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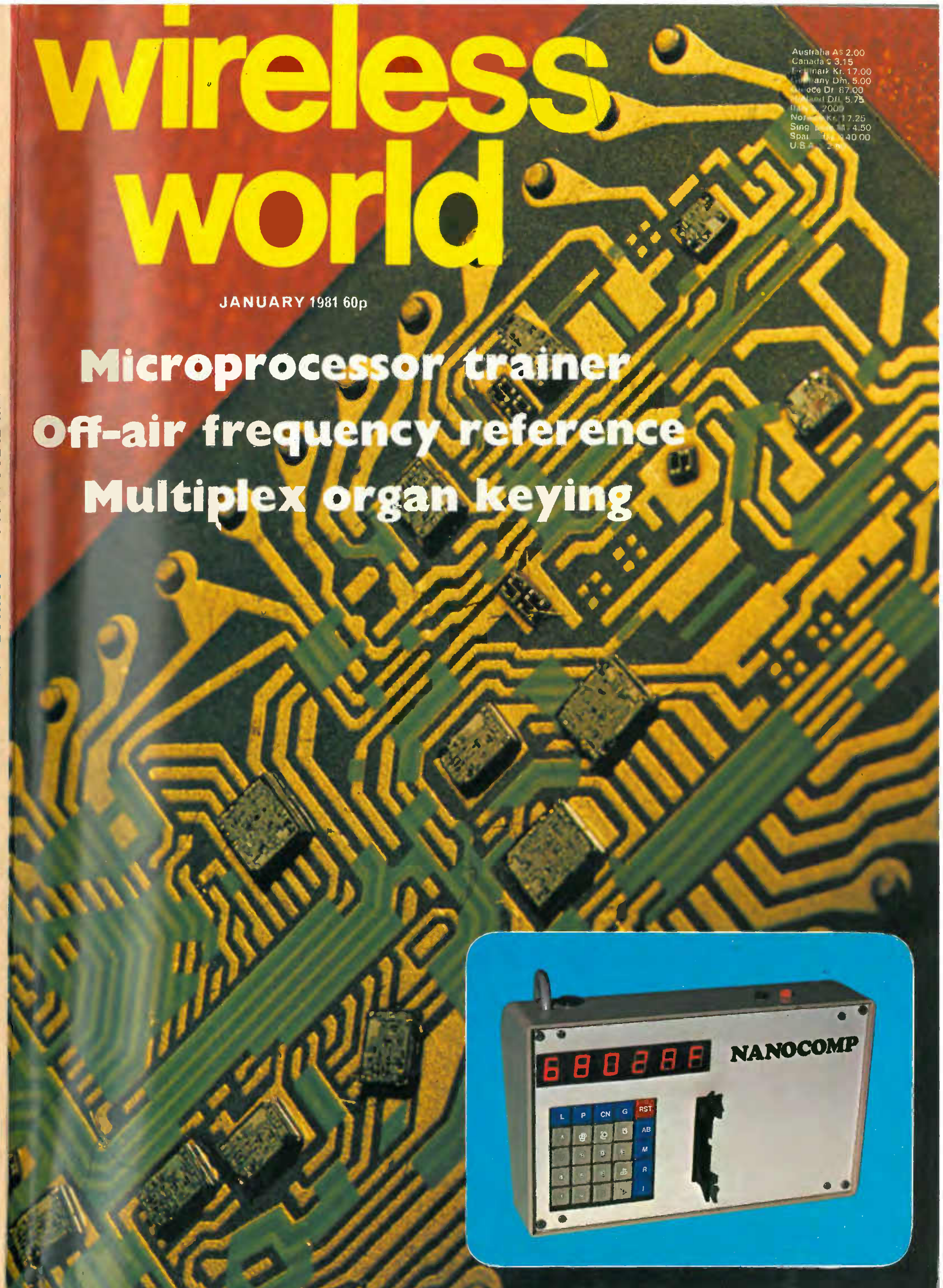
JANUARY 1981 60p

Microprocessor trainer
Off-air frequency reference
Multiplex organ keying

WIRELESS WORLD JANUARY 1981 VOL 87 NO 1540



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JANUARY 1981 60p

Microprocessor trainer
Off-air frequency reference
Multiplex organ keying

Front cover shows (inset) microprocessor trainer described in this issue with background of a Burr Brown thick film hybrid a-to-d converter photographed by Paul Brierley.

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wireless world

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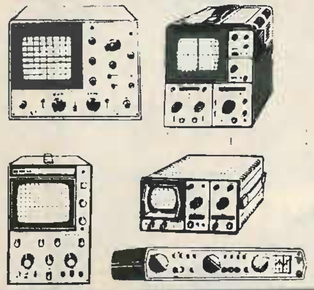

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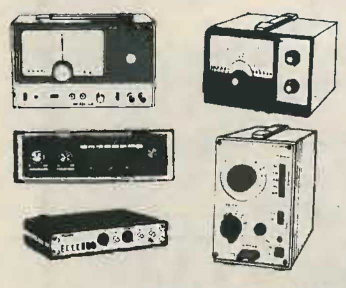

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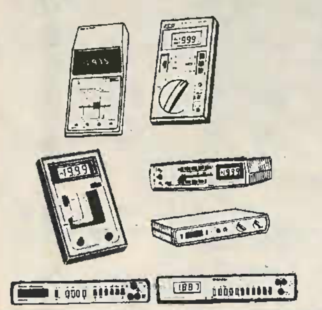

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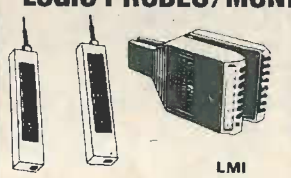

Logic probes indicating high/low etc states that scopes can miss. All circuit powered for all ICs.

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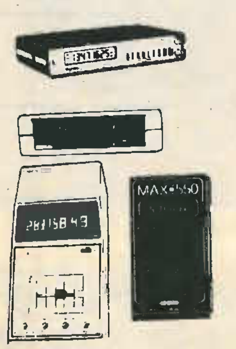

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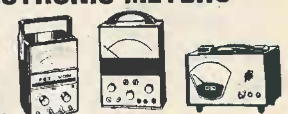

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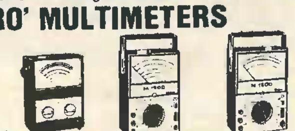

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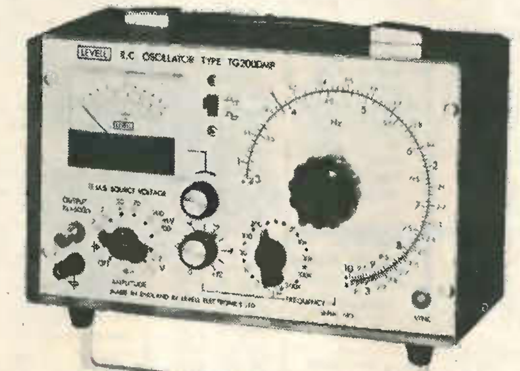

FREQUENCY	1Hz to 1MHz in 12 ranges. 0 to 1% fine control on TG200DMP.
ACCURACY	±1.5% ±0.01Hz up to 100kHz. ±2% up to 1MHz.
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DISTORTION	<0.05% from 50Hz to 15kHz, <0.1% from 10Hz to 50kHz, <0.2% from 5Hz to 150kHz, <1% at 1Hz and 1MHz.
SQUARE OUTPUT	TG200D, DM & DMP only, 7V peak down to <200μV. Rise time <150nS.
SYNC OUTPUT	<1V r.m.s. sine in phase with output
SYNC INPUT	±1% freq. lock range per volt r.m.s.
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SIZE & WEIGHT	260 × 130 × 180mm. 4.3kg with batteries.

TG200	TG200D	TG200M	TG200DM	TG200DMP
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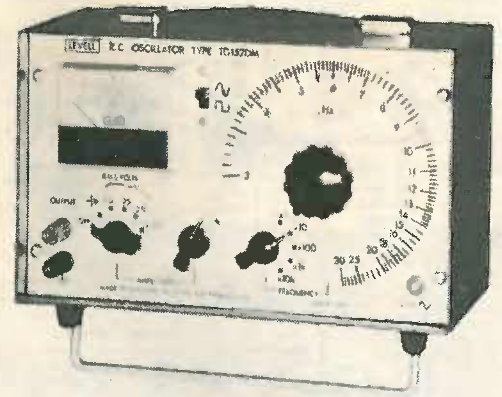

FREQUENCY	3Hz to 300kHz in 5 decade ranges.
ACCURACY	±2% ±0.1Hz to 100kHz. Increasing to ±3% at 300kHz.
SINE OUTPUT	2.5V r.m.s. down to <200μV
DISTORTION	<0.2% from 50Hz to 50kHz. <1% from 10Hz to 200kHz.
SQUARE OUTPUT	2.5V peak down to <200μV.
SYNC. OUTPUT	2.5V r.m.s. sine.
METER SCALES	0/2.5V & −10/+10dB on TG152DM.
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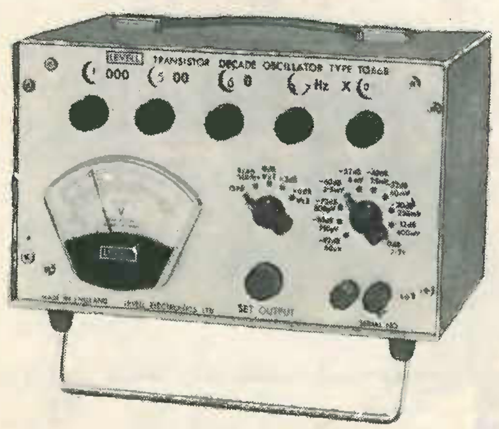
TG152D Without meter **£80** TG152DM With meter **£99**



FREQUENCY	0.2Hz to 1.22MHz on four decade controls.
ACCURACY	±0.02Hz below 6Hz. ±0.3% from 6Hz to 100kHz. ±1% from 100kHz to 300kHz. ±3% above, 300kHz.
SINE OUTPUT	5V r.m.s. down to 30μV with Rs = 600Ω.
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Kit: £79.95

Including VAT, post and packing, free course in computing.

This is the ZX80. A really powerful, full-facility computer, matching or surpassing other personal computers at several times the price. 'Personal Computer World' gave it 5 stars for 'excellent value'. Benchmark tests say it's faster than all previous personal computers.

Programmed in BASIC – the world's most popular language – the ZX80 is suitable for beginners and experts alike. And response from enthusiasts has been tremendous – over 20,000 ZX80s have been sold so far!

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* Up to 26 single dimension arrays.
* FOR/NEXT loops nested up to 26.
* Variable names of any length.
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* Randomise function, useful for games and secret codes, as well as more serious applications.
* Timer under program control.
* PEEK and POKE enable entry of machine code instructions.
* High-resolution graphics.
* Lines of unlimited length.

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The ZX80's 1K-BYTE RAM is the equivalent of up to 4K BYTES in a conventional computer – typically storing 100 lines of BASIC.

No other personal computer offers this unique combination of high capability and low price.

The ZX80 as a family learning aid. Children of 10 years and upwards are quick to understand the principles of computing – and enjoy their personal computer.

The Sinclair teach-yourself BASIC manual

If the specifications of the Sinclair ZX80 mean little to you – don't worry. They're all explained in the specially-written 128-page book (free with every ZX80). The book makes learning easy, exciting and enjoyable, and represents a complete course in BASIC programming – from first principles to complex programs.

Kit or built – it's up to you

In kit form, the ZX80 is pleasantly easy to assemble, using a fine-tipped soldering iron. And you may already have a suitable mains adaptor – 600 mA at 9V DC nominal unregulated. If not, see the coupon.

Both kit and built versions come complete with all necessary leads to connect to your TV (colour or black and white) and cassette recorder. Plug in and you're ready to go. (Built versions come with mains adaptor.)

Now available for the ZX80... New 16K-BYTE RAM pack

Massive add-on memory. Only £49.95.

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For example, you could write an interactive or 'conversational' program to show people what your ZX80 can do. With 16K-BYTES of RAM, they could be talking to your computer for hours!

Or you can store a mass of data – perhaps in a fairly simple program – such as a name and address list, or a telephone directory.

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We're also confident that it won't be long before you can buy cassette-based software using the full 16K-BYTE RAM. So keep an eye on the personal computer magazines – and brush up your chess perhaps!

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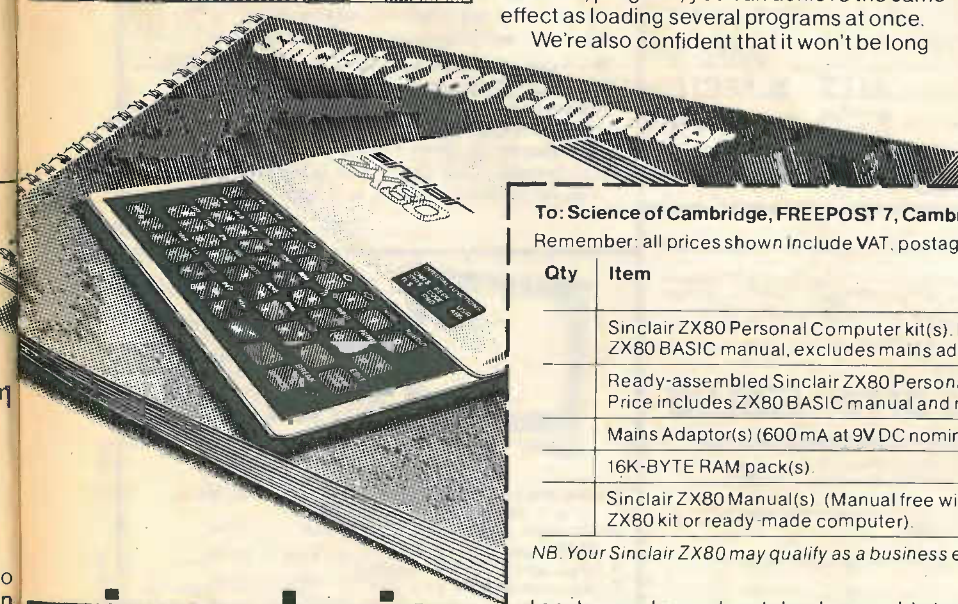

sinclair ZX80

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	16K-BYTE RAM pack(s).	18	49.95	
	Sinclair ZX80 Manual(s). (Manual free with every ZX80 kit or ready-made computer).	06	5.00	

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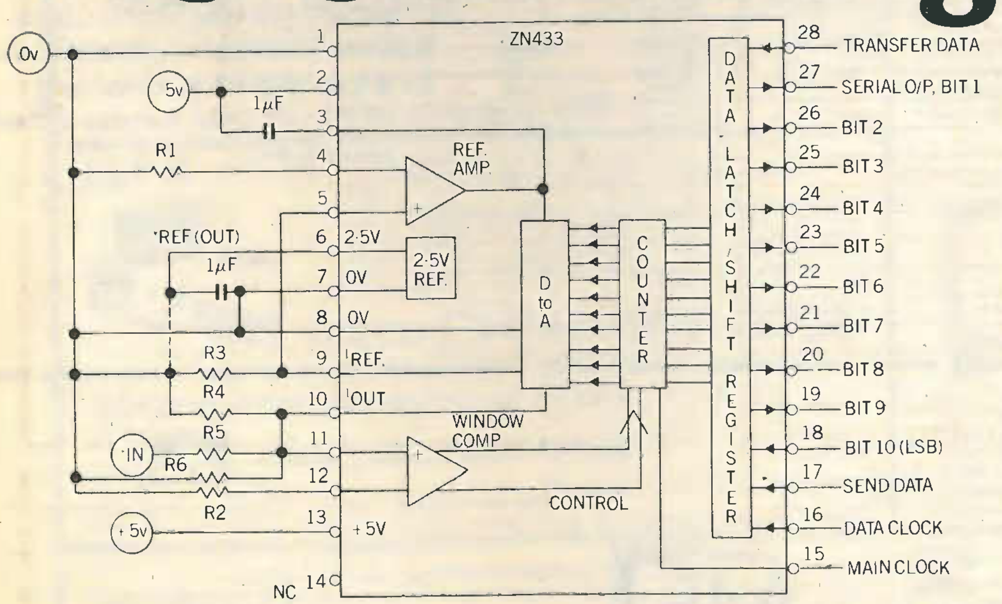

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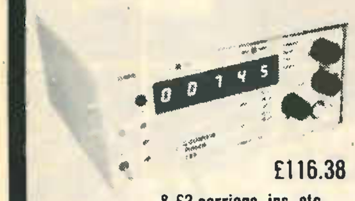
DC to 150MHz — 8 DIGITS, 3 CHANNELS

MEASURES —
- FREQUENCY — Ch A and Ch C
- PERIOD — Ch A
- TIME — ± Ch A to ± Ch B
- PULSE WIDTH — Ch A + or —
- COUNT — Ch A (may be gated and reset by B & C)

AVERAGES 1 to 1000 events

£175
& 3.50 carriage, ins. etc.

TYPE 745 COUNTER TIMER



DC to 32MHz — 5 DIGITS

MEASURES —
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- PERIOD
- TIME
- COUNT

£116.38
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6 GATE TIMES / TIME UNITS
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1Hz to 99.9KHz

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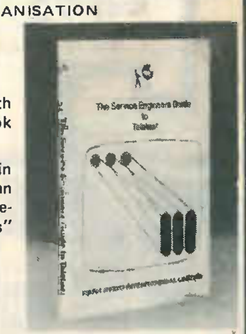
A DIVISION OF THE RANK ORGANISATION

The Service Engineers Guide to Teletext



Rank Radio International, first in the field with Teletext receivers, have prepared this hardback book especially for the engineer and the enthusiast.

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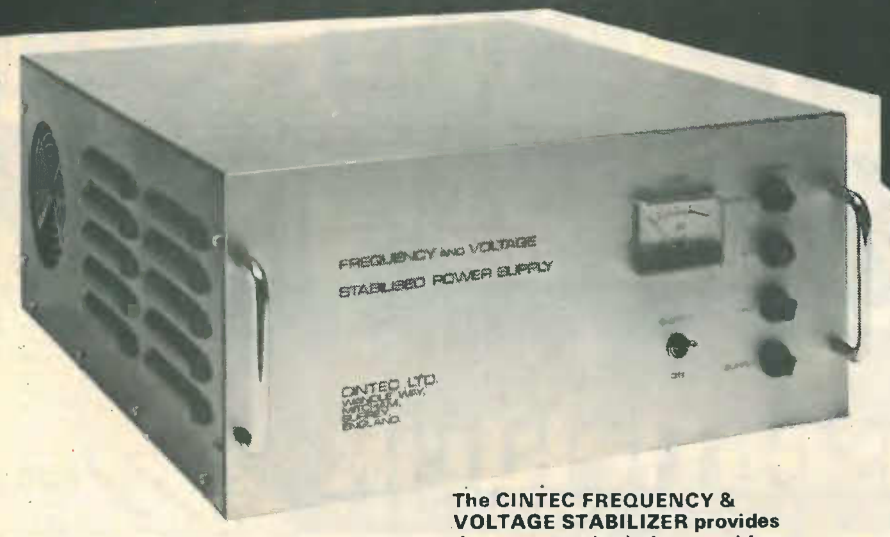

APPLICATIONS

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* MEDICAL
* MARINE
* COMPUTERS
* NAVIGATIONAL SYSTEMS

Applications for the use of CINTEC FREQUENCY & VOLTAGE STABILIZER are more numerous than can be listed. Therefore, if you have a supply problem, contact CINTEC LIMITED whose engineers will be only too pleased to assist.

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SPECIFICATION

INPUT		105-125 volts or 210-250 volts at 45-65Hz.
OUTPUT		115 volts or 230 volts
RATING		500VA or 250VA
STABILITY	Voltage	± 1% No load to full load—
	Frequency	± 0.01% No load to full load
FREQUENCY		50Hz or 60Hz. Single or dual versions
WAVEFORM		SINUSOIDAL
DISTORTION		Less than 2%.
AMB TEMP		−20°C to + 40°C
COOLING		Fan cooled
DUTY		Continuous
DIMENSIONS		432 (W) x 196 (H) x 508mm (D) (17" x 7¾" x 20")
WEIGHT		45 or 30Kg unpacked
CONSTRUCTION		Cabinet or rack mounting
TERMINATION		Cannon Connectors at rear of case
NATO CODIFIED		

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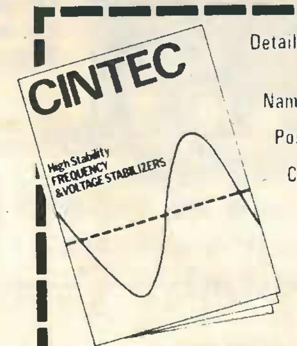
In addition to the A.C. operated models, a 24v D.C. INVERTER Stabilizer is available which operates from a heavy duty 24 volt battery and has output ratings similar to the A.C. models. This type of Stabilizer is particularly suitable for mobile operation.

Cintec Ltd., Wandle Way, Mitcham, Surrey CR4 4NB, England. Tel: 01-640 2241. Telex: 946177



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WW6

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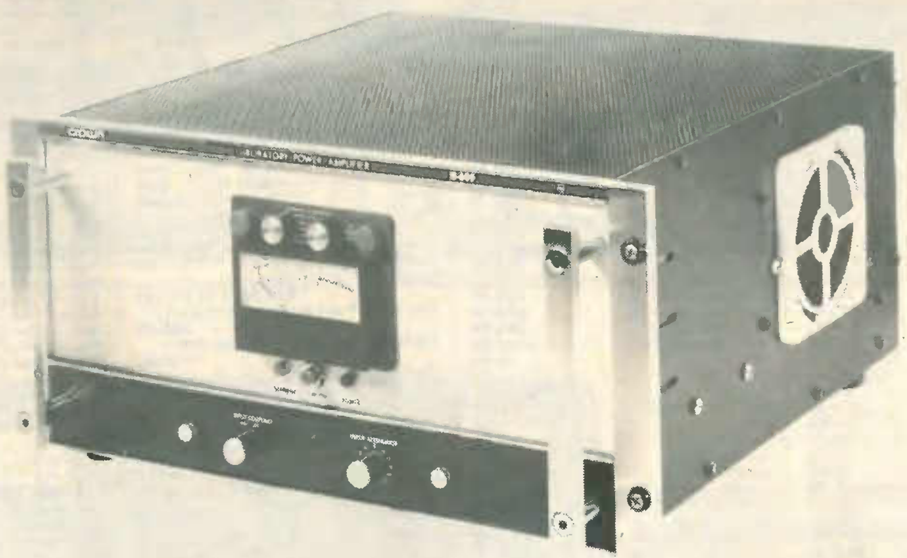
INDUSTRIAL MUSCLE



Model — M600

- ★ POWER RESPONSE DC — 20KHz ± 1dB.
- ★ OUTPUT POWER IN EXCESS OF 1.5kW INTO 2.75 Ohm LOAD (CONTINUOUS R.M.S.).
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- ★ HARMONIC DISTORTION LESS THAN 0.05% DC-20KHz AT 1kW INTO 6 OHMS
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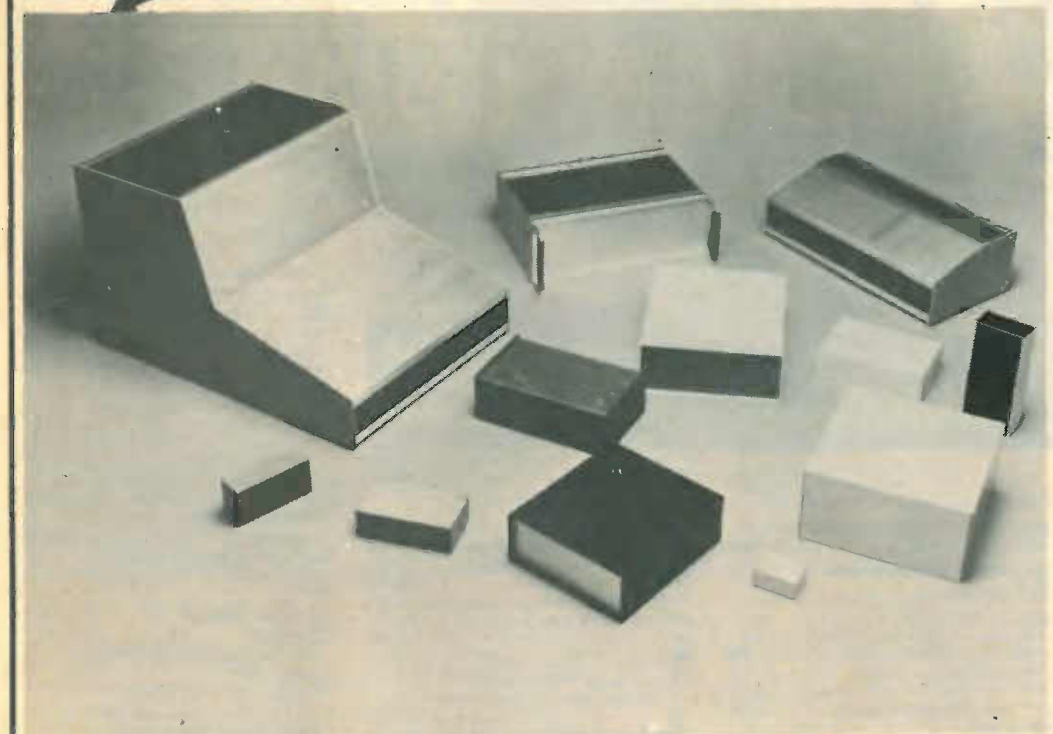
INSTRUMENT CASES AND BOXES



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COUNTERS
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Fluke 1910A Counter 7 Digit 5Hz-125MHz.

DIGITAL VOLTMETERS
Fluke 8010A 3.5 Digits. DCV, ACV, Ohms.
Solartron 7040 4½ Digit. DCV, ACV, DCI, ACI, Ohms.

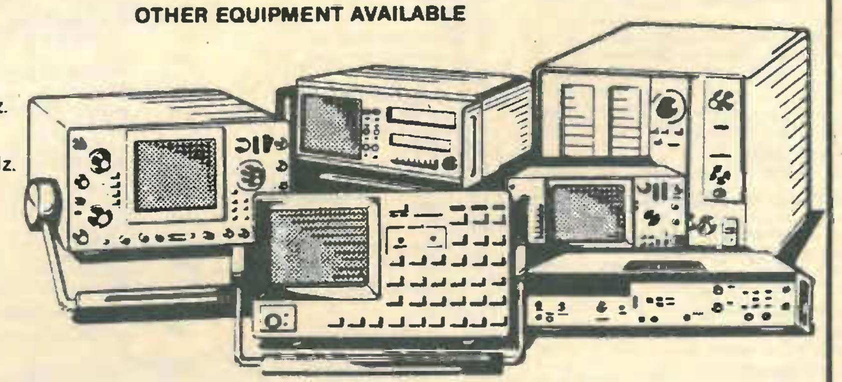
SOUND LEVEL METER
Bruel & Kjaer 2209 Sound Level Meter.

METERS
Hewlett-Packard 3400A True RMS Voltmeter 10Hz-10MHz.

OSCILLOSCOPES
Telequipment D.83 DC-50MHz.
Tektronix D.34 DC-15MHz.
Tektronix 465B DC. 100MHz.
Tektronix T.935A DC-35MHz.

RECORDERS
Data Labs Transient Recorder DL.905
J.J. Lloyd X-Y Plotters.
J.J. Lloyd CR.600 2 Pen Recorder.

OTHER EQUIPMENT AVAILABLE



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4342A 'Q' Meter QLC complete	1250
MARCONI	
TF868A Universal Bridge	250
TF1313A Universal LCR Bridge 0.1%	375
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B224 Wide range LCR Bridge	475
B500 Log LCR Bridge	225
B601 RF LCR Bridge (Detector and Oscillator not incl).	125
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Q801. Y parameter test set. Plus transistor adaptor unit	230

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STC	
74216A Noise Generator CCITT	240
74261A Psophometer CCITT	475
TEKTRONIX	
1502 Portable TDR Cable Tester	2,725
WANDEL u. GOLTERMANN	
DLM-1. Send/receive system	1500
LDS-2. 200Hz-600kHz sender for measuring group delay and attenuation variations	3250
LDEF-2. Filters for DLM unit	250

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5300A Display Module. 6 Digits. 3×10^7	90
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5303B DC-520 MHz. (Plug-on) 125mV sens. 50Ω	120
5308A 0-75 MHz. Universal Module. 50mV sens. 1MΩ	100
5267A Time Interval Plug-in 10ns	120
5345 DC-500 MHz Time Int. Ave. Burst Total Ratio	1225
10590A Adaptor converts 5245 Plug-ins to 5345	225
RACAL	
9024 10 Hz-600 MHz 7 + 1 digits	250
9835 6 Digit DC-20 MHz 10mV	100
9837 DC-80 MHz 6 digits	130
SYSTRON DONNER	
6053 9 Digit 20 Hz-3 GHz BCD O/P	850
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PHILIPS	
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1600A 16 channel 20 MHz clock MAP A & B store	1850
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7D01F 16 channel up to 50 MHz clock MAP	2650

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DRANETZ	
606-3 Disturbance Analyser Avg. Sag/Surge	2625
GAY	
LDM Records +ve/−ve transients of 50ns on AC or DC Lines	1250

Modulation Meters

	Prices from £
AIRMEC	
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MARCONI	
TF2300A 1-1000 MHz. AM/FM	450

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	Prices from £
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OS1000A DC-20 MHz. dual trace	310
3300B Dual Trace DC-50 MHz 5mV/div. Dual Timebase	600
GOULD ADVANCE	
OS1000B DC-20 MHz Dual Trace X-Y TV Sync	400
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1703A Storage 1000Div/ms. DC-35 MHz. Dual trace Mains/Ext DC	1200
181A Storage 1000Div/ms DC-100 MHz Main frame only	650
182C DC-100 MHz Mainframe, large screen	525
MEDELEC	
M-scope 4 channel DC-100 kHz U/V Chart	1650
PHILIPS	
PM 3211 DC-15 MHz Dual Trace 2mV	425
PM3233 Dual Beam DC-10 MHz 2mV/div.	400
TEKTRONIX	
475 Dual Trace DC-200 MHz 2mV	1125
485 Dual Trace DC-350 MHz 50Ω 1 MΩ 250 MHz	2100
545B/1A1. DC-30 MHz. dual trace. Delayed timebase	325
585A/82. DC-80 MHz. dual trace 10 mV sensitivity	525
547/1A1. DC-50 MHz. dual trace DTB	525
547/1A4. DC-50 MHz. four trace DTB	625
7403N DC-60 MHz 3 Plug-in Mainframe	450
7704A DC-200 MHz. CRT Readout. Mainframe for 4 Plug-in	1200
TELEQUIPMENT	
D34 Dual Trace DC-15 MHz 2mV Mains/Batt	525
D75 Dual Trace DC-50 MHz Dual Timebase	600
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Type R. Transistor R.T. tester. Pulse rate 120 pulses/sec. R.T. Less than 5 mμs	100
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6460 10 MHz-40 GHz (Depending on Head)	300
6420 10 MHz-12.4 GHz 10mw	110
MARCONI	
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475R 10-2100V 5mA DC Stab.	150
FARNELL	
L30B 0-30V 1A DC Stab.	55
FLUKE	
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ITT	
Power Lab. up to 30V Dual Supply	90
MARCONI	
TF2154/1 0-30V 1A. 0±15V 2A 0±7.5V 4A	60
SMITHS	
4701 5-7V o/p Power Pack	32
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DCR 300-2.5 0-300V 2.5A DC Stab.	375

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150. I.C. pulse generator	50
EH RESEARCH	
122. 1 KHz-200 MHz 5V/50Ω RT 12ns	220
139(L). 10Hz-50 MHz 10V/50Ω RT 5ns	175
1221. Timing Unit 6 Channel 0-10 MHz 5V/50Ω RT 8ns	50
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ME102B. Wow and flutter meter	75
ME102C. Wow and flutter meter	90

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7046A Two pen A3 0.25mV-5V/cm	995
KUDELSKI	
Nagra 4.2 LSP Professional Audio Recorder (Batt optd)	1215
PHILIPS	
PM 8251 Single pen 10in chart 10mV-50V FS	450
RACAL	
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3046. 10 inch Chart Single Pen. 0.5 mV-100 V/P2.60cm/min and/hr	350
3047. 2 Pen Version of 3046	425

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DYMAR	
1525 100 kHz-184 MHz Int/Ext AM/FM Batt/Mains	525
GENERAL RADIO	
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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
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
TF 2012 UHF, 400-520 MHz. FM	550
RACAL	
9081 5-520 MHz LED Display O/P − 130dBm AM/FM	1875
SCHAFFNER	
NSG330 Ignition Interference Attachment	150
NSG200B Mains Interference Simulator (Mainframe)	250
STC	
74216 Noise Generator 20 Hz-4 kHz Flat/CCITT Wtg	315

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HEWLETT PACKARD	
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8445A Automatic pre-selector 10 MHz-18 GHz	1300
8555A RF Plug-in 10 MHz-18 GHz 1 kHz Res	3000
851B/8551B Display & RF Section	1,350
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022. DC-100 kHz. Dynamic range 60dB fits into various 500 series CRO's	350
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VS60 Sweep Generator 5-100 MHz Rate 60 Hz	950
TV Markers set of 5: 31.5, 32.5, 35, 39.5 & 41.5 MHz	195
LN40A Log Amplifier	105

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1604BLS −60°C to +170°C Type K Thermocouples	82
1625BLS −100°C to +300°C Type T Thermocouples	90
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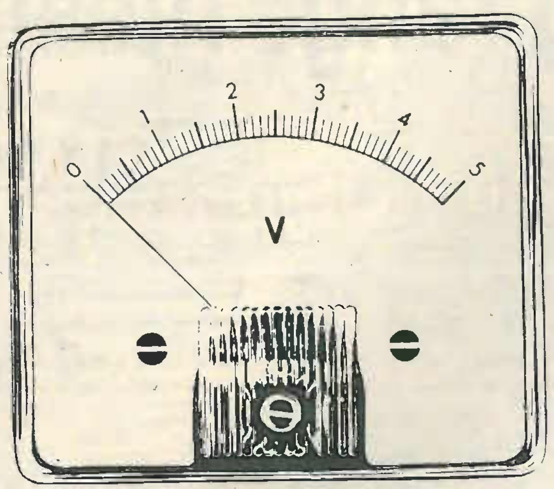

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74LS26	45p
74LS27	45p
74LS30	18p
74LS32	23p
74LS37	35p
74LS38	35p
74LS40	25p
74LS42	66p
74LS47	78p
74LS48	85p
74LS49	99p
74LS73	30p
74LS74	30p
74LS75	42p
74LS85	98p
74LS86	38p
74LS90	35p
74LS93	70p
74LS96	150p
74LS107	40p
74LS112	75p
74LS123	63p
74LS125	60p
74LS126	60p
74LS132	78p
74LS138	69p
74LS139	75p
74LS148	170p
74LS151	75p
74LS153	75p
74LS155	65p
74LS157	74p
74LS160	115p
74LS161	78p
74LS163	90p
74LS164	90p
74LS165	150p
74LS168	190p
74LS173	100p
74LS174	89p
74LS175	99p
74LS181	280p
74LS190	110p
74LS195	87p
74LS196	100p
74LS221	110p
74LS240	210p
74LS241	200p
74LS242	220p
74LS244	175p
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4020	88p
4021	100p
4022	88p
4023	22p
4024	50p
4025	20p
4026	130p
4027	45p
4028	75p
4029	80p
4030	50p
4031	195p
4033	145p
4035	104p
4036	290p
4037	105p
4038	110p
4039	290p
4040	99p
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4050	40p
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4052	75p
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4063	112p
4066	56p
4067	422p
4068	19p
4069	19p
4070	28p
4071	25p
4072	25p
4075	20p
4076	88p
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AF139	0.42
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BC109B	0.10
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BC141	0.25
BC142	0.21
BC143	0.24
BC147	0.09
BC148	0.09
BC149	0.09
BC157	0.10
BC158	0.09
BC159	0.09
BC160	0.28
BC161	0.28
BC170B	0.10
BC171	0.06
BC171A	0.10
BC172	0.09
BC172C	0.10
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BC212	0.09
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BC213	0.09
BC213L	0.09
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BC214L	0.09
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BC338	0.09
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BF179	0.34
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BF181	0.29
BF182	0.29
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BF195	0.11
BF196	0.11
BF197	0.11
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BF199	0.14
BF200	0.30
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	4K7 5K6 6K8	0.17
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	5K6 6K8 8K2 10K 12K	0.15
	15K 22K	0.18
11 WATT	1R 1R5 2R2 3R3 4R7 5R6 6R8 10R 15R 22R 33R 47R 68R 100R 150R 220R 470R 680R 1K 2K2 3K3 4K7 6K8 i0	0.17
	10K	0.18
	15K	0.21
17 WATT	1R 1R5 2R2 3R3 4R7 6R8 10R 15R 22R 33R 47R 68R 100R 150R 220R 470R 680R 1K 3K3 4K7 6K8 10K	0.24
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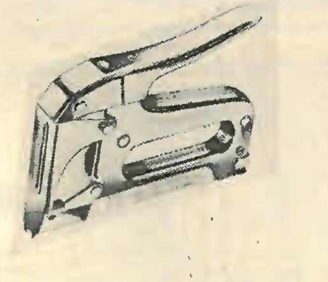

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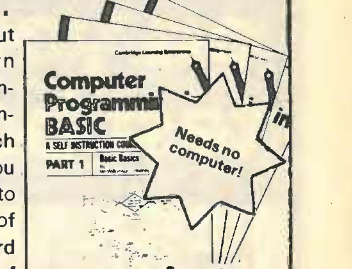

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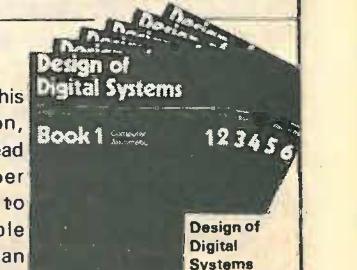

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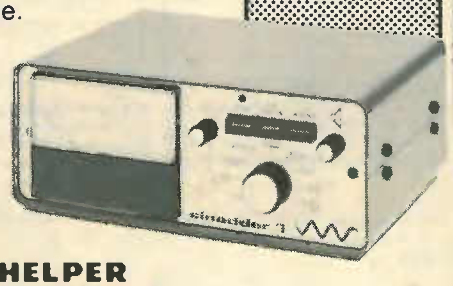

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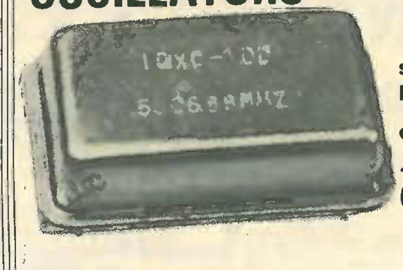

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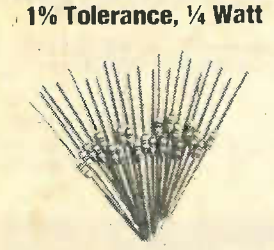

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180R	1k8	18k	180k
200R	2k	20k	200k
220R	2k2	22k	220k
240R	2k4	24k	240k
270R	2k7	27k	270k
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330R	3k3	33k	330k
360R	3k6	36k	–
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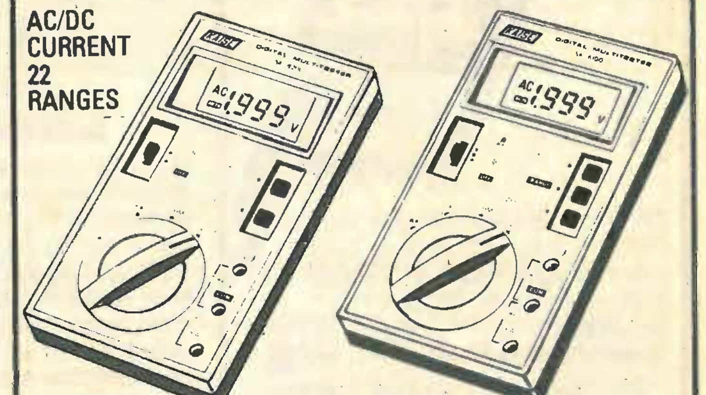

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A testing time for electronics

Why would a British nationalized industry not wish to associate itself publicly with the work of one of its engineers in using microprocessors, quite properly, to improve its industrial performance? This is what happened with an article we published recently. The engineer was quite free to publish the work, but his employer, the nationalized industry, specifically asked for their name not to be revealed in the article. You would think they would be proud to show their owners, you and me, what they were doing in this up-and-coming technology. Could it be that, with a national background of economic recession and high unemployment, they felt it was not exactly the right time to admit responsibility for "new technology" which might mean a permanent reduction in their work force?

A few years ago the argument that the use of electronics in new products and manufacturing processes would create more jobs than it displaced was readily accepted because of the confidence engendered by the rapid expansion of the free-market economies in the 1950s and '60s and the resulting high level of employment. Today, although the argument could still be valid – because we can point to actual new jobs that have been created – it is beginning to look somewhat feeble against the scale of current events. In Britain we now have over two million unemployed. This fact has come to some people as a sudden shock. Even so they dismiss it as a temporary, though severe, effect of yet another of those swings in the recurring trade cycles we have known for a century or more. It must end, they say. But other, perhaps more discerning, observers see the present figure of two million unemployed as not merely a temporary freak but as part of a longer term "structural" change, as the economists call it. Up to about 1967 unemployment in the UK, running at about 300,000, was roughly matched by the number of job vacancies available. But after 1967 this situation no longer obtained. The unemployment curve began to "take off" upwards, leaving the "vacancies" curve much as it had been before. This trend has continued unmistakably for over a decade.

If these analysts are right and there is indeed a long-term structural increase in unemployment, then electronics and any other technologies being used to improve labour productivity will be scrutinized and tested as never before in the full glare of the public arena. If the higher labour productivity indicates a loss of jobs, rather than an increase of output with the existing level of employment, then the new technology will be opposed far more strongly than if we were living in an expanding economy. Those who introduce it will have to prove, under the most searching examination, that they are not bringing social disruption in its wake by adding even more people to that sad group which always bears the brunt of industrial change – the poor, the unemployed, the unskilled, the handicapped, the chronically ill and the inadequate.

One can only be glad that these new conditions are clearly understood by the central economic organization of the Western capitalist countries, the OECD. In a recent report "Technical change and economic policy" (written by a group including two men with an electronics background) this influential body states firmly that technical change can never be a goal in itself. It must be politically supported by the populations of these countries, and this social sanction "will be forthcoming only if there is a satisfactory balance between the generation of new employment and the loss of old jobs and if technical change is perceived to improve the quality of life."

Nanocomp

by R. Coates

Using the 6802 microprocessor and only 8 other i.cs, this microcomputer design provides up to 4K of e.p.r.o.m., 1K of r.a.m., p.i.a., six digit display and up to eight monitor commands. Although ideal as a trainer, the Nanocomp is also a useful tool for general microprocessor applications. The unit can be built on one printed circuit board and housed with a power supply in a small case.

A versatile and simple microprocessor trainer

Two problems which prevent many electronic engineers from learning to use microprocessors are the complexity and cost of taking the first step. Constructing a unit can reduce the cost but may require some troubleshooting if it doesn't work. A simple unit that can be built easily may have limitations which restrict its use. With these points in mind, a microprocessor trainer has been designed which is suitable for a novice but provides sufficient facilities for use as a tool.

A block diagram of the design is shown in Fig. 1. Only 9 i.cs are used, which makes construction quite easy for anyone with the minimum of experience. The central processing unit is a Motorola 6802. Although not a particularly well known microprocessor, it is based on the popular 6800 device and includes clock generation and 128bytes of r.a.m. This reduces the cost and simplifies construction because only one crystal is required to complete the clock generation circuit. For programming, the 6802 is identical to the 6800 and is therefore well supported with software. Apart from the c.p.u. r.a.m., there are two other blocks of memory available. An e.p.r.o.m. permanently stores the monitor program, which takes care of the general "housekeeping" duties such as scanning the keypad, refreshing the display and providing debugging facilities to help with program development. The monitor occupies about 850bytes of the e.p.r.o.m. To improve flexibility, the unit has been designed to accept 1K, 2K and 4K e.p.r.o.ms so that the user can write programs and have them permanently stored for an application such as a dedicated controller. The second memory block is a 1K r.a.m. for developing and running programmes.

The final section of the block diagram contains the input/output (i/o) circuit which drives the keypad and display, and allows interfacing to other circuits.

The complete circuit is shown in Fig.2. A clock reference is provided by the 3.2786 MHz crystal and C_1. However, other crystals between 400kHz and 4MHz can be used with an adjustment to C_1 for reliable oscillation. The 6802 clock circuit divides the oscillator frequency by 4 to provide an 819kHz system clock signal (Ø2 of the 6800) at E. This frequency leaves a small safety margin for the devices, which have a maximum operating frequency of 1MHz. A 74LS00 gates the E signal with VMA (valid memory address) to provide VMA.E which is used by the address decoder IC_9 to ensure that other devices on the bus are only accessed when a valid address is present on the address bus. The address decoder generates select lines for the memories and i/o chips by decoding the three most significant address lines. This provides selection of 8 4K address blocks, of which Y1, Y4 and Y7 are used. Note that the most significant address line, A15, from the c.p.u. is not used because sufficient address space is available without it.

Data pins D0 to D7 of the c.p.u. are connected to the data bus. The control bus comprises E, VMA.E, read/write, reset (connected by a push switch and used to start the monitor program at switch-on, and to initialise the i/o chip for programming), $\overline{IRQ}$ and $\overline{NMI}$ interrupt lines which allow program execution to be interrupted or, in the case of $\overline{NMI}$ (non-maskable interrupt), termination of a monitor command with the Abort key which returns the processor to the monitor switch on point. Both interrupts are connected to external pins for use by an external circuit if required.

As mentioned previously, three sizes of e.p.r.o.m. can be used. Although the 2708 is the cheapest device it will provide only a small amount of spare memory space, and it requires +5V, -5V and +12V supply rails. The 2516 and 2532 only require +5V and leave just over 1K and 3K respectively for expansion.

The main r.a.m. is provided by two 4-bit 2114 i.cs. With the 819kHz clock, slow

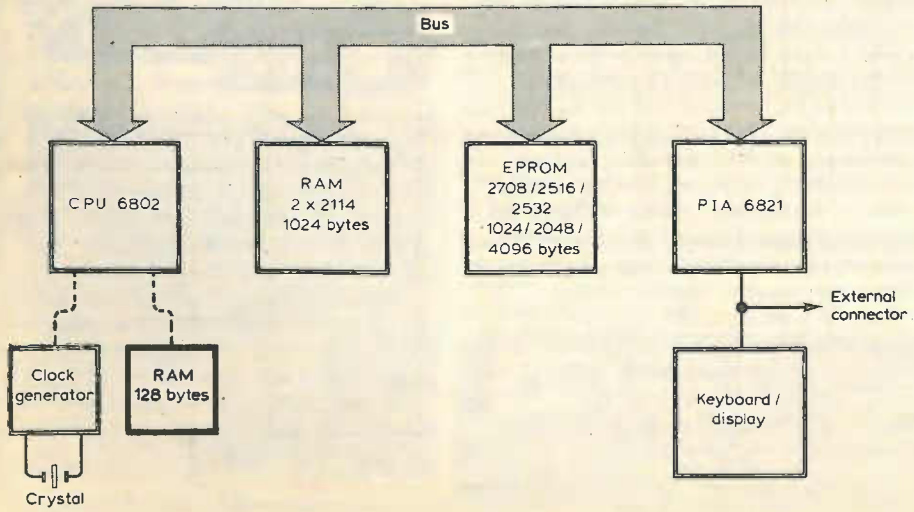


Fig. 1. Block diagram. The 6802 is similar to the 6800 but contains a clock generator and 128bytes of r.a.m.

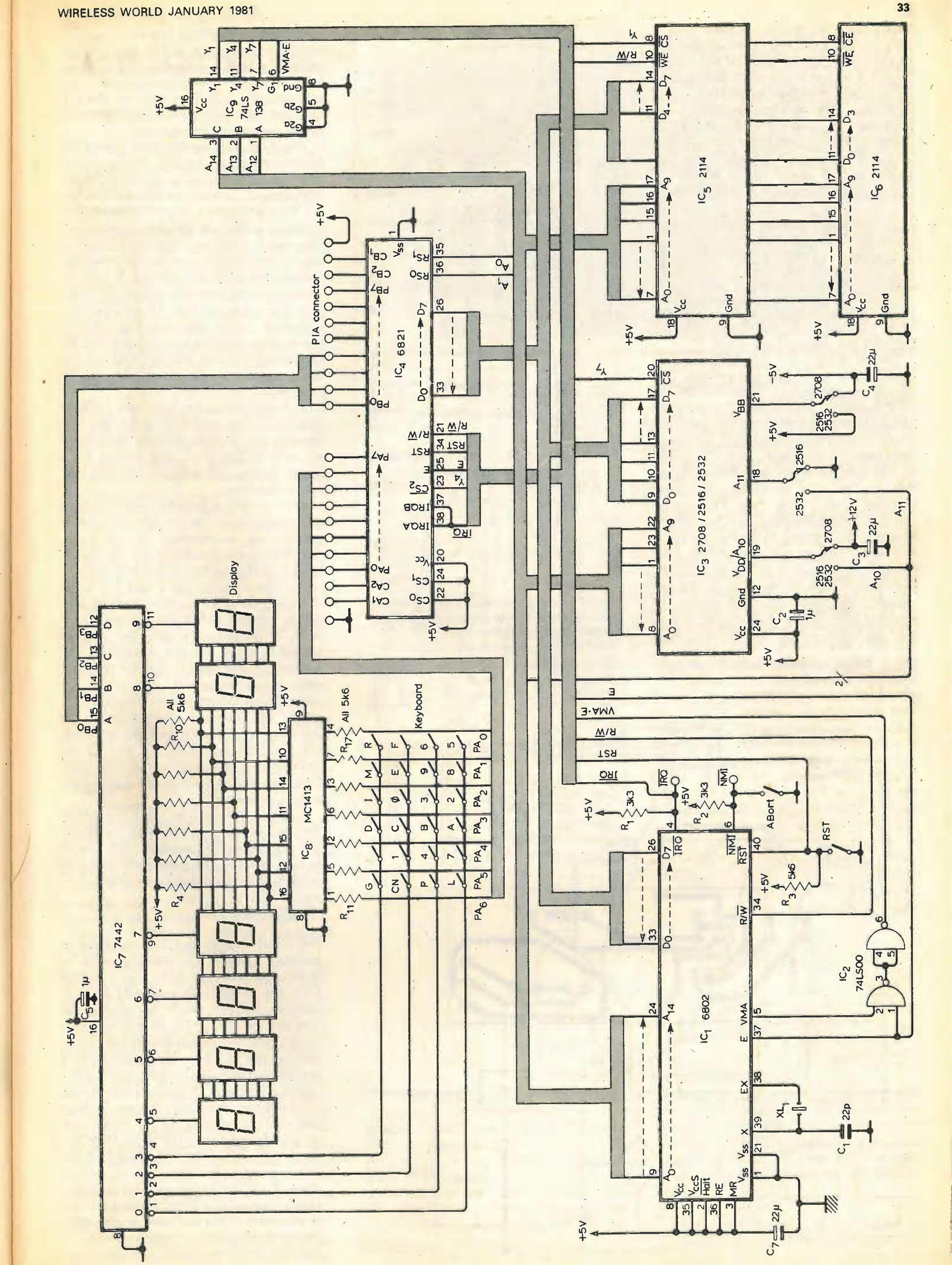


Fig. 2. Complete logic diagram. Although the circuit can use a 1K 2708 e.p.r.o.m., 2 or 4K devices are recommended because they provide spare memory space and require only one supply rail. ▶

(450ns) devices will work without trouble. An input/output device, IC_4, the MC6821 peripheral interface adaptor (p.i.a.), provides two sets of 8 data lines for communicating with external circuits. One set of lines (PA) is t.t.l. compatible, and the other (PB) is m.o.s. compatible. The lines can be individually programmed as inputs or outputs and can for example, with suitable buffering, drive relays or read the states of microswitches. Also available are four control lines, two for each set of data lines, which can be used to control transfers of data between the p.i.a. and external devices. Two are inputs only, and two are inputs or outputs. The inputs can drive the $\overline{IRQ}$ line so that the c.p.u. can service them immediately if required. All of these lines, together with ground and +5V, are available at a multiway connector.

Twelve of the p.i.a. data lines are also used to drive the display and keypad. The display comprises six common-cathode l.e.d. numerals which can show a 4-digit address and 2-digit data. The display data is not latched but multiplexed, so a constant refresh is required. This is achieved by the monitor which has a sub-routine that can be used to display data in a program. Data lines PB0–PB3 select which digit is to be refreshed, the binary numbers are decoded by IC_7 which sinks one of its outputs low. Six of the 7442 outputs are connected to the cathodes of the displays, thus the appropriate digit is selected. Segment drive information is provided by PA0-PA6. Resistors R_4 to R_{10} turn the segments on, and the segments

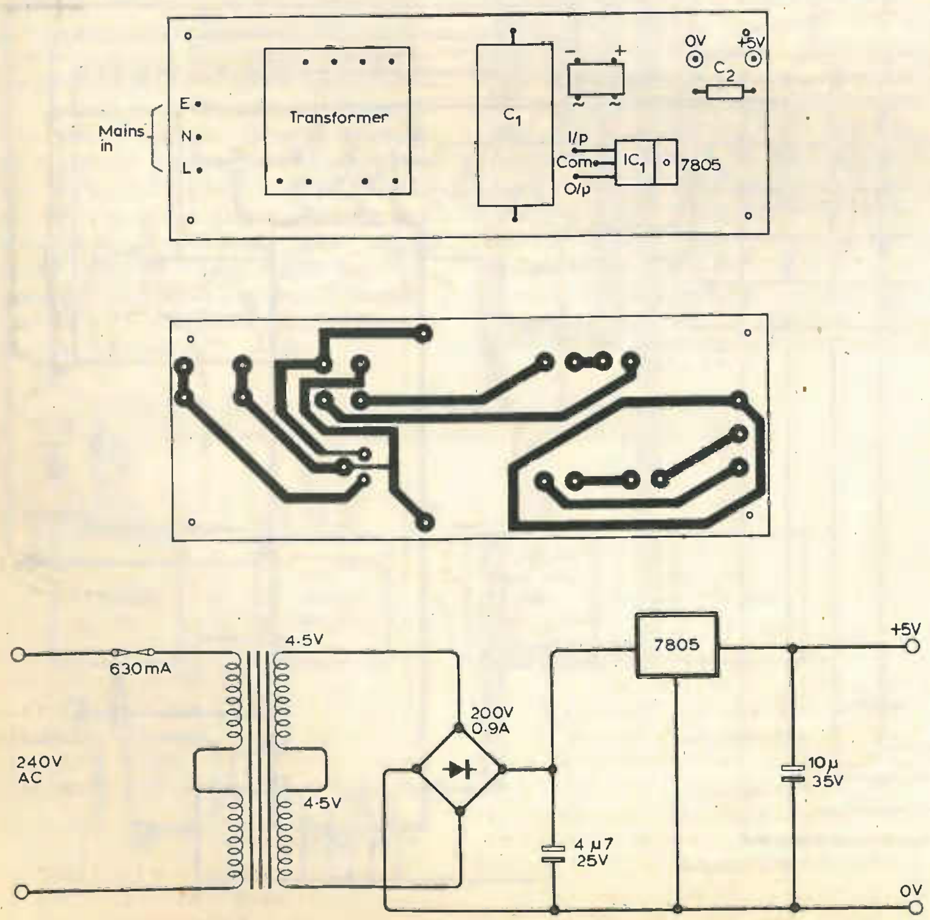
Table 1. Memory map.

e.p.r.o.m.	monitor	7FFF
		7C00
	user e.p.r.o.m.	7800
		7400
		7000
		4003
	p.i.a.	4000
		13FF
	program r.a.m.	1000
c.p.u. r.a.m.		007F
	display buffer	007A
	monitor workspace	006A
		0060
	monitor stack	0040
	user stack	
	spare	0000

p.i.a.

4000	output/data direction register A
4001	output/data direction register B
4002	control register A
4003	control register B

Fig. 3. Single rail power supply. The p.c.b. measures 160 x 60 mm.



are turned off by a logic 1 on the p.i.a. line which turns on one of the seven shunt transistors in IC_8. Although this arrangement is a little wasteful on power, (the consumption is highest with the display off) it provides a simple drive circuit which in this design is more important.

The p.i.a. lines are also used to read the keypad switches, but for this operation they are programmed as inputs. With no keys pressed, no loads are presented on the t.t.l. compatible inputs which are therefore pulled up by internal resistors. The keys are arranged in a matrix and IC_7 selects one of four rows in the same way that display digits are selected. If a key is pressed in that row, the appropriate PA0-PA6 input is pulled low. To read the keypad, each row is selected in turn and the inputs monitored for a low on one line. By identifying the row selected and the column pulled low, the pressed key can be determined.

Although the p.i.a. lines are available externally, they cannot be used to drive an external device while servicing the keypad or display. This is a small penalty for a simple design, and does not normally present a problem.

Construction is straightforward because all components, except for the power supply, can be mounted on one p.c.b. Sockets are recommended for the m.o.s. devices and pins for all external connections. The switches are a tight fit, but if the holes are drilled a little oversize they can be manoeuvred in place. If the circuit is to be housed in a box, the switches should be raised as much as possible. The legends on the switch caps are transfers such as Letraset. All components are mounted on the top side of the board together with four wire links to select the e.p.r.o.m. For a 2708 no links are used, for the 2516 and 2532, C_3 and C_4 are omitted and the two links from their positions inserted along with the link by the e.p.r.o.m. socket.

The power supply in Fig.3 is a simple 5V design intended for use with the single-rail e.p.r.o.ms. The complete unit can be housed in a case, see component notes, or used on an open printed circuit board.

Testing

For initial testing, the r.a.ms need not be inserted. Connect the power supplies to their respective pins (note that if a 2708 e.p.r.o.m. is used with separately switched supplies, the -5V should be switched on first and off last). After switch on, press Reset (RST) and a dash should light up on the far left display. This symbol is a prompt and indicates that the unit is waiting for a command. If it does not light with a correctly programmed e.p.r.o.m., check that power is reaching the i.cs. Next, with an oscilloscope connected to pin 38 of IC_1, check that the crystal is oscillating. If the crystal is alright but there is no oscillation, check C_1 and experiment with different values, particularly if the frequency is not as specified. If the oscillator is operating, test the E output of IC_1 which should be a square wave at one quarter of the crystal

frequency. This waveform will contain some ripple. If an oscilloscope is not available, a high-impedance voltmeter connected to pin 37 should read between 24 and 25V. If the fault still persists, it is likely to be a dry joint or a board fault. Because many of the tracks on the top side of the board are covered by components, it is advisable to carefully examine the board before the components are mounted.

Operation

The memory map for the unit is shown in Table 1. Note that the e.p.r.o.m. occupies 7000 - 7FFF, although the monitor program only occupies 7C00 - 7FFF. Addresses 7E63 to 7FE7 are unused because, in the original unit, routines for a paper-tape punch and load were stored there. This space can be used for load and dump routines to suit the users storage medium.

The reset button is used at switch-on, or if control of a program is lost, to run the monitor program. Sixteen hexadecimal keys enter data, and the remaining eight keys enter monitor commands. L and P are spare keys, used in the original for load and punch with the paper-tape unit, which can be used for extra facilities.

These do not need to be storage routines, but any routine the user wishes to write and include in the monitor. Locations 7DC4/5 should contain the 16-bit start address of the routine to be run on pressing the L key, and 7DCB/C the address for the P key. For testing the unit these keys can be ignored.

The memory (M) command allows a memory location to be examined and altered if required. This key is acknowledged by M in the far right display. A 4-digit hex address, when entered, appears on the left four digits, and the data in that location appears on the right two digits. To alter the contents of the location, enter two hex digits, which will be shifted into the data display from the right (if a mistake is made, keep entering appropriate digits until the correct data appears in the display). Next press the Increment (I) key, which stores the displayed data in the memory location and advances the display to the next memory location. If the memory contents do not need altering, press I to advance or Abort to terminate command and return to monitor start.

Register display (R) displays the contents of the various c.p.u. registers following a SWI instruction in a program. The command is automatically entered after a SWI, but may be re-entered with the R key. The condition code register contents are first displayed, the right two digits denote the register being displayed CC= condition code register, b= AccB, A= AccA, IH= Index register, PC= program counter, SP= stack pointer position) and the left four digits show the register contents. The I key will increment through the various registers or AB will abort. After displaying SP, the unit will automatically return to monitor start.

Go (G) is used to go to a user program and A will acknowledge command. When

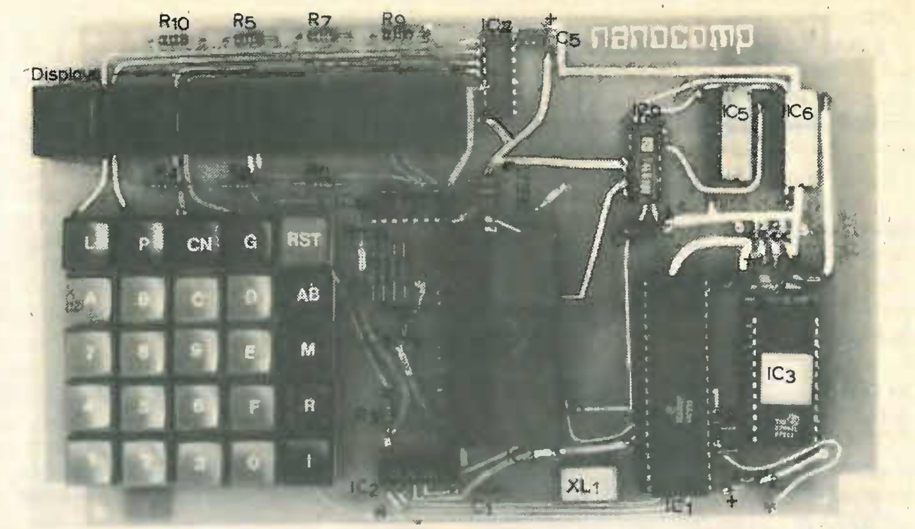
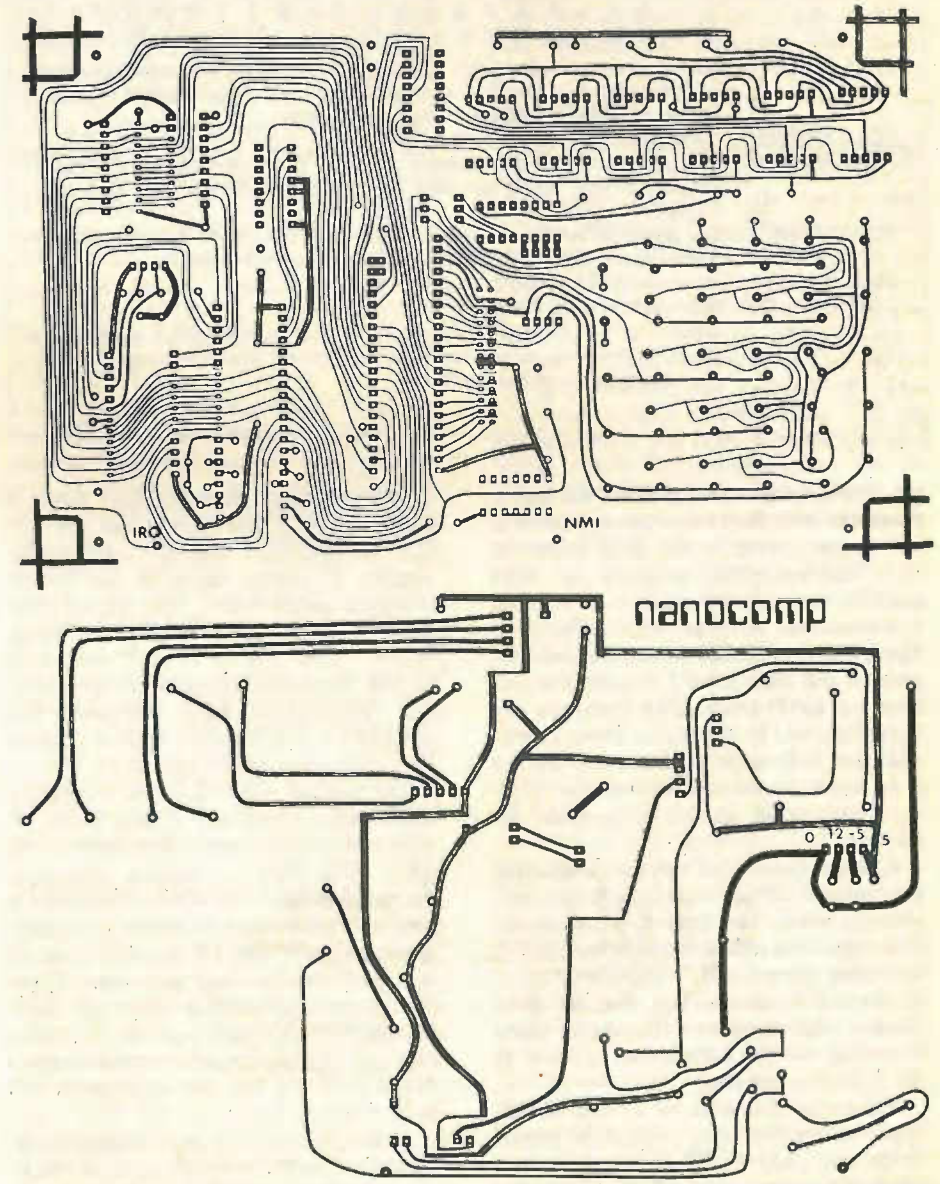


Fig. 4. Assembled printed circuit board and layout details. The board measures 200 x 120mm.



the 4-digit hex start address of the program is entered the program will run. If a program is interrupted by a SWI instruction, the continue (CN) key will run the program from the instruction following SWI. If a program is interrupted by the abort key, CN will make it continue from the interruption provided the abort key (NMI) has not been modified by the user program for a different purpose.

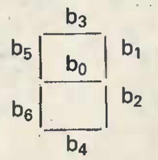
Abort (AB) stops the current command/program by operating the non-maskable interrupt line. The program then jumps to the location specified by memory location 0072/0073. These are set, during Reset operation, to the monitor start address but may be altered to use the $\overline{NMI}$ facility.

Programs

If one of the larger e.p.r.o.ms is used, the programs at 7800 - 7BFF can be run immediately. Two of these are games and two

Table 2. Useful monitor subroutines.

7C7B DISPRESH Refreshes display with contents of display buffer (six locations of r.a.m., one for each display digit) which contains the seven segment information for the display. For a program to use the multiplexed display, the data must be written in locations 007A (left digit) to 007F (right digit) and DISPRESH continually accessed. Each segment of a digit is allocated to a bit in the data word, to turn a segment on set that bit to 1. The bit/segment allocation is



7C20 GETKEY Alternately scans keyboard and refreshes display until a key is pressed. It then waits for the key to be released, and returns with the key code in accumulator A.
The codes for the keys are
0 1 2 3 4 5 6 7 8 9 A B C D E F L PCNG M R I
22 24 02 12 14 00 10 04 01 11 03 13 23 33 21 20 05 15 25 35 31 30 32

7CE7 HEXCON Converts a key code in Acc A into the hex equivalent for that key and returns with it in Acc A. If a non-hex (command) key code is entered, the routine defaults back to the monitor start.

7CE4 KEYHEX Combines GETKEY and HEXCON.

7CB5 BADDR Builds a 4-digit hex address entered from keyboard, refreshing display whilst doing so, and returns with that address in index register.

7CFF L7SEG Converts the left hex digit of a byte in Acc A to the seven segment code required by the display, and returns with it in Acc A.

7D03 R7SEG As above but for right hex digit of byte.

7D15 7TOHEX Converts a seven segment hex code in Acc A to that hex digit and returns with it in Acc A. Defaults to monitor start if code is not hex.

7CCC 7HEXIN Uses KEYHEX to accept two hex key entries, and combines the two hex digits into one byte in Acc A.

are useful programming aids. To run a program, press Reset to obtain a prompt in the display, press G and then enter the start address. The program at 7800 converts hexadecimal numbers to decimal and vice-versa. After pressing G 7800, the display will be blank. For a decimal to hex, press L and then enter a decimal number from 1 to 65535 followed by I, and the hex equivalent will be displayed. Press I again and enter L for another decimal to hex, or P for a hex to decimal conversion. After each conversion press I to prepare for another.

A tedious aspect of machine code programming is calculation of the two's complement offset for branch instructions. This task is simplified by the branch calculator program at 7A00. When the program is entered S appears on the far right display, which indicates that the program is waiting for the 4-digit start address of the branch instruction.

Enter this followed by I, and d will appear on the display to request the 4-digit destination address. When this is entered, the two's complement offset appears on the two far right displays. If two dashes appear, the branch is outside the range of a branch instruction. Press I to prepare for another calculation.

The two games programs are at 7A80 and 7930. The first is "Mastermind", and after entering, I will appear on the display. After a few seconds, required for generation of the secret code, press I and try to solve the 4-digit code using numbers 0 to 7. After entering the first 4-digit guess, a 2-digit number will appear on the two right hand displays. The first indicates the number of correct digits in the correct positions (called bulls). The second indicates the correct numbers in the wrong places (called cows). Press I and enter another number. The game finishes when four bulls have been deduced, and pressing I will indicate the number of tries. Pressing I again starts a new game.

The second game is called duckshoot and locations 0000 and 1 have to be set with a number to control the speed of the game. With 0020 as a starting point, run the program and two ducks will traverse the display. To shoot the ducks the display number (1 to 6 from left to right) must be entered when the duck is present. When hit, the duck disappears and the game finishes when no ducks are left. To terminate the demonstration programs, press AB or RST and the monitor program will be re-entered.

Although this unit was originally designed as a versatile training aid, it can be used as a desktop computer and as a software development tool. The spare e.p.r.o.m. space allows it to be used as a form of calculator or a controller. Useful programming information is available in the M6800 Microprocessor Instruction Set Summary from Motorola distributors, and an ideal book is the *6800 Programming Reference Manual* which gives details of the c.p.u. and p.i.a. devices together with a full description of the instructions. □

Component notes

Keyswitches
Grey RS 337-611
Blue RS 337-605
Red RS 337-598

Displays
FND500 or FND560

Case
RS 508-475

Connector plug
26 way insulation displacement type
RS 467-352

Software
A software listing for the Nanocomp can be obtained by sending a stamped addressed envelope to Wireless World, Room L303, Quadrant House, The Quadrant, Sutton, Surrey.

Printed circuit boards
A set of p.c.bs (1 double sided, 1 single sided) will be available for £9.00 inclusive of v.a.t and UK postage from M. R Sagin, 23 Keyes Road, London N.W.2.

The Author

Bob Coates studied electronics at the Rolls-Royce Aero Engine Division where he gained a HND. In 1974 he joined a research & development establishment and is currently working on microprocessor systems design for industrial control and data acquisition. Apart from electronics, Bob's interests include amateur radio (G4DIH).

Component kit
We understand that Technomatic, 17 Burnley Road, London N.W.10, will be offering a kit of components including a programmed r.o.m. for the Nanocomp.

WORLD OF AMATEUR RADIO

A direct-conversion breakthrough

About two years ago, the Plessey Company demonstrated a novel "on-channel" form of low-power v.h.f. "repeater", developed primarily for military tactical radio networks. This attracted considerable interest among amateurs as offering a system which could extend the range of simple hand-held transceivers not equipped for 600 kHz off-set operation through the conventional amateur repeaters, and also offering the possibility of single-channel duplex operation on narrow-band-frequency-modulation if two such units were used. At the time the company, for reasons of commercial security, were unwilling to disclose even the principle on which this system worked.

At the I.E.E. recently, Chris Richardson, the inventor, revealed that the key feature lies in the use of a direct-conversion receiver in which the transmitted signal acts also as the local oscillator for the two-phase balanced mixer used to recover the signals in a form suitable for n.b.f.m. demodulation, enabling a deep rejection notch to accurately track the instantaneous outgoing frequency. Direct-conversion ("zero i.f.") receivers have been popularized and used by many amateurs during the past decade, and it is clear that the technique is being taken increasingly seriously by professional designers. Work at STL, Harlow, by Ian Vance, G3WMS, has shown that it is possible virtually to design a mobile v.h.f. radio on a single microchip by using direct-conversion techniques *(The Radio & Electronic Engineer, April 1980)*. This design again uses two-phase (quadrature) techniques to facilitate demodulation of n.b.f.m. signals and allows "a measure of integration previously unobtainable in radio equipments", though further development is envisaged.

Here and there

Extensive tropospheric ducting during early October resulted in many contacts between amateurs in the south of England and Eastern Europe on the 144, 432 and 1296 MHz bands. The first-ever contacts between the U.K. and Czechoslavakia by means of 2300 MHz (13cm) ducting were made by several East Coast stations, including G4BYV and G3LQR.

The weekly "World Radio Club" programmes for short-wave listeners, radio amateurs and anyone interested in the radio sciences does not appear in the programme schedules of the BBC World Service for January 1981, though it is still not clear whether this will prove to be a temporary or permanent closure of the "club". Started in 1967, this programme has run without breaks for more than 700 editions and more than 40,000 listeners in all parts of the world have written in to register themselves as members. Producers have included John Pitman, Joy Boatman and currently Reg Kennedy, while Henry Hatch, G2CBB, a retired BBC engineer, has been taking part in the programme since the start.

Richard Thurlow, G3WW, is currently installing in his Robot 400 slow-scan television equipment additional memory boards to convert his equipment into the form of colour s.s.t.v. developed by Don Miller, W9NTP. He reports that A.H.G. Waton, G3GGJ (19 New Road, Barton, Cambridge CB3 7AY, tel. Comberton (0220-26) 2129) is undertaking to supply amateurs on a non-profit basis with commercially printed boards, complete with 240 plated-through links and produced from the original W9NTP artwork, together with associated circuit data relating to the W9NTP and ZL1BLV designs.

Science Museum GB8SM

The Science Museum amateur radio station, GB2SM, has recently been using the callsign GB8SM to mark its 25th anniversary. The station, since 1955, has progressed from a simple table-top layout into one of the most elaborate amateur stations in regular operation anywhere in the world. The present equipment includes Collins, Racal, Eddystone, "KW" (Decca) and Trio units arranged to permit three separate operating positions to be manned simultaneously. Staff operator since 1955 has been Geoff Voller, G3JUL, assisted by volunteers. Over the years the station has had thousands of contacts world-wide and has been visited by many of the millions who come to the Science Museum.

RSGB's record year

The annual report of the Radio Society of Great Britain (to June 30, 1980) shows that the membership has reached an all-time high of 25,658, while total income of the Society from all sources for the first time exceeds £0.5 million, resulting in a surplus for the year (after tax) of over £24,000. The 1979 World Administrative Radio Conference is seen as "successful from an amateur point of view". The RSGB also "welcomes" the Home Office "Open Channel" proposals as "being in line with its own view" and feels that a 928 MHz frequency "should satisfy the large majority of users, while at the same time minimizing most potential interference problems."

Though the report does not mention it, 1981 also promises to provide a special footnote in the Society's history: wife of the 1981 President, Mrs E. O'Brien, holds her own amateur callsign, G3WIO. Basil O'Brien, G2AMV is an amateur enthusiast of many years standing. He comes from outside the "electronics" field, being a retired bank manager.

An additional GB2RS news bulletin is now being transmitted on Sunday mornings at 9 a.m. local time on 7047.5 kHz from stations in Northern Ireland. These amplitude-modulated signals can be received on conventional "all-band" domestic receivers in many parts of the U.K. and supplement the 11 a.m. 7 MHz a.m transmissions from the West Midlands.

In brief

Doug Finlay, D.F.C., G3BZG, a former R.S.G.B. president (1957) and later (1970-74) general manager of the society died during September ... About 50 Dutch amateurs are now licensed to use c.w. between 1720 to 1740 kHz and 1830 to 1850 kHz with power limited to 10 watts d.c. input .... The A.R.R.L. are preparing a proposal to be submitted to F.C.C. advocating an amateur band at about 900 MHz. The League have recommended that the 10 MHz band, due to be released when the WARC 1979 Radio Regulations become established, should be used only for c.w./r.t.t.y. operation with a maximum power of 250 watts, but are advocating extra phone segments above 14,150 kHz and a new phone segment from 7075 to 7100 kHz... The amateur radio club of London Weekend Television now holds the callsign G4LWT ... Class B licences in the sequence G6AAA etc are due to be issued soon .... The F.C.C. have "deregulated" much of the American 50 MHz amateur band which extends from 50 to 50.4 MHz, retaining as compulsory band-planning only the segment 50 to 50.1MHz allocated to c.w. and confining repeaters to the segment above 52 MHz.... A new proposal has been submitted to the R.S.G.B. Repeater Working Group for an experimental 145 MHz repeater capable of handling s.s.b. signals, initially to be located at the University of Sheffield. A previous proposal for a linear repeater ran into considerable opposition and was not implemented . . . The Lincoln Short-Wave Club has now been allotted the callsign G5FZ, the callsign originally issued to the Lincoln Wireless Society in 1922 .... The most northerly beacon is a new 28.225 MHz station VE8AA located in the Canadian North West Territories on an island in Lake Contwoyto at latitude 65.5° North, longitude 102° West. It has been heard in the U.K. and should provide a valuable guide to propagation studies.

PAT HAWKER, G3VA

The first thousand transmitters

Britain's u.h.f. colour television reaches 98.7% coverage

by Edward Trickett B.Sc., Ph.D

BBC Engineering Information Department

On the seventh of November, 1980, Mike Neville, star of 'Look North', opened a small television transmitting station at Hedleyhope in the Deerness Valley, County Durham. The Hedleyhope relay contains the one thousandth u.h.f. television transmitter to be brought into service by the BBC.

In less than 17 years, 51 main stations and more than 450 relay stations have come into service. With the exception of two stations which do not carry BBC2 (Sandale provides BBC1 Scotland for Dumfries and Galloway, and Wrexham-Rhos offers BBC Cymru/Wales) all the stations have transmitters for BBC2 and BBC1 (or BBC Cymru/Wales).

Hedleyhope is a long way from Crystal Palace, where the United Kingdom's u.h.f. television service began in 1964, carrying the brand-new service, BBC2. Like its predecessors (the original BBC television service in 1936 and ITV in 1955) BBC2 was pioneering a new broadcasting band of higher frequency than any used before in the UK. But it was also using a new line standard destined to be the vehicle for colour transmissions.

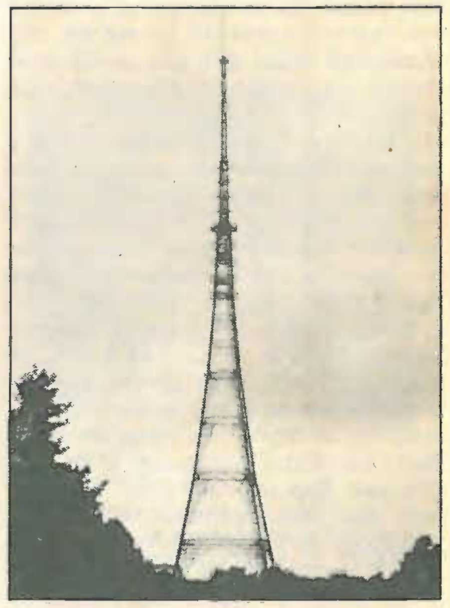
The BBC's u.h.f. transmitter network is a major engineering achievement which stretches the length and breadth of the country, from Baltasound to St Helier, from Dover to Fermanagh and from the Scillies to Peterhead. The problem compared with v.h.f. is that more than 500 stations have been needed to reach the present 98.7 per cent coverage of the 55 million people in the UK. By comparison, the BBC's 405-line v.h.f. network needed only 110 stations to give 99 per cent coverage.

The u.h.f. network represents a great deal of co-operation between BBC and IBA engineers. The service has been planned using the computer at the BBC's research department in Kingswood, Surrey, where the transmitting parameters of all the u.h.f. stations in the UK plus those of the main stations in nearby countries in Europe, are held in memory. The Stockholm plan of 1961 allocated all main station channels and maximum powers, but the detailed planning of the relays is done with the computer. The proposed parameters are fed in to check for possible interference. Even though u.h.f. transmissions do not normally propagate over great distances, some 500 stations, each using 4 channels out of a possible 44, mean that finding useful channels for new relays is getting difficult.

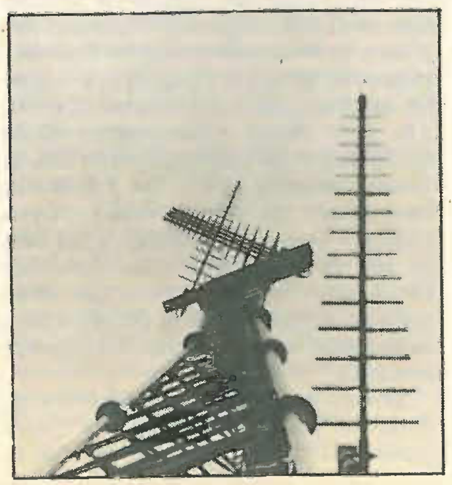
Where possible, existing v.h.f. sites doubled as u.h.f. transmitting stations although more main stations were needed and have been built, with the BBC responsible for site acquisition of half the sites and the IBA responsible for the other half. At each station one organisation is the tenant of the other. The landlord is responsible for the building, tower or mast, aerials and transmitters for its own services: the tenant organisation looks after its own transmitters.

The relay network also used existing v.h.f. sites where possible but many more sites have been obtained on the same landlord/tenant relationship. The obstruction caused by terrain is much greater at u.h.f. than at v.h.f. and the relay stations fill in the gaps left by the main stations. The flat lands of eastern England need very few relays but the heavily-populated valleys of South Wales and industrial Yorkshire and Lancashire need very many. On the whole the relays serving larger populations have been built, and the number of people served by each new relay has fallen from half-a-million (Sheffield) down to between 500 and 1000 for most current stations. Hedleyhope serves 1000 people.

Hedleyhope, the BBC's 500th u.h.f. station, with modular, 3-legged tower, log-periodic aerials and prefabricated building, all of BBC design.



The Crystal Palace tower where the country's u.h.f. services began in 1964. The u.h.f. aerials are in the white cylinder at the top.



Looking up at the mast at Hedleyhope. Log-periodics abound. That on the right is the receiving aerial. The transmitting aerial puts most power in the direction of the stack of four with a little at right angles to serve an odd few houses in that direction. Note the simple tower construction.

Deficiencies in coverage are measured during detailed surveys by the service planning section of the research department. Possible transmitting sites are investigated using the computer and ground profiles drawn from ordnance survey maps. Site tests are carried out with mobile test transmitters and aerials and to check for good received signals. These methods ensure that optimum coverage can be achieved in any area where deficiencies exist.

At this stage, either the BBC's site acquisition section or its IBA counterpart takes over. There has to be main power available within a convenient distance, and reasonable access. Then the landlord has to purchase the freehold or negotiate a lease on the site and obtain planning permission and air navigation obstruction clearance. In some areas there can be objections to even a small pole on environmental grounds but the broadcasters are at pains to erect the most discrete structure consistent with performing the necessary service. They have no power of compulsory purchase, and planning consent has to be obtained in the usual way.

Totley Rise, Sheffield. One of the BBC's tiny, unobtrusive installations with wooden pole, log-periodics and pre-fabricated building.

Providing the stations

The BBC's transmitter capital projects and architectural and civil engineering departments are responsible for turning the research department's specification for each station into reality. The specification includes transmitted power, channels, aerial radiation patterns and height. The most appropriate equipment, aerial support structure and building are all carefully selected to fulfil these requirements.

Most components are ordered in quantity and parts are allocated to each station while it awaits its turn to be built. At present the broadcasters are opening 70 new stations each year and it is vital to maintain a steady flow of materials to meet this target.

On many small BBC sites the concrete tower base (which includes the building base) is laid by BBC staff. A BBC-designed pre-fabricated building is equipped at the Brookmans Park workshops. Building, tower components and aerials are taken by lorry to the site, where the rigging team puts the pieces together. The aerial engineer pays a brief visit to check that the transmitting aerial (which he assembled at the workshops) is a good impedance match when installed with its feeders. He checks the received signal and installs the combining and splitting filters. The relay engineer installs the transposers to complete the installation. The tenant's representatives install their transposer(s) and finally the manager of the transmitter maintenance team accepts the BBC equipment on behalf of the transmitter group, who will operate it. The station is now ready for switch-on and appropriate publicity is arranged through local papers, the 'Service Information' programme and the trade, a week ahead of the opening date. An engineer from the BBC's engineering information department visits the service area with a survey vehicle in the first week or two of operation to check the performance of the station. He advises both dealers and members of the public on the spot about reception conditions as he finds them.

So far only the planning and provision of the stations have been considered, but the expansion of the networks has made huge demands on the ingenuity of our engineers. At several stages in the programme when there was no suitable commercial device, the equipment has been designed within the BBC. The Hedleyhope relay, for instance, has aerials, tower, transposers, amplifiers and channel-selection and combining equipment all of BBC design.

The programme has been a continuing story of smaller and smaller stations serving fewer and fewer people. Inevitably the cost per person served increased and the BBC has made considerable efforts to reduce complexity and expense. The Hedleyhope station has cost some £50 per viewer whereas a high-power station for a densely-populated area would cost 30 or 40p.

Transmitters

Crystal Palace was a test-bed for u.h.f. equipment for several years before it went into programme service in 1964 and the

The main stations in the BBC's u.h.f. transmitter network.

BBC also benefited from the experience of the West Germans who had already begun a u.h.f. service. We aimed to make all u.h.f. stations unattended, requiring maintenance rather than operational staff. So klystrons were used for the main station power amplifiers because of their reliability and long life. Recently the amplifier drives at these stations have been replaced and klystron amplifier efficiency has been improved by 50 per cent although we are still experimenting to obtain even higher efficiencies. Initially, parallel transmitters were used, with separate sound and vision amplifiers (i.e. four amplifiers) so that one half of the system could fail or be maintained whilst the other continued in service. Later, we used one klystron each for vision and sound with a 'cut-back' condition whereby one could carry both signals with a loss of 7dB in power output.

Transposers at the early relays used valves with klystron or travelling-wave-tube final amplifiers. Solid-state transposers came in early and were used initially with output valves or travelling-wave tubes but the most powerful amplifiers using solid-state techniques were 50W units. For most of the smaller stations, 2W and the occasional 10W amplifiers have been adequate. For that, out of the BBC designs department was rolled the 'Blue Streak' – not a rocket as the name suggests, but a transposer/amplifier unit with a very good specification and designed for ease of maintenance. Interconnections are the most likely source of problems in r.f. equipment, so all of the Blue Streak's interconnecting leads are visible and replaceable from the front.

Although this makes it an ugly duckling, the equipment has proved extremely reliable in service. For the future, the designs department has developed a new transposer, already nicknamed 'Silver Streak' which out-performs its predecessor at lower cost. In a very small space, four 2-watt units can be installed side-by-side and only one spare is necessary because the operating frequencies are determined in a separate unit.

Inside Hedleyhope. Gordon Bowhay, of the BBC's transmitter capital projects department, is putting the finishing touches to his 'Blue Streak' installation. The instruments at bottom left are test gear, not station equipment.

Shatton Edge. The 'slimline' tower was originally developed for use in the Peak District National Park. The 'trough' receiving aerials are just above the special stone building. The cantilevered cylinder contains a 'cardioid' transmitting aerial.

Aerials

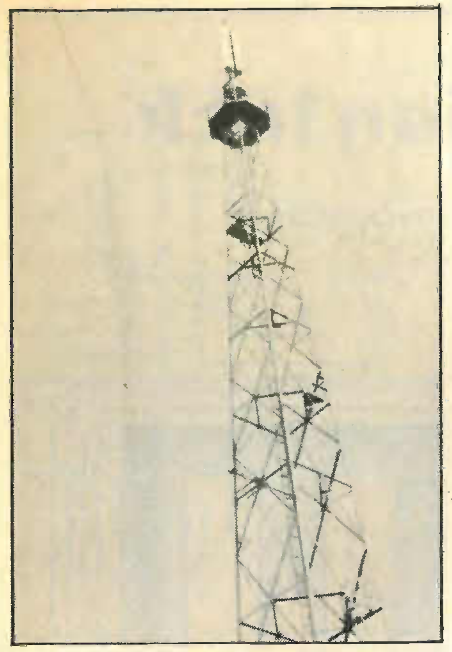
The most obvious feature of a u.h.f. main station is the white glass-reinforced plastic radome which appears as a cigarette-like cantilever on the masts and towers. The transmitting aerials consist mostly of panels, normally four wavelengths high, arranged in stacks on three or four sides of the central spine. The aerials are in two halves, fed by independent feeders and phasing is arranged to give an overall downward tilt to the main beam. At most stations one aerial carries all four services but there are a few where one is used for the BBC and one for the IBA services.

Most early relay stations used cardioid-pattern transmitting aerials built to a BBC specification. Enclosed in a structural gap cylinder, they consisted of a pole with dipoles on one side. Later aerial systems were built using components designed by a team at the BBC's research department. The trough aerial (resembling a pig-trough) was used occasionally for transmitting and more often for receiving. The panel aerial, essentially two slots etched into a printed circuit board and panel and protected by a plastic cover, became the common building block of the Phase 1 stations serving populations down to 1000. The log-periodic aerial has since taken over and is the common component for both reception and transmission at Phase II relays serving groups of people down to 500.

The early heavy-duty towers were not acceptable to the environment conscious planners for the Peak District National Park. A new, more elegant, tower was commissioned. Named the 'slimline', it appeared in the Peak Park and in every other part of the country from St Just in Cornwall to Fodderty in Easter Ross. Even this was too big for the smaller stations which use either simple poles or a lightweight, modular tower designed by the BBC's architectural and civil engineering department at a fifth of its predecessor's price. The tower was designed to be put up by the BBC teams who previously had only erected the aerial systems after contractors had erected the actual tower.

Distributing the signals

A number of main transmitters receive their feed by Post Office (British Telecom) link. This applies to at least one station in each region as there are regional opt-outs on BBC1. The remaining main stations take their picture by off-air reception using BBC-designed rebroadcast-quality receivers. Relay stations almost all use transposers to avoid the need for demodulation to baseband. In a number of cases the Post Office was unable to provide the necessary links and the BBC planned its own link systems to do the job. The three most obvious examples are in Scotland where the feeds to the Inner and Outer Hebrides and to the Shetland Islands are all carried by microwave links installed by the broadcasters. The relay at Torosay (Mull) receives its signal by link from the relay station at South Knapdale, above Loch Fyne in Argyllshire. The main station at Eitshal (Lewis) is fed by a 6-hop link from Rosemarkie on the Black Isle near Inverness. This network, which straddles northern Scotland, was planned and installed by staff in the communications and links unit of the BBC's transmitter capital projects department. The country the route crosses is so rugged that two sites without electrical power are used for passive deflectors. The chain of links carries the v.h.f. radio, as well as the television channels, to the Melvaig transmitter on the Wester Ross coast. The feasibility of a link to Shetland via Fair Isle was investigated by the BBC and the eventual installation was the responsibility of IBA staff. Both Torosay and Bressay (Shetland) are classed as relays but actually use klystron amplifiers for the BBC services and, of course, cannot employ transposers.



St Just. Another 'slimline' tower but with 'panel' transmitting aerials.

The way ahead

The current phase of the relay programme is taking in stations for as few as 500 people and last May the Home Secretary authorised a third phase for populations as low as 200, where practicable. The broadcasters are now looking towards even simpler and cheaper equipment, 'Silver Streak' being the first of this.

The Home Secretary has also given permission for people in communities of less than 200 to install their own cable systems or transmitters but, of necessity in collaboration with the broadcasters. Already more than 60 applications have been received by the BBC.

The 405-line transmissions in Bands I and III are to be phased out between the beginning of 1982 and the end of 1986. Not all of Band I will be available for broadcasting after that, but the remainder and Band III are under consideration for 625-line area television or another near-national network.

So it would seem that we have exploited all the possibilities for terrestrial television broadcasting in the United Kingdom. It remains now to use the next group of broadcasting bands with satellites as discussed by my colleague Dr G. J. Phillips in his articles in this journal of October and November 1980.

I am indebted to the BBC's Director of Engineering for permission to publish this article. □

The author

Dr Trickett was educated at King Edward VII School Sheffield and University College Durham, gaining his doctorate under a BBC research scholarship. He began working for the Corporation in 1968. After a short time in the research department he joined the transmitter capital projects department. Three years ago he joined the engineering information department and is currently employed as a public-ity engineer.

Smaller television cameras

There is a continuing pressure from broadcasters and industrial/commercial users to reduce the size and weight of television cameras. The broadcasters need them small for ENG (electronic news gathering) while the industrial users need them small to mount on machinery or to be unobtrusive for surveillance purposes. Soon, home video will be adding to this pressure (see News, December). Two recent responses from the electronics industry have been the c.c.d. (charge coupled device) image sensor and the single-gun photoconductive tube for producing colour pictures. New examples of these were presented at the International Broadcasting Convention, Brighton, in September, and also by Howard Steele, managing director of Sony Broadcast, in his October inaugural address as chairman of the IEE's Electronics Division.

The c.c.d. image sensor is claimed to be "the first commercially available sensor with the full 625-line tv capability." Developed by the GEC Hirst Research Centre, Wembley, it takes the form of a 14mm×10mm polycrystalline silicon chip mounted in a 30-pin package (type number MA357). The incident light image is converted from a pattern of photons to a corresponding pattern of electric charge by an 8.5mm×6.4mm image section on the chip, which contains 864 horizontal electrodes and 385 vertical charge transfer columns. This charge pattern is transferred, by a three-phase pulsing applied to the horizontal electrodes, line by line downwards into a storage section on the chip. The charge collection plus transfer time is equal to one field period (20ms in the 625-line standard) and the transfer takes place in the blanking interval.

At the bottom of the storage section each line is transferred in parallel into a line read-out section, from which it is read out sequentially in the time of an active tv line, 52μs. While each line is being read out a second pattern of charge is being collected in the image section. Although charge is collected from the whole image area in each field, the three-phase pulsing system causes the centres of charge collection to be shifted up and down between fields to give in effect a 2:1 interlace in the vertical direction. Thus the c.c.d. device is compatible with the 625-line tv standard, where 575 lines are displayed and the remaining 50 lines are used for field blanking periods.

Picture quality from the GEC device is not yet good enough for television broadcasting, but the present performance is claimed to be adequate for "a wide variety of industrial, professional and military applications."

The new single-gun colour tube, intended for ENG cameras and developed by the Sony Corporation, is only ⅔inch in diameter. It is called the Trinicon because of its similarity to the well-known vertical-stripe Trinitron cathode-ray tv display tube made by the same company. The light image, in fact, is focused onto a colour filter array consisting of red, green and blue vertical stripes, each only 9 microns wide, which are integral with the face-plate of the tube. An unusual feature of the tube is the colour coding principle, which uses a phase reference carrier onto which the red, green and blue signals are modulated. This phase reference carrier is generated within the tube by the electron beam scanning an inter-digital electrode structure (rather like two combs) behind the target, and is subsequently used in synchronous demodulators to obtain two quadrature modulated colour-difference signals.

In this system the incident light image is modulated by the striped colour filters to produce a three-channel pulse amplitude modulated signal containing the three colour components E_R, E_G and E_B. The base band and first harmonics are expressed as $E'=a_0\ (E_R+E_G+E_B)+(E_R-(E_G+E_B)/2)\ a_1 \cos\ (\omega t+\phi)+\sqrt{(3/2)}\ (E_G-E_B)\ a_1 \cos\ (\omega t+\phi-\pi/2)$.
In this equation the first term is the luminance signal while the remaining two are the quadrature modulated colour-difference signals which are subsequently recovered in the synchronous demodulators.

The inter-digital electrode structure which produces the phase reference carrier is related to the spatial pattern of the red, green, blue colour filter stripes in that a pair of the interleaved "fingers" or digits occupies the same horizontal distance (27 μm) as one red-green-blue triad of filter stripes (each 9μm). A small offset voltage is applied between the two comb-shaped elements forming this structure and is alternated at the television line rate, so producing the phase reference carrier onto which the red, green and blue signals are modulated. Outside the tube these phase-reference and colour-signal components are separated by a correlation system.

An ENG colour camera using this single new tube weighs 200g and occupies a volume of 80cc compared with the 1200g and 600cc of a corresponding three-tube ENG camera. The power consumption of the tube supplies (1.5W) is, as might be expected, about a third of the three-tube camera consumption.

Electronic combination lock

Mains independent, with four digit code via keyboard

by Jan Hruska B.A.

This article describes how a key-operated mechanical lock can be converted to an electronic combination lock by the addition of a commercially available solenoid operated lock, a keyboard and some c.m.o.s. logic. In design, this lock is similar to the one published in the March 1980 issue of W.W. (Ref. 1.), but it has the following advantages: it is totally independent of the mains: it uses fewer integrated circuits. Although the author specifies a solenoid lock for use with the electronic system, the keyboard and accompanying circuit can be used for activation of a number of devices for various applications.

The system consists of three parts, a keyboard, a processing unit with batteries and a solenoid operated lock. When the correct 4-digit code is entered via the keyboard outside the protected area the solenoid of the electric lock is activated for approximately two seconds by the timer section of the processing unit. The 4-digit code required for activation is predetermined in binary form by the settings on two 16 pin d.i.l. switches which may be mounted on the same p.c.b. as the rest of the logic and timing circuit. Binary code setting provides security against easy reading by a layman.

If a mortise type solenoid lock is used in conjunction with a standard Yale type lock, the door can be opened either by using a key or the keyboard code. The processing unit inside the protected area requires connection to the keyboard outside via an eight core cable and connection to the solenoid via a twin core cable. A 4×4 matrix encoded hexadecimal keyboard is used. Vandalizing of the keyboard or cutting of the wires leading to it do not cause activation of the lock.

The processing unit contains the logic necessary to identify the correct sequence of the four digits and operate the lock, the switches for setting the code and the 6V power source. A total standby current of 200μA is required for the c.m.o.s logic i.cs and a short-burst current of 700mA while the solenoid is being activated. Since the lock activation time of two seconds is small compared with the standby time, four HP2 type batteries connected together will give operation for up to one year. If required, the processing circuit can be made up on a piece of Veroboard measuring 107×54mm and housed, along with the batteries, in a plastic box measuring about 110×190mm.

One type of solenoid operated lock which can be used in the system is the 11K model from Baron Security Group (Ref. 2.) which costs around £13.90 plus v.a.t. This lock was used in the prototype and although the manufacturers specify 8V a.c. as the operating voltage, it worked reliably on 6V d.c.

System operation

The 4 digits are entered sequentially via the 4×4 matrix hexadecimal keyboard as shown in Fig. 1. Each digit is debounced and encoded by a 74C922 encoder. The resulting binary code is then fed to the four-stage shift registers for which two 4015 dual shift registers are used. Comparison between the four digits in the shift registers and the code set in binary in the 16 d.i.l. switches is then carried out by the four 4-bit comparators. If both sets of 16 bits correspond the A=B outputs of the cascaded 4063 comparators will go "high" and trigger the c.m.o.s. 555 timer which will in turn energize the lock through the buffer circuit for about two seconds.

When choosing a code, it is advisable not to use four identical digits as, due to the shift register logic, an intruder would only have to enter one correct digit to activate the lock if a correct code had been used previously. The system described has been in operation in the Medical Engineering Laboratory, Oxford, for more than six months and everybody found it convenient not having to fuss with keys in order to gain access to a busy room with restricted access.

References:

1. Alan Oakley, *Wireless World*, March 1980, p.65-67, "Electronic combination lock".
2. "Remote Control Electric Locking Systems" leaflet, Baron Security Group, 34/35 Dean Street, London W1V 5AP, Tel. 01-439 4536.

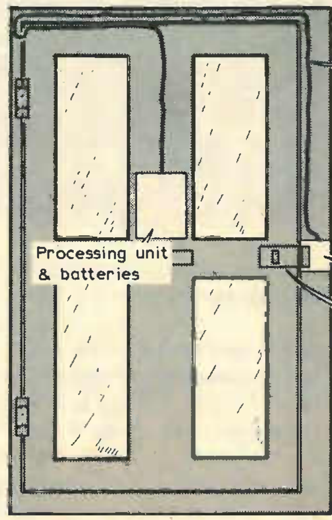
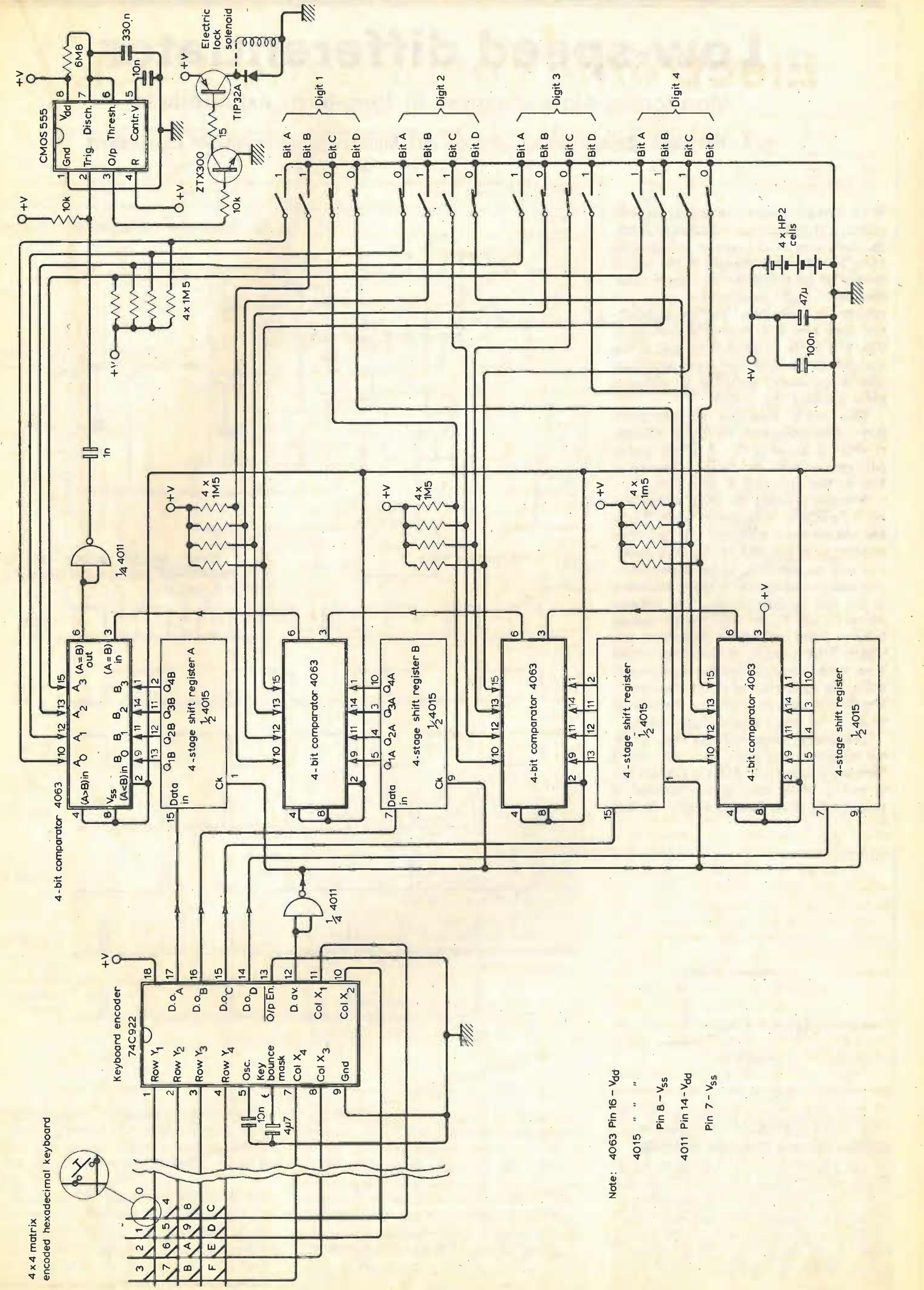


Fig. 2. If the Yale and solenoid locks are mounted as shown here, the door can be opened either by using the key or the combination-lock keyboard.

Fig. 1. Complete circuit diagram. The settings of the d.i.l. switches have been drawn so that a code of 3, 6, 9, 7 would be required to activate the solenoid. ▶

Components list

1 4x4 matrix encoded hexadecimal keyboard
1 74C922 keyboard encoder (c.m.o.s.)
2 4015 dual shift register
4 4063, 4-bit comparator
1 4011 quad 2-input NAND gate
1 555 c.m.o.s. timer
2 d.i.l. switch, 8-pole single-throw
1 ZTX300 or similar n-p-n transistor
1 TIP32A or similar p-n-p power transistor
1 1A diode
1 15Ω resistor
2 10kΩ ,,
16 1.5MΩ ,,
1 1nF capacitor
2 10nF ,,
1 100nF ,,
1 330nF ,,
1 4.7μF tantalum capacitor
1 47μF ,, ,,



Low-speed differentiator

Monitoring slow changes in long-term experiments

by **L. Hayward,** Department of Geology and Mineralogy, University of Queensland

With certain electro-chemical experiments, it often becomes desirable to obtain the derivative of the output voltage/time curve in order that changes in the rate of change of amplitude become more easily observed. Such experiments often last minutes or even days, and consequently the classic type of RC differentiator seen in Fig. 1 is likely to be of little use, as the changes are so slow that great amplification is necessary, resulting in excessive noise masking the output.

This article describes an alternative form of differentiator, the block diagram of which is shown in Fig. 2. When read in conjunction with the timing diagram of Fig. 3, the operation is as follows.

A buffer presents the input signal to a pair of c.m.o.s. transmission gates. These are alternatively switched on for short periods, as determined by the clock generator and the sampling period monostable. The sampled voltages at t_1 and t_2 are stored in C_1, and C_2 respectively. The voltages across C_1 and C_2 are buffered by voltage followers, and applied to a differential amplifier. After t_1 and t_2, the resultant output from the differential amplifier is proportional to the difference of the charges on C_1 and C_2 that were set up during the interval t_1 to t_2. In other words $V_{(out)}=\Delta v/\Delta t$.

The timing diagram shows that, whilst the samples t_1 to t_2 and t_3 to t_4, etc., are of the same polarity, i.e. A-B, the periods t_2 to t_3 and t_4 to t_5, etc., give a reversal of polarity, i.e. B-A. Consequently, a further sampling gate is required to eliminate the unwanted period. An output storage capacitor and output buffer complete the device, the complete circuit being shown in Fig. 4.

In operation, maximum sensitivity will be obtained when the clock frequency approaches the fastest rate of change of the signal. Clearly, the clock frequency should not be equal to, or less than this. The clock frequency is roughly adjusted by selection of capacitor, and fine tuned by the potentiometer RV_1. The only other adjustment is by RV_2 (differential balance). This is most easily set by observing the result of the triangle wave input (in Fig. 5). The output from the differentiator under these conditions should be a square wave, since we have a constant positive rate of change (gradient) followed by a negative gradient, and the amplitude of this square wave will be related to the input frequency. Set up RV_2 for maximum flatness of the square-wave output.

The circuit described is useful where a trend, rather than absolute results, are required. Clearly, this simple design could be elaborated to reduce offsets, and to use rather than eliminate the alternative sampling period, by more complex switching. Considering these limitations, the differentiator performs well and produces consistent results. □

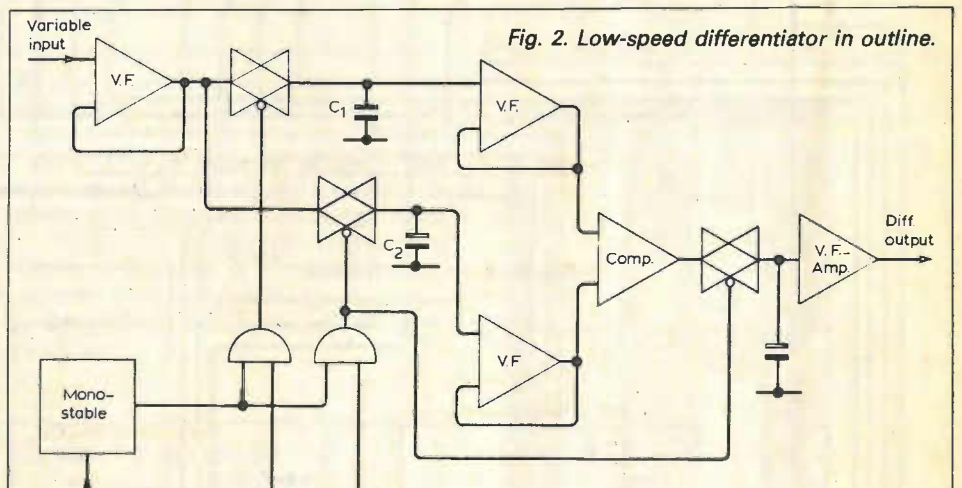
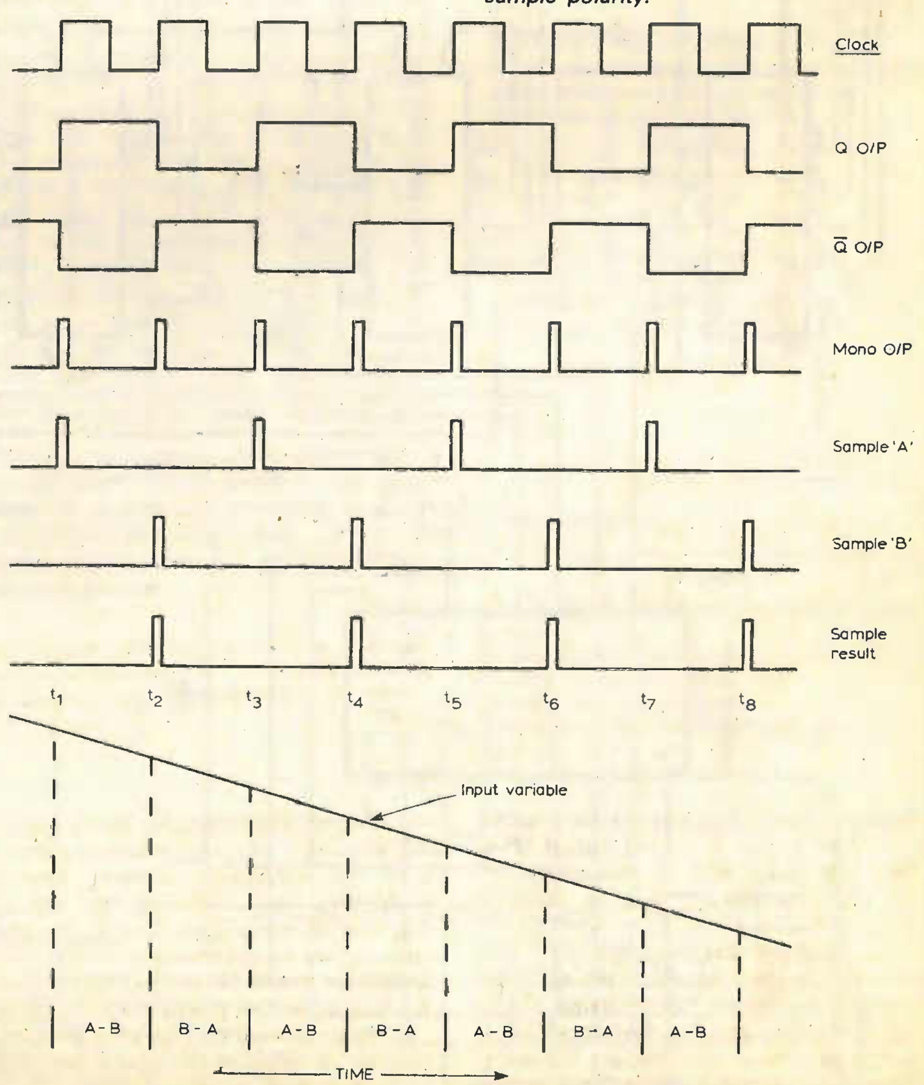


Fig. 2. Low-speed differentiator in outline.

Fig. 3. Timing diagram shows need for third transmission gate to avoid reversal of sample polarity.



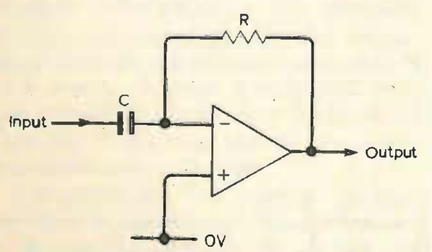


Fig. 1. Ordinary type of RC differentiator – useless for very long time intervals.

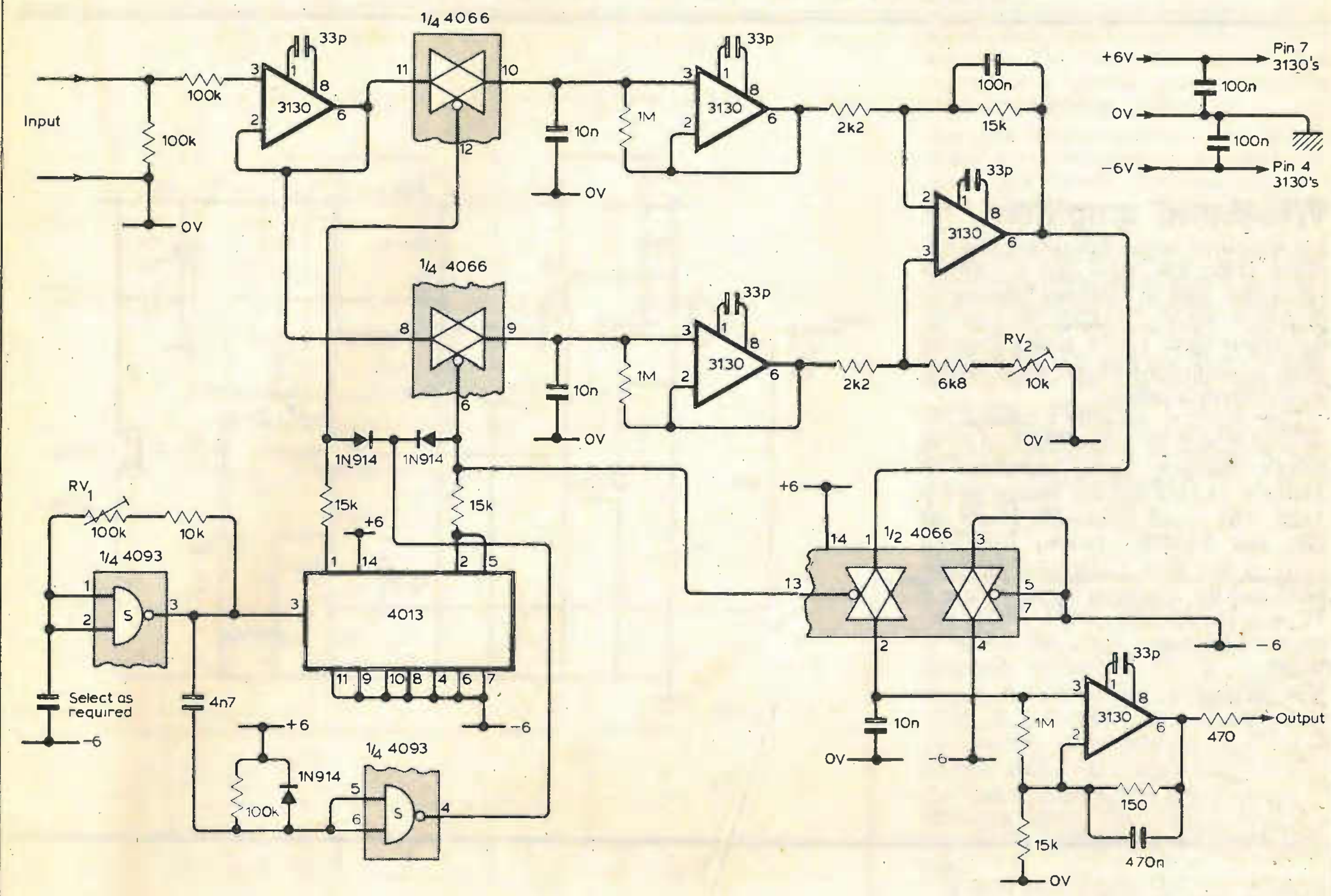


Fig. 4. Complete circuit diagram. 4013 is a dual, D-type flip-flop.

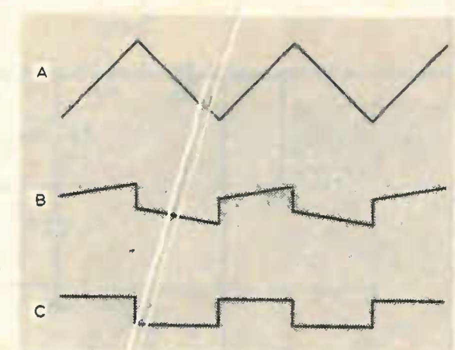


Fig. 5. The effect of adjusting RV_2 for differential balance. Triangular-wave input at (a) should produce square-wave output, as at (c).

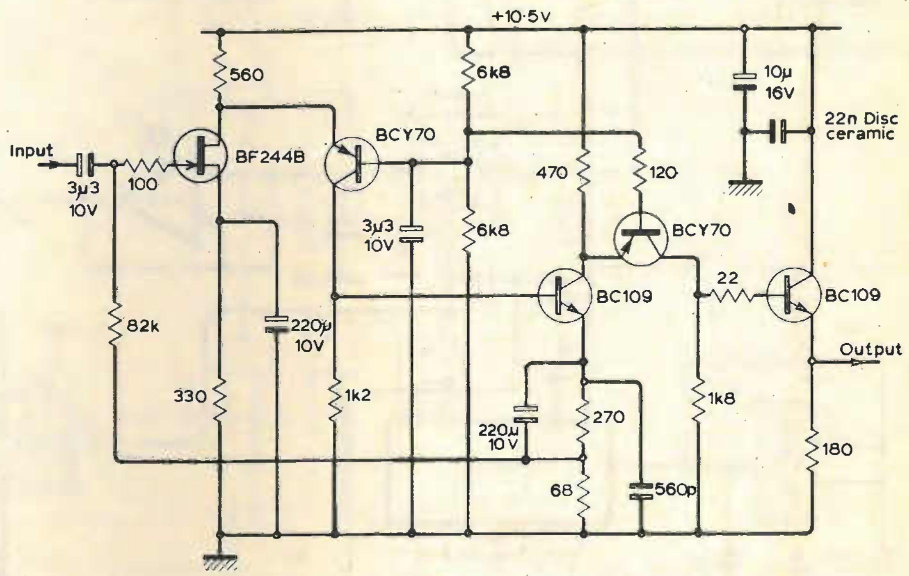
CIRCUIT IDEAS

Wideband amplifier

For low signal level applications, this amplifier offers low noise and a 9.8MHz bandwidth with a minimum amount of frequency selective peaking. As a result, the output signal has an almost constant phase relationship with the input signal, which improves stability.

The circuit is basically a cascode arrangement with the output buffered by an emitter follower. Input impedance at 2MHz is 18.5kΩ and the voltage gain is 32dB. The −3dB bandwidth points are 6Hz and 9.8MHz. Output amplitude ripple is less than 1.2dB over the passband, and the maximum output voltage is 3V pk-to-pk.

D. R. Wightman
Waihi
New Zealand

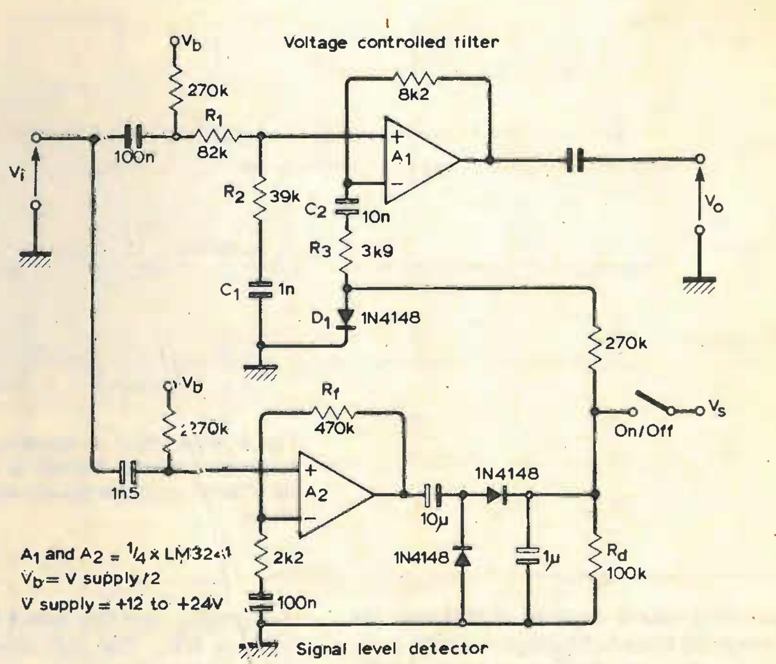


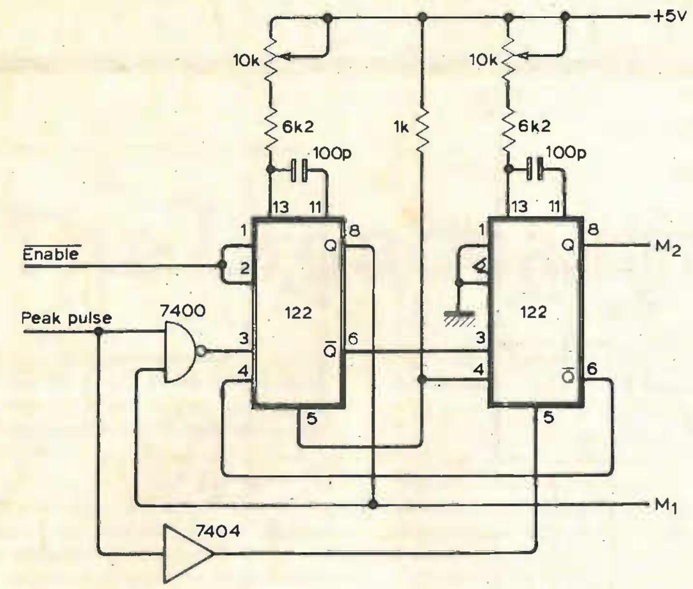
Dynamic noise reducer

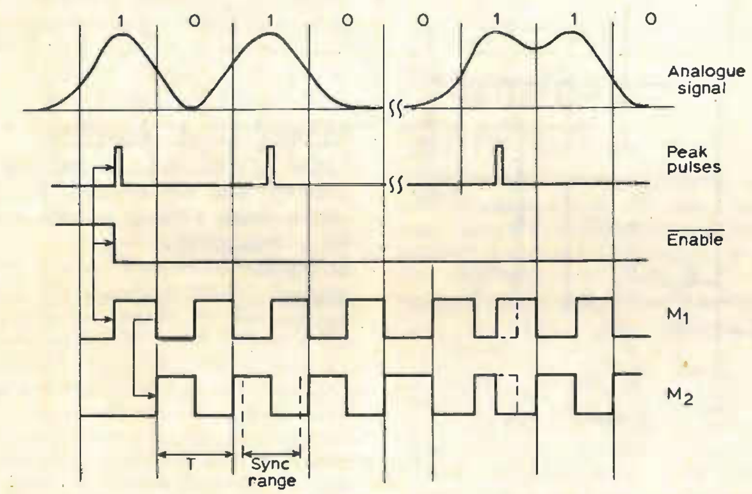
This circuit was developed for use with a good quality cassette recorder, such as the Linsley Hood design, where the cost and complexity of a Dolby B or similar system was not justified. Noise from a replayed tape is most noticeable at low recorded signal levels, and the noise spectrum peaks in the 5 to 10kHz region. Reduction of the background noise is achieved by applying a progressive treble cut to signals which fall below about −35dB (relative to the nominal 0VU replay level), to roughly match the falling treble response of the ear.

A voltage controlled filter uses a diode as a variable resistance element which is modulated by the detected signal level. At high signal levels the gain is unity over the audio spectrum, but falls to −10dB at frequencies above 5kHz as the h.f. content of the input signal is reduced. The level-detector delay time and sensitivity are determined by Rd and Rf respectively. A stereo noise reducer can be built using one LM324 or similar quad op-amp. For recording, a complementary characteristic can be obtained by connecting D_1 in series with C_1R_2 instead of C_2R_3.

G. C. Hammond
Nuneaton
Warwickshire







Phase synchronised monostable oscillator

Two monostables form an oscillator whose phase can be synchronised with an incoming pulse. The circuit was originally used to replace a damped resonant-amplifier clock regenerating circuit in a data recording system. Analogue data from the signal processing system was peak detected, and the write data was encoded to have a maximum of four clock periods between peak pulses.

The oscillator is started by the first peak pulse which occurs at the start of each data steam. Successive peak pulses update the phase of the oscillator and keep the clock in phase with the analogue data. If a peak pulse is early, M_1 is triggered and M_2 is reset, which effectively resets the phase to zero. If the peak pulse is late, M_1 is retriggered which extends its period by the amount the pulse is overdue.

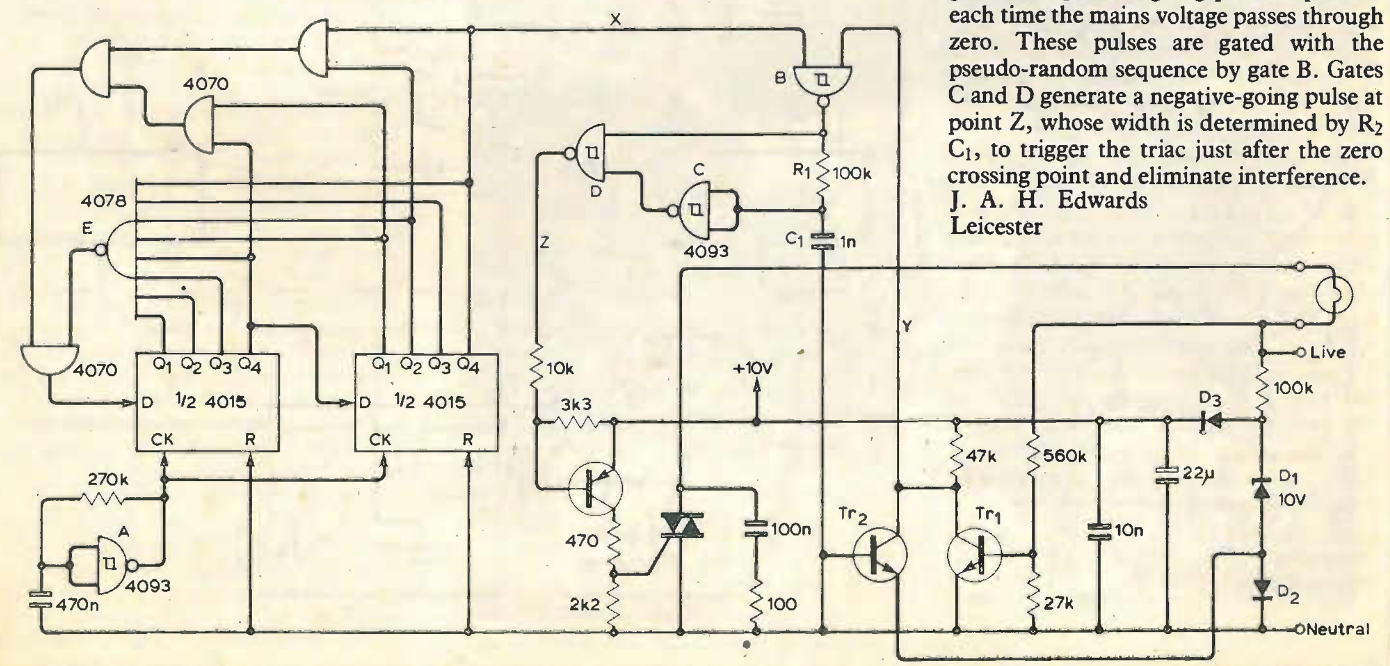
E. M. Davies
Towcester
Northants

Visual fire effect

A realistic fire effect, suitable for amateur dramatics, can be achieved with the circuit shown. A wooden base carries three 60W bulbs, the two outer lamps are red and are permanently on to produce the effect of glowing coals. The middle bulb is yellow and flashes randomly to give the effect of flickering flames. The unit is covered by a log effect moulding taken from an electric fire.

A 4015 shift register and the exclusive – OR gates form a maximum length pseudo-random sequence generator. This is clocked at 10Hz by the oscillator using Schmitt trigger A. The pseudo-random pattern of ones and zeros at point X repeats every 25s, and gate E prevents the generator from locking up in the all-zeros state. Diodes D_1, D_2 and D_3 provide a +10V supply for the circuit, and Tr_1, Tr_2 generate a positive-going pulse at point Y each time the mains voltage passes through zero. These pulses are gated with the pseudo-random sequence by gate B. Gates C and D generate a negative-going pulse at point Z, whose width is determined by R_2 C_1, to trigger the triac just after the zero crossing point and eliminate interference.

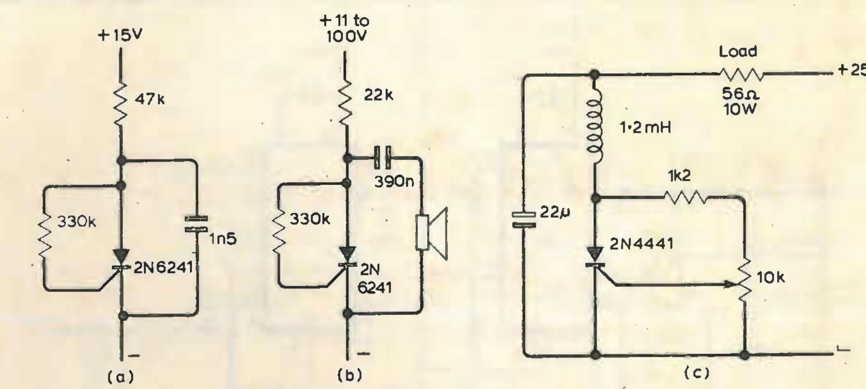
J. A. H. Edwards
Leicester



Simple s.c.r. oscillator

Fig. (a) shows a basic s.c.r. oscillator with a frequency of 7kHz. The voltage across the s.c.r. rises until there is sufficient gate current to switch it on. The anode resistor is chosen so that when the s.c.r. conducts, the current is below the minimum sustain current and the device switches off. A new cycle then starts. Supply voltage and temperature are critical and not every s.c.r. will oscillate. An improved circuit is show in Fig. (b) where an inductor, such as a speaker coil, is connected in series with the capacitor to provide an output frequency from 100Hz to 10kHz. The components are not critical and the circuit will work with a wide range of supply voltages. Because the back e.m.f. of the inductor helps to switch the s.c.r. off, this principle can be used to control a d.c. load as shown in Fig. (c). Current through the load can be controlled between 25 and 90% with the potentiometer.

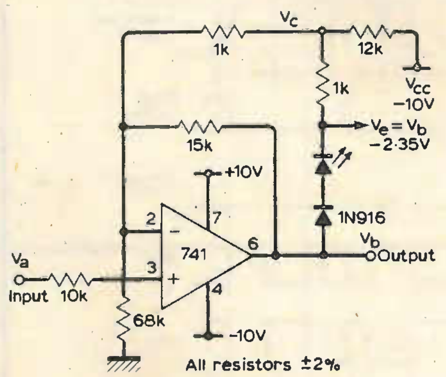
D. Di. Mario
Rome
Italy



Linear l.e.d. control

Linear control of l.e.d. intensity can be achieved with one op-amp. The input is varied from +5.6 to −6.2V where the l.e.d. extinguishes.

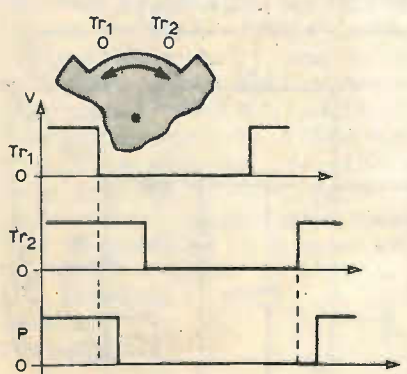
P. Amin
Harlow
Essex

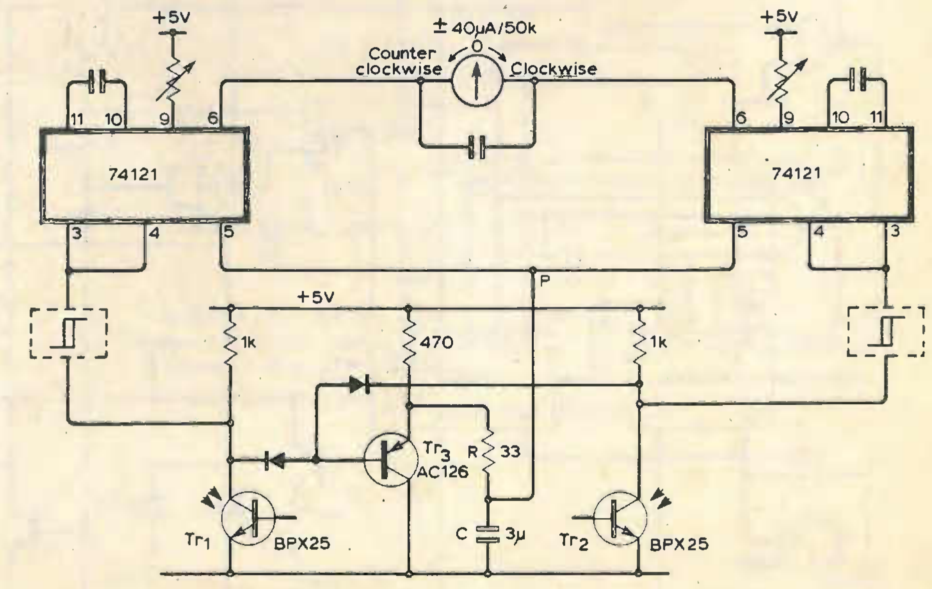


Tachometer indicates rotation sense

Rotation speed and sense can be detected by two phototransistors as shown. One monostable is triggered by the phototransistor which turns on first, depending on the direction of rotation. Tr_3 inhibits the remaining monostable and a RC combination produces a delay to permit triggering of the first monostable. The light sources must produce a V_{ce} of 300mV for Tr_1 and Tr_2, and Schmitt triggers are recommended to produce fast trigger edges, especially at slow rotational speeds.

S. Ion
Romania





NEWS OF THE MONTH

The Broadcasting Act 1980

One of the main effects of the Broadcasting Act, which received the Royal Assent in November, is to extend the life of the IBA by fifteen years. Under previous legislation the life of the IBA was due to expire at the end of 1981. Now, as recommended by the Annan Committee on broadcasting, the Authority will go on until the end of 1996 – and this may be extended by statutory instrument for up to five years.

Another important effect of the Act is to hand over the fourth television channel to the IBA to provide a new service (other than in Wales). Here the IBA has to ensure that the fourth channel programmes contain a suitable proportion of matter calculated to appeal to tastes and interests not generally catered for on ITV; to ensure that a suitable proportion of programmes are of an educational nature; to encourage innovation and experiment in programming and generally to give the fourth channel a distinctive character of its own.

Programmes will be obtained and assembled into schedules by a subsidiary formed by the IBA for that purpose. Finance for engineering, transmitting and supervising the fourth channel, and for the purchase by the subsidiary of programmes for the service, will come from the ITV programme companies, who will have the right to sell advertising time among fourth channel programmes broadcast in their regions. The IBA will be required to include in its annual report information about the way the fourth channel service has differed from the ITV service, both in content and sources of programmes, and how innovation and experiment has been encouraged. Information will also be required about compaints received concerning the sale of advertising of either channel.

The Act provides for Welsh Language programmes to be concentrated on the fourth channel in Wales, with the possibility of changing to a two-channel solution after a period. A Welsh Fourth Channel Authority, consisting of a chairman and four members appointed by the Home Secretary, will have overall responsibility. A substantial proportion of programmes must be in Welsh. When Welsh programmes are not being broadcast programmes shown on the channel will normally be those being transmitted on the main fourth channel service at that time. The BBC will have to supply the Welsh Authority with Welsh language programmes free of charge and the IBA's Welsh contractor has to do so in return for payment. The last-mentioned contractor may sell advertising time on the fourth channel in Wales.

The Welsh Authority's expenses will be met by payments agreed between it and the IBA (or in default of agreement, fixed by the Secretary of State) which the IBA will raise from the ITV programme contractors.

A selection of the Act provides for new financial arrangements for independent local radio. Rental payments will be made to the IBA by the ILR contractors in respect of the Authority's cost in supervising and expanding the system, and there will be a levy payable to the Exchequer on their profits. The rate of levy is set at 40 per cent, but this (like the 66.7 per cent levy on the profits of ITV contractors) could be varied by order. Also, the IBA will be able to make grants to local radio contractors. This will enable the Authority to help the expansion of independent local radio and to improve the quality of its service.

Under the Act, ITV and ILR contracts will run for a maximum of eight years (subject to a transitional provision for independent local radio in existence before the introduction of the legislation). But a first ILR contract in an area previously unserved by ILR may run for a maximum of ten years. In addition, the IBA is required to re-advertise both ITV and ILR contracts when the contract periods comes to an end. The ILR will have to publish a notice of its intent to enter a contract and the date from which the contract will run run and invite applications for that contract.

Ptarmigan takes off

Plessey, the prime contractor for the battlefield communication system, Ptarmigan, say that its total value will be "several hundred million pounds", and that it will provide over 400 new jobs. Sub-contractors include STC, Marconi, Airtech, BICC, Marshall of Cambridge and Membrain. Plessey's order book now stands at £1,200 million.

Ptarmigan is designed for the British Army and RAF in Germany, although it is meant to be compatible with older equipment such as Bruin, which it replaces, and other systems being developed in Europe. It is a trunk digital radio network with access for 'subscribers' and is described by General Sir Hugh Beach as "like System X with car radiophone, only more so".

A full range of facilities, such as abbreviated dialling, call transfer, hold, conference and storage, are available. In addition to speech, the system can handle telegraph, data and facsimile.

Development of Ptarmigan started in 1973, and first deliveries of equipment are expected around 1982, although there appears to be an element of uncertainty about this. The army seems to think that the second half of the decade is a more realistic expectation, and the mid-'80s has also been mentioned.

Both Plessey and General Beach (Master General of the Ordnance) find themselves unable to comment on the award of the production contract vis-à-vis the moratorium on new defence contracts introduced on August 8. It seems likely that the production contract is considered a continuation of the development contract and consequently immune to cancellation.

Ptarmigan mobile 'subscriber' terminal in a Land-Rover.

Two-year trial period for subscriptions tv

Following his consideration of a report submitted to the House of Commons in February, the Home Secretary, William Whitelaw, has decided to allow 12 pilot schemes in subscription tv (using cable systems) to begin operation in the UK, initially for a two-year period.

In a written answer to a question from Colin Shepherd (the MP for Hereford), he said that, since it "would not be practical nor appropriate for the Home Office to supervise the programmes shown nor to exercise the functions of a broadcasting authority", most of the broadcast material would consist of feature films. Licensees may not seek exclusive rights to show sporting and entertainment events of national importance. **Advertising will not be permitted.**

As well as being required to conduct research into public reactions to such a service, each licensee will be expected to monitor progress and submit reports to the Home Office from time to time.

The Home Secretary also said that he is considering a levy "for the benefit of the film industry, and . . . any additional safeguards needed to protect the cinema and television broadcasting services." Applications for licences will only be considered from existing licensees of broadcasting relay systems. The schemes will be conducted at the commercial risk of the operator who will also be required to provide details of the technical characteristics of the system and to comply with any licence conditions calling for the suppression of interference with other forms of broadcasting. The Department of Trade will not charge a levy in respect of the showing of films in the pilot schemes, although a licence fee will be charged to cover the administrative costs incurred by the Home Office.

Licences have been granted for broadcast relay since the late 1920s, first to relay sound and then tv programmes. In 1965 an experiment was set up as a reaction to suggestions by several companies, resulting in three companies being issued with licences for an experimental service. However, two of these companies decided that the restrictive conditions imposed by the Post Office (which was the licensing authority in 1965) and the lack of commercial assurance for the future, were not acceptable, and surrendered their licences.

The third company, Pay-TV Ltd, mounted experiments in London and Sheffield and operated technically successful services from 1966 to 1968. The company was satisfied that the results showed the acceptibility of the service and that commercial viability could be achieved if coverage could be extended from the experimental 12,500 to 250,000 homes. Permission to increase the coverage was refused, however, and the service closed down.

In contrast, many cable tv networks are in operation in the US and by 1976 there were 633,000 homes so equipped, most of the stations providing feature film and general sport programmes, in fact much like the system currently envisaged by William Whitelaw. Many of these US networks now receive their signals via satellites.

US local TV stations recommended

Hundreds of low-power local television stations may be set up in the USA as a result of a recent recommendation. With a power of about 1kW and covering areas with a radius of about 25km, they are intended for specialized services such as dealing with local community events. They have been planned not to interfere with the broadcasting of normal, high power commercial television stations, but the National Association of Broadcasters in the US is worried because they think the FCC may not have studied the problems thoroughly enough. Obviously, the proprietors of existing commercial TV stations will see the new service as a possible threat to their present advertising revenues.

News in brief

More than 700 Japanese government officials, businessmen and technical personnel attended the second British Overseas Trade Board seminar on **industrial energy saving and efficiency**, held in Tokyo late in September. The seminar was held at the World Import Mart building and was the first such meeting in Japan sponsored by a foreign government organization.

Digital Communications Corporation, a member of the M/A-Com group of companies (US) has formed DDC Ltd, a British subsidiary. The new company's product range will include satellite ground station, terrestrial p.c.m. and data transmission equipment for private and national organizations. The company's head office will be located at Humphrys Rd, Dunstable, LU5 4SX.

Communications 82 will be held at the National Exhibition Centre, Birmingham, from Tuesday 20 until Friday 23 April 1982 (inclusive). This will be the sixth in a series of biennial international expositions dealing with communications equipment and systems.

The British Standards Institution has published a six-part delineation of *High Fidelity Audio Equipment and Systems; Minimum Performance Requirements.* For further information, contact the BSI, 2, Park St, London W1A 2BS or telephone 01-629 9000.

A ten-year collaboration project, aimed at producing a new generation of computers based on the use of Josephson junctions (superconductors) or similar high speed logic elements, is to be embarked on by the US, France, Germany the UK and Japan. A major target of the scheme will be to produce a computer which accepts not only the spoken word but pictures in various forms as well as designing its own (simple) programs and diagnosing its own faults.

On 7 Nov the BBC's 1000th colour tv transmitter was put into service (see Dr Trickett's article this issue). The transmitter is located at Hedleyhope in Co. Durham and will serve about 1000 homes in Waterhouses, Esh Winning and East Hedleyhope. The services and channels relayed are BBC1 (North-East) – ch.40, BBC2 – ch.46, ITV (Tyne-Tees) – ch.43 and the 4th channel (when operational) – ch.50. Polarization is horizontal.

A short course entitled **Thermal Design of Electronic Systems** will be presented at Cranfield Institute of Technology during the week 26-30 Jan 1981. It will consist of two three-day tuition blocks covering (1) fundamentals and applications of conduction, convection and radiation to temperature control (2) liquid pool boiling, heat pipes, phase change materials, fluidized beds and thermoelectric cooling. This section of the course will also deal with thermal imaging and laser Doppler anemometry. Apply to the Short Course Officer, Cranfield Institute of Technology, Cranfield, Bedford MK43 0AL.

Studios 7 and 8 at BBC Television Centre are now being lit by a microprocessor-controlled system developed by Thornlite in collaboration with the BBC's Capital Projects Department. The unit can control up to 500 studio lights and use nine Motorola 68000 microprocessors.

SRC, inflation, Einstein and quasi stellar mirages

The continuing success of the Science Research Council in discharging its commitment to the social, technical and economic ramifications of industry and academia, in spite of the rigours of inflation, is given detailed support in its report for 1979-80, published early in November.

Alongside comparisons of expenditure of grants (£19 million in 1979 compared with £3½ million in 1970) the report records some "striking discoveries." The most notable of these is probably the confirmation of Einstein's prediction, made fifty years ago, that gravitational fields could act as "lenses". During a uniform survey of quasi-stellar objects (q.s.os) at the Nuffield Radio Astronomy Laboratory, Jodrell Bank, a radio source was identified with a close pair of q.s.os on a photograph. They were found in collaborative studies at Kitt Peak Observatory to have identical spectra and nearly equal brightness, coupled with identical large red-shifts.

This is in fact only one q.s.o. and the most plausible explanation is that the light from this object is reaching us by alternative paths distorted by a strong gravitational field. Recently, workers at the Mount Palomar Observatory have detected a massive galaxy on a line of sight to this object and substantially nearer to us. The mass and position of the galaxy account for the observed effect and although the shift of a stellar image seen near the Sun was an early confirmation of Einstein's prediction, this is the first occasion on which one stellar object has been seen as two.

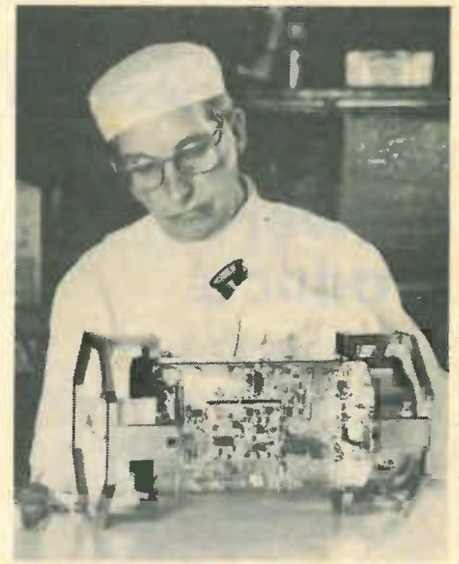
In another area of its activity, the SRC reports on its involvement with the University of Essex and the Mullard Space Science Laboratory of University College in obtaining data from the GOES-2 satellite. This information provides confirmation of the linear instability theory of plasma physics and is especially significant because of the importance of plasma techniques in power generation by nuclear fusion.

During the conference to introduce the report, Sir Geoffrey Allen, Chairman of the SRC, said that the cut-backs in funding caused by the present government's policies had not been as serious as was expected when he gave last year's report. However, there is a "cashflow" problem, introduced by contractors (presumably worried about the chances of payment if left too late) putting in bills immediately.

Among the facilities introduced in the current year, the electron beam lithography units at Rutherford and Appleton Laboratories carry important implications for engineering in that they can provide a precision i.c. mask-making service, supplementing the device fabrication facilities already established at Edinburgh, Southampton, Surrey and Sheffield universities.

Also in this context, Sir Geoffrey hinted at the strong possibility that the name of the Council might soon be changed to read "Science and Engineering Research Council."

The report of the Science Research Council for the year 1979-80 is available from HMSO, price £7.10.



A prayer modem in its assembly stage by a Tibetan operative at Lhasa. Each verse is assembled in hexadecimal form before being modulated and passed into a "loop" circuit where it is converted to analogue form and fed to the output stage at the standard monotone voice frequency.

Photo by courtesy of Advanced Prayer – Wheel Designs Inc. (and STC!)

A JOB FOR LIFE

What British company is characterized by the following phrases, quoted from a recent speech? "When an individual joins a company operating a life-long employment system he does so with a tacit understanding that, in normal circumstances, he will remain an employee of the company until retirement. The company will not discharge the employee before he reaches retirement age unless an exceptional situation arises".

"It provides strong employment stability which the employees appreciate and rigidity in the workforce size which constrains the companies in times of business recession. For the company it also serves as a guarantee against future labour shortages".

"There is a very strong emphasis on group effort towards achieving a specific business target which is hardly present in the USA where the emphasis is on individual performance.....".

"The system allows the employee to feel that he can place his trust in the company, he can rely on it and thereby obtains a deeper interest in its affairs than he might otherwise acquire. The company is encouraged to place its trust in the continuing co-operation and service of its regular employees. The result is collective dedication to achieving the company's objectives."

"Employees do not find it necessary to resist technical change and innovation even though it may mean assignment to other jobs because they recognize that such changes are unlikely to affect adversely either security of employment or income. Nevertheless, it would be wrong to assume that employees are servile. The emphasis is on a reasonable approach being made by both company and employees to issues of common concern which allows the company to maintain a high level of productivity so that the *status quo* continues".

"Under the seniority wage system the income of an employee is directly related to length of service with the company. Such factors as individual ability, responsibility and the demands of the job itself play a smaller part in the determination of an employee's income within a group having similar tasks. It follows that there are no comprehensive company salary or wage structures. Job evaluation, as we know it, is also missing".

"Such a system ensures that income increases with time in much the same way as the demands on it increase for the greater proportion of a family man's career".

"Strikes are viewed generally as being more in the nature of demonstrations.......".

The speech was in fact the inaugural address of the new president of the IERE, John Powell, who is engineer-in-chief of Cable and Wireless. The subject was "Resource management: a key to immediate improvement in productivity" and a good deal of the address was about the success Cable and Wireless has had in the management of its work force. The quotations above were from Mr Powell's admiring description of Japanese industry, and it was clear he felt his own firm's success in management was because its methods had an "affinity to the employment pattern found in the large Japanese companies". Mr Powell concluded: "I believe that employment practices in British manufacturing industry tend towards those generally found in the USA and therefore differ considerably from those developed in Cable and Wireless. Would there be value in rethinking this whole issue of resource management? My answer is an unqualified yes."

Final testing of the SBS communications satellite at the Hughes Aircraft facility at El Segundo, California. This satellite, the first of three to be put into orbit so as to provide "secure" voice, video, data and facsimile traffic for US business, was launched on Nov 15 and is owned jointly by IBM, Comsat General Corporation and Aetna Life and Casualty.

Faulty vision caused by brewer's products

An example of tv "hash" on channel B3, photographed by Roger Bunney during v.d.u. business hours (0800 to 1700).

In view of the heavy fines imposed upon 27MHz c.b. users and the claims made by the Home Office that such illegal activity seriously interferes with established authorized services, Roger Bunney's reception experiences in the Romsey area force some interesting comparisons.

He works as a television technician and journalist, contributing articles on long-distance tv reception to the magazine Television (IPC Magazines) and a considerable part of his professional activity involves monitoring the broadcast bands 1 to V. Arriving in Romsey, Hampshire in 1972, he set about building a 50ft lattice mast to carry the necessary aerials. One of the most successful and active bands for DX is Band 1 (48-68MHz), where sporadic E combines with the favourable conditions of the F_2 layer to make reception up to 500 miles possible.

In September 1976 the entire Band 1 spectrum was disrupted by high level interference, which was eventually traced to a nearby industrial site. The Whitbread-Wessex brewing concern had established a distribution office about 60 yards away, equipped with six v.d.u.s and related equipment for receiving information by cable (Post Office) from the main brewery in Portsmouth. The disruption produced a whining "motor" effect, peaking at intervals of about 1.5MHz from 30MHz up to 100MHz.

Efforts were made to contact the makers of the equipment with a view to suppression but a solicitor was eventually engaged (after a severe lack of response!) and the v.d.u. manufacturer eventually paid for a stacked aerial array. However, this had little effect and the Home Office subsequently made measurements using Mr Bunney's array and Post Office arrays mounted on a vehicle. Although the actual results were never provided, the Home Office eventually wrote pointing out that action would not be taken nor public funds used to terminate the nuisance.

The attitude of the Home Office seems unfortunate, to put it mildly. A source of interference which is producing a public nuisance has been allowed to continue for several years, despite acknowledgement that the problem exists and within a domestic broadcast band. This was also noted by another citizen, who laid a similar complaint based on interference to local f.m. radio reception, but who has since left the area. One criticism that could be levelled at the complainant is that he is necessarily seeking remote and weak signals and can therefore expect problems, but this seems to imply that domestic users and enthusiasts are relegated to a position where they must suffer interference from vested interests and commercial organizations.

Perhaps it's time for the statutory limits to interfering radiation to be reconsidered.

Shuttle will assist in closer look at Venus

One of Jimmy Carter's last official acts as President of the United States was to approve NASA's request for funding of a mission to map the surface of Venus, to begin in 1986.

After launch by the space shuttle, the Venus Orbiting Imaging Radar (VOIR) spacecraft would circle the planet for seven months taking pictures as well as making measurements of the surface and atmosphere.

Dr Robert Frosch, NASA's chief administrator, says that this scientific project will "reveal the true nature and geological history of our sister planet in the same way that Mariner 9 enabled us to see Mars." Venus is completely veiled in clouds. No permanent feature has ever been identified by telescope. The current plans provide for arrival of the vehicle in December 1986, at which point the spacecraft would be inserted into polar orbit at an altitude of about 180 miles.

The mapping activity would result in near-global coverage of the planet with moderate resolution imagery (corresponding to 2000 feet) and a smaller section in higher resolution (about 150m – 500ft).

News in brief

The first telecommunications equipment show and seminar ever held in China is to be staged at the Beijing (Peking) Exhibit centre from Nov 3 to 13 1981 by the Electronic Industries Association (US) and the National Council for US-China Trade. Approximately 100 American manufacturers are expected to exhibit equipment at the shgow.

The International Association of Broadcasters (IABM) has moved to new headquarters at Triumph House, 1096 Uxbridge Rd, Hayes, Middlesex. The telephone number is now 01 573 8333.

A bureau approach to viewdata, enabling small-scale users to exploit Prestel-like hardware in a private system, is to be set up by GEC Viewdata Systems. Pages of internal information are held on the organization's viewdata computer, which can be called up, modified, and new pages inserted by users of various departments of the organization. A typical system, holding about 30,000 pages, would cost about £50,000, excluding the cost of terminals.

Public payphones which use plastic cards instead of coins will be tried out by British Telecom next year in London, Birmingham and Manchester. They will be sited near conventional payphones, giving users a choice, although it will be necessary to buy the cards, which are erased automatically when inserted into the mechanism. Each card unit is priced at 5p and there will be two basic cards on sale – one of 40 units costing £2 and a 200 unit card at £10.

Bus for a bus

Lucas and Leyland have jointly developed a multiplexed bus system to replace most of the complicated electrical wiring in a passenger bus or other vehicle.

Although "critical loads" such as headlamps and stop lights will still be wired conventionally, all the control wires for door solenoids, internal lighting, horn, etc., can be replaced by the bus. The system comprises a three- or four-wire "ring main", a microprocessor-based controller and up to 30 local receiver units. The bus provides a common power rail, a single wire for the transmitted data and one wire for a synchronising clock. An optional fourth wire can be added to provide a noise-free return.

The controller reads the state of the driver-operated switches, sends sync pulses at 32kHz to set the receivers to stand-by and then transmits the 5-bit address of the first receiver in the sequence. Clock pulses synchronise the loading of this address into a memory in each receiver and, to overcome false addressing caused by noise, the same address is transmitted again and loaded into a second memory. Each receiver compares the two stored addresses which, if identical, are compared with the fixed address of the receiver. Consequently, only one receiver responds and opens an input gate to receive five bits of command data. The controller then transmits inverted command data as a check for false instructions. When the receiver has verified the command, the output stages are switched accordingly and a reply is sent to the controller, which indicates the state of the outputs and hence the effectiveness of the command. This procedure is then repeated for the next receiver in the sequence. When all the receivers have been addressed, the cycle repeats with the controller re-reading the states of the driver-operated switches.

Each receiver incorporates a fail-safe circuit which switches the affected loads to a safe state if a failure occurs.

Leyland have also developed a diagnostic system which, via the bus, can quickly check the electrical circuits on the vehicle and provide a print-out. Although the multiplexed bus technique is by no means original, this appears to be the first instance of its use in a vehicle. Some bus operators have been sceptical about the reliability of parts that do not move, but the designers stress the more positive points of the system which include the claim that it will be no more expensive than an equivalent conventional wiring harness, will be far more flexible and, with the addition of vehicle condition monitoring and diagnostic systems, far more useful.

Multiplex keying system for organs

TDM system reduces complexity and cost, allows mixture stops, transposition and pizzicato effects

by A. W. Critchley, Dipl.El., M.I.E.R.E.

Home organ projects suffer from a high mortality rate perhaps principally as a result of their inflexibility and the time taken to get acceptable results; it is common to be overtaken by technology! This article presents the basis for a system intended to reduce the drudgery and cost of building an organ, whether pipe, electronic or hybrid. It shows that the resulting system is flexible enough to permit a wide range of organ features, many hitherto unobtainable on electronic organs, which can result in them being able to simulate pipe organs more closely at a fraction of the cost.

The principles can easily be adapted for microprocessor control at a much lower hardware cost and complexity. But for the experimenter or technician without microprocessor capability who likes to know how things are done and who wants to be able to change it around without too much effort, the microprocessor approach takes away a lot of the fun and relegates everything to a mystery black box.

The method of controlling the keying to be described is offered as a practical solution to the problem of multiple key contacts, whether the organ is a pipe or electronic, church or entertainment type. It has advantages over conventional wiring, not least being the cost, which can be paid for out of the saving in copper wire:

Cable size from the console is significantly reduced.
Circuitry is inexpensive and uses standard c.m.o.s. devices.
Single-pole contacts throughout of light current capacity – a milliamp or so just to keep the contacts clean.
Keyboard wiring is simple and can be standardised.
Octave coupling within manuals is simply a matter of incorporating delays.
Inter-manual coupling is identically done using longer delays.
Any required pitch can be selected with ease.
Mutation and mixture stops are no problem.
Any kind of organ can be controlled – pipe or electronic.
No limit to the size of organ.
Extra consoles may be added.
Second-touch keying is easily catered for.
All other switch information can be included if desired.
Only a handful of printed-circuit boards is required.
It is flexible to permit custom designing.
Coupler switches are not used, avoiding high-current supplies.

Disadvantages include complex circuitry in which a single failure could render the whole organ inoperative, a high level of servicing competence being necessary.

Key matrixing

The system basically comprises a matrix for the pedals and keys to minimise the number of wires that have to be connected to the keys. The contact information is then turned into a series of pulses by sequential scanning of the matrix, see Fig. 1. Data is passed over a single wire through various delay systems to demultiplexers which recover the keyed information to switch on and off the

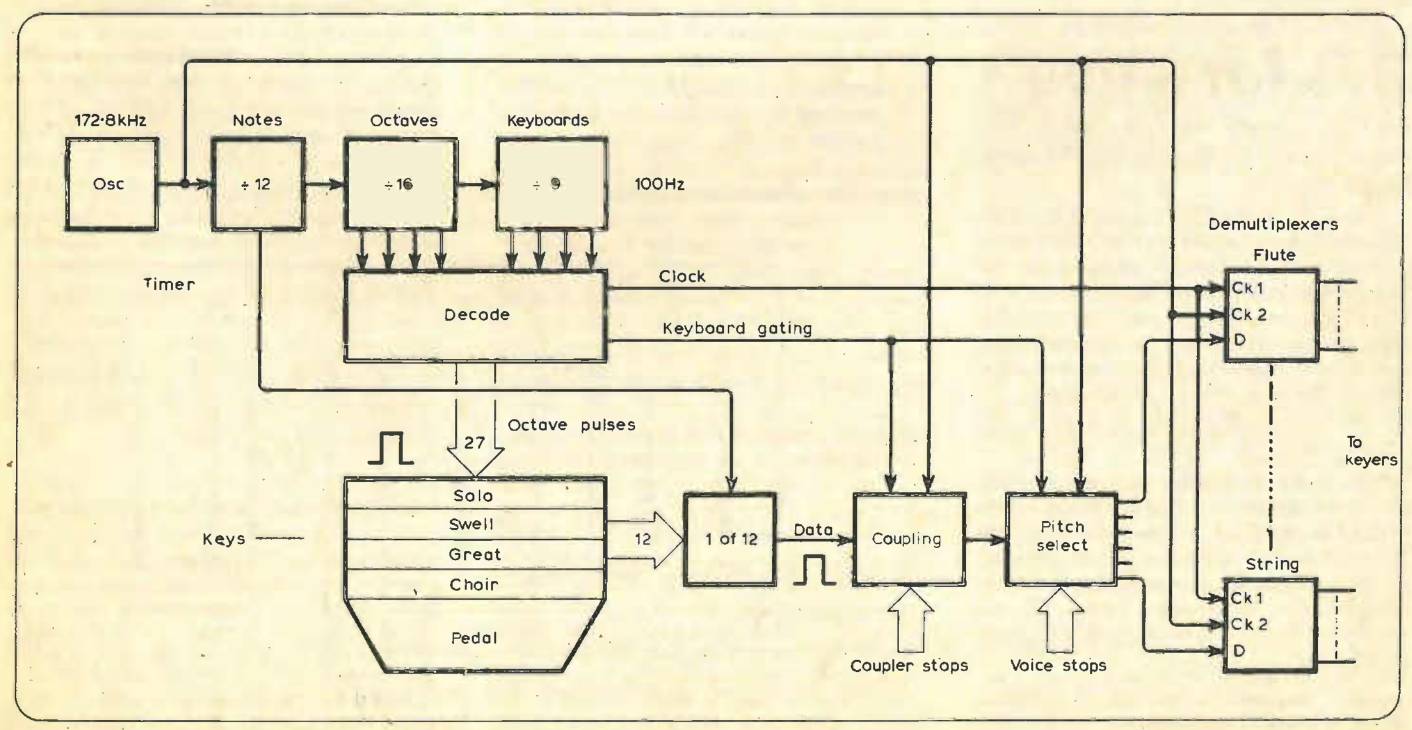


Fig 1. Sequential scanning of keyboard matrix in electronic or pipe organs reduces wiring by sending data over single wire.

appropriate musical notes in various pitches and tones. These may be made by pipes, oscillators, or any other means; this article does not discuss this part of the organ. The delays consist of shift registers and perform the tasks of pitch selection and coupling.

It is convenient to arrange the keyboard matrix in the form of manuals and octaves in one direction and notes in the other, although for a matrix with the minimum number of wires an 8 x 8 format would be optimum, and would lend itself to microprocessor control more readily. Each octave comprises the 12 notes C, C#,D, . . . A#,B. All identical notes are wired together resulting in twelve wires on one side of the matrix. On the other side of the key contacts each manual has all 12 notes in each octave wired together and every key has a series diode to prevent back-circuits (Fig. 2) resulting in six wires per manual plus three for the pedals (32 notes max.). For a four-manual organ, then only 39 wires are necessary. The whole organ is scanned sequentially note-by-note and octave-by-octave from the lowest pedal to the highest manual key such that the serial data output represents a series of rising pitches. Pulses occur only when the keys are pressed. The repetition rate of this scan has to be fast in order to permit fast playing such as trills and glissandos. A one-hundredth of a second is reasonable for this resulting in a pulse repetition rate of less than two hundred kilohertz for a four-manual organ.

Octave and manual coupling

As the serial keyboard data is in the form of one pulse per note it is clear that 12 pulses separate keys an octave apart in pitch. Therefore to couple an octave is simply a matter of delaying the data by 12 pulses and adding it to the data stream when whichever keys were played will also sound their octaves.

Sub-octave coupling is almost as simple. The data itself are delayed by 12 pulses and the undelayed data added instead. The output is of course delayed by 12 pulses but this is easily taken care of in the demultiplexers by delaying the decoding signals to match.

Fig. 3 shows the system for swell octave and sub-octave couplings together with a unison-off coupler which merely removes the normal pitch. Also shown is a choir octave coupler. This is possible with the same circuit by time-sharing as the data for this manual comes at a different time than that for the swell. Gating of the data has to be done in any case as we do not want to octave-couple all manuals at once. The gating pulse lasts only as long as that particular manual is being scanned and may be applied at the input, output or via the stops as shown. As the data are delayed by up to 24 pulses the scanning time per manual has to be increased by two octaves to prevent this data from intruding into the data for the next manual.

Coupling between manuals is simply a matter of lengthening the delays involved so that the delayed data turns up in the right place in the scan of the next manual.

The problem

One of the biggest problems in the manufacture of an organ, electronic or pipe but particularly electronic, is in the wiring of the key contacts and coupler stops. These affect which notes are played when keys are pressed on the manuals (keyboards). The traditional approach in the pipe organ is to wire one contact per key to the magnet (solenoid air-valve) which allows one pipe to speak from one rank of pipes. It is customary to be able to couple keyboards together in a variety of ways, so that for instance when the great-manual keys are played they perform the functions of the swell-manual keys as well, but not vice versa. The swell keys do not have to go down although in olden days they used to with mechanical actions.

Each coupling requires an extra contact on every key as well as a series switch to effect control. This last is operated by a solenoid action as 61 poles are required, one for each key per manual. Several hundreds of milliamps are required to operate the solenoid and almost as much to operate each pipe magnet.

On larger organs similar couplings can be selected so that the coupled manual can be played at a different pitch; usually an octave higher and/or lower. This coupling can be on the same manual too. If the swell manual is coupled to the great manual so that the swell plays an octave higher, then the coupler stop is called swell-to-great octave or swell-to-great 4 ft. The majority of organs can also couple the manuals to the footpedals, which are simply a large set of keys, but none of the couplings are normally performed in the reverse direction.

Each key can therefore have many contacts. There is not room for more than perhaps eight without resorting to multi-pole relays. Consequently the number of wires involved with a large organ is colossal. Not only is it tedious to wire up, but it is also bulky and expensive as well as being inflexible in its requirements. There is a multiplicity of things that can go wrong; especially where contacts are involved at high currents.

Electronic organs usually require even more contacts per key but for different reasons. It is common to switch actual signals with the key contacts which are then arranged in isolated pairs. Each key requires, say, five pairs to control five harmonically-related frequencies such as the sub-harmonic, the fundamental, second, third and fourth harmonics. This means that inter-manual coupling must also have five pairs of contacts per key. This is just not practical. Most electronic organs that do have couplers couple either in another way altogether or else couple only the fundamental pitches. The classical organist generally does not like electronic organs and this lack of adequate coupling may be one reason why.

The system described in the article is capable of controlling any kind of organ in which the various pitches are turned on and off by remote means. This can be solenoid-operated pipes or electronic oscillators with transistor switches, etc., in any combination. It does not show how the switching is performed.

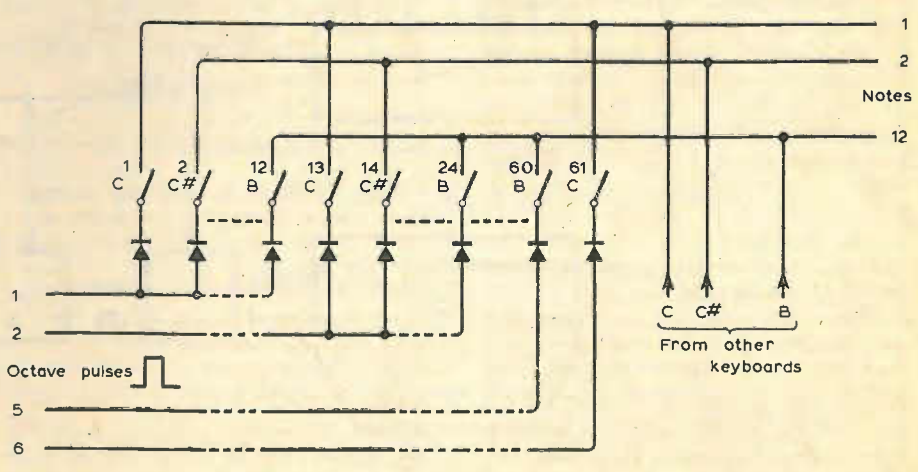


Fig. 2. Identical notes are wired together on one side of matrix, with all 12 notes in each octave wired together via diodes on the other side.

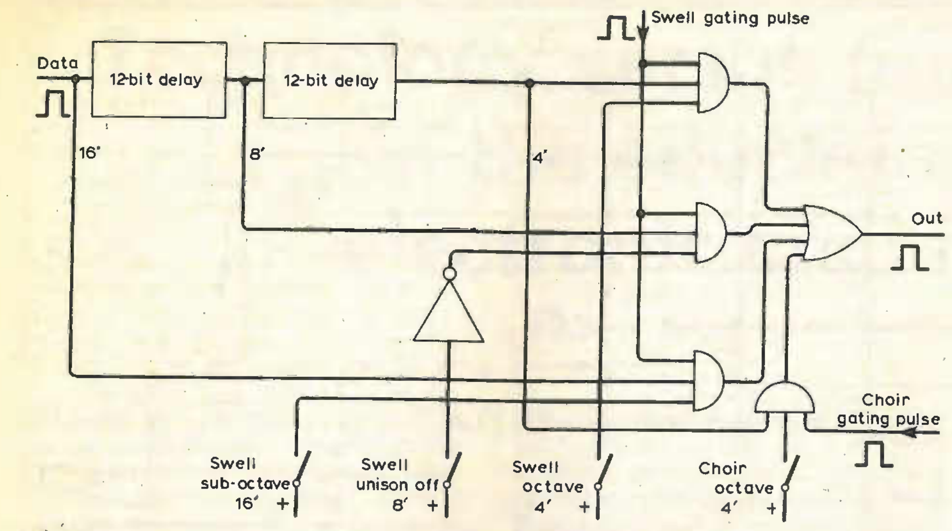


Fig. 3. As scanning is sequential note-by-note and octave-by-octave, 12 pulses separate keys an octave apart, and octave coupling is achieved using 12 pulse data delays.

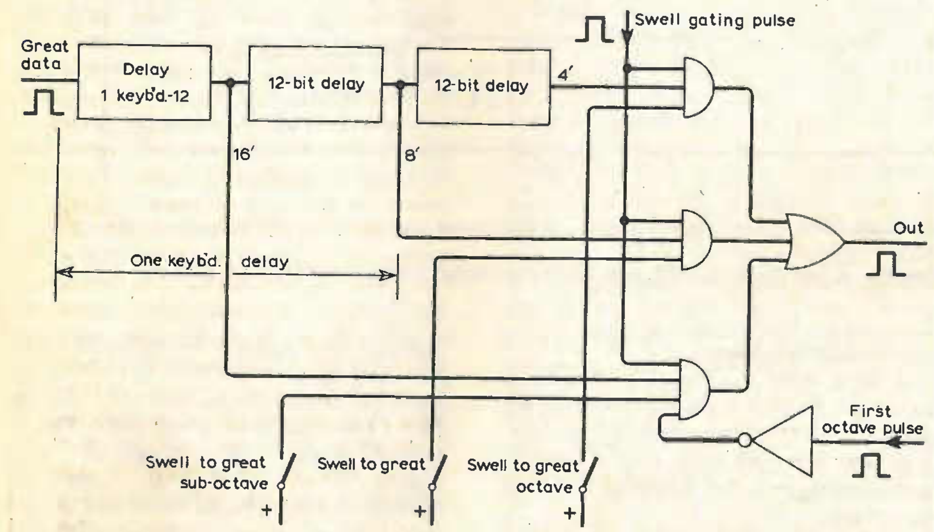


Fig. 4. Coupling between manuals is achieved by lengthening delays so that delayed data occurs at the right place in the scan.

This may also be done plus or minus an octave. Fig. 4 shows the system.

Any method of coupling octaves will involve the use of notes beyond the normal range of the keyboards. These are not normally coupled in a pipe organ because the pipes for them are not there. This results in the player running out of notes and can be a nuisance. On unit or extension organs the pipes are there for that reason among others, but it is not a bad idea to omit the lowest octave of an inter-manual sub-octave coupler in any case to avoid muddy sounds. In fact, some ranks of pipes stop at Tenor C anyway. The omission of the lowest octave in the system described is easily done by including the first octave gating pulse from the timing system – as shown.

There is a convention regarding which manuals may be coupled together on a large organ. The swell manual may be played from the choir or the great but not the other way around. Similarly, the choir may be played from the great. The solo manual (the top one) cannot couple to the other manuals whilst the pedals may only be coupled to manuals. Taking this into account, the arrangement of the delay systems for inter-manual coupling may be optimized by scanning the matrix in a staggered manner. For a two-manual organ this would be pedal, great and swell whilst a four-manual organ might be pedal, great, choir, swell and solo.

Addition of extra manual delay periods for coupling means that extra manual periods are required in the scanning process to avoid intrusion of pulses into the next pedal scan period. A two-manual organ therefore requires five such periods in the scan.

Fig. 5 shows the complete coupling system for a two-manual church organ.

Multiple pitches

Even the simplest organ should have the ability to play notes at different pitches when a single key is pressed; electronic organs do this by keying up to five pitches per key into separate busbars where they are filtered to form five pitches of tones. Pipe organs solve the problem by having separate ranks of pipes for each type of sound so that, for instance, an 8ft flute would have 61 pipes (one per key) and a 4ft flute would have another 61 and sound an octave higher. This is the brute force approach and a typical small church organ with, say, eight swell ranks, four great ranks and two pedal ranks would have 796 pipes. Clearly, a large pipe organ is going to have a colossal number of pipes and be cumbersome and difficult to keep in tune as well as having a lot of wire from the keys.

In 1891 Robert Hope-Jones devised the unit organ in which only a small number of ranks could be played at any pitch from any manual. Ranks were not duplicated in tone and six or eight could provide the tone range for the whole organ, provided that the ranks were extended and the voicing was altered to boost up the middle volume to compensate for the extra non-unison pitches. There was one drawback: it was no longer possible to have independent control of the volume levels of the different manuals. Hope-Jones also devised the electric action with which to control the unit system which is nowadays known as the extension system. Later manufacturers, notably the Wurlitzer company, improved on his ideas to make the giant cinema organs of yesteryear. Even some of the biggest of these had no more pipes in them than a small church organ but what sounds they could make. Of course, they had special effects such as xylophones, principally for the accompaniment of silent films and, incidentally, are marvellous examples of ergonomics in the layout of their console facilities; something from which church organs could benefit.

The extension principle requires each rank to be extended so as to provide extra upper and lower octaves; 97 pipes would be required to cover the range from 16 to 2ft. Nevertheless, fewer pipes are required than for a conventional organ. The availability of these extra pitches enables octave coupling to be properly carried out.

In electronic organs the extension principle is carried to the extreme in that a single rank of frequency generators is switched into a few busbars and the different voices obtained by filtering. The problem of lack of volume independence between manuals is overcome by controlling the volume of the entire organ by one control pedal. It is, however, possible to separate some voices for control by a second pedal after the manner of a cinema organ. By this means the resultant voicing may be varied without releasing any keys by cross-fading the two pedals, not an easy task with one foot!

Couplers were not often found on cinema organs because of the great variety of sounds that could be obtained without them due to the extended ranks. They are not often found on electronic organs either, not because they are not necessary but because they are difficult to incorporate. Now that the circuitry within electronic organs is becoming cheaper and simpler the extension principle is being rediscovered. A single rank of generators is still used but separate keying for different voices (ranks) is beginning to be

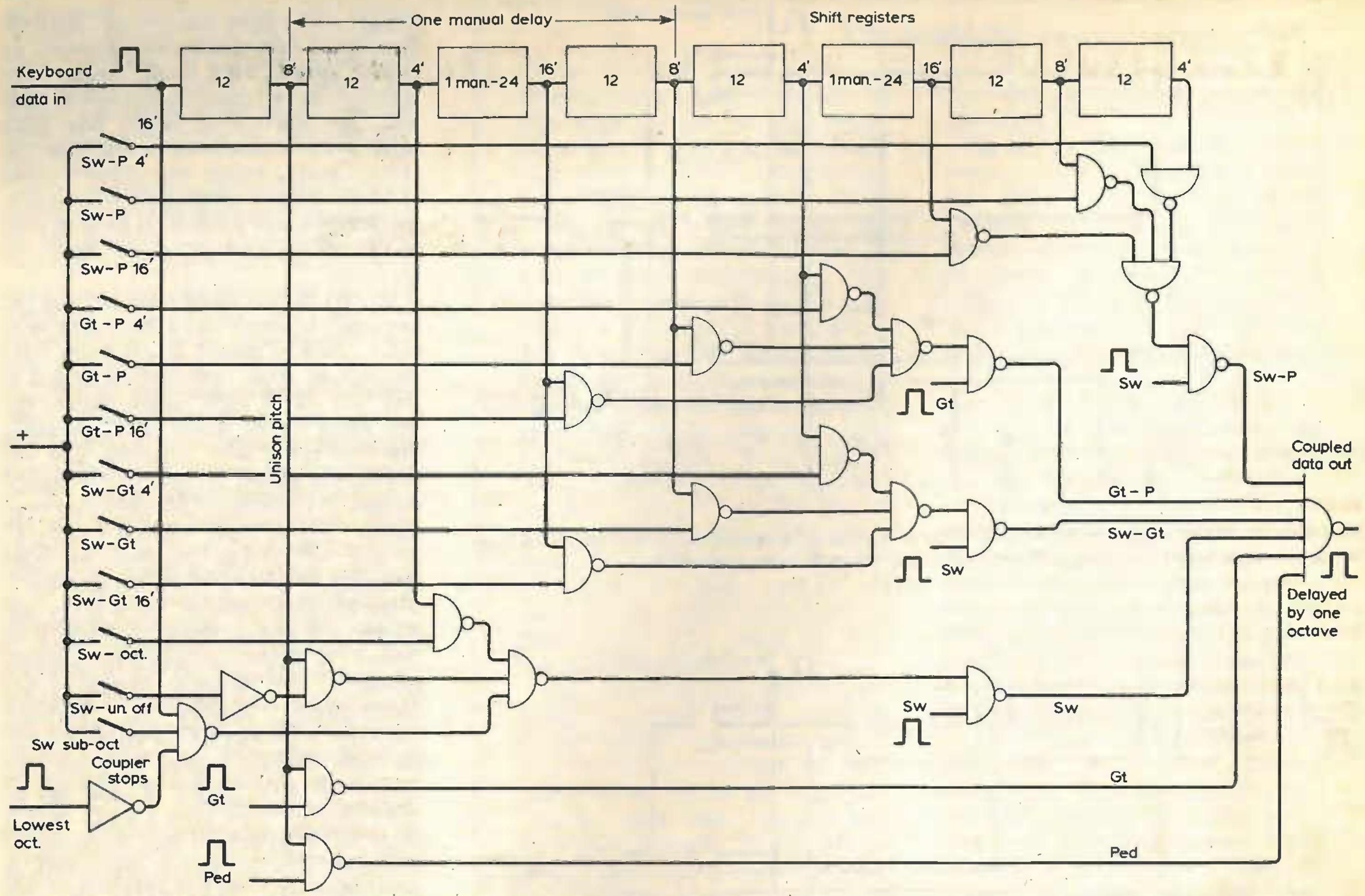


Fig. 5. Extra manual delays are required during scanning to avoid intrusion of pulses into next pedal scan period. Diagram shows coupling system for two-manual church organ.

employed. This enables more realistic sounds to be obtained as the voices can be balanced in level at different pitches by using several filters instead of just one. Also tricks like 'chiff' can be incorporated into a flute rank without affecting other ranks.

Extra ranks of generators are becoming popular, too; for instance, the celeste voice is tuned slightly sharp to give a wavering effect (not to be confused with tremolo or vibrato) and the unda maris is a flute tuned slightly flat. The same principle also provides the chorus effect by using two parallel generators with a slight frequency difference between them. The second generator is usually at a lower level.

The keying system described provides the ability to obtain keying for all pitches required in the extension principle – or the conventional manner.

A long delay in the data stream is equivalent to inter-manual coupling and a delay of 12 pulses gives octave coupling. The same principle holds good for multi-pitch keying by using delays of less than one octave.

The selection of a shift register output only a few sections away from the normal 8ft output is equivalent to changing the pitch of the entire organ. For example, if the delay is made seven sections then an 8ft note C would result in a 5⅓ft note G which is musically higher by a fifth in the diatonic scale. Logically then, one can tap the shift register at every necessary pitch increment and through simple gating by the stops can control the appropriate frequencies from the generators (or pipes). For a large organ many pitches are required from 32ft for the pedals to 1ft or less, with various odd ones in between to cater for mutations or mixtures. Fig. 6 shows how this is achieved whilst Fig. 7 (part 2) shows a control system in which similarly-voiced stops are collected together. Each keyboard has its own gating pulses so that only one such shift register is necessary for the entire organ. Again, the length of the delay involved necessitates extra time in the scanning process.

At this point the traditional and extension organ principles diverge. The traditional one would use all the outputs to drive independent demultiplexers (one for each rank) whereas the extension type would further collect together all outputs of identical voicing to drive one demultiplexer per voice only. In Fig. 7 this results in three demultiplexers instead of six.

To be continued

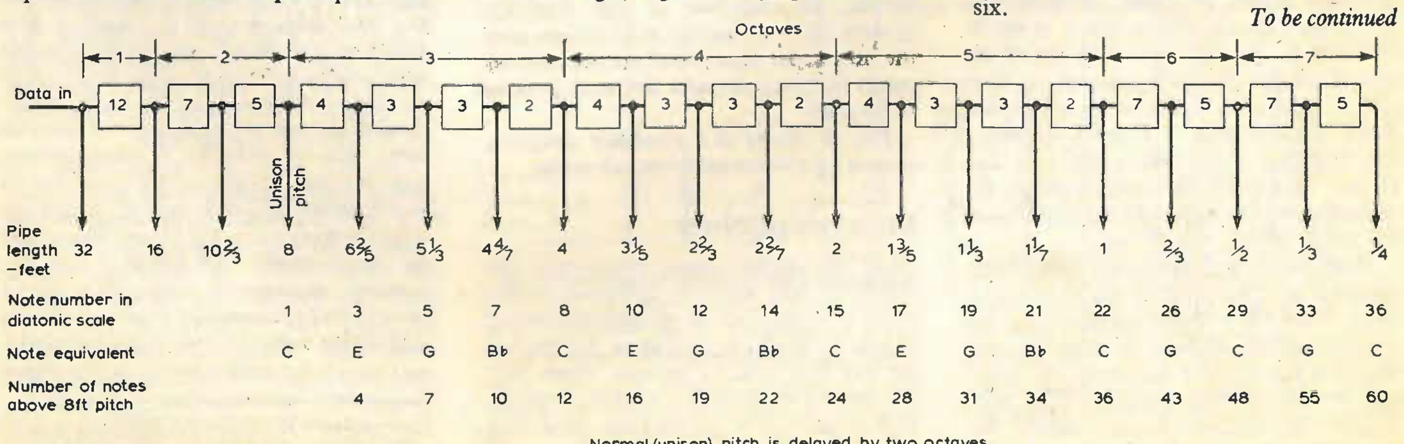


Fig. 6. Shift register can be tapped at necessary increments and simple gating controls appropriate frequencies from generators or pipes. (See part 2, Fig. 7, for simplified control system.)

Technology versus fundamentals in the education of electronic engineers

by **D. A. Bell**, F.Inst.P., F.I.E.E.

It has long been customary to speak of the education-and-training of engineers. The two aspects are combined in the French word *formation* and there is now a move to anglicize this French word to desribe the process of turning a school boy/girl into an engineer. But in Britain there is an argument whether academic institutions (universities and polytechnics) should be responsible for training as well as education, since the 2-year graduate apprenticeship has been in decline since the outbreak of the second world war. There was a Greek legend that instead of being born in the usual way the goddess Athene sprang from the head of Zeus fully grown and fully armed. To expect an engineer to arise fully developed from the ceremony of conferring his degree may be just as irrational as the Greek legend: a degree course cannot include all the "know-how" of every firm by whom a graduate might be employed, and the employer must be prepared to provide some technical training, either formally or informally. But the employer can rightly expect the graduate to know basic matters and the problem in designing a degree course is to decide what is basic both in fundamentals and in current technology.

Which kind of engineer?

It has always been a major problem to cater adequately for those students whose university performance, whatever their A-level grades, suggests that they are not capable of the standard which universities describe as 'honours' and the professional institutions are now describing as that of 'innovative engineers'. It may be noted that the latter distinction arises because the institutions are now according professional status to technician engineers. At one time the distinction was between (innovative) professional engineers and (follow-the-beaten-path) technicians; but technicians now make such an important contribution to the progress and conduct of all branches of engineering that it seems only right that the more senior of them should be accorded professional status.

There is also a suggestion that innovative engineers should be produced only through 'enhanced' engineering courses. Apart from the certain objections of the majority of universities which will not have 'enhanced' courses* and which would therefore be condemned to producing only technician engineers, this raises the question of whether students can be classified as 'innovative' or 'technician' types before entry to a university course. If university departments ran their own entrance examinations, with interviews, they could probably pick the few 'high fliers' (although psychologists maintain that interviews conducted by amateurs are useless); but when on average the number of applicants is at least ten times the number of places (×5 for UCCA choice and ×2 for examination failures) individual examination is impracticable. Such statistical evidence as there is suggests that the correlation between A-level grade and degree class is positive but very weak; and since the applicants are already a selected group of about 20% of the age group, with complex selection criteria, further selection within this group is difficult. (Apart from intellectual ability, the selection of the 20% depends, amongst other things, on peer attitudes, parental attitudes, parental income, and the consequent ambitions of the individual.) Therefore a number of universities have adopted the policy that no students are admitted direct to the 'pass course' (the future technician engineers) but admissions are to the honours course with relegation to pass for those who prove unable to sustain the standard of the honours course. The discussion in this paper will be based on the assumption of this policy.

Educating the innovative engineer

Even within the 'innovative engineer' group there will be a considerable range of aptitudes, interests and consequent careers. But although the British system provides more individual care of students than do most others, it is not practicable to have as many distinct courses as there are students. Some compromise in course content is inevitable. (This is ruling out the unit course or 'cafeteria' system.)

A major problem is that of keeping the technological content of a university course reasonably up-to-date. From a fundamentalist view point this is not very important: the education which a student receives will have to set him up for a working lifetime of some forty years. Academics cannot foretell all the technological developments of the next forty years, so to a large extent they must teach fundamentals and leave it to graduates to continue their education, by reading and perhaps 'refresher' courses, and to re-interpret fundamentals in terms of the later developments in technology. An example of re-interpretation is that the development of waveguides, with longitudinal components of field, required the replacement of the over-simplified idea that "electromagnetic waves have fields transverse to the direction of propagation" by the more precise statement that "electromagnetic waves *in free space* are transverse, but in the neighbourhood of conductors the disposition of fields is governed by boundary conditions". Naturally courses should be kept reasonably up-to-date in technology. But apart from the general effort involved – e.g., the transition from thermionics to the solid state – one may have used a particular piece of technology to illustrate a particular principle and new technology will mean a search for a new illustration.

The technology is important to the technician engineer, but does it matter to the innovative engineer? The writer once complained to a former industrial colleague that an otherwise good book on communication did not contain any descriptions of hardware. He replied "Does it matter? We find we can design systems without reference to the hardware". Yet one must know the limits of the hardware: one could not design a satellite communication link without knowing what noise figures were attainable in the receivers and what radiated power to expect from the satellite. The low-noise capabilities of parametric amplifiers can either be introduced as part of a fundamental study, using the Manley-Rowe relationship, or merely stated as a fact.

When presenting Nyquist's formula for Johnson noise and noise figures, should one emphasise equipartition or the noise figures of current devices? A typical problem is how far one should teach solid-state physics. Most current devices can be explained in terms of band theory and Fermi level; but the Gunn diode requires an appreciation of effective mass, and who knows what the future will bring? On the other hand, does a graduate need to know all the detailed technology of m.o.s., c.m.o.s., n.m.o.s., v.m.o.s. as well as of s.o.s.* which introduces an important new angle? He ought at least to appreciate that devices of the m.o.s. family are in general

* Hull has an enhanced course.

* s.o.s. stands for "silicon on sapphire"; and the sapphire substrate is chosen for its thermal conductivity, not for any electrical property.

slower than bipolar devices and that the access time of r.a.ms is now to be measured in nanosecods: the idea of 1μs as a short time is as out of date as the 60 m.p.h. express train!

Mathematics

Mathematics often forms a practical barrier between the two types of courses. It is an interesting question whether British mathematics teaching is bad or mathematics forms an intellectual sieve of great discriminating power; but it is a fact that the mathematical content of honours degree courses in electrical/electronic engineering courses has tended to increase. Forty to fifty years ago the use of Heaviside's operational calculus was avant garde; today, the student is expected to use Laplace transforms at a fairly early stage. The digital computer is of course ubiquitous, sometimes in microprocessor form, and the trend towards digital handling of all data has made the z transform and the Fast Fourier transform essential tools. Autocorrelation (and cross correlation) are now familiar operations, and for some specializations one needs an acquaintance with Hadamard/Walsh functions and transform, a corner of group and field theory and now Fermations and Carmichael numbers (pseudo-primes). The engineer may need a nodding acquaintance with a far wider range of mathematics than is covered by any one academic mathematician. From the mathematician's point of view this 'nodding acquaintance' is nearer to technology than to a fundamental study; but from the engineer's point of view it is only the honours student *(or* graduate) who can be expected to take on so many new ideas. After all, mathematics is supposed to be the epitome of fundamental study, of universal application.

The 'tool kit'

But as far as engineering technology is concerned, the graduate should include in the 'tool kit' which he takes to his first job some up-to-date knowledge. (Without it, he would take a long time to earn the respect of the technicians on whom he will depend.) Most engineering honours courses now include a project, the successful completion of which requires a student to design and either construct or have constructed a specific piece of hardware. This requires some expertise in the handling of currently available devices and so contributes to the practical side of the 'tool kit'.

Educating the technician engineer

So much for the education of the honours graduate or innovative engineer, but what about the pass graduate or technician engineer? Clearly the one policy which is unsatisfactory is to allow the pass student to flounder in honours studies and award him a pass degree for a very poor performance in the honours examinations. The general principle is to take him out of the more mathematical and abstract courses and substitute partially with more practical courses based on current technology. ('Partially' because the pass degree student generally cannot assimilate information as fast as the honours student can.) The lecturer who gives an honours course may be able to provide a 'mugs' guide' to the same subject: for example, one can give the bare fact that the radiation resistance of an aerial is proportional to $(h/\lambda)^2$ whereas for an honours course one would derive this from electromagnetic theory. One would need to supplement this with more descriptive material about current types of aerial.

Non engineering studies

The problem of fundamentals versus technology arises equally in the field of business studies and management which we are nowadays urged to include in the undergraduate curriculum. (There are really two branches, the one being finance and the other being largely personnel management.) There is no doubt that lack of either type of expertise can be disastrous: Rolls Royce is the best known example of lack of financial expertise, and it is probable that a significant number of strikes could be eliminated by wiser management. But in the larger firms these functions should be controlled by specialists; and if one takes the traditional I.E.E. view that the professional engineer starts on 90% technology and 10% administration, but in course of time reverses the proportions, then any graduate of honours or innovative' pretensions should be able to acquire the appropriate skills when they are needed. It may be desirable to give undergraduates some exposure to these subjects by way of 'opening windows', but it is not necessary to treat them in depth. An exceptional case could be made out for the entrepreneur who founds his own business on some technological innovation, but one should not distort the main curriculum for the benefit of this exception! He must either learn fast or find a partner to look after the non-technical side of the business. The summary is that business topics should be taught on a technological rather than fundamental basis. (The meaning of 'fundamental' in this context was illustrated once by the sarcastic remark of a Professor of Economics to a Professor of Accounting: "You should not be teaching undergraduates the rules of accounting: you should be teaching them how to break the rules".)

The question of written (and spoken) communication has been left until last. It has recently been unfashionable to study language, particularly one's own language, fundamentally. The lack of inflections in English makes it particularly important to use a reasonable word order in order to establish the relationships between different parts of a sentence. (Though in the interest of emphasis, the present writer is prone to inverting the natural order of phrases on occasion.) Perhaps this should be regarded as the technological aspect of language, the fundamental aspects being linguistics and literature.

To summarize, the ancillary subjects such as mathematics, language and business and management studies should certainly be taught as technology, but in professional topics there is a need to teach fundamentals, if only as an insurance against the effects of technological change during the following 40 years.

I believe that "engineering" is primarily an *attitude of mind* which may be hinted at by the phrase "enthusiasm for getting things done properly". This attitude of mind is not dependent on the academic and technical content of a course, enhanced or not, but it can be influenced by the way in which material is presented.

Since this was written, an article on "Training of Engineers in Japan" by H.A.J. Prentice has appeared in *Electronic and Power* (the Journal of the I.E.E.), April 1980, vol. 26, pp. 327-329. The attitude of Japanese industry appears to be an extreme case of the policy on industrial training which has been suggested above.

This article is based on a paper presented at the conference on "Electronic Engineering in Degree Courses – Teaching for the 80's", Hull, 31st March to 3rd April 1980. Copies of the conference proceedings, covering all 43 papers, can be obtained from Mr K. A. Welsh, Department of Electronic Engineering, University of Hull, Hull HU6 7RX, price £12, plus post and packing (£1.25 in U.K.).

Professor Bell founded the Department of Electronic Engineering of the University of Hull in 1966 but retired in 1978. This article therefore presents his personal views, but in no way commits that Department. The importance of the subject has been enhanced by the publication of the report of the Finniston Committee on the Engineering Profession.

Professor David Bell, who joined the University of Hull in 1965 to set up its Department of Electronic Engineering, retired in September 1978. From 1949 to 1961 he was Reader in Electromagnetism in the electrical engineering department of Birmingham University, and thereafter till 1965 he was the director of AMF British Research Laboratory. He has contributed widely to the learned journals and has been writing for Wireless World throughout his career.

Multiphase low distortion oscillator

Sine wave generation with frequency independent amplitude control

by A. D. Ryder, M.A., Ph.D., F.I.E.E.

Linear oscillators, such as the well known Wien bridge, are easily constructed using op-amps, and have inherently low distortion provided the amplitude is kept within the linear range of the devices. The outputs are normally free from high-order harmonics, which can complicate the use of wave-shaping oscillators such as the 8038. This design is suitable for fixed or spot-frequency requirements, it will generate low-distortion signals of m phases where m = 3,5,7, etc. (m = 2n + 1) and, by adding inverters to the outputs, signals of 2m phases, i.e. 6,10,14, etc. The frequency range extends from zero to the limit of the op-amp characteristics.

The original application required a modulation source for multiple path f.m. of tone signals from an electronic organ, a technique used to enrich the sound by emulating a chorus of independent pipes. This requires frequencies down to 0.3Hz or below, ideally with some choice of frequency and modulation depth, i.e. oscillator amplitude. At such low frequencies a conventional thermal amplitude-control would need an intolerably long thermal time-constant to operate linearly. Unfortunately, the control-loop should introduce as little delay as possible because even a few extra oscillator cycles of settling time are inconvenient. This circuit is not frequency-dependent and, because it is repeatable, is preferable to thermal control even at high frequencies. The circuit in Fig. 1 comprises m stages, all identical except for the input connection of the first.

Each output phase P1 to Pm has the same op-amp source resistance and voltage capability, and the phase balance depends primarily on the matching of R, Rx, and C. The simplest way to change frequency is by switching capacitors C. The vector diagram for the second stage, see Fig. 2, is typical. Feedback current p is the vector sum of $r=P2/R$ and $c=P2/X$, where X is the reactance of C, and the inverting connection maintains current p equal to the input current q, where $q=P1/Rx$. The stage gain is unity when

$$\sqrt{\frac{1}{R^2}+\frac{1}{X^2}}=\frac{1}{R_x} \text{ or } X=\frac{X}{\sqrt{R^2+X^2}}$$

The stage produces a phase-shift of 180°$-\phi$ where $\tan\phi$ is equal to R/X (1), and the condition for unity gain is $x=\cos\phi$ (2). From expression (1), $\tan\phi=2\pi fRC$ or $f=\tan\phi/2\pi RC$ (3). In a three-phase oscillator, each stage is required to produce unity gain at 120° phase-shift, ϕ=60°, therefore $x=\cos 60°=½$. From (3), the corresponding frequency is $\sqrt{3}/2\pi RC$ or $0.276/RC$.

Because ϕ lies between 0 and 90°, the attainable shift per stage lies between 90° and 180°. To use five or more stages, the total loop phase-shift must be a multiple of 360°. The spoke diagram in Fig. 3 shows how this works for a 5-phase oscillator, m=5 n=2, where the phases are separated by 72° (360° /5) but each stage generates 144°. In this case $x=\cos 36°=0.809$ and $f=0.116/RC$. As m = 2n + 1, two steps of n phases will always produce an (m – 1) shift around the diagram, and m such steps will visit all spokes. For m greater than 5 there may be more than one possible shift per stage, geometrically, within the 90 to 180° limits. For example, when m = 7, phase separation 51.4°, it is possible to visit either 102.8° in steps of two, or 154.2° in steps of three. However, it is necessary to design for the highest usable phase-shift, i.e. the mode for which the loop gain is highest, 360n/m° per stage. The angle ϕ is then equal to half the phase separation. In general, the capacitive feedback discriminates against harmonics and, so far as d.c. is concerned, the loop feedback is negative because m is odd, which tends to stabilize the working point.

The oscillator loop is given 50% excess gain by making R_3 two-thirds of the basic value, which is offset by antiphase feedback via A_2 and R_4. Amplifier A_2 is a multiplier, or a variable-mu device such as the 3080, and its gain is controlled by the oscillation amplitude which is detected by a full-wave rectifier of two diodes per phase and differential amplifier A_1. In the steady state, the balancing output of A_2 has $\frac{1}{3}$ of Pm amplitude and just offsets the excess gain. The level at which the

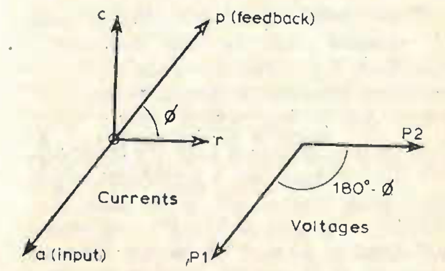


Fig. 2. Vector diagram for second oscillator stage.

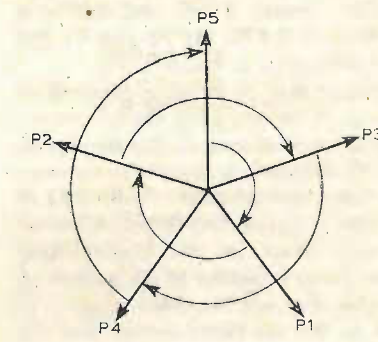


Fig. 3. Spoke diagram for a 5-phase oscillator, m=5, n=2. Phase separation is 72° and the sequence is P5-P3-P1-P4-P2.

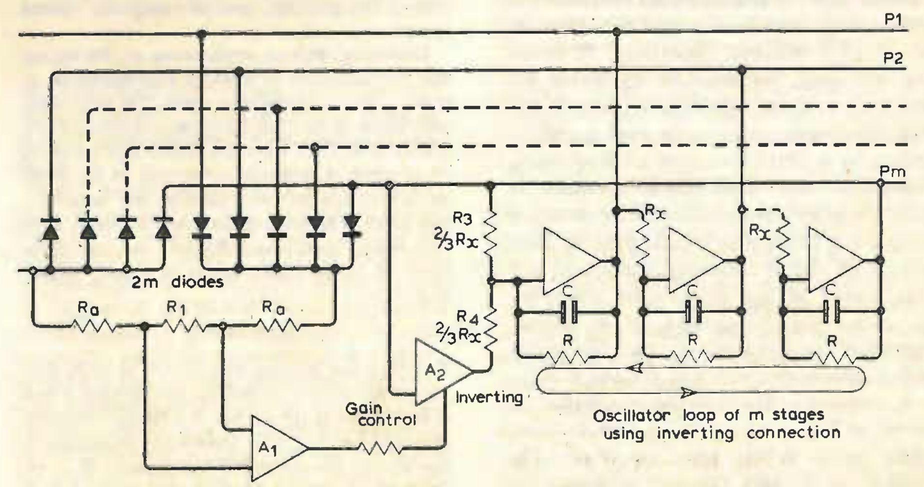


Fig. 1. Oscillator of m phases.

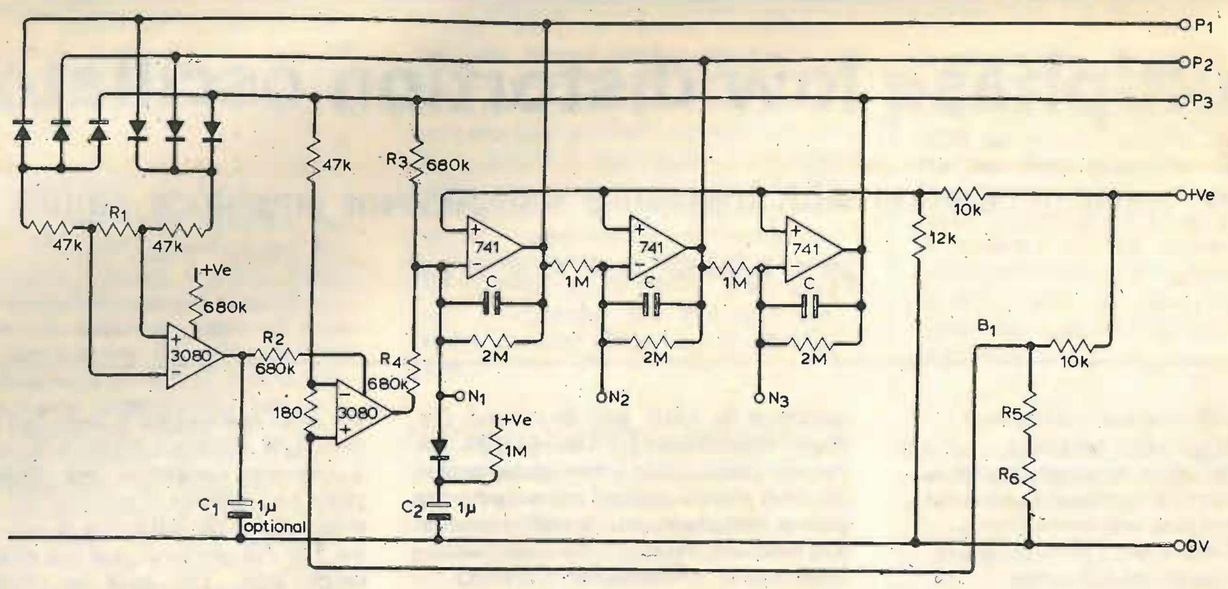


Fig. 4. Three-phase oscillator. f=0.3Hz with C=0.47µF.

oscillator stabilizes is set by R_1. Because the control loop is not frequency-dependent, it does not introduce a delay or overshoot. However, it does introduce harmonics due to the rectifier ripple. With three phases, assuming they are balanced, only the 6th harmonic is significant which has a peak level of 6% of the mean d.c. Therefore, the gain of A_2 is 6% amplitude-modulated at $6f$ and its output contains sidebands at $5f$ and $7f$, each of 3%. The current into stage P1 contains 1.5% of each harmonic because the total fundamental current is twice that contributed by A_2. At P1, however, the harmonics are reduced by feedback, 4.4× for $5f$ and 6.1× for $7f$, which then become 0.34% and 0.25%, a r.m.s. total of 0.42%. At P2 and P3 the rectifier distortion is below 0.1%.

Smoothing may be added if required at A_1 output. A reduction in the $6f$ component by a factor of five, so that the distortion at all outputs is below 0.1%, requires a smoothing time-constant of only 0.13 of the oscillation period and therefore has no significant effect on the control-loop response. Some switching of the smoothing is desirable if a wide frequency-range is to be used, so that the time-constant does not exceed about two periods.

With more phases, the distortion at P1 falls rapidly because the rectifier ripple is reduced and the fundamental frequency is higher, e.g., for m = 5 the distortion is below 0.1% without smoothing. If inverters are used, for example to derive six phases from three, additional diodes to the inverter outputs can also be used to reduce ripple. In a delay-line type of frequency-modulator the modulation process is differentiating[1] and, unless compensating integrating circuits are included, the harmonics of the modulating waveform are exaggerated in the modulation envelope. To avoid the integrators, it is advantageous to use a reasonably pure waveform with a distortion content of around 0.1%.

A practical three-phase oscillator is shown in Fig. 4 where $x = \frac{1}{2}$ and $R = 2m$, which gives 0.3Hz for C=0.47µF. The number of phases can be increased by adding 741 stages and diodes, and adjusting the resistor ratio in accordance with (2) above. If an adjustment is made to the feedback resistors, R_3 and the resistors in the 3080 circuits need not be altered. The 3080 has a current rather than voltage output, and R_4 is included for monitoring purposes only. Resistor R_2 defines the source resistance for the optional smoothing capacitor C_1 because the input resistance at pin 5 is low, and the time-constant R_2C_1 is about 0.2 of the period at 0.3Hz.

With a 12V regulated supply and germanium (OA47) diodes in the rectifier, the maximum usable amplitude per phase is about 3V r.m.s. with R_1 at 390Ω, and less than 0.3V with R_1 at 5kΩ. Resistors R_5 and R_6 allow the bias B1 to be adjusted for optimum balance, i.e. minimum fundamental at C_1. At switch-on, C_2 provides a negative pulse to N1, which considerably shortens the build-up time. This capacitor and the isolating diode can be omitted for high-frequency use. With 2% components for R and C, the frequencies of oscillators having 5, 7, and 11 phases were within 0.5% of those calculated from the mean of the measured component values. For large numbers of phases, diode V_f variations become more significant and eventually set the lower limit to the level of ripple which can be achieved at the rectifier output.

Reference

1. Ryder, A. D., Electronic organ tone system, *Wireless World*, March 1979, p54.

BOOKS

The most apt and concise description of this book is probably that given by the authors in the first sentence of the preface where they write, "This book is about communication – communication between man and machines, and between machines themselves". **Codes for Computers and Microprocessors** by P. E. Gosling and Q. L. M. Laarhoven is written as an aid to both students and designers alike and biased toward the practical side of computer related codes.

Beginning with an explanation of the theory and practical uses of number representation in binary, octal and decimal codes, the text gradually leads up to a full listing and comparison of ASCII, EBCDIC, card and punch tape codes. A set of tables is included at the end of the book for conversion between decimal and hexadecimal codes. The price of the book in floppy back form is £2.95, and the publishers are Macmillan Press, 4 Little Essex Street, London WC2R 3LF.

Far too many authors who set out to write simply on electronics evidently imagine that a lack of knowledge of the subject in a reader automatically qualifies him as a retarded, innumerate illiterate, to be addressed accordingly. It is refreshing, therefore, to find that Peter Laurie harbours no such delusion. His book **Electronics Explained** (£6.50, Faber and Faber) is not only rather more successful at making a fairly complicated subject simple than the average sample of its kind, of which there are many, but it manages to convey the information without battering the reader with his own inadequacy. Mr Laurie makes no bones of the fact that he was, not long ago, in the same position as the reader and is still finding out himself. He can also write.

The book is in three, fairly arbitrary sections – audio, radio and digital electronics – the first covering many of the basic devices and circuits used throughout electronics. The level of discussion is, of necessity, elementary, but is nonetheless of high quality. Logic is treated unusually thoroughly for a book of this type and includes a useful section on Boolean algebra to demonstrate its use in the reduction of logic functions to hardware. (Printers find this notoriously difficult to set because of the negating bars, and the only two errors discovered in a quick canter through the book were in this section, apart from a fairly sweeping statement on negative feedback on p.6). A final section provides some practical information on the realities of components and hardware in general, with advice on making circuits for experiment.

For anyone seeking a relatively simple 'way in' to electronics and the beginnings of computing, this is an excellent introduction.

LETTERS TO THE EDITOR

INEXPLICABLE EFFECTS IN AUDIO

Many readers will have met inexplicable effects in electronic circuits and systems, but will have shrugged their shoulders and not pursued the matter: time is money and engineers are not paid to investigate supposed paranormal phenomena. Ivor Catt reminds us that many elaborate electronic systems end up in 'Bin 13', and another WW author reminded me in private correspondence that "It's hard to get a name in electronics for designing things that work – and harder still to keep it".

Of course, it's comforting to think that inoperative designs are simply a case of shoddy engineering or inadequate application of fundamental theory but, with apologies to Yorkshire folks, 'There's nowt so queer as transistors'. Concert sound systems are known to be particularly prone to bizarre effects, many of them distinctly reminiscent of classic poltergeist phenomena. This is hardly surprising, considering the very powerful emotions that music can generate. Although a common scapegoat is "r.f.", equipment suffering from or causing disturbing effects always exhibits a remarkable self-healing capacity on its journey to the test bench. It is also an unwritten law that when paranormal effects occur, electronics engineers and 'scopes will not be in the vicinity, or the engineer will be bad tempered and the 'scope will develop a fault!

Space does not allow me to elaborate on the events I have experienced and heard about, but rest assured that the symptoms have been widely circulated amongst experienced audio engineers before being passed onto the list of the 'inexplicable'. I should be very happy to hear from readers who have 'Gremlin tales' to relate, or interesting opinions on the subject. I feel that with sufficient data, a tentative 'wrapping up' of Murphy, Sod, hi-fi mysticism (including phase funnies) and other colourful aberrations of pragmatic (i.e. Newtonian) physics could be on its way.

Ben J. Duncan
Tattershall
Lincoln.

MICROCHIPS AND MEGADEATHS

I believe your November leader on atomic holocausts is entirely proper to the magazine, since the most non-political of your readers must be affected by having lived with the atomic threat for as long as 35 years. However, more important than the physical dangers is surely the threat to an end to the race of man.

The current level of arms might be useful if it were used to bargain for reduction of arms but instead we have atomic proliferation over most of the globe. I used to jibe in the middle sixties that we should all be blown up in 1984 following a slighting remark by Bernard Levin speaking on tv about Patagonia. Patagonia is not a state now but there is still a ring of truth about this remark.

We are constantly told Russia is the enemy and that we are inferior in arms and must frantically increase our arms. In fact President Kennedy used an entirely mythical "missile gap" to help his election in 1960 and this was exposed by I.F. Stone, who used the technique of collating government reports; he was recently joined by Lord Zuckerman in testimony to the West misleading itself; the Pentagon Papers also testified to falsification, this time by the armed forces in the US.

The late Bertrand Russell, the finest mind of this century, was quite confident that we would never reach 1980 with the current level of arms. This seems reasonable even in relation to false alarms triggering a final holocaust. I have heard Sir Robert Watson-Watt explain that radar gives false alarms, for example from a flight of geese. A tape of data relating to a mock atomic attack has been played into the system as real data. A dropped spanner in a Titan missile silo recently led to a 6-megaton warhead, 300 times as powerful as that used on Hiroshima, being thrown 200 yards. Perhaps the Russians who devastated 5000 square miles in the late 'fifties by piling up a critical mass of atomic waste are even more prone to accidents of this sort.

Defence programmes are in practice extremely inefficient in terms of expenditure, relative to other products, which adds to the drain on national budgets. One argument against current levels of armament is that they ruin the times of peace. Anyone who would prefer to spend nothing on arms but use the £150 p.a. per head to spend on a family holiday instead is entitled to his views.

Much as I hate the Russian system I am not convinced that it constitutes a credible threat to the West. Do they really do advanced research with those Russian oscilloscopes? Are the none-too-sophisticated articles you print from Russia just a blind? Why does the US prop the USSR up with money and food?

This country may at present be in the middle of a fall in its standard of living to about half, because industry faces financial burdens unknown anywhere else in the world in their total impact. These include defence expenditure, along with paying for 2 million unemployed. Looking back people may feel they have been bamboozled by the US into defence expenditure they did not need while the US took care to prop up Russia to frighten the Western world. I wonder.

Bernard Jones
London W1

I have just read your November editorial and it was refreshing to find an electronics magazine taking a stand against the military electronics industry.

Whilst totally agreeing with you, I think it important to point out that, because the defence industry is so well funded, there are many interesting job opportunities within it. As anyone who has talked to a recruitment agency knows, the 'big name' military electronics companies have an almost permanent requirement for more electronics engineers and are, up to a point, prepared to pay for them. Electronics engineers want interesting, well paid work on state-of-the-art technology in well equipped laboratories – work which many defence orientated companies can provide more readily than medical, consumer or industrial electronic organisations.

I think the important point is that whether or not one decides, as an engineer, to work in defence electronics, one should have sound reasons for either choice. The sad fact is that many bright electronics engineers are working in defence industries for no *better* reason than that the job is interesting and/or well paid.

After all, as professionals, we surely want to be socially responsible.

G. Dodgson
Department of Medical Physics and Chemical Engineering
University of Sheffield

I wish to object most strongly to the contentious leading article in the November 1980 issue of your journal. Does the anonymous writer of this piece of rubbish think engineers are stupid? The whole point of modern guidance technology is to improve missile placement accuracy to that missile silos may be destroyed. The existence of the cruise missile means that centres of population are *less* likely to be attacked. Again, is a bayonet in the kidneys a better way to die than being frizzled in an A-bomb blast?

Basically I object to a technical journal like *Wireless World* being used as a vehicle by nameless writers whose output is best fitted for the *Morning Star* or the dustbin.

Please, please do not inflict us with articles of this kind. There are other platforms for authors like yours. Let us have something worthy of the reputation that *Wireless World* has.

N. J. Chetwood
Tewkesbury
Glos.

How encouraging it is to see the technical press lifting its eyes from its bench to look at the world outside (November editorial). Does this reflect a move among engineers at large?

We should be among the leaders of dissent, you say. So we should, if only in atonement for what engineers East and West have done, placing in the hands of maniacs playing power games the means to annihilate the race or, at best, to inflict suffering on a scale past imagining.

Those among us who respond to the propaganda of ideological hatred and righteousness which is the score for a macabre dance with destiny and believe that making, directing and sustaining its hellish weaponry is a Good Thing have, at least, the excuse of conviction. Not so the I'm Only Doing My Job Club, whose considerable membership calls in question the contention that we are of an intelligent, honourable profession concerned with the advancement of mankind.

Mrs Thatcher has a vision of a British industrial revival resting on the shoulders of the "defence" budget. Presumably no-one has explained to the lady that the bankruptcy of the British consumer electronics industry is, in large measure, due to the diversion of finance and skills to militarism. Be that as it may, could one find a more sterile philosophy than the notion that a nation's economic well-being should go hand-in-hand with its production and sale of engines of death?

As I write, 800 million people are starving and the wealthy squander the world's resources on armaments. It is surely time that engineers

began to end their serfdom to military/industrial empires, insisting that, instead, their knowledge and skills be applied to the task of making this planet a more congenial place. If they do not, they have at least the consolation that, unlike the physicists of Los Alamos, they will have scant opportunity for regret after their last great work has reached functional expression.
John G. McKenzie
Monifieth
Dundee

Congratulations on your editorial in the November issue. It is gratifying to see that some people connected with electronic engineering are willing to make known their opinions on the matter of "defence". I only hope that your good example is contagious and that it spreads to others. Perhaps your editorial will help to make responsible people employed on "defence projects" reflect on the possible consequences of their endeavours.

It seems to me that governments are largely to blame for the excesses of the armaments industry in encouraging this trade. In fact the trade is referred to as one of Britain's successes in improving her balance of payments, GNP etc. Unfortunately the alternatives to the armaments industry do not appear to be so remunerative: witness medical electronics, medical research – it's a matter of demand presumably. Many other countries are guilty of the same crime. I feel that comments such as yours can only help here.

Incidentally, I am not a pacifist or keen on unilateral disarmament. I have been employed as an electronics technician since being trained by the Royal Air Force in the 1950s. Most of the work I have been connected with has been of a peaceful nature. I also usually vote Conservative, the concept of free enterprise being attractive.
B. Morton
Berkhamsted
Herts.

Please accept my warmest congratulations on a most courageous editorial in your November issue. I agree with every word; without the compliance and connivance of engineers the arms race would greatly diminish.

While reading about the candidates for re-election to the Council of the IERE in the latest journal I was interested to see how many worked for the military in one way or another and I wondered how much this is true of the whole Council and if the Institution is in the grip of the military-industrial complex. If this is so I see little hope of the Institution freeing itself from the self-perpetuating system you spoke of.
Wilfred Laycock
Abingdon
Oxfordshire.

Comment from the IERE

First, I would like to assure you that we are well aware of Mr Laycock's views on the merits of engineers who work in the military sphere of activity: we published one of his letters on this theme in the November 1979 issue of *The Radio and Electronic Engineer*. And second, concerning his thoughts on the occupations of the members of the IERE Council, I would suggest that he writes to me direct with some constructive comment when he has finished the 'wondering' he mentions in his second paragraph. No doubt by then he will be able to explain to me how he justifies his conclusion that the IERE is at present tied to "the self-perpetuating system you spoke of" in your editorial.
S. M. Davidson
Secretary, IERE
London WC1

The present 41-member Council of the IERE includes a retired air vice-marshal (the secretary), a brigadier, a colonel, a retired lieutenant-commander, a major-general, a Ministry of Defence director, a professor of the Royal Military College of Science and three senior engineers from companies well known in military electronics manufacturing. – Ed.

THE "TWINS" PARADOX OF RELATIVITY.

The late Professor Dingle's simple question to the scientists (October issue) has never been answered because Special Relativity Theory (S.R.T.) is defended by the astute deployment of the proverbial red herrings.

S.R.T. speaks only of relative uniform straight line motion but the defenders of that faith invoke acceleration and gravity to account for the slower ageing of one of the twins. Please note that I am careful to avoid commitment as to which twin suffers what and for which reason; I have learned *some* lessons from the relativists.

It surely must be obvious to all that *if* the relative variation in the rate of clocks is to be justified by acceleration or gravity then that justification is tantamount to the admission that the clocks in *pure* S.R.T. (as taught in undergraduate texts) do not in fact run, physically, at different rates; they only appear to do so. That which applies to clocks must also stand true for measuring rods and mass, or so S.R.T. avers.

We are thus left with the fact, unpalatable though it may be, that all of the alleged experimental confirmations of S.R.T.are a result of accidental coincidence and not predictions of the theory at all.

Since Prof. Dingle did not himself provide an alternative explanation I now ask to be allowed to clean up the mess, an activity that is not without precedent in science. Let us start with mass.

In a letter in the November 1979 issue responding to Prof. Jennison's June 1979 article "What is an Electron", I postulated that mechanical force was radiation pressure and provided a completely new derivation of the Newtonian kinetic energy equation. As far as I am aware that derivation has been neither challenged nor refuted. In his article Prof. Jennison also used the radiation pressure of light as a mechanical force and I have not seen *that* factor of his argument questioned. Any refutation of either of these ideas must first, obviously, deny the experimental facts of radiation pressure.

In my derivation I allowed the effect of a force, related to a datum, to diminish linearly with the velocity of the affected mass between the limits zero and infinity. This accounted for the Newtonian view but in the real world the diminution occurs linearly between the limits zero and c.

We have two velocity contexts to contend with, that of real physical behaviour and that of our calculations. It is an unfortunate fact that our only method of measuring velocity happens to coincide with our calculations. Using a rigid measuring rod we can only measure velocities that are a fraction of the velocity scale zero to infinity because the measuring rod cannot *of itself* limit the distance that it *might* measure in unit time. It is linked firmly to the infinite scale of positive whole numbers and hence to our calculations. Knowing this we must say:

$$V.k = V$$

where on the left-hand side is behaviour, V as we measure and k the now experimentally determined Lorenz transform. This transform applies to the numerical ratio which we call velocity but *not* to its components.

We see just why M, L and T seem to be at variance with our velocity measurements and calculations. Using the equation it is possible to account for all of our experimental results leaving M, L and T invariant. It is interesting to note that Prof. Dingle himself expressed a fleeting doubt concerning the measurement of velocity in "Science at the Crossroads".

Finally, just to round things off, it is to be noted that if *any* of the justifications for the alleged null result of the Michelson and Morley experiment is true, then it must be concluded on grounds of pure logic that the experiment was a decisive demonstration of the existence of absolute space.
Alex Jones
Alderney
Channel Islands.

DOSIMETERS ADVERT

Your October issue included an advertisement by Dondene Ltd for dosimeters. The general information, principle and construction details are a word for word copy of our standard sales leaflet (copy enclosed). Furthermore, the sectional drawing has also been reproduced without our permission.

One of our staff purchased a dosimeter from Dondene. Briefly, it is of a different construction to that shown on the advertised drawing. The company that produced the purchased dosimeter ceased trading in this business some 15-20 years ago. The unit is not hermetically sealed and the charging mechanism is not compatible with available charging units.

R. A. Stephen is and has been for many years the UK's only designer and producer of dosimeters and we should like to make it clear that we are not in any way associated with this flippant advertisement.
R. W. Hawley
R.A. Stephen and Company Ltd
Mitcham
Surrey

DISPLACEMENT CURRENT

Dozens of people in this country, professors and Nobel Laureates, have gained financially from the subject of electromagnetic theory. Something is expected from them in return. It would be a great shame if Professor D. A. Bell, the only man among them who has bothered to contribute to the discussion in *Wireless World*, should suffer thereby. We should congratulate him for standing up to be counted.
Ivor Catt
St Albans
Herts.

AUDIO KITS

It is a long time since I have read such libellous piffle as that contained in the November letter from M. J. Evans on the subject of kits. It would appear that, through not having taken sufficient care when choosing his purchase, he is now publicly venting his spleen on all kit manufacturers and the kit-building public as well.

Mr Evans complains that the amplifier kit he bought was four times more powerful than he needed: it really is too bad of these wicked kit suppliers to let Mr Evans have the amplifier he ordered! He also complains that the kit took 100 per cent longer to build than he estimated: who got his estimate wrong then?

Certainly, the kit of which Mr Evans complains was a bit of a rat's nest to build, but a photograph is included in that manufacturer's literature and it is up to the buyer to judge whether he wants to indulge in that kind of work. Should Mr Evans feel that any error of description was made, then his remedy is at law with the manufacturer concerned. If there is no error, then the fault must lie squarely on Mr Evans' shoulders.

Either way, the argument is a private one between an individual and a company and should not involve *Wireless World* or *Hi Fi News* readers, or other kit companies who give the public first-class products and designs. If Mr Evans' wish is purely to hurt the manufacturer with whom his argument lies, his missiles are a little tardy, since the offending kit became obsolete over a year ago, advertising was withdrawn from *Hi Fi News* before that, and he would now appear to be about to cease offering any hi-fi amplifier kits.

The further suggestion is made that the public should refrain from building anything so complex as a stereo amplifier. As a general principle, a good kit makes construction easier, provides a better standard of finish and design and has the additional benefit of a second group of engineers looking at the design in production terms after the circuit designer has finished with it. In the case of my company's products, careful design and attention to detail produces stereo amplifier kits that wouldn't cause a tea-drinking chimpanzee much trouble provided that he could read and hold a soldering iron! Stereo amplifiers are easy, Mr Evans, if you buy properly in the first place.

But is this public, of which Mr Evans is so dismissive, as incompetent as he suggests? Magazine readers have been building radio and electronic projects almost from the turn of the century. After the last war, people built television receivers from kits without the benefit of printed circuits: nowadays they build teletext decoders and microcomputers.

So please, Mr Evans, do not allow your silly vendetta to knock magazine readers and the trade which serves them: they are our future engineers, our customers and our friends and we do not like it. Without them, no magazine could exist and the world would be a poorer place.
A. H. Milligan
Hart Electronic Kits Ltd.
Oswestry

Having just given up, yet again, the construction of a disastrously bad "kit", I would like to add one or two observations to Mr Evans's letter in the November issue.

It would appear from the pages of the electronics press that there are kits available for almost any piece of apparatus you can imagine, supplied by an army of different manufacturers, if manufacturer is the right word. My own experience of kits has varied from the idiot-proof masterpiece of planning and instruction to the present bout of transistorised insanity. While I would disagree with Mr Evans's inclusion in his total costs of £300 plus for labour (surely he enjoys his hobby?), I object to the amount of rectification work that some kit suppliers subject us to.

The cassette deck kit which I am at present engaged upon should be held up to prospective manufacturers as an example of how not to go about it. The problems started before the kit even arrived, since I had sent my money with the order before I found out that no kits had actually been made at that time, and therefore, had a four month wait, at the end of which there appeared a half set of electronics with one p.c.b. missing. They still hadn't been made. Then the case arrived. The advert in *W.W.* had painted glowing pictures of a beautiful satin anodised aluminium case with teak ends. What actually arrived were two pieces of pressed steel, stove enamelled battleship grey, with two pieces of Melamine covered chipboard, and no means of holding any of it together.

After a few irate phone calls, always taken by the shop assistant as the manager was never available, the remainder of the bits and the second p.c.b. arrived along with what can only be described as a few helpful clues as to the assembly procedure. I like to think of myself as resourceful, so on I went. The p.c.b. assemblies went together quite well, although some of the components were fiendishly difficult to identify, but the pile of spare resistors and capacitors left over at the end was a bit disconcerting. "What was missing?" I asked myself, and spent another hour deciding that they really were spare.

The hard part is still in progress. None of the mounting holes in the case is in the right position, the cassette transport has a record button but no switch mechanism, and the battleship grey is looking quite scarred by the attempts to make things fit. I now seem to be faced with either a transport which fits the case but can't be worked properly because it is too deeply recessed, or one that works but which won't allow the lid to fit.

The whole thing, excluding Mr Evans's £2 an hour labour charge, has so far cost me about £65. I noticed the other day in our local hi-fi shop a beautiful front-loading satin anodised cassette deck, with Dolby, and only £62!

My message is simple: if you are thinking of buying a kit (1) don't buy from anyone who is not well know for kits; (2) if a kit is advertised as being suitable for the experienced constructor, it is either too difficult for you or you could design a better one anyway; (3) wait a few months before you buy it, the chances of it arriving whole and with all the latest updates will be much higher; and (4) make sure you can't buy better and cheaper ready made.

Unless, of course, you enjoy your hobby!
P. B. Hodgson
Grantham
Lincs.

I think your correspondent M. J. Evans in the November issue is a little hard on kit suppliers and totally wrong in his opinion of those who buy them.

In recent years I have bought several kits from firms who advertise in this magazine. They have been at the least adquate mechanically, acceptable in appearance and used good quality components. I cannot say they have all been trouble-free initially but once commissioned have given reliable service and excellent performance. I have been building audio equipment since about 1947. In those days I used to buy all the components separately but today that is a very tedious task conveniently overcome by the kit.

People build their own equipment, I would have thought, largely out of the interest it gives them. To cost the time involved as if one would otherwise have been doing a paid job is, as with any other hobby, ludicrous. Does it matter if it takes 40 hours or 80 hours or as long as you enjoy taking? These people also, incidentally, usually finish up with a machine costing about half the price of a commercial unit of similar performance.

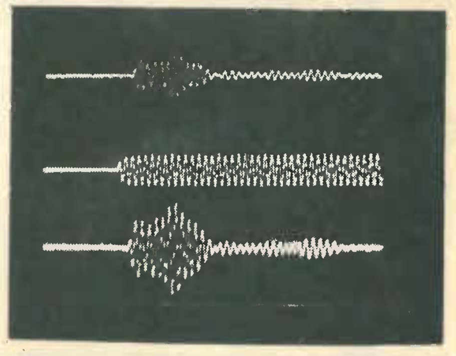
I do not think there are many people who will spend £100 or more on a kit if they do not either have confidence in their own ability or have ready access to competent assistance. Despite how some kits may be advertised it is extremely naive to think a sophisticated instrument can be built from its individual components without some initial troubles. As your correspondent says, there are kits in which most of the assembly work is done to reduce this risk but to me that is little different from buying ready made equipment. But that is the point, the variety is there – you make the choice.

Finally, may I join the statistics "guessing game" even though I intend to cheat by using facts? From my own experience and that of colleagues the score is 100 per cent working and 100 per cent satisfied.
R. W. Hurst
Welwyn
Herts.

MULTISECTION TONE EQUALISER

I was interested to note that the authors of "Multisection Tone Equaliser" claimed that the equaliser was "primarily designed to cancel room resonances and equalise loudspeaker responses" (June/July 1980 issue). However, such a claim is rather a myth as an equaliser of the type described in the article is quite incapable of cancelling room modes even though many commercial units are now on the market bearing similar claims.

The problem stems from a basic lack of understanding of the acoustics of listening rooms and the formation of standing waves and resonances. Standing waves/room resonances are in fact occurrences in the time domain which also manifest themselves as irregularities in the frequency domain, particularly when measured under the steady state conditions the electronics



Traces illustrating loudspeaker-room interaction with or without an equaliser. The middle trace is the input tone burst. At the bottom is the room response without an equaliser; at the top the response with an equaliser. Note how the equaliser fails to compensate for envelope distortion and hence timbre and character. (Timebase 20ms/div.)

and audio industries usually rely on. But when trying to equalise such frequency aberrations one is looking at the effect rather than the cause – and it is the cause, occurring in the time domain, which must be corrected for, rather than the symptom shown up in the frequency domain. Some recent investigations, reported elsewhere [1], clearly showed this. The investigations, using a number of commercially available units, showed that subjectively resonances could only be partially tamed – they certainly were not cancelled, as both oscilloscope and ear clearly testified.

Although the "loudness" of a resonance could be reduced with an equaliser, this is only half the story, as a resonance also affects the "attack" and "decay" of a note as well as its steady state response, and thus completely alters perceived timbre and character (see traces). The equaliser, because of its mode of operation, just could not cope with such waveform distortions, which the ear clearly detected. The basic room resonance is still excited but at a lower level rather than true cancellation taking place.

Furthermore, the bandwidth of the equaliser filter circuits, unless very narrow, can also produce quite audible changes in the response at other frequencies. It was also noted that not all programme material excited room modes – but the equaliser filter is always in circuit, removing a "chunk" of the signal when not required to do so.

One possible solution to the problem might be to use a series of extremely narrow-band filters precisely tuned to the frequencies of the worst room resonances—apart from requiring a number of high Q tunable filters with their attendant phase shift problems in a stereo set up, this method still does not attack the problem in the right way. Compensation must take place in the time domain (3 dimensional) if room resonances are to be successfully "cancelled".

Peter Mapp
Department of Electrical Engineering Science
University of Essex.

Reference

1. Mapp, P.A., Graphic Equalisers Myth or Magic? *Hi-fi for Pleasure, October 1980.*

THE FLOATING BRIDGE

In his two articles on bridge amplifiers (September and October issues) Mr Brady presents many stimulating circuit ideas and practical suggestions. His analysis of the circuits is, however, presented mainly in the form of a plausibility argument and he leaves the potential designer without the necessary analytical tools. It is evident from the article that Mr Brady has carried out a small signal analysis of the circuits; perhaps this is not reproduced because of the obscurity lent by his choice of circuit representation. I believe I can improve on this.

The diagrams repeatedly include an amplifier symbol with its output connected to signal earth (Fig. 1). By this Mr Brady means that, since the power supply is left floating with respect to signal earth, this amplifier causes the signal which would have appeared at its output to appear inverted at the power supply lines A, B, C. Let us draw this explicitly (Fig. 2). In Fig 2 the amplifier behaves the way one is normally entitled to expect from this symbol. Its output voltage with respect to signal earth is proportional to the differential input voltage. Two important features of Fig. 2 are: (1) the inverting and non-inverting inputs have (apparently) been exchanged; (2) the relationship of the power supply to ground is explicit.

Terminals A, B, and C are equivalent in a small signal analysis where we may properly expect to ignore power supplies. The voltage swings available at the final output terminals can be determined later from the practical circuit diagram of the bridge output stages without the complication of including signal paths.

Finally, to demonstrate the utility of this transformation, I have re-drawn Fig 1 of the first article as my Fig 3. This circuit is amenable to the kind of analysis we all know and love. For the first amplifier we have:

$$\frac{V_i-\Delta V_1}{R_1+1/j\omega C_1}+\frac{y-\Delta V_1}{R_2}=0 \qquad (1)$$

$$V_A=G_1\Delta V_1 \qquad (2)$$

If we assume that the loop gain through both

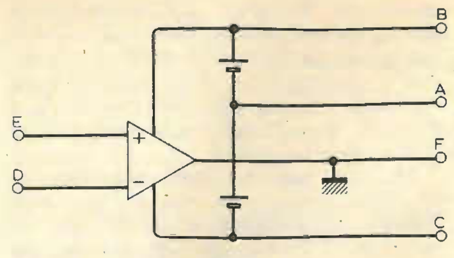


Fig.1

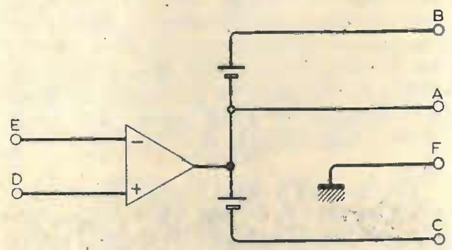


Fig.2

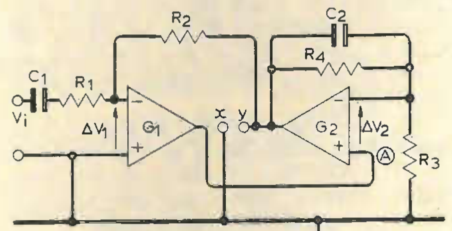


Fig.3

amplifiers $y \rightarrow A \rightarrow y$ is negative so as to maintain stability and that G_1 is very large so that $\Delta V_1 \rightarrow 0$ (by equation (2)), we have:

$$\frac{V_i}{R_1+1/j\omega C_1}+\frac{y}{R_2}=0 \qquad (3)$$

and hence the gain of the total amplifier, which is insensitive to the nature of G_2, the gain of the second amplifier. This justifies Mr Brady's comments about the relative quality of A_1 and A_2 at the top of page 42 of the first article.

J. Allen
Cheltenham
Glos.

The author replies:

The reason for the inclusion of an earth in the position shown in the article (e.g. my Fig. 1) is that in a simple design the input may be with respect to earth, which has great convenience. (If a 'change-of-origin' is included this is of course not necessary.)

I think Mr Allen's Fig. 3 will not work, for two reasons. First, where is the power supply? In his Fig. 2 the power supply has A as mid-point. If this is intended for Fig. 3, then when G_1 is driving current, the closed path is from the supply, through G_1, into A, through the battery and back into the amplifier – which path does not drive current through the output at all.

Perhaps Mr Allen intends some other power supply arrangement.

Ignoring this problem, then the feedback loop controlling the G_1 in his Fig. 3 includes the characteristics of G_2. Though there *is* negative feedback, the open-loop gain will be some horrendous problem to calculate unless the G_2 is of good-quality design. The two amplifiers are coupled together in this way – which the original design hoped to avoid.

R. M. Brady
Trinity College
Cambridge

DISPLACEMENT CURRENT

In order to avoid any suggestion of 'increasing the noise level' in this seemingly interminable correspondence (November letters) I will limit myself to one fact, one question and one comment.

(1) The fact. My reference to Hobbes' *Leviathan* was correct. I noticed it in 1943 and verified it in 1978.

(2) The question. A body continues in motion *or at rest* unless disturbed by some force. Electromagnetic radiation has momentum, so once launched it appears to behave according to Newtonian mechanics. If there be 'energy current' what force accelerates it (instantaneously?) to the velocity of light?

(3) The comment. L.H. Higgins says in November letters that Catt, Davidson and Walton "only need to define what they mean by energy current". But so far they have not done so and I do not believe they can.

D.A. Bell
Beverley, Yorkshire

PARALLEL TRACKING PICKUP ARM

I have just completed Rod Cooper's parallel-tracking arm system, as described in your December 1979 and January 1980 issues. It works beautifully and it is quite fascinating to watch the drive system adjusting the tracking speed of the arm. I used a Swiss made micro-motor with a 54:1 reduction gearbox in place of the suggested drive system as I was not very enthusiastic over the cross drive and dual belts, which would need rather careful assembly.

I do not know whether any of your readers actually managed to assemble the whole thing in the suggested 40 hours! I used the components already machined by the supplier (J. Biles), but found that a lathe and milling machine in my home workshop were needed for some operations, such as the forming of the nylon sliding block, motor pulley, cartridge clamp, etc.

Now that it is hardly worth attempting construction of home radio and hi-fi equipment it is very helpful to find designs such as this, and the conjunction of electronic and mechanical elements adds greatly to the interest of the project.

Frank Gutteridge
Corsier, Switzerland

P.R.B.S. GENERATORS.

Further to my letter (September) and the replies (November) concerning p.r.b.s. generators, may I thank Mr Hall and Dr Thackeray for their comments? The reference to Golomb is particularly useful.

The details I originally described were side products of some unrelated programming I was investigating on a Z80 system, and I must admit I did not delve deeply into the subject. I found no positive analysis, so I performed the negative one presented.

I have satisfied myself that generators a multiple of eight elements long do not produce the full sequence when simple feedback is used, but I have not found a reason for it (yet). Accordingly I have altered my Z80 routine, which I do not present here as it forms an interesting machine code exercise. The sequence previously produced was so long that I never noticed that it was shorter than expected.

Incidentally, a number of degenerate values for 'a' slipped into my table. Readers may find it instructive to locate them.

K. Wood
Ipswich, Suffolk

Artificial intelligence

Computing techniques adapted for use in intelligent machines

by Malcolm Peltu

One British pioneer thinks that the most important use of artificial intelligence will be to save us all from the havoc likely to be caused by too much reliance on computers. Be that as it may, there is already a growing body of AI work on more specific problems such as in robotics, speech understanding, visual perception, automating reasoning procedures, understanding natural languages and man-machine communication. This article first takes a look at the history and politics of the subject in Britain then, through examples of research in computational vision, speech understanding and man-machine communication, gives an insight into the general nature of this developing cousin of computer science.

Computers were an essential aid to putting men on the moon; yet a small step for a man, like crossing a busy road, is still a giant and unbridged step for a computer. Computers can store vast libraries of information and play a pretty good game of chess; but no machine can match the ability of a child to learn a language or read a picture book. The ability of computers to perform many complex tasks, although they have immense difficulty in doing what comes naturally to humans, raises important and intriguing questions about the nature of human intelligence and the limits of machine or 'artificial' intelligence.

The techniques of computer science which underpin modern applications of computing power are based on mathematical and logical methods of analysing system functions and translating them into sequences of detailed instructions which program the computer into performing a pre-defined task. In the 1950s a new breed of computer scientist began to emerge – the artificial intelligentsia. Whereas conventional computer science was primarily concerned with tackling information processing tasks that could be analysed into clearly defined and unambiguous programs, the new subject of artificial intelligence (AI) was starting to explore the ambiguities and uncertainties involved in trying to understand the principles, and building working models, of intelligent behaviour.

For the past 25 years or so there has been a running battle between computer scientists and AI researchers, with the traditional computer specialists often complaining that AI is too vague a subject to be regarded as a coherent discipline and that the artificial intelligentsia are a rather dilettante lot, drawing off valuable research resources from mainstream computing. There is, however, a growing and impressive body of AI work covering such diverse areas as robotics, speech understanding, visual perception, automating human reasoning procedures, understanding natural human languages, improving the methods used for communicating between people and machines – and for playing 'intelligent' games like chess.

One of Britain's most distinguished AI pioneers believes that the most important contribution from AI will eventually be to help save mankind from the havoc that could be caused by increased reliance on that potentially Frankensteinian invention, the digital computer. Professor Donald Michie, head of the Machine Intelligence Unit at Edinburgh University, thinks that AI can open a "human window" onto the way computers reach decisions which have a direct impact on human safety and prosperity. The Three Mile Island nuclear incident in 1979, for example, nearly became a horrifying disaster because the operator could not "understand" the myriad of warning messages provided by the computer-controlled monitoring system. And last year the world was twice brought to the brink of a nuclear war because of computer failures in the US defence network.

In robotics AI systems are needed for recognising objects. This mobile robot developed at Warwick University has sensory equipment enabling it to avoid obstacles and to seek out, approach and grasp an object such as the plastic bin shown.

If that nuclear war alert had gone as far as reaching the President, how could he have interrogated the computer to find out the validity of its warning? asks Professor Michie. Computer science, he says, has produced complex information processing machines which perform calculations and search through information at such speeds that it is often difficult, if not impossible, for humans to trace back the 'thought' processes used by the computer to reach a particular conclusion.

As AI is concerned as much with human intelligence and understanding as with computer processes Professor Michie believes that its development of what are known as *expert systems* will make computer systems more understandable by forcing designers of automation equipment to fit the machine procedures into "the human mental mould." When you remember that computers are already relied on for controlling the operation of and diagnosing faults in tasks such as air traffic control, factory automation, medical analysis and building environment control, as well as nuclear power stations and national defence systems, the importance of opening such a human window should not be underestimated.

Yet, in the UK at least, computer scientists continue to cast doubt on the validity of AI's right to exist as a research area in its own right and even on the integrity of some AI practitioners. Last September at an international seminar of computer scientists at Newcastle University sponsored by the computer manufacturer IBM, the scepticism of British and some European computer scientists to AI was evident, despite the presentation by speaker after speaker of an impressive body of research work in this field. It appeared that each concrete advance in AI, such as speech understanding by computers or automatic recognition of visual scenes, was regarded by the sceptics as an example of computer science, rather than AI. The scepticism culminated in an acid after-dinner speech at the end of the conference by Professor Euan Page, vice chancellor of Reading University and former head of the Newcastle computing laboratory. Although he accepted that some specific progress had been made, Professor Page still chose to turn to Roget's Thesaurus to point out that 'artificial' is a synonym for words such as "bogus, phoney, pseudo, meretricious and flash." He also blamed AI for creating the public fear of Big Brother computers and scare stories about incorrect computer gas bills because the artificial intelligentsia had given birth to the notion of super-intelligent machines that will control the world.

This kind of petty bickering would be of only passing interest in the cloistered halls of academia if it did not reflect an attitude which has contributed significantly to Britain's low level of advanced industrial automation. In 1972, applied mathematician and now vice-chancellor of University College, London, Sir James Lighthill was called in by the Science Research Council to look at AI, primarily because many computer scientists were worried that this dubious new subject was siphoning off funds that they should have been receiving. According to one computer scientist who was on the Council at the time, the real aim of the Lighthill report was "to do a hatchet job on AI."

Although his report said there was some signs of progress in aspects of what has been called AI (such as advanced automation), Sir James was generally dismissive of AI claims. As a result, AI funding – and in its wake robotics research which had been tarred with the AI brush – was drastically cut back, although in the early 1970s British research workers, such as Professor Wilf Hegginbotham at Nottingham University and Professor Michie at Edinburgh were in the forefront of developments. For almost a decade, according to Dr Mike Larcombe of Warwick University, a leading member of the British Robot Association, this "neglect and persecution" of AI and robotics work almost threw Britain out of the advanced automation race, the flag being carried by a few individuals and groups operating in a fragmented, unco-ordinated way. Earlier this year, however, the Science Research Council decided to invest £2.5 million over three years in industrial robotics research. According to Dr Larcombe this money came at the eleventh hour for the hardy band of research workers, like himself, who had struggled on in the 1970s. Otherwise the temptations of the more enthusiastic and plentiful environment of the US would have drawn the last life blood out of robotics research in Britain. In the US, AI is generally accepted as an important aspect of computer-related developments.

Dr Larcombe pointed out that in Britain it was the robot research academics who have lead the way in creating an awareness of and involvement in advanced industrial automation whereas there was, until recently, "a general level of ignorance in British industry" about the importance of automation. Although grateful for the new research funds for robots, he is cautious about the way the funds have been tied to creating partnerships for research projects with industry. As British industry starts from such a backward international position, he fears that the aims of the projects funded in this way will be to catch up with past neglect rather than to forge ahead into new areas, such as mobile robots, which is his main interest.

Fig. 1. A noisy visual scene, which can be interpreted by the human eye and brain with the aid of a large stored set of patterns. (If you can't see what the picture shows, refer to the main text.)

Computational vision

The cold AI climate that set in after the Lighthill report did drive many researchers away from the UK. One of those was Dr Harry Barrow who worked on the Freddy project at Edinburgh University in the early 1970s. This was one of the first attempts to produce a robot that could see and intelligently manipulate objects. It had started to show inklings of success when the Lighthill blight fell. Now, robots that can see are recognised as one of the most significant advances in automation.

Dr Barrow went to the US and is currently working at the AI Centre at SRI International on computational vision. The attempt to give computers 'eyes', 'ears' and 'voices' has typified one stream of AI research which mixes analyses of physical and sensory properties with attempts to understand how people make sense out of a host of stimuli. The other main strain of AI work is concerned with purely 'intellectual' questions, such as natural language communications and the process of human reasoning. Dr Barrow described at Newcastle one of the most advanced artificial vision systems, called Hawkeye. US Defence and Highways Departments are thinking of using it to draw maps automatically and to monitor traffic flows. Using a television camera and a video processing system which translates images into a digital code that can be fed into computers, Hawkeye is capable, for example, of recognising and counting ships going into and out of a harbour or vehicles on a road.

To a human being this is not a difficult task. For a computer, however, there are two main problems. First, it has to analyse a scene into quantifiable factors that could subsequently be used in interpreting the nature of the images, such as the length and position of boundaries between objects, illumination, reflectance and surface orientation of areas within the scene. And then it has to make sense out of that scene. There is an enormous amount of information in a given scene. A typical colour tv picture, for example, requires about 1Mbit of information to be transmitted in digital form. With computational vision, a scene is broken down into pixels (picture elements), with values being assigned at each point for a predetermined set of qualities, such as luminance and reflectance. A typical picture analysed by Hawkeye has about 2,000 to 4,000 pixels.

The problems that could be encountered in interpreting a picture are indicated in Fig. 1, which is a noisy visual scene in which it is difficult to pick out any meaningful shapes or objects. Somehow, however, the human eye and brain can detect that it is a spotted dog drinking water in a stone-strewn street (provided the picture is presented the right way up). To a computer, of course, it would be a meaningless jumble of black and white splodges. The aim of AI is to crack the mystery of how intelligent people can extract sense from such an apparently

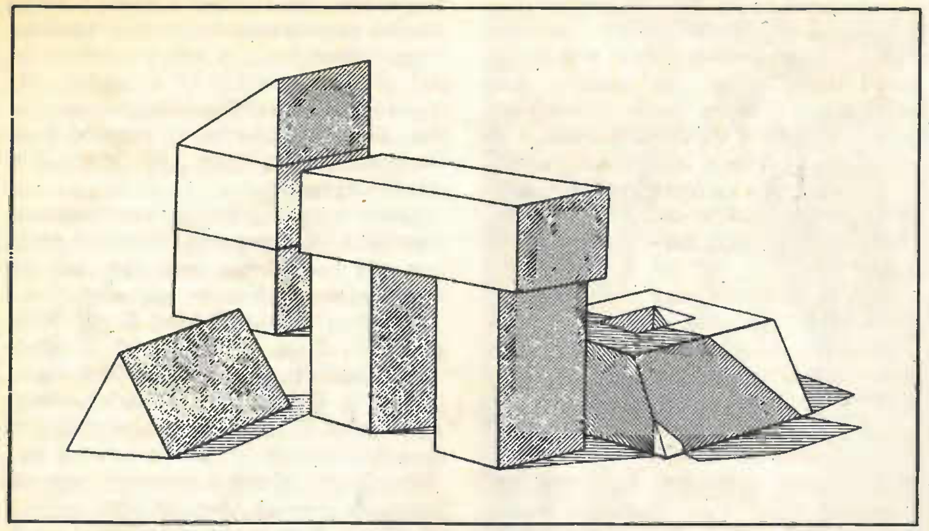


Fig. 2. A line drawing correctly interpreted by David Waltz's program for computer vision.

meaningless visual 'noise'.

According to Professor Michie, "The rate of input of visual information to the higher centres of the brain is not great enough to do more than give hints and prompts." From these partial stimuli, the brain constructs meaning, he says, from a large repertoire of stored 'models' of the real world held in the brain's memory.

The earliest AI experiments in vision, such as the Freddy robot at Edinburgh, reduced noise by being limited to simple 'block worlds' in which the only objects had simple, straight-line edges. The main task in the low level (noise reducing) analysis was to find, trace and segment boundaries defining homogeneous areas – in other words, to find the edges of blocks.

Even in a simple block world with a limited number of objects and specially lit to avoid shadows, this was a difficult task; for example, when blocks partially obscure each other so that the computer has to try to build up images of whole three dimensional objects from two-dimensional line drawings in which the edges of one block might be obscured in many places by other blocks. Any one object also obviously has different shapes when viewed from different angles. David Waltz of the University of Illinois developed a sophisticated computer vision system which could use lines (see Fig.2) to represent not only the edges of objects but also shadows, cracks and other physical attributes.

A great deal was learnt from working in the block world, although it was clearly too restricted to be of much use in a real world of irregularly-shaped objects which can be brought to the eye from an infinite number of view-points. Yet Hawkeye, which 'looks' into just such a variable real world, still employs similar basic principles in abstracting information from the noisy picture, although the interpretation is far more complex and subtle than just producing a two-dimensional frame representation.

An important problem at the low level end of sensory analysis is the speed with which information can be processed. Given that a visual scene could contain many thousands of picture elements with many different measurements needed at each element, it is clear that the computer should be able to perform calculations on all elements very quickly. Traditionally, however, computers have been able to process information serially, i.e. only one calculation can be performed at a time. This has been satisfactory for most commercial and industrial data processing needs because the speeds of the processors (performing hundreds of thousands or even millions of instructions per second) have been satisfactory. Recently, however, new types of *array* processors have been developed. These consist of a network of many little processors which can operate independently of each other but within a co-ordinated plan. This technique is ideal for computational vision tasks which require the parallel processing of a variety of information.

Michael Duff at University College, London has developed a special computer language for the Clip-2 parallel array processor which is capable of carrying out low-level image analysis far more efficiently than by other means.

The professor of electronics at Brunel University, Igor Aleksander, is developing a pattern-recognition machine which exploits the recent availability of low cost microelectronics memory chips to store information. His machine will have a network of such memory chips, each of which contains a key piece of information that will be used to identify, say, an object in a scene. It will accept tv quality pictures as input; as the picture comes in, it will be analysed and compared with the 'keys' in the memory chips. The chips communicate with each other to indicate whether or not they have identified the object or an aspect of the object. Professor Aleksander believes that such a system is similar to the neural structures in the brain, where memories and information in the brain are linked by association in order to identify people, images, letters of the alphabet, etc.

The Hawkeye system, however, does not rely on any new types of computer processor. It also does not attempt to be totally automated and is designed to operate in interaction with people who can help to supplement its intelligence. Hawkeye contains a computerised library of images relating to geometric and topological data found in the environment being viewed. It also contains 'intelligence' information needed to make sense out of the images, such as the fact that roads and rivers run under bridges, that buildings stand vertically or that, say, in a view of a dock area, ships move on the sea area and different types of ship have particular characteristics. Like most current AI developments, Hawkeye does not attempt to be a general purpose intelligence capable of instantaneous adaptation to any environment. For each task it is doing, it has to be given information about that particular slice of the world and it is intelligent only with that slice of life.

Much of the criticism levelled at AI in the past was aimed at some rather silly claims made by pioneer artificial intelligentsia, such as a statement by Herbert Simon and Allen Newell of the Carnegie-Mellon University in Pittsburgh in 1958 that: "There are now, in the world, machines that think, that learn and that create. Moreover, their ability to do things is going to increase rapidly until – in the visible future – the range of problems thay can handle will be co-extensive with the range to which the human mind has been applied." This idea of the universal robot is still a long, long way over the horizon. But within particular areas – **domains** is the AI jargon word – machine intelligence is indeed flourishing. Given its library of background information and a simple language with which to communicate with an operator, Hawkeye is already able to automatically produce primitive maps, provided it is given guidelines, such as indications of landmarks near a road. It is also beginning to be able to monitor chip movements in the San Francisco Bay docks and motor traffic on a highway in California. It can answer questions like "What is this building?" and "How high is it?" when the user points to a particular part of an image with a special pointer.

Future work in computational vision is likely to develop the themes started in those early block worlds and now being developed in systems like Hawkeye. On the one hand, there is a lot of work going into low level analysis of sensory input to determine the appearance of the image and array processors could play a significant role in this. At the other end there is work into psychological understanding of human perception. In the middle, the AI expert 'engineer' is trying to produce working models of machines that can 'see'. In industry, the most obvious need is for robots that can recognise objects but, as Hawkeye has shown, computational vision has many other potential benefits.

Speech understanding

Speech understanding – computer 'ears' – poses a similar type of problem as computational vision. Brian Pay of the man/computer research team at the National Physical Laboratory, Teddington, has said, "People are extremely inefficient at speech recognition but brilliant at speech understanding."

Speech recognition is concerned with the receipt of aural stimuli and interpretation into sounds, words and sentences. This is equivalent to the low level visual analysis and is often literally a noisy jumble. At a party, for example, a person will be bombarded with a jumble of voices and noises yet is capable of picking out and understanding particular voices and conversations. Computer speech understanding started with low level speech recognition. There have been systems on the market for about a decade which can be trained to recognise individual words spoken in isolation by the person who trained the machine. When the computer is being trained, the operator repeats a set of words to the machine. The voice patterns of the operator for each word are analysed and stored. When the operator speaks them in a working situation, the input pattern is matched against those in the computer memory and, if found, the appropriate word is 'understood' and the computer responds accordingly.

The more difficult task which is only just beginning to be overcome is continuous speech understanding, where the computer can understand a stream of words spoken naturally. This is extremely difficult. At the physical level it is a complex task to identify particular words because people do not enunciate words clearly and crisply, words merge into each other, people swallow the ends of words and sentences, miss out words, etc. But even if the words are identified, the human processes of making sense out of them is still insufficiently understood, as with finding meaning in visual images.

AI research has tackled the problem by analysing linguistic components, such as grammatical structures, syntax and other speech characteristics. In addition, the machine needs to be given information about the nature of the world in which it is functioning to help it understand speech, just as a centre forward at a football match would interpret the command "shoot!" in a different way from somebody at a rifle range.

Those continuous speech understanding computers that have begun to emerge from the research laboratories operate within clearly defined domains but they show sufficient progress to indicate that there is no insuperable barrier, although at present they are limited and slow. IBM, for example, has developed an automatic equipment which can understand words spoken from a vocabulary of the 1,000 most used words taken from words and sentences used by lawyers in submitting US patent applications in laser technology. Although it can recognise words with a 91 per cent accuracy and type them out automatically, a 30 second burst of speech takes about 100 minutes before it is typed out.

Computer controlled speech synthesizers

Although computers find it difficult to 'see or hear no evil (or anything at all), they find it relatively easy to speak. Ironically, the ability to talk is the main capability which *seems* to make computers intelligent, yet automatic speech requires relatively little intelligence compared with other AI tasks. Electronic sound synthesizers have been around for a long time and it is now easy to generate an artificial voice. It is also possible to store recorded human speech in computerised form. A data base of words and phrases recorded by a person can therefore be stored in a computer and can then be joined together to respond to a particular enquiry under the control of a computer program.

Many companies already use computer controlled voice response systems to automatically answer enquiries and requests from dealers, salesmen and customers. The computer-based System X telephone exchanges being introduced by the Post Office (see News, November 1980 issue, p.52) will also use automatic voice response based on human speech recording to provide a variety of new automated services. There is also a growing range of consumer products that can 'speak', from the Texas Instruments Speak and Spell educational aid and an automatic language translator to cookers and ovens. From a computer programming point of view, however, voice output is no more difficult than putting out information in any other form.

The main problem with speech reproduction is making the artificial response sound natural. With synthesized speech this is difficult because voice quality is dependent on the physiological characteristics of the throat and breathing. When recorded voices are used, the problem is overcoming artificial pauses between words or phrases when they are 'spliced' together to form a particular response and to allow for the same word having a different emphasis or inflexion depending on its context in a sentence. This is being tackled more through patient study of human psychology and perception than by any technical breakthrough.

Portable "turtle" drawing device built by the Department of Artificial Intelligence at Edinburgh University. It comprises a press-button box, a microprocessor and a mobile robot. The microprocessor runs a sub-set of the LOGO programming language. Each button on the box corresponds to a language instruction: for example, the "forward" button moves the turtle forward when given a numerical input for distance; the "right" button turns it on the spot clockwise when given a numerical input in degrees of rotation. The turtle carries a drawing pen and can leave a trace of its movement path – that is, it can make a line drawing. It is used to teach basic programming ideas to children and adult novices, using drawing as the context. With the device they can write programs for drawing simple regular shapes.

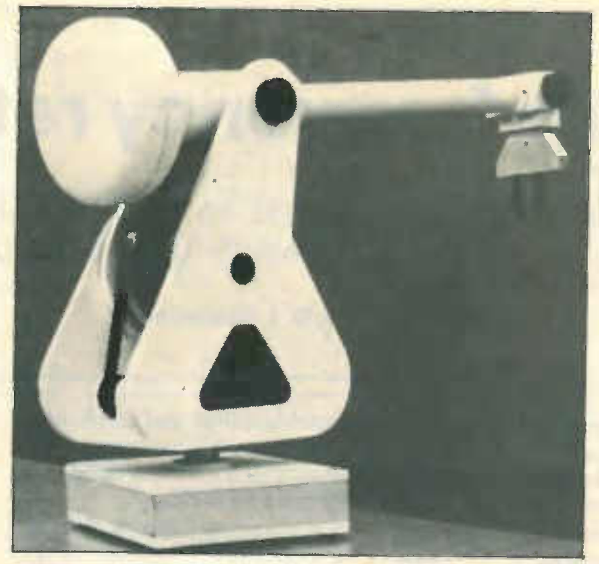
Man-machine communication

One of the important reasons for wanting computers to see, speak and listen is to assist in communication between people and computers. At present this communication typically takes place through a visual display unit. The information is keyed in and responses are presented on the screen. Although the words used in such a dialogue may be English, the 'language' available for the communication is usually extremely limited and inflexible – an error can be caused if a full stop is missed out in some cases or if a word is even slightly mis-spelt.

A vital area of AI research has been into natural language communication which allows all the flexibility and natural dialogue characteristics of ordinary human interaction. This is essentially a subset of the task being tackled with speech understanding systems except that there is no problem about recognising the words being put in. The question is how to understand the meaning of a sentence. Once again, AI work in this field is taking place within an acceptance of the need for defined domains. Typical person/computer dialogue systems assume a basic 'script' or 'scenario'. This typifies the particular interaction taking place in which there is a

certain number of objects and ideas being discussed and a particular pattern to the discussion, such as a doctor/patient relationship.

A milestone in natural language systems was a doctoral thesis in 1971 by Terry Winograd at the Massachusetts Institute of Technology. It was rooted in the block world that was then an intrinsic part of AI, robotics and computational vision work. The Winograd program displayed a block world scene on a screen containing a variety of blocks each with its colour printed on it as a word, together with a simulated robot arm. The user could then ask the 'robot' to carry out a variety of tasks in a natural language dialogue (see Fig.3). Here are some excerpts from a dialogue between a person and a simulated robot operating on such a set of toy blocks:



This robot arm, for light assembly tasks, is a successor to the "Freddy" robot used by the Department of Artificial Intelligence at Edinburgh University for experiments in computer control of robots. The arm has joints, each actuated by an electric motor. Torque is transmitted between motor and joint by a gear train and in two cases by toothed belts. Angles of joints are measured by incremental shaft encoders. These are interrogated by a 16-bit microprocessor which computes the difference between where the joint is and where it ought to be and, allowing for the speed of the joint, issues a command signal to the corresponding motor.

Person: How many blocks are not in the box?
Computer: Four of them.
Person: Is at least one of them narrower than the one which I told you to pick up?
Computer: Yes, the red cube.
Person: Can a pyramid be supported by a pyramid?
Computer: I don't know.

Person: Will you please stack up both of the red blocks and either a green cube or a pyramid?
Computer: O.K. (carries out the action on the display screen)
Person: Had you touched any pyramid before you put the green one on the little cube?
Computer: Yes, the green one.
Person: When did you pick it?
Computer: While I was stacking up the red cube, a large red block and a large green cube.
Person: Why?
Computer: To get rid of it.

Xerox Corporation has developed a system called GUS, as part of its work on new, more naturally human information systems, which foreshadows the kind of public information services that might eventually become widespread. For example, a business executive specifies that he wishes to interact with a GUS computerised travel consultant. The dialogue goes like this:

Client: I want to go to San Diego on May 28.
GUS: What time do you want to leave?
Client: I must be in San Diego before 10 a.m.
GUS: Would you like P.S.A. flight 102 that arrives at 9:15 a.m.?
Client: What is the next flight?
GUS: Air California flight 310 that leaves at 8.30 a.m. and arrives at 10.00 a.m.
Client: I'll take the first one.
GUS: In what name should I make a reservation?
Client: Dan Bobrow.
GUS: I have confirmed the following flight: P.S.A. flight 102 on Wednesday May 28 from San Jose to San Diego which leaves at 7.30 a.m. and arrives at 9:15 a.m.

These kinds of dialogues are an important aspect of the AI development which comes closest to the core of real human intelligence – expert systems. The starting point of an expert system is an expert, called a 'domain specialist'. Expert systems exist in domains as varied as geology, biochemistry, medical diagnosis and applied mathematics.

The expert computer system holds the distilled knowledge of the domain expert, written by an AI specialist in a logical programming language using statements that are easy to interpret. The form of these statements might typically be: "IF condition *x* AND condition *y* BUT NOT condition *z* THEN there is a reasonable/poor/good chance that condition A is true/false." For example, "IF the temperature is over 80 degrees AND door 53 is locked THEN there is a reasonable (0.6) probability that a fire will break out."

Expert systems perform as well as – or sometimes better than – the domain specialists whose knowledge and experience formed their basis. What is more, the expert system program is written in understandable human reasoning terms so that anyone can understand the process used by a computer to reach a decision and the probabilities of various of its decisions being accurate. The expert system program can even be used as a tutor.

Expert systems are of practical use. B.P., for example, is currently working with Edinburgh University to produce an expert system for an oil rig which will be able to help identify any faults and explain the most appropriate course of action without having to immediately send for a Red Adair. And the multinational group Schlumberger is using an expert system to help find new oilfields!

The image created by science fiction writers of mankind being superseded by a race of superintelligent robots has been the image most associated in the popular mind with AI. The reality, however, could be that AI helps to turn the computer into a genuine workhorse and intellectual friend of people by removing the mystique of automation, simplifying and humanising the interaction between man and machine and providing a window into the "mind" of the computer. So when a computer is trying to warn us of something dangerous about to occur, we can question it and if necessary, heed its warning.

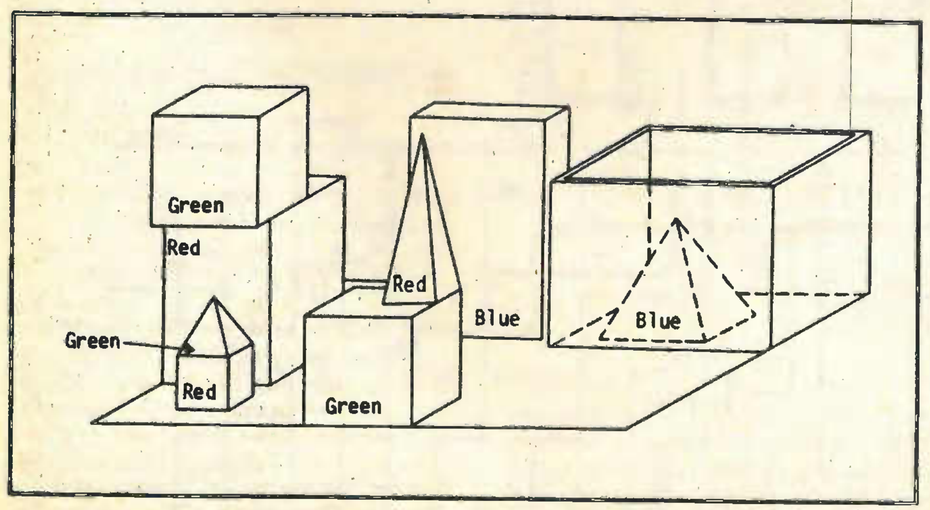


Fig. 3. Winograd's simple world for understanding natural language. A screen displays these blocks, each of which has a word printed on it indicating a colour.

Off-air frequency reference

Seven outputs from 1Hz to 10MHz, phase locked to the Driotwitch transmission

by D. I. Stansfield

Although l.s.i. techniques have simplified the construction of a frequency counter, accuracy depends on the stability and adjustment of the reference oscillator. Unless this oscillator is temperature controlled and adjusted in conjunction with a standard frequency source, even a quartz crystal will not provide better than 1 part in 10^5 accuracy.

This unit provides a 10MHz signal, phase-locked to the BBC 200kHz Radio 4 transmission from Droitwitch. The long term accuracy is that of the BBC standard and the error due to jitter is less than 0.1 cycles pk-to-pk over an ambient temperature range of 0 to 30°C.

The heart of the frequency reference contains a quartz crystal oscillating at 10MHz. Logic divides this output to produce a 200kHz signal which is compared in phase with the transmission as shown in Fig. 1. The resulting error signal is filtered by an active-loop filter and used to fine-tune the quartz crystal with a varicap diode. The active-loop filter enables the loop-lock conditions to be accurately specified, the static phase-error to be kept small and, in the event of interference being received, the oscillator frequency to be kept close to its locked frequency due to the memory action of the filter time constants. The 200kHz signal is received with a tuned ferrite-rod aerial, see Fig. 2, followed by a two-stage tuned amplifier and a two-stage limiter. A buffered 200kHz output from the main divider chain is further divided to provide outputs down to 1Hz.

The main problem associated with using Radio 4 as a frequency standard is the removal of amplitude modulation. Even after full limiting, residual modulation appears as jitter on the phase detector output in Fig. 3, and if the detector output is not sufficiently filtered, the jitter appears as phase modulation on the 10MHz signal. Because heavy filtering is necessary, a crystal oscillator is used to maintain the unlocked frequency within the narrow lock-up range of the p.l.l.

Loop consideration

Because the lock-up temperature range and amount of filtration are in conflict, it is necessary to specify the operating condition. For reliable lock-up over the ambient temperature range 0 to 30°C, and because crystal stability is about 20 p.p.m. above 90°C, the control range required is

$$20\times\frac{30}{90}\times\frac{10^7}{10^6}$$

i.e. 66Hz at 10MHz.

This can be adjusted by C_{23}. For high-gain loops, the lock-up range is $2\sqrt{\zeta}\omega_n K_v$ (1) where $K_v=K_p K_o N$. For the 4046 in this configuration, K_p is 10V/rad, K_o by measurement is $93\times2\pi/10$ rad/V at 10MHz, and the division ratio N is 50. Therefore, K_v is $10\times93\ 2\pi/50=11.68$.

For average conditions a loop damping factor ζ of 0.707 is satisfactory, therefore from (1)

$$\frac{66\times2\pi}{50}=2\sqrt{0.707}\omega_n\,11.68$$

$$\therefore\ \omega_n=2.08$$

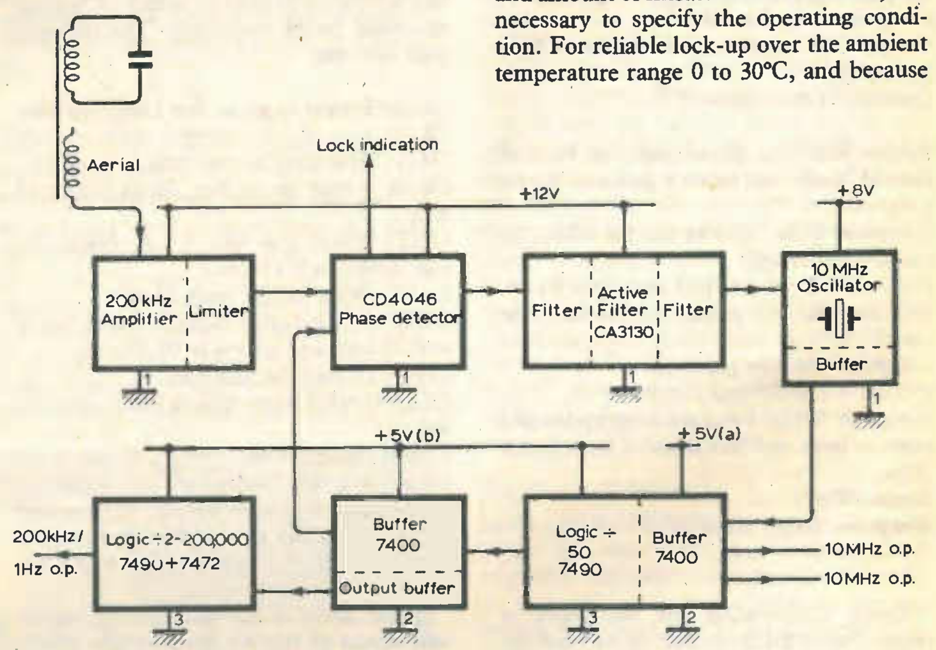
Considering the loop filter components in Fig. 4

$$T_1=C_1R_1=\frac{K_v}{\omega_n^2}=\frac{11.68}{(2.08)^2}\qquad T_2=C_1R_2=\frac{2\zeta}{\omega_n}=\frac{2\times0.707}{2.08}$$

$$\therefore\ T_1=2.69\qquad \therefore\ T_2=0.679$$

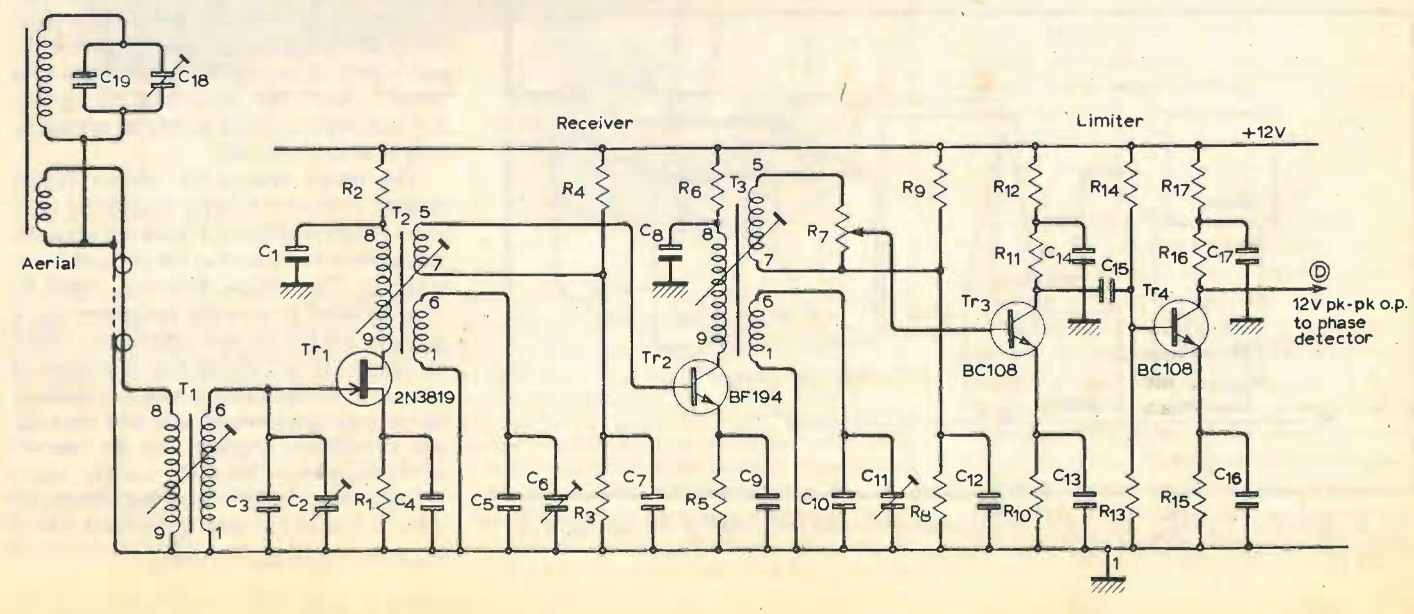
Because C_1 = 1μF, $R_{1/2}$ = 1.3MΩ and R_2 = 670kΩ. To increase the loop filtration, C_2 can be included, but to avoid affecting loop performance $10(C_2 R_{1/2}) < C_1 R_1$, therefore C_2 = 0.2μF. Lock-up time is roughly $5/\omega_n\omega 2s$.

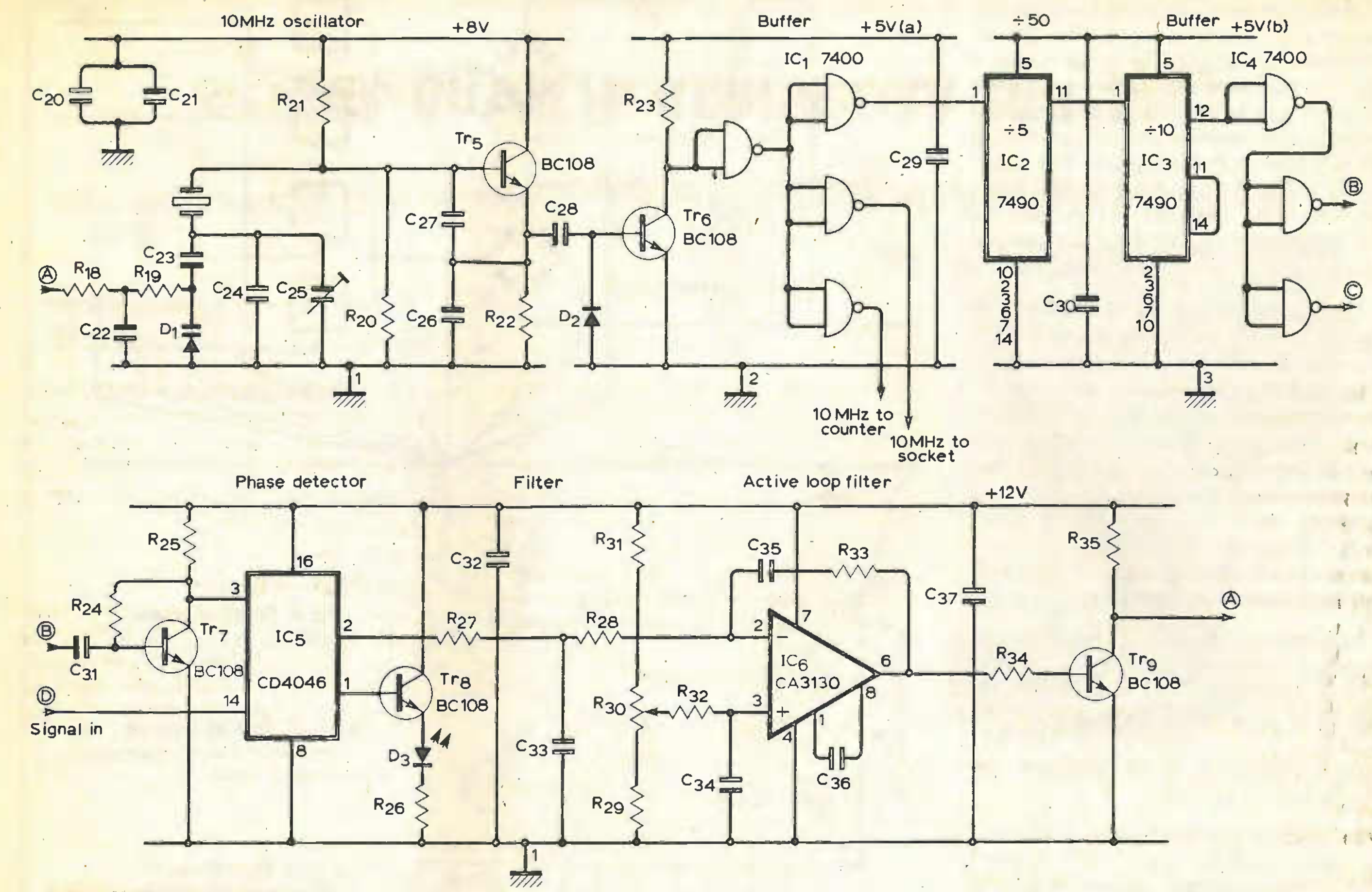
Measurements of the voltage present across the tuning diode show less than 10mV pk-to-pk noise, which is equivalent to $93/10\times0.01$ = 0.09Hz at 10MHz.



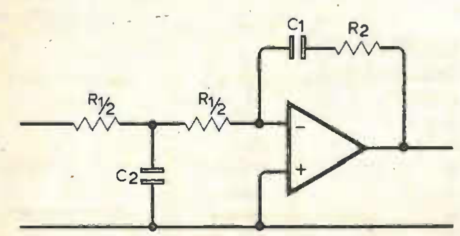
▲ *Fig. 1. Block diagram.*

Fig. 2. 200kHz receiver and limiter. ▼



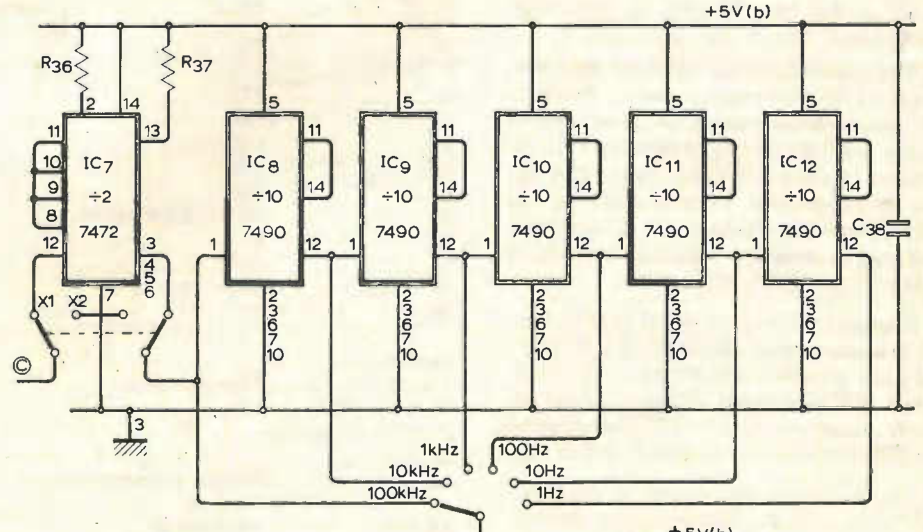


▲ *Fig. 3. Phase locked 10MHz oscillator.*



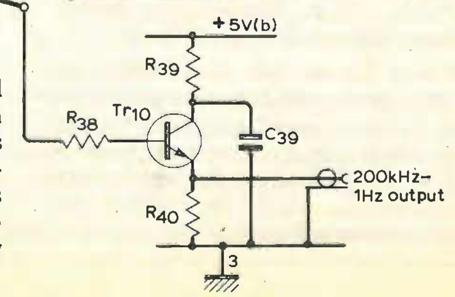
◀ *Fig. 4. Active-loop filter.*

Fig. 5. Divider chain with ×2 switching. ▼



Construction

The receiver is a conventional design and produces a 20mV output about 240km from Droitwitch. A manual gain control is included for adjusting the limiting conditions. Because high gain is used, it is necessary to screen the receiver in a die-cast box and to locate the aerial 2m away



from the receiver. To minimize signal frequency and counter noise, buffers are included before and after the divider chain in Fig. 5, and separate earth and power supplies are provided. Double-sided printed circuit board is also important with one side used as an earth plane. The power supply in Fig. 6 uses 1A voltage regulators and smoothing capacitors to provide the low noise level necessary for a clean output signal.

Adjustment of the receiver should be carried out using an oscilloscope to observe the waveform before the limiting stages. The aerial trimmer and each tuned stage is set to resonance so that the a.m. envelope is at a maximum. If the envelope amplitude is unstable and does not exhibit normal modulation variations, the receiver is probably oscillating and the feedback source should be investigated. The gain control is adjusted to give 10V pk-to-pk free from amplitude variations.

Adjustment of the loop is carried out by observing the phase-lock l.e.d. as follows, with no input signal – l.e.d. extinguished, with input signal connected and loop close to lock – l.e.d. pulses at the beat frequency, with input signal connected and loop locked – l.e.d. on.

To adjust the loop set point, disconnect the input signal and apply +10V to pin 2 of IC_6, check output voltage to diode is >10V. Apply 0V to pin 2 of IC_6 and check output voltage to diode is <0.5V. Resistor R_{34} can be adjusted if required. Next, adjust R_{32} for 5V to the diode with no drift. Reconnect the input signal and set C_{25} to obtain the lock indication. Finally, measure the ambient temperature and adjust the varicap voltage with C_{25} as shown in Fig. 7.

Because indication of lock is provided, if the unit is connected to an 8-digit 10MHz counter, count rates up to 10^7 per second or 10^8 in ten seconds can be accurately achieved.

The current system used by the BBC employs satellite transmitters at Westerglen and Aberdeen which are phase locked to the main Droitwich transmitter. In locations where a subsidiary transmitter signal is comparable in magnitude to the Droitwich transmission, the cleanest signal may be obtained with the aerial rod in line with the second transmitter.

If greater short-term signal purity is required, the crystal oscillator can be temperature stabilized to allow a narrower lock range and additional filtration. Alternatively, a narrow band crystal filter centred at 200kHz can be included before the limiter to reduce the energy of the a.m. sidebands. These improvements would, however, increase the cost of the unit.

Within the next five years Radio 4 will be changed to 198kHz, although it will maintain the present accuracy. To lock onto 198kHz, the receiver must be modified to include a mixer and narrow-band crystal filter to pick out the required sideband as shown in Fig. 8.

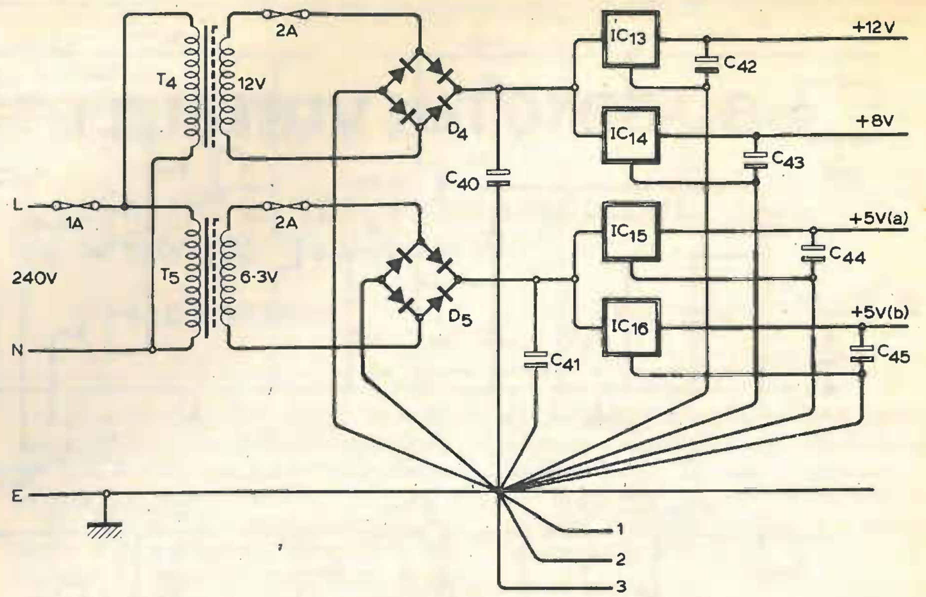


Fig. 6. Four rail power supply.

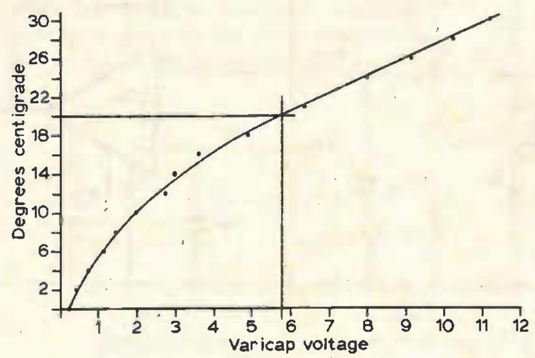
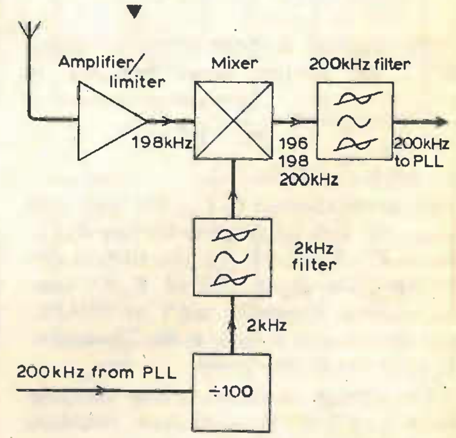


Fig. 7. Varicap voltage versus ambient temperature (loop locked).

Fig. 8. Modification necessary for 198kHz.



COMPONENTS

Resistors ½W	5%
1,36,37	1k
2	330
3,13	8k2
4	39k
5	870
6	4k
7	10k preset
8,10,22,35	2k2
9,18,19,29,31,38	4k7
11,16	5k6
12,17	100
14	56k
15,26	470
20,21	27k
23	560
24	620k
25	10k
27,28	1M
30	1k 10 turn trimmer
32	470k
33	670k
34	330k
39,40	51

Capacitors	
1,4,7,8,9,12,13, 14,15,16,17,21, 29,30,31,32,34,37, 38,39,	100n polyester
2,6,11,18,	30/80pF compression trimmer
3,5,10	180pF mica
19	300pF mica
20	10µF electrolytic
22,33	220n polycarbonate
23	10pF mica
24	27pF ceramic
25	2/10pF rotary trimmer
26,36	100pF mica
27	220pF mica
28	150pF mica
35	1µF polycarbonate
40,41	4000µF electrolytic
42,43,44,45	100µF electrolytic

Transistors	
1	2N3819
2	BF194
3-10	BC108

Transformers/coils
1 Denco I.T. Blue
2,3 Denco I.T. Yellow
4 12V 2A mains transformer
5 6.3V 2A mains transformer

Integrated circuits	
1,4	7400
2,3,8,9, 10,11,12	7490
5	4046
6	CA3130
7	7472
13	7812
14	7808
15,16	7805

Ferrite rod aerial
8 × ⅜in with 200 turns of 36 s.w.g. spread wound over 6in, and 15 turns of 36 s.w.g. close wound at one end of the rod.

Diodes	
1	OA81
2	BA102B
3	l.e.d.
4,5	2A 50V bridge rectifier

Crystal – 10MHz

F.m. detectors

A survey and a system of classification

by **S. W. Amos,** B.Sc. M.I.E.E.

An earlier article, in the April 1980 issue, was devoted to a survey and a classification of a.m. detectors. In this article the author similarly examines f.m. detectors.

The purpose of a detector is, of course, to abstract information from a modulated signal. Often the wanted information is a copy of the waveform of the modulation content but it is not always so. For example an f.m. detector may be required to give an output for a.f.c. purposes and here a filter is incorporated to eliminate modulation-frequency components from the output.

F.m. detectors are sometimes called discriminators or frequency discriminators but a discriminator differs from a detector in that it is required to produce an output substantially proportional to the deviation of the frequency (or phase) of an alternating input from some predetermined value (BS 301 5013). This suggests that the function of a discriminator is similar to that of a demodulator and is more specialised than that of a detector which is therefore a more general term. This distinction is not perfectly observed in the terminology of the circuits: for example two circuits with substantially the same performance and purpose are the Seeley-Foster discriminator and the ratio detector.

Frequency discriminators are sometimes called phase discriminators. The relationship between frequency modulation and phase modulation is simple: in frequency modulation, for a constant-amplitude modulating signal, the phase shift of the carrier is swept between limits which are inversely proportional to the modulating frequency: in phase modulation the limits are fixed. Similarly in phase modulation, for a constant-amplitude modulating signal, the frequency of the carrier is swept between limits directly proportional to the modulating frequency: in frequency modulation the limits are fixed. In practice this means that one form of modulation can be converted to the other by including a 6dB per octave filter in the modulating-signal path and, by use of such a filter, the same circuit can be used for the detection of f.m. or p.m. signals. For simplicity all the circuits mentioned in this article are referred to as f.m. detectors or discriminators.

An examination of the various types of f.m. detector suggests that they all belong to one of the following four categories:
(a) those consisting essentially of an f.m.-to-a.m. converter followed by an a.m. detector,
(b) those using phase comparators i.e. circuits in which the output is dependent on the degree of overlap of two sets of carrier-frequency pulses,
(c) those using a counter circuit as a discriminator,
(d) those using the locked-oscillator principle.

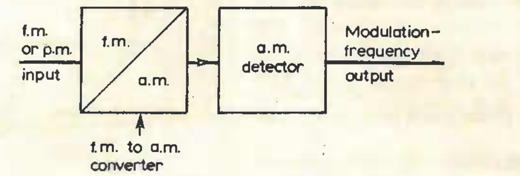


Fig. 1. Block diagram illustrating the form of a number of types of f.m. detector.

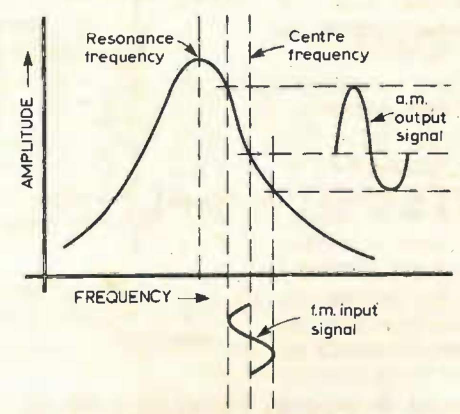


Fig. 2. Simple f.m. slope detector.

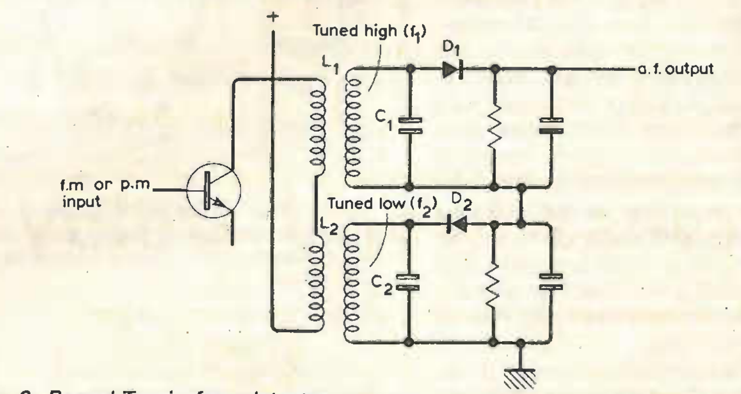


Fig. 3. Round-Travis f.m. detector.

This classcation will now be examined in detail.

F.m. detectors incorporating an f.m.-to-a.m. converter

Perhaps the most obvious way of detecting an f.m. signal is to convert the frequency variations into corresponding amplitude variations of the carrier which is then applied to an a.m. detector. A number of types of f.m. detector operate on this principle which is illustrated in Fig. 1.

Slope detector. A simple way of achieving f.m.-to-a.m. conversion is to make use of the slope of the skirts of the amplitude/frequency characteristic for a tuned circuit. If the resonance frequency of the tuned circuit is so chosen that the centre frequency of the signal falls on a suitable part of the characteristic, as shown in Fig. 2, then the output is a signal which is amplitude-modulated and frequency-modulated by the same modulating signal. If this output is applied to an a.m. detector, the frequency modulation will be ignored but the amplitude modulation will give an output at the modulation frequency. The curvature of the skirts of the resonance curve causes harmonic distortion which can be minimised by choice of Q value and resonance frequency for the tuned circuit but the distortion is still serious.

Round-Travis detector. In this form of detector the distortion caused by curvature of the tuned-circuit characteristic is reduced by use of the push-pull principle. Two similar tuned circuits are used, one (L_1C_1, resonant at a frequency f_1 above the centre frequency and the other (L_2C_2) resonant at f_2 an equal amount below the centre frequency. The signals developed across L_1C_1 and L_2C_2 are detected by separate a.m. detectors, their outputs being connected in series opposition. One possible circuit diagram for a Round-Travis detector is shown in Fig. 3 in which simple sampling-type detectors are shown.

The operation of the detector is illustrated in Fig. 4. At the centre frequency equal outputs are received from the two diodes so that the net output is zero. At frequencies above the centre frequency D_1 gives a larger output than D_2 and the combined output is positive: at frequencies below the centre frequency D_2 gives a larger output than D_1 and the combined output is negative. Thus the net output indicates by its polarity whether the instantaneous frequency of the input is above or below the centre value and by its magnitude the extent of the deviation.

Fig. 4 shows that the complementary curvature of the characteristics for L_1C_1 and L_2C_2 yields a straighter overall amplitude/frequency relationship than is possible from a single tuned circuit. The overall relationship shown in Fig. 4 has the S-shaped form characteristic of that of many f.m. detectors.

The Round-Travis detector was at one time used in f.m. receivers but has long since been abandoned in favour of some of the alternative types described later. It has two main disadvantages:

- L_1C_1 and L_2C_2 must be so adjusted that their resonance frequencies f_1 and f_2 are symmetrically disposed about the centre frequency. Thus alignment of the detector circuit is more complicated than for a number of the alternative types which require alignment only at the centre frequency.
- It responds to any amplitude modulation of the input signal. To obtain maximum signal-to-noise ratio, an f.m. receiver should respond only to frequency modulation of the input signal and should ignore any amplitude modulation which may be present. Some f.m. detectors can be designed to have inherent a.m. rejection and these are naturally preferred.

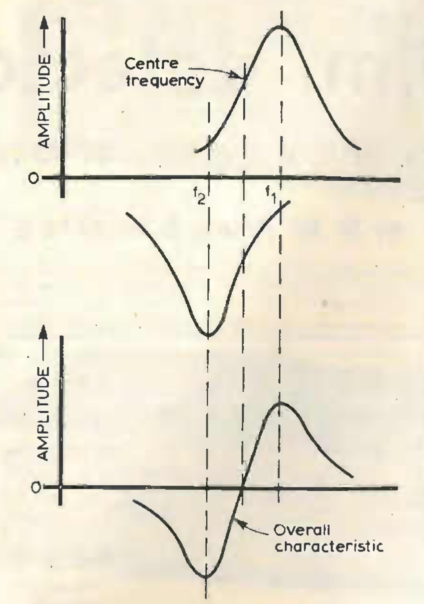


Fig. 4. Derivation of overall characteristic of Round-Travis f.m. detector.

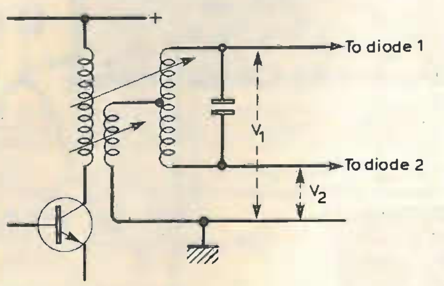


Fig. 5. Method of deriving the two diode inputs in Seeley-Foster and ratio detectors.

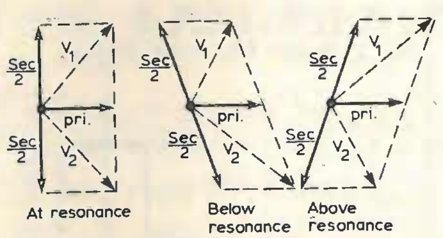
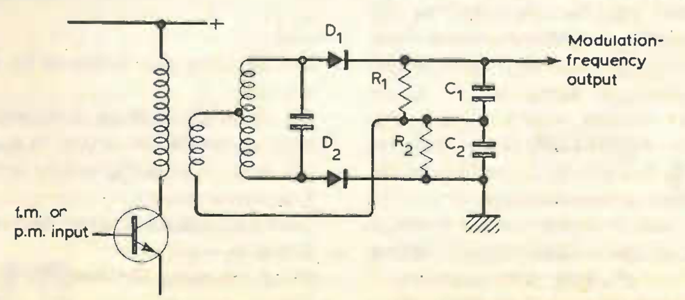


Fig. 6. Vector diagram for the circuit of Fig. 5 showing how the voltages V_1 and V_2 applied to the diodes vary with frequency.

Fig. 7. One circuit for a Seeley-Foster discriminator.



Seeley-Foster discriminator. This f.m. detector uses an arrangement of diodes similar to that of the Round-Travis circuit but the method of providing the diode input signals is different. The method makes use of the phase relationship between the voltage across the tuned secondary winding of a transformer and that across the primary winding. Whether the primary winding is tuned or not, these two voltages are in quadrature when the applied signal is at the resonance frequency of the secondary winding. At frequencies above resonance the secondary voltage lags the quadrature condition to an extent dependent on the frequency deviation and at frequencies below resonance the secondary voltage leads on the quadrature condition to an extent depending on the deviation.

If therefore the secondary winding is centre-tapped and if a sample of the primary voltage is injected into the centre tap, as shown in Fig. 5, the voltages V_1 and V_2 at the two ends of the secondary winding vary with frequency in the same way as those from the two tuned circuits in the Round-Travis circuit. This is shown in the vector diagram of Fig. 6 which illustrates the relative magnitudes of V_1 and V_2 at resonance, above and below resonance. These diagrams apply when the primary voltage is equal to half the secondary voltage.

Thus a Seeley-Foster circuit could be made up from the circuit shown in Fig. 5 feeding into two simple diode circuits as shown in Fig. 7. An alternative circuit which simplifies the design of the transformer is to use a capacitive link between primary winding and secondary centre tap as shown in Fig. 8. By this means the whole of the primary voltage is injected into the secondary circuit.

The introduction of the capacitor C_p interrupts the diode circuit. Normally when a diode detector is fed via a series capacitor the diode and its load resistor are both shunt-connected to ensure that the capacitor can be charged once per cycle when the diode conducts and can discharge through the load resistor when the diode is cut off by the input signal. In the circuit of Fig. 8(a) the series capacitor can certainly charge when the diodes are driven into conduction by the input signal

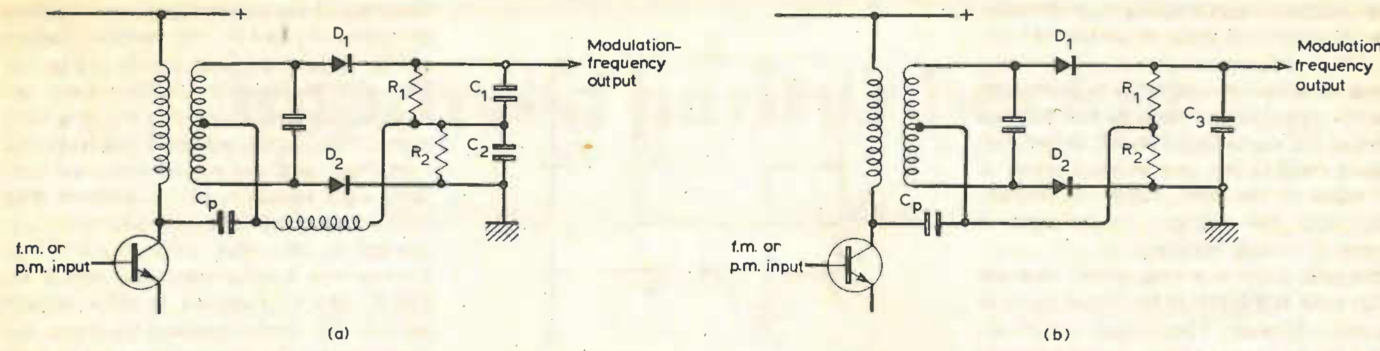


Fig. 8. Two forms of Seeley-Foster circuit using a capacitive link between primary and secondary windings.

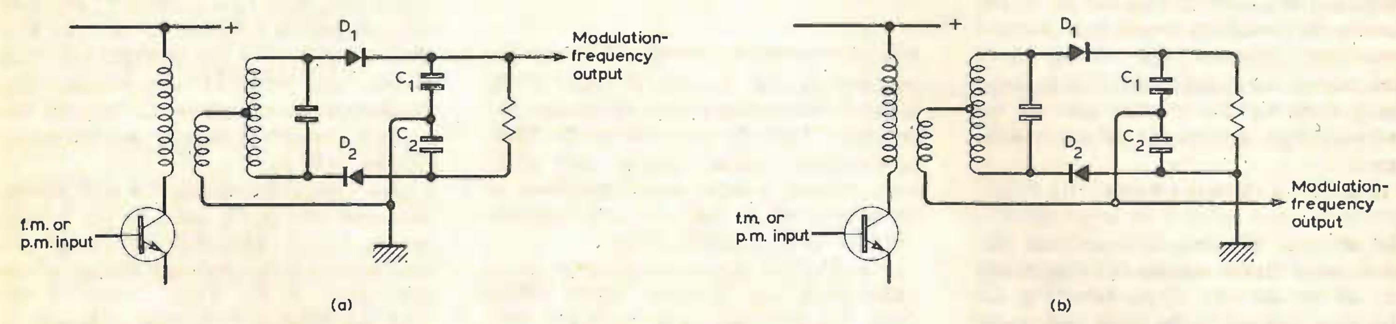


Fig. 9. Simplified circuits for (a) balanced and (b) unbalanced forms of ratio detector with no provision for a.m. rejection.

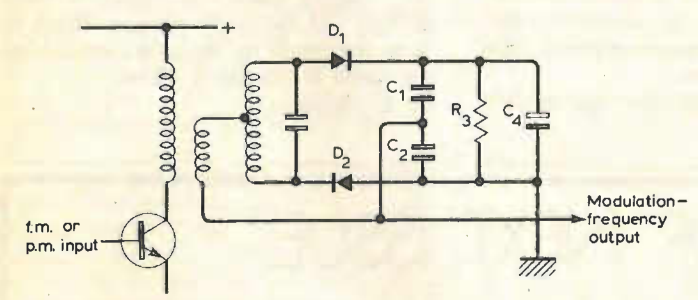


Fig. 10. The circuit of Fig. 9 (b) modified so as to give a measure of a.m. rejection.

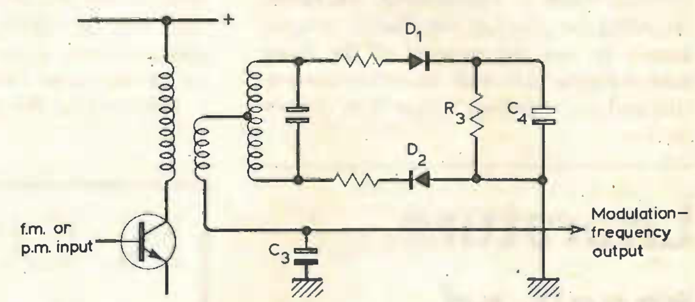


Fig. 11. An unbalanced ratio-detector circuit with a single reservoir capacitor C_3.

but, for the periods when the diodes are cut off by the input signal, a discharge path must be provided between the right-hand plate of C_p and the junction between R_1C_1 and R_2C_2. Moreover this path must not introduce significant damping of the primary circuit. There are two techniques which are commonly adopted to achieve this end:

- As shown in Fig. 8(a) an inductor can be introduced between the secondary centre tap and R_1R_2 junction. This should have an inductance such that its reactance is large compared with that of C_1 and C_2 at the operating frequency.
- If the link between R_1R_2 and C_1C_2 is cut a direct connection can be made between the coupling capacitor and R_1R_2 junction as shown in Fig. 8(b). Damping of the primary circuit can be minimised by using sufficiently large values for R_1 and R_2. As shown C_1 and C_2 can be replaced by a single equivalent capacitor, C_3.

The Seeley-Foster discriminator was extensively employed in early f.m. receivers. Alignment is straightforward, needing only a signal source at the centre frequency and linearity can be made acceptable. Its chief disadvantage, shared with the Round-Travis circuit, is that it responds to any amplitude modulation of the input signal. Thus to obtain the high signal-to-noise ratio of which an f.m. receiver is capable it is necessary to precede the Seeley-Foster circuit by one or more amplitude-limiting stages to minimise any a.m. content in the received signal.

Ratio detector. By a simple modification the Seeley-Foster discriminator can be made capable of a useful degree of a.m. suppression. The detector circuit so produced is known as the ratio detector and it is not surprising that it rapidly displaced the Seeley-Foster discriminator. The way in which the ratio detector operates can be approached in the following way.

If one of the diodes in the circuit of Figs. 7 or 8(a) is reversed, the net output is the sum of the voltages across the individual diode loads (not the difference as in the Seeley-Foster circuit). Thus for an input to the circuit at the centre frequency there is a voltage at the combined output approximately equal to the sum of the peak input voltages to the diodes: this compares with zero output from the Seeley-Foster circuit.

If the frequency of the input is displaced from the centre value the output across one diode load increases whilst that across the other decreases as shown for V_1 and V_2 in Fig. 6 and the combined voltage output tends to be independent of frequency and thus of frequency modulation. This combined output is proportional to input signal amplitude and can be used to operate a tuning indicator.

Even though the voltage across (C_1+C_2) is constant (for a given input amplitude) the voltages across the individual reservoir capacitors C_1 and C_2 vary with the frequency of the input signal and either capacitor can be used as the source of modulation-frequency output from the detector. In a balanced ratio detector circuit the junction of C_1 and C_2 is earthed and the detector output is taken from the non-earthy terminal of C_1 (as shown in Fig. 9(a)) or C_2. In an unbalanced ratio detector one end of the combined diode load is earthed as shown in Fig. 9(b) and the detector output is taken from C_1C_2 junction. In both types of circuit the constant voltage across the series-connected reservoir capacitors C_1 and C_2 is divided in a ratio determined by the peak inputs to D_1 and D_2: this is the origin of the name of the circuit.

To make the circuit capable of a useful degree of a.m. rejection the diode load resistor(s) are given low value(s) so that the tuned circuit feeding the detector is heavily damped. A large value capacitor is then connected across the load resistors to give a time constant approaching one second. Fig. 10 illustrates these modifications applied to an unbalanced circuit. The voltage across the long-time-constant network is in practice approximately equal to the peak value of the input signal to the diodes and adjusts itself to any permanent change in the value of the peak input. As already mentioned this voltage can be used to operate a tuning indicator.

Suppose there is a momentary increase in the peak amplitude of the signal input to the ratio detector. The voltage across the diode load circuit cannot instantaneously adjust itself to equal the peak value of the spike and as a result the diodes are driven heavily into conduction and their forward resistance increases the already-heavy damping on the tuned circuit thus momentarily reducing the voltage gain of the previous stage, minimising the effect of the spike.

Similarly if there is a momentary reduction in the peak value of the input signal to the detector, the long-time-constant network again cannot register the change and the diodes are cut off so removing the damping imposed by the diode load on the tuned circuit. Thus the gain of the previous stage is momentarily increased, offsetting the effect of the change in input signal. In fact the removal of the diode load damping can result in overcompensation and a common technique is to include

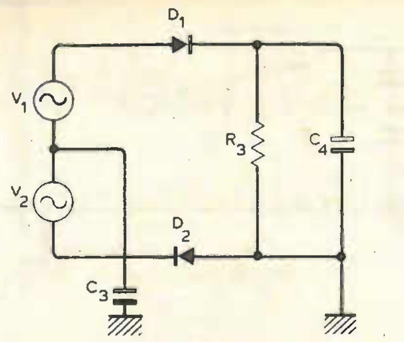


Fig. 12. Equivalent circuit of Fig. 11.

low-value resistors in series with the diodes as shown in Fig. 11, the resistance being adjusted empirically to give optimum a.m. rejection. Thus the inclusion of the long-time-constant circuit enables very short term changes in input signal amplitude to be minimised: in fact the ratio detector operates as a dynamic limiter.

Fig. 11 gives the circuit diagram of an unbalanced ratio detector which differs from that described earlier in that it contains only a single reservoir capacitor C_3 in place of the two shown in earlier circuits. The way in which the modulation-frequency output is developed across C_3 can be explained as follows.

If we replace the secondary and tertiary windings of the transformer by equivalent generators V_1 and V_2, the essential feature of Fig. 11 take the form shown in Fig. 12. Both diodes conduct together once per carrier cycle and, because of the long time constant R_3C_4, the period of conduction is very brief and occurs as the combined diode input signal (V_1+V_2) reaches its peak value. As a result of this conduction C_4 is charged to the peak value of (V_1+V_2). During this brief conduction period D_1 and D_2 can be regarded as short circuits and D_2 effectively connects C_3 across the generator V_2. C_3 thus charges to the peak value of V_2. For an input signal at the centre frequency V_1 is equal to V_2 and thus C_3 is charged to a voltage equal to one half that across C_4. For the remainder of each carrier cycle when D_1 and D_2 are non-conductive the charge on C_3 remains except for a small leak through any resistor in parallel with it.

One cycle later, during the next period of conduction of D_1 and D_2, the voltage across C_3 is adjusted by charge or discharge to agree with any change in the peak value of V_2. Thus a copy of the changing value of V_2 is built up across C_3 and this is, of course, a representation of the changing phase relationship between primary and secondary voltages which, in turn, represents the frequency-modulated waveform of the input signal.

To be continued

Literature received

Switching diodes from Unitrode are listed and described in brochure (SSD-600D), which contains details of both commercial and JAN/-JANTX devices. Unitrode (UK) Ltd, Deepdene House, Bellegrove Road, Welling, Kent DA16 3PY. WW401

Serck Controls have expanded the range of Lexor **delay lines**, which are the subject of a series of leaflets, covering various types with delays of 1ns to 1000ns. Leaflets available from Serck Controls, Rowley Drive, Coventry CV3 4FH. WW402

Colour brochure from SE Labs contains brief information on the company's range of **multichannel oscillographs**, signal conditioners and transducers. Frequency response equipment is also mentioned. Obtainable from The Instrumentation Division, SE Labs (EMI) Ltd, Spur Road, Feltham, Middx TW14 OTD. WW403

Application notes on the use of **Exar devices** as sine-wave converters, modems, and carrier detectors, with some general information on the use of op-amps is available from Rastra Electronics Ltd, 275-281 King Street, Hammersmith, London W6 9NF. WW404

Radio Link is a **radiotelephone** message-handling system from Blick which is described, together with a radio pager, in a leaflet available from Blick International Systems Ltd, Blick House, Techno Trading Estate, Bramble Road, Swindon, Wilts. SN2 6ER. WW405

Improved parity checker

Moving check detects double errors

by N. Darwood

An improved method of parity checking is described, which avoids the difficulty of recognizing two errors.

Before proceeding with the suggested innovation, it may be helpful first to see what parity is and how conventional parity-checking systems work.

In the particular sense of error detection in a group of digits, the parity of a number is the sum of its digits. For example, the parity of 142 is odd, because the sum of its digits is 7, which is an odd number: 93 has even parity. Numbers in the binary notation are similarly assigned even or odd parity if the sum of the constituent 1s is even or odd: 1000100, for example, exhibits even parity, while 0110100 has odd parity.

Parity bits are used in both serial and parallel data channels, in which they are often called horizontal and vertical parity bits respectively, as indicated by Fig. 1. In either case an extra bit (the parity bit) is added to the number. It is made either a 1 or a 0 such that the total number of 1s overall (i.e. in the number plus the parity bit) is even. Some examples are shown below:

Data	P
1000100	0
1110111	0
0110100	1
1101101	1
0110011	0
0100000	1

Data plus the parity bit is called a word in Fig. 1.

An error in transmission changes a 1 to a 0 or a 0 is changed to a 1. On reception, each word (a horizontal row in the first method of Fig. 1; a vertical column in the second method) is checked by counting the number of 1s in each word. If odd, then an error has occurred. If two errors occur in a word the parity is not altered and they will pass undetected, but three can be detected as an error. The fact that two errors are not detected is a disadvantage of conventional parity checkers. This article remedies this disadvantage.

The new coding method came into being following a requirement for a check on a serial digital data channel, as in Fig. 1 (a). Having reviewed the two methods of how a parity bit can be employed the obvious solution was to tack on a parity bit at the end of each word. Unfortunately, the data

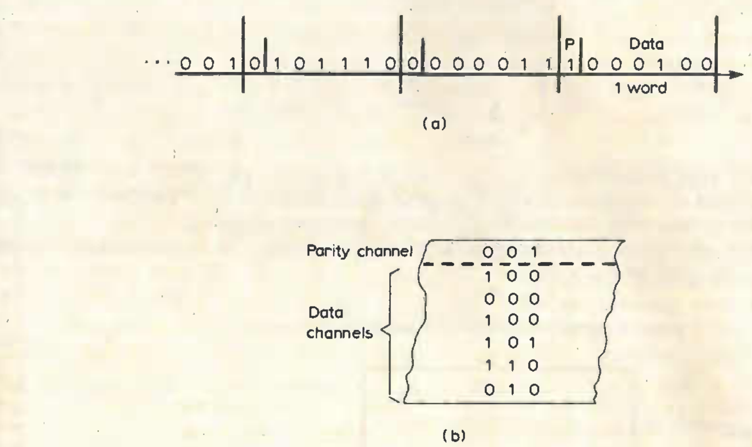


Fig. 1. Parity bits in serial (a) and parallel (b) data channels.

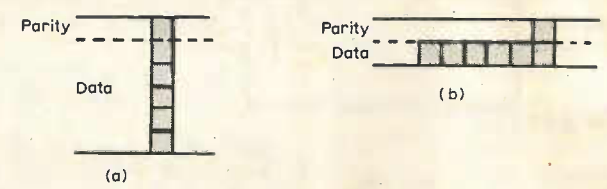


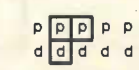
Fig. 2. Checking area of a parallel channel can be 'bent' to enable one parity bit to check serial data as in (b).

stream could not be interrupted to insert the parity bit, which meant that an extra channel, acting as a vertical parity bit, would have to be used. A first attempt at a solution is shown below, where each column is of even parity.

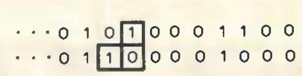
Parity	...11001010
Data	...11001010

Although this trial attempt at a solution will detect one error, two errors will pass undetected. But what is worse is that here there is 100% redundancy.

Figure 2(a) emphasizes that the 'checking area' of the parallel channel of Fig. 1(b) is a vertical column, so that, for a serial data channel, the checking area can be rotated through a rightangle as shown in Fig. 2(b). This forms a vertical parity bit which checks horizontal data bits. Any single error within the checking area will be detected because it will make the parity odd but, what is more, now two errors will be detected, as will any number of errors in a block of 12 (with one exception). To understand why this is so, assume only a two serial data bit checking area. The checking area is then depicted thus,



A typical sequence would be as shown below, with the checking area at one position



At the receiver, the parity-checking circuit will check for even parity over the 3-bit area. For this illustrative case, all single, double and treble errors (with one exception) will be detected, as will a block of four errors.

How the multiple errors are detected can be shown by passing the error pattern through the checking area, as in Fig. 3(a), where any odd number of errors in the checking area indicates an error.

The only pattern not detected is

As this pattern passes through the checking area, an even number of errors is counted at each position and no error is

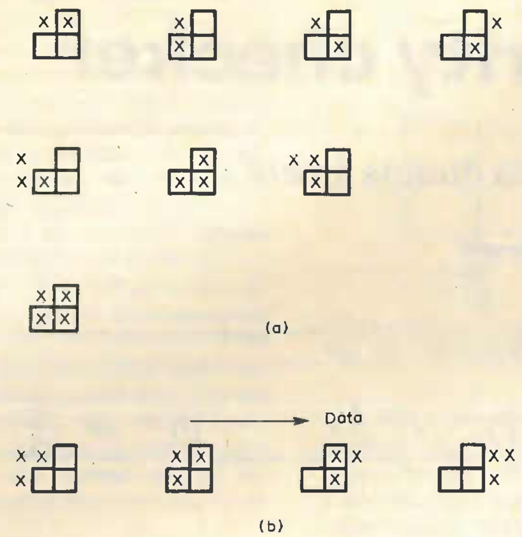


Fig. 3. Two, three and four errors, distributed as at (a) are detected, since the parity check gives an odd result at some point as the data stream passes the checking area. The pattern at (b) is not detected, because the parity remains even at any position.

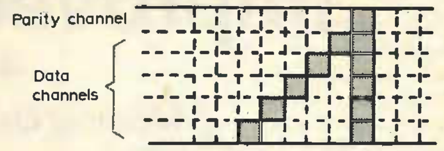


Fig. 5. Suggested checking area for parallel data channel.

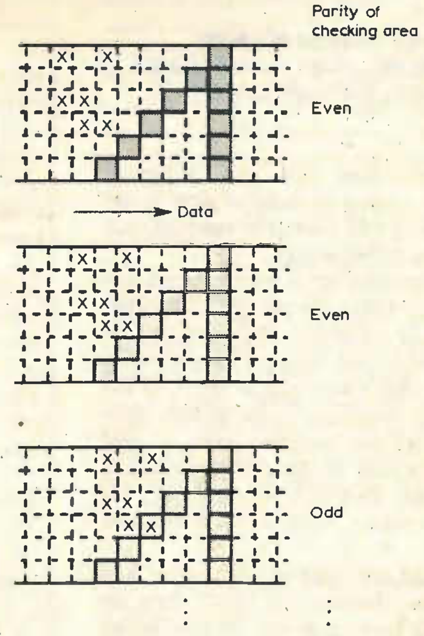


Fig. 6. Operation of the parity check of Fig. 5.

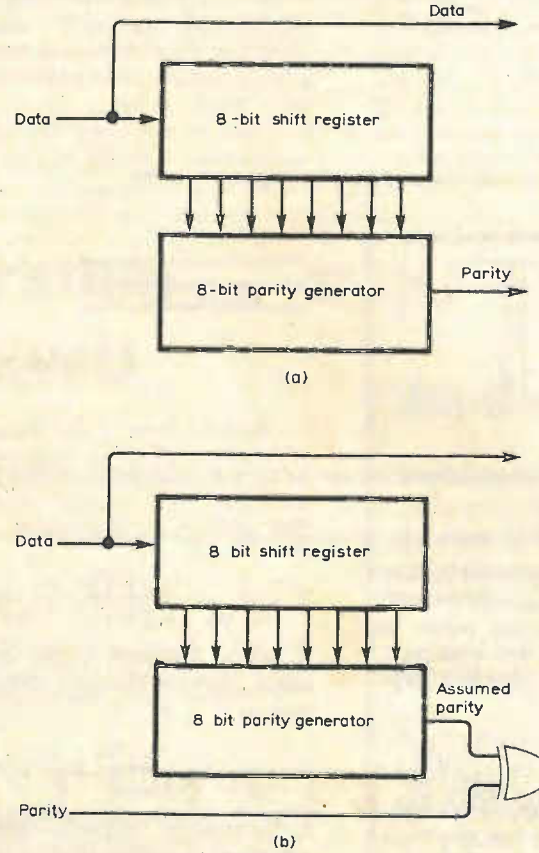


Fig. 4. Logic diagram of parity generation and checking.

indicated. Fig. 3(b) shows why this is so.

In a working parity checker, it is convenient to use eight channels because 8-bit i.cs are readily available. At the transmitter, the parity-generating logic consists of a shift register, which forms the eight fictitious channels from which the parity bit is generated by an 8-bit-input parity-generating chip. Fig. 4(a) shows a typical arrangement.

At the receiver, shown in Fig. 4(b), the same circuit is used to form an 'assumed parity' which is compared with the actual received parity bit. The comparison is shown below

Assumed	Received	Error
0	0	No
0	1	Yes
1	0	Yes
1	1	No

This logic function is the final exclusive-Or in Fig. 4(b). Finally, the checking area for the 8-channel system is

x
x x x x x x x x

The one combination of errors not detected is shown below

x x x x x x x x
x

Note that this error pattern is the checking area, rotated through 180°. Why it is not detected can be seen by passing it through the checking area.

The principle of moving parity, can be extended to embrace the parallel system shown in Fig. 1(b). Fig. 5 shows a checking area which is easy to implement in hardware. Even so, it is difficult to find an error pattern in a block of 36 that can pass undetected, other than the checking area rotated through 180°. An example of one attempt is shown in Fig. 6 to demonstrate how the checker works.

Further reading

Darwood N. 'A Moving Parity Check Method' *Electronic Engineering*, April 1979.

NEW PRODUCTS

Video recorder

Low weight is the main feature of the VT 7000 video recorder from Hitachi, as it weighs only 6.8kg, including its rechargeable battery pack. This v.h.s. recorder can be powered by its own batteries, a car battery or by the mains supply. There are two possible ways of operating the recorder: one can either use the touch buttons on the front of the unit, or the remote control keypad which is supplied as standard. Numerous sockets are provided for connexion to a monitor or other v.t.r., video camera, microphone, earphone, and for receiving audio and video signals from another v.t.r. or external sound equipment. To extend the scope of the VT 7000, the same manufacturers have also introduced a tuner, the VT TU 70, which is similar in style to the recorder. A time-control mechanism on the tuner can be set, with the aid of an inbuilt digital clock, to record programmes after a time interval of up to 10 days from any one of the 12 tv channels. An a.c. mains-powered charger for the batteries of the VT 7000 is built into the tuner. Both recorder and tuner are supplied with all the necessary connecting leads and their prices are £579 and £159 respectively, including v.a.t. Hitachi Sales (UK) Ltd, Hitachi House, Station Road, Hayes, Middx.

WW301

WW301

Linear test system

A large range of devices including d.-to-a. and a.-to-d. converters, can be tested by means of the LTS 2000 benchtop automatic test instrument from Analog Devices Inc. This system is designed for use in incoming inspection, device selection and grading and other such applications. At the heart of the system is a 16-bit microcomputer, backed up by 4Kbyte of e.p.r.o.m., 60Kbyte of r.a.m. and a 92Kbyte floppy-disk unit. Other main parts of the system are a 40-character dot-matrix display, a thermal printer and an alpha-numeric keyboard. Devices to be tested are interfaced to the test-unit via "family boards" which contain all the circuits necessary to measure a general class of components. In the simplest mode of operation of the LTS 2000, the operator needs only to press the 'START TEST' button to obtain a pass or fail message from the display. Setting up of the system is also relatively simple, since programming is carried out by a "fill-in-the-blanks" method which gives complete prompting: programs can also be supplied by the manufacturer. Full editing facilities are provided for both types of programming. Among the other types of device which can be tested are op-amps, comparators, voltage regulators, isolation amplifiers and c.m.o.s. switches. Analog Devices Ltd, Central Avenue, East Molesy, Surrey KT8 OSN.

WW302

WW302

Thermometer

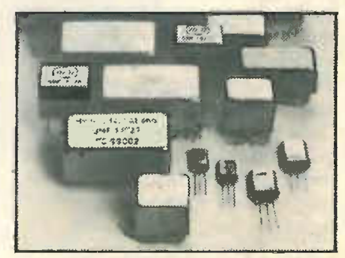
Conversion of the displayed temperature reading from °C to °F or vice versa, storage of maximum or minimum temperature values, and automatic calculation and display of the probe temperature minus the value stored in the memory are some of the features made possible by the use of a microprocessor in the hand-held digital thermometer type KM10,000 from Kane-May Ltd. For temperatures from −200 to +200°C, the resolution of the reading is 0.1°C (outside this range, the resolution is 1°C), and from −213 to +1820°C the accuracy of the reading is ±0.2°C, ±0.1%. For °F, the resolution is 1°F for the full range. A backlit 10mm l.c.d. display is used to display the temperature and give indications as to the mode of operation, as well as providing numerically coded information in the event of a fault condition being discovered by the continuously running self-test. Warnings are also given for over and under-ranging of a particular thermocouple, a broken thermocouple and for incorrect execution of the temperature difference function. The unit is powered by rechargeable batteries. Kane-May Ltd, Burrowfield, Welwyn Garden City, Herts.

WW303

WW303

Crystal filters

Quartz crystal filters in a new range, designed for i.f. selection in u.h.f. and v.h.f. telephone systems, are available from Hy-Q Quartz Products Ltd. The QMF Series filters are for use in i.f. amplifiers with a centre-band frequency of 10.7MHz, and are obtainable in three basic types, for either 12.5kHz, 20kHz, 25kHz channel spacings. Each of these basic types is available in either 2,4,6 or 8 pole versions, which give stop bandwidths ranging from 18 to 90dB at the channel spacing frequency. An



operating temperature range of between −40 and + 80°C is quoted for these filters which can have either hermetically sealed or epoxy-filled cans, and are said to be suitable for use in mobile and portable transceivers. Hy-Q Quartz Products Ltd, Station Rod, Whittlesford, Cambridge CB2 4NL.

WW304

Multi-colour display

One of the reasons why analogue-reading meters are still used extensively in control and inspection "go, no-go" applications is that they are less tiresome to read than their digital counterparts. However, Eureka Electronics Ltd have announced the availability of the MCDPM digital panel meter which could provide an answer to the aforementioned drawback in digital meters as the colour of its display indicates the range into which the input voltage falls. The levels at which the displayed digits change colour are adjusted by trimmer potentiometers. In the standard version three ranges are indicated by green, yellow and red digit colours and three c.m.o.s. compatible outputs are provided, one of which goes "high" when the relevant colour is displayed to allow such devices as audible warning units, etc., to be driven with the aid of a suitable buffer. Colouring of the digits is achieved by using filtered backlighting. The 0.5in high, 3½ digit l.c.d. display has a viewing angle of 150°, a contrast ratio of better than 20:1, and its decimal point position is selectable at the input connector. An input impedance of greater than 100MΩ is quoted for both the N311 and N111 types which differ slightly in accuracy and other electrical specifications. Both types also have f.s. resolutions of ±199.9mV or ±1.999V as standard, with two other ranges as options. Many variations on the standard versions can be provided on request, including up to five digit colours in one unit. Standard models are priced at around £68 each. Eureka Electronics Ltd, Castle House, 27 Castle Street, Brighton, East Sussex BN1 2HD.

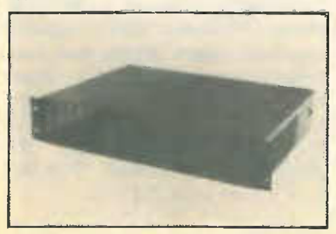
WW305

WW305

Instrument cases

A manufacturing service for small batches of custom-made equipment cases can now be provided by Le Clair Precision, who claim that they can produce cases quickly, and to any design in most materials and finishes from a simple sketch. This service is expected to be of particular interest to companies manufacturing specialized equipment in small quantities and to research and development departments requiring prototype equipment cases. Costs are said to be generally competitive with those for adapted standard equipment cases, and will depend upon size and features required. Le Clair Precision, The Green, Theale, Reading, Berks.

WW306



Power supplies

Recently introduced to the market is a range of 13.5V d.c. stabilized power supplies specifically designed for use with amateur radio equipment. The DRAE range from Davtrend Ltd consists of 3, 6, 12 and 24A output current versions all with fuse-protected outputs, current limiting, current foldback, thermal overload shutdown and crowbar overvoltage protection. Surge current ratings are typically twice as high as the continuous current ratings given above. Davtrend Ltd, 89 Kimbolton Road, Portsmouth, Hants.

WW307

Keyboard encoder

Up to 144 keys can be interfaced with a c.r.t. terminal using the n.m.o.s. MM57499 keyboard encoder from National Semiconductor, and a 4-12 line decoder. If interfacing of only 96 keys is required, no external components are needed, as this 28 pin i.c. provides direct interfacing, with serial transmit and receive, to a 12 × 8 matrix keyboard. The MM57499 also features a 400 word per minute burst rate and phrase storage, which allows the user to program in and store up to 14 key-stokes of data, which can be recalled using a single key. This data can be either a series of characters or control functions. Full upper and lower case ASCII, numeric and function encoding are "on-chip" and a "lock-out" feature is also provided to prevent two or more keys from being activated at the same time. National Semiconductor (UK) Ltd, 301 Harpur Centre, Horne Lane, Bedford.

WW308

Chopper op-amp

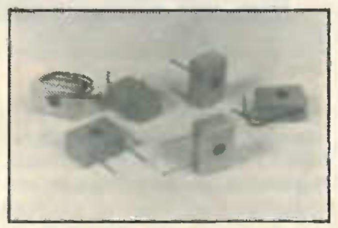
An input offset voltage of 1μV and an input bias current of 10pA maximum at 25°C are features of the ICL7650 chopper-stabilized op-amp from Intersildatel. Only two external capacitors are required for storing the correcting potentials on the chopper amplifier nulling inputs. Chopper drive and other control circuits are included on the chip, although the 14-pin package version also has provision for an external clock if required. Chopping spikes at the input and output are said to be minimized due to a unique design approach. The gain bandwidth product is 2MHz, the slew-rate is 2.5V/μs and the common-mode and power supply rejection is 120dB. The 7650 is available in both T099 and 14-pin plastic or ceramic d.i.p. versions and is internally compensated for unity gain operation. In addition, the output clamp circuit reduces overload recovery problems so that the device may be used as a precision comparator. Intersildatel (UK) Ltd, Snamprogetti House, Basing View, Basingstoke, Hants RG21 2YS.

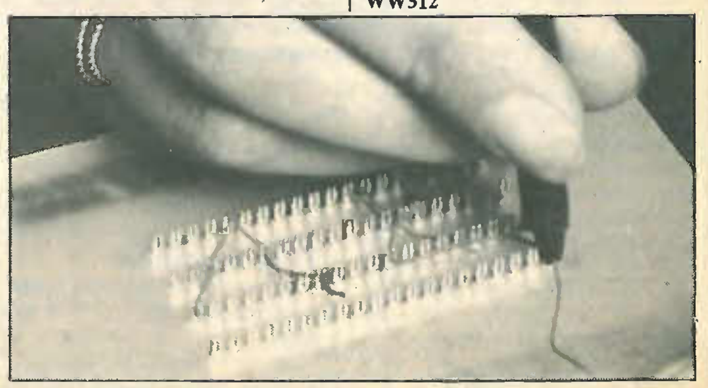
WW309

P.c.b. buzzers

Sound output levels of between 70 and 83 dB(A) at 22cm can be obtained from these miniature p.c.b.-mounting buzzers from Highland Electronics Ltd. Four types are available, in a range from 1.75 to 30V d.c., and the current consumption is 25mA maximum. The frequency of the tone produced is 400Hz. Both flat and right-angle-mounting versions can be obtained, all with dimensions of 22 × 15 × 10mm and weighing 7 gm each. Highland House, 8 Old Steine, Brighton, East Sussex. BN1 1EJ.

WW310





14-bit d-to-a

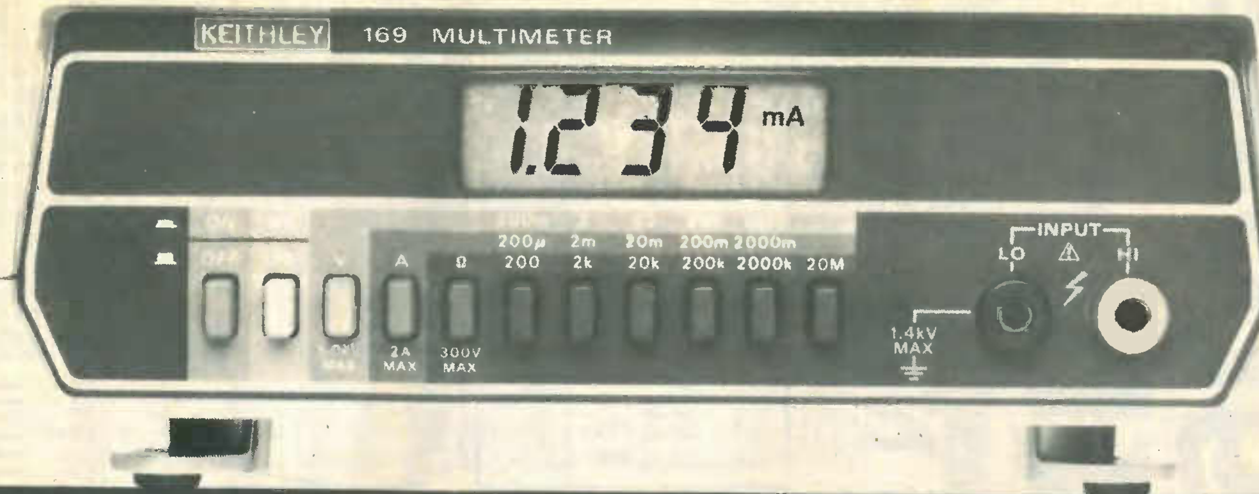
A signal to noise ratio of typically 85dB in the audio band is one of the features of the TDA1540 14-bit digital to analogue converter from Mullard Ltd. This converter is designed for use as a digital signal processor in sound recording and reproduction systems and includes "on-chip" data latches which eliminate the need for a deglitching circuit at the output. Other specifications for the TDA1540 are a non-linearity error of less than 3.10^{-5}, a current settling time 1μs to 1/2 l.s.b. of the 4mA full scale output, 300mW power dissipation and t.t.l. compatible outputs. Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD.

WW311

Prototype wiring system

An interesting alternative to wire wrap point-to-point wiring has recently been launched in the UK. The system, known as Quick Connect, uses an insulation displacement technique originally developed by Bell Laboratories, and provides sockets or terminals which are compatible with standard p.c.b. holes. Each socket/terminal has an insulation displacement connection tine on the underside of the board, which can accept two 30 gauge solid wires to provide four connections. To make a connection the wire is simply pushed, with the pencil provided, into the tine which penetrates the insulation and forms a gas tight contact with a typical resistance of 10mΩ. Because no wire stripping is necessary the system is very quick, especially when "daisy chain" connections are required. An important advantage of Quick Connect is the re-usable tine, which allows wired boards to be modified or stripped and used again. Another advantage is the low profile, 6.35mm compared with 16.64mm for wire wrap. At present Quick Connect can be used in three ways. Sockets and terminals can be supplied in bandoleer strips for insertion by the user, customers' boards can be factory fitted with the contacts, or standard socket boards can be purchased for general prototyping work. Astralux Dynamics Ltd, Red Barn Road, Brightlingsea, Colchester, Essex.

WW312



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HY60

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

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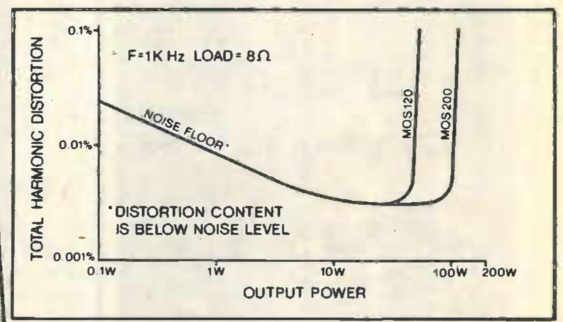

Load impedance both models 4Ω-∞ Input sensitivity both models 500mV
Input impedance both models 100KΩ Frequency response both models 15Hz-100KHz - 3dB

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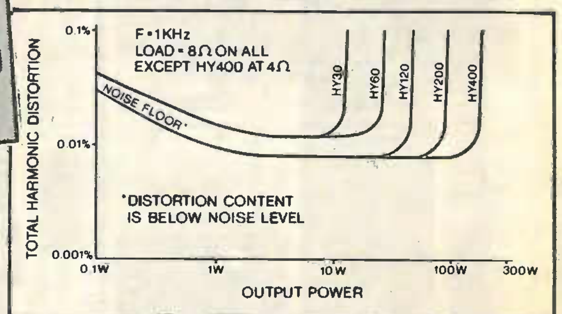
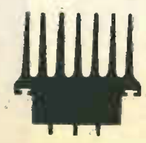
Model	Output Power RMS	Distortion Typical at 1KHz	Slew Rate	Rise Time	Signal/Noise Ratio DIN AUDIO	Price & VAT
HY30	15W into 4-8Ω	0.015%	15V/μs	5μs	100dB	£6.34 + 95p
HY60	30W into 4-8Ω	0.015%	15V/μs	5μs	100dB	£7.24 + £1.09
HY120	60W into 4-8Ω	0.01%	15V/μs	5μs	100dB	£15.20 + £2.28
HY200	120W into 4-8Ω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



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



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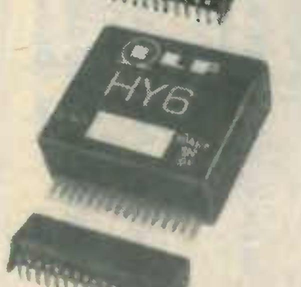

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HY6 (mono) and **HY66** (stereo) are new to I.L.P's range of advanced audio modules. Their improved characteristics and styling ensure their being compatible with all I.L.P power-amps both MOSFET and BIPOLAR, giving you chance to get the best possible reproduction from your equipment. HY6 and HY66 pre-amps are protected against short circuit and wrong polarity. Full assembly instructions are provided. Mounting boards are available as below.
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HY6 mono £5.60 + 84p VAT Connectors included
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B6 Mounting Board for one HY6 78p + 12p VAT
B66 Mounting Board for one HY66 99p + 15p VAT

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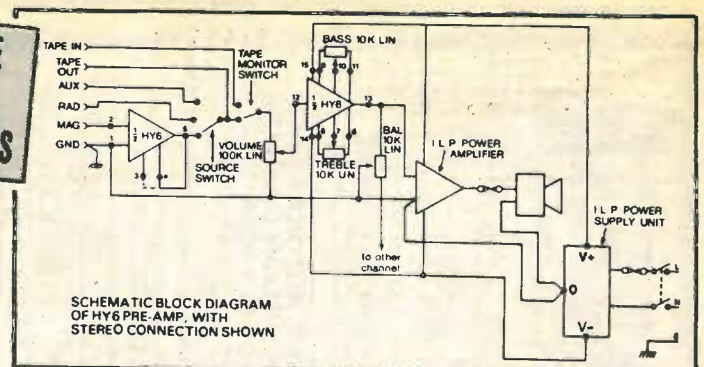

SCHEMATIC BLOCK DIAGRAM OF HY6 PRE-AMP, WITH STEREO CONNECTION SHOWN

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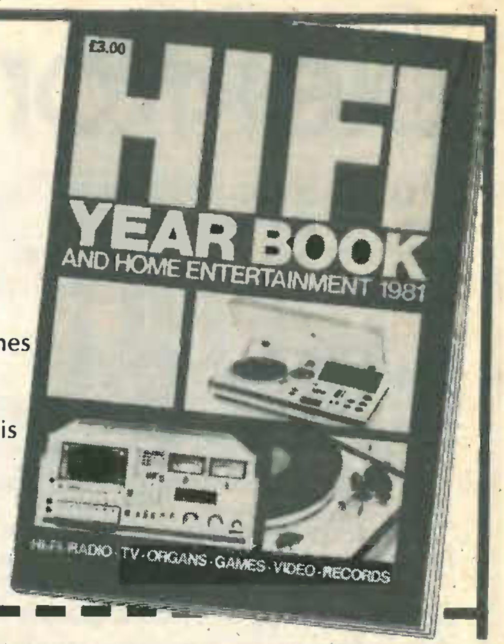

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WW2

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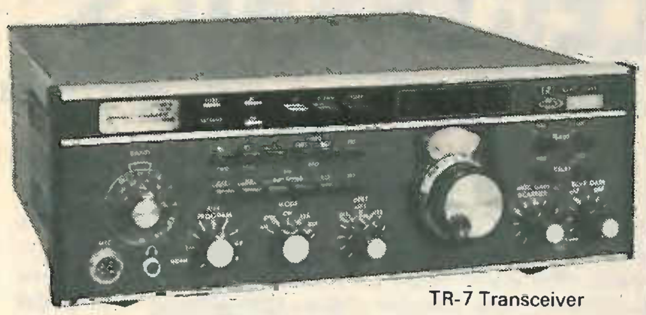

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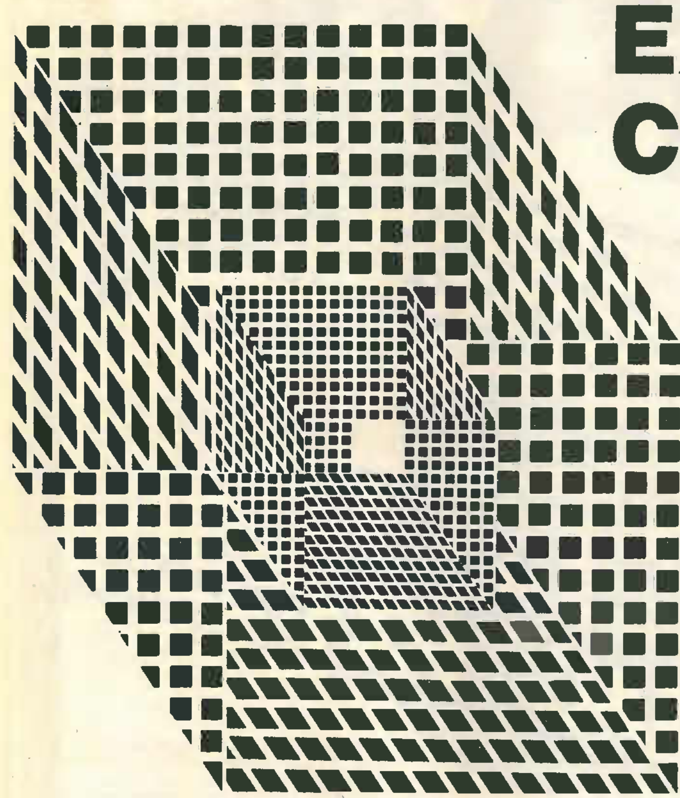

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HART

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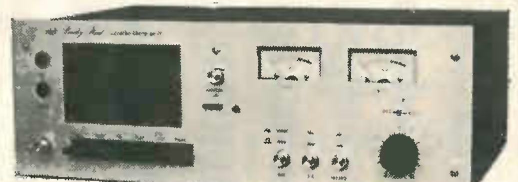
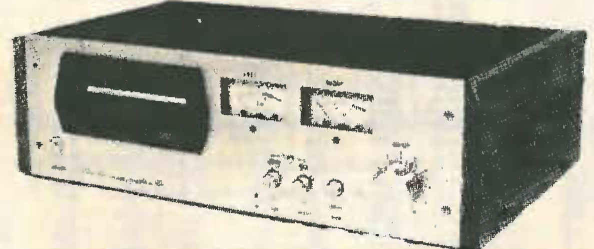
LINSLEY HOOD CASSETTE RECORDER 2



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.

LINSLEY HOOD CASSETTE RECORDER 1



We are the Designer Approved suppliers of kits for this excellent design. The Author's reputation tells all you need to know about the circuitry and Hart expertise and experience guarantees the engineering design of the kit. Advanced features include: High-quality separate VU meters with excellent ballistics. Controls, switches and sockets mounted on PCB to eliminate difficult wiring. Proper moulded escutcheon for cassette aperture improves appearance and removes the need for the cassette transport to be set back behind a narrow finger trapping slot. Easy to use, robust Lenco mechanism. Switched bias and equalisation for different tape formulations. All wiring is terminated with plugs and sockets for easy assembly and test. Sophisticated modular PCB system gives a spacious, easily built and tested layout. All these features added to the high-quality metalwork make this a most satisfying kit to build. Also included at no extra cost is our new HS15 Sendust Alloy record/play head, available separately at **£7.60** plus VAT, but included FREE as part of the complete kit at **£75** plus VAT.
REPRINTS of the 3 articles describing this design **45p.** No VAT.
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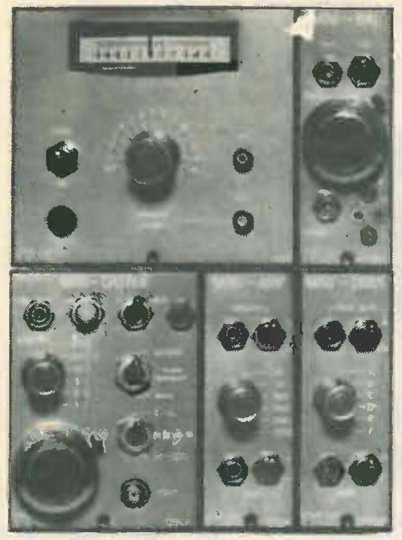

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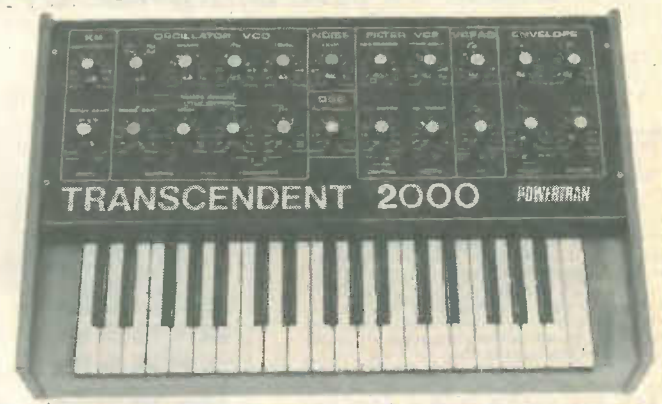
TRANSCENDENT 2000 SINGLE BOARD SYNTHESIZER

Designed by consultant Tim Orr (formerly synthesizer designer for EMS Ltd.) and featured as a constructional article in ETI, this live performance synthesizer is a 3 octave instrument transposable 2 octaves up or down giving sweep control, a noise 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.

The kit includes fully finished metalwork, fully assembled solid team cabinet, filter sweep pedal, professional quality components (all resistors either 2% metal oxide or ½% metal film), and it really is complete — right down to the last nut and bolt and last piece of wire! There is even a 13A plug in the kit — you need buy absolutely no more parts before plugging in and making great music! Virtually all the components are on the one professional quality fibreglass PCB printed with component locations. All the controls mount directly on the main board, all connections to the board are made with connector plugs and construction is so simple it can be built in a few evenings by almost anyone capable of neat soldering! When finished you will possess a synthesizer comparable in performance and quality with ready-built units selling for many times the price.

Comprehensive handbook supplied with all complete kits! This fully describes construction and tells you how to set up your synthesizer with nothing more elaborate than a multi-meter and a pair of ears!

COMPLETE KIT ONLY £168.50 + VAT!



Cabinet size 24.6" × 15.7" × 4.8" (rear) 3.4" (front)

NEW! TRANSCENDENT POLYSYNTH

Cabinet size 31.1" x 19.6" x 7.6" (rear) 3.4" (front)

EXPANDABLE POLYPHONIC SYNTHESIZER
AS FEATURED IN
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COMPLETE KIT from £320 + VAT

By brilliant design work and the use of high technology components the Polysynth brings to the reach of the home constructor a machine whose versatility and range of sounds is matched only by ready-built equipment costing thousands of pounds. This latest addition to the famous Transcendent family is a 4 octave (transposable over 7 octaves) polyphonic synthesizer with internally up to 4 voices making it possible to play simultaneously up to 4 notes. An add-on unit permits expansion up to 8 voices. Each voice is a complete synthesizer in itself with 2 VCOs, 2 ADSRs, 1VCA and 1 VCF. Being voltage controlled all voices can be adjusted simultaneously by master controls yet their own pitch and gate signals mean each voice can be operated independently from the keyboard.

Although using very advanced electronics the kit is mechanically very simple with minimal wiring, most of which is with ribbon cable connectors. All controls are PCB mounted and the voice boards plug into PCB mounted sockets. The kit includes fully finished metalwork, solid teak cabinet, professional quality components (resistors 2% metal oxide or 0.5% and 0.1% metal film), nuts, bolts, etc. Complete kit with 1 voice £320, 2 voices £368, 4 voices £464, expansion unit to extend to 8 voices £275 (all prices subject to V.A.T.). A mere fraction of what you would have to pay for a ready-built comparable instrument!

TRANSCENDENT DPX MULTI-VOICE SYNTHESIZER

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

COMPLETE KIT ONLY £299 + VAT!

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

The Transcendent DPX is a really versatile 5 octave keyboard instrument. These 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 as 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 as 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 vibrator comes in only after waiting a short time after the note is struck for even more realistic string sounds.

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!

POWERTRAN

MANY MORE KITS ON PAGES 95 and 99. ORDERING INFORMATION ON PAGE 95

All projects on this page can be purchased as separate packs, e.g. PCBs, components sets, hardware sets, etc. See our free catalogue for full details and prices.

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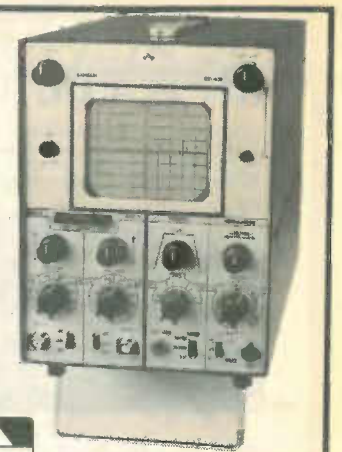
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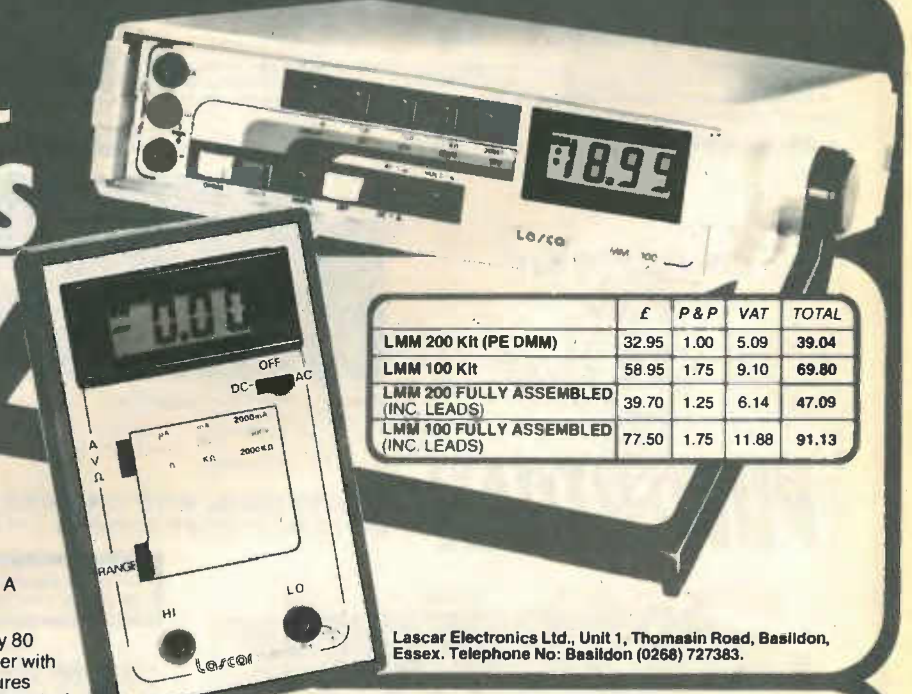
3½ DIGIT LCD MULTI-METER KITS



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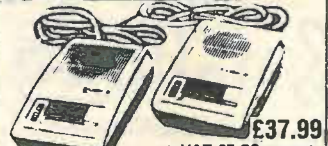

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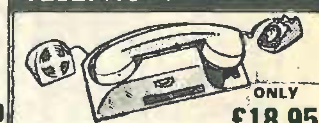

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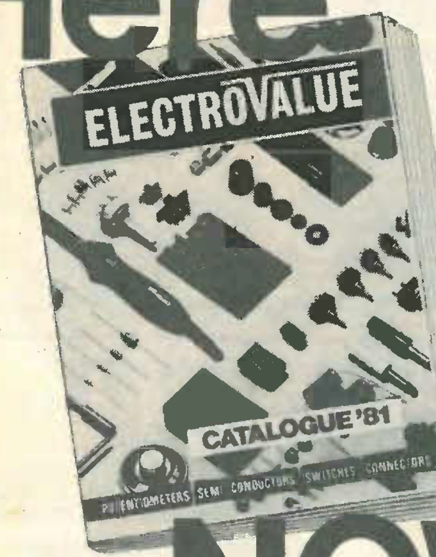

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8020A 3½ Digit hand held LCD DMM, spec as per 8024A with extra conductance range of 2mS but no peak hold, level or continuity ranges. Complete with carrying case. **£112.00**

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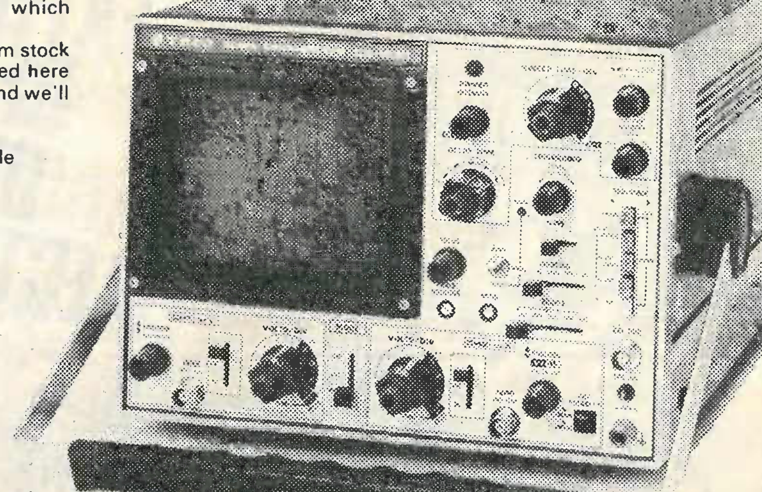
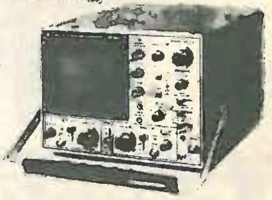


C.R.T.:
120 x 96 mm rectangular PDA with internal graticule
Y Bandwidth:
DC - 30MHz
Sensitivity:
5mV/div (30MHz)
2mV/div (20MHz)
Input RC:
1M/23pF
Risetime: 11.7nS
Beam Switch:
Chop/alternate
Modes:
CH1, CH2, Dual, Add, Subtract
Time Base:
Triggered, auto, or single shot
Sweep Time:
0.5S/div-200nS/div (40nS using X5 mag) 20 ranges in 1-2-5 sequence
Sweep Delay:
100mS-1uS adjustable with trace bright up for delay location
Z Modulation:
TTL compatible 10K impedance 5MHz bandwidth
Trace Rotation:
Electrical
And the Price?
£455 + VAT (includes 2 probes)

Also
CS1577A
Dual 30Mhz/2mV Signal Delay etc
£410 + VAT



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NRD 515 SYNTHESISED HF MONITORING RECEIVER	£948.75 inc. VAT
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NVA 515 LOUDSPEAKER UNIT	£27.60 inc. VAT
CFL 260 600Hz CW FILTER	£34.50 inc. VAT

The NRD 515 is a PLL-synthesised communications receiver of the highest class featuring advanced radio technology combined with the latest digital techniques. The new NRD 515 is full of performance advantages including general coverage, all modes of operation, PLL digital VFO for digital tuning, 24-channel frequency memory (option), direct mixing pass-band tuning, etc. JRC's 65 years of radio communications experience will give you "the world at your fingertips". The NRD 515 is but a single item from the JRC product range which extends all the way to full marine radio installations for supertankers.

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Manufactured under licence from the BBC the **PPM2** drive circuit used with an *Ernest Turner* meter movement is the definitive Peak Programme Meter approved by broadcasting authorities in the U.K. and overseas for critical programming monitoring. Reviewed Studio Sound September 1976. **PPM3** drive circuits have unbalanced inputs and may be used in equipment which will be required to pass IBA Code of Practice inspection. Drive circuits, meter movements, flush mounting adaptors and illumination kits from stock. Other level monitoring units are illuminated **PPM Boxes,** rack mounting **Peak Deviation Meters** and **Programme and Deviation Chart Recorders** for test purposes or making continuous record of levels in broadcasting.
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53	350	**10.08**	1.31
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84	1000	**20.64**	2.39
93	1500	**25.81**	O.A.
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500	**20.13**	1.89	67W
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2000	**54.97**	O.A.	95W

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Burglar Alarm Ultrasonic 20ft range, no installation costs. Key operated; built-in siren (external can be added). Looks like a speaker. **£98** £2 P&P + VAT.

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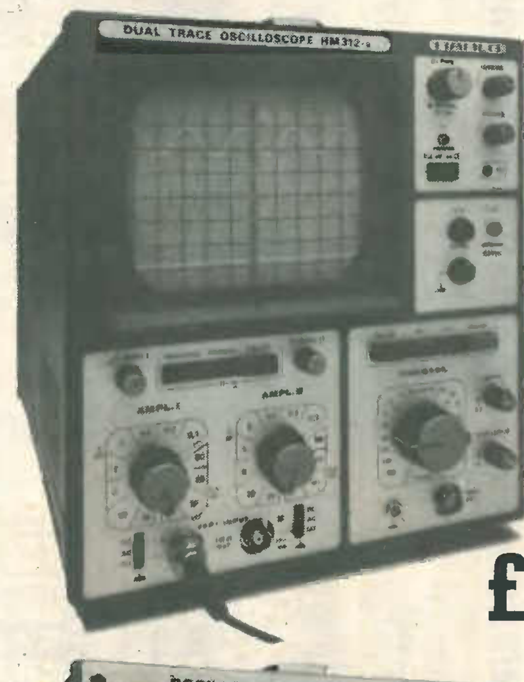

HM312 Dual Trace Oscilloscope.
DC-20MHz. Sensitivity 5mV-20V/cm. Time base range 0.5uS-0.2S/cm with x5 horiz mag to 100nS/cm, with variable control uncalibrated to 40nS/cm. CRT screen 8 × 10cm. Full XY using chII as X input. Bandwidth 2.3MHz. TV trigger.

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£220

HM512 Dual Trace Oscilloscope with delayed sweep.
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Quantum Electronics

The 102, shown above, must be the most cost-effective pre-amp available, catering for auxiliary, 2 or 3 head tape and providing a perfect match for any cartridge, moving coil or magnetic, by using our unique low-cost matching card to define the sensitivity and cartridge loading. Prudent choice of components and elegant circuitry give outstanding objective and subjective performance (see Popular Hi-Fi August). The module used in the 102 is available separately, as are suitable mains supplies and moving coil head amp/modules. There are two matching stereo power amp kits which are supplied with built and tested circuit boards, requiring only straightforward assembly and point to point wiring. The new ready-built 'D' versions feature separate d.c. supplies for each channel and other refinements which elevate their performance into the super-fi class but which are not incorporated in the kits. Our power amp modules and supplies below enable an amp of high specification to be constructed.

★ COMING SOON: ACTIVE CROSSOVERS ★
102 pre-amp: module only £63.50; built £92

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POWER AMP MODULES AND SUPPLIES

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M854 £26.00 M3008 £53.96
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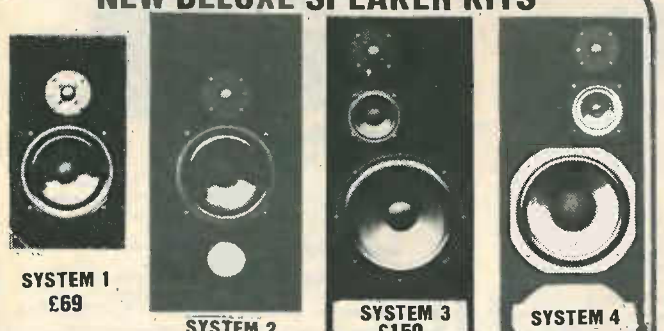
★ EXCELLENT TRADE PRICES ★

NEW DELUXE SPEAKER KITS



SYSTEM 1 £69 — SYSTEM 2 £89 — SYSTEM 3 £159 — SYSTEM 4 £359

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Have you wondered why the existing sources of speaker kits offer a bewildering choice of systems, particularly combinations of 200mm bass unit and tweeter? Don't they know which ones are best? If so, why bother with the rest! Well we have sorted out these super kits so you can order in confidence, knowing you get our full endorsement of their performance and value. The kits incorporate professionally finished front baffles with the drive units already mounted so all the fiddly work is done for you. All that is left to do is to make a simple box. Crossover networks, foam and terminals are included. Systems 1 and 2 use a 200mm bass and 25mm dome tweeter from Son Audax, System 2 being a reflex design that we enthusiastically recommend. System 3 is a competitive 3-way I.B. using Seas bass and mid with a Son Audax tweeter, cleverly incorporating a stand at the bottom of the enclosure, as does System 4, undoubtedly the best kit on the market, using a Volt 250mm bass driver with a 250mm ABR on the rear baffle (also supplied), a modified Peerless mid and Son Audax tweeter. We will also be retailing selected drive units at competitive prices, e.g. Son Audax 200mm bass, 20B25J4 £13.50; 25mm tweeter, HD100D25, £9.

All our prices include V.A.T. and delivery. Export no problem — please send for a specific quote by return. All equipment can be wired for 110V mains. Please send a large S.A.E. or dollar bill for our full information and review reprints.

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DET22	21.95	PC85	0.75	1A3	0.85	6S6C	2.35	76	0.95
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EBC90	0.90	PCF805	2.45	4B32	18.25	6SR7	1.10	1625	1.80
EBF80	0.80	PCF806	1.20	5B/254M	14.00	6SQ7	0.95	1629	1.85
EBF83	0.60	PCF808	2.05	5B/255M	11.50	6V6G	1.50	2051	2.90
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ECC82	0.60	PCL805/85	1.25	5Y3GT	0.80	6Z4	0.70	6060	1.95
ECC83	0.65	PD500/510	4.30	5Z3	1.50	787	1.75	6064	2.30
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ECC85	0.60		2.80	5Z4GT	1.05	9D2	0.70	6067	2.30
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ECC189	0.95	PL82	0.70	6AC7	1.15	10F18	0.70	6146B	5.20
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ECF80	0.85	PL84	0.95	6AH6	1.15	11E2	19.50	6550	6.60
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ECH81	0.70	PY33	0.70	6AM6	1.50	12AX7	0.65	1CP1	18.50
ECH84	0.80	PY80	0.70	6AN8A	2.50	12BA6	0.90	3BP1	11.00
ECL80	0.70	PY81/800	0.80	6AQ4	3.40	12BE6	1.25	5FP7	18.00
ECL82	0.75	PY82	0.65	6AQ5	1.00	12BH7	1.10	4EP1	32.00
ECL83	1.40	PY83	0.80	6AQ5W	1.80	12C8	0.65	88J	14.00
ECL85	0.80	PY88	0.85	6AS6	1.15	12E1	18.95	88L	14.00
ECL86	0.90	PY500	1.70	6AT6	0.90	12J5GT	0.55	CV1526	16.00
EF37A	2.15	PY809	6.45	6AU6	0.60	12K7GT	0.70	DG7-5	22.40
EF39	1.80	PY801	0.80	6AV6	0.85	12K8GT	0.80	DG7-32	34.80
EF80	0.65	QQV03/10	2.85	6AX4GT	1.30	12Q7GT	0.60	DG7-36	36.00
EF83	1.75	QQV03-20A	14.40	6AX5GT	1.30	12SC7	0.65	DPM9-11	38.40
EF85	0.60	QQV03-25A	21.20	6BA6	0.55	12SH7	0.65	D13-33GM	41.80
EF86	0.75	QQV06/40A	16.10	6BE6	0.60	12SJ7	0.70		
EF89	1.05	QV03-12	4.20	6BG6G	1.60	12SQ7	1.45		
EF91	1.50	SC1/400	4.50	6BJ6	1.30	12SQ7GT	0.85		
EF92	2.90	SC1/600	4.50	6BQ7A	0.85	12Y4	0.70		
EF95	0.65	SP61	1.80	6BR7	4.80	13D3	0.70		
EF96	0.60	TT21	16.50	6BW6	6.20	13D5	0.90		
EF183	0.80	U25	1.15	6BW7	0.90	13D6	0.80		
EF184	0.80	U26	1.15	6C4	0.50	14S7	1.15		
EF804	4.95	U27	1.15	6C6	0.55	19AQ5	0.85		
EF812	0.75	U191	0.85	6CH6	8.20	19G3	11.50		
EFL200	1.85	U281	0.70	6CL6	1.70	19G6	8.50		
EH90	0.85	U301	0.65	6CX8	3.80	19H5	39.55		
EL32	1.10	U600	11.50	6CY5	1.15	20D1	0.80		
EL34	1.80	U801	0.90	6D6	0.70	20F2	0.85		
	2.90*	UBC41	1.20	6EA8	3.20	20E1	1.30		
EL37	4.40	UABC80	0.75	6F6	1.60	20P1	0.65		
EL81	0.95	UAF42	1.20	6F6GB	1.10	20P3	0.75		
EL82	0.70	UBF80	0.70	6F7	2.80	20P4	1.25		
EL84	0.80	UBF89	0.70	6F8G	0.85	20P5	1.35		
EL86	0.95	UBL21	1.75	6F12	1.50	25L6GT	0.95		
EL90	1.00	UCC84	0.85	6F14	1.15	25Z4G	0.75		
EL91	4.20	UCC85	0.70	6F15	1.30	30C15	0.50		
EL95	0.80	UCF80	1.30	6F17	1.15	30C17	0.50		
EL504	1.70	UCH42	1.65	6F23	0.75	30C18	2.45		
EL509	2.70	UCH81	0.75	6F24	1.75	30F5	1.15		
EL802	1.70	UCL82	0.95	6F33	10.50	30FL2	1.40		
EL821	8.20	UF41	1.35	6FH8	3.60	30FL12	1.25		
EL822	9.95	UF80	0.95	6GA8	0.90	30FL14	2.15		
EM31	1.60	UF85	0.95	6GH8A	0.95	30L15	1.10		
EM80	0.85	UL41	2.30			30L17	1.10		
EM81	0.85	UL84	0.95			30P12	1.15		
EM84	0.85	UM80	0.90			30PL13	1.25		
M87	1.30	UM84	0.70						
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EY81	0.85	UY85	0.85						
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EY88	0.65	VR150/30	1.35						
EZ80	0.70								
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GZ33	4.20								
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Ref.	VA (Watts)	£	P&P
0/★	20	**4.84**	.91
149	60	**7.37**	1.10
150	100	**8.38**	1.31
151	200	**12.28**	1.31
152	250	**14.61**	1.73
153	350	**18.07**	2.12
154	500	**22.52**	2.47
155	750	**32.03**	OA
156	1000	**40.92**	OA
157	1500	**56.52**	OA
158	2000	**67.99**	OA
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★ 115 or 240 sec only. State volts required. Pri 0.220-240V.

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Separate 12V windings Pri 220-240V

Ref.	12v (Amps)	24v (Amps)	£	P&P
111	0.5	0.25	**2.42**	.52
213	1.0	0.5	**2.90**	.90
71	2.0	1.0	**3.86**	.90
18	4.0	2.0	**4.46**	1.10
85	5.0	2.5	**6.16**	1.10
70	6.0	3.0	**6.99**	1.10
108	8.0	4.0	**8.16**	1.31
72	10.0	5.0	**8.93**	1.31
116	12.0	6.0	**9.89**	1.52
17	16.0	8.0	**11.79**	1.52
115	20.0	10.0	**15.87**	2.39
187	30.0	15.0	**19.72**	2.39
226	60.0	30.0	**40.41**	OA

50 VOLT RANGE (Split Sec).

Pri 220-240V. Voltages available 5, 7, 8, 10, 13, 15, 17, 20, 25, 30, 33, 40 or 20V-0-20V and 25V-0-25V.

Ref.	50v (Amps)	25v (Amps)	£	P&P
102	.5	1	**3.75**	.90
103	1	2	**4.57**	1.10
104	2	4	**7.88**	1.31
105	3	6	**9.42**	1.52
106	4	8	**12.82**	1.75
107	6	12	**16.37**	1.89
118	8	16	**22.29**	2.39
119	10	20	**27.48**	OA
109	12	24	**32.89**	OA

30 VOLT RANGE (Split sec)

Pri 220-240V. Voltages available 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30V or 12V-0-12V and 15V-0-15V

Ref.	30v (Amps)	15v (Amps)	£	P&P
112	.5	1	**2.90**	.90
79	1	2	**3.93**	1.10
3	2	4	**6.35**	1.10
20	3	6	**7.39**	1.31
21	4	8	**8.79**	1.31
51	5	10	**10.86**	1.52
117	6	12	**12.29**	1.67
88	8	16	**16.45**	1.89
89	10	20	**18.98**	1.89
90	12	24	**21.09**	2.24
91	15	30	**24.18**	2.39
92	20	40	**32.40**	OA

60 VOLT RANGE

Pri 220-240V (Split Sec.) Voltages available 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60V, or 24V-0-24V and 30V-0-30V

Ref.	60v (Amps)	30v (Amps)	£	P&P
124	.5	1	**4.27**	1.10
126	1	2	**6.50**	1.10
127	2	4	**8.36**	1.31
125	3	6	**12.10**	1.39
123	4	8	**13.77**	2.12
40	5	10	**17.42**	1.89
120	6	12	**19.87**	2.12
121	8	16	**27.92**	OA
122	10	20	**32.51**	OA
189	12	24	**37.47**	OA

SCREENED MINIATURES Primary 240V

Ref.	mA	Volts	£	P&P
238	200	3-0-3	**2.83**	.63
212	1A, 1A	0-6, 0-6	**3.14**	.90
13	100	9-0-9	**2.35**	.44
235	330, 330	0-9, 0-9	**2.19**	.44
207	500, 500	0-8-9, 0-8-9	**3.05**	.85
208	1A, 1A	0-8-9, 0-8-9	**3.88**	.90
236	200,200	0-15, 0-15	**2.19**	.44
239	50MA	12-0-12	**2.88**	.37
214	300,300	0-20, 2-20	**3.08**	.90
221	700 (DC)	20-12-0-12-20	**3.75**	.90
206	1A, 1A	0-15-20, 0-15-20	**5.09**	1.10
203	500, 500	0-15-27, 0-15-27	**4.39**	1.10
204	1A, 1A	0-15-27, 0-15-27	**6.64**	1.10

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Pri 200/220 or 400/440
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VA	Ref.	£	P&P
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350	247	**18.07**	2.12
1000	250	**45.94**	OA

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Voltages available 105, 115, 190, 200, 210, 220, 230, 240. Voltages for step up or step down.

Ref.	VA (Watts)	TAPS	£	P&P
113*	15	0-115-210-240V	**2.73**	.81
64	75	0-115-210-240V	**4.41**	1.10
4	150	0-115-200-220-240V	**5.89**	1.10
67	500	" "	**12.09**	1.91
84	1000	" "	**20.64**	2.39
93	1500	" "	**25.61**	OA
95	2000	" "	**38.31**	OA
73	3000	" "	**65.13**	OA
80s	4000	0-10-115-200-220-240	**84.55**	OA
57s	5000	" "	**98.45**	OA

*0, 115, 220, 240 Step Up or Step Down

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250VA	**£13.38**	1.67	69W
500VA	**£20.13**	1.89	67W
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1500VA	**£42.82**	OA	93W
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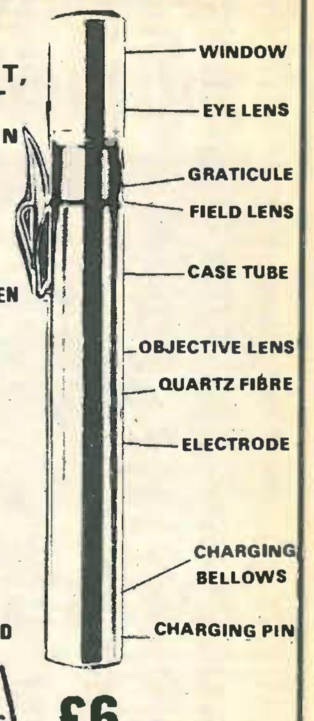

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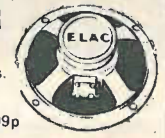
ELAC HI-FI SPEAKER 10in. TWIN CONE

Large ceramic magnet. 50-16,000 c/s. bass resonance 40 c/s. 8 ohm impedance. 10 watts. RMS. **£7.95** Post 99p



POTENTIOMETERS Carbon Track

5kΩ to 2MΩ. LOG or LIN. L/S **50p.** DP **90p.** Stereo L/S **£1.10.** DP **£1.30.** Edge Pot 5K. SP **45p.** Sliders Mono **65p.** Stereo **85p.**

EMI 13½ x 8in. LOUDSPEAKERS

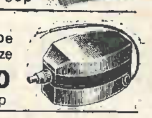
With tweeter and crossover. 10 watt. 3 or 8 ohm. **£9.95** Post 99p

With tweeter and crossover. 8 ohm. 15 watts, **£10.95** Post 99p

SUITABLE BOOKSHELF CABINET £9.50.

Bass woofer, EMI 15 ohm. 20 watt. **£10.95** Post 99p

THE "INSTANT" BULK TAPE ERASER Suitable for cassettes, and all sizes of tape reels. AC mains 200/250V. Hand held size with switch and lead. Will also demagnetise small tools **£7.50** Post 50p
Head Demagnetiser only £5



RELAYS. 12V DC **95p.** 6V DC **85p.**
BLANK ALUMINIUM CHASSIS. 6 x 4—**£1.20;** 8 x 6—**£1.50;** 10 x 7—**£1.90;** 12 x 8—**£2.20;** 14 x 9—**£2.50;** 16 x 6—**£2.40;** 16 x 10—**£2.70.**
ANGLE ALI. 6 x ¾ x ¾in—**25p.**
ALUMINIUM PANELS. 6 x 4—**24p;** 8 x 6—**38p;** 14 x 3—**40p;** 10 x 7—**54p;** 12 x 8—**70p;** 12 x 5—**44p;** 16 x 6—**70p;** 14 x 9—**94p;** 12 x 12—**£1;** 16 x 10—**£1.16.**
PLASTIC AND ALI BOXES IN STOCK. MANY SIZES
ALUMINIUM BOXES. 4 x 4 x 1½ **£1.** 4 x 2 x 2 **£1.** 3 x 2 x 1 **80p.** 6 x 4 x 2 **£1.30.** 7 x 5 x 2½ **£1.45.** 8 x 6 x 3 **£2.20.** 10 x 7 x 3 **£2.50.** 12 x 5 x 3 **£2.30.** 12 x 8 x 3 **£3.**
BRIDGE RECTIFIER 200V PIV 4 amp **£1.50.** 8 amp **£2.50.**
TOGGLE SWITCHES SP **30p.** DPST **40p.** DPDT **50p.**
RESISTORS. 10Ω to 10M. ¼W, ½W, 1W, **1p;** 2W **10p.**
HIGH STABILITY. ½W 2% 10 ohms to 1 meg. **8p.** Ditto 5%. Preferred values, 10 ohms to 10 meg. **3p.**
PICK-UP CARTRIDGES SONATONE 9TAHC **£2.50.**
BSR Stereo Ceramic SC7 Medium **£2.** SC8 High **£2.**
PHILIPS PLUG-IN HEAD. All 1020 (G306 - GP310 - GP233 - AG3306 - AG3310) **£2.**
LOCKTITE SEALING KIT DECCA 118 £1.
SOLDERING IRON 240V 40W **£2.75.**
VALVE OUTPUT Transformers (small) **90p.**
CAR SPEAKERS on Baffles 7 × 4½ × 1½in. deep, 4 ohms. Twin Units Bass and Treble 10 watts, RMS, Door Mounting. Stereo pair **£14.**
GRAPHIC EQUALISER. Car Radio, Cassette, Power Booster, Stereo 20 watts RMS per channel, 5 sliders Graphic Equalisation 5½ wide × 7½ deep × 2in. high. 12 volt **£30.**

MINI-MULTI TESTER

Deluxe pocket size precision moving coil instrument, jewelled bearings — 2000 o.p.v. Battery included. 11 instant ranges measure: DC volts 10, 50, 250, 1000. AC volts 10, 50, 250, 1000. DC amps 0-100mA. Continuity and resistance 0-1 meg ohms in two ranges. Complete with Test Prods and instruction book showing how to measure capacity and inductance.

£6.50

PANEL METERS £4 each 50μa 100μa 500μa, 1ma, 5ma, 50ma, 25 volt, 50 volt, VU Meter. Facia size 2⅜ × 1¾ × 1½in. Fixing hole 1½in. dia. Lighting kit 6 or 12v **90p extra.**

RCS SOUND TO LIGHT KIT Mk. 2 Kit of parts to build a 3 channel sound to light unit 1,000 watts per channel. Suitable for home or disco. Easy to build. Full instructions supplied. Cabinet **£4.50** extra. Will operate from 200MV to 100 watt signal. **£18** Post 50p

200 Watt Rear Reflecting White Light Bulbs. Ideal for Disco Lights, Edison Screw. 6 for **£4,** or 12 for **£7.50.** Post 50p.

"MINOR" 10 watt AMPLIFIER KIT £14.00 This kit is suitable for record players, guitars, tape playback, electronic instruments or small PA systems. Two versions available: Mono, **£14.00;** Stereo, **£20.** Post 45p. Specification 10W per channel; input 100mV; size 9½ x 3 x 2in. approx. SAE details. Full instructions supplied. AC mains powered. Input can be modified to suit guitar.

RCS STEREO PRE-AMP KIT. All parts to build this pre-amp. Inputs for high, medium or low imp per channel, with volume control and PC Board **£2.95** Post 35p
Can be ganged to make multi-way stereo mixers

MAINS TRANSFORMERS ALL POST 99p.

250-0-250V 70mA, 6.5V, 2A	£3.45
250-0-250V 80mA, 6.3V 3.5A, 6.3V 1A	£4.60
350-0-350V 250mA, 6.3V 4A CT, 5V 2A,	£12.50
300-0-300V 120mA, 2×6.3V 2A C.T.; 5V 2A	£10.00
220V 45mA, 6.3V 2A	£2.50

GENERAL PURPOSE LOW VOLTAGE.
Tapped outputs available

2 amp. 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 25 and 30V	£6.00
1 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£6.00
2 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£9.50
3 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£12.50
5 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£16.00

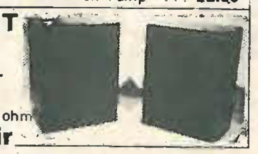
12V, 100mA	£1.30	20V, 40V, 60V, 1 amp	£4.00
12V, 750mA	£1.75	12V, 3 amp	£3.50
10-0-10V 2amp	£3.00	10V, 30V, 40V, 2 amp	£3.50
30V, 5 amp and 17V-0-17V, 2 amp	£4.00	2 of 28 volt 1 amp	£5.00
0.5, 8, 10, 16V, ½ amp	£2.50	20V, 1 amp	£3.00
9V, 3 amp	£3.50	20V-0-20V, 1 amp	£3.50
25-0-25V 2 amp	£4.50	9-0-9 volt 50ma	£1.50
30V, 1½ amp £3.00 2 amp	£3.50	2 of 18V, 6 amp,	£11.00
6V ½ amp	£2.00	12-0-12V, 2 amp	£3.50
15-0-15V, 2 amp	£3.75	9V, ¼ amp	£1.50
		32-0-32V, 6½ amp	£11.00

AUTO TRANSFORMERS. 115V to 240V 150W **£8** 500W **£12.**

CHARGER TRANSFORMERS		CHARGER RECTIFIERS	
6-12 volt 3 amp	£4.00	6-12 volt 2 amp	£1.10
6-12 volt 4 amp	£6.50	6-12 volt 4 amp	£2.00

OPUS COMPACT SPEAKERS

FLUTED WOOD FRONTS
TEAK VENEERED CABINET
11×8½×7in
50 to 14,000 cps.15 watts 8 ohm
Post £2 **£20 pair**



LOW VOLTAGE ELECTROLYTICS ALL 10p
1 mfd, 2 mfd, 4 mfd, 8 mfd, 10 mfd, 16 mfd, 25 mfd, 30 mfd, 50 mfd, 100 mfd, 250 mfd. All 15 vgts. 22 mfd/6v/10v; 25 mfd/6v/10v; 47 mfd/10v; 50 mfd/6v; 68 mfd/6v/10v/16v/25v; 100 mfd/10v; 150 mfd/6v/10v; 200 mfd/10v/16v; 220 mfd/4v/10v/16v; 330 mfd/4v/10v; 500 mfd/6v; 680 mfd/6v/10v/16v; 1000 mfd/2.5v/4v/10v; 1500 mfd/6v/10v/16v; 2200 mfd/6v/10v; 3300 mfd/6v; 4700 mfd/4v. **ALL 10p.**
500mF 12V **15p;** 25V **20p;** 50V **30p.**
1000mF 12V **20p;** 25V **35p;** 50V **50p;** 100V **70p.**
2000mF 6V **25p;** 25V **42p;** 40V **60p;** 1200mF 76V **80p.**
2500mF 50V **70p;** 3000mF 50V **65p;** 2000mF 100V **£1.**
4500mF 64V **£2.** 4700mF 63V **£1.20.** 2700mF/76V **£1.**
5000mF 35V **85p.**

HIGH VOLTAGE ELECTROLYTICS

8/350V	35p	8+8/450V	75p	32+32+16/350V	90p
16/350V	45p	8+16/450V	75p		
32/500V	75p	20+20/450V	75p	100+100/275V	65p
50/500V	£1.20	32+32/350V	50p	150+200/275V	70p
8/800V	£1.20	50+50/500	£1.80	220/450V	95p
16/500V	65p	50+50/300V	50p	80+40/500V	£2

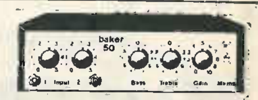
TRIMMERS 10pF, 30pF, 50pF, **5p.** 100pF, 150pF, **15p.**
CERAMIC, 1pF to 0.01mF, **5p.** Polystyrene 2 to 5000pF, **5p.**
PAPER 350V-0.1 **7p;** 0.5 **13p;** 1mF 150V **20p;** 2mF 150V **20p;** 500V-0.001 to 0.05 **12p;** 0.1 **15p;** 0.25 **25p;** 0.47 **35p.**
MICRO SWITCH SINGLE POLE CHANGEOVER 20p.
SUB-MIN MICRO SWITCH, 25p. Single pole change over.
TWIN GANG, 385pF **£1;** 500pF **£1;** 365 + 365 + 25 + 25pF, Slow motion drive **£1.** 120pF **50p.** 3 Gang 365pF **£2.**
TRANSISTOR TWIN GANG. Japanese Replacement **50p.**
NEON PANEL INDICATORS 250V 30p.
ILLUMINATED ROCKER SWITCH. Single pole. Red **65p.**
WIRE-WOUND RESISTORS 5 watt, 10 watt, 15 watt **15p**
CASSETTE MOTOR. 6 volt **£1**
CASSETTE MECHANISM. 12v Stereo Playback only **£5**
U.H.F. COAXIAL CABLE SUPER LOW LOSS. 25p yd.

BAKER LOUDSPEAKERS "SPECIAL PRICES"

Post £1.50 ea.

MODEL	INCHES	OHMS	WATTS	TYPE	PRICE
MAJOR	12	4-8-16	30	HI-FI	£12
DELUXE MK II	12	8-16	15	HI-FI	£14
SUPERB	12	8-16	30	HI-FI	£20
AUDITORIUM	12	8-16	45	HI-FI	£20
AUDITORIUM	15	8-16	60	HI-FI	£35
GROUP 35	12	4-8-16	40	PA	£12
GROUP 45	12	4-8-16	45	PA	£15
GROUP 50	12	4-8-16	60	PA	£20
GROUP 75	12	4-8-16	75	PA	£22
GROUP 100	12	8-16	100	PA	£25
GROUP 100	15	8-16	100	PA	£29
DISCO 100	12	8-16	100	DISCO	£26
DISCO 100	15	8-16	100	DISCO	£29

BAKER 50 WATT AMPLIFIER



£69 Post £2.00
Ideal for Halls/PA systems, Discos and Groups. Two inputs. Mixer, Volume Controls, Master Bass, Treble and Gain Controls. 50 watts r.m.s. Three loudspeaker outlets 4, 8, 16 ohms.

BAKER 150 WATT MIXER/POWER AMPLIFIER

Professional 4 inputs with volume controls. Will mix mics, decks, musical instruments, etc. **£89**
Slave version available **£75** 100 Volt Line **£14** extra. Post £2.00

FAMOUS LOUDSPEAKERS "SPECIAL PRICES"

Post £1.50 ea.

MAKE	MODEL	SIZE	WATTS	OHMS	OUR PRICE
SEAS	TWEETER	4in	50	8	£7.50
GOODMANS	TWEETER	3½in	25	8	£4.00
AUDAX	TWEETER	3¾in	60	8	£10.50
SEAS	MID-RANGE	4in	50	8	£7.50
SEAS	MID-RANGE	5in	80	8	£10.50
SEAS	MID-RANGE	4½in	100	8	£12.50
GOODMANS	FULL-RANGE	5½in	15	8	£6.50
GOODMANS	FULL-RANGE	8in	30	8	£9.50
GOODMANS	AXIOM	8in	15	15	£8.00
SEAS	WOOFER	8in	30	8	£14.00
RIGONDA	GENERAL	10in	20	8	£6.50
GOODMANS	AUDIOM	12PG	60	8/15	£20.00
GOODMANS	AUDIOM	12PD	60	8/15	£20.00
GOODMANS	AUDIOM	12P	50	8/15	£20.00
GOODMANS	AXIOM	402	12in	60/15	£20.00

BATTERY ELIMINATOR MAINS to 9 VOLT D.C. Stabilised output, 9 volt 400 m.a. U.K. made in plastic case with screw terminals. Safety overload cut out. Size 5 x 3¼ x 2½in. Transformer Rectifier Unit. Double insulated. Suitable Radios, Cassettes, models, **£4.50**

TEAK VENEERED HI-FI SPEAKER CABINETS
For 13x8in. or 8in. speaker **£9.50** Post 99p
For 6½in. speaker and tweeter **£8.50** Post 99p
Many other cabinets in stock. Phone your requirements.
SPEAKER COVERING MATERIALS. Samples Large S.A.E.
LOUDSPEAKER CABINET WADDING 18in wide **25p** ft.

CROSSOVERS. TWO-WAY 3000 c/s 3 or 8 or 15 ohm **£1.90.** 3-way 950 cps/3000 cps, **£2.20.**
LOUDSPEAKER BARGAINS
3 ohm, 4in, 5in, 7x4in, **£1.50;** 6½in, 8x5in, **£3;** 8in, **£3.50.**
8 ohm, 2in, 2⅝in, 3in, 3½in, 5in, **£1.50;** 8in, **£4.50;** 10in, **£5;** 12in, **£6.**
15 ohm, 3½in, 5x3in, 6x4in, 7x4in, **£1.50.**
25 ohm, 3in, 5x3in, 7x4in, **£1.50.**
120 ohm, 3¼in dia. **£1.50.**
MOTOROLA PIEZO ELECTRIC HORN TWEETER £6.50 Handles up to 100 watts. No crossover required.
BLACK PLASTIC CONSTRUCTION BOX with brushed aluminium facia. Sturdy job. Size 6¼ x 4¾ x 2in. **£1.50**

GOODMANS RUBBER SURROUND BASS WOOFER
Standard 12in. diameter fixing with cut sides 12" x 10". 14.000 Gauss magnet. 20 watts RMS 4 ohm imp. Bass resonance = 30 c.p.s. Frequency response 20-8000 c.p.s.
BARGAIN, £8.50. Post £2

ALUMINIUM HEAT SINKS. FINNED TYPE. Sizes 5"×4"×1" **95p.** 6½"×2"×2¼" **45p.**
JACK PLUGS Mono Plastic 25p; Metal 30p.
JACK PLUGS Stereo Plastic 30p; Metal 35p.
JACK SOCKETS. Mono Open 20p; Closed 25p.
JACK SOCKETS Stereo Open 25p; Closed 30p.
FREE SOCKETS — Cable end 30p.
2.5mm and 3.5mm JACK SOCKETS 15p.
2.5mm and 3.5mm JACK PLUGS 15p.
DIN TYPE CONNECTORS
Sockets 3-pin, 5-pin 10p. Free Sockets 3-pin, 5-pin 25p.
Plugs 3-pin 20p; 5-pin 25p.
PHONO PLUGS and SOCKETS ea. 10p.
Free Socket for cable end ea. 15p.
Screened Phono Plugs ea. 15p.
TV CONVERGENCE POTS 15p each
Values = 5,7, 10, 20, 50, 100, 200, 250, 470, 2000 ohms.

DRILL SPEED CONTROLLER/LIGHT DIMMER KIT PRINTED CIRCUIT. Easy to build kit. Controls up to 480 watts AC mains **£3**
DE LUXE MODEL READY BUILT 800 watts plus Photo Electric Sunset "On" feature. Front plate fits standard box **£4.**

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Open 9-6. Closed all day Wed. Open Sat. 9-5.

Radio Books and Components Lists 20p. (Minimum post/packing charge 50p.) Access or Barclaycard Visa. Please Tel: 01-684 1665 for same day despatch. Cash prices include VAT.

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Telephone: ELY (0353) 860185 (2 lines) Tuesday to Saturday

Two new high-performance mobiles at very competitive prices. The C-7800 for 70cm operation, is fully synthesised with five memories, two-speed scan from mic etc, etc, and the C-8800 is the matching unit with the same features covering the 2m band in 5kH or 25kH steps

C-7800 £275 inc VAT
C-8800 £250 inc VAT

C-8800

PX402 13.8V DC 3 amp continuous 4 amp max fully stabilised power supply with overload protection **£19.95** plus VAT. P&P £2.00.

RADIO TELEPHONE EQUIPMENT

TRADE PRICE LIST

PYE OLYMPIC M201 high band AM multi-channel sets complete but less loudspeakers and mikes. Few only **£100 each + VAT**
PYE PFS U.H.F. hand portable complete with leather case but less batteries **Only £40 each + VAT**
PYE PF2 U8 T band ideal for 70cm. These sets are in as new condition. Complete with mike, battery and aerial **£80 each + VAT**
PYE U.H.F. PAGERS. PG3U. Used condition less batteries, few only **£40 each + VAT**
PYE MF5AM MOTOFONES. Low band, sets complete and in good condition **£45 each + VAT**
PYE POCKETPHONE. Base station F450, complete less mike **£45 each + VAT**
PYE REPORTER MF6AM. High band sets complete but less cradles, few only **£150 each + VAT**
PYE RTC Controller units for remotely controlling V.H.F. or U.H.F. fixed stations, radio telephones, overland lines **£20 each + VAT**
PYE WESTMINSTER W15AM. High band and low band available. Sets complete and in good condition but are less speakers, mikes, cradles, and L.T. leads (sets only) **£70 each + VAT**
PYE BASE STATION F.27. LOW AND HIGH BAND. Few only **£75 each + VAT**
PYE BASE STATION F30AM. Low and high band with and without T/T. Prices from **£220 each + VAT**
PYE CAMBRIDGE AM108 (boot mount) low band 12.5 KHz sets only no control gear. Good condition **£20 each + VAT**
F30 AM spares: Mod trans **£3.00 each**
Mains trans **£5.00 each** 80 + 40 uf **£1.00 + VAT**
PYE PC1 PC 906 A controllers **£150.00 + VAT**
PYE PC1 controllers from **£50.00 + VAT**
PYE F30 FM low band. Local control, mint condition **£400.00 + VAT**
PYE AC 15 PV Mains power unit for W15AM good condition, only **£50.00 + VAT**
PYE T412 U.H.F. base station, one only **£250 + VAT**
PYE T150 High band FM transmitter **£100 + VAT**
PYE F480/470 U.H.F. base stations from **£150 + VAT**
PYE CAMBRIDGE AM 10B high band boot mount sets complete, less control gear **£20 each + VAT**
PYE CAMBRIDGE AM10 D low band dash mount, fair condition **£35.00 each + VAT**
CARRIAGE ON R/T EQUIPMENT MOBILES £2.00 EACH B/S £15.00 EACH.

XTALS 10.7 MHz HC6U Type. Large range in stock **£2 each + VAT**
IC AUDIO AMP P.C.B. output 2 watts into 3 ohm speaker. 12 volts D.C. supply. Size approx 5½" x 1¼" x 1" high with integral heat sink, complete with circuits **£2.00 + VAT**
NICAD CHARGER CONVERTER P.C.B. (Low power inverter). Size 4" x 1¾" x 1" high 12vdc supply, 60v dc output through pot on P.C.B. for charging portable batteries from mobile supply. Only needs an BFY50/51/52 or similar transistor which can be mounted direct on to P.C.B. pins on the board fitted with star-type heatsink (not supplied) **£2.00 + VAT**
10.7 MHz x TAL FILTERS (2.4 KHz Bandwidth). Low imp type carrier and unwanted sideband rejection min —40dB (needs 10.69835 and 10.70165 XTALS for USB/LSB not supplied). Size approx 2" x 1" x 1" **£10.00 + VAT**
LOW PASS FILTERS (low imp type). 2.9 HMz. Small metal encapsulation. Size 1½" x ¾" x ¾" **75p each + VAT**
XTALS FOR TV SYNC. GEN. 20.25 KHz for 405 lines, B7G glass type **£2.00 + VAT**
TV OFF AIR RECEIVER KIT. Contains Mullard ELC 1043/05 tuner unit, aerial socket, I.F. amp module, detector module and sound quad coil. Supplied with circuit diagram. Ex-brand new equipment **£10.00 + VAT**

WIRE WOUND RESISTORS 330 ohm 5 watt 5% vertical mounting, flame proof, 100 for only **£1.00 + VAT**
WIRE WOUND RESISTORS 5K1 7 watt 5% vertical mounting, flame proof 150 for only **£1.50 + VAT**
TWIN MAINS LEAD 2 x 0.5mm white 100 metres **£6.00 + VAT**
WIRE WOUND RESISTORS 2R7 10 watt 10% horizontal mounting, flame proof, 80 for **£1.00 + VAT**
CARBON FILM RESISTORS. ½ watt, 8% on bandolier 18 ohm and 330 ohm available only **£1.00 per 500 + VAT**
SKELETON PRESETS. standard type 10K **£5.00 per 1,000 + VAT**
GOULD POWER SUPPLY type MMG5-5 5v at 5A output, 110v and 240v ac input, brand new **£25 each + VAT**
REDWING REFRIGERATED MILK CABINET and dispenser takes 3 x 2p could be used for soft drinks **£25.00 + VAT Buyer collects**
GEC PORTABLE TV Featherite LOPT and scan coils, large quantity available, any sensible offers, all brand new.
BARRY MOUNT shock absorbing machine mounts type GBC-2030-T6, brand new. Size 3" x 3" x 1½" high **4 for £5 + VAT**

TERMS OF BUSINESS: Cheques or P.O. with order, made payable to B. Bamber Electronics, or phone your Access or Barclaycard No. Please add **15% VAT** on all goods advertised after adding postage as applicable.
CARRIAGE: Orders under £5 nett invoice add 75p. Orders over £5 but less than £20 add 50p. Orders over £20 at cost. **Callers welcome.** Tues.-Sat. 9.30 a.m.-5.30 p.m.

WW — 075 FOR FURTHER DETAILS

TELEPRINTER TYPE 7B: Pageprinter 24v d.c. power supply. Speed 50 bauds per min. S/hand good cond. (no parts broken, **£28.75. OR GPO MODEL,** as above except motor 110/230V d.c. **£34.50.** Carriage either type **£9.50.** Send SAE for list of Teleprinter spares available.
FRIDEN FLEXOWRITER with Perforator. 230V a.c. Excellent cond. **£86.25 ea.** Carr. £10.
RADAR ECHO BOX TS.488A X-band. **£65.** Carr. £5.
TS.147 RADAR TEST SET Combination Sig. generator and frequency meter and power meter. Provides C.W. & F.M. signals. 115V a.c. **£225.** Carr. £7.
HEWLETT PACKARD Signal Generator HP608B. Freq. 10-400MHz C.W. & A.M. Output 1microvolt to 8V, 50.. Mod. 400-1000Hz. 230V a.c. **£225.** Carr. £10.
AUTO TRANSFORMER: 230/115v 50 c/s 1000 watts. Mounted in strong steel case 5" × 6½" × 7". Bitumen impregnated. £17.25 + carriage.
TRANSISTORISED 3cm RADAR AMPLIFIER SWITCH: with 24v waveguide switch, 9 × 4cm ins. with crystal CV.2355 and spark gap VX.1046. **£17.25** + £1 post.
INSULATION TEST SET 0 to 10KV, negative earth, with Ionisation Amplifier, 100/230 Volts AC. **£48.87** + carr.
BC-221 FREQUENCY METER: 125-20,000kc/s complete with original calibration charts **£24.15** + carr.
ROTARY INVERTER TYPE PE-218E: Input 24-28v. DC 80 amps, 4,800rpm. Output 110v AC 13 amp 400c/s, 1PH. P.F.9. **£23** + carr.
RESONATOR PERFORMANCE CTC 424 8.5 to 9.0 kmc/s 3 cm **£80.50** + post £2.
INVERTER 24v. DC input 400 cycles 1pH 6600 r.p.m. 200v. peak. **£8.05** + £2 post.
OXYGEN BOTTLE 1800lb. w.p. **£11.50** + carr.
NOISE SOURCE UNIT with CV.1881 noise source mount. Produces thermal poise 15.5dB 200/250v. AC **£80.50.**
HS33 HEADSET. Low imp. **£5.35** + 75p post.
MUIRHEAD DECADE OSCILLATOR TYPE 890D: £92 + carr. £5.
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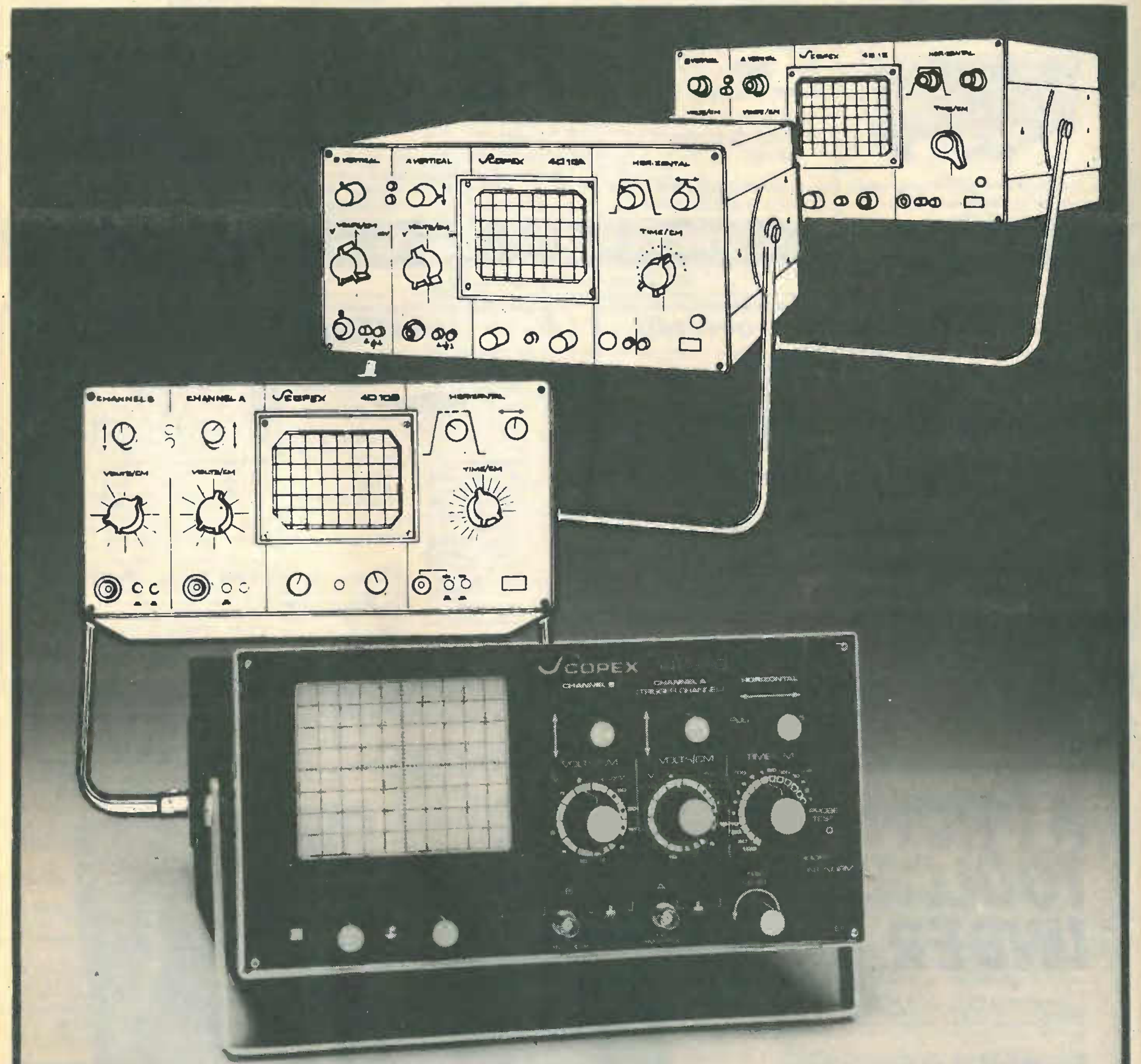

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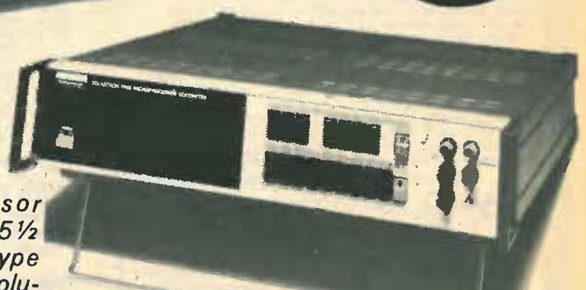

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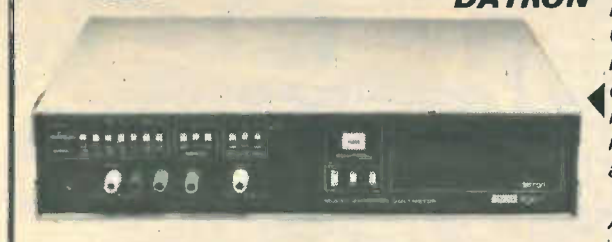

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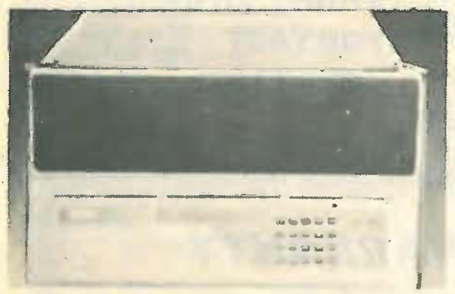

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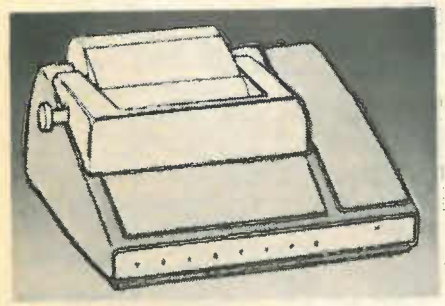

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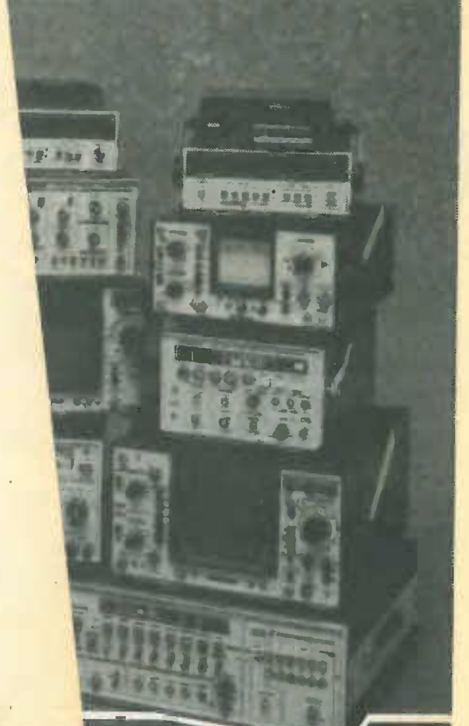

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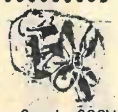

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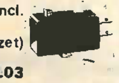

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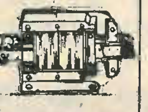

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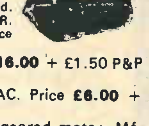

100 rpm 110V AC 115lb. in. 50Hz. 2.6 amp. Single phase split capacitor. Immense power. Totally enclosed. Length 250mm. Dia. 135mm. Spindle dia. 15.5mm, length 145mm. Tested. Price **£12.00** + £1.50 P&P (**£15.53** inc. VAT). R. & T. Suitable Transformer for 230-240V op. Price **£8.00** + 75p P&P (**£10.05** 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 **£6.00** + £1.00 P&P (**£10.35** 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 **£2.90** + 30p P&P (**£3.68** 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**).

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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.

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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 (**£2.66** inc VAT & P).

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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
14 mfd.	400V AC	£3.00
15 mfd.	250V AC (block)	£1.50
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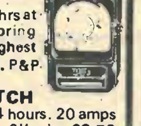
20 mfd.	250V AC	£2.25
50 mfd.	370V (block)	£5.00

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



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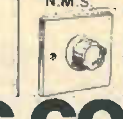

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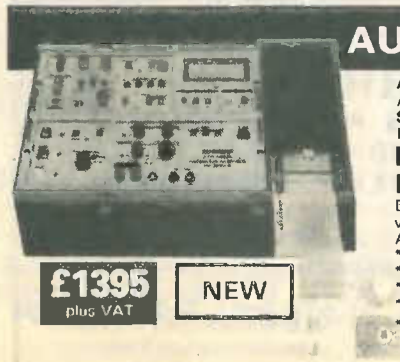

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	LBO 510A	4 MHz	20 mV	Single Trace	5"	
	LBO 512A	10 MHz	10 mV	Single Trace	5"	
	LBO 513	10 MHz	5 mV/1 mV	Single Trace	5"	
	LBO 514	10 MHz	5 mV/1 mV	Dual Trace	5"	
	LBO 552A	10 MHz	20 mV	Dual Trace	5"	Stereo Scope
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	LBO 507A	20 MHz	10 mV	Single Trace	5"	
NEW	LBO 515B	30 MHz	5 mV	Dual Trace	4.5"	Sweep Delay
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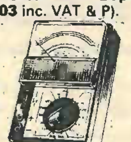

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Powerful continuously rated AC motor complete with 5 blade 6½" or 4 blade 3" aluminium fan. New reduced price **£3.50** P&P 65p (**£4.77** inc. VAT & P.) N.M.S.

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12V 11 way 4 bank (3 non-bridging, 1 homing) **£3.50** P&P 35p (**£4.43** inc. VAT & P).

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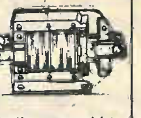

12V DC SOLENOID N.M.S.
12V DC heavy duty Solenoid 4 Kp pull. Easily removable from plate. Ali. chassis containing 4 × 24V DC Push Solenoids (1½ lb approx). 5-fig Counter. 6 min photo cells. Sub-min Microswitches etc, etc. Ex-equip London Transport Printer. Price: **£9.00** + £1.00 p. & p. (total incl. VAT **£11.50**).

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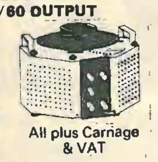

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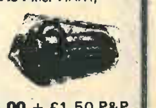
100 rpm 110V AC 115lb. in. 50Hz. 2.8 amp. Single phase split capacitor. Immense power. Totally enclosed. Length 250mm. Dia. 135mm. Spindle dia. 15.5mm, length 145mm. Tested. Price **£12.00** + £1.50 P&P (**£15.53** inc. VAT). R. & T. Suitable Transformer for 230-240V op. Price **£8.00** + 75p P&P (**£10.05** 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.
1 rpm 230/240V AC synchronous geared motor. Mf. **HAYDON 2 rpm** 230/240V AC Synchronous geared Motor. Mf. **CROUZET.** Either type **£2.90** + 30p P&P (**£3.68** inc. VAT). N.M.S.

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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
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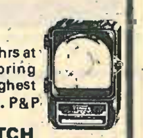

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(840)

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(870)

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(Clinical Measurement Department)
Salary: £5750-£7177 p.a.

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(842)

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(838)

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Prescot Street, Liverpool L7 8XP

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(Medical Physics Technician Grade III)

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WIRELESS TECHNICIAN

Wireless Workshop, Helen Street, Glasgow.
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Application forms may be obtained from The Assistant Director of Manpower Services, Glasgow Sub-Region, Strathclyde House (8), India Street, Glasgow G2 4PF, to whom completed forms, quoting Ref. G3105, should be returned by 30th December, 1980.

R. M. O. McCulloch
Director of Manpower Services

(866)

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(776)

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IBA INDEPENDENT BROADCASTING AUTHORITY

Applicants (male or female) should write or telephone for an application form quoting Ref: WW/512CC to: Glynis Powell, Personnel Officer, IBA, Crawley Court, Winchester, Hampshire SO21 2QA. Telephone: Winchester 822270.

(846)

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Applications stating age, experience and details of educational and technical qualifications should be forwarded to the Airport Director, Leeds Bradford Airport, Yeadon, Leeds LS19 7TZ as soon as possible.

(839)

Leeds Bradford Airport

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Please apply in writing to: **Chief MLSO, Department of Physiology, The Middlesex Hospital Medical School, London, W1P 6DB.** (777)

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GRADE 5

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(843)

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DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING

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For **Post 2** (sponsored by SRC) the appointment will be for a period of three years at Higher Research Scientist/Senior Research Scientist level according to qualifications and experience. Possession of a higher degree could be an advantage but ability to carry out mathematical work is essential. Reference HQ 120/1/97.

Salary scales: Research Scientist £4809-£6480; Higher Research Scientist (minimum of 2 years' postgraduate experience) £6075-£7999; Senior Research Scientist (minimum of 4 years' postgraduate experience) £7644-£9619.

Accommodation for a single person may be available in a Hall of Residence and there is a possibility of housing for a married candidate.

Application forms and further information may be obtained from the Civilian Administration Office, Royal Military College of Science, Shrivenham, Swindon, Wilts SN6 8LA, telephone (0793) 782551, Ext. 421. Please quote relevant reference number(s).

CLOSING DATE FOR APPLICATIONS: 8th January, 1981. (863)

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DEPARTMENT OF ENGINEERING

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For further details and an application form, to be returned by 30 January, 1981, please contact the **Personnel Office, Bristol Polytechnic, Coldharbour Lane, Frenchay, Bristol BS16 1QY.**

Please quote Reference Number L52/56 in all communications.

(874)

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Application form and job description from: Area Personnel Department, South Wing, Normansfield, Kingston Road, Teddington, Middlesex. Tel: 01-977 8833 Ext. 312.
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For further details and application form please contact Personnel Department, Ext. 2001.

BRENT & HARROW HEALTH AUTHORITY (855)

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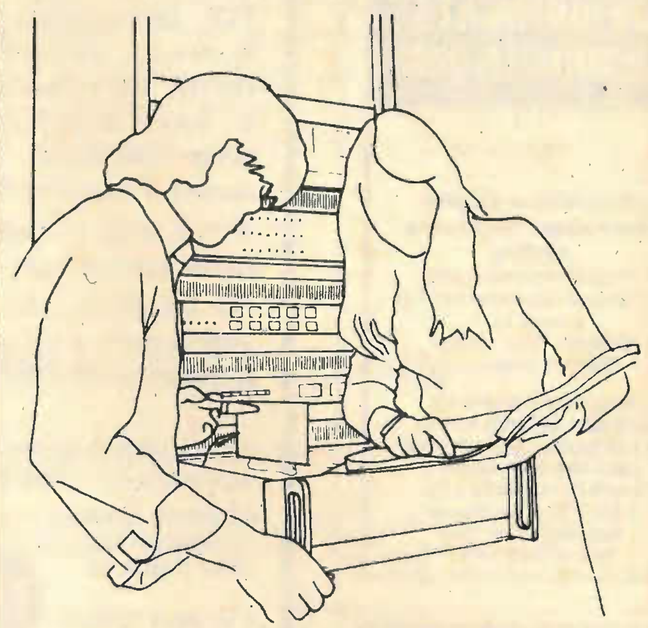

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(£5,300-£7,060)

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A clean current driving licence and ability to drive private and commercial vehicles are essential.

Application forms and further information are obtainable from Scottish Office Personnel Division, Room 110, 16 Waterloo Place, Edinburgh EH1 3DN (quote ref. PM(PTS) 2/13/80 (031-556 8400, Ext. 4317 or 5028).

Closing date for receipt of completed application forms is 11 February, 1981. (891)

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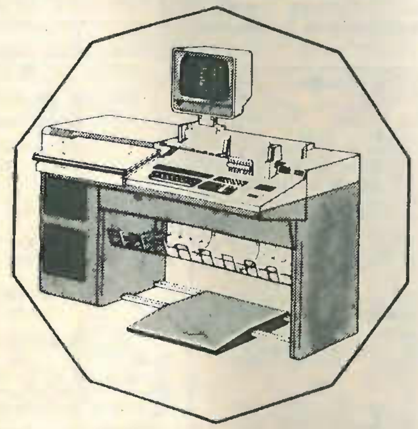

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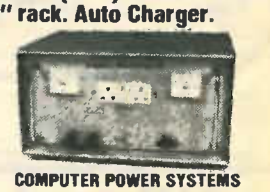

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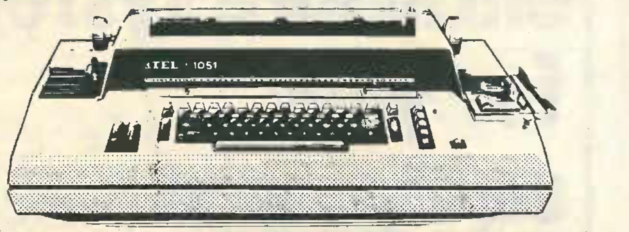

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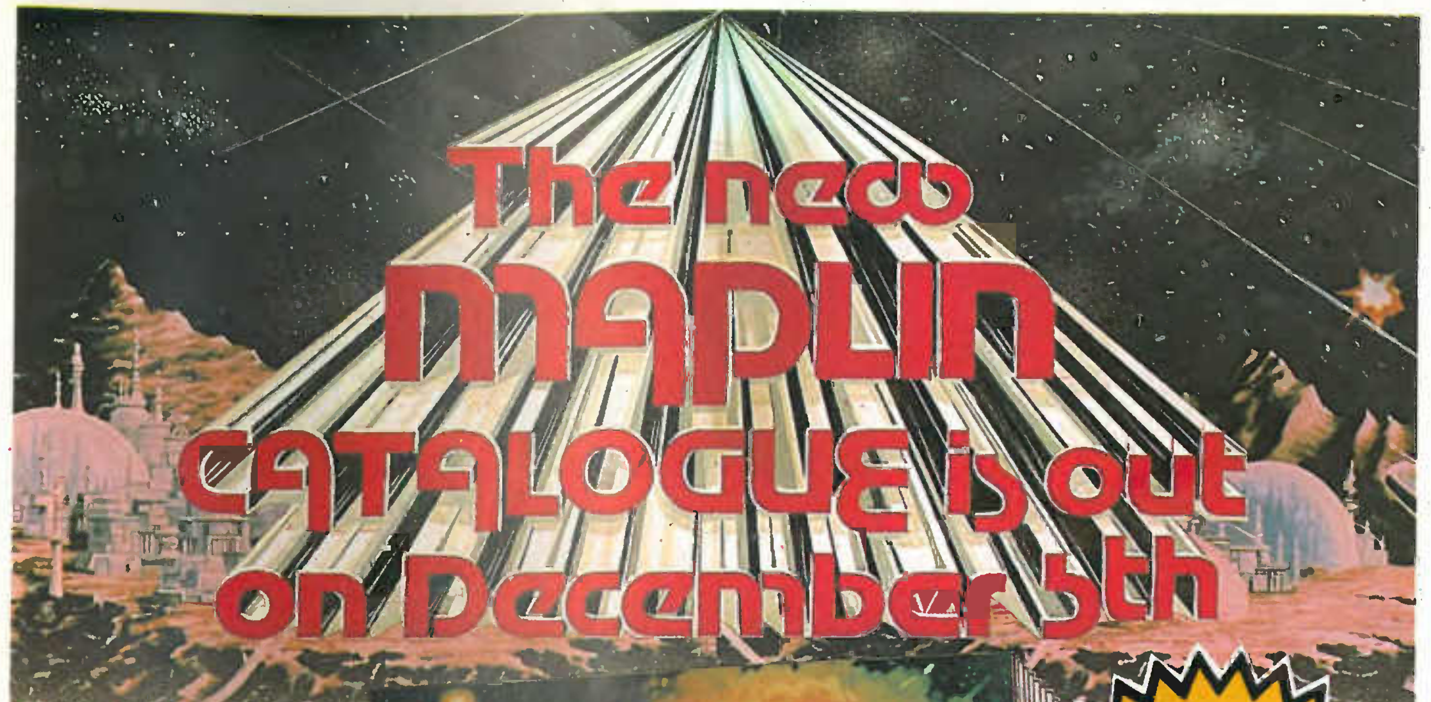

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