are back-dated to April 1980. The basic minimum salary for a trainee technician is now £2,367 (at age 16) with the grade 1A technicians minimum at £3,288. Grade 8 represents the maximum at £9,045.

Under the 17% settlement, minimum lecturers' salary will be £5,505 with the maximum at £11,572, rates effective from October 1980.

Professors' average pay will go up from £14,148 to £16,765. An additional cost of living figure is to be added to lecturers' and professors' salaries after talks with the government in September.

First small-dish digital video transmissions by satellite

Successful transmission of digital video colour tv signals through a European space satellite using small-dish terminals at both ends of the link, has been achieved by the IBA at Crawley Court, Winchester, reports Pat Hawker.

Digital signals were passed through the 120 MHz transponder on the OTS satellite launched in May 1978 and the experiment was carried out with the co-operation of British Telecom and the European EUTELSAT organisation. The test signals, using the IBA-developed experimental 60 Mbit/s encoder/decoder, were both sent and received at Crawley Court using the 14 GHz 2.5 metre dish "up-link" terminal (at about 1.5kW transmitter power) and the 3 metre dish receiving aerial.

During preliminary tests using pseudo-random digital signals, error rates of the order of only one in 10 million bits were recorded. During transmission of 625-line colour tv pictures through the system no degradations, other than those introduced by the encoder/decoder system, were observed.

The techniques used here are for experimental purposes only and are not being proposed as an international standard, but the work has shown that digital video could provide useful advantages for news gathering and national and international links through satellites.

Despite one or two humorous suggestions as a caption to this picture, including "off-resonance draught detector in action" and "an obsessive approach to stereo speaker positioning", the gentleman is in fact a fully-equipped boardroom "bug" detector. The equipment is the Scanlock Mark VB and the makers, Audiotel International, claim that its sensitivity and frequency coverage (100 to 1800MHz) make it possible to detect a bug automatically in less than a second.

Seeing and hearing things at Decca

London Print and Design, a relatively unknown company based in Northington Street, has bought the old Decca record manufacturing plant, lock, stock, and barrel. The plant, which is located at New Malden, Surrey, was taken over by Racal earlier this year (see *Wireless World*, April 1980) and immediately offered for sale again.

Speculation about who would eventually make a move to acquire the high technology disc business has been running high since the non-manufacturing part was sold to the German company Polygram.

Rumour has it that LPD will use the plant, through the co-operation of key technical staff from Decca, to press videodiscs in partnership with companies interested in the home video entertainment field. LPD has been advertising the sale as well as asking companies interested in the pressing equipment to approach them. The plant has an annual production capacity of 14 million discs, although there is a chance that the central matrix unit could be retained at New Malden, with up to four "satellite" pressing plants operating at other sites, each producing about 3½ million discs annually.

For some reason best known to itself, LPD chooses not to reveal the nature of its current business, but informed guesses point to links with printing, designing and maybe some more pressing business in the near future.

Japanese satellite completes global telex link

An arrangement made recently between British Telecom and the Japanese telephone authority makes it possible for telephone and telex users in the UK to reach ships in the Indian Ocean, using the satellite earth station at Yamaguchi, south-west of Hiroshima.

This amounts to an extension of the Marisat system which already provides satellite links for ships in the Atlantic and Pacific and is the final link required to provide global coverage. The main advantage of the system, set against normal radiotelephone messages, is that calls are free of fading and distortion. About 320 ships throughout the world are now equipped to use the Marisat system.

To make a satellite telex call, British users should follow the dial/key procedure for making international calls to places outside Europe and North Africa. The keying codes to use are 581 for ships in the Atlantic and 582 for those in the Pacific. The caller then keys the ship's seven-digit call number, followed by a plus sign.

To make a satellite telephone call, British customers should dial 100 and ask the local exchange operator for Freefone 2187, the International service at Faraday Exchange, London. Callers should give the name of the ship it is wished to contact, its location and the vessel's satellite call number.

Designing with microprocessors

5 — Test-and-skip systems

by D. Zissos and Laurelle Valan

Department of Computer Science, University of Calgary, Canada

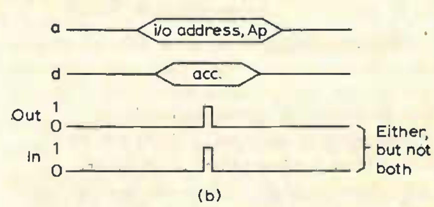
This and the following article describe step-by-step procedures for the design and implementation of microprocessor-based systems using the test-and-skip mode. In the second article the design steps will be illustrated by means of a fully worked out example.

In the previous article we explained the nature of the synchronization problem, which results from the fact that the microprocessor operation cannot be slowed down to the speed of slow peripherals by reducing the frequency of its clock. Two solutions, which do not involve adjusting the clock frequency, were outlined. One uses software and the other hardware. In the first case, the microprocessor executes a programming loop, during which the status of the peripheral is read and *tested*. If the peripheral is found to be busy, the process is repeated, that is the microprocessor *skips* execution of the next instruction. *The test-and-skip* process is repeated until the peripheral becomes ready, at which point the microprocessor exits the software wait loop. In the second solution hardware is used to put the microprocessor chip into an idling (wait) state while the peripheral is responding. When in the wait state all microprocessor activities are suspended without turning off the clock. Microprocessor-based systems using this method are referred to as *wait/go* and will be discussed in detail in a later article.

I/O instructions

Before we describe the philosophy and steps we use to design and implement test-and-skip, and indeed all types of microprocessor-based systems, it will be useful, particularly in the case of the inexperienced reader, to recall the step-by-step execution of i/o instructions, which was described in detail in an earlier article.

Briefly what happens is this. The op code is fetched from memory and copied into the instruction register (i.r.) during cycle M1. Next, the i/o address is fetched from memory and copied into addressing register r. The i/o instruction is executed by connecting within the m.p.u. chip the address bus to the addressing register and the data bus to the accumulator, as shown in Fig. 1. In addition, the timing and control unit generates on specified pins of the m.p.u. chip either a read or write pulse, denoted by In and Out, depending on whether data is to be copied from the peripheral into the accumulator, or vice versa – see Fig. 1(b). The presence of an allotted address signal and an i/o pulse at the input of an interface causes it to activate the peripheral. In other words the input to an interface in a microprocessor-based system consists of software-generated electrical pulses.



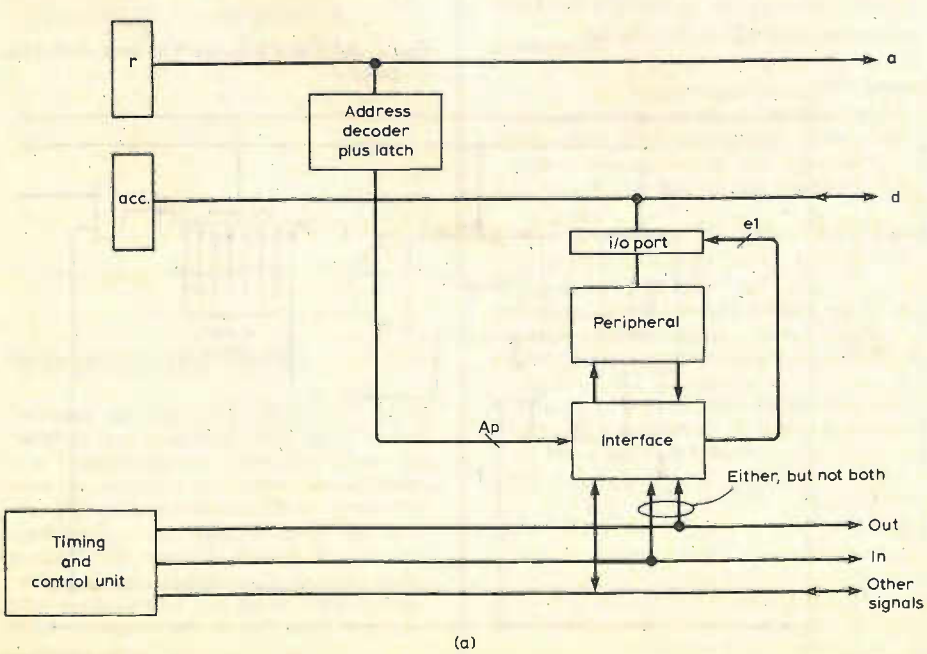


Fig. 1. (a) Microprocessor/peripheral links during execution of an i/o instruction. (b) Microprocessor signals during execution of an i/o instruction.

In practice the relative timing of i/o pulses, addresses and data vary from microprocessor to microprocessor. However, in our design procedures it is not necessary to consider such signals until the implementation stage.

Design philosophy

The design philosophy adopted is one that allows the inexperienced user to produce sound and reliable systems simply, while at the same time providing the specialist with the tools to improve his technique in dealing with more sophisticated assemblies. As in the case of logic circuits, elegance of design is not sought but can be achieved.

In developing our design philosophy, we considered the following as important.

System reliability. All systems must function correctly.

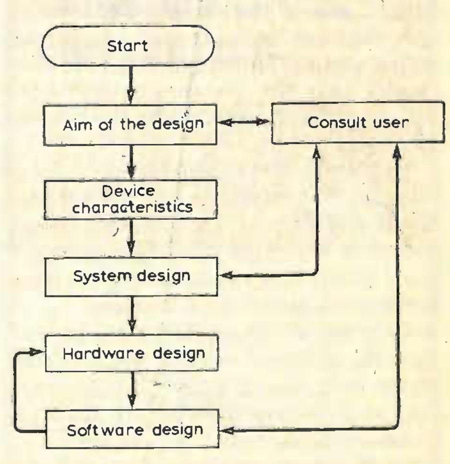


Fig. 2. Chart showing the successive steps in the design process.

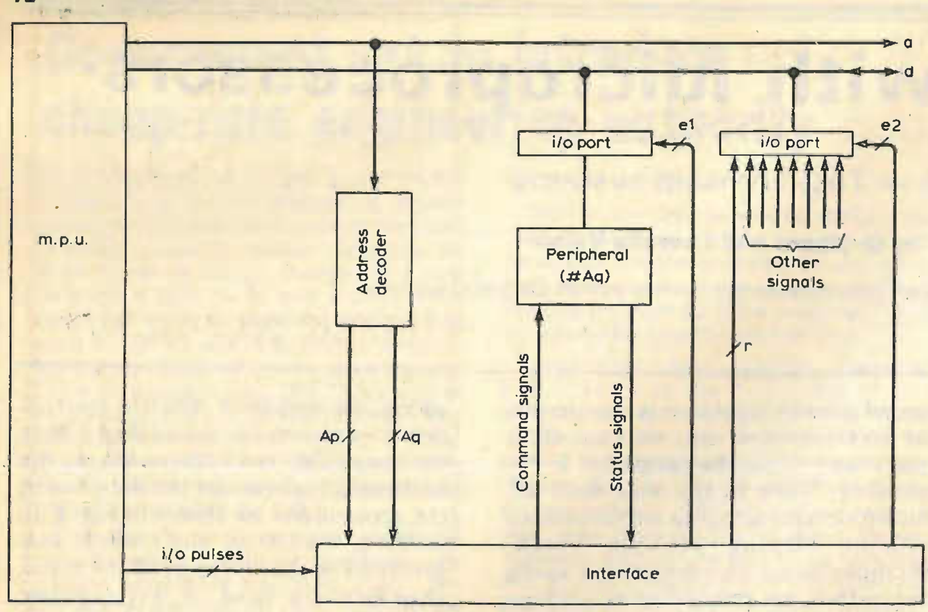


Fig. 3. Configuration of a basic test-and-skip system.

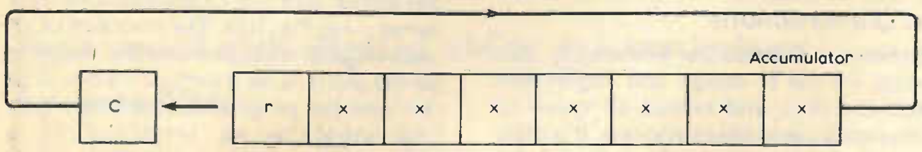


Fig. 5. Left-shift through carry.

Circuit maintainability. The systems should be easy to maintain.

Design effort. This must be minimal to allow for greater creavity.

Documentation. This should be concise and to the point. Symbols and diagrams are preferable to verbal statements; they are more readily understood by non-English speaking persons and are likely to prove more attractive to the export market.

Design steps. These must be easy to apply. In our case no specialist knowledge is necessary.

Modifications. The systems should be easily modifiable to meet new conditions as they arise.

Design steps

Our design process is accomplished in five steps, listed below. See also Fig. 2.

Step 1: aim of the design. The system specification is expressed in the designer's terms. This step is introduced to ensure that the system requirements are interpreted correctly by the system designer.

This stage is critical for successful co-operation between the system designer and the user. Failure at this stage is usually the cause of system misoperation which then produces the need for subsequent design modifications.

Step 2: device characteristics. In this step the designer studies the terminal characteristics of the devices to be used. Any consideration of purely internal characteristics should be avoided.

Step 3: system design. In step 3 the designer specifies the system characteristics in general terms by means of a block diagram and a system flow chart.

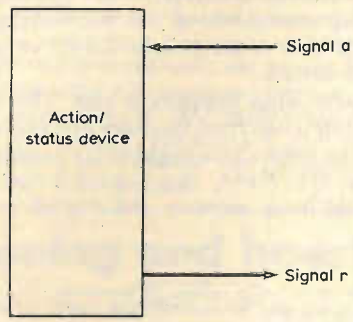


Fig. 6. Terminal characteristics of action/status devices. Signal a means that a 0 to 1 signal transition on the action terminal activates the device. No activation is possible when signal r=0. Signal r indicates the availability (r=1) or unavailability (r=0) of the device.

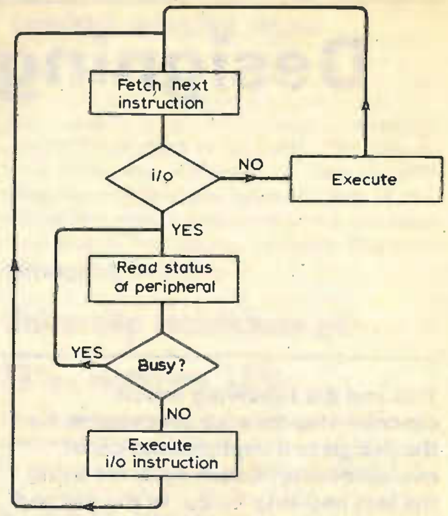


Fig. 4. Step-by-step operation of test-and-skip systems.

Step 4: hardware design. The fourth step involves the design and implementation of the system hardware. This step is provisional, and its results may well be modified in the light of the experience of the next step. It is accomplished conventionally, using well-established methods.

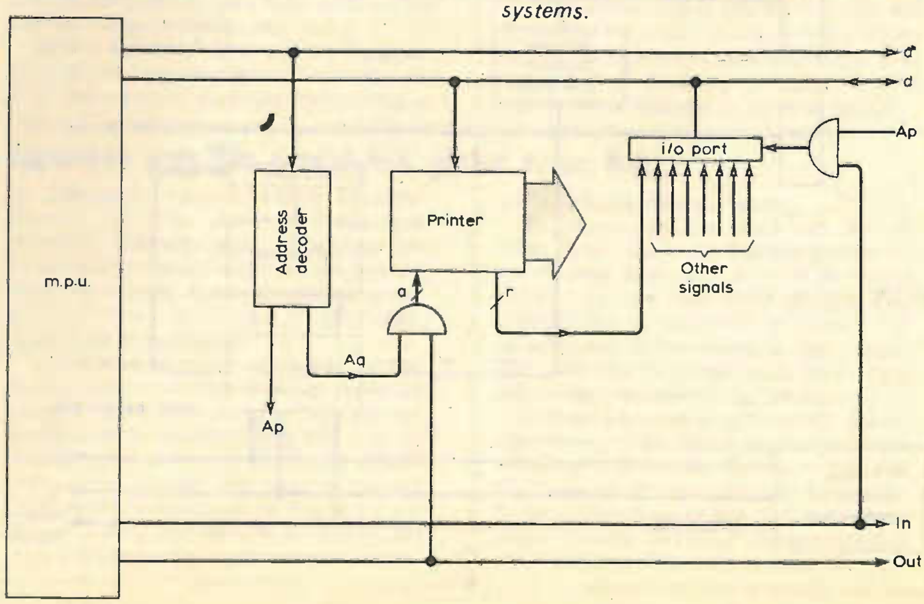
Step 5: software design. On the basis of the hardware design in step 4 and assuming the necessary machine code instructions, the basic software for the operation of the device is designed. This process may well indicate improvements to the hardware which was designed in step 4. In fact, steps 4 and 5 should be repeated until a satisfactory design is obtained.

It is advisable to use a programming model when executing this step.

Basic configuration

The basic configuration of a test-and-skip system is shown in Fig. 3. The function of the interface is to provide the microprocessor with status information about the peripheral (indicating

Fig. 7. Interface hardware of test-and-skip systems.



whether it is ready or not), and to activate the peripheral at the correct time, that is when i/o instruction with address Aq in our case is being executed.

Peripheral status information is made available to the program through an input port. If the ready/unready state of the peripheral is indicated by the '0' and '1' values of signal *r* in Fig. 3, to determine whether the peripheral is ready or not, the programmer proceeds in the following manner. He executes an IN instruction with address Ap. Execution of this instruction copies the signals *rxxxxxxx* in Fig. 3 into the accumulator. If $r = 0$ the process is repeated, otherwise the next (i/o) instruction is executed, which allows the microprocessor to communicate with the peripheral, as shown in Fig. 4. The programmer has several options to determine the value of *r*. We shall describe two such options. He can AND the contents of the accumulator (*rxxxxxxx*) with 10000000 (80 in hex), which modifies them to *r*0000000. If $r = 0$ the zero flag is set, otherwise it is reset. Alternatively, he can shift the accumulator left through the carry flip-flop, as shown in Fig. 5, which shifts the value of *r* into the carry flip-flop.

If we assume that our peripheral is an action/status device, that is a device whose terminal characteristics are shown in Fig. 6, the hardware implementation of a test-and-skip system is shown in Fig 7. Action/status devices are described in Appendix 1 of "System Design with Microprocessors", Academic Press, 1978.

In the next article we shall demonstrate design steps by means of a PRINT problem. This problem, which will also be implemented using the wait/go, interrupt, d.m.a. and d.d.t. modes, has been chosen, first because a printing operation can be readily visualized and secondly, the character printer used can be assumed to have been in existence in the 1940s, that is well before the era of computers and microprocessors. □

WW index for 1979

The index for Volume 85 (1979) of *Wireless World* is now available, from the General Sales Department, IPC Electrical-Electronic Press Ltd, Room CP34, Dorset House, Stamford Street, London SE1 9LU, price 75p including postage. Cheques should be made payable to IPC Business Press Ltd.

We apologize for the unusually long delay in the production of this index. This was due to a combination of editorial staff problems and more general industrial disputes.

An acoustically small loudspeaker

continued from page 67

containing the 5in unit. In this fashion, a two-way, second-order crossover is obtained for the price of a single-stage filter, and considerable bass extension with an inexpensive unit. The success of this design is best judged by the observation that, when placed in a corner, 102dB SPL peaks were measured while playing a recording of cannon shots during the "1812" overture, without any sign of stress. Naturally there is a price to be paid, and that is increased harmonic distortion. This could not be heard during music, but sine-waves or pink noise showed it up, and the result was that the source of sound could be located, which is not generally true for such low frequencies. Frequencies below 100 Hz were found to occur infrequently during most music, but bass guitar, bass drum, and organ enthusiasts may prefer some other solution below 100 Hz. That due to Linkwitz[2] is an alternative.

The on-axis response of the units was measured above 300 Hz in situ using third-octave pink noise. That below 300 Hz was measured by taking the near-field response of each unit to eliminate the effects of the room. The results are shown in Fig. 5. The off-axis response was measured above 300Hz in situ, rotating the loudspeaker. Curves are shown for 30 and 60 degrees horizontally off-axis, and show that an integration has been achieved between drive units, and that there are no large steps in the off-axis response to cause shifting or diffuse stereo imaging.

Design and construction will be described next month.

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IN OUR NEXT ISSUE

Unique pickup arm

By displacing the horizontal and vertical pivots of an arm from each other it becomes possible to increase the radius of the arc in which the pickup travels across the record and so reduce tracking distortion. This article describes a practical design for home construction.

Amplifier-loudspeaker interface distortion

Matti Otala examines distortion caused by intermodulation between the signal and a delayed, frequency transformed version generated by the loudspeaker and propagated in the feedback loop. Measurements on four power amplifier circuits are discussed.

Designing inductors carrying d.c.

It's difficult to select initially a core for a winding that is carrying d.c. A simple procedure allows different cores to be compared and the optimum one chosen for a particular inductor design.

On sale October 15

WORLD OF AMATEUR RADIO

Voice synthesiser

The "Wooden Fender" group of amateurs in and around Colchester, Essex — including a number at the University of Essex — have built and installed what is thought to be the first computer-generated voice synthesiser on a local u.h.f. repeater, GB3CE, located in the Colne Estuary and using channel RB14 (output on 433.350MHz). According to Ian Dilworth, G3WRT, the computer has initially been programmed to synthesise the call-sign and "QRA locator" (ALO5E); in addition the repeater announces frequency and channel number. The basic system, however, has been designed to provide a voice output of the strength and frequency check of the incoming signals, although this has not yet been implemented.

The value of v.h.f. repeaters to provide relatively long ranges in conjunction with simple hand-held transceivers is being proved by experiments that have been carried out by the Canadian Department of Communications during recent years in a remote arctic area 500km north of Fort Chimo, Quebec. There an experimental system for "trail and remote camp radio" has been under test to enable an Inuit hunting community to keep in touch with their village by means of a specially-developed battery-operated h.f./v.h.f. repeater installed on Diana Island, 280 metres above sea level and from the community village at Koartac. The Department acknowledges that the system uses technology drawn from North American amateur use of v.h.f./f.m. "autopatch" repeaters (shared hilltop facilities with automatic, mobile tone-access to the public switched telephone network). The economic existence of many arctic communities depends on hunting, fishing and berry-picking requiring villagers to spend long periods away from their homes, on the trail or in remote camps.

Repeater abuse

In the UK and USA, unfortunately, the use of amateur v.h.f. repeaters continues to be the subject of controversy and abuse. Paul Essery, G3KFE, in a strongly-worded editorial in *Shortwave Magazine* writes provocatively "The outcome of the inept plan to quadruple the number of London repeaters can now be seen this appeasement of the deliberate interferers (of all kinds) has merely played into their hands and produced four times the abuse and misuse of these relays. The time is now well overdue for firm action to be taken, for the good of amateur radio . . . If the Home Office is unable or unwilling (as seems to be the case) to make a concentrated effort to find, close-down and prosecute the offenders, then the RSGB — which holds the licences for these repeaters — has no choice but simply to close down the repeaters."

Not everyone will agree with this analysis but it is a fact that, in the USA, the owners of repeater licences are increasingly complaining that they are being held responsible by the FCC for the content of the communications, including the profanities and jamming, going through their repeaters. Under American regulations, both the repeater owner and the station originating a message are responsible for the content of any communications transmitted through the repeater. The real miscreant is clearly more difficult than the owner to identify and trace. The FCC, it has made clear, has no intention of relaxing regulations in this area.

Open Channel

While the general question of the recent Home Office discussion document on "Open Channel" is not a matter for *WoAR*, the reaction of radio amateurs, as such, seems generally favourable. It is of course recognised that it will not be easy for industry to provide low-cost, rugged base, mobile and handheld transceivers at the unexpectedly high frequency of 928MHz. Few existing inexpensive u.h.f. power transistors or varactor multipliers could provide 5 watts output, though it is possible that some use could be made of super-regenerative receiver techniques and s.a.w. (surface acoustic wave) u.h.f. oscillators.

928MHz meets the RSGB request that Open Channel should not be placed close to an amateur band; it is conveniently almost exactly mid-way between the 432 and 1300MHz bands. Amateur experience on these bands shows that 928MHz is not necessarily a short-range "line of sight" band, particularly during conditions of anomalous propagation or from hill-top sites.

There remains the danger that Home Office efforts to reduce illegal activity on 27MHz could result in more "piracy" in the amateur bands, particularly 28MHz. In the USA, despite the availability of the 40 channels around 27MHz, there is already increasing intrusion into the low-frequency (c.w.) end of the 28MHz amateur band. Similarly despite efforts by the FCC to stamp out the use of high-power "linears" by c.b. operators (including forbidding the sale of any linears covering the 28MHz band) there are still c.b. operators using 2kW p.e.p. s.s.b. equipment.

The Home Office makes the valid point that "if an individual wishes to use sophisticated equipment to communicate over long ranges and make international contacts, he should become a licensed radio amateur by taking the appropriate radio examination." The introduction of "multiple-choice" questions in the Radio Amateurs' Examination since 1979, and the consequently higher "pass rate," has removed the argument that amateur radio is open only to those experienced in taking written examinations. But it is to be hoped that the Home Office will consider the possibility of introducing some form of "novice" licence.

The fact that the Home Office is not proposing to allocate "call-signs" for Open Channel should also prevent its becoming a "shamateur" band and so help keep it as a useful and welcome facility for the general public, while not ruling out its use for "fun" purposes.

Amateurs in hospital

Fred Judd, G2BCX, points out that provided permission is obtained in advance, there is usually no objection to the use of amateur radio equipment in British hospitals. Permission needs to be obtained from the Unit Administrator and/or the District Works Officer of the hospital concerned and tests should always be made to ensure there are no electromagnetic compatibility (e.m.c.) problems with sensitive hospital equipment.

In brief

Fee for the Morse test in the UK has gone up from £6 to £8 . . . Danish amateurs now have permission to use 1720-1740 kHz and 1830-1850 kHz, 10 watts c.w. . . . "Rusty" Russell, G5WP, of Guildford, one of the only two British amateurs ever to have won the BERU Commonwealth Contest and a consistent "dx" operator on 3.5MHz, has died . . . Australian amateur licences rose in 1979 from 10,587 to 12,596, of which 6,126 are "full" licences, 3,273 "limited" and 3197 "novice" . . . RSGB reports show that the number of RAE courses being run this season at local adult education centres is about 50 including many towns not listed last month Amersham, Birmingham (2), Borehamwood, Brentwood, Burgess Hill, Bury, Canterbury, Chester, Chingford (2), Cove, Crawley, Derby, Dudley, Exeter, Grafton, Harrow, Hemel Hempstead, Highbury, Huddersfield, Knottingley, Nottingham, Paddington, Southampton (2), Stockton-on-Tees, Stretford, Turnford, Wakefield and Walsall . . . Forthcoming events include Welsh Amateur Radio Convention at Blackwood, Gwent on September 28 and the British Amateur Television Club Convention at Post House Hotel, Leicester on October 5 (from 11 a.m.).

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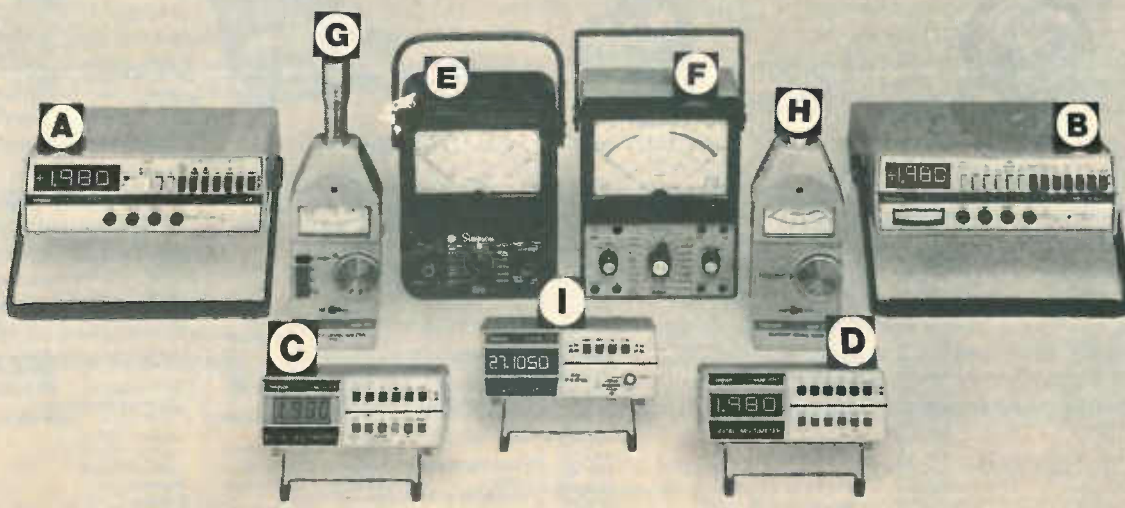

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Satellite broadcasting in the eighties

A report on technical progress in Europe

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

This article outlines the framework set by the 1977 ITU plan for satellite broadcasting in Regions 1 and 3 and reviews the work that has been done so far to implement it. After showing the coverage areas for different countries in Europe the author discusses the life expectancy and costs of broadcasting satellites, considers the design of domestic receiving equipment and aerials and, in a second article, will report on the current plans for building satellites by the European Space Agency and other groups.

We are in the decade of a new method of transmitting broadcast programmes – television and sound – into the home. The transmitter is placed in an orbit above the equator at a height of 36,000km so that it moves round at the same rate that the Earth spins on its axis; it can thus remain at a fixed point in the sky. Doubts on the one hand and over-optimism on the other hand existed in the early seventies. Now, however, three points seem to be established; experiments have proved it works as expected; costs can be assessed and appear acceptable and, finally, it is increasingly appreciated that (whatever other methods of distribution such as optical-fibre cable may ultimately prevail in the nineties or beyond) it is a method of distribution that comes closer to the ideal concept of broadcasting than any other method. There is surely an elegant simplicity in a transmitter of about 100 watts being able to provide a television programme to any home within a moderatly-sized country provided there is access to a simple receiving system in line-of-sight from the satellite.

The ITU plan for 12GHz

A broadcasting satellite conference held in Geneva in 1977 agreed a plan for ITU Region 1 (Europe/USSR/Africa) and Region 3 (Asia/Australasia), in which orbit positions and frequencies were assigned to prescribed beams covering each country (or sub-division of a large country). This plan will not only ensure the orderly development of satellite broadcasting itself, but will also help to avoid mutual interference problems with other services using the same frequency band, notably terrestrial microwave links. With a few exceptions, every country in Europe and Africa was assigned five frequency channels within the 11.7 to 12.5 GHz range. Polarisation (circular, clockwise or anticlockwise) was also specified. Each channel is suitable for a frequency-modulated television signal within a 27MHz bandwidth; the actual channel spacing was about 19.2MHz, giving 40 channels in all, but possible adjacent-channel as well as co-channel interference was allowed for in the plan. A regional conference to conduct a similar assignment plan for Region 2 (Americas) is due to take place in 1983.

In the 1977 plan a power was also specified for each transmission. This was derived on the basis of providing a power flux density of at least −103dB(W/m²), sufficient for good reception with an individual 0.9m diameter antenna, for 99% of the time in the worst month*. Fig. 1 gives the areas of coverage to this standard for the UK and Ireland. Fig. 2 gives some examples of coverage on the same basis for four other cases: France, Luxembourg, Monaco and the large beam that was allowed on certain channels to cover the four Nordic countries as a group. These figures assume ideal pointing of the satellite antenna; it is seen the coverage areas allow some latitude for pointing error (0.1° maximum is assumed). Considerable overlaps occur: for example, the French beam covers southern England, Switzerland and northern Italy.

One can also indicate over what area

*Power flux density figures can be converted into the more familiar field strength figures by subtracting them from 146. The result is then in dB relative to 1 microvolt per metre. Thus −103dB(W/m²) = 43dB(μV/m) = 140μV/m. – Ed.

Table 1: Channel assignments and orbit positions for countries of Western and Southern Europe

Orbit position	37° West	31° West	19° West	5% East
Lower half (11.7-12.1 GHz) Right-hand polarisation	San Marino 1,5,9,13,17 Lichtenstein 3,7,11,15,19	Ireland 2,6,10,14,18 United Kingdom 4,8,12,16,20	France 1,5,9,13,17 Luxembourg 3,7,11,15,19	Turkey 1,5,9,13,17 Greece 3,7,11,15,19
Upper half (12.1-12.5 GHz) Right-hand polarisation	Monaco 21,25,29,33,37 Vatican[1] 23,27,31,35,39	—	Belgium 21,25,29,33,37 Netherlands 23,27,31,35,39	Cyprus 21,25,29,33,37 Iceland[2] 23,27,31,35,39
Lower half (11.7-12.1 GHz) Left-hand polarisation	Andorra 4,8,12,16,20	Portugal[3] 3,7,11,15,19	West Germany 2,6,10,14,18 Austria 4,8,12,16,20	Finland 2,6,10 Norway 14,18 Sweden 4,8, Denmark 12,16,20
Upper half (12.1-12.5 GHz) Left-hand polarisation	—	Iceland 21,25,29,33,37 Spain[5] 23,27,31,35,39	Switzerland 22,26,30,34,38 Italy 24,28,32,36,40	Nordic[4] 22,24,26 28,30,32,36,40 Sweden 34 Norway 38

Notes

1. 0.6 degree beam except channel 23 which covers mainland Italy. 2. Covers Iceland, Azores and part of Greenland. Channels 27 and 35 registered under Denmark. 3. Same transmission channels also beamed to Azores (common programme). 4. Eight channels in a wide-beam covering Nordic countries; assigned to Finland (22, 26), Sweden (30, 40), Denmark (24, 36) and Norway (28, 32). 5. Same transmission channels also beamed to Canary Islands (common programme).

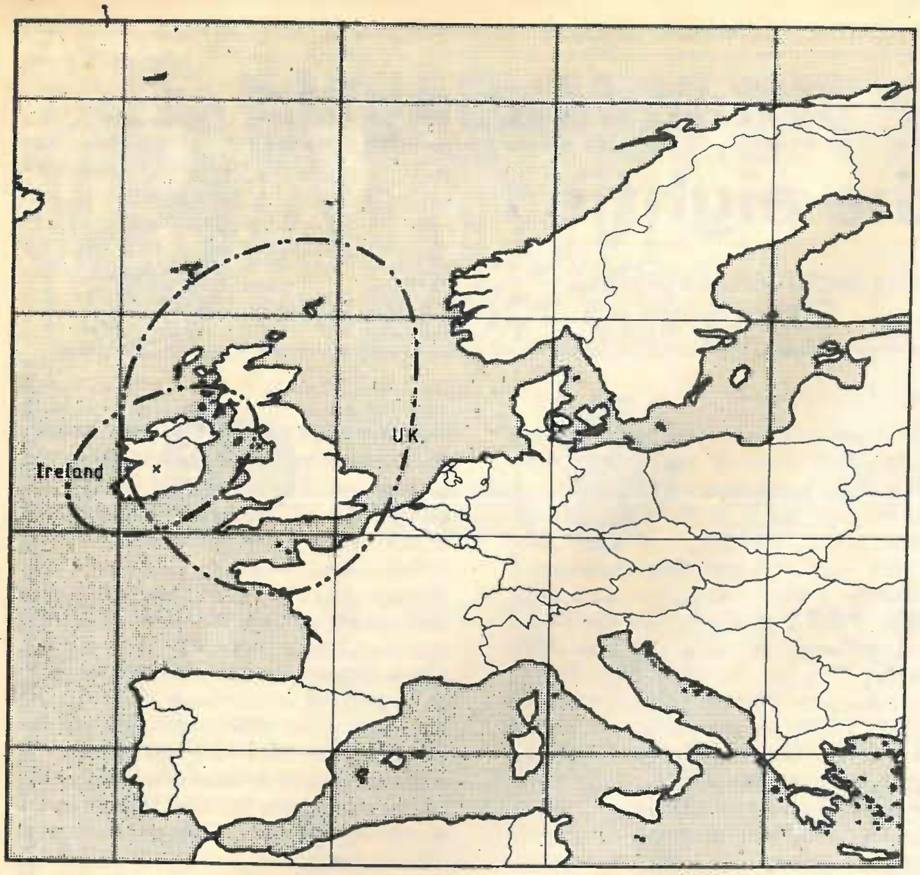

Fig. 1. Examples of coverage areas for individual reception in the UK and Ireland. Flux density is —103dB(W/m²).

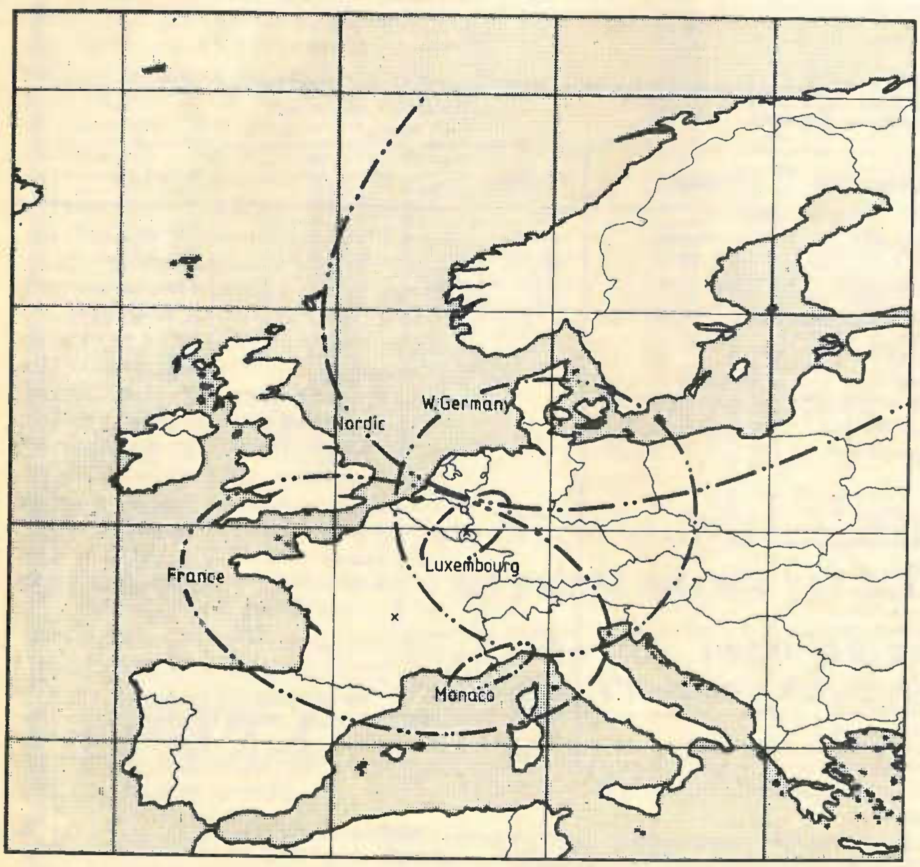

Fig. 2. Coverage areas for individual reception in W. Germany, France, Luxembourg, Monaco and the Nordic countries. Flux density is —103dB(W/m²).

a satisfactory signal can be received with a somewhat larger receiving antenna. For convenience we can take the —111dB(W/m²) flux density limit corresponding to the level indicated at the 1977 conference for reasonably noise-free community reception; this is illustrated in Figs. 3 and 4 for the same countries. In some areas this coverage may not extend to the limits shown because interference from other satellites, while planned to be negligible for individual reception within the country to which the transmissions are aimed, may be slightly disturbing near the limit shown for community reception.

A summary of the allocations for all countries in Western Europe is given in Table 1. Where possible, a definite request by a country to have the same orbit position as another country was met in the plan; this facilitates individual reception of transmissions of two or more neighbouring countries in border areas, where there may be common interests, cultures or language.

In order to bring out the factors which affect the ease of reception in any country of transmissions other than those intended for that country, the table distinguishes groups of channels according to polarisation and whether they are in the upper or lower half of the 11.7 to 12.5 GHz band. This is discussed later.

Satellite life and costs

Transmitters in the sky are no new thing. We have employed geostationary satellites for more than a decade to relay telephone traffic and television signals between continents. The powers of the transmitters on a satellite for this purpose are generally below 20 watts; they also beam their signals over large areas. As a result a very large receiving antenna is needed on the ground (e.g. a 30m diameter reflector to receive 4GHz signals) in such point-to-point links.

For broadcasting the available transmitter power is concentrated by beaming over the limited coverage areas, typically with a bandwidth of one degree for many European countries. A power of the order of 100-200 watts is then sufficient for individual reception with an antenna diameter of 0.9m.

The experiments in Canada and USA since 1976, with the CTS (Hermes satellite), have come closest to this concept and successfully demonstrated television reception with small terminals. The satellite employs a 200W repeater at 12GHz and the beam is about 2.5 degrees wide.

Two important points govern the costs of satellite systems. First, the reliability should be as high as that from current terrestrial services. Secondly, the satellite should remain accurately in its allocated position so that individual receiving antennae set up in fixed positions, pointing to the satellite, will remain effective. Because of orbitperturbing forces, station-keeping requires fairly frequent correction by gas jets on the satellite, and the quantity of fuel to operate these is the critical factor which governs the life of a satellite. A seven-year life is typical if a reasonable allocation of payload between the fuel and other essential items is made. Thus a reliable service requires a spare satellite in orbit and a third ready to be launched at any time, so the cost of making and launching a single satellite is not sufficient investment to provide a service for 10 or 20 years.

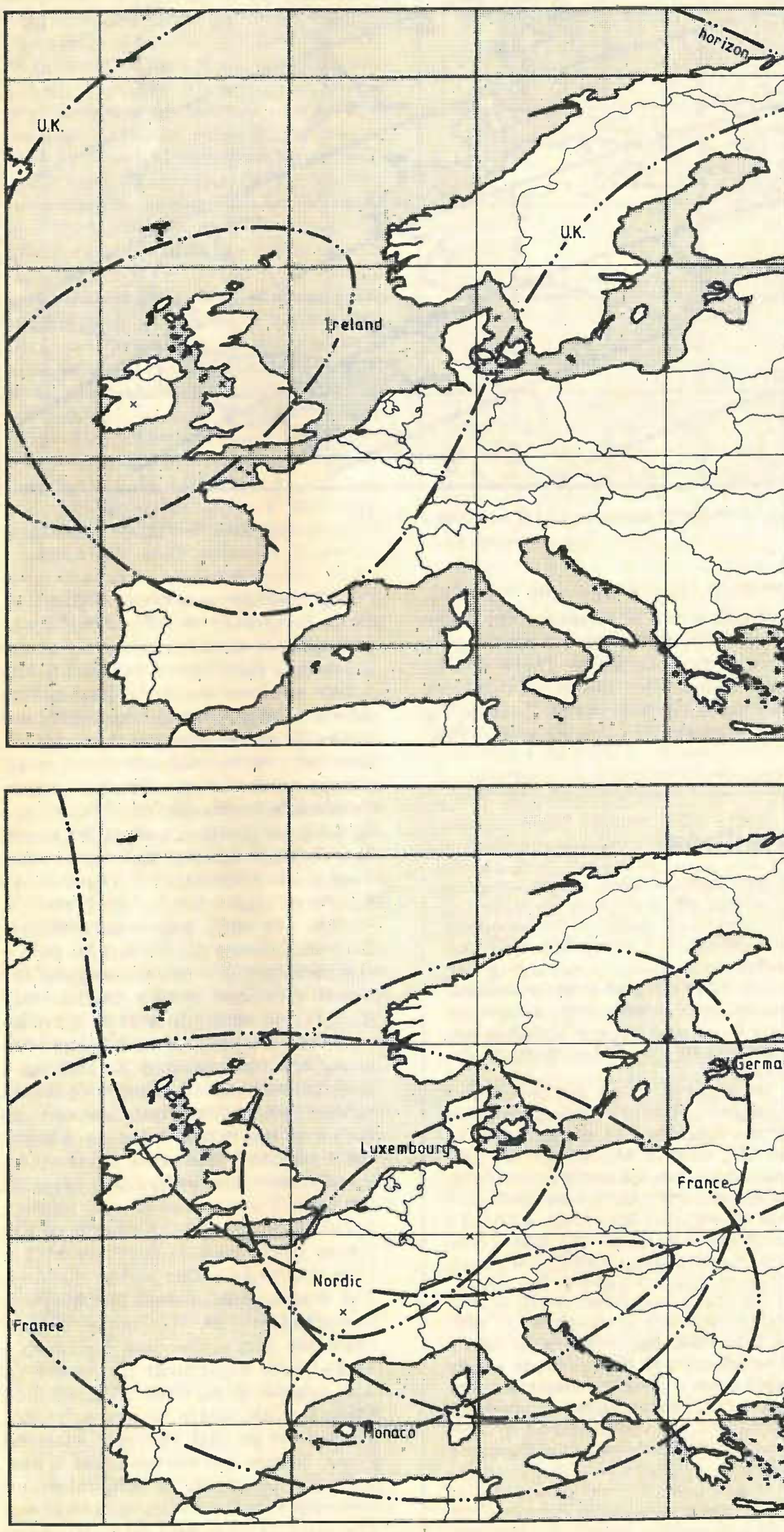

Fig. 3. Coverage area for reception on a larger antenna (1.8 to 2.0m diameter), for countries given in Figs. 1 and 2. Flux density is —111dB(W/m²).

For example, for 10 years' reliable service, allowance must be made for the provision and launching of five satellites. So if the cost of a satellite giving transmissions on four channels is £12 million, with a similar cost for launching, some £120 million is required over 10 years.[1] Nevertheless the cost of £3 million per annum per channel is actually less than total engineering cost to the broadcasters of providing a national service at u.h.f. by terrestrial transmitters. Of course, an overall national picture, taking into account the receiver cost, would show a somewhat greater total cost for a satellite system. National decisions to implement satellite broadcasting will have to take into account total costs but, if broadcasters' costs are not prohibitive, it is reasonable to expect that continuing development in receiver technology will provide receivers at a price acceptable to a steadily increasing proportion of the public.

The receiving antenna

For terrestrial television we are used to aerials which range from little more than the proverbial wet string near transmitters to large Yagis at the fringe which usually need mounting high up to get good signals.

Receiving antennae for domestic reception of satellite broadcasting signals, however, are uniformly sized because everyone will get a flux within the narrow limits of −100 to −103dB(W/m^2) according to the standard mentioned earlier. Also, the 12GHz signals are such that a clear line-of-sight is usually essential, but with the angles of arrival of satellite signals for the UK, as shown in Fig. 4, almost everyone can find somewhere on their premises that meets the requirements. This has in fact already been confirmed[2] by asking the occupiers of several hundred homes to observe shadows when the sun was shining at 3 p.m. British Summer Time in mid-October — this being a time when the sun has the same position in the sky for the UK as the assigned satellite position. The limited sample suggested that suitable sites for antennae could be found in 99.5% of cases. Furthermore in many, but not all, cases the most suitable site is low on the side of the house or on the ground rather than at roof level.

The requirement of a 0.9m diameter antenna is not a precise one. It depends on receiver noise performance, the available signal flux and the importance attached to a low-noise signal. As a guide, with the suggested antenna size, 8dB noise figure gives 14dB carrier-to-noise and a slightly noisy picture when the flux is just −103dB(W/m^2). Manufacturers' developments now suggest that noise figures of 5dB with a mixer first stage, or 4dB with a f.e.t. amplifier, will be obtainable at modest cost. Some allowance for pointing error and reduced antenna efficiency should be borne in mind when considering the likely performance of domestic equipment over a period of several years.

In order to exploit extensive frequency re-use in the 1977 plan, advantage was taken of the directivity of receiving antennae, corresponding to a 2 degree beamwidth (at −3dB) for a 0.9m dish. Antennae lined up on one satellite position have a poor response to signals from neighbouring positions. The plan used 6 degree spacing between adjacent allocated orbit positions, and at 6, 12 and 18 degrees respectively the antenna responses are assumed to be 20, 28 and 33 dB below the maximum. Furthermore it is assumed that in the direction of maximum response (i.e. for the same orbit position) the response to a signal with a polarisation opposite to that of the wanted signal is 20dB down. It is thus clear that an antenna, when set up for one orbit position, cannot be used by the viewer to receive from another. Receiver requirements are considered next, but clearly where a viewer in the UK wishes to receive transmissions planned for France or vice-versa, a first essential is either to have two antennae, or one that can be rocked between two carefully set-up aiming positions. Possibly, if there is a demand, some neater arrangement such as a single reflector with two feeds will be designed.

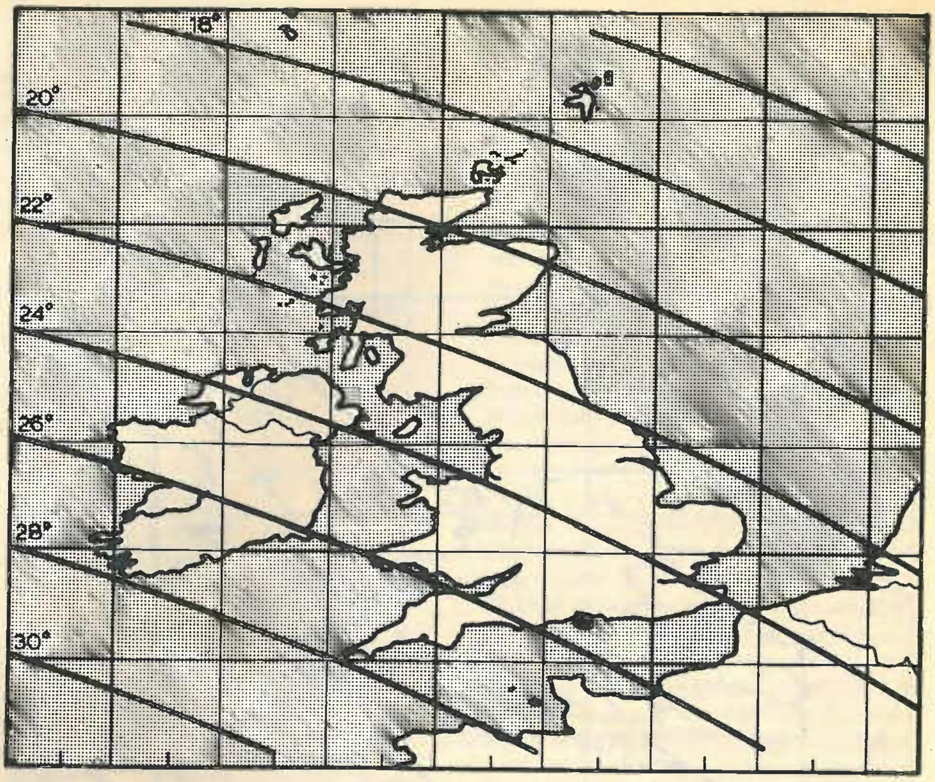

Fig. 4. Angle of elevation of UK satellite at 31°W.

Domestic receivers

The ITU plan, as seen from Table 1, calls for a tuning range of 400MHz to receive all channels of any one country, although it can be foreseen that, when several countries have begun using most of their channels, there will be some demand for means of receiving over the full 800MHz band. Considering the basic 400MHz receiving system first, it might well be as outlined in Fig. 5. A down-converter to 900-1300MHz is placed on, or adjacent to, the aerial and employs a fixed-tuned oscillator, and avoids a microwave down-lead (which would be either lossy or expensive) but leaves the actual tuning in the room set. Secondly, terrestrial television must continue to be catered for since, in the foreseeable future, this would continue as the most practical system for television networks giving regional or local programme variations. Thirdly, an f.m./a.m. converter is not featured. Rather, the early appearance of sets with dual tuners (i.e. a.m./f.m. television receivers) is to be encouraged if the benefit from the picture quality with direct f.m. demodulation is to be obtained. (A f.m./a.m. unit demodulating and remodulating for feeding a conventional television receiver would have three intermediate frequencies with a change to base-band, i.e. a quadruple superhet; this could be prone to interference and suffer a.m. system distortion.)

The basic set-up in the home of the future could well expand somewhat from this modest start as Fig. 6 shows. The system now extends the distribution of the 900-1300MHz signals to more than one room. The one containing audio/radio equipment now uses an a.m. television receiver with a video input facility, and a separate f.m.-to-video tuner so that interplay with the video cassette and television set is possible. The possibility of a digital sound multiplex in place of television on one of the satellite channels has also been anticipated. The assumption in this example is that the digital sound signal

UK's change of heart on satellites

In 1976 we reported that Britain's broadcasters were showing very little interest in the prospect of satellite broadcasting. Their general attitude seemed to be that the UK already had good coverage from terrestrial broadcasting and consequently there was little need for this new type of service. Since then they have shown a distinct change of heart. The BBC for example has stated that it proposes to take up two of the five satellite broadcasting channels allotted to the UK (see table in Dr Phillips's article), one for subscription television and the other carrying "the best programmes from BBC1 and BBC2." Thames Television's director of sales has publicly discussed the interest of the tv programme companies. The IBA, though somewhat less positive, have said that if a national decision is made to establish satellite broadcasting in the UK they would not stand aside.

The reasons for this volte-face are largely commercial. First there is the fear of losing British audiences and advertising revenue to competition from Continental satellite broadcasters — notably from those countries whose satellite coverage areas "overspill" onto the UK. Secondly, programme companies in Britain see opportunities to get revenue from advertisements broadcast into European countries by this means. In addition British space and electronics manufacturers see profitable markets in supplying the actual satellites and their associated ground equipment, and in seeking such business they are officially encouraged by the Department of Industry.

In response to all this the Home Secretary, who is of course responsible for the regulation of broadcasting in the UK, said in March that he had decided to launch a study of the implications of setting up a satellite broadcasting service by about 1985 — which would be the earliest practicable date — or by about 1990. The Home Office is now conducting this study, which covers technical, financial and resource matters, in consultation with the BBC, IBA, DoI, other government departments and organizations which might have a direct interest. It takes account of the Government's plans for the fourth television network. The results of the study, which will present the various options and their implications as a basis for making a decision on satellite broadcasting, are expected to be published at about the end of this year. — *WW staff.*

would be approximately within the normal video bandwidth and would frequency-modulate the transmission in the same way as for television.

A receiver for the international viewer can be considered with reference to Table 1. Here the situation may vary. Certain pairs of countries (UK and Ireland, France and Belgium, West Germany and Austria, for example) need no more than the basic receiver to see each other's programmes. In other cases the neighbour might have the other half of the 800MHz band, different polarisation, or both. A receiver to tune over 800MHz would be very convenient but could be difficult to design on the basis of a fixed oscillator and extending the range of the first intermediate frequency to 900-1700MHz. I would suggest a simple alternative: if the basic 400MHz units have a wide market and therefore reasonable cost, two such units could be attached to the antenna with two down-leads, each carrying 900-1300MHz, one for each half of the band. The receiver would have two input sockets and a two-way selector switch.

To change polarisation, a remotely-controlled switched-polarisation feed could be fitted at the antenna. However, with more than one television set in the home, this solution could frustrate independent choice of viewing. An alternative would be an 'orthogonal feed' from which the left- and right-handed polarisations could be simultaneously connected to two basic first frequency-changers, again using two down-leads. Elaborating further, some 19° West satellite viewers in favourable locations might want to receive most or all of the eight European national services. They would require four 400MHz units and four down-leads in order to cover both polarisations over an 800MHz bandwidth.

To complete the picture on the receiver design the u.h.f. tuner must be considered. This will select channels within the first i.f. range and the conventional approach would be to have a second, tunable, frequency-changer and a final i.f. in the region of 125MHz. Image rejection would be necessary in this tuner. A surface-acoustic-wave filter could be a good choice for the i.f. filter in front of the f.m. discriminator which has to operate with a 27MHz

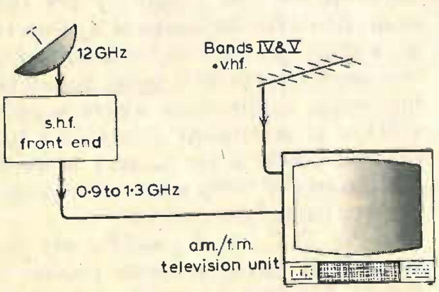

Fig. 5. Simple system with an a.m. / f.m. room television receiver unit.

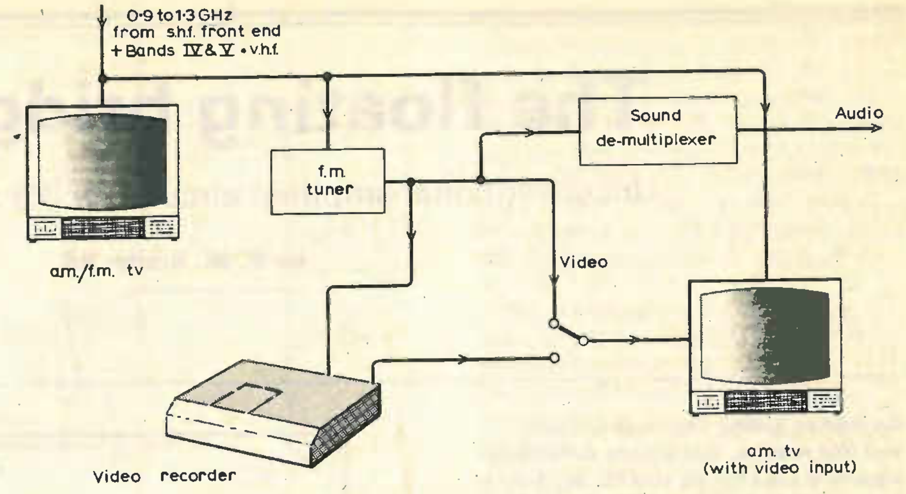

Fig. 6. Possible developments for unit video and unit aidio in the home.

bandwidth with low group-delay distortion. A less conventional approach, under study in France, is a phase-locked-loop f.m. demodulator which can operate directly on the required signal in the 900-1300MHz band and provide a video output directly.

The method of transmitting the television sound component in satellite broadcasting is under active study by the European Broadcasting Union. Although the starting point in 1977 was to consider a f.m. subcarrier compatible with the terrestrial system (e.g. a 6MHz subcarrier in the case of television Standard I, as used in the UK), serious consideration is being given to alternatives for enhancing the sytem to provide a pair of channels for stereo or second language. Digital modulation for the sound signal, which could give better quality and higher signal-to-noise ratio than is possible with analogue systems, is also being considered.

Feeder links (up links)

The system envisaged for a broadcasting satellite system is that a signal modulated to exactly the same standard as the downcoming transmission should be sent up to the satellite. This allows the satellite to be designed as a frequency-translating relay. The detailed assignments, or even the choice of the frequency band, for the up-links or feeder links were not dealt with at the 1977 conference because priority was given to attaining an agreed down-link plan. Studies having established that a bandwidth at least as great as the down-link broadcasting band would be essential, the 1979 World Administrative Radio Conference was able to allocate for world-wide use the band 17.3 to 18.1GHz for feeder links to broadcasting satellites transmitting in the 12GHz band. In limited geographical areas, alternative frequencies have also been allocated for feeder link use, if required, including the 10.7 to 11.7GHz band in the European area.

Although interim arrangements can easily be made at early stages when the band is relatively uncrowded, it is agreed that a detailed assignment plan for feeder links should be made and the expectation in the case of Regions 1 and 3 is that the frequency channelling and assignments could, as a starting point, be a carbon copy of the down-link plan translated from 11.7-12.5GHz to 17.3-18.1GHz. One advantage would be a constant frequency change of 5.6GHz for all transponders, which would lead to some economies in design. If changes or adjustments had to be made to the assigned frequencies, they could be made without enormous repercussions (as would be the case in attempting to change the closely interwoven down-link plan). This is because up-link antennae at Earth stations are expected to be so directional that the choice of frequencies for transmissions aimed at one satellite would have little effect on the choice for transmissions aimed at other orbital positions. The main task is to agree on a series of mini-plans, each acceptable to a group of countries assigned to one orbit position, but with an overall check on the effect on other orbit positions. An ITU conference to be held in 1983 for planning down-links in Region 2 will also be asked to consider detailed feeder link planning for the same region. It is not yet decided whether the conference needed for feeder link assignments in Regions 1 and 3 will take place at the same time or later.

To be continued

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The floating bridge — 2

Unconventional amplifier circuits for 15 and 200 watts

by R. M. Brady, BA

As well as giving practical circuits and test results, this article describes a general plan for A_1 and for A_2 which makes full use of the unique way in which these circuits may be simplified. In particular by using an i.c. which is able to control A_1 without loss of performance, and by exploiting the fact that A_2 need be made only to poor performance specifications. It also takes a further, more quantitative, step in distortion analysis. The unconventional approach to these circuits, was outlined in the first part of this article, September issue.

A design for A_1 which uses a B-type feedback loop with the simplest earthing system is shown in Fig. 11, and although the following analysis is based on this circuit, it applies equally well to A-type bridges, and to circuits incorporating a change-of-origin device. P_1 is a high voltage-gain i.c., and EF_1 is what would conventionally be called an emitter follower, containing the power transistors. C and D are points which are kept at a constant potential with respect to earth by C_1 and C_2, and they act as power supply points for P_1*. Impedances Z_1, Z_2, Z_3 and Z_4 are part of the feedback loops of the circuit.

Closer inspection of the circuit shows that EF_1 is arranged in an A-type feedback loop, and its complex voltage gain is Z_4/Z_3 (not unity, so that "emitter follower" is probably a misleading name for this part of the amplifier). It is this ability to extract voltage gain from EP_1 which makes this circuit uniquely suited to be controlled by an i.c. — it may be arranged that the voltage gain demanded of the i.c. is around unity, so that a high bandwidth may be obtained.

If G is the gain of the i.c., and if Z_3 and Z_4 are small enough that the gain of the emitter follower approximates to Z_4/Z_3, then the open-loop gain of the whole amplifier becomes

$$\frac{GZ_4Z_1}{Z_3(Z_2+Z_1)}$$

In the actual circuits. described later, $Z_3/Z_4 = Z_1/(Z_1+Z_2)$, so that this expression reduces to G **. The 741 amplifier is used and as this is frequency compensated the whole amplifier is stable. Fig. 12 shows the loop gain of the 741 amplifier as a function of frequency.

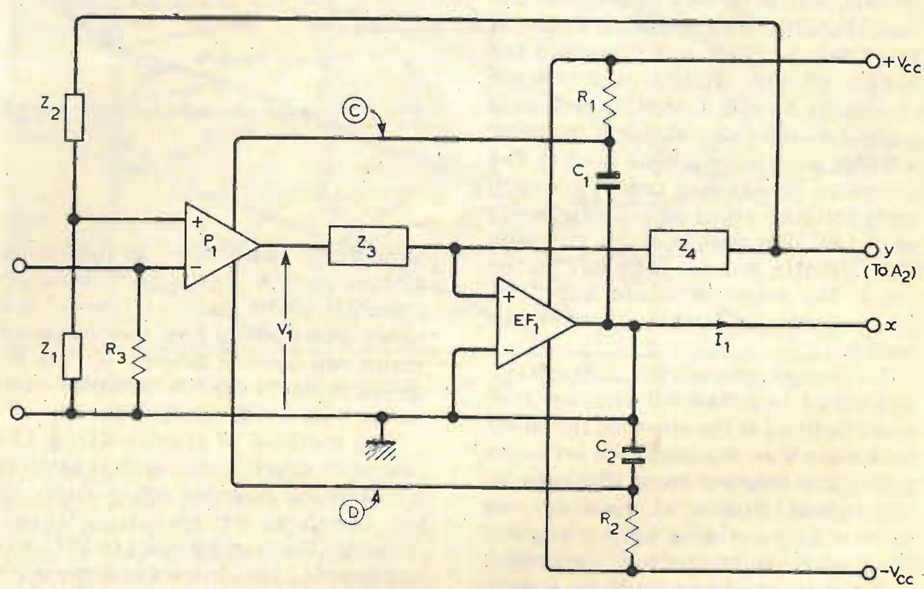

Fig. 11. Circuit for amplifier A_1 based on version B. Z_1, Z_2 and R_3 are part of the feedback loop of Fig. 5 with $Z_1 = R_1C_4$, $Z_2 = R_2$, $R_3 = R_5$. EF_1 is arranged in an A-type feedback loop with voltage gain Z_4/Z_3 so only low voltage swings are needed in the operational amplifier P_1.

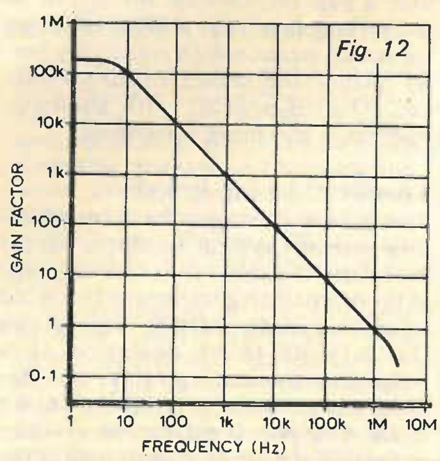

Fig. 12

To quantify the coupling between A_2 and A_1, imagine that A_2 produces a distortion signal of V volts. At low frequencies this couples into A_1, largely via the extra current $2V/R_1$ which is injected into point x through R_1 and R_2 ($R_1 = R_2$). If the impedance of the emitter follower (V_1/I_1) in Fig. 11 is Z, and the loop gain of P_1 is G, then this current results in a distortion voltage across y-x of

$$\frac{2VZ(Z_1+Z_2)}{R_1GZ_1}$$

Taking typical values of $Z = 0.1$ ohm, $(Z_2 + Z_1)/Z_1 = 30$, and $R_1 = 220$ohm the distortion coupling is around $3/G$ per-cent at low frequencies. Inspection of Fig. 12 shows that this coupling is hardly worth considering. At high frequencies, the value of $(Z_2 + Z_1/Z_1$ falls, to some extent counteracting the fall in gain of the i.c., and also the distortion produced by A_2 diminishes because of the low response cut-off of this amplifier.

Cheapness and simplicity are the main criteria for the design of A_2. Figs 13 & 14 show two alternative designs for this amplifier, the first being suited to low-power applications where supply voltage is accurately controlled for example where a car battery is used, and the second being a little more complicated but far more robust.

In Fig. 13 C_1, R_1, C_2 and R_2 are the same components as those shown in Fig. 11 Resistors R_3 and R_4 are set so

*C is the "semi-stabilized" voltage point referred to in part 1.

** The actual situatiuon is a more complicated, but this analysis is a good approximation.

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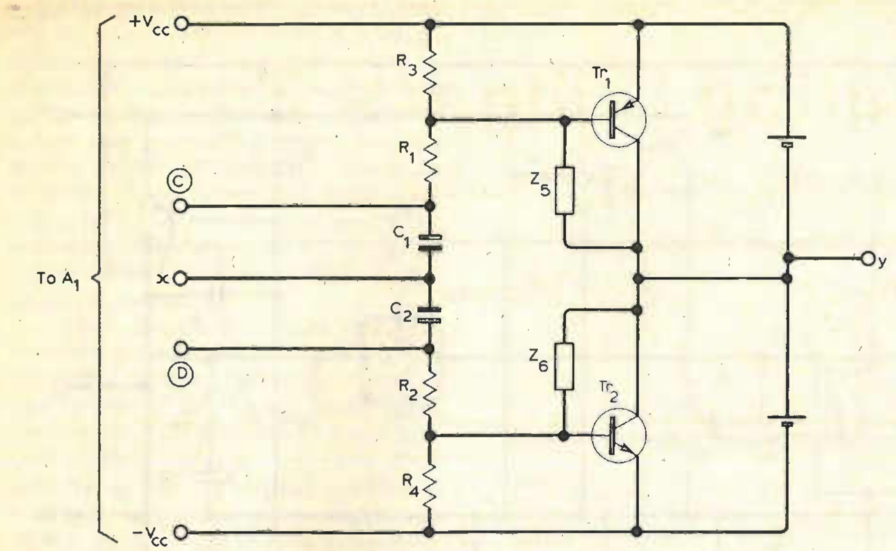


Fig. 13. Simple design for A_2 — cutting all corners because distortion in this amplifier does not affect the output. So that $y = -x$. Gain should be about -1 and is $Z_5/R_1 = Z_6/R_2$. At high frequencies, the gain must fall and so a capacitor is included in each of Z_5 and Z_6. Components C_1, C_2, R_1 and R_2 are needed for A_1 also and so serve a double purpose.

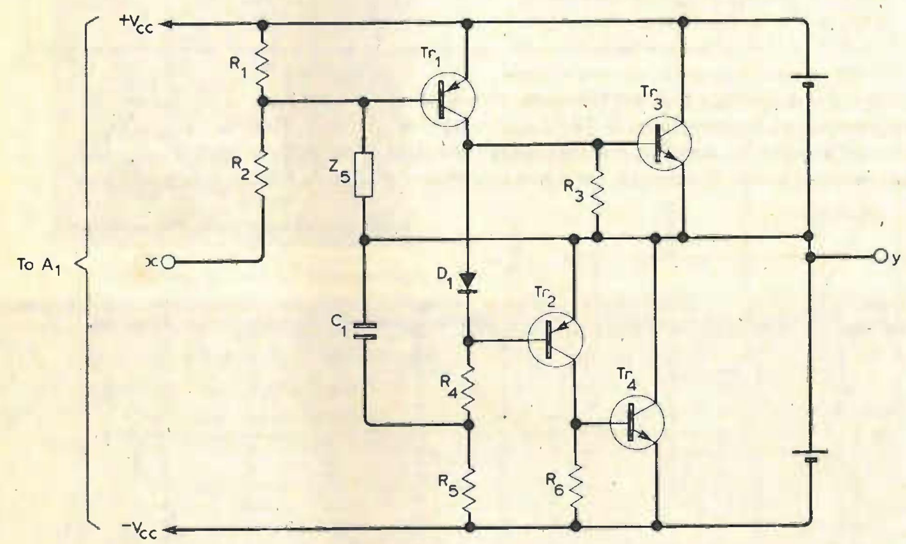
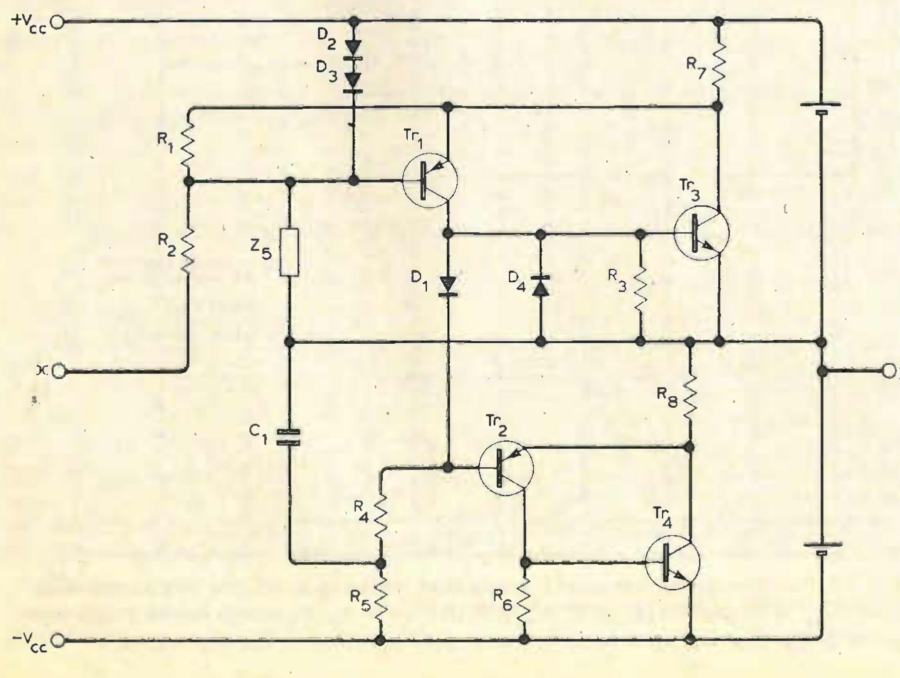


Fig. 14. High power design for A_2. This is a more conventional design, with gain Z_5/R_2.



that in the quiescent state Tr_1 and Tr_2 are only just turned on (one of R_3 and R_4 may be a preset if desired). As x rises with respect to point A, C_1 and C_2 pull C and D up with it, thus switching off Tr_1 and switching on Tr_2, so that y falls. The gain of A_2 is $(y-A)/(x-A)$ and is a little less than Z_6/R_2; it is arranged to fall off at around 5 to 10kHz where full power output is not required from A_1.

Fig. 14 shows an emitter follower version which is controlled by Tr_1 so that the gain is Z_5/R_2. To prevent large distortion at low signal levels due to effects at the crossover point, R_3 is included.

A large open-loop gain is made possible by low values of Z_5 and R_2, so that Tr_1 and R_3 are capable of helping substantially at the crossover point.

Fig. 15 shows this circuit with current protection incorporated. When Tr_1 and Tr_3 are conducting, a voltage is showed across R_7 which is proportional to the current flowing. When this voltage becomes about 0.6V D_3 and D_2 conduct, preventing large currents from passing through Tr_3; a similar mechanism around D_1 and D_4 protects the Tr_2-Tr_4 pair. If desired, more accurate control may be obtained by inserting a p-n-p silicon transistor in place of D_2 and D_3, with its emitter to the + supply, its collector to the base of Tr_1 and its base to the emitter of Tr_1; and a second in a similar configuration around Tr_2.

12 volt 15 watt amplifier

A circuit for a type-B bridge amplifier which is suitable for operation using a 12 volt power supply is given in Fig. 16. Comparing this with Fig. 11 components R_1 and C_1, R_3 and C_2, R_4*, and R_5 and C_3 are represented by Z_1, Z_2, Z_3 and Z_4 in the block diagram representation. Transistors 2 to 5 are represented by EF_1, and C_4, C_5, R_9 and R_{10} have their counterparts in C_1, C_2, R_1 and R_2. Capacitors 6 & 7 are represented in Fig. 13 by Z_5 and Z_6. The circuit shown differs from the plan in that Z_5 and Z_6 are largely reactive, so that at low frequencies the gain of A_2 is dictated mostly by the current gain of Tr_6 and Tr_7. Notice P_1 is being operated with a low supply voltage, so that a potentiometer is needed to control the

* In series with the output impedance of P1 which is about 75 ohms.

Fig. 15. High power design for A_2 with current protection. This protects both amplifiers A_1 and A_2, but it is easier to put current protection into A_2 as quality output is not required from this amplifier. Current must pass through R_7 — if too much passes D_2 and D_3 conduct switching off the drive, or through R_8 — when D_4 and D_1 conduct it too much passes.

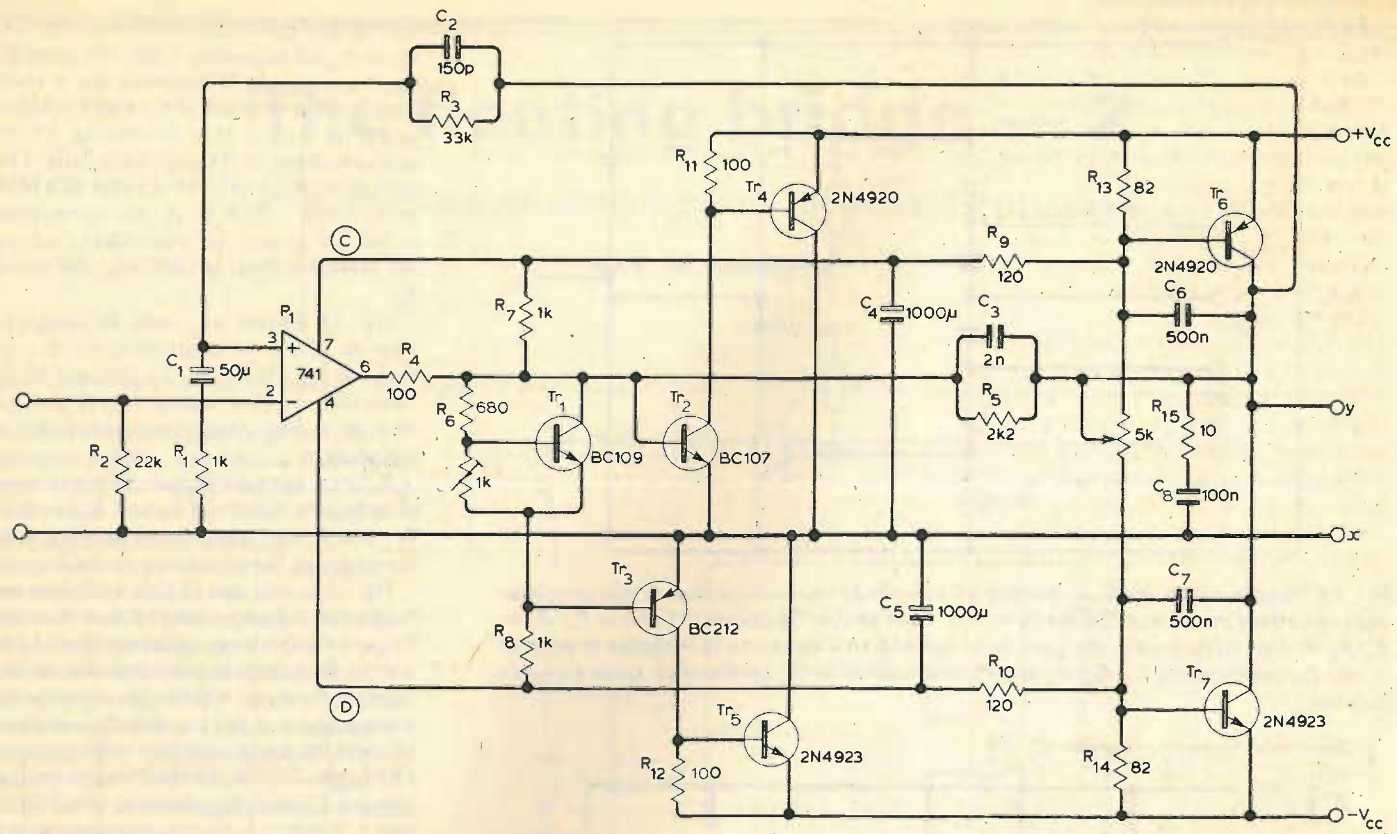


Fig. 16. 12-volt version of the floating bridge gives 12 watts output, distortion-free, into 4 ohms; more power is available if a lower impedance loudspeaker is used. High quality amplifier A_1 comprises a 741 i.c. driving the "emitter follower" stage Tr_2 and Tr_3, gain R_3/R_1. Low-quality amplifier A_2 is based around Tr_6 and Tr_7. Potentiometer is adjusted until the output voltage y is half way between the supply rail voltages in the quiescent state. If a supply voltage other than 12 volts is used R_{13} and R_{14} may need adjustment.

quiescent value of y accurately. Components R_{15} and C_8 are included to by-pass inductive loads.

A computer analysis of the response of this amplifier is shown in Fig. 17 in which G is the signal gain, stretching across the whole audio bandwidth. It is dangerous to attempt to restrict this response because the loop gain L is already falling at 6dB per octave and so any interference would almost certainly result in instability. Also on this graph is the calculated A_2 rejection factor, which does not fall below 55dB hence distortion induced in the output by A_2 is negligible. The distortion to be expected of this amplifier at medium signal levels is discussed in the appendix. The performance to be expected of the amplifier at high and very low signal levels is not very different from that discussed here.

Fig. 18 shows a change of origin suitable for this amplifier; in the circuit tested it was mounted on the same board as the main amplifier, though this is not necessary. Point F is suitable for use as a power supply point for a pre-amp, though this may need slight modification if the pre-amp takes significant current. If a positive earth is to be used, the change of origin may be modified by changing Tr_{101} and Tr_{102} for similar p-n-p devices e.g. BC212, point C for point D, and +12V supply for −12V supply, so that the input signal is now compared to the + rail.

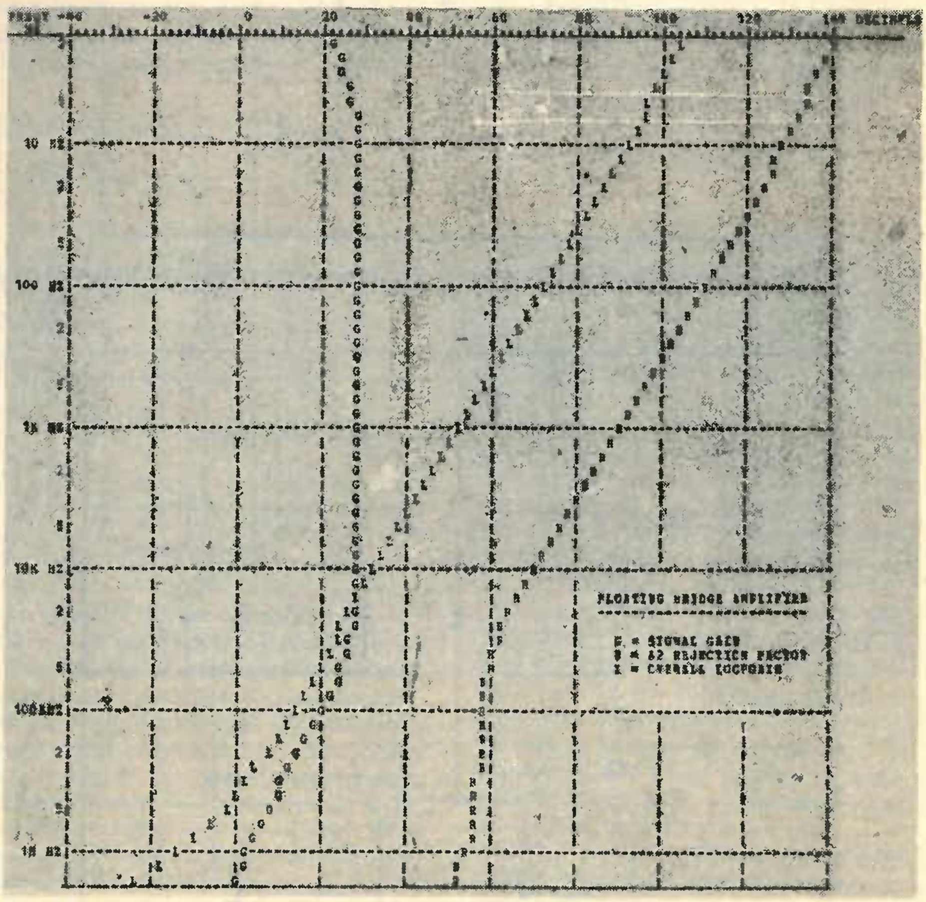


Fig. 17. Predicted performance of the amplifier, showing open-loop and closed-loop gain of A_1, and rejection factor of A_1, to distortion in A_2. Rejection factor is very high, showing that A_2 can indeed be of very poor quality without affecting output.

Before switching on for the first time, set the preset resistor to its maximum resistance, and set the potentiometer to the middle of its resistance range. When power has been switched on, adjust the pot so that $x=Y=V/2$ where V is the power supply voltage. Now insert an ammeter in the power rail, and adjust the preset until the current begins to increase rapidly as it is turned, and then adjust back a little. The amplifier is now ready for operation.

If the change of origin is to be mounted on a separate board, use the following screening system. Connect the screen of the coaxial lead from pre-amp to main amplifier to point x at the amplifier end only; leave the other end flying. (If convenient provide a track in the pre-amp to which the screen may be physically mounted). This cable is at x potential, so keep it well away from the sensitive components of the pre-amp.

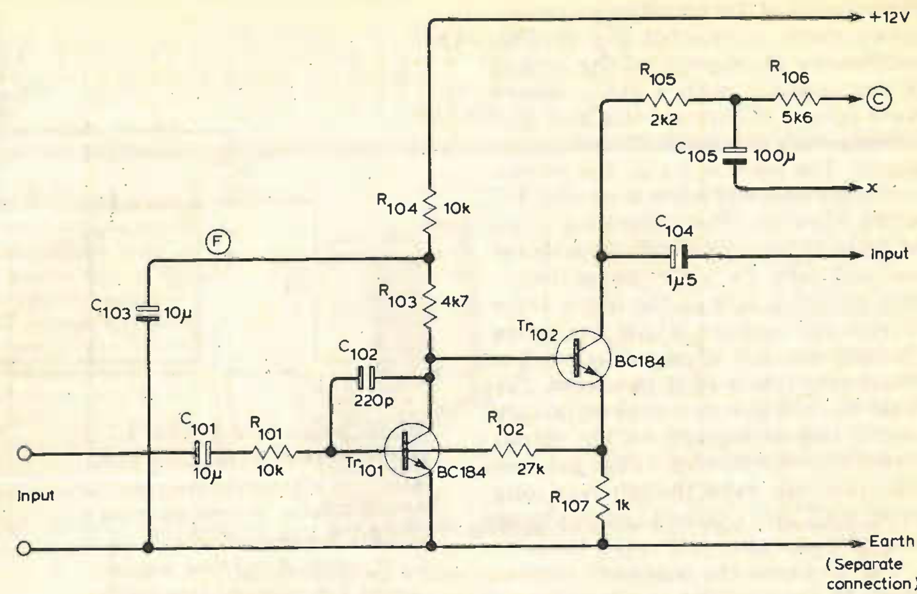


Fig. 18. Practical circuit for a "change of origin" for the 12 volt amplifier allows earth to be connected to the negative power rail. If a positive earth is required, use BC212 for Tr_{101} and Tr_{102} and replace point C by point D, so that a "mirror image" may be built.

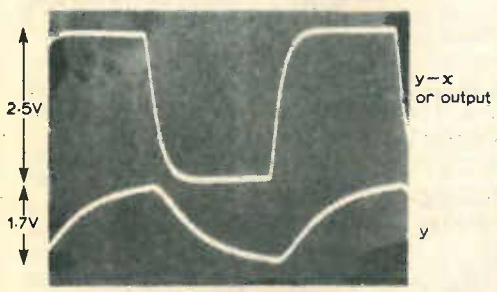
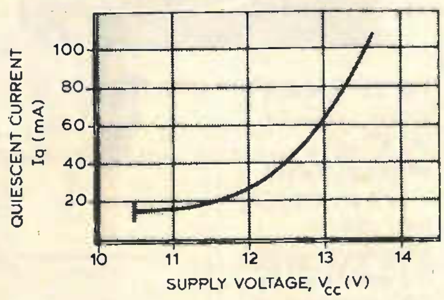


Fig. 19. Response of the 12 volt version to a 3kHz square wave input. Upper trace shows the 30kHz cutoff due to C_2 in Fig. 15. Lower trace is the output of the poor quality amplifier. A_2 showing cutoff at about 5kHz. Note that the output, y—x, is decoupled from the A_2 output, y.

Fig. 20. Quiescent current through the 12 volt version of the floating bridge as a function of supply voltage. If a supply other than 12 volts is used, or if the transistors are liable to become hot, resistors R_{13} and R_{14} which control the quiescent current through A_2 should be altered accordingly.



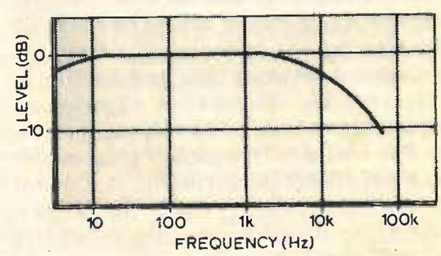


Fig. 21. Signal response of the A_2 amplifier as a function of frequency.

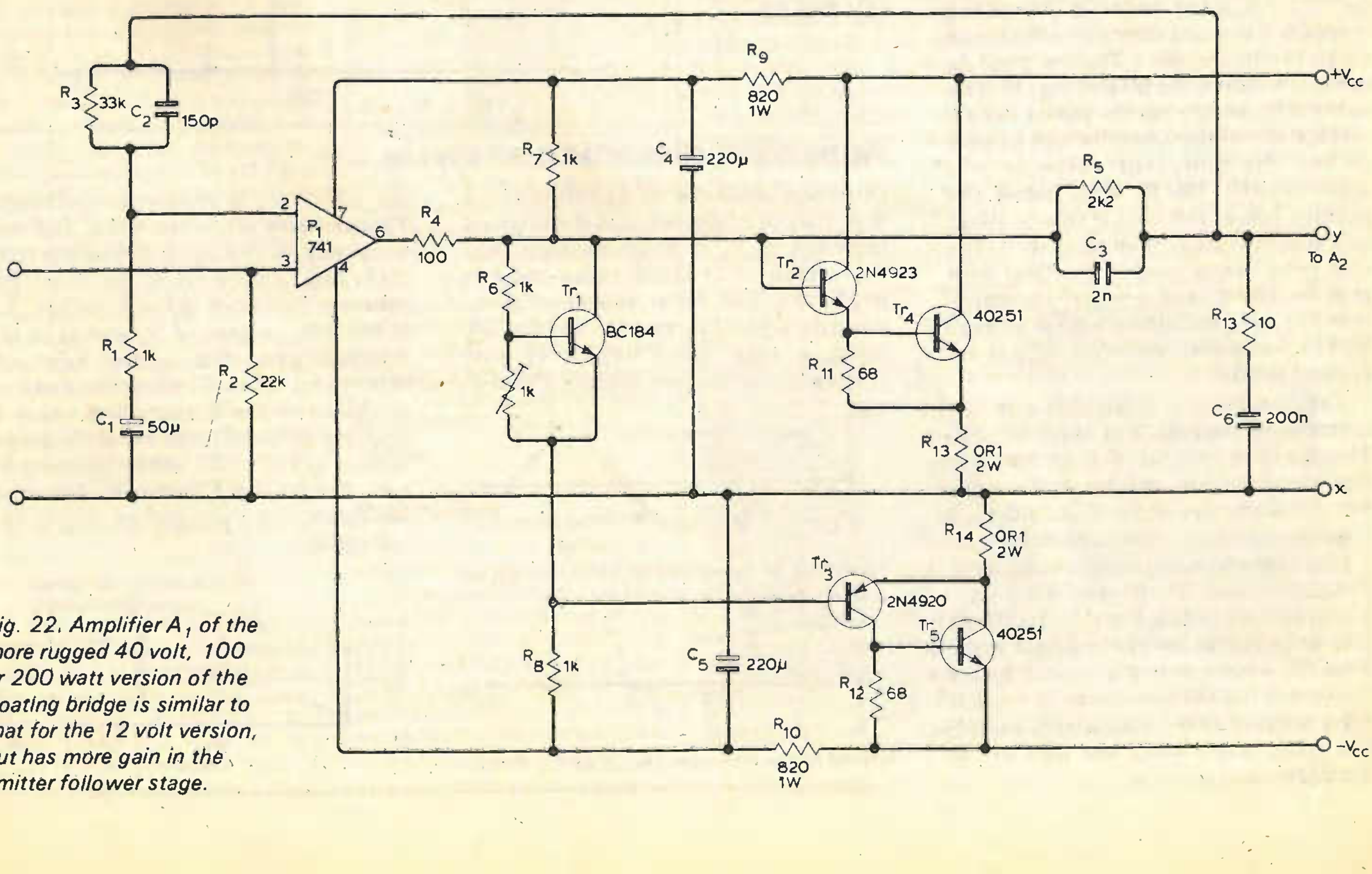


Fig. 22. Amplifier A_1 of the more rugged 40 volt, 100 or 200 watt version of the floating bridge is similar to that for the 12 volt version, but has more gain in the emitter follower stage.

Performance of this amplifier under test is very much as predicted. Fig. 19 is an oscilloscope photograph of the output of the amplifier with a 3kHz square wave input, a 16-ohm resistive load, and an accurately controlled 12 volt power supply. Top trace is y-x or the output across the load, and below is a trace of y, or the A_2 output. The integrating times of these traces correspond to 20kHz for y-x, and 5kHz for y. Crossover distortion is clearly seen in the lower trace (crossover occurs when y-x goes through zero, not when y does so), but this does not show up in the upper. The high A_2 rejection factor is strikingly seen in this photograph, for the output remains horizontal after A_1 has got over the transient, even though A_2's long integrating time constant causes y to be changing at a great rate at this time.

Fig. 20 shows the quiescent current taken by the amplifier as a function of supply voltage. Below 10.5 volts the i.c. becomes unstable and low frequency oscillation sets in, whereas above 13.5 volts A_2 begins to take an unacceptable current. (This may of course be changed by altering the value of the resistors connected between base and emitter of Tr_6 and Tr_7. The i.c. is capable of operating with up to 30 volt supply.)

The measured frequency response of the amplifier is shown in Fig. 21. Cut-off at the high frequency end of the range is didctated mostly by the characteristics of the change of origin device, and these are fairly "safe" if changed.

40 Volt 200 Watt amplifier

A 40-volt amplifier design is suitable for high power applications, and is capable of driving an eight-ohm load at 100 watts or four-ohm load at 200 watts, with high fidelity performance. The circuit for A_1 is shown in Fig. 22 and the feedback loops are identical with those in the 12 volt amplifier. The design of A_2 in Fig. 23 follows the plan of Fig. 15. The value of R_3 determines the power supply voltage which the amplifier will be able to use: the quiescent value of y is approximately $190/R_3$ volts below the positive power rail, and if this is about half supply voltage then all is well. The change of origin used is identical with that for the 12-volt circuit, excepting that Tr_{102} is replaced by a higher voltage BC147 transistor; and that R_{104} is increased to 27kΩ.

The distortion analysis given in the appendix is valid for this amplifier also Though finer control of the crossover region may be had because of the emitter resistors. Tr_4 is now included in possible sources of crossover distortion.

Fig. 24 is an oscilloscope photograph of the response of this amplifier to a 3 kHz square wave input. Hideous crossover distortion in the lower trace does not couple into the signal across the load. A further point to notice is that the y signal is more accurately controlled, being very closely one half of the y-x signal. □

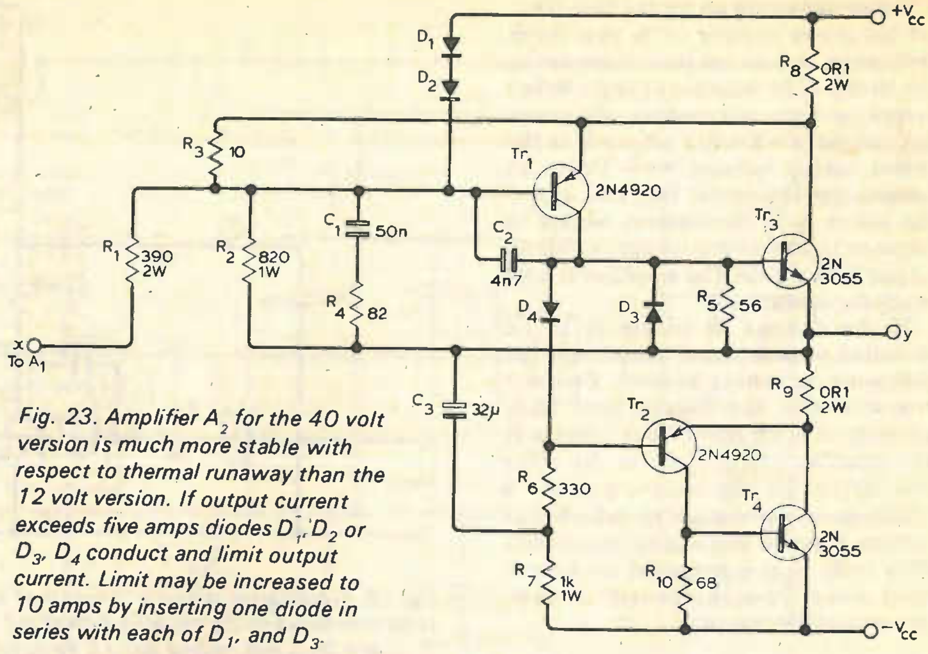
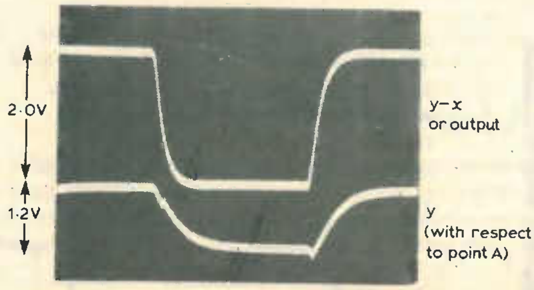
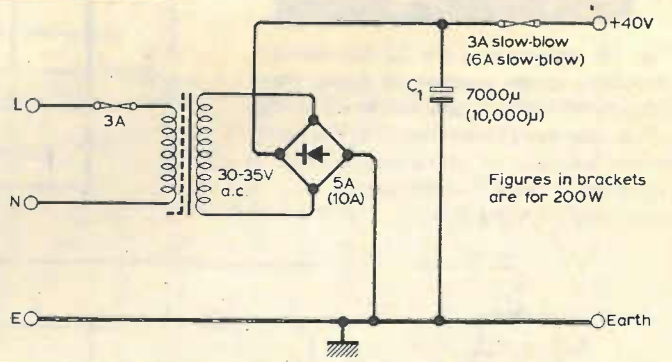


Fig. 23. Amplifier A_2 for the 40 volt version is much more stable with respect to thermal runaway than the 12 volt version. If output current exceeds five amps diodes D_1, D_2 or D_3, D_4 conduct and limit output current. Limit may be increased to 10 amps by inserting one diode in series with each of D_1, and D_3.



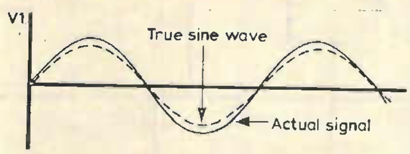
◀ Fig. 24. Response of the 40 volt version to 3kHz square wave input. Upper trace is the output, y—x, and appears to be distortion-free despite the very bad crossover distortion in the output y of amplifier A_2 (lower trace).

Fig. 25. Suitable ▶ power supply for the 40 volt amplifier. Values shown are for 100 watt version; alternative values in brackets are for 200 watt use.

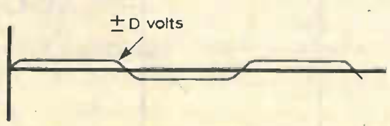


Appendix: distortion analysis

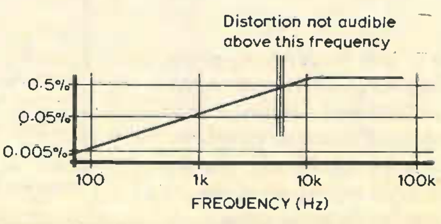
Distortion produced by A_2 and induced in A_1 may be neglected, and the internal feedback in P_1 is large enough that distortion of $D\ G/3P$ volts peak is neglected. The main source of nonlinearity is the EF_1 system, see Fig. 11. With a sine wave input at low frequency, V_1 will look typically like:



This may be regarded as the sine wave plus an extra:



which is the voltage required to drive the EF_1 if Z_4 is removed. Its major Fourier harmonic is the third, and this has a peak magnitude of a little less than D/3. This component is the dominant source of distortion in the amplifier. If P is the voltage gain of P_1 and G is the amplifier gain, then a third harmonic distortion of $D\ G/3P$ volts peak is produced at the output. The value D depends on the adjustment of the preset resistor in Fig. 16 but will be typically 0.1 volt. The resulting harmonic distortion for a pure sine wave and an output of 5 volts peak is:



NEW PRODUCTS

New computer products

The fourth Microcomputer show, which this year moved to the Wembley Conference Centre, attracted 52 exhibitors and increased the attendance by 500 to 8,500 over three days. Although the show specializes in small business systems and personal computers, James Scott Electronic Developments reported a sale of v.d.us, worth around £½ million, to a German client. Comart were demonstrating a North Star Horizon hard-disk system which provides 18M bytes, expandable to 72M bytes, of storage on a 14in Winchester disk/drive. The Byte shop, now a subsidiary of Comart, announced a Prestel board which uses their own software to create Prestel compatible colour displays that can be stored, edited and transmitted.

A new serial printer from Mannesmann Tally features a print mechanism and print head which are claimed to offer a double life of 200 million characters. The printer, type MT1602, looks like the T1602 but offers improved performance. A microprocessor selects the shortest print path and accelerates the head across blank spaces to provide a printing speed of about 160 c.p.s.

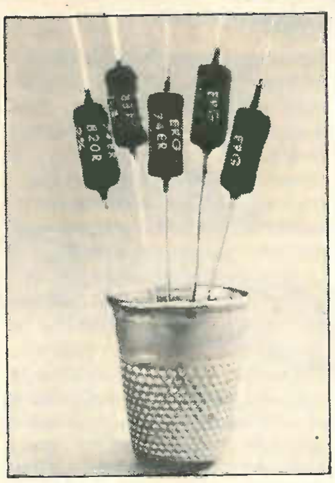
Micro byte's new "stereo S100 sound computer board" is an interesting add-on for the hobbyist. This card uses two AY-3-8910 sound i.cs which accommodate three tone channels, three amplitude controls, a noise generator, a 16-bit envelope period control, two parallel I/O ports and three d-to-a converters. The card is supplied in kit form with four parallel I/O ports, two amplifiers and a prototyping area. A 60 page manual supplements the card, and Basic and assembly language programming examples are provided.

A single-board computer kit was also announced by Micro byte, who expect deliveries to start in September. The board comprises a Z80 operating under CP/M, 64K of r.a.m., one floppy-disk controller, serial and parallel ports, and a 24×80 v.d.u. Very little literature was available at the show, but the advertised price of £395 + v.a.t. makes it worth investigating.

BMG Microsystems, a wholly British computer company, has developed a production management system, based on their MS5000 microcomputer, for scheduling and cost control. BMG say that the system provides small and medium sized engineering companies with a versatile tool that is easy to use and does not require computer expertise. The standard system uses an 8in floppy-disk and a single v.d.u., but this can be expanded to include several v.d.us and up to 20M bytes of exchangeable disk storage. The makers are currently working on the implementation of a 16-bit processor and larger disk capacities.

Miniature power resistors

Wirewound resistors of small physical size, yet with good surge capabilities and power ratings up to 3W at 20°C, are introduced by Erg Components. With features such as an all welded construction for good reliability, a black silicone resin coating and a temperature coefficient of typically



60 p.p.m./°C for values above 1Ω, the Erg 74ER series is said to fill in a gap between metal-oxide and vitreous enamel w.w. type resistors. Their performance complies to BSE 9114 N001, and they measure 11.8mm long with a diameter of 5.25mm. Resistance values down to 30milliohm are available. Erg Industrial Corporation Ltd, Luton Rd, Dunstable, Bedfordshire LU5 4LJ.

WW301

Btu meter

A portable infrared sensing device, the Thermoflow, which enables the measurement of heat losses and gains without actual contact, is now available from Unity Power Systems. A large digital display gives a direct readout in Btu/ft²h when the unit is pointed at the source, making it a

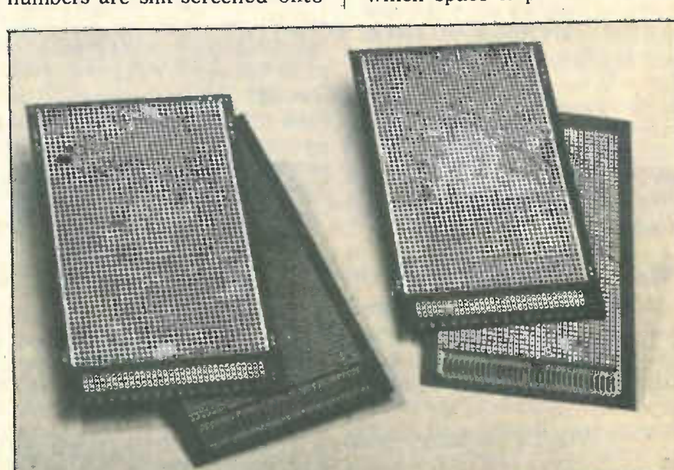
simple matter to determine heat flow over a certain period of time. Two modes of operation, selected by means of a trigger switch, enable either the checking of heat losses from steam, pipes, walls, windows etc, or the checking of heat loading from such items as lighting units and electronic appliances. Features are battery operation, automatic ambient temperature compensation and an 8-14 micron filter which eliminates potential errors due to water vapour, carbon dioxide, sky radiance and reflected sunlight. The instrument is supplied complete with carrying case, weighs about 1kg and costs in the region of £600. Unity Power Systems, Pembroke House, 44 Wellesly Rd, Croydon, Surrey CR9 2BU.

WW302

Eurocard boards

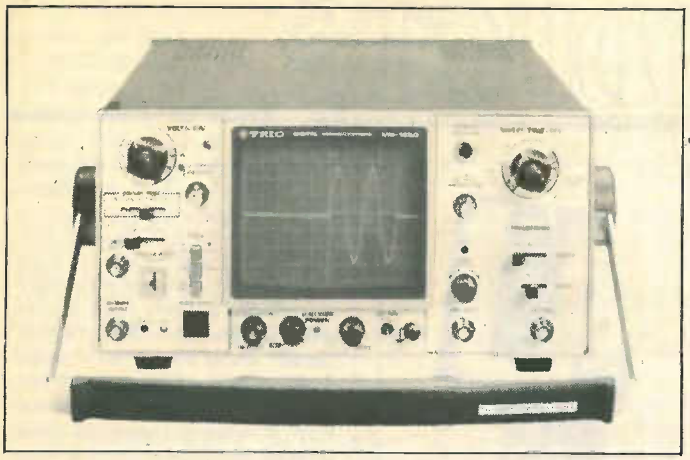
Extensions to Vero Electronics Ltd's Eurocard range have been made to include fully pierced Veroboards, which are available with or without maximum copper colander ground planes. Positions are provided for linking directly to board or pins from connectors, and either soldering or wire-wrapping techniques can be used for wiring. Grid reference numbers are silk-screened onto the component side for the convenience of the user, and their size makes them compatible with subracks to DIN 41494, IEC 297 and SC 48D specifications. Also introduced are single-height, square-pad boards with maximum copper colander ground planes. These boards have been designed primarily to accommodate wire-wrap sockets. With holes accurately positioned on a 2.54mm matrix, they will accept any size of integrated circuit. Vero Electronics Ltd, Industrial Estate, Chandlers Ford, Eastleigh, Hampshire SO5 3ZR.

WW303



Digital storage oscilloscope

Storage of waveforms in a digital memory of 8-bit × 1024-word capacity is the main feature of the MS-1650 oscilloscope from Trio, which, when used as an ordinary oscilloscope, has a frequency bandwidth of zero to 10MHz, and an input sensitivity of 10mV/div. Maximum write speed is 1μs/word, and analogue input signals may be sampled at any time, converted into 8-bit digital signals by an a.-to-d. converter, and then stored temporarily in the memory. The stored signal may be displayed immediately on the oscilloscope screen, or used to drive a pen recorder via the memory output. Ability to store the signal generated prior to the trigger pulse, facilitates the storage and display of one-shot, transient and repeated signals, and simultaneous display of stored and real-time waveforms, which may also be overlapped, enables comparisons to be made. Retention of the memory data when the power is removed, is possible by means of an optional NiCad battery for which space is provided inside



the cabinet. The MS-1650 incorporates a 118×98mm c.r.t., weighs only 9kg, measures 284×138×400mm, and costs £1440 with a two year guarantee. House of Instruments, 34/36 High St, Saffron Walden, Essex CB10 1EP.

WW304

Multi-turn encoders

Tracking absolute encoders with resolutions of up to 1 part in 500 000, and a choice of 10, 64 or 100 turns for full-scale count, have been introduced to the UK by Techmation Ltd. These units, manufactured by Computer Conversions Ltd, convert any shaft input to 5 or 6 digit b.c.d. or 19 bits of binary information, corresponding directly to the shaft angle, with an error of less than ±1 part in 10^5. Output data is continuously available, accurate up to input rates of 10^4 degrees/second, and in addition, readout units are available with either 4, 5 or 6-digit, 0.5in high displays, and have t.t.l.-compatible data, busy and inhibit outputs for interfacing with a computer. Resetting of the zero point to any value is possible via an offset adjuster, and any output scale factor can be provided (such as pounds, feet, etc.). Rack or panel mounting versions exist, either with an internal power supply or without, in which case external supplies of ±15V and +5V d.c. are required. Other specifications include 0 to 70°C (or −55 to +85°C) operating temperature range and a maximum transducer/readout-unit cable length of 1000ft. Techmation Ltd, 58 Edgware Way, Edgware, Middlesex HA8 8JP.

WW305

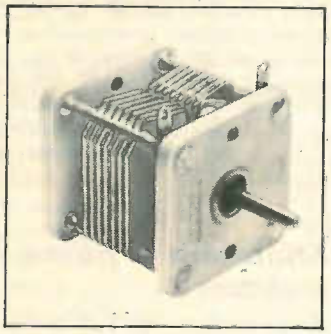
Matrix panel

ASCII compatibility enables the new version of the Argus gas plasma display panel, from Perdix Components Ltd, to be used as a direct replacement for a c.r.t. It can accept ASCII data in one of three ways, 20mA Loop, RS232-C or differential t.t.l., and among the standard commands to which it can respond are "carriage return", "line feed", "form feed" and "shift out" (cursor home). Cursor addressing can be carried out by using device control channels one and three. Standard panels are manufactured in a variety of forms, from a single line of 40 characters, to a 480 character (40×12) message panel, all having 120° viewing angles in both planes and 5×7 dot characters. Operation at data rates from 150 to 19 200 baud is possible. Other features of the new Argus display, which is expected to be of particular use in applications where weight, size and power-consumption are critical factors, are its high-brightness and dead background, optimum line-to-line spacing, and a flicker-free display during updating, made possible by the use of superior data organization. Perdix Components Ltd, 98 Crofton Park Rd, London SE4.

WW306

Capacitive sensor

Angular displacement can be measured directly using the C11K capacitive sensor from Jackson Brothers (London) Ltd. Error in linearity is less than 1% f.s. of the 100pF devices, which have a differential arrangement consisting of two sets of stator-vanes, and one set of rotor-vanes, enabling their use in bridge circuits for improved accuracy and cancellation of the effects of environmental changes. The standard unit costs around £10 with electrical characteristics such as an insulation resistance of $10^9\Omega$, 500V d.c. breakdown voltage, 50 p.p.m./°C temperature coefficient and a Q of 1000. Continuous rotation can easily be translated, with minimal step inaccuracies, into a triangular waveform, which has a pitch corresponding to 180° of angular movement. A virtually unlimited life is claimed for the C11K, the only points subject to wear under normal conditions being the constant-contact wiper and the low-torque bearings. Maximum operating torque is less than ½oz-in and the sensor, with vanes made from silver-plated brass, measures 1.3cu.in without shaft and solder-lugs. Its drive shaft protrudes from both ends, one end having a plain diameter of 1/8in, the other stepped, with diameters of 1/8in and 1/16in, and mounting into transducer heads, linear/rotational translator units etc., is possible via two thread bushes, with one inch



centres, in each ceramic end-plate. Jackson Brothers (London) Ltd, Kingsway, Waddon, Croydon, Surrey CR9 4DG.

WW307

Microprocessor tutor

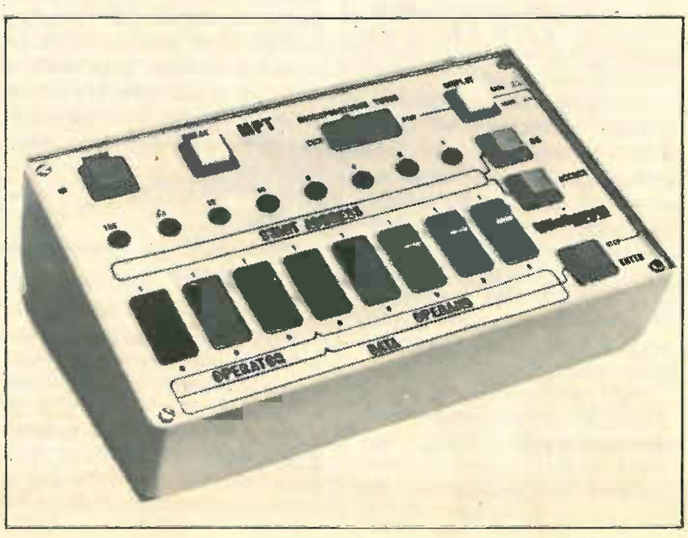
Developed with the aid of the Newcastle Science and Technology Education Centre, this desk-top unit, called the Microprocessor Tutor (MPT), is manufactured by Welwyn Electric Ltd, and has been designed to teach the uses and applications of the microprocessor simply and cheaply in schools, colleges and universities. It is claimed that the MPT has already been tested in more than fifty educational establishments. Program instructions and data are entered in the form of 8-bit words by means of eight switches with "0" and "1" positions, the program and data entry being indicated by a row of eight l.e.d.s, and the instruction set is intentionally limited to load, store, add, substract, and, complement, branch (always), branch (if accum=0) and halt, for reasons of simplicity. A 'step' button allows programs to be run, one instruction at a time, with the l.e.d.s displaying the current data or the address at each step. Among the operations which can be demonstrated using the MPT, are the entering, storing and recalling of digital data, the addressing of memory locations and stepping from one instruction to another automatically. For practical demonstrations, a "traffic lights" simulator is provided along with instructions for writing programs to control their speed of operation, and program modifications to enable the delay time of the lights to be automatically changed as "traffic" builds up. Also included is a small d.c. motor for use in conjunction with motor-speed control programs. Welwyn Electric Ltd, Bedlington, Northumberland NE22 7AA.

WW308

Wire-wrap kits

UK-manufactured kits, each comprising base board, precision screw-machined socket terminals, 96-way DIN connector(s), ejector keys, solder clips and a pin insertion/extraction tool, are made by Cavac Systems Ltd, and offered in single, double or triple Eurocard and maximum I/O double Eurocard styles. They feature maximum-power and ground-plane areas and are developed for use in prototype and pre-production applications. An alternative version can be supplied with a selection of discrete i.c. sockets instead of loose socket/terminals. A full data sheet, detailing the component parts and giving ordering information, can be obtained from Cavac on request. Cavac Systems Ltd, Unit 15, Suttons Park Avenue, Suttons Industrial Estate, Early, Reading RG6 1AZ.

WW309



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Cabinet size 19.0" × 15.7" × 3.3"

Television not included in price

The kit for this outstandingly practical design by John Adams published in a series of articles in Wireless World really is complete!

Included in the PSI COMP 80 scientific computer kit is a professionally finished cabinet, fibre-glass double sided, plated-through-hole printed circuit board, 2 keyboards PCB mounted for ease of construction, IC sockets, high reliability metal oxide resistors, power supply using custom designed toroidal transformer, 2K Basic and 1K monitor in EPROMS and, of course, wire, nuts, bolts, etc.

KIT ALSO AVAILABLE AS SEPARATE PACKS

For those customers who wish to spread their purchase or build a personalised system the kit is available as separate packs e.g. PCB (16"×12.5") £43.20. Pair of keyboards £34.80. Firmware in EPROMS £30.00. Toroidal transformer and power supply components £17.60. Cabinet (very rugged, made from steel, really beautifully finished) £26.50. P.S. Will greatly enhance any other single board computer including OHIO SUPERBOARD for which it can be readily modified. Other packs listed in our FREE CATALOGUE.

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	Set of components including IC sockets, plug and socket but excluding RAMs	£11.20
	2114L RAM (16 required)	£4.50
	Complete set of board, components, 16 RAMS	£89.50
8K ROM board	Fibre glass double sided plated through hole PCB 5.6"×4.8"	£12.40
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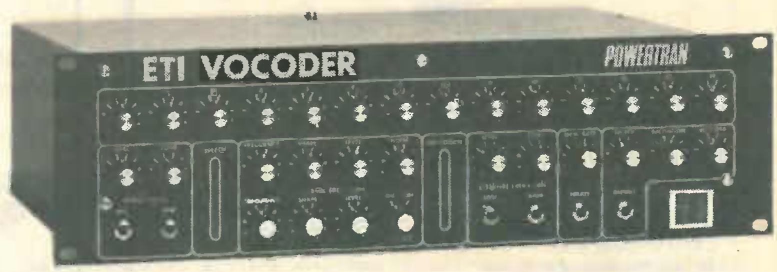
	Complete set of board, components, 8 ROMs	£68.50

NEW!

ETI VOCODER

COMPLETE KIT ONLY £195+VAT

Being published in Electronics Today International



Panel size 19.0"×5.25". Depth 12.2"

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NOISE GENERATOR!
SLEW RATE CONTROL!

2 OSCILLATORS!
voiced/unvoiced detector!
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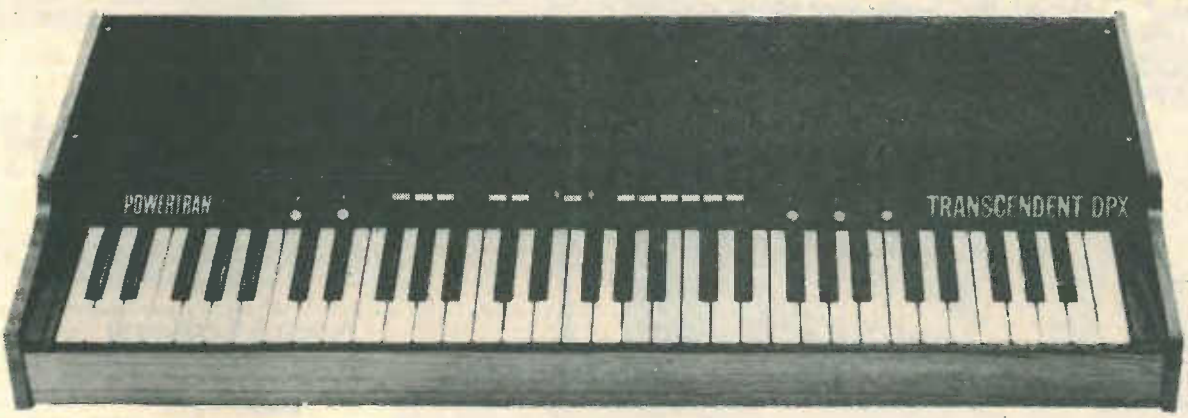
TRANSCENDENT DPX

DIGITALLY CONTROLLED, TOUCH SENSITIVE, POLYPHONIC, MULTI-VOICE SYNTHESIZER

Another superb design by synthesizer expert Tim Orr — published in Electronics Today International

The Transcendent DPX is a really versatile new 5 octave keyboard instrument. There are two audio outputs which can be used simultaneously. On the first there is a beautiful harpsichord or reed sound — fully polyphonic, i.e. you can play chords with as many notes as you like. On the second output there is a wide range of different voices, still fully polyphonic. It can be a straightforward piano or a honky tonk piano or even a mixture of the two! Alternatively you can play strings over the whole range of the keyboard or brass over the whole range of the keyboard or should you prefer — strings on the top of the keyboard and brass at the lower end (the keyboard is electronically split after the first two octaves) or vice versa or even a combination of strings and brass sounds simultaneously. And on all voices you can switch in circuitry to make the keyboard touch sensitive! The harder you press down a key the louder it sounds — just like an acoustic piano. The digitally controlled multiplexed system makes practical touch sensitivity with the complex dynamics law necessary for a high degree of realism. There is a master volume and tone control, a separate control for the brass sounds and also a vibrato circuit with variable depth control together with a variable delay control so that the vibrato comes in only after waiting a short time after the note is struck for even more realistic strong sounds.



Cabinet size 36.3"×15.0"×5.0" (rear) 3.3" (front)

COMPLETE KIT ONLY £299 +VAT

To add interest to the sounds and make them more natural there is a chorus/ensemble unit which is a complex phasing system using CCD (charge coupled device) analogue delay lines. The overall effect of this is similar to that of several acoustic instruments playing the same piece of music. The ensemble circuitry can be switched in with either strong or mild effects.
As the system is based on digital circuitry digital data can be easily taken to and from a computer (for storing and playing back accompaniments with or without pitch or key change, computer composing, etc., etc.)
Although the DPX is an advanced design using a very large amount of circuitry, much of it very sophisticated, the kit is mechanically extremely simple with excellent access to all the circuit boards which interconnect with multiway connectors, just four of which are removed to separate the keyboard circuitry and the panel circuitry from the main circuitry in the cabinet.
The kit includes fully finished metalwork, solid teak cabinet, professional quality components (all resistors 2% metal oxide), nuts, bolts, etc., even a 13A plug!

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MANY MORE KITS ON PAGE 95. MORE KITS AND ORDERING INFORMATION ON PAGE 93.

TRANSCENDENT 2000 SINGLE BOARD SYNTHESIZER

LIVE PERFORMANCE SYNTHESIZER DESIGNED BY CONSULTANT TIM ORR (FORMERLY SYNTHESIZER DESIGNER FOR EMS LIMITED) AND FEATURED AS A CONSTRUCTIONAL ARTICLE IN ELECTRONICS TODAY INTERNATIONAL.

The TRANSCENDENT 2000 is a 3 octave instrument transposable 2 octaves up or down giving an effective 7 octave range. There is portamento, pitch bending, a VCO with shape and pitch modulation, a VCF with both low and high pass outputs and a separate dynamic sweep control, a noice generator and an ADSR envelope shaper. There is also a slow oscillator, a new pitch detector, ADSR repeat, sample and hold, and special circuitry with precision components to ensure tuning stability amongst its many features.
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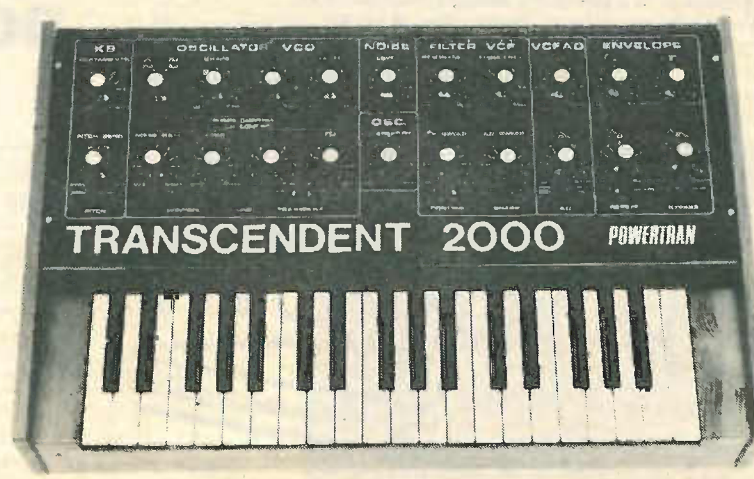

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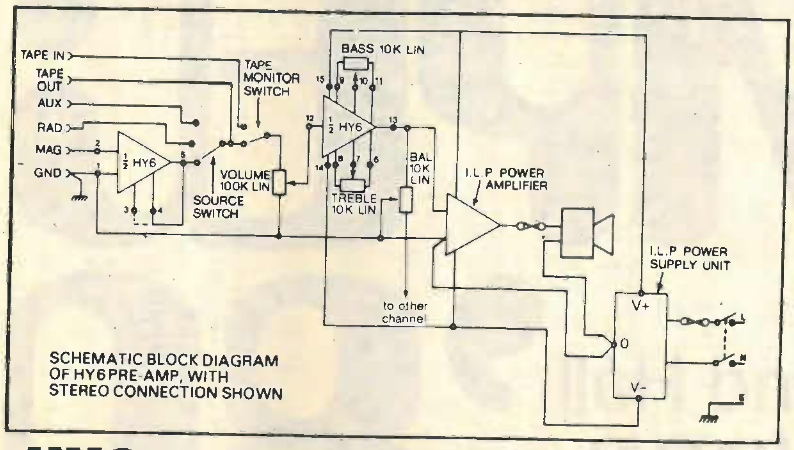

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100 THY5A/100	£0.52
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400 THY5A/400	£0.66
600 THY5A/600	£0.79
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Volts No:	Price
50 THY10A/50	£0.59
100 THY10A/100	£0.66
200 THY10A/200	£0.71
400 THY10A/400	£0.81
600 THY10A/600	£1.14
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IN5408 1000V	£0.34
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CA3020	£1.95	LM304	£1.84	NE558	£0.69	72741	£0.27	TAD100	£1.49
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CA3035	£1.61	LM309	£1.72	NE566	£1.38	UA7447C	£0.69	TBA810S	£0.86
CA3036	£1.15	LM380	£0.97	NE567	£1.95	72747	£0.69	TBA810	£1.12
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CA3081	£1.72	MC1352	£1.61	72710	£0.34	SN76660	£0.86	TBA641A	£1.84
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CA3090	£4.14	MC1496	£1.03	72711	£0.36				
CA3123	£2.18								

AUDIO MODULES

AMPLIFIERS

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PA12	Supply voltage 22-32v input sensitivity 300mv suit: AL10/AL20/AL30	£9.83
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MONO PREAMPLIFIERS

MM100	Supply voltage 40-65v inputs: Mag, P.U., Tape Microphone Max. output 500mv	£14.29
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POWER SUPPLIES AND TRANSFORMERS

PS12	24v Supply suit 2×AL10, 2×AL20, 2×AL30 & PA12/S,450	£1.90
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SPM120/45	45v Stabilised supply — suit 2×AL60, PA100 to 25 watts	£7.34
SPM120/55	55v Stabilised supply — suit 2×AL80, PA200	£7.34
SPM120/65	65v Stabilised supply — suit 2×AL120, PA200, 1×AL250, PA200	£7.34
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MISCELLANEOUS

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2035	2 amp 55v	£7.35	£1.47
2036	750mA 17v suit PS12	£3.75	
2040	1.5 amp 0-45v-55v suit SPM 120/45, SPM 120/55v	£5.98	£1.21
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AC126	0.23
AC127	0.23
AC128	0.23
AC141	0.29
AC141K	0.40
AC142	0.23
AC142K	0.35
AC176	0.23
AC187	0.23
AC188	0.23
ACY17	0.98
ACY18	0.92
ACY19	0.86
ACY20	0.80
ACY21	0.86
ACY39	1.72
AD149	0.80
AD161	0.52
AD162	0.52
AF106	0.52
AF114	0.86
AF115	0.86
AF116	0.86
AF117	0.86
AF139	0.46
AF186	1.38
AF239	0.52
AFZ11	3.16
AFZ12	3.16
ASY26	1.38
ASY27	1.03

ASZ15	1.44
ASZ16	1.44
ASZ17	1.44
ASZ20	1.72
ASZ21	2.30
AU113	1.96
AUY10	2.30
AU110	1.96
BA145	0.15
BA148	0.15
BA154	0.10
BA155	0.12
BA156	0.10
BAW62	0.06
BAX13	0.07
BAX16	0.10
BC107	0.14
BC108	0.14
BC109	0.15
BC113	0.14
BC114	0.15
BC115	0.16
BC116	0.17
BC117	0.20
BC118	0.12
BC125	0.18
BC126	0.23
BC135	0.16
BC136	0.17
BC137	0.17
BC147	0.10
BC148	0.09
BC149	0.10
BC157	0.10
BC158	0.09
BC159	0.12
BC167	0.14
BC170	0.13
BC171	0.12

BC172	0.12
BC173	0.14
BC177	0.17
BC178	0.16
BC179	0.18
BC182	0.13
BC183	0.12
BC184	0.13
BC212	0.15
BC213	0.14
BC214	0.17
BC237	0.10
BC238	0.14
BC301	0.38
BC303	0.38
BC307	0.12
BC308	0.12
BC327	0.23
BC328	0.21
BC337	0.21
BC338	0.20
BCY30	1.15
BCY31	1.15
BCY32	1.15
BCY33	1.04
BCY34	1.04
BCY39	3.45
BCY40	1.15
BCY42	0.29
BCY43	0.29
BCY58	0.18
BCY70	0.17
BCY71	0.20
BCY72	0.15
BCZ11	1.72
BD115	0.52
BD121	1.50
BD123	1.50
BD124	1.50

BD131	0.40
BD132	0.44
BD135	0.39
BD136	0.39
BD137	0.40
BD138	0.46
BD139	0.49
BD140	0.51
BD144	2.30
BD181	1.26
BD182	1.36
BD237	0.46
BD238	0.63
BDX10	1.05
BDX32	2.30
BDY20	1.44
BDY60	1.72
BF115	0.29
BF152	0.21
BF153	0.23
BF154	0.20
BF159	0.26
BF160	0.18
BF167	0.23
BF173	0.23
BF177	0.28
BF178	0.28
BF179	0.29
BF180	0.35
BF181	0.35
BF182	0.35
BF183	0.2
BF184	0.29
BF185	0.29
BF194	0.10
BF195	0.10
BF196	0.12
BF197	0.14
BF200	0.31
BF224	0.23
BF244	0.32

BF257	0.28
BF258	0.30
BF259	0.37
BF336	0.35
BF337	0.35
BF338	0.36
BFS21	4.55
BFS28	2.56
BFS61	0.23
BFS98	0.23
BFW10	0.74
BFW11	0.74
BFX84	0.25
BFX85	0.26
BFX87	0.24
BFX88	0.24
BFY50	0.30
BFY51	0.30
BFY52	0.30
BFY64	0.30
BFY90	1.44
BSX19	0.24
BSX20	0.23
BSX21	0.23
BT106	1.44
BTY79/400R	3.67
BU205	2.02
BU206	2.59
BU208	2.30
BY100	0.52
BY126	0.16
BY127	0.17
BZX61 Series	0.21
BZY88 Series	0.15
CRS1/40	0.69
CRS3/06	0.52
CRS3/40	0.86

CRS3/60	1.04
GEX66	1.73
GEX541	4.60
GJ3M	0.86
GM0378A	2.02
KS100A	0.52
MJE340	0.92
MJE370	1.35
MJE371	0.71
MJE520	0.60
MJE521	0.63
MJE2955	1.44
MJE3055	0.86
MPF102	0.35
MPF103	0.35
MPF104	0.35
MPF105	0.35
MPSA06	0.28
MPSA56	0.30
MPSU01	0.41
MPSU06	0.53
MPSU56	0.56
NE555	0.52
NKT401	2.30
NKT403	1.99
NKT404	1.99
OA5	1.09
OA7	0.63
OA10	0.74
OA47	0.16
OA70	0.35
OA79	0.35
OA81	0.35
OA85	0.35
OA90	0.09
OA91	0.09
OA95	0.09
OA200	0.10
OA202	0.10
OA211	1.15
OAZ200	1.15

OAZ201	1.15
OAZ206	1.15
OAZ207	1.15
OC16	2.30
OC20	2.88
OC22	2.88
OC23	3.16
OC24	3.45
OC25	1.04
OC26	1.04
OC28	2.30
OC29	2.30
OC35	1.73
OC36	1.73
OC41	0.92
OC42	0.86
OC43	2.59
OC44	0.69
OC45	0.63
OC71	0.63
OC72	0.63
OC73	1.15
OC74	0.74
OC75	0.74
OC76	0.63
OC77	1.38
OC81	0.74
OC81Z	1.38
OC82	0.74
OC83	0.74
OC84	0.74
OC122	1.73
OC123	2.02
OC139	2.59
OC140	3.16
OC141	3.74
OC170	1.15
OC171	1.15
OC200	1.73
OC201	2.02
OC202	2.02

OC203	2.02
OC204	2.88
OC205	2.88
OC206	2.88
OC207	2.02
OCP71	1.44
ORP12	1.15
R2008B	2.02
R2009	2.59
R2010B	2.02
T1C44	0.35
T1C226D	1.38
TIL209	0.23
T1P29A	0.47
T1P30A	0.48
T1P31A	0.51
T1P32A	0.55
T1P33A	0.79
T1P34A	0.84
T1P41A	0.72
T1P42A	0.81
T1P2955	0.77
T1P3055	0.64
T1S43	0.52
ZS140	0.29
ZS170	0.24
ZS178	0.62
ZS271	0.26
ZS278	0.65
ZTX107	0.13
ZTX108	0.12
ZTX109	0.14
ZTX300	0.14
ZTX301	0.15
ZTX302	0.17
ZTX303	0.20
ZTX304	0.22
ZTX311	0.14
ZTX314	0.23
ZTX500	0.15
ZTX501	0.16

ZTX502	0.18
ZTX503	0.20
ZTX504	0.23
ZTX531	0.23
ZTX550	0.18
1N914	0.06
1N916	0.08
1N4001	0.07
1N4002	0.07
1N4003	0.08
1N4004	0.08
1N4005	0.09
1N4006	0.09
1N4007	0.10
1N4009	0.07
1N4148	0.07
1N5400	0.15
1N5401	0.15
1S44	0.05
1S920	0.08
1S921	0.08
2G301	1.15
2G302	1.15
2G306	1.27
2N404	1.15
2N696	0.29
2N697	0.29
2N698	0.35
2N705	1.38
2N706	0.17
2N708	0.23
2N930	0.23
2N1131	0.30
2N1132	0.30
2N1302	1.15
2N1303	0.86
2N1304	1.38
2N1305	1.03
2N1306	1.84
2N1307	1.15
2N1308	2.30

2N1309	1.38
2N1613	0.29
2N1671	1.73
2N1893	0.29
2N2147	2.02
2N2148	1.89
2N2218	0.29
2N2219	0.28
2N2220	0.21
2N2221	0.21
2N2222	0.21
2N2223	3.16
2N2368	0.20
2N2369A	0.24
2N2484	0.23
2N2646	0.63
2N2904	0.29
2N2905	0.29
2N2906	0.24
2N2907	0.24
2N2924	0.24
2N2925	0.25
2N2926	0.16
2N3053	0.20
2N3054	0.58
2N3055	0.81
2N3440	0.69
2N3441	0.92
2N3442	1.26
2N3614	1.73
2N3702	0.13
2N3703	0.15
2N3704	0.15
2N3705	0.15
2N3706	0.15
2N3707	0.15
2N3708	0.12
2N3709	0.15
2N3710	0.12
2N3711	0.12

2N3771	2.02
2N3772	2.30
2N3773	3.45
2N3819	0.41
2N3820	0.52
2N3823	0.63
2N3866	0.83
2N3904	0.15
2N3905	0.15
2N3906	0.15
2N4058	0.16
2N4059	0.12
2N4060	0.14
2N4061	0.14
2N4062	0.15
2N4124	0.17
2N4126	0.17
2N4286	0.23
2N4288	0.25
2N4289	0.28
2N5457	0.40
2N5458	0.40
2N5459	0.40
2S017	7.48
2S019	7.48
2S026	13.80
2S103	1.73
2S302	0.86
2S303	0.86
2S322	0.92
2S324	1.44
2S701	1.73
2S745A	0.40
2S746A	0.40

VALVES

A1834	10.35
A2087	13.58
A2134	10.06
A2293	8.62
A2426	17.63
A2521	24.38
A2900	14.43
A3343	25.56
AZ31	1.26
AZ41	1.32
BK448	106.03
BK484	143.35
BS90	52.27
BS810	35.24
BT5	52.61
BT17	96.83
BT19	32.78
BT29	296.70
BT69	301.99
BT75	102.46
BT95	100.15
CBL31	2.30
CL33	2.30
CY31	1.15
C1K	21.30
C3A	11.50
C3JA	23.23
DA41	21.50
DA42	12.30
DA100	52.90
DAF91	0.46
DAF96	1.15
DET22	32.78
DET24	52.90
DF91	0.46
DF96	1.15
DK91	1.21
DK92	1.44
DK96	1.26
DL92	1.26
DL94	1.38
DL96	1.26
DLS10	9.48
DLS15	12.37
DLS16	12.37
DLS19	12.37
DM70	1.44
DM71	1.44
DM160	3.96
DY86/7	0.73
DY802	0.96
E55L	25.17
E80CC	10.13
E80CF	12.96
E80F	14.19
E80L	13.98
E81CC	6.62
E81L	14.06
E82CC	7.03
E83CC	7.16
E86C	12.48
E88C	7.12
E88CC	3.86
E90CC	9.90
E90F	10.38
E91H	5.34
E92CC	9.40
E99F	10.16

E130L	19.39
E180CC	6.86
E180F	9.66
E182CC	9.90
E186F	12.58
E188CC	9.40
E280F	25.88
E283CC	9.02
E288CC	18.54
EA52	23.69
EA76	2.30
EABC80	1.38
EAC91	0.92
EAF42	1.44
EAF801	2.02
EB41	2.30
EB91	1.01
EBC33	2.02
EBC41	1.44
EBC81	1.26
EBC90	0.97
EBF80	0.58
EBF83	1.44
EBF89	0.97
EBL31	2.88
EC90	1.28
EC91	8.69
EC92	1.44
EC157	310.50
ECC33	4.02
ECC35	4.02
ECC40	2.30
ECC81	1.01
ECC82	0.82
ECC83	1.01
ECC84	1.36
ECC85	1.38
ECC86	2.30
ECC88	2.07
ECC89	1.88
ECC91	10.27
ECC189	1.90
ECC807	2.02
ECC808	2.59
ECF80	1.24
ECF82	1.38
ECF86	1.73
ECH35	2.30
ECH42	1.32
ECH81	1.38
ECH83	1.44
ECH84	1.47
ECL80	1.15
ECL81	1.73
ECL82	1.15
ECL83	1.73
ECL84	1.61
ECL85	1.28
ECL86	1.38
EF37A	4.02
EF39	3.16
EF40	3.45
EF41	2.30
EF42	2.30
EF50	1.73
EF54	5.75
EF55	2.88
EF80	0.92
EF83	2.02
EF85	0.92

EF86	1.74
EF89	1.84
EF91	2.07
EF92	6.68
EF93	1.15
EF94	1.24
EF95	6.27
EF98	1.44
EF183	0.92
EF184	0.96
EF804S	12.65
EF805S	12.65
EH90	1.61
EK90	1.24
EL32	1.73
EL33	4.02
EL34TH	2.53
EL34MUL	3.16
EL36	1.84
EL41	1.44
EL42	2.02
EL81	2.88
EL83	4.03
EL84	1.15
EL86	2.88
EL90	1.10
EL91	8.21
EL95	1.51
EL156	27.60
EL360	9.77
EL500/504	2.16
EL509	3.63
EL821	11.46
EL822	12.55
EM34	5.75
EM80	1.26
EM81	1.15
EM84	1.15
EM85	1.44
EM87	1.73
EN32	16.28
EN91	2.94
EN92	6.18
EY51	2.02
EY81	1.89
EY83	2.02
EY84	10.57
EY86	0.96
EY88	2.02
EY500A	2.23
EY802	94
EZ35	97
EZ40	1.44
EZ41	1.44
EZ80	0.96
EZ81	0.96
EZ90	1.38
FW4-500	2.88
FW4-800	2.88
G1.371K	41.40
G551K	12.65
G180.2M	18.42
G240.2D	12.85
G400.1K	19.28
GN4	8.62
GN4A	8.62
GS16	10.35
GT1C	14.38
GU50	14.31
GU51	13.62

GXU1	16.10
GXU2	28.43
GXU3	30.49
GXU4	32.77
GXU50	17.25
GY501	3.16
GZ32	1.44
GZ33	4.60
GZ34	2.88
GZ37	4.60
KT61	4.02
KT66	11.50
KT88	13.80
KTW61	2.02
KTW62	2.02
KTW63	2.02
M8079	12.29
M8080	9.49
M8081	11.30
M8082	9.87
M8083	8.54
M8091	11.99
M8096	4.31
M8097	4.09
M8098	5.29
M8099	5.98
M8100	9.49
M8136	9.75
M8137	9.73
M8140	5.17
M8141	5.52
M8142	7.48
M8144	4.31
M8149	5.86
M8161	9.11
M8162	10.36
M8163	5.17
M8190	5.29
M8195	4.25
M8196	7.47
M8204	6.57
M8212	12.47
M8223	3.80
M8224	4.66
M8225	2.99
M8248	13.32
MU14	1.73
MX119	58.65
MX123	67.85
MX145	58.65
VX151	17.25
MX152	135.70
MX161	166.75
MX163	23.11
MX164	25.88
MX166	142.60
MX168	48.30
N78	10.35
OA2	2.13
OA3	5.69
OA4	4.02
OB2	1.44
OB3	2.20
OC2	3.04
OC3	2.20
OD3	2.20
OZ4	1.84
PC86	1.61
PC88	1.61
PC95	1.49

PC97	1.38
PC900	1.38
PCC84	1.15
PCC85	1.38
PCC88	1.38
PCC89	1.56
PCC189	1.61
PCC805	1.51
PCC806	2.07
PCE82	2.07
PCF80	1.15
PCF82	1.15
PCF86	1.84
PCF87	1.84
PCF200	3.74
PCF201	2.45
PCF801	1.84
PCF802	2.19
PCF805	1.84
PCF806	1.84
PCF808	1.84
PCL82	1.15
PCL83	2.30
PCL84	1.15
PCL85	1.24
PCL86	1.24
PCL805/85	1.24
PD500	4.14
PE06-40N	31.40
PFL200	2.07
PL36	1.38
PL81	1.38
PL81A	1.38
PL82	1.38
PL83	2.55
PL84	1.24
PL504/5	1.61
PL508	2.07
PL509	3.73
PL519	3.73
PL801	1.27
PL802	3.40
PY33	1.27
PY81	0.97
PY82	0.92
PY83	0.81
PY88	1.01
PY500A	2.07
PY800	0.97
PY801	0.97
QQV02-6	14.44
QQV03-20A	20.13
QQV06-40A	47.15
QQV07-50	60.66
QQZ03-20A	59.80
QQZ06-40A	55.10
QU37	14.38
QV03-12	5.13
QV04-7	2.88
QV08-100	122.26
QY3-65	57.06
QY3-125	61.02
QY4-250	70.16
QY4-400	80.44
QY5-500	168.83

QY5-3000A	333.91
QZ06-20	30.48
R10	5.75
R17	1.89
R18	4.89
R19	1.38
R20	1.86
RG3-250	35.77
RG3-250A	37.49
RG3-1250	36.23
RG4-1250	43.93
RG4-3000	89.64
RR3-250	53.54
RR3-1250	94.83
S11E12	40.25
S130	3.45
S130P	4.03
STV280-40	11.50
STV280-80	24.15
SU41	2.88
SU42	10.35
TD03-10	32.78
TD03-10E	32.78
TD03-29F	33.93
TT15	34.50
TT21	14.16
TT22	18.17
TT100	59.51
TY2-125	69.01
TY2-400	74.07
TY4-500	101.44
TY5-500	178.25
TY6-800	181.70
TY6-5000A	337.51
TY6-5000B	264.50
TY6/5000W	290.98
TY7-6000A	357.49
TY7-6000W	286.33
TZ40	17.25
U18-20	2.88
U19	15.81
U25	1.33
U26	1.66
U37	10.35
UABC80	1.44
UAF42	1.44
UB41	1.44
UBC41	1.73
UBF89	1.38
UCC84	1.26
UCC85	1.38
UCF80	1.32
UCH42	1.38
UCH81	2.67
UCL82	1.20
UCL83	1.66
UF41	1.15
UF42	1.44
UF80	1.66
UF85	1.66
UF89	1.66
UL41	2.88
UL84	1.38
UM80	1.15

UY41	1.44
UY85	1.20
VLS631	15.24
XG1-2500	40.42
XG2-6400	113.50
XG5-500	28.52
XG2-6400	106.15
XR1-1600A	38.53
XR1-3200	93.15
XR1-3200A	93.15
XR1-6400	102.01
XR1-6400A	164.23
YD1120	264.50
YD1240	366.62
Z759	19.32
ZM1000	6.03
ZM1001	6.19
ZM1020	10.63
ZM1021	10.17
ZM1022	10.60
ZM1023	8.81
ZM1040	22.26
ZM1041	19.16
ZM1042	20.44
ZM1051	100.05
1B3GT	2.58
1B24	11.50
1B35A	28.75
1B63	57.50
1R5	1.21
1S5	0.46
1T4	0.46
2AS15	11.50
2C39A	21.85
2C43	20.70
2D21	2.94
2E26	15.34
2J42	89.70
2J55	239.97
2J70A	270.25
2J70B	418.34
2K25	40.25
3-300Z	57.50
3-500Z	63.25
3A5	2.70
3B24	9.20
3B28	8.63
3B29	11.50
3B240M	17.25
3B241M	17.25
3C23	18.73
3C45	28.18
3CX100A5	23.00
3E29	29.67
3S4	1.26
3V4	1.38
465A	29.15
4-125A	41.99
4-250A	41.99
4-400A	52.05
4B32	29.16
4C35	46.00
4CX250B	31.63
4CX350A	48.88
4X150A	24.41
4X150D	28.75

5B254M	23.12
5B255M	23.12
5C22	46.00
5J180E	1380.00
5R4GY	2.30
5U4G	3.86
5U4GB	2.90
5V4G	1.75
5Y3GT	0.98
5Z3	1.73
5Z4G	1.75
5Z4G7	1.75
6-30L2	1.79
6AB4	1.44
6AB7	1.73
6AC7	1.61
6AF4A	1.84
6AG7	2.30
6AH6	5.52
6AK5	4.15
6AK6	2.81
6AL5	1.01
6AM4	2.65
6AM5	8.21
6AM6	2.07
6AN5	4.45
6AN8A	3.97
6AQ5	1.10
6AS6	5.73
6AS7G	9.49
6AT6	0.98
6AU5GT	4.97
6AU6	1.24
6AV5GA	4.52
6AV6	0.98
6AX5GT	3.57
6B7	1.73
6B8	2.02
6BA6	1.15
6BA7	5.89
6BA8A	4.31
6BC4	4.27
6BE6	1.24
6BH6	1.75
6BJ6	1.24
6BK4	4.84
6BL6	97.75
6BL7GT	4.44
6BM6	97.75
6BN6	1.89
6BQ7A	4.28
6BR7	4.60
6BR8	2.02
6BS7	4.60
6BW6	4.60
6BW7	1.75
6BX7GT	5.70
6BZ6	2.73
6C4	1.01
6CB6A	2.86
6CD6GA	5.83
6CG7	2.62
6CH6	9.78
6CL6	4.12
6CW4	8.83
6D2	1.01
6DK6	3.00
6DQ6B	4.89
6EA8	3.38

6EB8	2.44
6EW6	1.73
6F6	2.02
6F23	1.84
6F28	1.33
6F33	29.90
6H1	14.38
6H2N	1.21
6H3N	1.21
6H6	1.73
6J4	6.10
6J6	6.21
6J7	8.07
6K4N	1.44
6K6GT	1.50
6K7	1.73
6K8	2.02
6KD6	7.31
6L6G	2.88
6L6GA	1.73
6L6GT	2.24
6L6GC	2.88
6L7	2.30
6N2P	1.21
6N3P	1.21
6N7	1.73
6P25	4.14
6Q7	2.53
6R7	2.07
6SA7	1.67
6SC7	1.73
6SF7	1.84
6SH7	1.73
6SJ7	1.84
6SK7	1.50
6SK7GT	3.08
6SN7GT	1.84
6SQ7	1.50
6SR7	1.73
6SS7	2.07
6U5G	2.30
6U8	0.92
6U8A	3.38
6V6GT	1.84
6X4	1.38
6X5GT	0.97
7B7	1.96
7C5	3.40
7C6	2.60
7H7	2.30
7R7	1.73
7S7	2.59
7Y4	1.84
7Z4	2.13
11E3	60.82
12AT6	1.38
12AT7	1.01
12AU6	2.97
12AU7	0.83
12AV6	2.55
12AV7	4.00
12AX7	1.01
12AY7	4.69
12B4A	3.62
12BA6	2.52
12BE6	2.79
12BH7	1.29
12BY7	3.11
12E1	19.67
12E11TT	19.26

12E14	34.50
13E1	123.05
19H4	28.75
19H5	40.25
24B9	53.07
30C15	1.84
30C17	1.84
30C18	1.84
30F5	1.93
30FL1/2	1.28
30FL12	2.07
30FL14	1.84
30L1	1.15
30L15	2.07
30L17	2.07
30P4	1.06
30P19	1.38
30P1	2.88
30P13	2.07
30PL1	2.88
30PL14	1.93
30PL15	2.07
35W4	0.69
50C5	0.81
75B1	5.18
75C1	2.70
85A1	8.63
85A2	2.65
90AG	14.90
90AV	14.90
90C1	2.70
90CG	16.72
90CV	17.50
92AG	14.90
92AV	14.90
95A1	7.19
150B2	3.34
150B3	6.15
150C2	2.13
150C4	2.65
211	6.90
723AB	40.25
803	11.50
805	23.00
807	4.31
811A	18.32
812A	18.26
813	85.87
833A	128.80
866A	15.23
872A	21.47
922	5.01
931A	16.97
1624	2.59
1625	1.96
2050	8.00
4212E	304.75
4212H	304.75
5544	62.10
5545	67.85
5551A	106.03
5552A	143.35
5553A	259.10
5642	6.45
5654	3.93
5651	2.65
5670	5.18
5675	19.91
5687	6.31
5696	4.35

5718	7.87
5725	5.62
5726	3.62
5727	5.42
5749	5.14
5751	4.80
5763	4.66
5814A	4.28
5840	5.06
5842	13.90
5876A	19.55
5879	5.38
5886	12.08
5963	3.38
5965	4.00
6005	5.62
6021	5.13
6057	4.02
6058	12.47
6059	4.60
6061	4.89
6062	4.31
6063	4.20
6064	8.54
6067	4.02
6072	5.80
6080	7.88
6097A×B×C	46.00
6146A	10.30
6146B	8.12
6159B	17.27
6189	10.03
6201	5.28
6442	17.25
6883B	12.77
6973	4.38
7025	2.73
7551	6.45
7586	11.66
7587	20.11
7609	36.57
7868	5.04
7895	13.25
8005	75.03
8068	6.33
8122	60.11
8136	2.48
8417	6.76
18042	8.63
18045	12.06

Tested Ex-Equipment

4CX250B	5.75

BASES

B7G unskirted	0.17
B7G skirted	0.35
B9A unskirted	0.17
B9A skirted	0.35
Int Octal	0.40
Loctal	0.63
Nuvistor base	0.86
8 pin DIL	0.17
14 pin DIL	0.17
16 pin DIL	0.20
Valve screening cans all sizes	0.35

CRTs

2AP1	9.78
2BP1	10.35
3BP1	11.50
3DP1	5.75
3EG1	8.05
3FP7	6.90
3GP1	6.90
3JP1	9.20
3JP2	9.20
3JP7	11.50
3KP1	17.25
3RP1	40.25
3WP1	23.00

5ADP1	40.25
5BP1	11.50
5CP1	11.50
5CP1A	46.00
5FP15A	17.25
5UP7	16.10
DG7-5	28.75
DG7-32	41.40
DH3-91	35.65
DH7-11	78.20
VCR97	13.80
VCR138	11.50

VCR138A	14.38
VCR139A	9.20
VCR517A	11.50
VCR517B	11.50
VCR517C	11.50

Tube Bases Prices on application

INTEGRATED CIRCUITS

7400	0.18
7401	0.18
7402	0.18
7403	0.18
7404	0.20
7405	0.18
7406	0.46
7407	0.46
7408	0.23
7409	0.23
7410	0.18
7412	0.30
7413	0.37
7416	0.37
7417	0.37
7420	0.20
7422	0.23

7423	0.37
7425	0.35
7427	0.35
7428	0.49
7430	0.20
7432	0.35
7433	0.41
7437	0.37
7438	0.37
7440	0.21
7441	0.97
7442	0.83
7447AN	1.04
7450	0.21
7451	0.21
7453	0.21
7454	0.21

7460	0.21
7470	0.40
7472	0.38
7473	0.41
7474	0.46
7475	0.62
7476	0.46
7480	0.63
7482	0.86
7483	1.04
7484	1.15
7486	0.40
7490	0.60
7491	0.92
7492	0.69
7493	0.69
7494	0.92

7495	0.83
7496	0.92
7497	3.45
74100	1.73
74107	0.52
74109	0.81
74110	0.58
74111	0.81
74116	2.02
74118	1.15
74119	1.73
74120	0.95
74121	0.46
74122	0.69
74123	1.15
74125	0.63
74126	0.63
74128	0.69

74132	0.81
74136	0.63
74141	0.92
74142	2.65
74143	2.88
74144	2.88
74145	1.04
74147	2.30
74148	2.02
74150	1.84
74151	0.97
74154	2.02
74155	0.97
74156	0.97
74157	0.86
74159	2.42
74170	2.65
74172	5.06

74173	1.61
74174	1.73
74175	1.04
74176	1.26
74178	1.44
74179	1.44
74180	1.32
74190	1.73
74191	1.73
74192	1.55
74193	1.55
74194	1.44
74195	1.15
74196	1.38
74197	1.26
74198	2.59
74199	2.59
76013N	2.02

TAA570	2.65
TAA630S	4.02
TAA700	4.50
TBA480Q	2.12
TBA520Q	2.65
TBA530	2.28
TBA540Q	2.65
TBA550Q	3.70
TBA560CQ	3.70
TBA673	2.52
TBA700	1.75
TBA720Q	2.65
TBA750Q	2.38
TBA800	1.38
TBA920	3.34
TBA920Q	3.34
TBA990Q	3.34
TCA270Q	3.34
TCA760A	1.59

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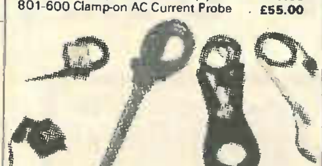

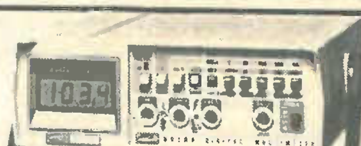

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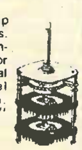

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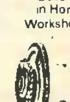

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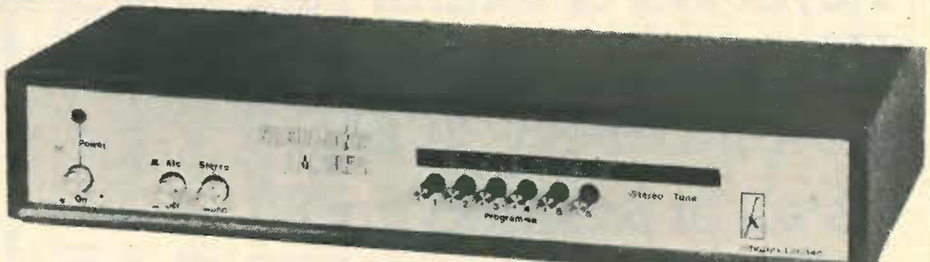
Brief Spec. Amplifier Low field Toroidal transformer, Mag. input. Tape In/Out facility (for noise reduction unit, etc.) THD less than 0·1% at 20W into 8 ohms. **High Slew Rate.** Low noise op. amps used throughout. Power on/off FET transient protection. All sockets, fuses, etc., are PC mounted for ease of assembly. Tuner section uses UM 1181 FET module requiring no RF alignment, ceramic IF, INTERSTATION MUTE, ano phase-locked IC pilot cancel, stereo decoder, LED tuning and stereo indicators. Tuning range 88-108MHz 30dB mono S/N @ 0.7μV. THD 0.3%.

PRICE: £69.95 + VAT

NELSON-JONES Mk. 2 STEREO FM TUNER KIT



A very high performance tuner with dual gate MOSFET RF and Mixer ready built front end, triple gang varicap tuning, linear phase I.F. and 3 state MPX decoder.

PRICE: £74.95 + VAT

NRDC-AMBISONIC UHJ SURROUND SOUND DECODER

The **first ever** kit specially produced by Integrex for this British NRDC backed surround sound system which is the result of 7 years' research by the Ambisonic team. W.W. July, Aug., '77.
The unit is designed to decode not only UHJ but virtually all other 'quadrophonic' systems (Not CD4), including the new BBC HJ. 10 input selections.
The decoder is linear throughout and does not rely on listener fatiguing logic enhancement techniques. Both 2 or 2 input signals and 4 or 6 output signals are provided in this most versatile unit.
Complete with mains power supply, wooden cabinet, panel, knobs, etc.

Complete kit, including licence fee **£57.70** + VAT or ready built and tested **£76.95** + VAT

S5050A STEREO AMP

Very high performance kit

50 watts rms-channel. 0.015% THD. S/N 90 dB, Mags/n 80 dB. Output device rating 360w per channel.
Tone cancel switch. 2 tape monitor switches. Metal case — comprehensive heatsinks.

Complete kit only **£69.95** + VAT

(Also available our 20w/ch BIFET S2020 Amp)

INTRUDER 1 Mk. 2 RADAR ALARM

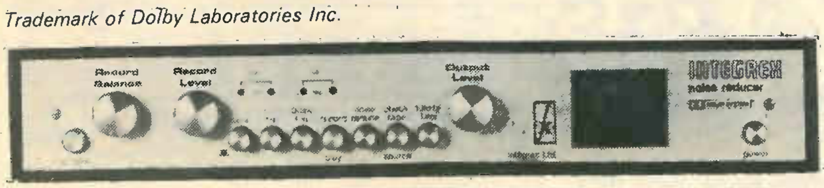
With Home Office Type approval

The original "Wireless World" published Intruder 1 has been re-designed by Integrex to incorporate several new features, along with improved performance. The kit is even easier to build. The internal audible alarm turns off after approximately 40 seconds and the unit re-arms. 240V ac mains or 12V battery operated. Disguised as a hard-backed book. Detection range up to 45 feet. Internal mains rated voltage free contacts for external bells etc.

Complete kit **£52.50** plus VAT, or ready built and tested **£64.50** plus VAT.

Wireless World Dolby noise reducer

Trademark of Dolby Laboratories Inc.



Typical performance
Noise reduction better than 9dB weighted.
Clipping level 16.5dB above Dolby level (measured at 1% third harmonic content)
Harmonic distortion 0.1% at Dolby level typically 0.05% over most of band, rising to a maximum of 0.12%
Signal-to-noise ratio: 75dB (20Hz to 20kHz, signal at Dolby level) at Monitor output
Dynamic range >90dB
30mV sensitivity

Complete Kit **PRICE: £49.95** + VAT (3 head model available)

Also available ready built and tested .... **Price £67.60** + VAT
Calibration tapes are available for open-reel use and for cassette (specify which) .... **Price £2.75** + VAT
Single channel plug-in Dolby (TM) PROCESSOR BOARDS (92 x 87mm) with gold plated contacts and all components .... **Price £10.50** + VAT

We guarantee full after-sales technical and servicing facilities on all our kits, have you checked that these services are available from other suppliers?

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MARCONI Type TF791D carrier deviation meter, very good condition, few only £90.00+VAT
MARCONI Type TF1060 u h f. signal generator 0-1200MHz, few only £60.00+VAT
MARCONI Type TF1064 v h f signal generator 68-108MHz 118-185MHz 450-470MHz am and fm good condition £80.00+VAT
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HAMEG OSCILLOSCOPE NM 307 LPS triggering bandwidth DC to 10MHz component tester Timebase 02 US 02/CM £149.00+VAT
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BNC RIGHT-ANGLED PLUGS 75 ohm type GE 3750Z C12 50p each or 12 for £5.00+VAT
HIGH QUALITY RELAYS 4 pole C/O 3A contacts 12v DC coil 150ohm size approx 1"x¾"x1¼" with plastic covers 80p each or 2 for £1.50+VAT
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The Leaders in Short Wave

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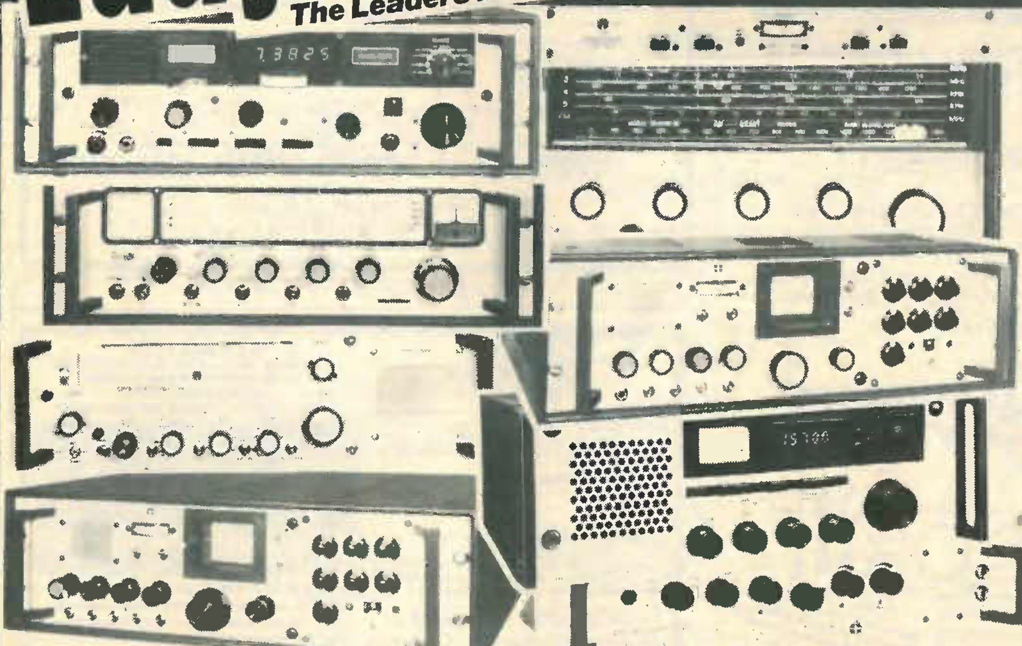

Sonic Sound, the premier home entertainment store have now added yet another big name in the field of sound equipment to further enhance their prestige in London's centre of the audio/visual and Hi-Fi field in Tottenham Court Road.

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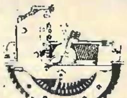

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Sub. Min. Honeywell Lever m/s type 3115m 906t. 10 for **£3.50** post paid (**£4.37** incl. VAT). These V3 types.
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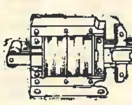

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VARIABLE 0—260V

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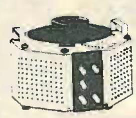

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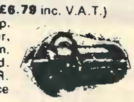
HELLERMAN DEUTSCH. Hermetically sealed sub.-min. Relay. 12-24V. D.C. 2 c/o 850 ohm coil. 0.2 pitch. P.C. mounting. L. 20mm. W. 10mm. H. 12mm. Fraction of maker's price: **£2.50** post paid (**£2.88** incl. VAT). N.M.S.

METERS (New) — 90mm DIAMETER
AC Amp. Type 62T2: 0-1A, 0-5A, 0-20A. **AC Volt,** 0-15V, 0-300V. **DC Amp,** Type 65C5 0-2A, 0-10A, 0-20A, 0-50A. **DC Volt.** 0-15V, 0-30V. All types **£3.50** ea plus P&P 50p (**£4.60** inc VAT) 0-50A DC, 0-100A DC. Price **£5.00** plus 50p P&P (**£5.94** inc VAT).

GEARED MOTORS
4.8 rpm SIGMA motors approx. 35lb inch.
7½ rpm KLAXON motors approx. 25lb inch.
28 rpm WYNSCALE motors approx. 20lb inch.
71 rpm WYNSCALE motors approx. 10lb inch.
Above four motors are designed for 110V AC supplied with auto transformer for 240V AC operation **£9.25** (P&P 75p). Total incl. VAT & P **£11.50,** N.M.S.

19 rpm FHP 220/240 AC reversible torque. 14.5kg. Gear ratio 144—1. Brand new, including capacitors, mf. **CITENCO.** Price **£14.25** + £1.25 P&P (**£17.83** inc VAT). N.M.S.
30 rpm 230/240V AC 50lb. in. mf. **PARVALUX.** Price **£15.00** + £1.50 P&P (**£18.98** inc. VAT N.M.S.
56 rpm. 240V AC. 50lb. in. 50Hz 0.7 amp. Shaft length 35mm. Dia. 16mm. Wt. 6kg. 600g. Mf. **FRACMO.** Price **£15.00** + £1.50 P&P (**£18.98** inc. VAT). R.&T.

24V D.C. Reversible Motor
Parvalux type SD12L, 24 D.C. shunt wound Motor. **133rpm. 65lbs.** in. Gearbox ratio 30-1. Current 6-8 amp. Rating continuous. Will operate on reduced power and speed at 9V D.C. or less. Size Dia. 16mm, Width 150mm, Shaft dia. 16mm. Price **£16.00** plus p&p £2.00. (**£20.70** inc VAT). N.M.S.
60rpm 100lb in rating. Price as above.
100W Rheostat 1 ohm speed control **£5.90.** (**£6.79** inc. V.A.T.)
100 rpm 110V AC 115lb. in. 50Hz. 2.8 amp. Single phase split capacitor. Immense power. Totally enclosed. Length 250mm. Dia. 135mm. Spindle dia. 15.5mm, length 145mm. Tested. Price **£12.00** + £1.50 P&P (**£15.53** inc.VAT). R. & T. Suitable Transformer for 230-240V op. Price **£8.00** + 75p P&P (**£10.05** inc. VAT).



200 rpm 35lbs in 115V 50Hz. Price **£16.00** + £1.50 P&P (**£20.13** inc. VAT). N.M.S.
Suitable Transformer for 230-240V AC. Price **£8.00** + £1.00 P&P (**£10.35** inc. VAT). N.M.S.
12V DC type SD2 Shunt 1/30th ph continuously rated 4,000 rpm. Mf. **PARVALUX.** Price **£10.00** + P&P (**£12.35** inc. VAT). N.M.S.
1 rpm 230/240V AC SYNCHRONOUS GEARED Motor. Mf. **HAYDON 2 rpm** 230/240V AC Synchronous geared Motor. Mf. **CROUZET.** Either type **£3.90** + 30p P&P (**£4.83** inc. VAT). N.M.S.

24V DC GEARED MOTOR
24V DC 200 rpm 10 lbs/ins continuously rated geared Motor mfg by either Parvalux or Carter. Easily removable from heavy ali chassis containing 9 × 24V DC Solenoids, microswitches, friction clutch, precision gearing, etc. etc. Ex-equipment London Transport Ticket Printer. Price: **£11.00** + £2.00 p. & p. (total incl. VAT **£14.95**).

ROTARY CARBON VANE VACUUM & COMPRESSOR
Direct coupled to 1/3 h.p. 110/115V A.C. Motor 4.2 amp. 1380 rpm. Motor manuf. by A.E.I. Pump by Williams. Max. Vac. 25" H.G. Max pressure cont. 10 p.s.i. int. 15 p.s.i. Max. airflow 3 c.f.m. at "0" H.G. Price **£30.00** + P & P **£3.00** (**£37.95** inc. VAT). N.M.S.
Suitable transformer for 240V op. **£10.00** P. & P. £2.00 (**£13.80** incl. VAT). N.M.S.

REDUCTION DRIVE GEARBOX
Ratio 72.1 input spindle ¼×½in. Output spindle ⅜×3in long. Overall size approx 120×98×68mm. All metal construction. Ex-equip tested. Price **£2.00** + 50p P&P (**£2.88** inc VAT & P).

AC Wkg TUBULAR CAPACITORS
Fraction of maker's price. Motor start, etc.

1.5 mfd.	440V AC	**60p**
2 mfd.	250V AC	**60p**
2 mfd.	450V AC	**75p**
2.2 mfd.	440V AC	**75p**
3 mfd.	440V AC	**£1.00**
4.1 mfd.	440V AC	**£1.00**
5 mfd.	400V AC	**£1.25**
5.3 mfd.	160V AC	**60p**
5.4 mfd.	280V AC	**75p**
6.5 mfd.	280V AC	**£1.00**
7.5 mfd.	200V AC	**£1.00**
10 mfd.	250V AC	**£1.00**
10 mfd.	400V AC	**£1.75**
14 mfd.	400V AC	**£3.00**
15 mfd.	250V AC (block)	**£1.50**
19 mfd.	280V AC	**£2.00**
20 mfd.	250V AC	**£2.25**
50 mfd.	370V (block)	**£5.00**

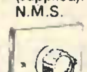
P&P up to 2.5 mfd. 25p. 3 mfd. to 20 mfd: 50p. 50 mfd. £1.50. All plus VAT. N.M.S.
SPECIAL DISCOUNT FOR BULK ORDERS

'VENNER TYPE' ERD TIME SWITCH
200/250V AC 30amp 2 on/2 off every 24 hrs at any manually pre-set time. 36-hour spring reserve and day omitting device. Built to highest Electricity Board Specification. Price **£9.50.** P&P 75p (**£11.79** inc. VAT). R&T.

SANGAMO WESTON TIME SWITCH
Type S251 200/250 AC 2 on 2 off every 24 hours. 20 amps contacts with override switch. Diameter 4" x 3" price **£8.50** P&P 50p (**£10.35** inc. VAT & P). Also available with solar dia. R&T.

PROGRAMME TIMERS
12 Cam Programmer Timers. 240v. A.C. op. Each Cam individually adjustable. Price **£7.50** plus 75p p&p. (**£9.49** inc. V.A.T.). R&T.
Ditto, 6 adjustable 6 fixed cams. Price **£6.00** plus 75p p&p (**£7.76** inc. V.A.T.) R&T.

MINIATURE PROGRAMMER
Crouzet 1 rpm 115V AC Motor operating 2 roller microswitches (4 amp). Can be used on 240V AC with either 0.25 mfd 250V Condenser or 5.6K wirewound resistor 7 watts (supplied). Price **£2.50** + 50p P&P (**£3.45** inc VAT & P). N.M.S.



800 WATT DIMMER SWITCH
Easily fitted. Will control up to 800W. of all lights except fluorescent at mains voltage. **Price: £3.90** + 50p P & P (**£5.06** incl. VAT).

N.M.S. — New Manufacturers' Surplus
R.&T. — Reconditioned and Tested

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7403	14p	74366	100p	4024	50p
7404	14p	74367	100p	4025	20p
7405	18p	74368	100p	4026	130p
7406	36p	74390	200p	4027	50p
7407	36p	74393	200p	4028	84p
7408	17p	74490	225p	4029	100p
7409	19p	**74LS SERIES**		4030	55p
7410	15p	74LS00	14p	4031	200p
7411	24p	74LS02	16p	4034	200p
7412	20p	74LS03	18p	4035	110p
7413	30p	74LS04	16p	4036	295p
7414	40p	74LS05	25p	4039	295p
74C14	90p	74LS08	22p	4040	100p
7416	27p	74LS09	21p	4041	80p
7417	27p	74LS10	20p	4042	80p
7420	17p	74LS11	40p	4043	90p
7421	40p	74LS13	40p	4044	90p
7422	22p	74LS14	50p	4046	110p
7423	34p	74LS20	20p	4047	100p
7425	30p	74LS21	40p	4048	55p
7426	40p	74LS27	38p	4049	45p
7427	34p	74LS30	20p	4050	45p
7428	36p	74LS32	27p	4051	80p
7430	17p	74LS37	30p	4052	80p
7432	30p	74LS38	38p	4053	80p
7433	40p	74LS42	70p	4054	150p
7437	35p	74LS47	75p	4055	125p
7438	35p	74LS51	24p	4056	135p
7440	17p	74LS55	30p	4059	600p
7441	70p	74LS73	50p	4060	115p
7442A	60p	74LS74	27p	4063	120p
7443	112p	74LS75	36p	4066	55p
7444	112p	74LS76	45p	4067	450p
7445	100p	74LS83	70p	4068	27p
7446A	93p	74LS85	80p	4069	20p
7447A	75p	74LS86	40p	4070	30p
7448	80p	74LS90	40p	4071	25p
7450	17p	74LS92	70p	4072	25p
7451	17p	74LS93	60p	4073	25p
7453	17p	74LS96	110p	4075	25p
7454	17p	74LS107	45p	4076	107p
7460	17p	74LS109	80p	4081	27p
7470	36p	74LS112	40p	4082	27p
7472	30p	74LS113	90p	4086	72p
7473	34p	74LS114	45p	4089	138p
7474	30p	74LS122	80p	4093	70p
7475	38p	74LS123	60p	4094	250p
7476	32p	74LS124	180p	4095	95p
7480	50p	74LS125	50p	4096	95p
7481	100p	74LS126	50p	4097	340p
7482	84p	74LS132	60p	4098	120p
7483a	90p	74LS133	30p	4099	200p
7484	100p	74LS136	55p	40100	220p
7485	110p	74LS138	65p	40101	132p
7486	34p	74LS139	75p	40102	180p
7489	210p	74LS145	120p	40103	180p
7490A	30p	74LS147	220p	40104	99p
7491	80p	74LS148	175p	40105	120p
7492A	46p	74LS151	80p	40106	90p
7493A	36p	74LS153	60p	40107	60p
7494	84p	74LS154	200p	40108	470p
7495A	70p	74LS155	80p	40109	100p
7496	65p	74LS156	90p	40110	300p
7497	180p	74LS157	60p	40114	250p
74100	130p	74LS158	60p	4502	120p
74107	34p	74LS160	90p	4503	70p
74109	55p	74LS161	75p	4507	55p
74116	200p	74LS162	140p	4508	290p
74118	130p	74LS163	100p	4510	99p
74119	210p	74LS164	90p	4511	120p
74120	110p	74LS165	140p	4512	80p
74121	34p	74LS166	180p	4514	265p
74122	48p	74LS173	110p	4515	300p
74123	60p	74LS174	100p	4516	110p
74125	75p	74LS175	100p	4518	100p
74126	60p	74LS181	320p	4520	100p
74128	75p	74LS190	100p	4521	250p
74132	75p	74LS191	100p	4526	108p
74136	75p	74LS192	100p	4527	150p
74137	50p	74LS193	100p	4528	100p
74141	50p	74LS195	140p	4532	140p
74142	200p	74LS196	120p	4534	550p
74145	90p	74LS197	90p	4538	120p
74147	190p	74LS221	120p	4543	180p
74148	150p	74LS240	175p	4553	320p
74150	130p	74LS241	175p	4556	72p
74151A	70p	74LS242	170p	4560	200p
74153	70p	74LS243	170p	4569	250p
74154	120p	74LS244	150p	4572	40p
74155	90p	74LS245	250p	4583	110p
74156	90p	74LS247	140p	4584	90p
74157	70p	74LS251	140p	4585	150p
74159	190p	74LS253	90p	4724	250p
74160	100p	74LS257	90p	40097	90p
74161	100p	74LS258	160p	14411	1100p
74162	100p	74LS259	160p	14412	1100p
74163	100p	74LS266	100p	14433	1100p
74164	120p	74LS273	170p	14500	700p
74165	130p	74LS279	90p	14599	290p
74166	120p	74LS283	90p	**INTERFACE ICs**	
74167	200p	74LS298	160p	AD536AJ	
74170	240p	74LS323	400p		1350p
74172	450p	74LS324	200p	AD561J	1400p
74173	120p	74LS348	200p	AD7524J	600p
74174	90p	74LS365	48p	DM8123	175p
74175	85p	74LS367	70p	DM8131	375p
74176	90p	74LS368	100p	DP8304	450p
74177	90p	74LS373	150p	DS8835	250p
74178	160p	74LS374	150p	DS8836	150p
74180	93p	74LS375	120p	DS8838	225p
74181	160p	74LS377	160p	MC1488	75p
74182	90p	74LS378	140p	MC1489	75p
74184A	150p	74LS390	120p	25S10	350p
74185	150p	74LS393	120p	75107	160p
74186	500p	74LS445	140p	75110	325p
74188	326p	74LS668	100p	75150	175p
74190	120p	74LS670	400p	75154	175p
74191	120p	**4000 SERIES**		75182	230p
74192	100p	4000	15p	75322	300p
74193	100p	4001	22p	75324	375p
74194	120p	4002	20p	75325	375p
74195	95p	4006	95p	75361	300p
74196	95p	4007	20p	75363	400p
74197	80p	4008	80p	75365	200p
74198	150p	4009	40p	75451 2	72p
74199	150p	4010	50p	75491 2	70p
74221	160p	4011	22p	8T26	160p
74251	140p	4012	25p	8T28	250p
74259	250p	4013	50p	8T95	200p
74278	290p	4014	84p	8T97	160p
74279	110p	4015	84p	81LS95	120p
74283	140p	4016	45p	81LS96	140p
74284	360p	4017	80p	81LS97	120p
74285	360p	4018	89p	81LS98	140p
		4019	45p	9601	110p

93 SERIES		**74S SERIES**			
9301	160p	74S00	60p	74S114	120p
9302	175p	74S04	60p	74S124	300p
9308	316p	74S05	75p	74S132	160p
9310	275p	74S08	75p	74S133	75p
9311	275p	74S10	60p	74S138	225p
9312	160p	74S20	60p	74S139	225p
9314	165p	74S30	60p	74S157	250p
9316	225p	74S32	90p	74S174	250p
9321	225p	74S37	90p	74S175	320p
9322	150p	74S64	60p	74S194	350p
9334	360p	74S74	90p	74S241	450p
936B	250p	74S85	300p	74S260	70p
9370	300p	74S86	180p	74S373	500p
9374	200p	74S112	120p	74S374	500p

LINEAR I.Cs

AY1-0212	600p	MC1458	48p
AY1-1313	668p	MC1495L	350p
AY1-1320	320p	MC1496	70p
AY1-5050	140p	MC3340P	120p
AY3-1270	840p	MK50398	750p
AY3-8912	650p	ML920	775p
AY5-1224A	240p	MM57160	620p
AY5-1315	600p	NE531	150p
AY5-1317A	775p	NE555	20p
AY5-4007D	520p	NE556	70p
CA3019	80p	NE562B	425p
CA3046	70p	NE564	420p
CA3048	225p	NE565	130p
CA3080E	72p	NE566	155p
CA3086	48p	NE567	140p
CA3089E	225p	NE571	425p
CA3090AQ	375p	NE5534A	250p
CA3130E	90p	RC4151	200p
CA3140E	50p	S566B	270p
CA3160E	100p	SAD1024A	1250p
CA3161E	140p	SFF96364	1100p
CA3162E	450p	SL490	400p
CA3189E	300p	SN76003N	250p
CA3280	160p	SN76013N	140p
DAC1408-8	200p	SN76013ND	120p
FX209	750p	SN76023N	140p
ICL7106	850p	SN76477	175p
ICL8038	300p	SP8515	750p
ICM7555	80p	TAA621	275p
LF13331	310p	TBA641B11	225p
LF351	48p	TBA651	200p
LF356P	95p	TBA800	90p
LM10C	425p	TBA810	100p
LM301A	27p	TBA820	90p
LM311	70p	TBA950	300p
LM318	200p	TCA210	250p
LM319	225p	TCA220	350p
LM324	45p	TCA940	175p
LM339	75p	TDA1004	300p
LM348	95p	TDA1008	320p
LM377	175p	TDA1010	225p
LM380	75p	TDA1022	570p
LM381AN	180p	TDA1024	120p
LM386	95p	TDA1034B	250p
LM393	100p	TDA1170	300p
LM709	36p	TDA2002V	325p
LM710	50p	TDA2020	320p
LM725	350p	TL071/81	45p
LM733	100p	TL072/82	75p
LM741	18p	TL074	130p
LM747	70p	TL084	110p
LM748	35p	TL170	50p
LM2917	250p	UAA170	175p
LM3900	70p	UDN6118	320p
LM3909	70p	UDN6184	320p
LM3911	130p	ULN2003	100p
LM3914	225p	XR2206	300p
LM3915	225p	XR2207	400p
LM4136	120p	ZN414	90p
LM13600	125p	ZN419C	225p
MC131DP	150p	ZN424E	135p
		ZN425E	400p
		ZN427E	750p

VOLTAGE REGULATORS
Fixed Plastic TO-220

1A	+ve		-ve	
5V	7805	60p	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	78HO5KC	550p
LM323K	500p	78MGT2C	135p
LM723	37p	79HGKC	650p
		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	18p
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**	
		9368	250p
3015F	200p	9370	300p
DL704	140p	UDN6118	320p
DL707 Red	140p	UDN6184	320p

TRANSISTORS

AC126	25p	BFR40	25p	TIP31A	58p	2N3553	240p
AC127/8	20p	BFR41	25p	TIP31C	62p	2N3565	30p
AC176	25p	BFR79	25p	TIP32A	68p	2N3584	250p
AC187/8	25p	BFR80	25p	TIP32C	82p	2N3643/4	48p
AF116	50p	BFR81	25p	TIP33A	90p	2N3702/3	12p
AD149	70p	BFX29	40p	TIP33C	114p	2N3704/5	12p
AD161/2	45p	BFX30	34p	TIP34A	115p	2N3706/7	14p
AU107	200p	BFX84/5	40p	TIP34C	160p	2N3708/9	12p
BC107/8	11p	BFX86/7	30p	TIP35A	225p	2N3773	300p
BC109	11p	BFX88	30p	TIP35C	290p	2N3819	25p
BC117	20p	BFW10	90p	TIP36A	270p	2N3820	50p
BC147/8	9p	BFY50	30p	TIP36C	340p	2N3823	70p
BC149	10p	BFY51/2	30p	TIP41A	65p	2N3866	90p
BC157/8	10p	BFY56	33p	TIP41C	78p	2N3902	700p
BC159	11p	BFY90	90p	TIP42A	70p	2N3903/4	18p
BC169C	12p	BRY39	45p	TIP42C	82p	2N3905/6	20p
BC172	12p	BSX19/20	20p	TIP54	160p	2N4037	65p
BC177/8	17p	BU104	225p	TIP120	120p	2N4058/9	12p
BC179	18p	BU105	190p	TIP122	130p	2N4060	12p
BC182/3	10p	BU108	250p	TIP142	130p	2N4061/2	18p
BC184	11p	BU109	225p	TIP147	130p	2N4123/4	27p
BC187	30p	BU205	200p	TIP2955	78p	2N4125/6	27p
BC212/3	11p	BU208	200p	TIP4055	70p	2N4401/3	27p
BC214	12p	BU406	145p	TIS43	34p	2N4427	90p
BC237	15p	E300	50p	TIS93	30p	2N4871	60p
BC327	16p	E308	50p	ZTX108	12p	2N5087	27p
BC337	16p	E310	50p	ZTX300	13p	2N5089	27p
BC338	16p	MJ2501	225p	ZTX500	15p	2N5172	27p
BC461	36p	MJ2955	90p	ZTX502	18p	2N5179	90p
BC477/8	30p	MJ3001	225p	ZTX504	30p	2N5191	90p
BC516/7	40p	MJE340	50p	2N457A	250p	2N5194	90p
BC547B	16p	MJE2955	100p	2N696	35p	2N5245	40p
BC548C	9p	MJE3055	70p	2N697	25p	2N5296	55p
BC549C	18p	MPF102	45p	2N698	45p	2N5401	50p
BC557B	16p	MPF103/4	40p	2N706A	30p	2N5457/8	40p
BC559C	18p	MPF105/6	40p	2N708	30p	2N5459	40p
BCY70	18p	MPS6531	50p	2N918	45p	2N5460	60p
BCY71/2	22p	MPS8534	50p	2N930	18p	2N5485	44p
BD131/2	50p	MPSA06	30p	2N1131/2	36p	2N5875	250p
BD135/6	54p	MPSA12	50p	2N1613	25p	2N6027	48p
BD139	56p	MPSA13	50p	2N1711	25p	2N6041	160p
BD140	60p	MPSA20	50p	2N2102	70p	2N6044	160p
BD189	60p	MPSA42	50p	2N2160	350p	2N6052	300p
BD232	95p	MPSA43	50p	2N2219A	30p	2N6059	325p
BD233	75p	MPSA56	32p	2N2222A	30p	2N6107	65p
BD235	85p	MPSA70	50p	2N2369A	25p	2N6247	190p
BD241	70p	MPSU06	63p	2N2484	30p	2N6254	130p
BD242	70p	MPSU07	60p	2N2646	45p	2N6290	65p
BDY56	200p	MPSU45	90p	2N2904/5	30p	2N6292	65p
BF200	32p	MPSU65	78p	2N2906A	30p	2SC1172	150p
BF244B	35p	OC28	130p	2N2907A	30p	3N128	120p
BF256B	70p	OC35	130p	2N2926	9p	3N140	120p
BF257/8	32p	TIP29A	40p	2N3053	30p	3N141	110p
BF259	36p	TIP29C	55p	2N3054	65p	3N201	110p
BFR39	25p	TIP30A	48p	2N3055	48p	3N204	120p
		TIP30C	60p	2N3442	140p	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	300p
2114-2L	500p
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	750p
6800	650p
6802	950p
6809	2500p
8080A	450p
8085A	1100p
1NS8060	1000p
Z80	750p
Z80A	950p

EPROMS

1702A	500p
2708	450p
2716 (+5V)	£10

SUPPORT DEVICES

3242	800p
3245	450p
6522	750p
6532	900p
6820	375p
6821	375p
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
Z80P10	600p
Z80AP10	700p
Z80CTC	600p

Z80ACTC	700p
Z80-S10-1	£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	175p
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.MHz	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

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

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

VEROBOARDS
DIP Breadboard 4.15 × 6.15 325p
(Suitable for 20 × 14 pin or 16 × 16 pin DIL ICs) 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 × 10 way	85p	2 × 22 way	135p
2 × 15 way	100p	2 × 25 way	160p
2 × 18 way	120p		

COUNTERS

74C925	475p
74C928	600p
ICM7216B	2000p
ICM7217A	850p
ZN1040E	700p

TTL & ECL

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

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555	£18/100	7805	£5/10
741	£16/100	7812	£5/10
2114L-3	£4.00	7905	£6/10
2708 (450 ns)	£4.25	7912	£6/10
2708 (650 ns)	£3.75	2114L (450 ns)	£28/8
2716 (plus 5V only)	£9.00		
4116 (200 ns)	£24/8		

P&P + VAT Extra

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

(The above boards are suitable for all DIL ICs.)

16 KEY KEYPAD (Reed Switches)	450p
UHF Modulator 6MHz	£3.75
UHF Modulator 8MHz	450p
Reed Switches (12VA)	£0.25
LOGIC PROBE	£18.00
SUPERTESTER 680R	£33.00
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	
3.75×17"	340p	+ combs	370p
4.75×17.9"	450p	Combs	7p

IC TEST CLIPS

14 pin	£2.60	24 pin	£4.90
16 pin	£2.75	40 pin	£7.90

We carry a large stock of 74 and 74LS TTLs, CMOS, Linears, Memories, etc. and can normally offer ex-stock deliveries. We welcome inquiries for volume quantities both from local and overseas buyers.

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DANGER from RADIATION Be prepared WITH OUR RADIATION DETECTOR

Recommended for: Civil Defence, Fire, Police, Hospital & Medical use

General Information:

Pocket dosimeters provide an accurate, reliable and immediate method of measuring the integrated dose of radiation received by those exposed to ionising radiation. The dose may be read at any time and in any place, providing a source of light is available.

Principle:

The dosimeter is an ionisation chamber type using a quartz fibre electroscope as the indicating element. A microscope is used to project the image of the moving quartz fibre element on to a graticule scale. The quartz fibre is mounted on a wire electrode; which in turn is supported by a high quality insulator. When the instrument is charged, positive charges distribute themselves over the wire electrode and quartz fibre causing the fibre to bend away from the electrode. The fibre will take up a position depending on the amount of charge on the system.

When the surrounding air in the ionisation chamber is ionised negative ions will be attracted to the positively charged electrode thereby reducing its charge. The resulting fibre movement will be related directly to the quantity of radiation producing the ionisation. The fibre movement can thus be calibrated directly in roentgen units and the rate of movement of the fibre will be proportional to the roentgens received per unit time.

Construction:

The microscope, electroscope and ionisation chamber are housed in an outer skin which may be of brass or aluminium. At one end of the tubular case is fixed a charging assembly, and at the other an eye-piece window. These two assemblies are soldered into the outer case to ensure a hermetic seal.

Each dosimeter is provided with protective end cap translucent window so that the cap need not be removed for reading.

Dosimeters meet vibration, drop, salt spray, humidity, water immersion and temperature tests.

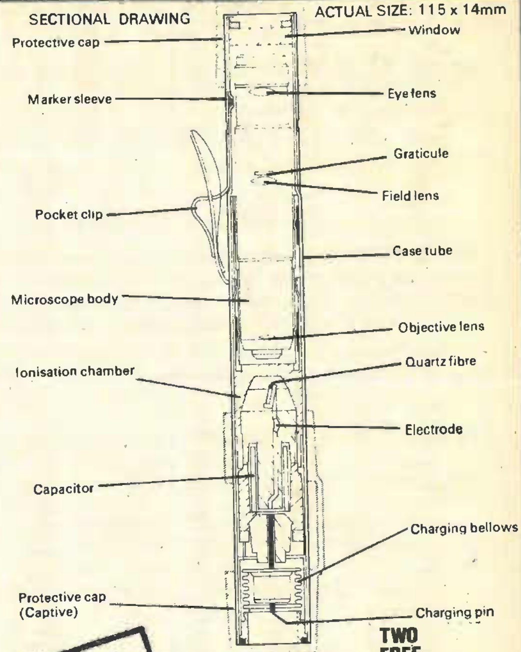
Features:

- These units will read automatically the amount of radiation in the air
- This instrument is only a little larger than a fountain pen
- Clips on to your top pocket
- Weight less than 3 oz.
- Contains three lenses
- Fully charged, tested and guaranteed. Refurbished by us
- British design and manufacture, rugged construction
- Manufacturer's list price of similar model is over £25
- Buy now whilst stocks available. Delivery by return post

● BE PREPARED, EVERY HOME SHOULD HAVE ONE ●

SECTIONAL DRAWING

ACTUAL SIZE: 115 x 14mm



SAVE £15

ALL YOURS FOR ONLY £10.95 incl. post paid

TWO FREE RE-CHARGE VOUCHERS WITH EVERY DETECTOR

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404 Edgware Road, London W2, England I.E.D.

BARCLAYCARD

Supplied complete with Data and information on radiation and detectors.

All units are checked and tested just prior to despatch by first-class mail in proper protective packing.

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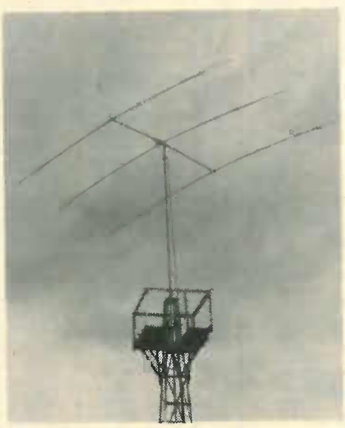
R

NEW FROM BARMECO

Introducing a new 3-element H.F. Tribanda with proven performance and reliability

THE WORLD RANGER TRIBANDER

Designed, engineered and manufactured in the U.K. Use of high quality materials ensures high electrical stability under all weather conditions with exceptional mechanical rigidity and strength. All traps are high grade P.T.F.E. formers with insulated windings.



SPECIFICATION:

Frequency	10, 15 & 20 metres
Impedance	52 ohms
R.F. Power (max.)	1 kW (AM) 2 kW (PEP)
VSWR (at resonance)	Less than 2.0:1
Forward gain	Up to 8.0 dB
Front-to-back ratio	25 dB
Mast diameter	31.75mm to 41.30mm
Wind survival	80 mph
Turning radius	14' 10"
Longest element	26' 0"
Boom length	12' 0"
Net weight	21 lbs.

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COMING SOON: A range of HF Monobanders and a 2 metre base station vertical

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Selective UHF V/Meter. Bands 4 & 5. USVF
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Miniature type (22mm diam.). Counting up to 15 turn "Helipots." Brand new with mounting instructions. Only **£2.50 each.**

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Sona-Graph model 7029A. 5-16000Hz Spectrum Analyser with type 6076C Plug-in unit. For the spectrogrphic Analysis of transient sounds such as speec, voice, doppler shifts, explosions etc. Supplied in excellent condition with handbooks.

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Input 190-260V AC. Output constant 220 Volts. 250W. **£25.** (£2 carriage)

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RADIOMETER Distortion Meter BKF6. **£125.**
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★APT 10459/8. 12-14V. @ 5 Amps. **£25.** (£2 p.p.)
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★We can supply the above power supply at any fixed voltage between 5V and 36V at 5A. **£25.**
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All the above power supply units are 230V. AC input and are stabilised and regulated and fused. All are fully tested before despatch and guaranteed in first-class order throughout. As with all our equipment there is a money-back guarantee if not completely satisfied.

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Supplied in excellent condition, fully tested:
115V. 4.5 x 4.5 x1.5" **£4.50.** 230V. £5. 115V. 3 x 3 x 1.5" **£4** + postage ea. 35p.

CT212 BF Signal Generators. 85KHz-32MHz. **£55.**

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Type SR5. Screen size 9 x 5". New condition. **£75.**

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DE FOREST ELECTRONICS TYPE MM200. DC.V.0-1KV. AC.V.0-700. DC.I.0-1A. AC.I.0-1A. Each in 4 ranges. Resistance 0-19.99 Mohms. 5 ranges. LED Display-1999.
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ADJACENT TO EDGWARE ROAD MET. LINE STATION

PLEASE ADD 15% TO ALL ORDERS INC. CARR.

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ALL PRIMARIES 220-240v

Type	Sec Taps	Amps	Price	Carr
1	24-30-40-48-60v	12	**£36.50**	£2.00
2	24-30-40-48-60v	10	**£31.50**	£2.00
3	24-30-40-48-60v	8	**£27.50**	£1.75
4	24-30-40-48-60v	5	**£16.75**	£1.75
5	24-30-40-48-60v	3	**£11.50**	£1.25
6	24-30-40-48-60v	2	**£7.50**	£1.25
	6-8-10-12-16-18-20-24-36-40-48-60v CAN BE OBTAINED FROM THE ABOVE RANGE			
7	19-25-33-40-50v	10	**£27.50**	£2.00
8	19-25-33-40-50v	6	**£19.50**	£1.75
9	19-25-33-40-50v	3	**£9.25**	£1.25
10	19-25-33-40 50v	2	**£7.75**	£1.25
	5-7-8-10-13-15-17-20-25-30-40-50v OR 25-0-25v OR 20-0-20v CAN BE OBTAINED FROM THE ABOVE RANGE			
11	12-15-20-25-30v	10	**£18.50**	£1.75
12	12-15-20-25-30v	5	**£10.50**	£1.50
13	12-15-20-25-30v	2	**£6.25**	£1.25
	3-4-5-6-8-9-10-12-15-18-20-24-30v OR 12-0-12v OR 15-0-15v CAN BE OBTAINED FROM THE ABOVE RANGE			
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18	12-24v	12v 4A, 24v 2A	**£4.25**	£1.25

HEAVY DUTY OP TRANSFORMERS

Type OT28EL 100 watts. 3.75Ω, 7.5Ω, 15Ω, 1.75K CT, 4 EL34 2x25 m/a dc max, **£15.50,** pp £1.25. Type OT29EL 50 watts, 3.75Ω, 15Ω, 3.5K CT, rated 2x125 m/a dc max, **£8.95,** pp £1.

LOW POWER LT TRANSFORMERS
Clamped, open frame tag connections
All primaries 240v

Type	Sec Taps	Amps	Price	Post
1	15v twice	200m/a ea	**£2.25**	75p
2	6v twice	500m/a ea	**£2.25**	75p
3	6v twice	4 amps ea	**£3.95**	£1.00
4	6v twice	1½ amps ea	**£2.95**	75p
5	8-9v twice	1 amp ea	**£2.95**	£1.00
6	10v twice	½ amp ea	**£2.50**	£1.00
7	12v twice	250m/a ea	**£2.25**	75p
8	12v twice	½ amp ea	**£2.25**	75p
9	12v twice	1 amp ea	**£2.95**	£1.00
10	24v CT	½ amp	**£2.25**	75p
11	30v CT	2 amps	**£3.25**	£1.00

AUTO STEPDOWN TRANSFORMERS FOR AMERICAN EQUIPMENT

240/110 volts. 80-2250 watts. Regular stock line. Types 80-1500 watts are fully shrouded. Fitted with American two or three pin socket outlets and 3 core 240v mains lead. Types 1750 and 2250 watts are steel cased with two American socket outlets. Neon indicator, three core mains lead and carrying handle. Send SAE for price list and further details. American sockets, plugs, adaptors also available.

SPECIAL OFFER OF HIGH GRADE EX-COMPUTER AUTO TRANSFORMERS.

Conservatively rated by famous makers, perfect condition, fraction of list price. Open frame construction top panel connections. 4000 watts tapped 0-105-115-125-135-200. 215-230-240-260v **£46.** Carr. £4. 3000 watts **£39.50.** Carr. £4.

HEAVY DUTY ISOLATION TRANSFORMERS
240-240v up to 15 Amps

Large selection available by famous makers. Fraction of list price. Please telephone for further details. 700 watt type PRI 200-240v sec 240v. Open frame, cable and connections.
£15. Carr £4.

AUTO TRANSFORMERS

Computer spec open frame type top panel connections tapped 0-90, 115-125-200-210-230-240-250 volts, conservatively rated 500 watts. **£9.50.** Carr £2.

VARIABLE TRANSFORMERS

Input 240v output 0-250v 5 amp type **£27.50** carr. £2. 2½ amp type **£18.75** carr. £1.50. Brand new regular stock line.

L.T. SMOOTHING CHOKES

Heavy duty open frame type. 24 m/h 45 amps. Terminal block connections. Size 8×8×8 **£19.50** carr. £4. 'C' core types 10 m/h 25 amps **£7.50** carr £3. 10 m/h 7.7 amps **£3.75** pp £1.25. 15 m/h 3.8 amps **£3.50** pp £1.25. Potted types 13 m/h 1.15 amps **£1.75** pp 75p. 100 m/h 2 amps **£3.50** pp £1. 4.8 m/h 10 amps open frame **£3.50** pp £1 Swinging "C" core type 10 m/h 4 amps-100 m/h ¼ amp to **£3.95** carr £1 50 HT chokes 4 H 250 m/a **£3** pp £1. 5 H 150 m/a **£2** pp 75p. 15 H 75 m/a **£1.50** pp 75p 50 H 25 m/a **£1.50** pp 75p

HIGH VOLTAGE INSULATION TRANSFORMERS AERE STANDARD
All primaries 220-240v

Type 1 sec 120-0-120v 1kVA, 15kVA DCWKG. **£50** carr. £5. Type 2 2.5v 35 amps and 4-5-6.3v 12 amps 10kV ACWKG **£20** carr £4. Type 3 sec. 2-0-2v 11 amps 25kv DCWKG **£7.50** carr. £2. Type 4 7v 25 amps 25kV DC WKG **£20** carr. £4. Type 5 1.25-0-1.25v 30 amps and 6.3v 5 amps KVDC WKG **£6** carr. £2.

HEAVY DUTY CONTACTORS

Coil voltage 24v DC one 100 amp make contact **£3**, pp 75p.

KINGSHILL STABILISED DC POWER SUPPLIES S SERIES

AC input tapped 200-240v DC output set at 28.1-33v. But by changing one easily accessible resistor marked R8 the following selections can be obtained, 0-6v, 6.1-11.5v, 11.6-16.5v, 16.6-20v, 20.1-24v, 24.1-28v, 38.1-41.5v, 41.6-46.5v, 46.1-49v. 1 amp output model. **£17.50** carr £2. 2 amp **£25** carr £2. 3 amp **£29.50** carr. £3. Data list of setting up resistors supplied. All units are brand new.

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AC input 200-220-240v DC output 112v or 125v 3 amps, plus or minus 3% choke/capacitor smoothed. FW Selenium rectification. Unused computer surplus. Fraction of maker's price **£27.50.** Carr. £4 Size of open chassis. 15 x 9½ins.

AEI 20 AMP CONTACTORS
BRAND NEW BOXED
FRACTION OF MAKER'S PRICE

Type	Coil voltage	Contacts	Price
0652	415vAC	3M 1B	**£1.50**
0655	415vAC	4M	**£1.50**
0648	110vAC	4M 4B	**£1.50**
0650	110vAC	6M 2B	**£1.50**
0653	110vAC	4M	**£1.25**
0654	110vAC	2M 2B	**£1.25**
0651	110vAC	3M 1B	**£1.25**
0649	42vAC	6M 2B	**£1.50**
0647	42vAC	4M 4B	**£1.50**

P&P 25p kq

AC WKG BLOCK CAPACITORS BY FAMOUS MANUFACTURERS

MFD	Volts	Price
0.75	440vAC	**50p**
1	470vAC	**60p**
1.25	360vAC	**65p**
2	400vAC	**75p**
2.4	360vAC	**75p**
2.5	360vAC	**75p**
2.7+0.1	700vAC	**£1.25**
3	440vAC	**£1.00**
4	250vAC	**£1.00**
5	360vAC	**£1.25**
6	440vAC	**£1.50**
7.2	440vAC	**£1.50**
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PP up to 2.5 MFD **25p,** 2.7 to 15 MFD **50p** +8% on total.

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Ex computer equipment, perfect condition, robustly housed in metal frame, overall size 11x7x7ins. fr outlet size 4x3ins. Motor spec. 1300 rpm cont. rated, cap start, cap inc with motor, quiet running **£4.95** carr. £2.

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Pri 240v sec 27v 3a open frame **£3.50** pp £1.50. Pri 240v sec 12v 5a open frame **£3.50** pp £1.50

LT TRANSFORMERS BY FAMOUS MAKERS. FRACTION OF LIST PRICE
All primaries 220-240v

Type 1 sec 43v 3a open frame. Tropicalised wire lead connections, **£3.95** carr £1.75. Type 2 sec 36v 6a open frame tag board connects **£7.50** carr £1.75, two will give 36-0-36v 6a price for two **£14** carr £2. Type 3 sec 10v 14a and 22.8v 10.5a, separate windings, open frame tag board connections, **£10** carr £2. Type 4 sec 24v 5a twice, will give 24-0-24v 5a or 24v 10a or 48v 5a, open frame, for drop thru mounting, easily adapted for normal mounting, **£8.50** carr £2.25. Type 5 c core, sec 12.6v 5.75a and 128-0-128v 14m/a top panel **£4.50** pp £1. Type 6 c core sec 13v 3a connections and 15v 1a separate windings, **£4.50** pp £1. Type 7 open frame, sec 65v 2.2a and 30-0-30 100 m/a, separate windings, tag board connections, **£4.50** pp £1.

LOW POWER LT TRANSFORMERS BY FAMOUS MAKERS, FRACTION OF LIST PRICE
All primaries 220-240v

Type 1 c core, sec 23.5-0-23.5 0.11a **£3.50** pp £1. Type 2, c core, sec 36v 0.35a, **£3.50** pp £1. Type 3 open frame 55w ½a **£3** pp £1. Type 4 c core, sec 10-7-0-7-10v 0.47a **£3.50** pp £1. Type 5, c core, sec 55-0-55 1557a and 6.3v 1.2a, **£3.50** pp £1. Type 6, c core, sec 36v 1a and 7.5-6-5v 1a **£3.50** pp £1. Type 7, c core, 18-22-27v ½a, twice **£3.50** pp£1. Type 8, open frame, sec 27v 1a **£2** pp £1. Type 9, open frame, sec 12v 1a and 24v ½a **£2** pp £1. Type 10, potted sec tapped 24-30-32v 2a, **£4** pp £1.50.

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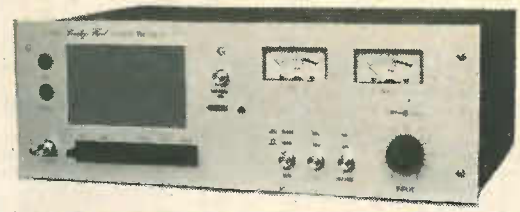
PRI 220-240v, sec 140v centre tapped (70-0-70v) 10 amps, size 7 x 7 x 7 ins, panel connections, **£27.50** carr £5. PRI 220-240, sec 12 volts 40 amps, **£22.50** carr £4. PRI 220v-240v sec 14v + 3 + 1½ + 1v 40 amps, 14-15-15.5-17-18-18.5 19-19.5v at 40 amp can be obtained. **£25** carr. £4. All types conservatively rated. Computer specs. Potted type PRI 220-240v, sec tapped 40-41-42 48-49-50v 10 amps conservatively rated. Size 9 x 7 x 6 ins. **£15** carr £4.

HT TRANSFORMERS BY FAMOUS MAKERS, FRACTION OF LIST PRICE

No 1 open frame, sec 260-0-260v 150 m/a and 205v 60 m/a, 6.3v 6a, 6.3v 1a, 5v 2a, **£6** pp £1.50. No 2 MT2AT open frame, 350-0-350v 80m/a, 6.3v 3a, 5v 2a or 6.31a, **£4.75** pp £1. No 3 open frame, sec 250v 100m/a and 6.3 4.5a, 15v 1.2a, **£4** pp £1. Type 4 open frame, sec 170v 40m/a and 6.3 3.3a, **£3** pp £1. Type 5 open frame, sec 112v 262m/a and 6.3 0.3a, **£3** pp £1. Type 6 c core, sec tapped 370-390-410v 6m/a, **£2** pp £1. EHT transformers pri 220-240v, sec 2000v 7m/a and 6.3v ½a, **£5** pp £1.50. Parmeko pri 220-240v, sec 1875v 60m/a and 500v 31m/a, **£6.50** carr £2. Pri240v, sec 2500v 0.11a Primary is also tapped at 260-280-300-330-350 to give variation on secondary. Top panel connections, **£15** carr £3.

LINSLEY HOOD CASSETTE RECORDER 2



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.

This latest version has the following extra features. Ultra low wow-and-flutter of .09% — easily meets DIN Hi-fi spec. Deck controls latch in rewind modes and do not have to be held. Full Auto stop on all modes. Tape counter with memory rewind. Oil damped cassette door. Latching record button for level setting. Dual concentric input level controls. Phone output. Microphone input facility if required. Record interlock prevents re-recording on valued cassettes. Frequency generating feedback servo drive motor with built-in speed control for thermal stability. All these desirable and useful features added to the excellent design of the Linsley-Hood circuits and the quality of the components used makes this new kit comparable with built-up units of much higher cost than the modest **£94.90** + VAT we ask for the complete kit.

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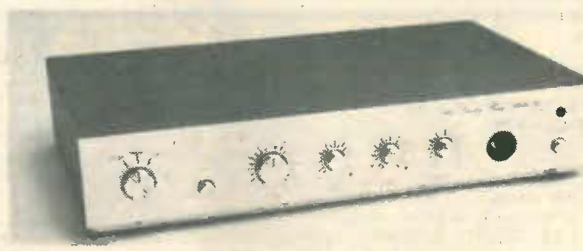
Features include capacitor tuned mosfet front end, integrated circuit I.F. strip, and phase locked loop stereo decoder chip. Stabilised power supply and rectifier on board only requires 19V AC at 175MA to power. Size 12½ x 3½ x 1¾.
Supplied complete with circuit diagram and ferrite rod aerial. FM section fully aligned and tested before despatch. Fantastic value at **ONLY £9.99** plus VAT. P.P. £1.

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.

All parts can be bought separately at a total cost of £79.12 but complete kits are available at a special introductory discount price of only **£78** + VAT.

SUPER BARGAIN OFFERS
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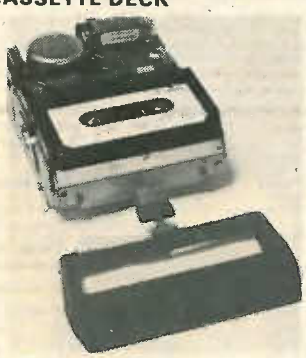
For those who missed our recent bargain CT4s we now are delighted to be able to offer Brand New Lenco FFR Decks complete with motor speed and auto-stop control board fitted and tested. These will operate with any supply between 9 and 16 volts. This deck can be used for both record and playback applications and is fitted with an erase head. A mono record/play head is fitted and we can supply an extra stereo head, if ordered with the deck at the very special price of £2 plus VAT. We also supply, with each deck and completely FREE, one of our specially moulded escutcheons. This deck would normally cost about £25 but we are able to offer them, while they last, at only £9.99 plus VAT.



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These circuits are just the thing for converting that old valve tape deck into a useful transistorised recorder. Total system is a full three head recorder with separate record and replay sections for simultaneous off tape monitoring. We also stock the heads. This kit is well engineered but does not have the detailed instructions that we give with our more recent designs. We would not therefore recommend it to beginners. Reprints of the original three articles 45p. Post free. No VAT.

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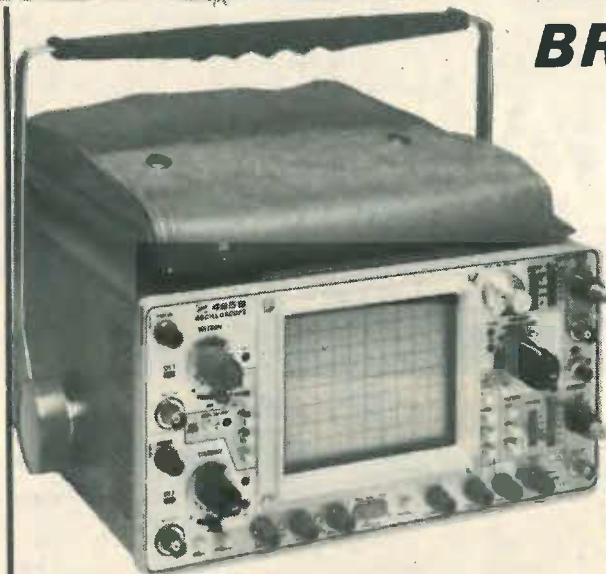

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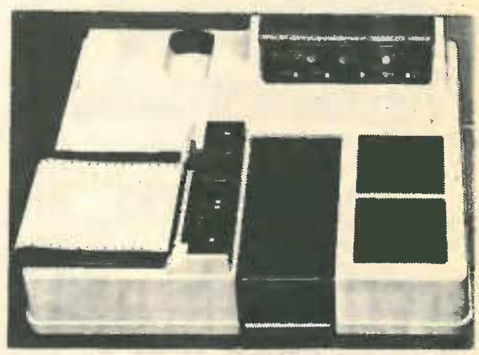

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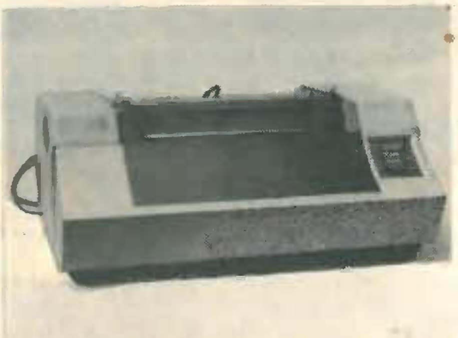
10½" chassis 16KW MOS DL11W KY11B—BRAND NEW **£4,500.00** (can be enhanced to 28KW)



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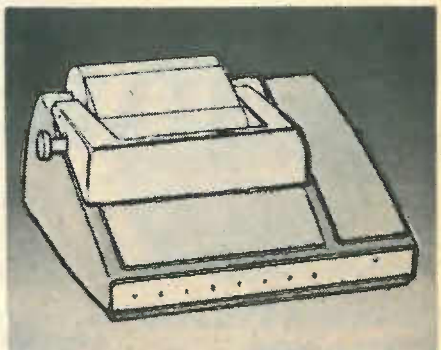

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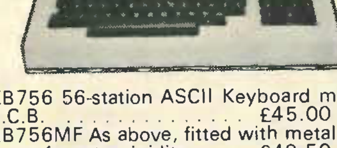

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Specification

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.
INDICATORS — Power On. Parity Error.
PARITY — Parity error indicated by Parity Light and question mark (?) displayed in character position.
TRANSMISSION — Asynchronous. Switch-selectable for any two standard rates up to 9600 baud.
OPERATING MODES — Full/Half Duplex.
MEMORY — High Speed MOS refresh.
STANDARD INTERFACE — CCITT V-24 (EIA RS-232 B/C).
REFRESH RATE — 50 fields per second.

When ordering please specify your choice of switch-selectable baud rates.
Standard: — Either A) 110/300 baud
or B) 300/1200 baud
Optional: A combination of any 2 of the following transmission speeds can be provided at a surcharge of £25.00.
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Hazeltine H-2000

The world's largest-selling teletypewriter-compatible video display terminal. The Hazeltine 2000 sets the standard in features, performance, reliability and value in an ever-expanding list of applications in Universities, Hospitals, Business, Finance and Government.
Features include ★ Switch-selectable transmission rates to 9600 baud ★ Three switch-selectable operating modes — full duplex, half-duplex or batch ★ Direct cursor addressability ★ Dual-intensity video ★ Tabulation ★ Powerful editing capability ★ Remote keyboard ★ Selective or automatic roll-up ★ Teletype compatible ★ Parity select ★ Large screen capacity ★ Clear 5 x 7 matrix character image ★ Full remote command set ★ Format capability ★ Standard peripheral interfaces.

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.
TRANSMISSION — Asychronous. Switch-selectable, for combinations of 5 standard rates, 110 to 9600 baud.
OPERATING MODES — Switch-selectable, full duplex, half-duplex or batch.
MEMORY TYPE — 2048 x 8 RAM.
EDITING FEATURES — Full Cursor Controls plus Insert/Delete Character, Insert/Delete Line, Clear Screen, Clear Foreground Data Only, Tab.
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.
AUXILIARY OUTPUT — Standard printer interfaces; Standard cassette interface.

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The Hazeltine Modular One terminal offers the full range of terminal performances — from simple teletypewriter compatibility to enhanced editing and polling capabilities.
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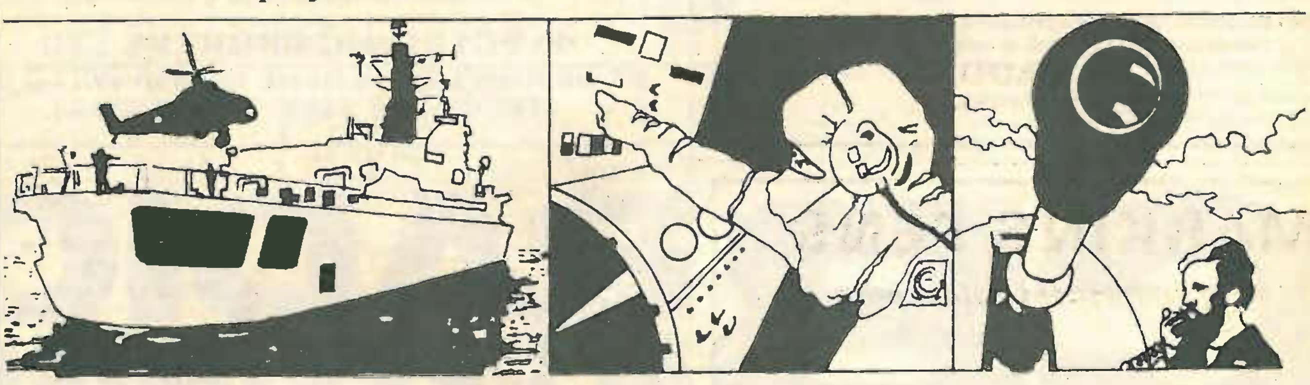

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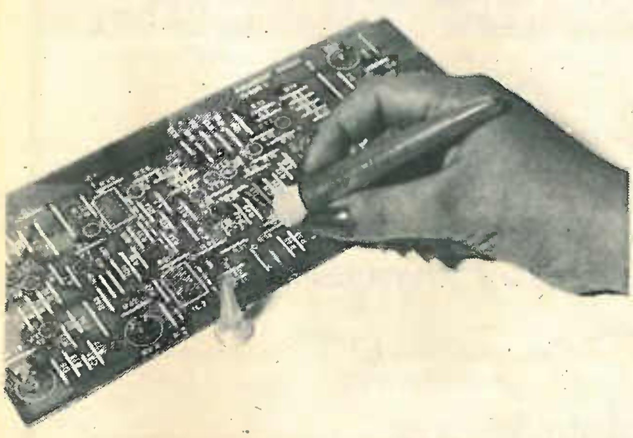

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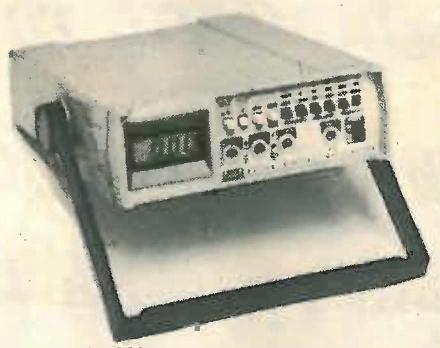

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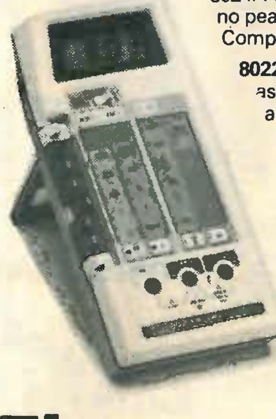

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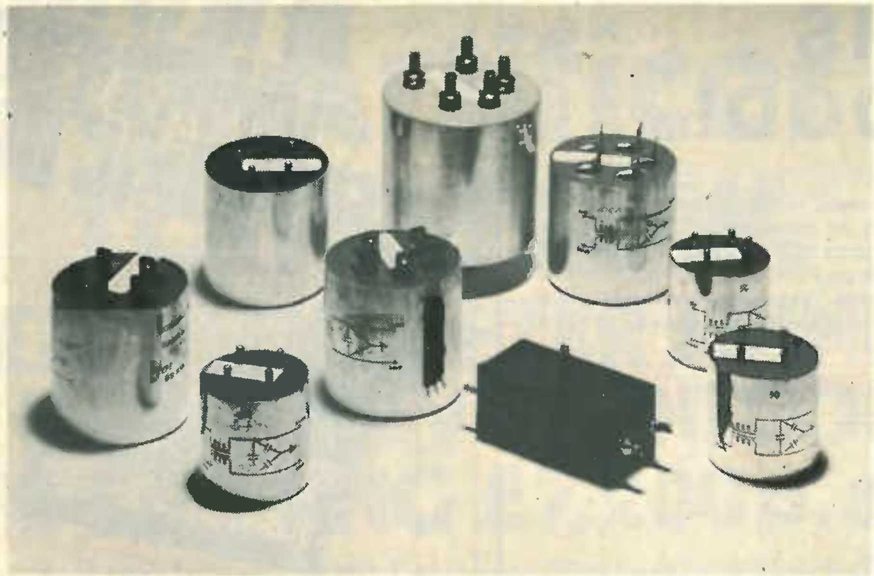

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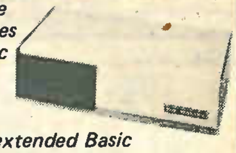

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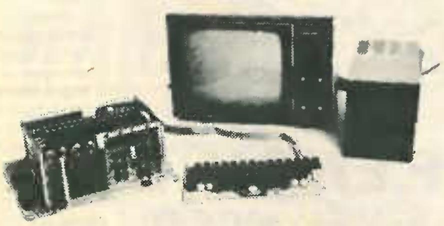

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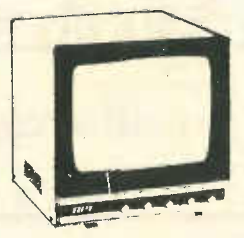

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This appointment will appeal to Electronics Engineers in industry or development or soon after completing an HNC course or on leaving the Armed Forces. It involves travel (mostly in the UK) and gives scope for working independently.

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(655)

CHIEF ENGINEER

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Applications are invited for the position of Chief Engineer for a new I.L.R. Station based in the West of Scotland (mainland). The Appointment would take effect from January, 1981, and applicants should be suitably qualified individuals having an enthusiasm for Local Radio and practical experience in all aspects of Installation, Maintenance, and Technical Operation of Sound Broadcast Equipment to the I.B.A. Code of Practice Standard.

Salary would be by negotiation.

Please reply, by 31st October, 1980, giving fullest career and qualification details to:

Moorfoot Services
"Argentine", Whiting Bay
Isle of Arran KA27 8PZ

Applicants for other Engineering Positions, to be engaged by May, 1981, are invited to respond to this advertisement.

(643)

Medical Customer Engineer
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Hewlett-Packard is a highly successful instrumentation and computer company with manufacturing divisions and sales offices worldwide. We are still enjoying sustained growth and currently require an experienced Customer Engineer in our Medical Group.

Working in the north and central London area you will be expected to provide a speedy, efficient and economical on-site repair and maintenance service to customers.

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Full training will be given in the U.K., and abroad. An attractive salary is offered for this position in addition to a comprehensive range of benefits including:-

* 2 Litre company car.
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For an application form, please ring Annabel Bayly on Wokingham 784774 or write to her at Personnel Department, Hewlett-Packard Limited, King Street Lane, Winnersh, Wokingham, Berkshire.

HEWLETT PACKARD

(679)

UNIVERSITY OF WARWICK

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Vacancies exist for two experienced television engineers to share responsibility for the maintenance and repair of high quality equipment in use in the Audio-Visual Centre's two studios, as members of a team providing television production, off-air recording and videotape playback facilities. Qualification to HND/HNC or Advanced C & G is desirable and previous experience of similar work or domestic radio and TV servicing would be an advantage. Salary would be at an appropriate point on the Technician Grade 4 scale: £4,431-£5,097 p.a., depending on age, qualifications and experience. Application should be made by letter quoting Ref. No. 2/2T/80/20 and should give full background details and the names of two referees, one of whom should preferably be the applicant's current employer, to the Personnel Office, University of Warwick, Coventry CV4 7AL by 24th September, 1980. (652)

BRISTOL POLYTECHNIC
DEPARTMENT OF ENGINEERING

Applications are invited for the following posts:

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GRADE T3/4 — Ref. No. T3382/54

ELECTRONICS MAINTENANCE TECHNICIAN

GRADE T3/4 — Ref. No. T3371/40

SALARY SCALE for the above: £4581-£5784 per annum

Both of these posts are situated in the Electronic Engineering Department and their basic function is to assist in the development and maintenance in a wide range of novel equipment.

For further details and an application form, to be returned by 30 September 1980, please contact Personnel Office, Bristol Polytechnic, Coldharbour Lane, Frenchay, Bristol BS16 1QY.

Please quote appropriate Reference Numbers in all communications.

(664)

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Applicants should ideally have a degree in electronics, physics or mechanical engineering.

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$21,000-26,000 p.a. (tax-free)

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He will have had a B.Sc. in Telecommunications Engineering or equivalent and has good command of English. He will also have had a minimum of five years' experience in repair of industrial radio related telecommunications equipment. Age range 27 to 45 years.

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Clear handwritten applications in ENGLISH, quoting the name of the publication where this advertisement was published and giving full details of their qualifications, training and experience as well as membership of professional associations and supported by copies of relevant testimonials, should be submitted separately to both the following addresses:

Senior Personnel Officer (R)
ADMA-OPCO
P.O. Box 303
Abu Dhabi
United Arab Emirates

Department of Petroleum
P.O. Box 9
Abu Dhabi
United Arab Emirates

(676)

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Plessey EAE design, install and maintain communications systems for the oil industry, at home and abroad.

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The work is demanding, but rewarding, offering you the chance to use your skills and your initiative to the full.

The company is based in Great Yarmouth, with offices in Aberdeen and Lerwick – but where relocation is necessary, we will give generous assistance with removal, legal and temporary accommodation expenses.

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

THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY
DEPARTMENT OF ELECTRICAL AND COMMUNICATION ENGINEERING

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Applicants should have practical experience in telecommunications, T.V., or broadcast engineering, and teaching experience at technician or technician/engineer level.

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The initial contract will be for 3 years. Other benefits include a gratuity of 24% taxed at 2%, appointment, repatriation and leaves fares for the staff member and family after 18 months of service, settling in and out allowance, six weeks paid leave per year, education fares and assistance towards school fees, free housing. Salary continuation and medical benefit schemes are available.

Detailed applications (two copies) with curriculum vitae, together with the names and addresses of three referees, should be received by the Registrar, Papua New Guinea University of Technology, P.O. Box 793, Lae, Papua New Guinea by **15 October 1980.** Applicants resident in the U.K. should also send one copy of application to the Association of Commonwealth Universities (Appts), 36 Gordon Square, London WC1H OPF.

(657)

OXFORD UNIVERSITY

DEPARTMENT OF ATMOSPHERIC PHYSICS

ELECTRONICS TECHNICIAN

A vacancy exists for an electronics technician (grade 5) to work on the construction, testing and maintenance of equipment used in the Department's space research programme. The successful applicant will become part of a small, energetic group involved in developing scientific instruments and launching them on Earth satellites and probes to the planets. Training will be given, as necessary, to young persons with suitable backgrounds. The salary scale is currently £4776-£5577 p.a. Applications, giving details of qualifications and experience, and the names of two referees, should be sent to Dr. F. W. Taylor, Dept. of Atmospheric Physics, Clarendon Laboratory, Oxford OX1 3PU.

(653)

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MANAGEMENT & EXECUTIVE SELECTION (682)

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01-502 1589/01-464 7714. EXT. 502 (533)

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The standards are high but then so are the rewards. In particular we are looking for the following men or women.

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A position that combines technical expertise with considerable managerial skills, in leading and directing a team of Design Engineers working with the most sophisticated techniques in radio communications applying advanced integrated circuit technology. Candidates must be honours graduates with a number of years post graduate development experience.

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Reporting to the Chief Engineer you should be an Electronics graduate with a minimum of six years experience of circuit design with a wide ranging knowledge of modem semi-conductor and thick film IC's, preferably covering both RF and digital applications.

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Co-ordinating and preparing technical proposals, specifications and tender bids for new development programmes, this position calls for considerable communication skills and commercial acumen. Applicants should be Electronics graduates with at least 10 years relevant experience.

Salaries of up to £10,500 and beyond are offered plus an excellent benefits package including BUPA membership and generous relocation assistance. Opportunities for further advancement are very good indeed.
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The Institut for Radio Astronomy in the Millimeter Wavelengths (IRAM) is interested in employing

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and

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Candidates with relevant experience should send a résumé by 30 September, 1980, to:

INSTITUT DE RADIO ASTRONOMIE MILLIMETRIQUE, (I.R.A.M.), Administration, B.P. 391, 38017 GRENOBLE CEDEX, Frnace.

(650)

LEEDS CITY COUNCIL

Department of Education

Leeds Polytechnic — School of Humanities & Contemporary Studies

SENIOR TECHNICIAN

(Ref. 150/2)

T3/4 £4581-£5784 (plus technician qualification allowance).

Responsible for the care and operation of two psychology laboratories. Duties will include the design, construction, repair and maintenance of electronic and laboratory equipment.

Ideally applicants might hold a City & Guilds Technician Certificate in Electronics or equivalent qualification, although relevant practical experience is equally important, and design and general engineering abilities are desirable.

Application forms, quoting reference number, from the Administrative Services Officer, Leeds Polytechnic, Calverley Street, Leeds LS1 3HE.

(681)

Develop your Electronics experience

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If you have sound up-to-date electronics engineering experience, plus an HNC or equivalent qualification and an ability to communicate what you know clearly and effectively, then a job as a Technical Instructor in our newly established Training School in Borehamwood, Herts might well appeal to you.

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As a member of our Training team you'll be developing and preparing courses; giving instruction and demonstrating techniques to a wide range of staff from junior craft apprentices to professional engineers.

We can offer you a good salary, attractive benefits and first-class opportunities to develop your career in this highly progressive company.

Write with details of your background which need not necessarily include experience of training, to Chris Hill at Marconi Avionics Limited, Elstree Way, Borehamwood, Herts. Or telephone 01-207 3455 any time and we'll send you more information. Quote reference MA 80/47.

(674)

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A GEC-Marconi Electronics Company

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Grade 5 or 6

required for the Department of Physiology to be responsible for the design and construction of prototype apparatus and the servicing of a wide range of electronic instruments for both research and teaching in the Medical Faculty. Good electronic background and qualifications (at least O.N.C. or equivalent) essential. Some experience in medical or biological field preferable though not essential. Salary on scale Grade 5 £5556 p.a. rising to £6357 p.a. (inclusive) according to qualifications and experience with possibility of the higher grade 6 salary on scale £6258 p.a. rising to £7323 p.a. (inclusive) for suitable applicant possessing higher qualifications and experience. Five weeks' annual holiday. Contributory pension scheme. Apply in writing with full details to The Head Clerk, Ref: 221796, King's College, London WC2R 2LS.

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(532)

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DEPARTMENT OF ELECTRONICS

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(665)

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(Clinical Measurement Department
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(662)

Nuffield Institute for Medical Research
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(on John Radcliffe Hospital site)

MEDICAL PHYSICS TECHNICIAN IV

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Applicants should have at least 2 years' previous experience and possess either 2 passes at GCE A level in appropriate science subjects, or equivalent qualification, or a recognised trade apprenticeship.

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Applications, stating age, qualifications and experience and giving the names and addresses of two referees, should be sent to: The Administrator, Nuffield Institute for Medical Research, Headley Way, Headington, Oxford OX3 9DS.
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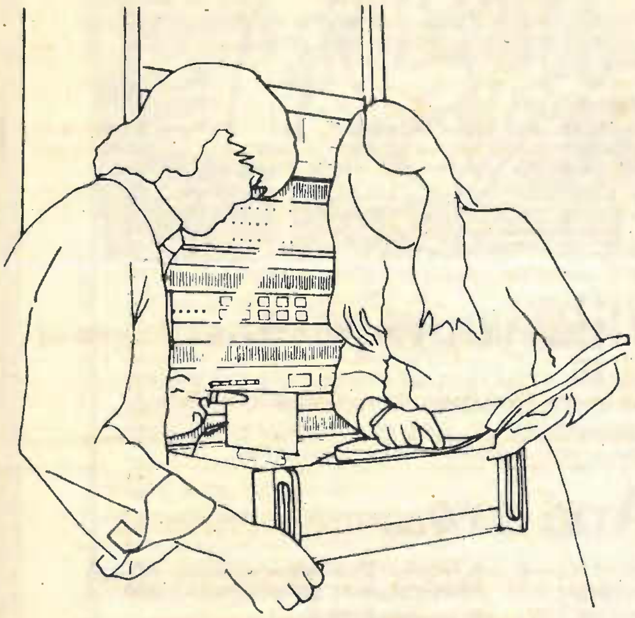

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Address ______________________________

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Telephone Work/Home (if convenient) ______

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Qualifications	None	C & G	HNC	Degree
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(668)

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£7115-£7915

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Candidates should preferably have an ONC, C&G, TEC/SCOTEC or equivalent qualification in Engineering or other relevant subject. They must have an aggregate of at least 8 years' recognised training (e.g. apprenticeships) and experience (which may include up to 3 years' relevant full-time study), and be experienced audio equipment technicians. **Ex-Service personnel** who have had suitable training and at least 7 years' appropriate service (as Staff Sergeant or equivalent) will also be considered.

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For further details and an application form (to be returned by 6 November, 1980), write to Civil Service Commission, Alencon Link, Basingstoke, Hants. RG21 1JB, or telephone Basingstoke (0256) 68551 (answering service operates outside office hours). Please quote Ref. T/5434.

(687)

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1 in 10^6?

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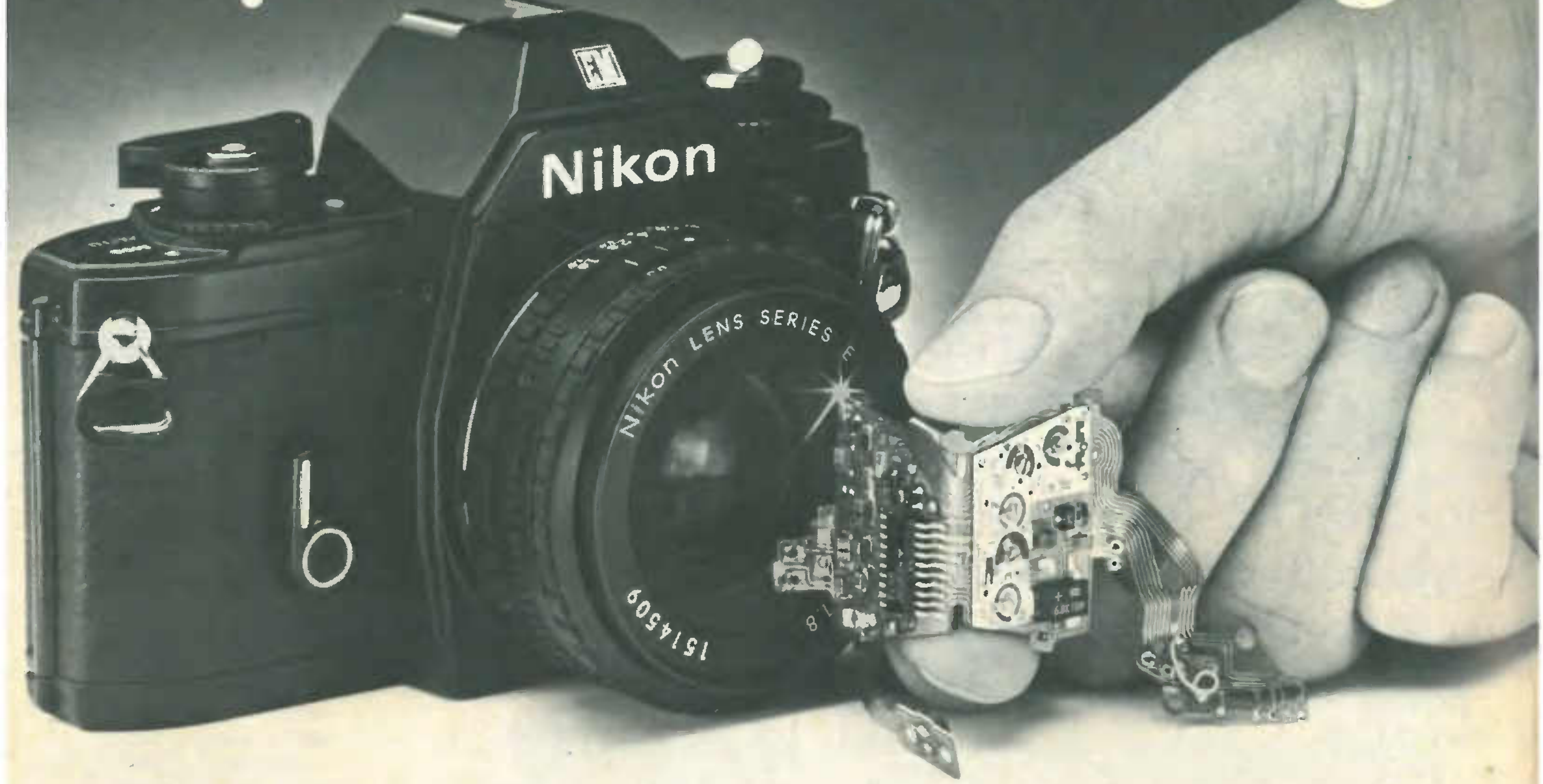

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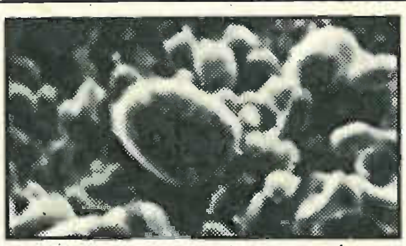

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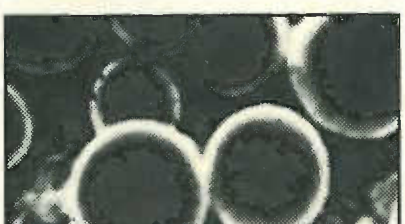

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