wireless world

RADIO TUNING STICKER

MARCH 1978 40p

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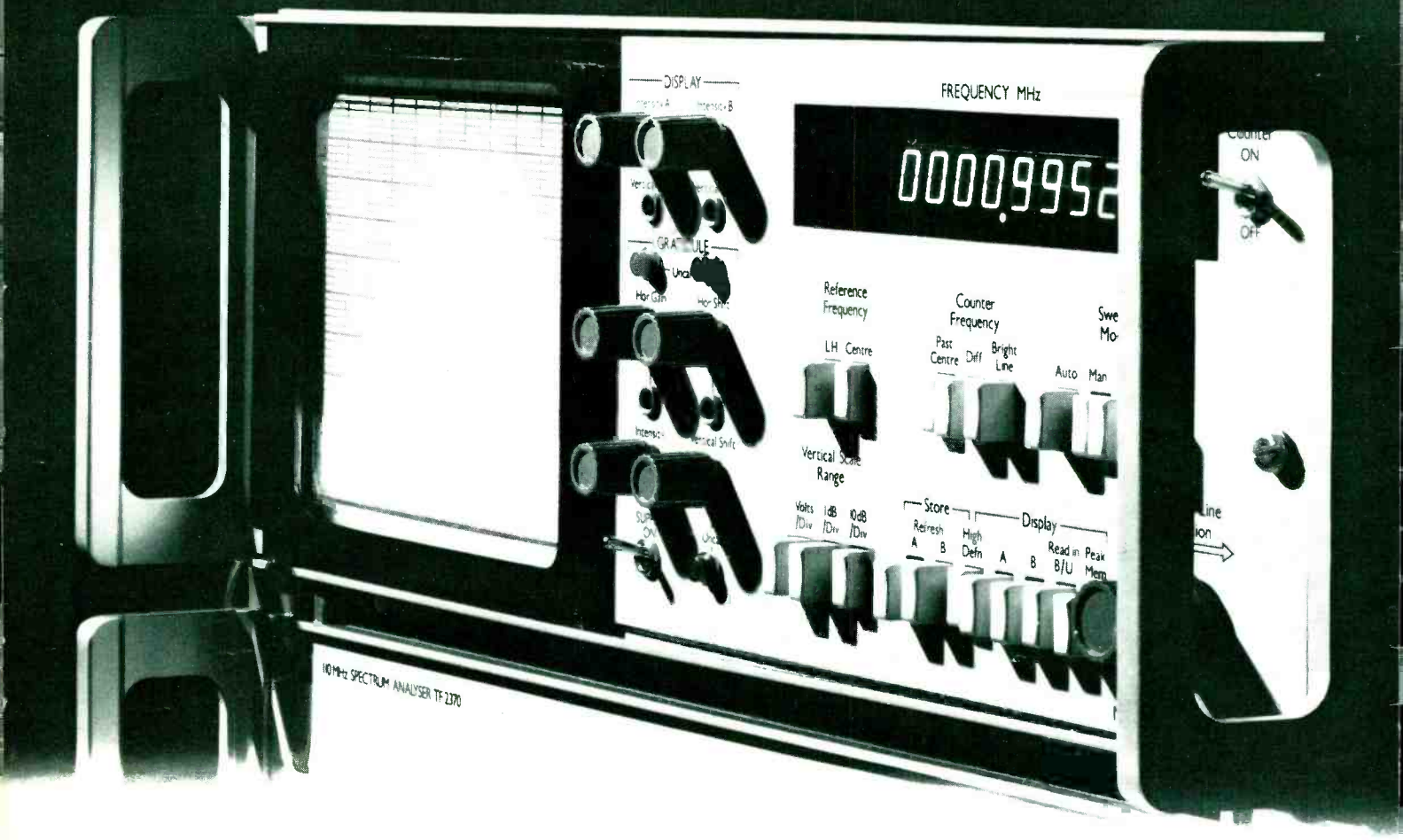
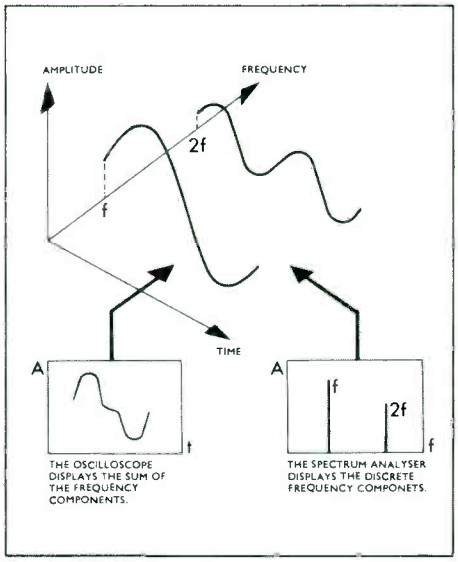
The oscilloscope with a difference...



. . . . . the difference is that it measures amplitude against frequency (instead of time). This comparatively small change has led to our instrument being called a "Spectrum Analyser" which, in turn, has caused oscilloscope users to believe it's for a completely different job, "they are complicated things used only by boffins and people concerned with light waves or something".

But – excuse us – that's where they're wrong. Our TF 2370 is easier to use than many oscilloscopes, it has a frequency range from 30 Hz to 110 MHz and gives much, much more information about waveforms of nearly all types than does a 'scope. And it has a built-in digital frequency meter and sweep (tracking) generator of its own so you can check amplifiers and filters too.

Signals are displayed with the fundamental, harmonics, sidebands and spurious content all clearly indicated and quite distinct from each other. You can see the waveform as it really is and measure hum, distortion, modulation depth and all sorts of things to an accuracy impossible on a 'scope – even on signals which 'scopes show as being 'pure'.



Our special digital store and television display system gives you a steady 'infinite persistance' picture on which you may also compare your ideal waveform with your actual live image. The graticule is electronically generated – so no parallax errors – and you can move it up and down, or sideways, or expand it, all at the twist of a knob or two.

Whether you are involved in design, production, calibration, maintenance or indeed virtually any application where oscilloscopes are used, you will find that the TF 2370 Spectrum Analyser will provide a faster, easier, more informative and accurate answer to nearly all your questions.

If you're still a sceptic ask us for literature or, better still, ring us for a demonstration.

mi MARCONI INSTRUMENTS

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Front cover shows part of Afghanistan imaged for land resource mapping by Landsat satellite and sent by radio to NASA receiving station.

IN OUR NEXT ISSUE

Cassette-deck calculator programmer **enables a simple, four-function calculator to carry out complex functions under the control of a programme stored on an ordinary audio cassette.**

Microwave landing systems. **ICAO will take a decision in April on the system to be adopted internationally. This article will describe the several competitors, together with some background on the subject.**

Also in the April issue will be the last in the series of articles by S. Fedida on *Viewdata*.

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MARCH 1978 VOL 84 NO 1507

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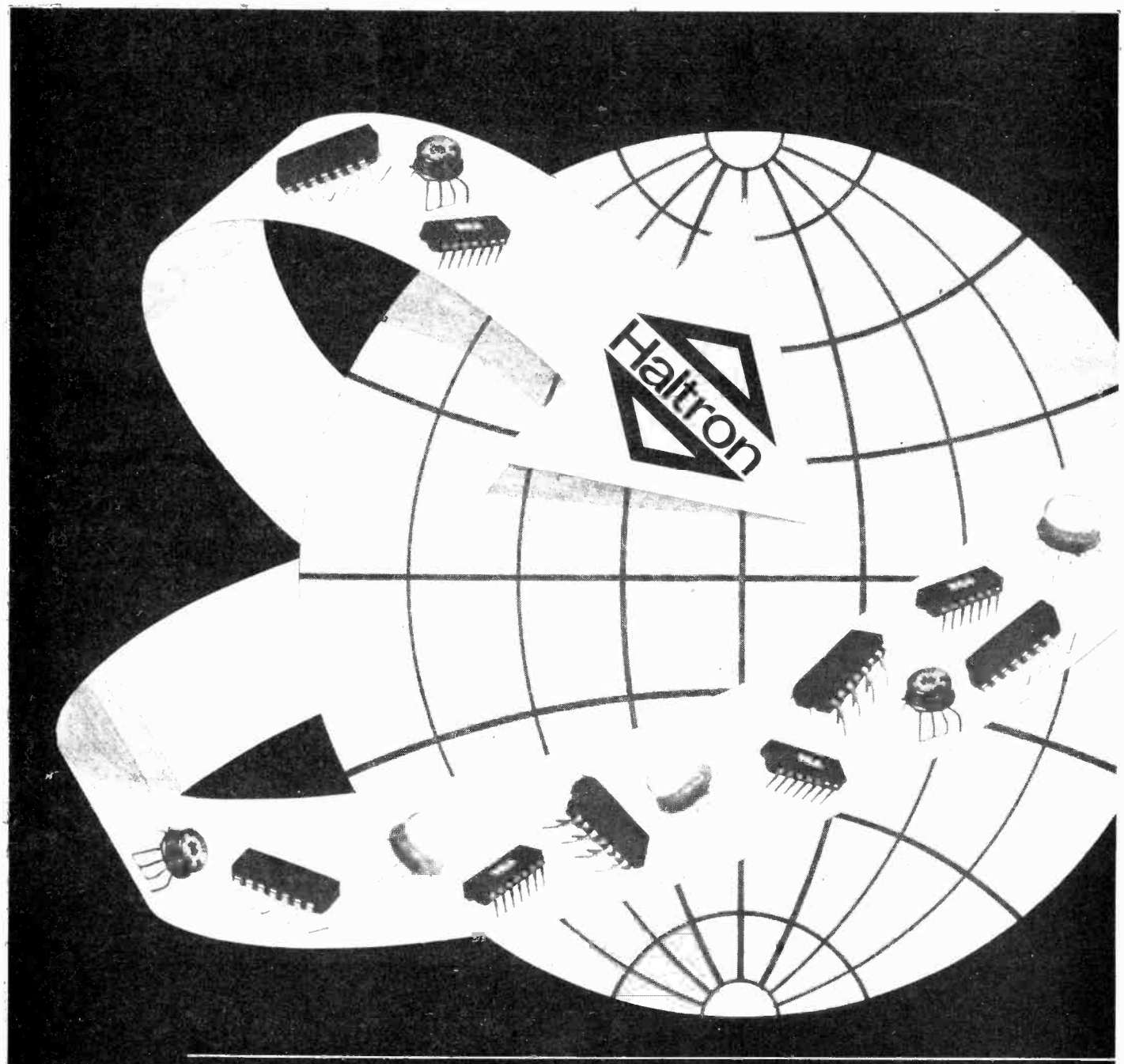

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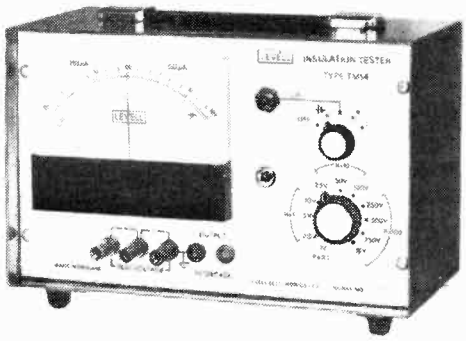

A logarithmic scale covering 6 decades is used to display either insulation resistance or leakage current at a fixed stabilised test voltage. The current available is limited to a maximum value of 3mA for safety and capacitors are automatically discharged when the instrument is switched off or to the CAL condition. The instrument operates from a 9V internal battery.

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Discharge time to 1% is 0.1s per μF on CAL position.

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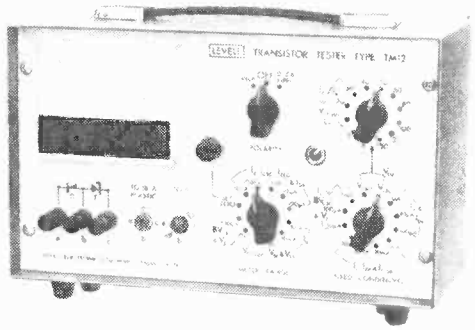
1V per decade ±2% with zero output at scale centre.
Maximum output ±3V. Output resistance 1k Ω.

type TM14 **£120**

TRANSISTOR TESTER



Tests bipolar transistors, diodes and zener diodes. Measures leakage down to 0.5 nA at 2V to 150V. Current gains are checked from 1μA to 100mA. Breakdown voltages up to 100V are measured at 10μA, 100μA and 1mA. Collector to emitter saturation voltage is measured at 1mA, 10mA, 30mA and 100mA for I_C/I_B ratios of 10, 20, 30. The instrument is powered by a 9V battery.

TRANSISTOR RANGES (PNP OR NPN)

I_{CBO} & I_{EBO}: 10nA, 100nA, 1μA, 10μA and 100μA f.s.d. acc. ±2% f.s.d. ±1% at voltages of 2V, 5V, 10V, 20V, 30V, 40V, 50V, 60V, 80V, 100V, 120V, and 150V acc. ±3% ±100mV up to 10μA with fall at 100μA < 5%+250mV.

BV_{CBO}: 10V or 100V f.s.d. acc ±2% f.s.d. ±1% at currents of 10μA, 100μA and 1mA ±20%.

I_B: 10nA, 100nA, 1μA . . . 10mA f.s.d. acc. ±2% f.s.d. ±1% at fixed I_E of 1μA, 10μA, 100μA, 1mA, 10mA, 30mA, and 100mA acc. ±1%.

h_{FE}: 3 inverse scales of 2000 to 100, 400 to 30 and 100 to 10 convert I_B into h_{FE} readings.

V_{BE}: 1V f.s.d. acc. ±20mV measured at conditions on h_{FE} test.

$V_{CE(sat)}$: 1V f.s.d. acc. ±20mV at collector currents of 1mA, 10mA, 30mA and 100mA with I_C/I_B selected at 10, 20 or 30 acc. ±20%.

DIODE & ZENER DIODE RANGES

I_{DR}: As I_{EBO} transistor ranges.

V_Z: Breakdown ranges as BV_{CBO} for transistors.

V_{DF}: 1V f.s.d. acc. ±20mV at I_{DF} of 1μA, 10μA, 100μA, 1mA, 10mA, 30mA and 100mA.

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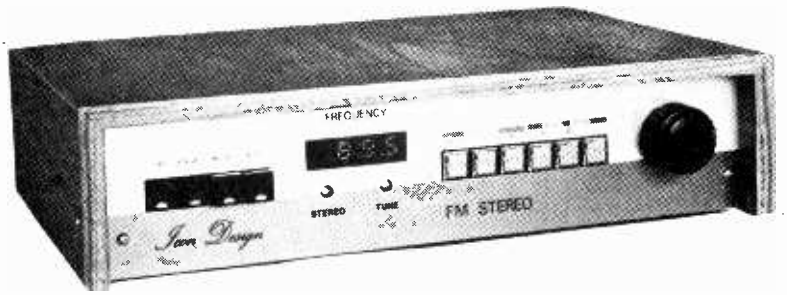
F.M. TUNERS, MODULES & KITS by *Icon Design*



THE WIRELESS WORLD TUNER*

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T2 TOUCH TUNED	**£121.00**	**£109.00**
T3 DIGITAL (AS SHOWN)	**£149.00**	**£139.00**

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This tuner must surely provide the best value for money available today. Combining the best of the modules shown below, it includes a full digital readout of frequency to a resolution of 0.1 MHz, so that exact station identification can be made. In addition, six pre-set stations may be selected by touch controls having internal solid state lamps, while manual tuning allows easy searching for distant stations under the guidance of the digital meter.

A switchable mute system allows reception of the weakest stations while muting inter-station noise and spurious responses. Perfect reception is assured by not permitting any station to be heard which is far enough out of tune to cause distortion. The tuning indicator lamp provides a means of very fine tuning, and is automatically extinguished between stations.

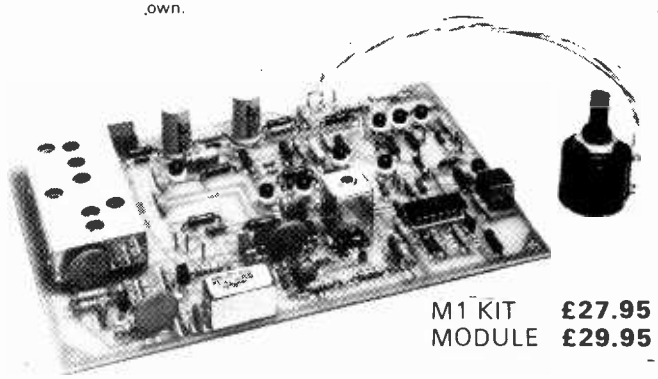
A powerful A.F.C. system is also incorporated which holds all stations in tune, while not preventing manual tuning.

Good stereo reception is assured by the use of a phase locked decoder with full 'birdie' and spurious output filtering.

Finally, but not least, the external appearance and styling bring a fresh new look to Hi-Fi. The sturdy wooden cabinet is finished in mat teak veneer, housing an attractive gold and brown anodised aluminium front panel, which carries black controls and inscriptions. The indicator lamps and digital displays are in red, giving the finishing touches to a tuner you will be proud to own.

MAIN RECEIVER MODULE M1

We have claimed before that this F.M system is the most advanced on the market, and after nearly three years we repeat our claim. Some have borrowed ideas, some have not, but no other tuner gives you all the features of this unit. How many tuners mute the spurious tuning effects found at either side of a correctly tuned station? How many tuners fade the sound out as you tune too far off station for good quality sound? How many tuners kill the tuning indicator so that it does not indicate when there is no station there? How many offer you drift free tuning? We could go on. If you want a tuner that has been well thought out and engineered, start with this module.



M1 KIT **£27.95**
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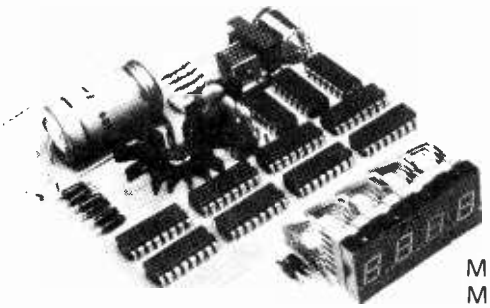
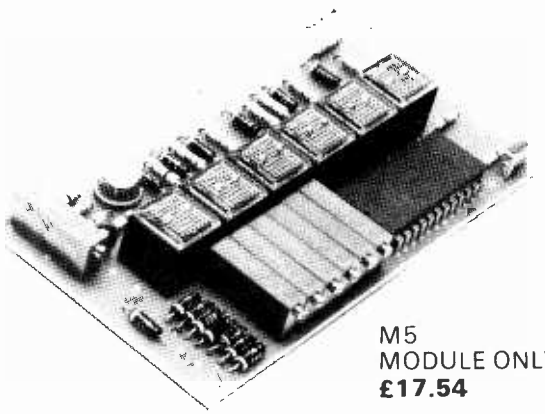
We are very proud of this one. We don't have to say it's the best, as far as we know it's the only one! On a board less than 4" square is all the electronics of a stable counter with i.f. offset (added) and a stabilized power supply! With the aid of a small daughter board (not shown) which fits neatly into the above module (M1), the exact station frequency is displayed to the nearest 0.1 MHz. It's a tuning scale 20" long with accurate calibrations every 0.1"! You get the transformer, daughter board (ready wired in), polarized filter, and a list of station frequencies. What more do you want?



M6
MODULE ONLY
£44.40



M5
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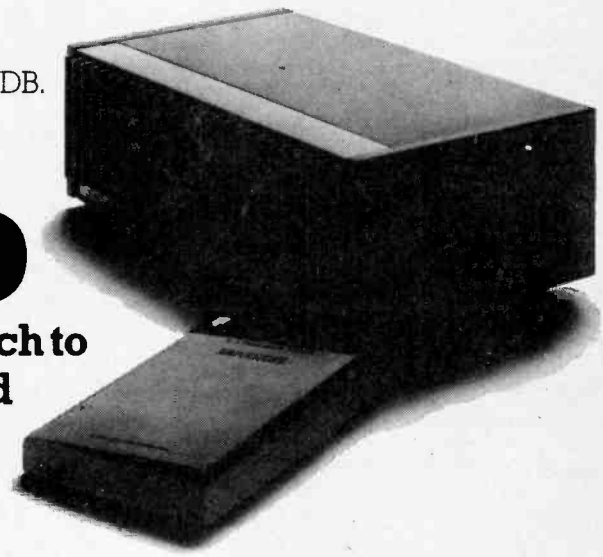

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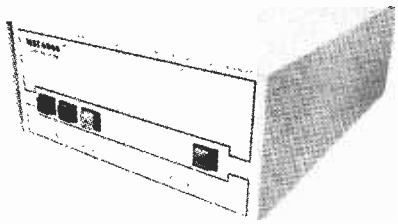

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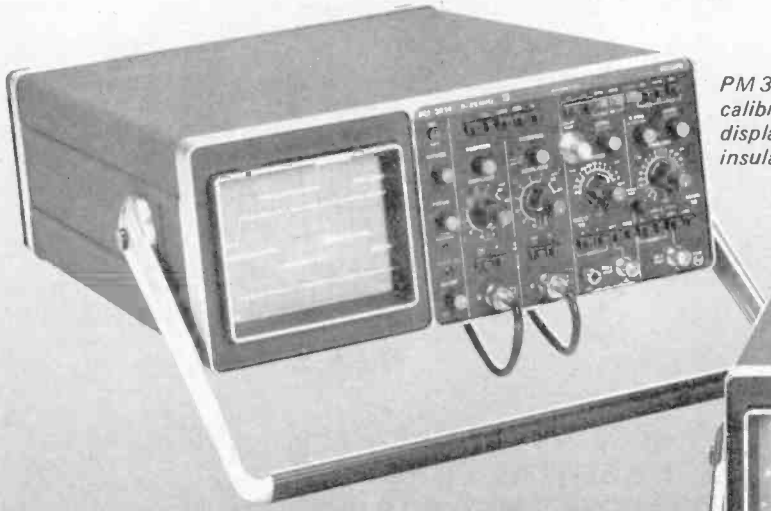
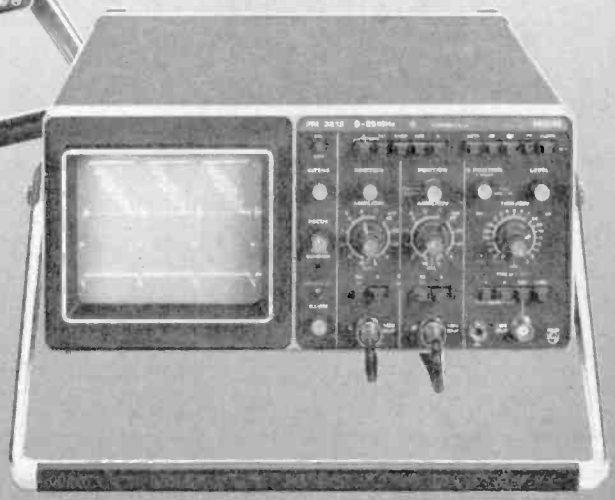


PM 3214: 25 MHz/2mV. Dual-trace with calibrated delayed sweep and simultaneous display of both time-base signals. Double-insulated power supply.



PM 3212: 25 MHz/2mV. Dual-trace. Comprehensive triggering facilities including peak detected auto mode, d.c. coupling, t.v. sync and composite.

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Triggering which can be sourced from either channel or external signal. For convenience and added versatility the PM3214 offers this facility on both time bases.

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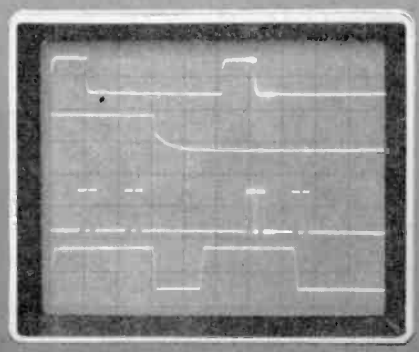

New price/performance standards are set by the PM3214, as demonstrated by the alternate timebase mode. This allows both the main and delayed timebase signals to be displayed simultaneously for both channels.

TV triggering, with the added benefit of fully automatic operation on the PM3212.

Both instruments also share a few more features: like a high light output display and small spot size; the facility for battery operation and the currently unique double-insulated power supply, which eliminates the need for an earth connection and with it the associated problems of earth loops and hum.

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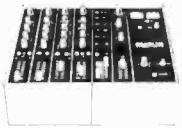

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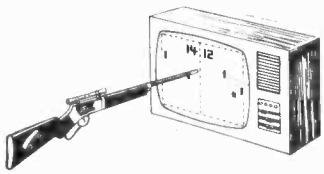

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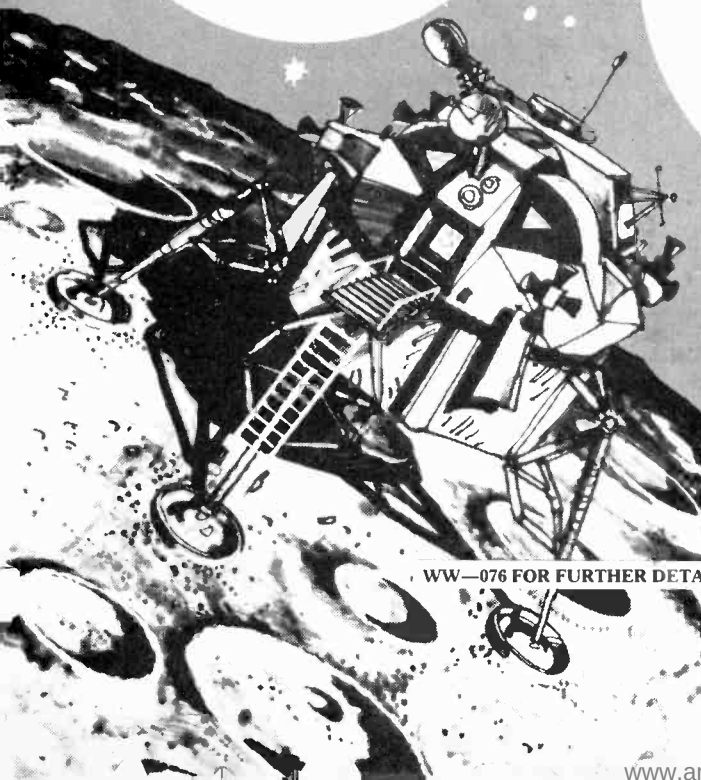

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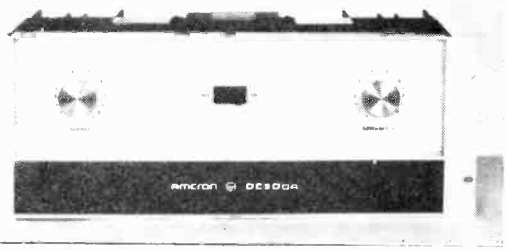

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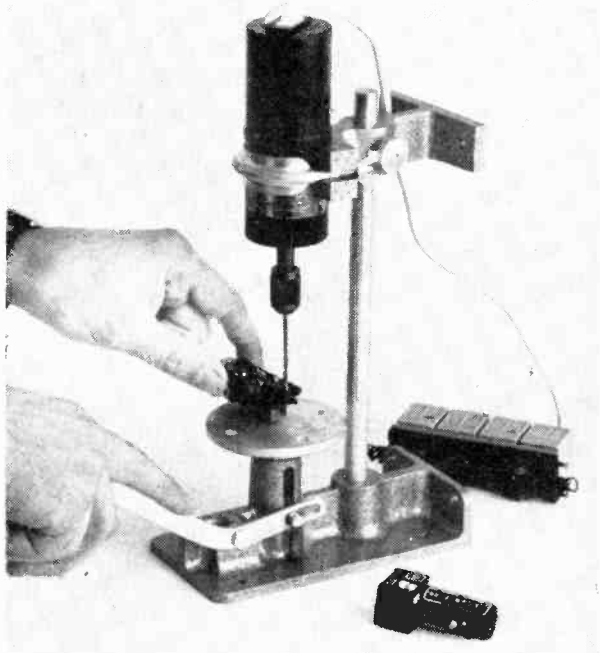

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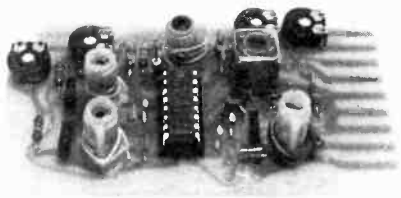

ALL NEW CATALOGUE

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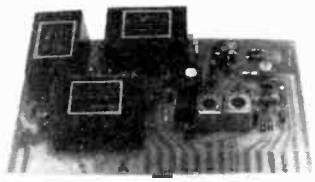

Always in the leading group, here is Ambit's 73189 IF system. optional 2 or 3 6pole linear phase IF filters, 2xMOSFET IF AGC stage, with the CA3189E. £16.25 built and aligned.

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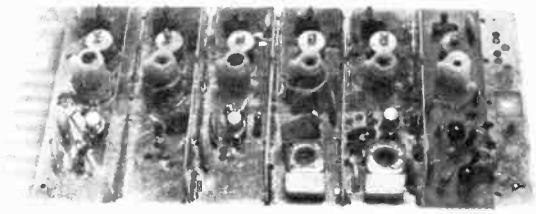

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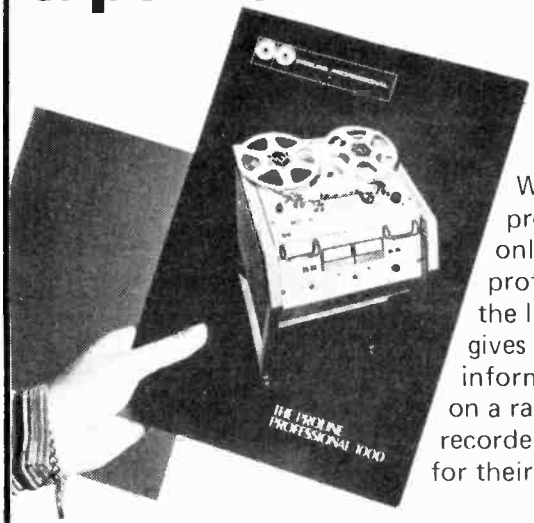

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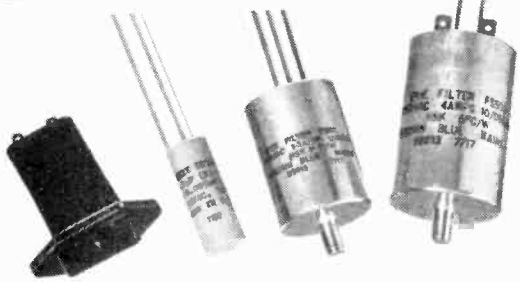

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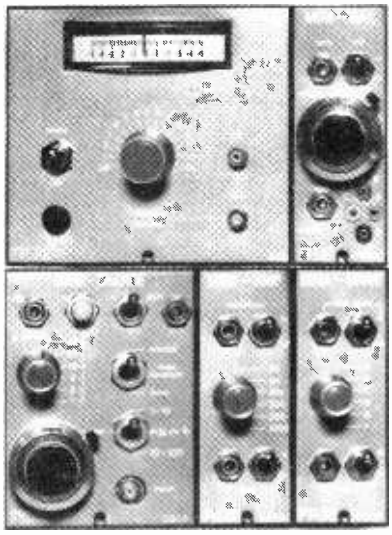

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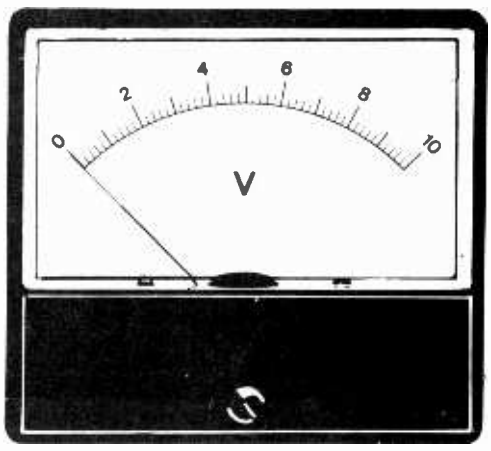

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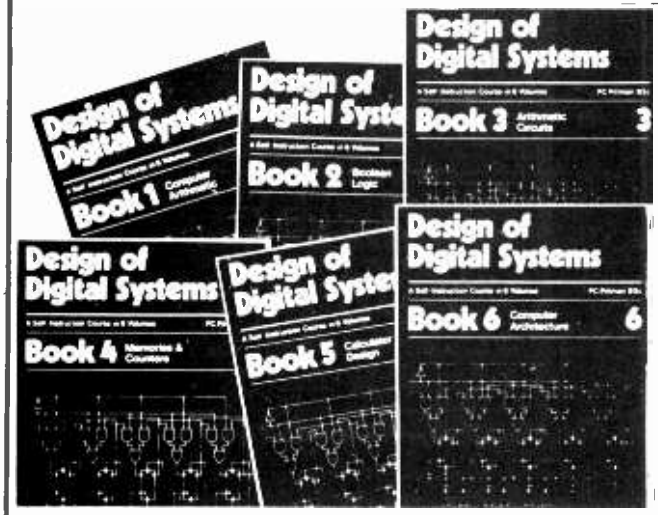

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Book 3 Half adders and full adders; subtractors; serial and parallel adders; processors and arithmetic logic units (ALUs); multiplication and division systems.
Book 4 Flip flops; shift registers; asynchronous and synchronous counters; ring, Johnson and exclusive-OR feedback counters; random access memories (RAMs) and read only memories (ROMs).
Book 5 Structure of calculators; keyboard encoding; decoding display data; register systems; control unit; program ROM, address decoding; instruction sets; instruction decoding; control program structure.
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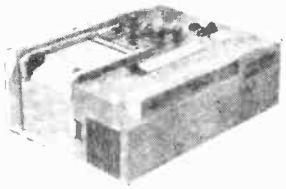

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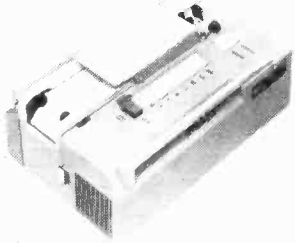

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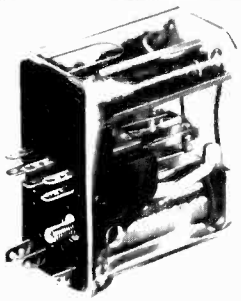

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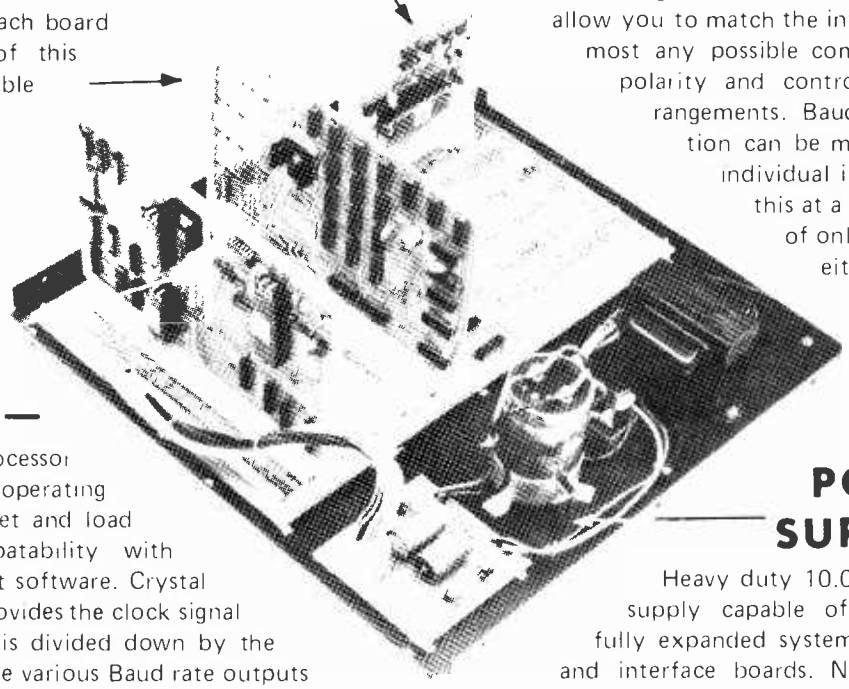

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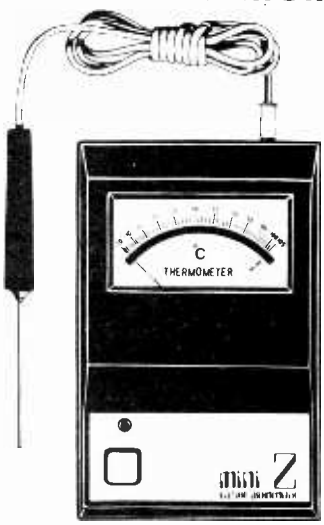

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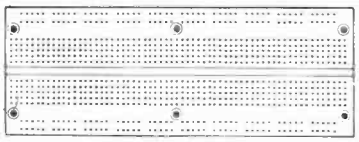
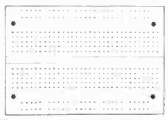


SK 10.

SK 50.



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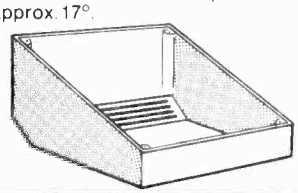

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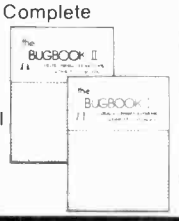

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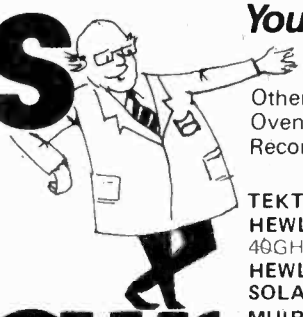

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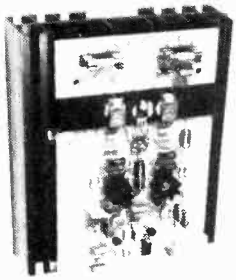

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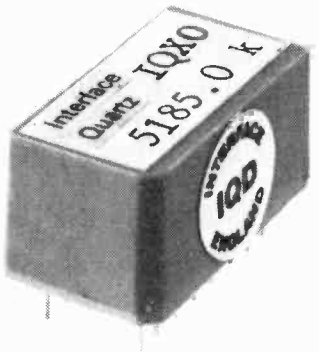

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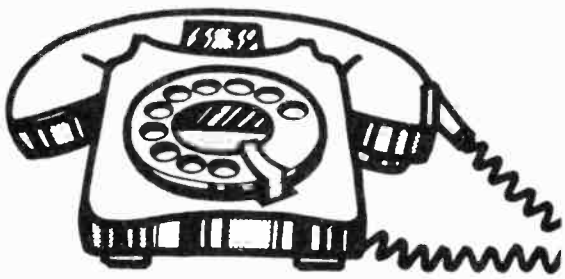

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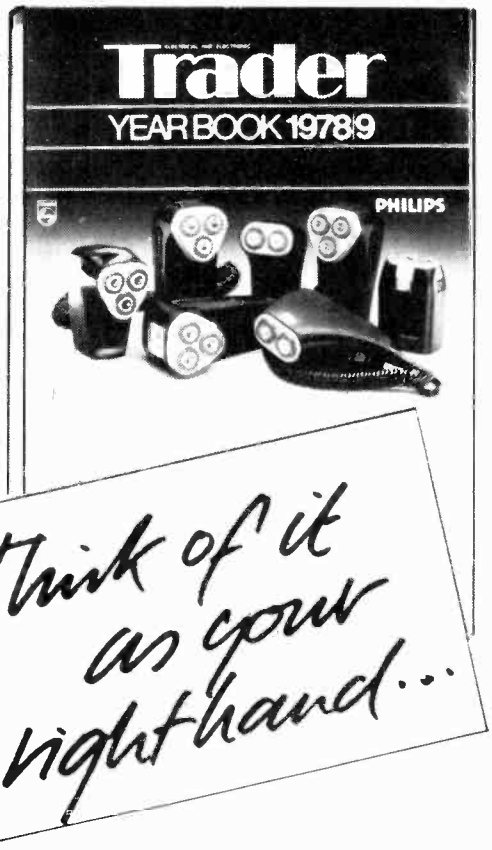

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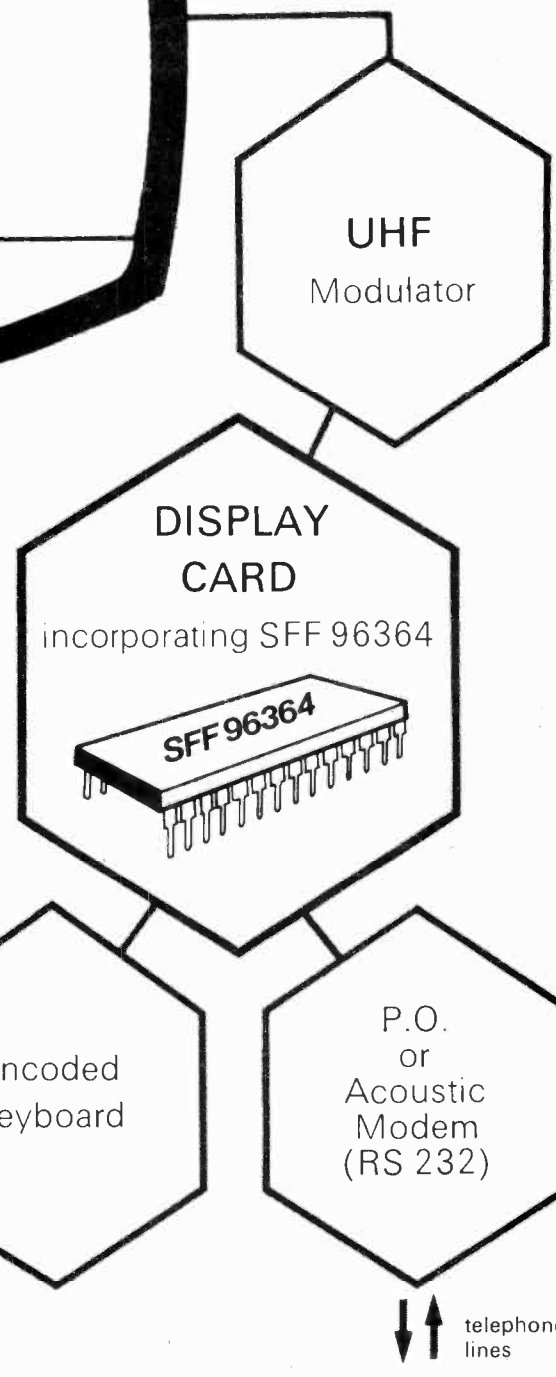

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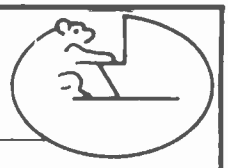

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2102-1	£1.50	4027 (250ns)	£6.00
2102L-1	£1.60	2114 (450ns)	£10.00
2112	£3.04	4116 (250ns)	t.b.a.

Please enquire for 16K dynamic and 100 up prices

MOTOROLA MICROCOMPUTING IC's

MC6800P	£14.00	MC6830L7	£11.33
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MC6850P	£6.74	MC14536P	£3.69
MC6810AP	£3.61	MC3459	£2.53

ZILOG MICROCOMPUTING IC's

Z-80 CPU 2 5MHz	£15.50	Z-80 PIO PS	£10.00
Z-80 CTC PS	£10.00		

MICROPROCESSORS

8080A	t.b.a.	6502	£14.93
SC/MP Mk II	t.b.a.	F-8	t.b.a.
		2650	t.b.a.

INTERFACING ICs

MC1488P	£1.40
MC1489P	£1.40
75150P	£1.30
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For V24, RS232C

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81LS95	£1.43
81LS96	£1.43
81LS97	£1.43
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8T26	£1.84
8T95	£1.60
8T97	£1.60
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LOW POWER SCHOTTKY TTL PRICE LIST

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74LS01	.21	74LS32	.24	74LS109	.38
74LS02	.21	74LS33	.40	74LS112	.38
74LS03	.21	74LS37	.30	74LS113	.38
74LS04	.26	74LS38	.30	74LS114	.38
74LS05	.26	74LS40	.27	74LS125	.56
74LS08	.21	74LS42	.88	74LS126	.56
74LS09	.21	74LS47	.96	74LS132	.90
74LS10	.21	74LS48	.96	74LS136	.38
74LS11	.26	74LS51	.21	74LS138	£1.05
74LS12	.21	74LS54	.21	74LS139	£1.05
74LS13	.55	74LS55	.21	74LS151	.96
74LS14	£1.26	74LS73	.34	74LS153	.96
74LS15	.21	74LS74	.38	74LS154	£1.98
74LS20	.21	74LS75	.55	74LS155	£1.05
74LS21	.26	74LS76	.34	74LS156	£1.05
74LS22	.21	74LS78	.34	74LS157	.96
74LS26	.31	74LS83	£1.05	74LS158	.88
74LS27	.21	74LS86	.38	74LS160	£1.22
74LS28	.40				

CONNECTORS & SOCKETS

Subminiature D Type

9 way plug	.58	25 way plug	.92
9 way socket	.68	25 way socket	£1.50
9 way cover	.74	25 way cover	.85
15 way plug	.74	37 way plug	£2.10
15 way socket	£1.09	37 way socket	£3.11
15 way cover	.83	37 way cover	£1.19

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45 way 0 1" single sided	£1.30
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64 way socket for Eurocard to DIN 41612	£2.99
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10 way socket Molex for S-50 bus	.32

D-I-L SOCKETS

(low profile gold plated)

					D-I-L PLUGS	
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For 77-68 (8" × 8" 0 1" edge 78 way)

CPU board	£10.00
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Bootstrap loader board	£10.00
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For E-77 (double Eurocard)

4K RAM board	£6.25
Prototyping p c b (low pack density)	£7.52

For 3U 43 way systems (4½" × 8")

2K RAM board	£8.50
Back plane (Vero) board approx 10" × 4"	£1.47

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4K RAM board	£12.00

For S-100 bus

4K RAM board	£15.00
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For Exorciser bus

Goods are normally shipped within 24 hours Barclaycard & Access VAT at 8% for Hardware Components 30p postage and packing unless otherwise stated Cheques to be made out to The Newbear Computing Store" Send for an up-to-date catalogue to The Newbear Computing Store 7 Bone Lane, Newbury Tel 0635-46898 Callers welcome Monday to Saturday 9 00 a m -5 30 p m The Newbear Computing Store is a division of Newbury Laboratories Ltd

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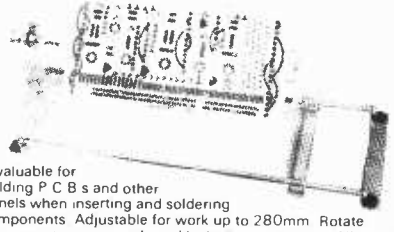

Invaluable for holding P C B s and other panels when inserting and soldering components Adjustable for work up to 280mm Rotate for access to reverse side and locks in any position All metal

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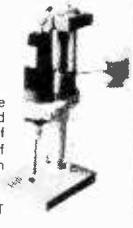

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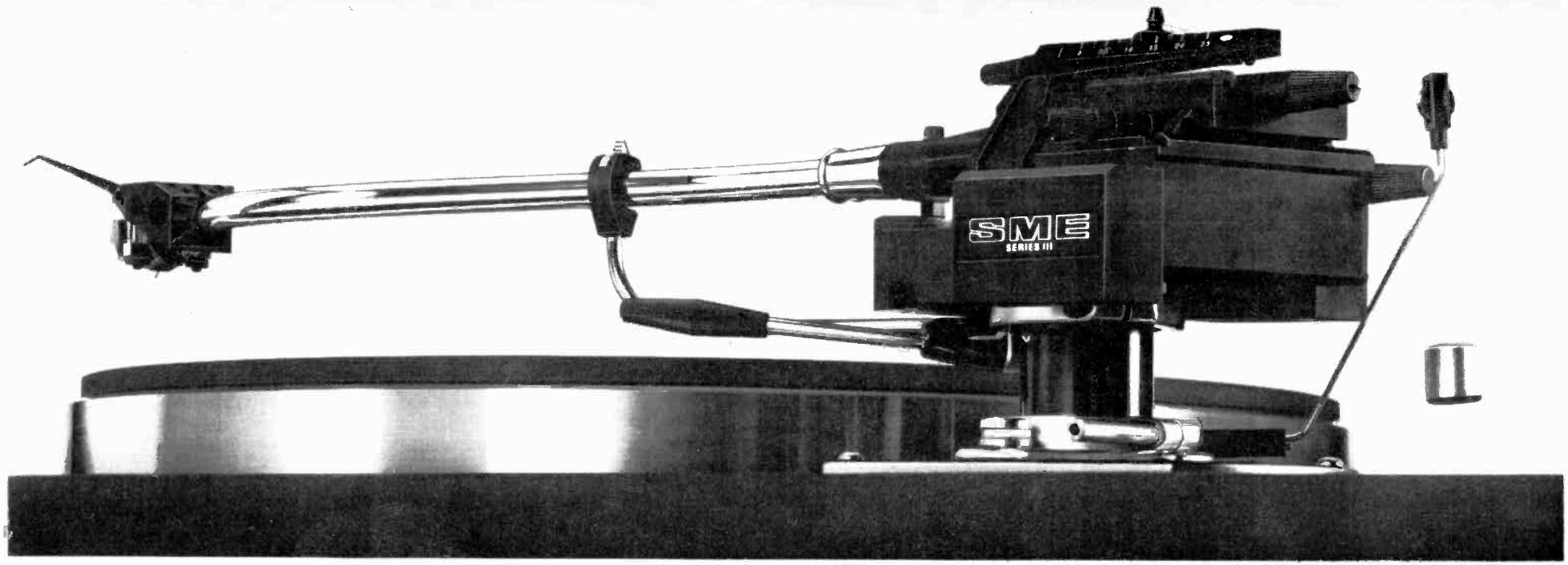

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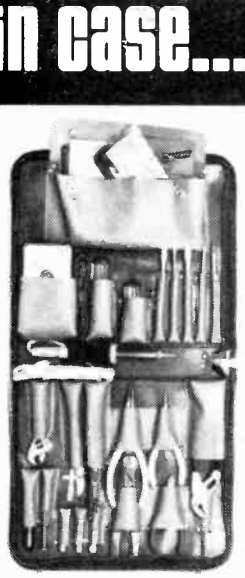
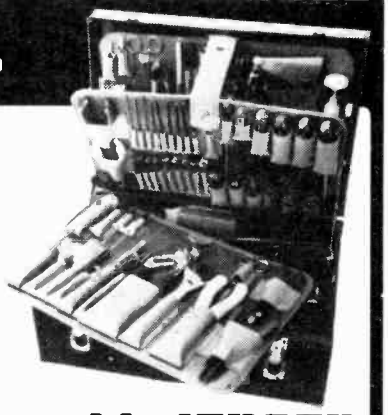
keep your tools handy in case...





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Catronics

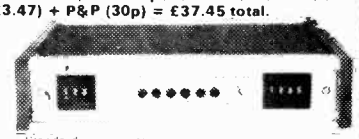
NEW FACILITIES AVAILABLE FOR WW TELETEXT DECODER

'Board 3' is now available as an additional unit to update the *'Wireless World'* Teletext Decoder to give double height characters, colour background, conceal/reveal, etc., as described in the December issue of *'Wireless World.'* Our Kit includes plated-through hole P.C.B., all components and installation instructions. Price £33.68 + VAT (£3.47) + P&P (30p) = £37.45 total.

PCB available separately at £19.60.

Our main kits contain all the printed circuit boards and components necessary to build the complete decoder

A reprint of the series of articles is available at £1.50 + large 15p SAE (included free in complete kit).



PRICES INCLUDE VAT	Standard version using 2513	New version with Texas X887	Post & Packing
Set of 5 PCBs	£21.70	£21.65	30p
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PLATED THROUGH hole PCBs for TEXAS version only at additional cost of £27.00
COMPONENTS ALSO AVAILABLE SEPARATELY — SAE for price list
READY BUILT & TESTED DECODERS — £241.87 + £5 Carr.
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Based on the design for a MATRIX H DECODER published in June issue of *Wireless World*, with subsequent corrections, this Catronics Decoder is now generally available from stock in two versions.

Kit: comprising P.C.B.s, i.c., and all components to mount on the boards at £39.30. Ready built: housed in attractive cabinet with integral power supply and STEREO/QUAD switching at £89.37

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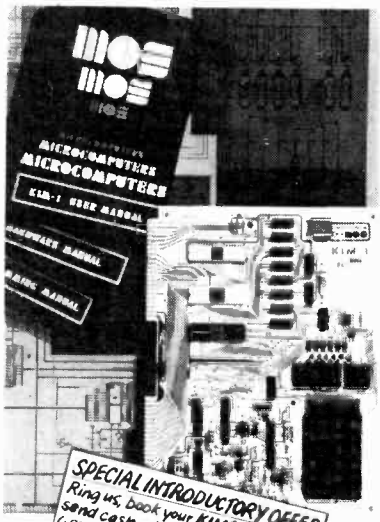

PRICE INCLUDES:

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GR ELECTRONICS LTD.,
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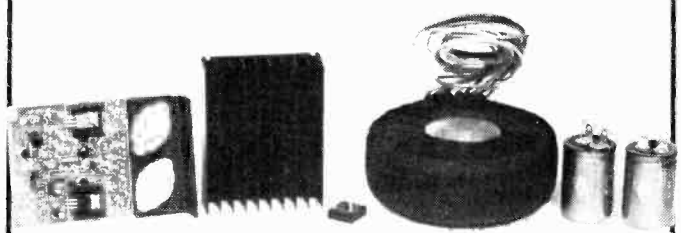
SPECIAL INTRODUCTORY OFFER
Ring us, book your KIM 1 and then send cash with order. At £199.00 (+8% VAT) it's the micro bargain of 1978

WW — 092 FOR FURTHER DETAILS

TWO NEW SUPERMODULES: 170W INTO 4 OR 8 OHMS



By popular demand we have designed higher powered versions of our well known modules. The CE 1704 which gives 170W into 4 ohms and the CE 1708 which gives 170W into 8 ohms are physically similar to the original types and have the same combination of compatible performance features which makes CRIMSON amplification audibly superior to the competition and the only choice if you have an ear to music. We have also produced suitable power supplies which again use our superb TOROIDAL TRANSFORMERS, only 50mm high, with a 120-240 primary and single bolt fixing.
Write or phone for more information and biased opinions.

POWER AMPLIFIER MODULES	Home	Europe
CE 608 60W/8 ohms 35-0-35V	£15.30	£16.60
CE 1004 100W/4 ohms 35-0-35V	£19.22	£19.30
CE 1008 100W/8 ohms 45-0-45V	£23.22	£23.00
CE 1704 170W/4 ohms 45-0-45V	£28.90	£28.46
CE 1708 170W/8ohms 60-0-60V	£31.90	£31.04
TOROIDAL POWER SUPPLIES		
CPS 1 for 2xCE 608 or 1xCe 1004	£14.47	£18.40
CPS 2 for 2xCE 1004 or 2/4xCE 608	£16.82	£20.57
CPS 3 for 2xCE 1008 or 1xCE 1704	£17.66	£21.35
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CPS 5 for 1 x CE 1708	£22.68	£26.50
CPS 6 for 2 x CE 1704 or 2 x CE 1708	£23.98	£27.70
HEATSINKS		
Light Duty 50mm 2 C/W	£0.90	£1.30
Medium Power 100mm 1.4° C/W	£1.60	£2.40
Disco/Group 150mm 1.1 C/W	£2.30	£3.65
THERMAL CUT-OUTS		
Recommended for improved reliability		
70 C for use with free air heatsink	£1.60	£1.90
40 C for use with fan cooled heatsink	£1.60	£1.90

T.H.D.	:	Typically <.02 any power, 1kHz, 8 ohms
T.I.D.	:	Insignificant
Slew rate limit	:	20V/μS
S/N ratio	:	110dB
Freq. response	:	10Hz-35kHz, -3dB
Stability	:	Unconditional
Protection	:	Drives and load Safely
Sensitivity	:	775mV (250mV or 100mV on request)
Size	:	120 x 80 x 25mm

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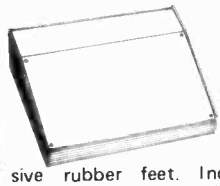
BIMCONSOLES
BIMBOXES
BIMBOARDS
BIMDRILLS
BIMDICATORS

MINI DESK BIMCONSOLES

Moulded in Orange, Blue, Black or Grey ABS and incorporating guides on all sides for holding 1.5mm thick pcb's. 1mm Grey Aluminium panel sits recessed into front of console and held by screws running into integral brass bushes. Stand-off bosses in base for supporting small sub-assemblies etc. 4 self adhesive rubber feet also included.

BIM1005 (161x96x58mm) £1.97*
BIM1006 (215x130x75mm) £2.70*

LOW PROFILE BIMCONSOLES

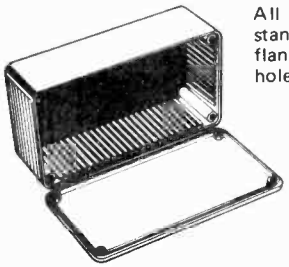


1mm Grey Aluminium panel sits recessed into front of console base, which is moulded in Orange, Blue, Black or Grey ABS and sits on 4 self adhesive rubber feet. Incorporating guides for holding 1.5mm thick pcb, the base also has stand-off bosses for supporting small sub-assemblies etc. and ventilation slots. Front panel is held by 4 screws which run into integral brass bushes.

BIM6005 (143x105x55.5[31.5] mm) £2.14*
BIM6006 (143x170x55.5[31.5] mm) £2.73*
BIM6007 (214x170x82[31.5] mm) £3.75*

ABS & DIECAST BIMBOXES

5 sizes, in either ABS or Diecast Aluminium
ABS moulded in Orange, Blue, Grey or Black
Diecast Aluminium available in Grey Hammertone or Natural



All boxes incorporate guides on all sides for holding 1.5mm thick pcb's and stand-off bosses in base for supporting small sub-assemblies etc. Close fitting flanged lids held by screws running into integral brass bushes (ABS) or tapped holes (Diecast).

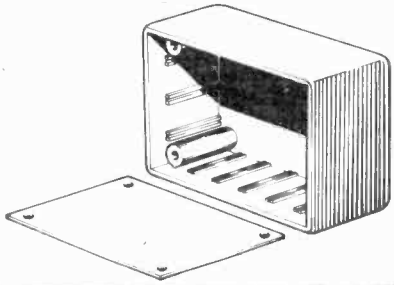
	ABS		Diecast	Hammertone	Natural
(100x50x25mm)	BIM2002/12	£0.87*	BIM5002/12	£1.20*	£0.97*
(112x62x31mm)	BIM2003/13	£0.97*	BIM5003/13	£1.50*	£1.20*
(120x65x40mm)	BIM2004/14	£1.05*	BIM5004/14	£1.86*	£1.49*
(150x80x50mm)	BIM2005/15	£1.18*	BIM5005/15	£2.38*	£1.91*
(190x110x60mm)	BIM2006/16	£1.84*	BIM5006/16	£3.41*	£2.85*

Also available in Grey Polystyrene (112x61x31mm) with no slots and self tapping screws BIM2007/17 £0.82*

MULTI-PURPOSE BIMBOXES

Moulded in Orange, Blue, Black or Grey ABS with 1mm thick Grey aluminium recessed front cover which is retained by 4 screws running into integral brass bushes. 1.5mm pcb guides are incorporated on all sides and as with all ABS boxes they are 85°C rated. 4 self adhesive rubber feet also included.

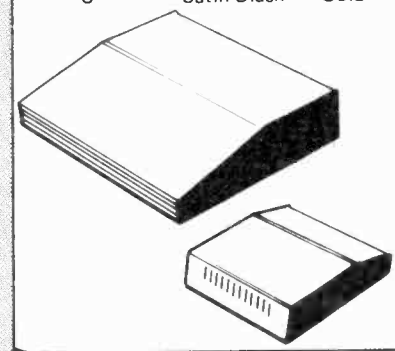
BIM 4003 (85x56x28.5mm) £1.13*
BIM 4004 (111x71x41.5mm) £1.42*
BIM 4005 (161x96x52.5mm) £1.87*



ALL METAL BIMCONSOLES

All aluminium, 2 piece desk consoles with either 15° or 30° sloping fronts, sit on 4 self-adhesive non slip rubber feet. Ventilation slots in base and rear panels permit efficient cooling.

Colour Code	Top Panel	Base
A	Off White	Blue
B	Sand	Green
C	Satin Black	Gold



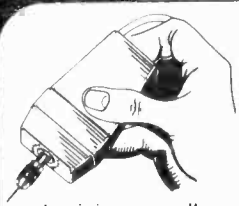
15° Sloping Panel

BIM7151 (102x140x51[28] mm)	£ 9.43
BIM7152 (165x140x51[28] mm)	£10.43
BIM7153 (165x216x51[28] mm)	£11.42
BIM7154 (165x211x76[33] mm)	£12.39
BIM7155 (254x211x76[33] mm)	£13.66
BIM7156 (254x287x76[33] mm)	£14.65
BIM7157 (356x211x76[33] mm)	£15.80
BIM7158 (356x287x76[33] mm)	£16.78

30° Sloping Panel

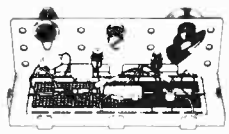
BIM7301 (102x140x76[28] mm)	£ 9.43
BIM7302 (165x140x76[28] mm)	£10.43
BIM7303 (165x183x102[28] mm)	£11.42
BIM7304 (254x140x76[28] mm)	£12.39
BIM7305 (254x183x102[28] mm)	£13.66
BIM7306 (254x259x102[28] mm)	£14.65
BIM7307 (356x183x102[28] mm)	£15.80
BIM7308 (356x259x102[28] mm)	£16.78

MAINS BIMDRILL

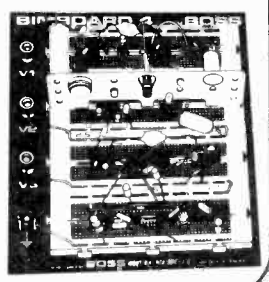


Operates directly from 220-240Vac and supplied with 2 metres long cable fitted with 2 pin DIN plug. Will drill brass, steel and aluminium as well as pcb's etc. Has integral biased-off switch and accepts tools with 1,2 and 3.2mm dia shanks £9.72*
Accessory Kit including 1mm, 2mm, .125" twist drills, 5 burrs and 2.4mm collet £2.20*

DIL COMPATIBLE BIMBOARDS



Bimboards accept all sizes of DIL packages as well as resistors, diodes, capacitors and LED's etc. They have integral Bus Strips running up each side for carrying Vcc and ground as well as Component Support Brackets for holding lamps, fuses and switches etc. Available as either single or multiple units, the latter mounted on 1.5mm thick, matt black aluminium back plates which stand on non slip rubber feet and have 4 screw terminals for incoming power.



Bimboard 1 contains 500 individual sockets whereas the multiple units containing 2, 3 or 4 Bimboards incorporate 1,100, 1,650 or 2,200 individual sockets, all arranged on a 2.5mm(0.1") matrix.

Bimboard 1 £ 9.72* Bimboard 2 £22.68*
Bimboard 3 £32.40* Bimboard 4 £42.12*

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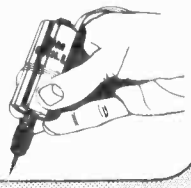
2 small but powerful 12V dc drills, easily held in hand or used with lathe/stand adaptor. Both drills have integral on/off switches and 1 metre long cable.

Mini Bimdrill with 2 collets up to 2.4mm capacity £7.56*



Major Bimdrill with 3 collets up to 3mm capacity £12.96*
Mains to 12 Volts adaptor, lathe, stand and accessory kits also available, details on request.

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The new, comprehensive JVC ¾" video cassette range

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A pioneering electronics organisation with 51 years' experience of high-technology engineering, JVC has been developing and introducing new and better video products for 21 years.

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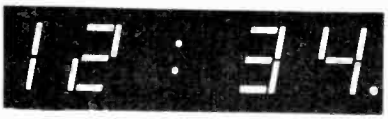

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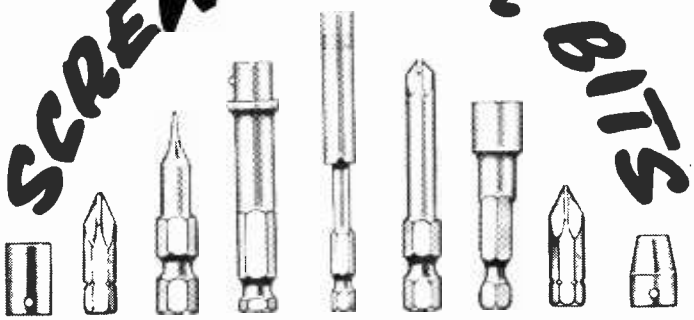

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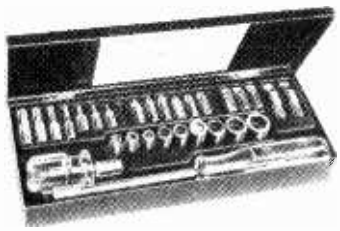

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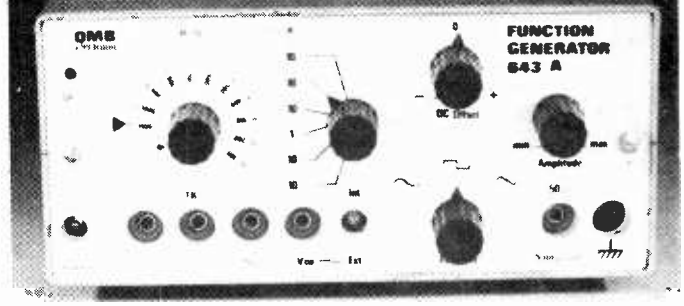

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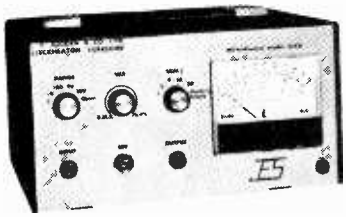

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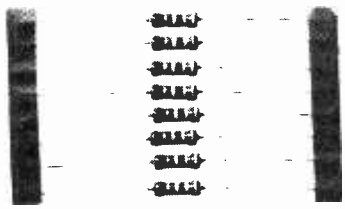

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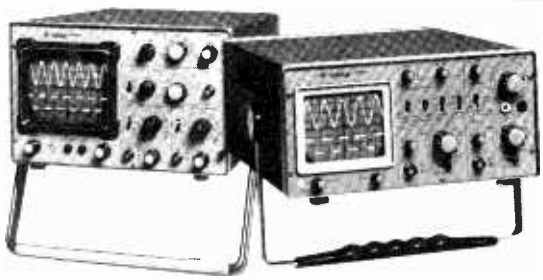

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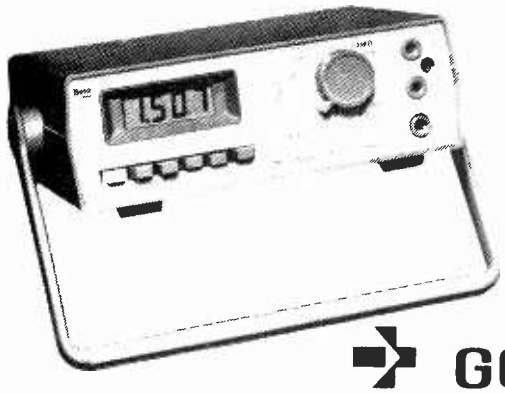

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Electronics and unemployment

SECRETARIES and newspapermen can now type "North Sea oil" with a facility they would normally experience only when typing out their own names. It becomes clearer every day that a counterfeit sense of pre-election prosperity is clouding the judgements of many of those in a position to influence the national well-being for the next 20 or 30 years. The oil money may be the worst thing that could have happened to us, disguising serious failings in the way our industries are run.

Of these the most sadly evident is the reluctance of the self-styled "wealth-creators" (about as sensible a description as calling the CEGB an energy-creator) to prepare for the day after tomorrow.

The electronics industry is sharing in this short-sightedness. So far, commentators on teletext, Viewdata and the electronic home have chosen to emphasise the positive aspects of these changes, that certain tasks may be made easier, and may lead to a much more pleasant style of life. When these things arrive they will make deep impressions on our lives, but there is a false tendency to imagine that these wonders will be gained at no cost at all.

The first signs of the price we will pay are already there. One is unemployment. Our government is disposed to persuade us that this is a cyclical aberration which will disappear with the passing of time, an improvement in world trade, and a judicious tax-cut or two.

The electronics engineer knows that this is not so. We may be in for a consumer-happy 1978 but there is a deep-rooted movement in industries of all kinds away from the employment of labour.

It used to be thought true that new technology would always create enough new types of job to take the place of redundant skills. Far from being a universal law, it now appears that such instances of this as have appeared in the past were just manifestations of a transition between the age of man and the age of the machine. Not many new jobs have resulted from the move away from Strowger exchanges, and we report elsewhere in this issue that advances in computer technology are to put people in the computer industry out of work. When technology makes it unnecessary for us to travel to our work the process will be complete.

There will be no commuters, and no need for railwaymen, bus-crews or city sandwich bars. Labour will have become so expensive, and will need to be so highly trained, that unemployment will be at 50%. The worker, free of his twice-daily train journey through the slums, will inconsciously devalue other people and their importance as the reason for increasing the community's prosperity, an effect already evident in parts of the United States.

The only products to be made will be those which provide some kind of diversion from the thought of endless years without a task to do. The Home Office and the Post Office will take over the Department of Education and, with a system of one-way programmed learning will have induced in the younger members of society a kind of baffled contentment.

The world need not be like that. Our only hope is that future technology is directed towards increasing output, not just decreasing staff. That means we must make the things required by places where there is a market, and forgo the short-term gains to be made from a series of electronic equivalents of the hula-hoop. It means selling to the third world, and it means planning ahead with the North Sea oil money that now threatens to drown us in complacency.

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Loudspeaker coloration

Eliminating unwanted sources of resonances

by D. A. Barlow, Ph.D

Loudspeakers have always been the weakest link in the chain of sound reproduction. The tone is coloured by the presence of unwanted resonances, which may still be audible in spite of considerable damping. The already-reported limits of audibility of resonances on white noise and music over a range of frequency and Q are discussed in relation to loudspeakers. The white noise test was severe and few if any speakers meet this "peak criterion," even over part of the audio range. Sources of unwanted resonances and methods of elimination are discussed and a design proposed for a speaker in which coloration is inaudible.

IN LOUDSPEAKERS, there are many causes of coloration or spurious effects not present in the electrical input signal. These usually take the form of resonances or anti-resonances. In bad cases, they show on a frequency response curve; less severe cases may be found by transient tests, or by watching the motion of the moving parts by holographic methods.[1,2] Resonances may be present in the diaphragm, surround, rear suspension, voice coil, dust cap, chassis, cabinet walls, etc. Other resonances are the fundamental ones of the drive units and of air cavities, including the air enclosed by the cabinet. Other effects, not necessarily audible, include acoustic interference between units in multiple speaker systems, phase differences between units, phase distortion in the crossover, diffraction at the edge of the cabinet, speaker frame, etc.

I have long thought that listening tests should be used where possible to determine the limits below which the various forms of distortion or imperfection in audio equipment become inaudible. Effort could then be concentrated on the most serious defects, and those which are inaudible can be ignored. In particular, listening tests were proposed to determine the limit of audibility of peaks, by introducing resonances of various frequencies and Qs electrically.[3]

Peak listening tests

Preliminary tests were made in 1972, using an Altec Room Equaliser. This has a number of resonant circuits covering the audio range. Each may be varied to be either a peak or a dip. Listening tests were carried out, using two makes of high quality headphones, thus avoiding the effect of room acoustics. Using white noise a single peak of 2dB in the mid-range was clearly audible, giving the noise a definite pitch. At the extremes of frequency, the ear was less sensitive, as might be expected. A 2dB dip in the mid-range equally gave a definite pitch to the white noise.

The main listening tests were carried out by Fryer[4]. A number of frequencies were used with a Q of 50, 25, 10, 5, 2.5, and 1. Three sources were used, white noise, the opening bars of Brahms first Piano Concerto, and Cleo Laine singing 'Peel me a grape'. The unbroken lines in Fig. 1 show the level at which the peak becomes inaudible. A-B tests were used with compensation for the increase in loudness caused by the addition of the peak. A large number of listeners took part, and were of various ages and occupations. Each listener listened alone, with no knowledge of other listeners' results.

White noise is the most sensitive, followed by the Brahms. As the Q is lowered, the level at which the peak can be detected is also lowered. A hump of given height, covering a large bandwidth is more noticeable than a spike of the same height, which affects only a very small bandwidth. The ear evidently detects mainly the energy or area under the peak. In some cases, at high Q, the peak can be well above the general level

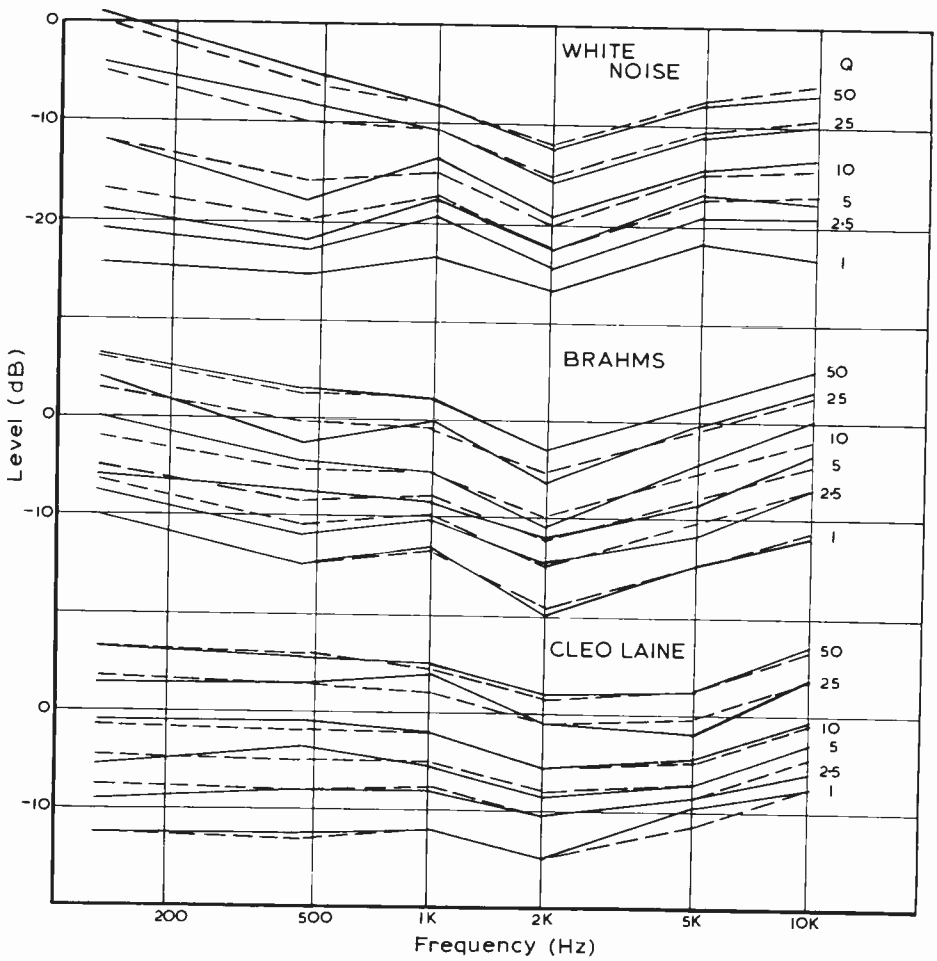

Fig. 1. Levels at which response peaks become inaudible for six values of Q and frequency, using three source signals. Broken curves indicate adjusted values (see text).

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before being detectable, but in other cases a low Q resonance, well below the general level, is still detectable. Damping a resonance may not give as great an improvement as hoped for, especially at low frequencies. It follows from these curves that a flat response, containing peaks damped down to the general level, is no guarantee of freedom from coloration; also that two speakers with smooth frequency response curves may have quite different degrees of coloration. Low-Q resonances near the extremes of frequency are similar in effect to tone controls, and alter the character of the sound rather than make it unpleasantly coloured.

There is naturally some scatter in results; for example the gap between the levels for Q of 25 and 10 for white noise at 450Hz appears excessive. There is good reason for thinking this. Reducing the Q from 25 to 10 by damping means reducing the level by 8dB, yet the detection limit drops 10dB. Thus damping the resonance would appear to make it slightly *more* audible! This is highly improbable. I felt justified therefore in smoothing the curves, removing this one anomaly. Values were adjusted so that the differences between the dB drop in reducing the Q, and the drop in detectable level followed a smooth curve in each case. This was done for all points, the change in actual values being kept to a minimum. The smoothed curves are indicated by the broken lines.

These curves agree in general with similar tests reported by Bowsher[5]. Under certain unstated conditions, Harwood[6] obtained different results. It can only be concluded that these conditions were unrepresentative of normal listening.

Application of results

The present curves, especially for white noise, represent a very severe demand on the loudspeaker; we may call this the peak criterion. Few if any commercial speakers meet the criterion, even over part of the frequency range. There are two basic ways of making a speaker

- by using a relatively large light diaphragm driven all over, for example by electrostatic, piezoelectric or electrodynamic means
- by using a relatively small diaphragm driven from a very small area, for example by a moving coil.

For satisfactory operation, the first type must have a very limp diaphragm, operating well above the fundamental frequency, in the hope that the overtones will be sufficiently damped as to be undetectable. There is very little information on this. The second type must operate at frequencies well below the diaphragm resonances. Most speakers fall between the two stools.

Thin cones made of paper, metal, plastics, carbon fibre, inevitably resonate over almost all of their working range. The object in designing such cones is to find a profile in which none of the resonances is pronounced. There is no way of calculating this, and a suitable shape can only be found by trial and error, a process which is still going on after nearly 50 years, and could go on ad infinitum. For this reason, it is always possible that a beginner may by chance produce a cone with a smooth response. In some plastic film diaphragms, the profile is known to be very critical and small deviations may give serious peaks. Even if a smooth response is obtained, resonances will be present. Such cones cannot be expected to meet the peak criterion.

If a cone is to operate below its breakup resonances, it must have the highest possible stiffness/weight ratio. As deformation is mainly in bending, the structure with the maximum bending stiffness must be used, viz. sandwich construction[7,8]. The maximum stress in bending is taken by the outer layers; these are therefore made in a material with the highest ratio of Young's modulus/density. The skins are glued to a core, which must be as thick and light as possible. Aluminium foil and expanded polystyrene are the obvious materials to use.

Possible speaker to meet the peak criterion

By using sandwich construction, it should be possible to meet the peak criterion except at the ends of the frequency spectrum, where the ear is less sensitive and where further tests are desirable. Sandwich cones are usually of high Q, but the breakup resonances can be damped down to the general level by means of suitable damping material applied to the cone neck[2]. If the white noise criterion is used, these resonances must be about 24dB down, assuming a Q of 1.

It is known from holographic examination that a 25cm diameter sandwich cone of 105° included angle has a first resonance, the umbrella mode, at 1300Hz, which is often difficult to detect acoustically or by impedance curves. Such a cone would meet the peak criterion by crossing over at about 300Hz with a 12dB/octave crossover. A 6dB/octave crossover would be of little value where a limit of —24dB is to be met.

The mid-range could be handled by a 7.6cm diameter cone. The first breakup would be at about 6kHz, allowing crossover at 1.5kHz. Damping of the resonances may require a rather large weight of damping compound. Driving from the periphery by means of a 7.6cm diameter voice coil may give higher breakup frequencies, although the mass of the voice coil former would be greater than for a smaller diameter coil. Furthermore, diffraction at the cone edge and resonance of trapped air may be problems. If beryllium or carbon fibre were available in suitable form, the breakup frequencies could be raised considerably, thus easing the design.

The treble cone could be 3.8cm diameter, again perhaps driven from the periphery. To raise the first breakup above 20kHz, beryllium or carbon fibre skins would be necessary. Smaller cones than this are difficult to construct and the maximum permissible weight for smaller cones is very low. The optimum cone angle is 90 to 105°. The use of a smaller included angle should raise the circumferential mode frequencies but decrease the radial mode frequencies. As there are no radial modes in sandwich cones, unlike paper, a small included angle could be used. However, this raised the first frequency, but lowered the frequency of the second mode, so that there was no advantage in going to smaller angles than 90°.

The suspensions of the mid and treble units should be designed to coincide with the planes of the centre of gravity and centre of inertia, thus avoiding any tendency to non-axial motion. Likewise, the leads must be brought out at 180°, as it is known from holography studies that if they are brought out together, the unbalanced mass will cause rocking of the cone. The fundamental resonances of the two units when mounted must be at least two octaves below crossover, assuming good damping.

Very little can be done about the fundamental resonance of the bass unit. Most speakers show the effect of the fundamental resonance in the slow decay of the bass in delayed resonance tests. The principal types of enclosure are the reflex and the totally enclosed. The full theory of the reflex has been given by Thiele[9]. With correct design, with correct coil and cone weights, flux density, etc, the bass response can be extended well below that for a similar totally enclosed cabinet. Thiele's work has been translated into practical terms by Garner and Jackson[10] and by Collinson[11] at my suggestion[3]. However, the reflex cuts off at 18dB/octave compared with 12dB/octave for the enclosed cabinet. In the present context, a sharp cut-off is to be avoided. It might be better to use an enclosed cabinet with enough acoustic and magnetic damping to be critical ($Q = \frac{1}{2}$), the response being —6dB at resonance. This represents some loss of bass, but as the cabinet is likely to be placed against a wall during use, there will be acoustic reinforcement of the bass.

The only other enclosure of interest is the folded pipe or labyrinth, now called the transmission line. This has the advantage of not increasing, or even slightly decreasing the fundamental resonance. Apart from any possible extension of the bass, this would place the fundamental resonance sufficiently low in frequency to be inaudible. Unfortunately, the finite length of the pipe and the necessary folds give rise to resonances of the enclosed air[12], and these are audible as 'bumbling', even when damped with long-fibre wool[13].

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Resonances of cabinet walls

The conventional rectangular cabinet inevitably suffers from bending resonances of the flat walls. In certain cases, especially with large cabinets, the sound output of the cabinet walls at the frequency of panel resonance can exceed that of the speaker by several decibels[1]. These resonances may be damped by thick layers of damping material glued to the panels, the weight of the damping compound being comparable the the panel weight. Bituminous damping felt is the most practical material [8, 10]. Damping compounds readily suppress the overtones, but are less effective at the fundamental. The answer is to use a cabinet of constant curvature, where there are no bending resonances, only resonances in direct stress[14]. This has now been utilised in two recent commercial designs. Such cabinets are so stiff in operation that almost any material may be used for bass cabinets. A cardboard tube of 30cm diameter has no resonances below 2kHz, and the radiation level at lower frequencies is 30 to 40dB below the signal. It is fully equal to brick and concrete and easily meets the peak criterion.

The obvious method of mounting a bass unit in a tubular cabinet would be at one end. The tube could be 60cm long × 30cm diameter with the bass unit facing upwards. A long pipe may give trouble with organ pipe resonances. With a crossover at 300Hz, the bass unit would be almost omnidirectional over its working range. This would avoid any possible apparent loss of mid-frequencies due to listening off-axis. Diffusers could not be used to increase the spread of the upper frequencies because they give irregularities in the response curves and audible effects at lower frequencies. Inverting the speaker unit so that the rear faced upwards, the rear face of the cone being clearly visible from the listening position, did not alter the directional properties. Mounting the speaker at one end of the tube, facing the longest direction has the advantage that the rear reflected wave will be at the lowest frequency; it is less likely to be audible and has the maximum thickness of acoustic absorbent through which to travel. Re-radiation of the reflected wave is thus at a minimum. A sandwich cone gives much less re-radiation than a conventional paper cone[15].

The mid and treble units could be mounted in the cylindrical surface, without unduly affecting the performance of the cabinet; if necessary, the cutouts could be stiffened up with additional material. The diffraction effects at the sharp edges of a conventional cabinet are avoided, and provided the units are not at centre height, a cylinder was found to be almost as good as a sphere or ellipsoid for avoiding diffraction. That diffraction effects can be audible in the worst case is shown by the following test.

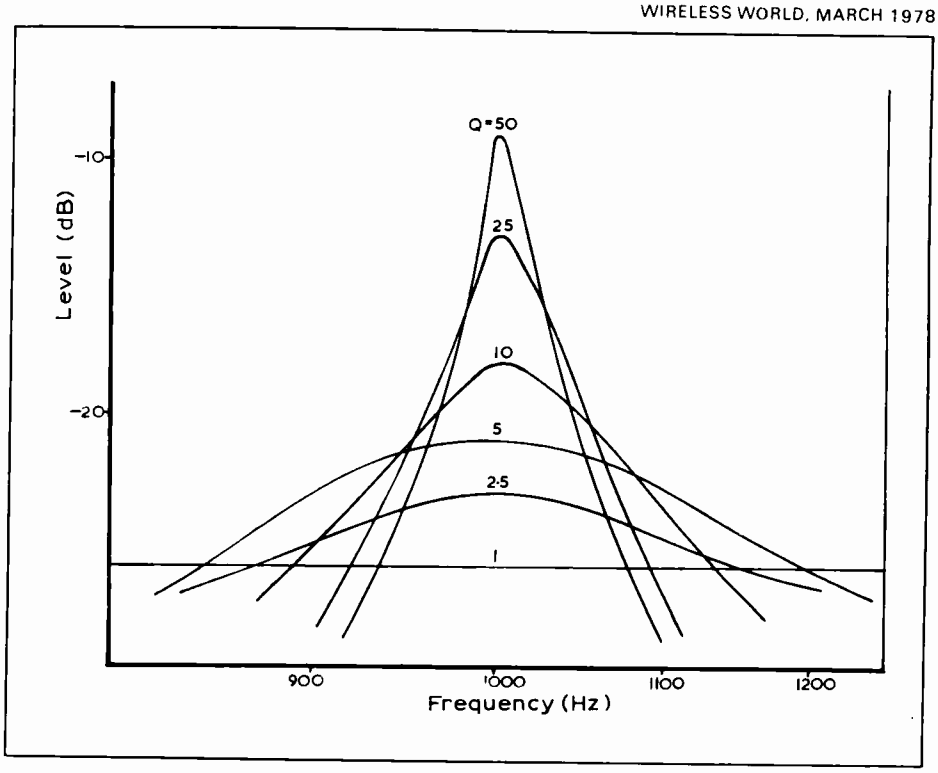

Fig. 2. In the listening tests discussed resonance peaks with Q of 1 to 50 were switched in and out in establishing level of inaudibility. Detectability decreased by 3dB for each doubling of Q.

A single speaker was used, as no two units sound the same on white noise, and differences due to position in the room are avoided. The speaker was mounted in a 30cm diameter sphere and fitted with a 30cm diameter removable flat baffle. On white noise, the difference with and without the baffle was quite clear. The effect of the baffle on the frequency response was to introduce a hump of 4dB at 1kHz and a hollow of 4dB at 1.8kHz.

In addition to spurious external radiation by the cabinet walls, there is the possibility of sound being transmitted from the bass into the treble cavity and vice versa. Tests in 1974, which unfortunately I could not complete, suggested that this transmission may not be negligible in all cases.

Crossover networks

It has been known for many years that there is phase distortion in most crossover networks, the 6dB/octave quarter section being the only common one free from this. Crossover filters have been studied by Wall[16] at my suggestion.[3] He devised a three-way filter without phase distortion. This uses a two-way half section with a mid-section to correc the phase. Baekgaard[17] has devised a similar filter. Although the mid-speaker operates only over a narrow band, the cut-off on each side is only 6dB/octave. If it is to meet the peak criterion, it must be free from resonances over eight octaves. Such a speaker would be a full range one and would hardly need crossovers. It might be possible to make an acceptable unit by rolling off both bass and treble acoustically by suitable design.

Another possibility is a linear-phase filter of the Gaussian or Bessel type, i.e. beyond cut-off the phase angle is proportional to frequency, although design data is scarce. Nomoto et al[18] have demonstrated the wavefront from speakers by means of measurement over a large number of microphone positions, using a computer. A two-way system using a Bessel filter showed a wavefront corresponding to the input signal, in contrast to a Butterworth filter.

A number of commercial speakers have been produced recently, in which the mid and treble units have been set back behind the plane of the bass unit. The acoustic centres should thus be in the same plane and acoustically in phase — the "linear phase" system. Some of these have crossovers without phase distortion, others have conventional crossovers. If in a two-speaker system, the treble unit is placed on top of the cabinet and moved back and forth, there is a slight difference in sound with position on white noise. This is clearly heard from above the speakers and is obviously due to reflection off the top of the cabinet. The test was repeated with thick absorbent on the top of the cabinet and with the treble unit mounted in a sphere to avoid diffraction effects. The difference with position was still present on white noise, again clearly so from above the speakers and was reflected from the top of the cabinet. Setting mid and treble units back necessitates steps in the front face of the cabinet, and these may be bevelled to reduce reflection. A treble unit was mounted off centre in the usual way near the top of the front panel of a typical rectangular cabinet. The edges of the cabinet were bevelled to reduce

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diffraction. A removable 7.8cm thick panel with a 45° bevel was fitted below the treble unit. On white noise, there was a small but definite difference with and without the panel. The effect of the panel on the frequency response was to create a small dip at 2kHz. It seems that any audible effect due to the acoustic centres being in the same plane is very small and is masked by reflection.

Other sources of spurious radiation

Other components of the speaker besides the cone may give spurious radiation. The surround in particular is of appreciable area and tends to move out of phase with the diaphragm, especially at large excursions at low frequencies. Also, it is well known that an insufficiently damped surround will give a dip and a peak in the response curve. The units could operate without surrounds. The moulded edge of the expanded polystyrene could be a clearance fit in the chassis rim. The clearance would be filled with a suitable magnetic fluid, a retaining magnet being incorporated in the rim of the chassis. The outer edge of the cone and inner edge of the chassis would need to be rounded to reduce diffraction. Two rear suspensions would probably be necessary for centering the bass unit.

Dust domes are another possible source of spurious radiation. There are two possible forms

- A rigid airtight continuation of the cone. This must meet the peak criterion; on an area basis, the radiation will be about 14dB below that of the cone.
- An open structure, allowing free passage of air. This assumes that the acoustic resistance offered by the magnet gap is sufficient to avoid losing bass. Rather than being strictly dust-tight, this prevents most foreign bodies from entering the magnet gap. Measurements showed that the conventional undoped impregnated fabric dome and plugs of (flexible) open-cell urethane foam were satisfactory. Any radiation by these components would be largely cancelled acoustically because of their open structure.

Voice coils are another possible source of resonance. The compliance of the neck of the former may resonate with the mass of the cone. The neck will deform by direct tension and compression, but is unlikely to buckle except for very long formers in thin material. It can be easily shown that the load needed to cause elastic buckling of the former far exceeds the load due to the driving force. A typical 2.5cm diameter former in kraft paper may resonate around 8kHz, and in many moving coil tweeters, the output consists mainly of cone and coil resonances. In the present case, short 3.8cm diameter formers in epoxy-glass fibre and in carbon fibre were stiff enough to avoid resonance in the audio range.

Another source of coloration is reflection from obstacles behind the cone or resonance of air cavities created by such obstructions, for example the chassis. It is well known that the rear radiation from a speaker is seldom as clean as that from the front. Listening tests were made with white noise fed to the unit with a very open chassis. On a flat baffle, the slightest obstruction at the rear was immediately audible from the front. The speaker was then mounted in the wall of a room and obstructions introduced at the rear. Small obstructions corresponding to a chassis were detectable, but gross obstructions, for example a shallow enclosing box were clearly audible. Providing the enclosure was fairly deep and filled with absorbent, it was very difficult to detect.

Acoustic interference between units is noticeable on sine wave in bad cases for example where two treble units are used in parallel, perhaps to increase power handling capacity. The loudness varies on moving the head. In more typical cases, the transient test results are poor at crossover frequencies, but whether this produces an audible effect is not known. It may be desirable to avoid crossing over in the mid-range where the ear is most sensitive to coloration. It might be passible to reduce interference by means of careful coaxial design.

Fallibility of listening tests

In production, the sensitivity of units will vary due to variation in mass of diaphragm, mass of dope applied, mass and resistance of voice coil, and magnetic flux. In a multiple speaker system, it is well known that if the units are not carefully matched for sensitivity, the whole character of the sound is altered. Furthermore, we have already seen that the character is altered by small differences in shape of response curve. Again, in listening tests on amplifiers in 1972, it was found that a gradual slope of +2dB from bass to treble due to slight inaccuracy of equalization gave a different character from the reverse slope. Speakers may well be judged on the character of sound which the listener prefers, rather than on the quality. Speakers used by the British Broadcasting Corporation have to meet very close tolerances, perhaps in order to maintain the same character of sound. Harwood[19] has described errors which can arise in listening tests. The question arises: if a speaker were built to be free from coloration, would it be recognised as such?

D. A. Barlow, B.Sc. M.Sc. Ph.D. F.A.E.S. . . . unemployed

Don Barlow left Fane Acoustics when they closed down their laboratory last year, reluctantly joining the unemployed. And it was another closure that forced him to leave the Rank Leak Wharfedale research laboratory three years before that. At RLW, he worked on a viscous-filled sphere suspension for turntables, also developing a lightweight tubular enclosure designed to be free from panel resonances. But perhaps his most well-known contribution to audio is the sandwich loudspeaker that he developed and produced whilst with H. J. Leak & Co. in the 1960s. He actually conceived the idea (*WW* Dec 1958, pp 564-9) in his spare time, his job then being concerned with the properties of aluminium alloys following graduation in metallurgy at Birmingham University back in 1943, and through which he gained an external M.Sc. 12 years later. Two other *WW* articles which reflected another spare-time interest — groove deformation in records — were published in May 1957, pp. 228-30 and April 1964, pp. 160-6.

References

1 Stroboscopic holographic interferometry for transducers. *Wireless World*, vol.73, 1967, p.471.
Barlow, D.A. Rank Leak Wharfedale Research Report 1970.
Fryer, P. A. Lecture to A.E.S. London, 12 June 1973.

2 Fryer, P.A. Holographic investigation of speaker vibrations. 50th A.E.S. Convention, London, 1975.

3 Barlow, D. A. Rank Leak Wharfedale Proposed Research Programme, 17 Sept., 1971.

4 Fryer, P. A. Intermodulation distortion listening tests. 50th A.E.S. Convention, London, 1975.

5 Bowsher, J. M. 47th A.E.S. Convention, Copenhagen, 1974.

6 Harwood, H. D. Audibility of phase effects in loudspeakers. *Wireless World*, vol.82, 1976, pp.30-2.

7 Barlow, D. A. Rigidity of loudspeaker diaphragms. *Wireless World*, vol.64, 1958, pp.546-9.

8 Barlow, D.A. Lecture to Brit.I.R.E. (now I.E.R.E.), 24 Jan., 1962.
Barlow D. A. Development of a sandwich-construction loudspeaker system. *J.A.E.S.*, vol.18, 1970, pp.269-81.

9 Thiele, A. N. Loudspeakers in vented boxes. *Proc. I.R.E. (Aust.)*, vol.22, 1961, pp.487-508. Reprinted in *J.A.E.S.*, vol.19, 1971, pp.382-91 & 472-83.

10 Garner, A. V. & Jackson, P. M. Theoretical and practical aspects of loudspeaker bass unit design. 50th AES Convention, London, 1975.

11 Collinson, J. D. Lecture to A.E.S., London, 2 March 1976.

12 Barlow, D.A. Letter, *Wireless World*, vol.71, 1965, pp.614-5.

13 Falkus, A.E. Private demonstration, April 1975.

14 Barlow, D. A. Sound output of loudspeaker cabinet walls. 50th A.E.S. Convention, London, 1975.

15 Cooke, R. & Fincham, L. Lecture to Brit. Kinematography, Sound & Television Soc., London, 16 March, 1969.

16 Wall, P. K. Active and passive loudspeaker crossover networks without transient distortion. 50th A.E.S. Convention, London, 1975.

17 Baekgaard, E. Loudspeakers – the missing link. 50th A.E.S. Convention, London, 1975.

18 Nomoto, I., Iwahara, M. & Onoye, H. Demonstration film to A.E.S., London, 11 May 1976.

19 Harwood, H. D. Some factors in loudspeaker quality. *Wireless World*, vol.82, 1976, pp.45-54.

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Consumer scene has to get better

MAKERS AND distributors of consumer electrical and electronics products can expect a better year in 1978 — as Jordan Dataquest point out in a recent survey, it couldn't be much worse than things have been up to now. The nine largest private companies in this sector made profits which averaged 0.7% in 1975 and '76.

About 140 of the 392 companies surveyed are private, and most of them are tiny: "The largest private company . . . engaged in electronics manufacture and also trading profitably is Stereosound Productions Ltd, which is 154th in order of size." The profit margin, said Jordan referring to private companies, "is distressingly low."

The survey goes on: "This low profitability may, of course, simply reflect the nadir of an economic cycle and low consumer demand. Nevertheless a perusal of the companies' figures for the previous year also reflects an unexciting picture. Moreover out of 392 companies nearly a quarter (23%) were losing money in the period reviewed." One company, however, whose performance had been outstanding was Waltham Electronics, a subsidiary of an Irish company, which increased its margin to 6.9% by nearly trebling profits on a slightly increased turnover of around £5.5 million.

● There is little doubt that the consumer goods trade will improve in the next year at least. One reason is that as an election approaches the Chancellor is likely to make as much as he can of any opportunity to cut direct taxation, and indeed he has already committed himself to doing this.

Another reason is that as a result of North Sea oil the pound is considerably stronger than it was, and this has caused inflows of foreign capital. These have been deposited in British banks and will make lending easier. This effect is an inflationary one in that it is a direct increase in the money supply. This is why the fiscal authorities have stepped in to try to halt the rise in the pound by buying gold and foreign currency in an attempt to halt these inflows of hot money which, apart from anything else, are just as likely to run out of the country again at the first sign of an economic squall. Another point about a rising pound is that it makes imports cheaper and reduces the profits of companies selling abroad. □

More space and support for Communications '78

THE FOURTH international communications equipment and systems exposition, Communications 78, is to be held at the National Exhibition Centre, Birmingham, April 4-7. For the first time, the event is being supported by the International Telecommunications Union, Post Office Telecommunications, and the Home Office's Directorate of Radio Technology and Directorate of Telecommunications. The IEE are again organising the conference but, for the first time, they are working with the IERE, the UKRI section of the IEEE, the IEEE Communications Society and the Convention of National Societies of Electrical Engineers in Western Europe (EUREL).

There will be three main themes: PTT Telecommunications, Fixed and Mobile Radio Communications, and Defence Communications. Each has been allocated a day of sessions. The inaugural day will include an address by the president of the IEE, Mr J. M. Ferguson. Three sponsored tours, called inward missions, have also been arranged for selected groups of visitors, preferably overseas visitors, interested in PTT, fixed radio or defence communications.

In 1972, when this event was first held, the exhibition covered only 120 square metres. In 1974 it increased by 50%, and in 1976 it doubled to 3,678 square metres. Next year's exhibition space will be three times that of the last – more than 12,500 square metres. So far 90% of this space has been allocated to electronics companies and other bodies. □

Gilbert Briggs

GILBERT BRIGGS, engineer, businessman, journalist and author, founder of Wharfedale, died on January 10 aged 87. His death followed those of Guy Fountain, founder of Tannoy, and l.p. inventor Peter Goldmark by a few weeks.

Briggs didn't start in audio at all. Brought up in an orphanage, he was self-taught, and his career began in the Bradford textile industry. He began Wharfedale Wireless Works in 1933, under his wife's name, where it remained for 20 years. He sold the business to Rank "for a slight profit" in 1958.

He built his first speaker in the autumn of 1932, winning a local radio society competition with it. A few days later, he once recalled, a wholesaler came round and ordered a gross of them. He agreed to supply them at a dozen a week. By March 1934 he had made 4,600 speakers and a loss of £1,000. By 1939 production was 9,000 speakers a year. During the war the factory made transformers for the navy.

After the war he began to write what many regard as a classic series of books on audio and related subjects. The methods he described are still valid today.

He also began a now-famous series of combined lectures, concerts and demonstrations at various places including Carnegie Hall. By the time the final concert was held at the Royal Festival Hall on May 9, 1957, seven of the fifteen items on the programme were in stereo and Leon Goossens (oboe) was taking part in the live demonstration.

He leaves a wife, Doris, and two daughters.

Racal — back to business

ON THE DAY two of their former executives and a Ministry of Defence functionary were found guilty of corruption at the Old Bailey, Racal shares went up 18 pence, according to the BBC financial report, and 9p if you believe *The Times* business section. The news seems to have damaged them not a whit. The wife of one of the convicted men said she would go out and celebrate the verdict with brandy at £7 a glass.

The trial arose from the Middle East arms scramble of the early 70s, caused by the conflict with Israel and increasing oil revenues. In 1966 the Defence Sales Organisation was set up to allow British firms to get the benefit of the arms contract bonanza. It was staffed partly by British Army officers but its first head was Raymond Brown, who had, as it happened, founded Racal with Calder Cunningham in 1950. Mr Brown was knighted in 1969, when he left the D.S.O.

In January 1971 Britain won an order to build 300 tanks for Iran. This was followed in May by a further order for 433 tanks, and the two orders were together worth £100 million. The middle man between the Shah and the British Government had been Sir Shaapoor Reporter, given an OBE in the same year as Sir Raymond received his knighthood, and a knighthood in 1973, for services to British exports. The Chieftain order earned, if that is the word, Mr Reporter £1 million, 1% of the sale price.

The next available contract was that to supply radios for the tanks, an order worth £4 million. Reporter, a close friend of the Shah, had to be paid commission if any Iranian contract was to be won. Normally the bribe would be added to the contract price, and since the money would come ultimately from the Iranian taxpayer the British authorities learned to live with the arrangement.

The British Ministry of Defence official in charge of trying to get British firms the order for the radios was, at the beginning of the seventies, Major D. A. C. Randel: by the time he was tried for corruption he had been promoted to lieutenant colonel. Randel was in the Royal Corps of Signals, attached to the Defence Sales Organisation.

One of the firms in the running for the contract was Racal subsidiary British Communications Corporation. The sales director was Frank Nurdin who, like Shapoor Reporter, had received an OBE in the 1969 honours list. He was determined that Racal's VRQ301 radios would be the ones installed in the Iranian Chieftains. Nurrdin, since dismissed by Racal and now working for Plessey, and his managing direcor, Geoffrey Wellburn, began a series of cash payments to Randel for favourable treatment of the Racal tender. Randel was convicted of receiving £7,000, £5,000 and £2,800 on three occasions during 1972.

According to evidence given at the trial, Randel had demanded ½% commission, or £20,000. He had developed a taste for the high life. He had joined a number of fashionable clubs and had opened a Swiss bank account. He first came to the notice of the army special investigation branch when, in 1974 as a consultant to the Oman government, it was noticed he was living beyond his means. He

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was arrested in April, 1976, and is reported to have told police: "I have had a bloody good time, really, a bloody good time."

Witnesses at the nine-week trial included Racal chairman Ernest Harrison, who denied any knowledge of the payments, as the two Racal defendants claimed he had, and Oliver Prenn, former chairman of Racal BCC, who said at first that he had told Wellburn to ignore pressure from Randel for ½% and that there had been no question of paying the Iranians. Three days later he went into the witness box to admit perjury. Five days later he resigned from Racal. Reporter had received 2% commission on the radio deal, as well as another sum for Reporter personally since the commission went mostly to charity.

The total was £250,000 in addition to the £1 million given him by the British Government through Millbank Technical Services, part of the Crown Agents, for the tank order.

There is no telling whether the trial will have any more far-reaching results than the sentences imposed: three years for Randel, 18 months for Nurdin and 12 months, suspended for two years, for Wellburn. At the time of the verdict a lot of newspaper speculation centred around embarrassment – which we can be sure was genuine – in Whitehall and the Government, and stories of a new broom sweeping through the defence sales system – which we can be equally sure were not.

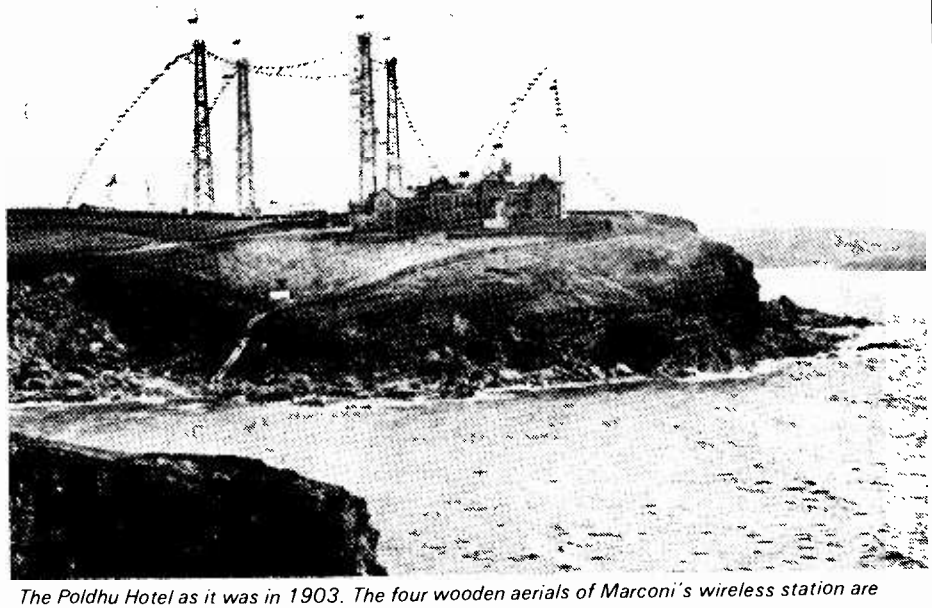
Defence sources believe that once the fuss over the trial has died down defence contracts with foreign countries will be conducted much as they have been, if only because of the difficulty of distinguishing between bribes and legitimate consultancy fees. There is some puzzlement that a company like Racal, which the sources say owes its success to providing good equipment and a first rate after-sales service, should have been singled out.

As taxpayers we can only wonder whether our own administrators are being suborned in a way that we seem prepared to suborn those of other countries, but we can feel justifiably annoyed that these "commissions" earn tax relief for the companies who pay them.

Racal's success in exports has been encouraged by successive ministers from governments of both parties, and the latest of them, Fred Mulley, did not allow an impending trial to deter him from opening Racalex 77.

● A Racal spokesman pointed out that the two executives had been fired in 1974 as soon as an internal investigation had revealed that "improper payments had been made." They reported these payments to the Ministry of Defence and the police, the spokesman said. The rise in share price "reflected the City view that we were in fact the ones who started this off." It was not the company that had been on trial.

According to the Iranian embassy an agreement existed between the two governments that all transactions on the tank orders were to be conducted on a government to government basis, and that the costs of re-equipping the Iranian Army were to be kept to a minimum. The trial now forced the Iranian government to re-examine whether this agreement had been broken. If so action would be taken to recover the money.□



The Poldhu Hotel as it was in 1903. The four wooden aerials of Marconi's wireless station are dressed for a visit by the Prince of Wales.

The Crown and the Home Office

THE DECISION that the Queen should not take part in an exchange of radio greetings with President Carter to celebrate the 75th anniversary of the first radio message from the United States to England was not wholly due to the malign influence of the Home Office, as has been reported elsewhere. Even had the Home Office given its blessing to the enterprise, which is extremely unlikely, the palace would not have taken part on the grounds that, as they told the Cornish amateur radio club who organised it, the Queen does not normally take part in 75th anniversary celebrations unless the circumstances justify it on some other grounds.

When the news that the President's well-wishes would go unanswered first appeared in the *Guardian* on January 10, Conservative MP Robert Adley issued a furiously intemperate statement saying he would put down a question condemning "this bureaucratic, bumbling, nonsensical decision (which) could only have been taken by a socialist minister who does not remotely understand the feelings of ordinary folk. It was taken by poor little Lord Harris, who no doubt sees his job as repeating parrot-like and rubber-stamping everything his civil servants tell him."

Mr Rees replied: "The international radio regulations forbid the use of amateur stations for transmitting international communications on behalf of third parties except in emergencies . . ."

The anniversary is an odd one. The first transatlantic signals had been transmitted in December 1901 when Marconi received the letter S in Morse at St Johns, Newfoundland, from Poldhu. Cornwall. Until 1949, Newfoundland was not part of Canada, and the Anglo-American Telegraph Company immediately served notice on Marconi that they had a monopoly of communications between England and the British colony.

The neighbouring Canadian government then offered Marconi £16,000 to build a station on their territory, and Marconi built it at Glace Bay, Cape Breton Island, Nova Scotia. It was completed in October, 1902. St Johns and Glace Bay, two of the coastal points nearest Europe, had been set up to prepare the way for contact with stations farther south, in the United States. A station had already been established at Cape Cod, Massachusetts.

On January 18, 1903, Cape Cod sent a message to Glace Bay from President Roosevelt, with instructions to forward it to Poldhu. In the early hours of the 19th, however, it was picked up at Poldhu direct from Cape Cod, making it the first wireless message transmitted direct from the US to England. In it, Theodore Roosevelt sent Edward VIII "most cordial greetings and good wishes." A full commercial service started between Canada and Clifden, Ireland, in February, 1908.

The Cornish amateurs began planning to celebrate the message's anniversary some 18 months ago. In April they wrote to Buckingham Palace suggesting that the Queen might like to reply to the messages they had arranged to receive from president Carter. The reply said the palace would look into it, but in June the palace wrote again saying she would not normally take part in a 75th anniversary and that, in any case, they understood that the message would be against international regulations. A further letter from Lord Harris went into more detail.

It had never been proposed that the Queen would go to Poldhu and speak into the microphone the amateurs had set up at the Poldhu Hotel. The idea was that the Queen would send a message in writing which would then be read over the air, and transmitted in Morse over a simulated spark transmitter. It would reply to a message from President Carter which had been arranged by Robert Dogherty of the Barnstable, Massachusetts, radio club. According to Lord Harris, "It is forbidden for amateur stations to be used for transmitting international communications on behalf of third parties."

In fact the latest edition of the radio regulations published by the ITU last September put it a little stronger than that; Article 41, paragraph two reads: "It is *abso-*

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WORLD OF AMATEUR RADIO

Transequatorial on 144MHz

One of the most interesting discoveries resulting from amateur v.h.f. operation during the past 30 years has undoubtedly been "transequatorial propagation": the ionospheric reflection of signals up to and above 50MHz, usually between places in roughly a north-to-south line, one on each side of the equator (e.g. Cyprus to Rhodesia, Japan to Australia).

What appears to have been the first 144MHz two-way contact to have been effected by means of transequatorial propagation was recorded in October 1977 between YV5ZZ in Venezuela and LU1ADA just south of Buenos Aires in Argentina. The 3,180-mile (4,446-km) contact also represented a new world long-distance record, other than by "moonbounce", for this band; previously the record was held for what appears to have been tropospheric ducting between Hawaii and the USA.

Since the transequatorial mode contact was between about 10° North and 35° South of the equator at roughly an equinox, this suggests that 144MHz contacts might be possible between say California (35° North) and Argentina. The YV5ZZ-LU1ADA contact was originally established on c.w. but s.s.b. was used later, with little fading. Subsequently YV5ZZ also contacted LU7DJX a little to the north of Buenos Aires.

This is a further important success for South American v.h.f. operators. In June 1977, PY20B in Sao Paulo heard the first transatlantic 144MHz signals when he received TU2EF in the Ivory Coast, over 3,496 miles away, although it seems unlikely that this was due to the transequatorial mode, and may have been the result of ducting: microwave radar signals are also believed to have been received in South America from Africa on various occasions. A 50MHz beacon station planned for the French space centre at Kourou, French Guiana (about 9° North) should prove valuable for the detection of long-distance v.h.f. propagation modes in the area.

T.v.i. and receiver immunity

The Home Office's "Radio interference report for 1976" (issued December 1977) reflects important changes that have been made in gathering and recording information about the interference complaints investigated by the Post Office Radio Service and brings it more into line with similar reports published in some other countries.

For radio amateurs the changes have resulted in the transfer of many complaints previously recorded as being caused by radio transmitters (when the transmitters were not at fault) into such categories as insufficient immunity of the receiving equipment. The 1976 total of complaints registered as being caused by amateur transmitters has thus dropped dramatically from 785 to only 151 (fundamental radiation) plus 36 (harmonic radiation).

The total number of interference complaints (identified or unidentified) was 42,395, representing a decrease of 4.73%; but although television complaints continue to fall (27,723 or −15.66%), complaints of interference to radio reception have been climbing steadily ever since 1971 and now reach 13,322. The Home Office suggests this reflects "growing interest in radio listening". Contact devices on domestic electrical appliances (eg thermostats) continue to represent the most common cause of electrical interference, although a very high proportion of all complaints still arise from poor aerials or faulty receivers.

RTTY trends

John Jones, GW3IGG, secretary of BARTG, notes that although the silent visual-display-unit (v.d.u.) approach to r.t.t.y. is bringing many new operators on to r.t.t.y., most of the operational stations continue to use hard copy machines for contacts. He notes a problem with the v.d.u. system is the loss of easy tabulations. Because of cost, he expects that the average amateur station will continue using hard copy machines rather than v.d.us for at least the next five years. He also forecasts that the "50 or 45 baud" speed problem will remain important, with increasing pressure from British amateurs to change to 50-baud operation within the next few years.

Just as the number of commercial stations providing c.w. transmissions suitable for morse practice has decreased sharply over the years, John Jones notes that the use of communications satellites and multi-channel links with error correction systems or privacy arrangements has led to a big reduction in the number of commercial stations on which r.t.t.y. systems can be set up with simple equipment for test purposes. He also suggests that amateur r.t.t.y. operators should employ more of the informal abbreviations used in amateur c.w. operation, on the grounds that it is faster to learn to abbreviate than to learn to type. Membership of BARTG now exceeds 600.

Scanning the bands

A new 23-cm beacon station, GB3MLE, has been installed in the enclosed room at the 900ft level (1,800ft a.s.l.) of the IBA's concrete tower at Emley Moor near Huddersfield, Yorkshire. It operates on 1296.93MHz with an effective radiated power of about 50 watts; also operating from this site is a 432.91MHz beacon station, GB3EM.

The tentative launch date for the Amsat AO-D satellite (if successfully placed in orbit this is likely to be known as Oscar 8) is now March 5. The transponder will operate only in the 144MHz to 432MHz mode during the first few days after launching. Since January 1, the Oscar 7 satellite is operating for two days in Mode B, followed by one day only in Mode A.

Arrangements for the International VHF Convention at the "Winning Post", Whitton, Middlesex on February 25 now include a trade exhibition, displays of home-made v.h.f. equipment (with emphasis on equipment made with the type of facilities available to most amateurs), and a programme of lectures.

P. Pierrat, F2TU, has described (*Radio-REF*, No 12, 1977) an ambitious light-weight parabolic dish aerial with a diameter of 6 metres. It has a claimed gain of some 28dB on 432MHz and the weight (not including source or counter-weights) is about 35kg.

Interest in 10GHz activity seems to be spreading to more countries in Europe. It is also reported that 500 of the 10GHz "Gunnplexers" marketed by Microwave Associates and suitable for amateur transceivers have been sold in 20 countries.

In brief

The new syllabus for the Radio Amateurs' Examination (to be largely based on multiple-choice questions) is causing some very raised eyebrows at the complete absence of any requirement to understand thermionic devices; it concentrates entirely on semiconductors . . . RSGB contests during March include: March 4-5, 144/432MHz; March 11-12, Commonwealth h.f. contest (former BERU contest); and March 19, 70MHz open . . . The mobile rally season opens on March 19 with the White Rose Mobile Rally at Lawnswood School, Leeds . . . Membership of the "G-QRP-Club" devoted to low power radio communication has now passed the 350 mark.

PAT HAWKER, G3VA

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Audio power amplifier design — 2

Negative-feedback concepts

The best result of mathematics is to be able to do without it — OLIVER HEAVISIDE

by Peter J. Baxandall, B.Sc.(Eng), F.I.E.E., F.I.E.R.E.

In the January issue the concept, and possible consequences, of slew-rate limitation were discussed, with particular reference to one cause, in which the first stage of an amplifier is unable to supply the current demanded by the collector-to-base feedback-stabilization capacitor in the second stage. With suitably modified circuit designs such effects may be made insignificant. Before specific circuits are discussed in later articles, the present article will deal with some basic ideas about negative feedback and transfer functions.

Feedback terms: definitions

Fig. 1 represents the general case of an amplifier with overall feedback. The + and — signs against the symbols for voltages indicate the polarities that exist when the instantaneous values are called positive. V_{out}/V_{in} is the gain with feedback, or closed-loop gain. A is the forward gain, or open-loop gain. From the diagram it is evident that

$$(\beta V_{out} + V_{in})A = V_{out}$$

(Except at middle frequencies, the + sign must be taken to mean addition taking account of phase angle.)
From the above

$$V_{out}(1 - A\beta) = AV_{in}$$

$$\text{or } V_{out}/V_{in} = \frac{A}{1-A\beta} \qquad (1)$$

This formula may be regarded as the universal feedback formula, and is just as relevant to positive-feedback applications such as Q-multipliers and some active filters as it is to negative-feedback amplifiers. At medium frequencies, where it will be assumed there are no unwanted phase shifts, A should be taken as a simple negative number if the amplifier phase inverts, β should be taken as negative if the output from the β network is subtracted from V_{in} instead of being added as shown. For a negative-feedback amplifier $A\beta$ will be negative at medium frequencies.

Sometimes the denominator of (1) is given as $1 + A\beta$, and then only the magnitudes and not the signs of A and β are to be inserted in the formula. The formula is specifically a *negative*-feedback formula, and the corresponding formula for *positive* feedback then has a denominator $1 - A\beta$. This is surely an unnecessary complication, which can lead to confusion in some applications where it is not immediately obvious whether the feedback is to be treated as positive or negative.

The loop gain is the gain right round the feedback loop, and is $A\beta$ in Fig. 1. This concept is simple enough in the ideal context of Fig. 1, but in many practical circuits some care must be taken when calculating or measuring the loop gain. For example, how do we calculate the loop gain in Fig. 2? If the loop is broken by removing the connection between P and Q, and a test voltage V_t is applied between P earth, then this would produce, at the junction of R_2 and R_3, with Tr_1 removed, a voltage of $V_t\beta$. This voltage is effectively applied to the emitter of Tr_1 in series with a resistance of $R_2R_3/(R_2+R_3)$, which appears in series with $1/g_m$, reducing the effective mutual conductance of the stage. Alternatively we may calculate the value of R_2 and $1/g_m$ in parallel, and use this value in place of R_2 for calculating the actual feedback voltage appearing at the emitter due to the test voltage V_t. In obtaining the relevant output voltage from Tr_2, knowing its collector current, it is necessary to add a load resistor between Q and earth of the same value as that previously provided by the feedback network.

Fig. 3 illustrates the meaning of the terms series, shunt, current and voltage feedback. It will be seen that the convention is that 'series' and 'shunt' relate to the way the feedback is injected into the input circuit, whereas 'voltage' and 'current' relate to the manner in which the feedback is derived in the output circuit. Voltage feedback causes the load to be fed as from a generator whose internal impedance, or output impedance as it is often called, tends to zero as the amount of feedback is increased, whereas current feedback causes the output impedance to tend to infinity with increasing feedback.

Fig. 4 shows how a combination of voltage and current negative feedback may be used to produce an amplifier with a prescribed value of resistive output impedance, such as might be required, for example, when feeding into a telephone line. This technique is less wasteful of available output power capability than is the alternative of

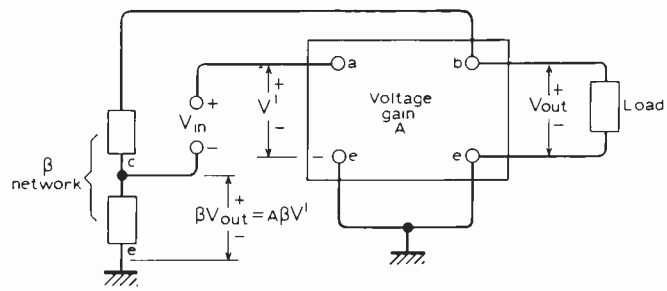
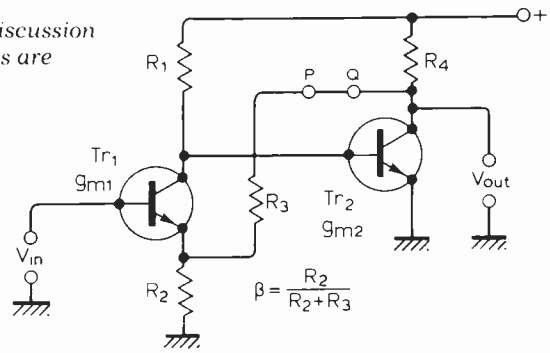


Fig. 1. Basic feedback-amplifier circuit.

Fig. 2. Circuit relating to discussion of loop gain. Biasing details are omitted for clarity.



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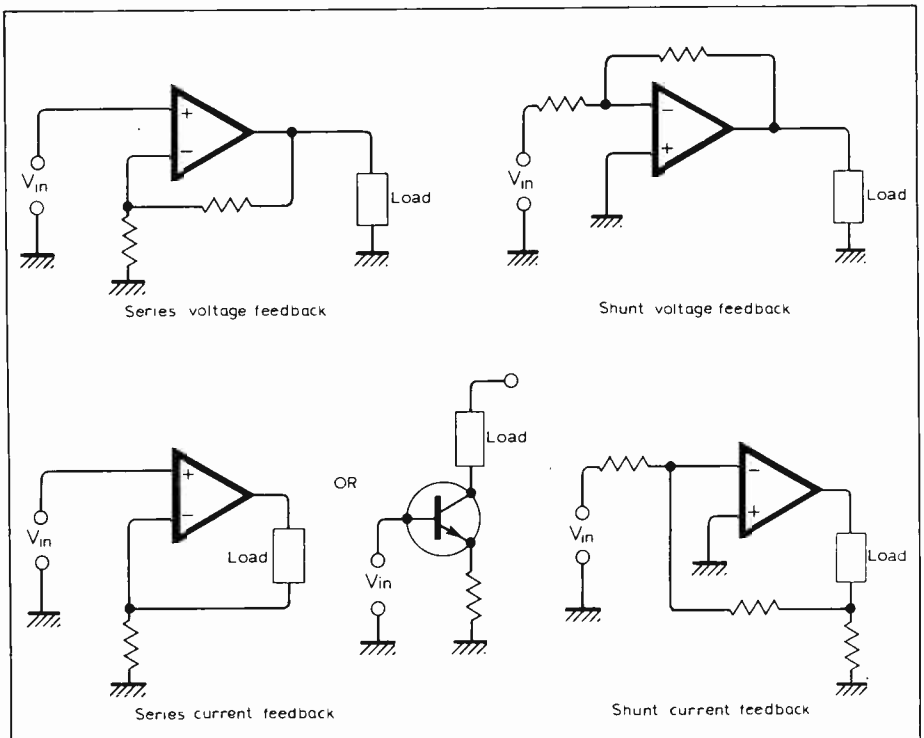

Fig. 3. Four different types of negative feedback.

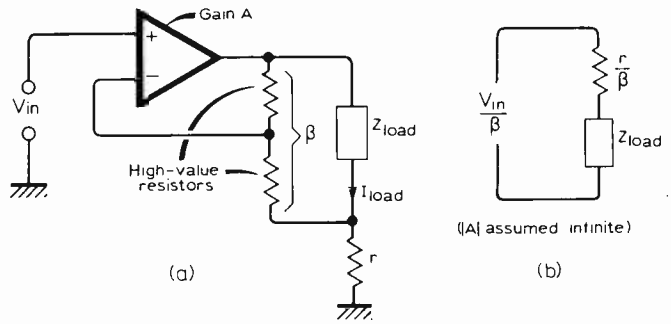

Fig. 4. (a) Feedback circuit with combined voltage and current feedback; (b) equivalent circuit as seen by load.

using an amplifier with simple voltage or current feedback, in association with a resistor equal in value to the required output impedance.

Considering Fig. 4(a), and assuming the ideal case of an infinite-gain amplifier, it is evident that

$$\beta V_{load} + r\, I_{load} = V_{in}$$

$$\text{or } \beta(Z_{load}\, I_{load}) + r\, I_{load} = V_{in}$$

which gives

$$I_{load} = \frac{V_{in}}{r + \beta Z_{load}}$$

or

$$I_{load} = \frac{V_{in}/\beta}{r/\beta + Z_{load}} \qquad (2)$$

This shows that the equivalent circuit must be as in Fig. 4(b). By arranging for the voltage drop across r to provide positive instead of negative feedback, a negative resistive output impedance may be obtained.

Amplifiers are often said to have x decibels of negative feedback at a specified frequency, and such a statement is open to more than one possible interpretation. It is sometimes taken to mean that $20\log_{10}|\text{loop gain}| = x$, but the normal and preferred meaning is that the amount of negative feedback is such as to reduce the amplifier gain by x dB, due precautions being taken to maintain equal loading conditions before and after closing the loop, as already explained. A little thought in relation to equation (1) will show that these two definitions of the amount of negative feedback are not precisely equivalent, and differ quite significantly when the amount of feedback is small. With the preferred definition, feedback is negative at a given frequency if it reduces the gain and positive if it increases the gain. Frequently a practical negative-feedback amplifier will exhibit a peak in its frequency response at high frequencies, near the unity-loop-gain frequency. In the region of the peak, the gain may be higher with feedback on than without it, so that the intended negative feedback has here become positive feedback.

It is sometimes said that feedback is negative if the real component of the feedback voltage, βV_{out}, is in antiphase with V'_{in} Fig. 1, V' itself being taken as purely real, and that feedback is positive if the real component of βV_{out} is in phase with V'. This, however, is a popular misconception, and is quite inconsistent with the distinction between positive and negative feedback given above – as will become evident from the discussion of phase relationships later in this series.

Stability considerations

The subject of stability in feedback systems is a vast one, on which many learned and highly mathematical treatises have been written. The most famous are probably those of H. Nyquist[1] and H. W. Bode[2], both of Bell Telephone Laboratories. Though old, these contributions deal with the fundamentals of the subject thoroughly and in depth, and are still regarded as absolutely sound. Many electronic engineers such as myself, particularly those lacking any formal training in feedback theory, are liable to feel rather overwhelmed by the amount and complexity of the available literature, and concepts such as complex frequency, poles and zeros, contour integration, the Heaviside operator, Laplace transforms and signal-flow graphs seem like insurmountable barriers to some people. However, I believe that the vital thing is to acquire sufficient theoretical understanding to be able to appreciate vividly the reasons for the various effects that occur, and what the available possibilities are for modifying the circuit design as first conceived to give optimum performance. The amount of detailed theoretical background necessary to achieve this is in fact surprisingly small – though some of the mathematical enthusiasts will probably deny this!

There are several reasons why it is unnecessary for a good amplifier designer to know as much mathematical feedback theory as is sometimes supposed. Firstly, much of the fundamental analysis was originally done to *find out* what the stability criteria were, and how they could be expressed in forms convenient for engineers to use. This having been done, and being well established, the engineer can use the results without needing to be able to prove them. Secondly, provided there is a proper qualitative understanding of the problem, the precise optimum values of some components are often best determined experimentally. This is largely because, at the quite high frequencies involved – which may extend up to several MHz – some degree of approximation to the true transistor behaviour would inevitably have to be adopted in a purely theoretical, perhaps

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computer-aided, design approach. Some people may say that arriving at optimum values for some components by trial and error does not constitute a respectable modern design technique, but I cannot agree with this outlook. One way to regard such a trial-and-error approach is to say that one is using the actual amplifier circuit itself as an analogue computer – changes are made to the circuit values and the results are displayed in analogue form on an oscilloscope. If carried out in an intelligent manner, this seems to me to be a much more direct, economical and generally sensible technique than that of forming a mathematical model of the circuit for processing by a digital computer, but I recognise that what is best done depends a good deal on the background and preferences of the designer.

In some quarters there is a belief that the circuit designer himself should spend his time in an office with paper and a computer, and leave the practical work to others, but I do not think that this philosophy is the most effective one. Experimental work is very stimulating – some unexpected effect is observed, and in a flash one may see that a modification to the circuit would be an improvement. This can often be tried immediately, and may lead to prolonged thought and further ideas. At some point a theoretical analysis may be called for, followed by more experimenting. It is this continuous alternation of experimental and theoretical activity that leads, in my experience, to the evolution of novel and improved designs. Of course, an almost inevitable result of such activity is often that what started off as a neat experimental board tends to have become a somewhat untidy bird's nest at a later stage. However, I think most amplifiers having any real originality of design have probably evolved through such a stage before reaching that of an elegant printed-circuit board.

A very real danger is that if an engineer becomes too absorbed in advanced mathematical techniques, he may fail to give enough attention to other more down-to-earth, but very important, aspects of the overall design work. In a contribution some years ago[3], I said "whilst it is virtuous to be able to analyse a circuit, it may be even be more virtuous to be able to see that a detailed analysis is unnecessary, or to invent a better circuit whose behaviour is more easily predicted."

The aim in what follows will be to present the minimum theoretical background which is thought to be necessary for anyone undertaking to design the feedback stabilization aspects of an audio amplifier with understanding and in a properly optimized manner. Little more than the j-notation[4] will be employed. However, some readers will doubtless wish for a rather broader background of theory, since much published literature on amplifier design uses the concepts of complex frequency, poles and zeros etc. At a fairly elementary level, the excellent series of articles by "Cathode Ray" (M. G. Scroggie) in this journal in 1962 may be recommended[5, 6, 7, 8]. A more advanced and complete treatment of feedback theory and practice will be found in a very good book "Amplifying Devices and Low-Pass Amplifier Design" by Cherry and Hooper[9]. Though they do not hesitate to use determinants etc. when thought to be appropriate, a true engineering outlook is evident and the book contains much very enlightened practical advice on design aspects.

In a.c. coupled amplifiers, stability problems arise at both low and high frequencies. Only the high-frequency problems will be considered here, i.e. all circuits will be treated as d.c. coupled amplifiers, but the principles discussed are very easily adapted, in common-sense ways, to the low-frequency situation when necessary.

Some simple notions about transfer functions will first be considered, because understanding these helps one to appreciate better how the whole negative-feedback story fits together. A transfer function for a feedback amplifier, or any other circuit, is simply an equation giving V_{out} as a function of V_{in}. It is normally assumed that the amplifier is free from non-linearity distortion, but apart from this reservation, the transfer function contains all the necessary information about the frequency response, phase response, transient response and stability margins of the amplifier. The snag is that, except in quite simple cases, deriving and simplifying the transfer function for a feedback amplifier is exasperatingly tedious, even for those with a natural aptitude for such things, which I certainly do not have! The Nyquist diagram, and Bode amplitude and phase plots considered later, represent a vastly more convenient and practicable approach for most amplifier design purposes.

However, it is always theoretically possible simply to use the j-notation to calculate the currents and voltages everywhere in the amplifier circuit due to V_{in} and V_{out}, and thus to form the transfer-function equation. Purely as an illustration of the ideas involved, consider the simple and somewhat idealized circuit of Fig. 5. Using the j-notation gives the current in C_2 as $j\omega V_{out}C_2$. The current in R_4 in the direction shown is V_{out}/R_4. The current in R_3 is the sum of these currents, enabling one to calculate V'. Continuing on these lines leads to the result:

$$V_{in} = -V_{out}R_{in}/R_1[1 + j\omega C_2R_3 + R_3/R_4 + j\omega C_1R_2\ (1 + j\omega C_2R_3 + R_3/R_4) + j\omega C_2R_2 + R_2/R_4 + R_1/R_4] \quad (3)$$

This as it stands is not much use, for one cannot easily see the physical significance of it. The vital thing when deriving transfer functions is to continue until they have been got into a nice tidy, recognisable form. By collecting terms and rearranging, equation (3) can be got into the form:

$$V_{out}/V_{in} = K \times \frac{1}{1 + j\omega T_1 - \omega^2 T_2^2} \quad (4)$$

K in this is given by:

$$K = \frac{R_1R_4}{R_{in}(R_1 + R_2 + R_3 + R_4)} \quad (5)$$

T_1 and T_2 are time constants, each given by a somewhat cumbersome expression with several terms in. One can, moreover, very usefully go a stage further than (4), and get it into the form:

$$V_{out}/V_{in} = K \times \frac{1}{1 + (1/Q)j\omega T - \omega^2 T^2} \quad (6)$$

Here T is obviously equal to T_2 of equation (4), and we also must have $(1/Q)T = T_1$, giving $Q = T/T_1$, i.e.:

$$Q = T_2/T_1 \quad (7)$$

Now the physical significance of (6) is instantly apparent if one knows how to "read" it. Q is the Q of a tuned circuit arranged as in Fig. 6(a), having a resonance frequency given by $\omega_0 = 1/T$.

Sometimes transfer functions such as

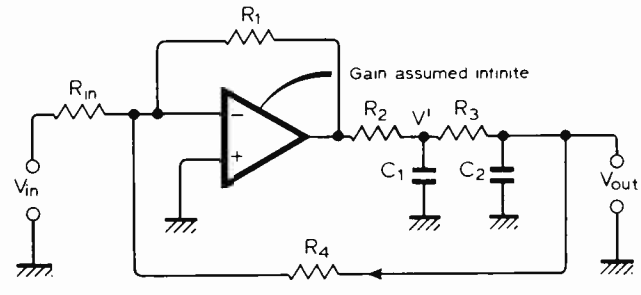

Fig. 5. Circuit relating to discussion of transfer functions.

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(6) are given in the form:

$$V_{out}/V_{in} = K \times \frac{1}{1 + (1/Q)pT + p^2T^2} \quad (8)$$

Comparing (6) and (8) it is evident that $p = j\omega$. Though it is perfectly all right, in a sine-wave context, to regard p simply as a convenient abbreviation for $j\omega$, its full significance is much deeper, for it is Heaviside's operator and means d/dt. Equations such as (8) are thus applicable not only under sine-wave conditions, but also for any other kind of input waveform. Mathematical techniques are available whereby, given the amplifier transfer function, the output waveform resulting from a voltage step or other transient input may be calculated. But in view of the ease with which such responses may be obtained using an oscilloscope, the actual need for such mathematical techniques seldom if ever arises in normal amplifier design work, in my experience. Sometimes when the transient response of an experimental amplifier circuit is under consideration, it is convenient to make up a little simulator circuit, in which all time-constants have been increased by a factor of, say, a thousand compared with the real circuit. The idealized response can thus be obtained, and the relationship between this and the response of the original circuit may shed light on the significance of stray capacitance or other overlooked effects in the latter. The ready availability of type 741 operational amplifiers makes it very quick and easy to do such tests.

Heaviside's operational calculus tends to be somewhat out of favour nowadays, but a very strong case in its favour is presented by two authors from the BBC Research Department in reference 10. It is argued that the technique gives a much better physical insight into the nature of the problem being investigated than do the alternative mathematical techniques available.

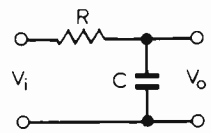
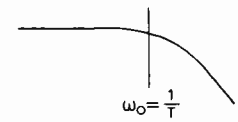
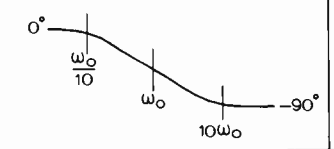
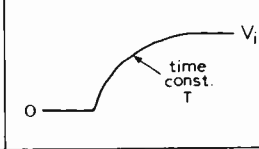
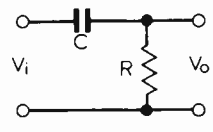
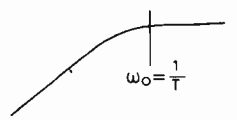
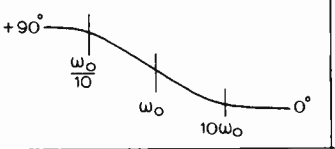
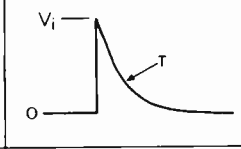
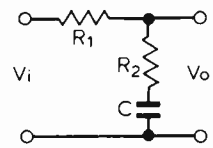
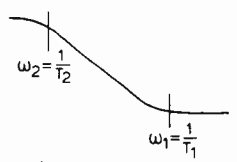
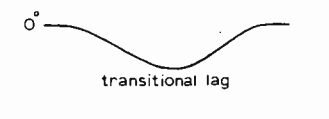
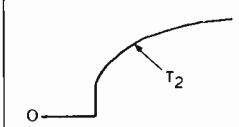
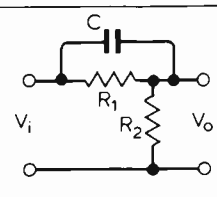
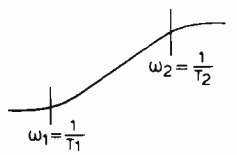
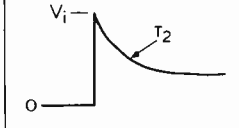
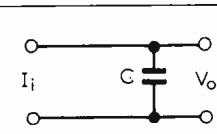
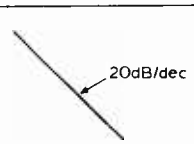
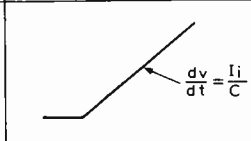
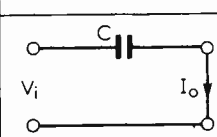
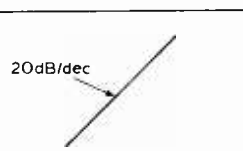
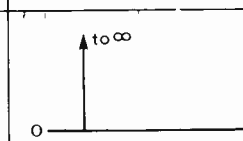
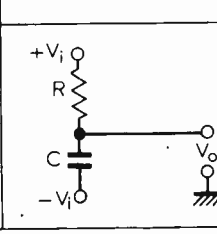
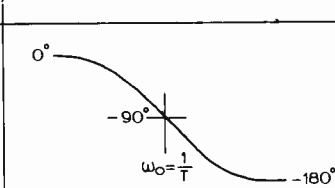
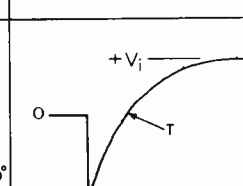
For amplifier designers, the important things to appreciate about transfer functions may be summarized as follows:

(a) Any linear network or amplifier has a transfer function.

(b) However complex the network or amplifier may be, the denominator of the transfer function — if you're clever enough — can be got into the form of a number of factors, which may be either quadratic ones as in equation (8), or simpler ones of the form $(1 + pT)$.

(c) If any of the quadratic factors in the denominator have negative Q, i.e. negative damping, the system will be unstable.

(d) The numerator can take various forms according to whether the system has a low-pass, band-pass or high-pass type of response, and whether there are notches in the frequency response or not.

	Circuit	Transfer function	Frequency response	Phase response	Step response
A		$\frac{V_o}{V_i} = \frac{1}{1+pT}$ $T = CR$			
B		$\frac{V_o}{V_i} = \frac{pT}{1+pT}$ $T = CR$			
C		$\frac{V_o}{V_i} = \frac{1+pT_1}{1+pT_2}$ $T_1 = CR_2$ $T_2 = C(R_1+R_2)$			
D		$\frac{V_o}{V_i} = K \times \frac{1+pT_1}{1+pT_2}$ $T_1 = CR_1$ $T_2 = C \times \frac{R_1R_2}{R_1+R_2}$ $K = \frac{R_2}{R_1+R_2}$			
E		$\frac{V_o}{I_i} = \frac{1}{pC}$		-90°	
F		$\frac{I_o}{V_i} = pC$		+90°	
G		$\frac{V_o}{V_i} = \frac{1-pT}{1+pT}$ $T = CR$	flat		

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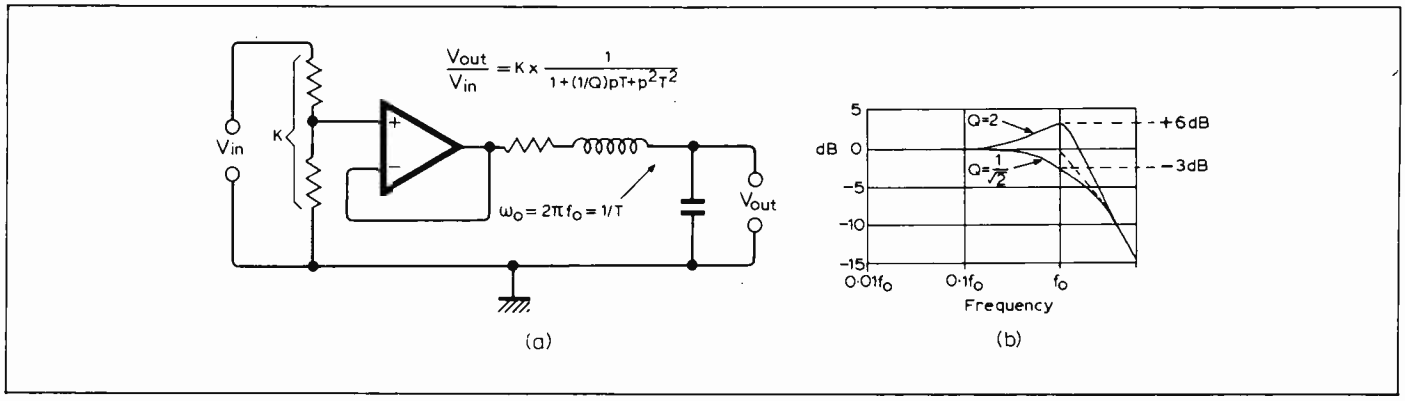

Fig. 6.(a) Circuit giving same response as Fig. 5; (b) and (c) show the frequency response and the step response respectively for two values of Q. $Q = 1/\sqrt{2}$ gives second order Butterworth response.

(e) Any required response characteristic whatever can be obtained from a combination of suitably-designed feedback amplifiers, without the need for any inductors, this being the basis of the whole subject of active filters.[11]

Though it is seldom sensible to try to derive the overall transfer function of a complete feedback amplifier, except in the relatively simple cases which usually apply in active-filter design, it is quite important to be able to derive the transfer functions of parts of the circuit of a feedback amplifier, for this is really the basis of most practical design work on such amplifiers. The table gives some simple networks familiar to most readers, together with their transfer functions and frequency, phase and step-input responses. The relevance of the all-pass case G will become evident later. Though the transfer functions may be worked out using the j-notation, and p substituted for jω at the end, it is really more convenient to work with p from the beginning. Thus the impedance of a capacitor is $1/pC$ and the impedance of an inductor is pL. Suppose, for example, we have R and C in parallel. The total impedance is given by

$$Z = \frac{R \times (1/pC)}{R + (1/pC)}$$

Multiplying top and bottom by pC gives

$$Z = \frac{R}{1 + pCR} \qquad (9)$$

This is therefore the ratio V_{out}/I_{in} for the network, and as would be expected it has the same form of transfer function as network A in the table.

A simple illustration of the practical utility of thinking of transfer functions in terms of p rather than jω arises if one considers the problem of determining the output waveform to be expected from network B in the table when the input waveform is a linear voltage sweep, or ramp. One simply "operates upon" the input waveform with bits of the transfer function in turn, chosen in the order that makes things easiest. Thus the ramp waveform multiplied by pT, i.e. differentiated, gives a step waveform. The step multiplied by $1/(1+pT)$ gives an exponential output waveform as shown at the top right-hand corner of the table. A particularly lucid and easy-to-understand paper dealing with topics such as this was written just after the war by Professor F. C. Williams[12]. Though the practical circuits are, of course, all valve ones, the lengthy discussion of the overall design philosophy is highly relevant to present-day problems. The aim was to evolve reliable circuits of precision performance, suitable for trouble-free production, using the minimum of mathematics. Acknowledgement is made to A. D. Blumlein for having provided much of the early inspiration for this work. Some of these pulse circuit ideas are of greater interest to audio engineers than in the past, even in the non-digital field, because of the increased attention now being given to transient response and impulse measuring techniques.

In planning the feedback stabilization details for most audio amplifiers, the normal practice is to think in terms of the rate at which the loop gain is attenuated with rising frequency, bearing in mind all along that the transient behaviour is closely related to this. The relevant techniques will be discussed in the next article.

References

1. Nyquist, H., Regeneration Theory, *Bell System Tech. J.*, Jan. 1932, p.126.
2. Bode, H. W., Network Analysis and Feedback Amplifier Design. (van Nostrand 1945).
3. Baxandall, P. J., Papers for the Practising Designer, Letter to Editor, *J.I.E.R.E.*, Dec. 1968.
4. Cathode Ray, "j", *Wireless World*, Feb. 1948.
5. Cathode Ray, Transfer Functions, *Wireless World*, April 1962, pp.177-181.
6. Cathode Ray, Poles and Zeros, *Wireless World*, May 1962, pp.225-229 and June 1962, pp.289-294.
7. Cathode Ray, Differential Equations, *Wireless World*, July 1962, pp.333-337.
8. Cathode Ray, Excitations and Responses, *Wireless World*, Aug. 1962, pp.379-383, Sept. 1962, pp.447-450 and Oct. 1962, pp.507-511.
9. Cherry, E. M. and Hooper, D. E., Amplifying Devices and Low-Pass Amplifier Design. (John Wiley 1968).
10. Head, J. W. and Mayo, C. G., Unified Circuit Theory in Electronics and Engineering Analysis. (Iliffe 1965).
11. Girling, F. E. J. and Good, E. F., Active Filters, *Wireless World*, Aug. 1969 to Dec. 1970 inc. 16 parts; see particularly Sept. 1969, pp.403-408. (Note: In these articles q is used in place of Q in equations such as my eqn. (8), Q being reserved for bandpass filters, where it has a somewhat different significance.)
12. Williams, F. C., Introduction to Circuit Techniques for Radiolocation, J.I.E.E., Vol. 93, Part IIIA, No. 1, pp.289-308 (1946). □

Corrections to January 1978 article

In Fig. 1, a resistor should be inserted in series with Tr_4 emitter. The arrow in Tr_1 collector lead should be labelled "I_{dc}." In equation (6), the denominator should be "$2\pi\hat{V}_{in}$". The equation just below equation (6) is completely wrong and should be:

$$\frac{\text{slew-rate limit}}{\hat{V}} = 2\pi f_{crit} \qquad (7)$$

In Fig. 3(a), the top waveform was inadvertently cut off at the bottom and should be a complete sinewave. Apologies for the bad reproduction of these waveforms. In the fourth line of the footnote on page 55, the word "is" should be inserted before "approximately". On page 56, first column, 14 lines from the bottom, the word "amplifier" should be inserted between "the" and "slew-rate".

Advertisement correction

We have been asked by E & L Instruments U.K. to inform readers that there is an error in their current series of advertisements in *Wireless World*. This is an omission of the fact that Quarndon Electronics, Slack Lane, Derby, are also making the £12.50 special offer for the SK10, cash with order. Quarndon are also implementing, on behalf of E & L Instruments, the lifetime guarantee on the SK10 sockets.

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I.E.A. 78

The Instruments, Electronics and Automation Exhibition

The Instruments, Electronics and Automation Exhibition is again to be held at the National Exhibition Centre in Birmingham alongside its sister exhibition Electrex. The event, I.E.A. 78, will run from 13th to 17th March and will be open daily from 9.30 a.m. to 6 p.m. Price at the door is £1.

List of Exhibitors

AB Engineering Co.
AGA Infrared Systems
AHB Heim-Electric
Adcola Products
Agmet Instrumentation
Albrecht, W. KG
Alma Components
Amelec Instruments
Anadex Instruments Inc.
Analytical Devl. Co.
Anderman and Ryder
Anders Electronics
Anglo Weld Equipment
ARI Industries Inc.
Ashford Controls
ASPO OY
Augat
Automatic Systems Laboratories
Avdel
Avery, W & T
Avtech Electrosystems

B & K Laboratories
B & R Relays
Bafco Inc.
Bahco Tools
Ball-O-Meter
Barry Instruments Corp.
Barry Belting Industries
Batley Valve Co.
Bauch, F. W. O.
Belix Co.
Bell & Howell
Berger Lahr UK
Blakeborough, J. & Sons
Bopla GmbH
Bourns (Trimpot)
Bristol Automation
BPL (Instruments)
British Sonceboz Co.
British Standards Institution
Bryan's Southern Instruments
Budenberg Gauge Co.
Burgess Micro Switch Co.
Burr-Brown International
Butler, Howerd

CDC Elettromeccanica
CIL Electronics
C. S. I. BV
CSM (Engineering)
Calex Electronics
Cambion Electronic Products
Carter Parratt Group
Cassenelli S.R.L.
Celdis
Cetronic
Charles Austen Pumps
Chemical and Thermal Controls
Chessell
Circuit Automation
Clarke-Hess Comms. Research Corp.
Collison, H.F. — Goodwell
Conard Controls
Contraves
Control and Readout
Control Systems Research Inc.
Control Technology
Controls and Automation
Copes Regulators
Cosmocord
Coutant Electronics
Creative Instrumentation
Critchley Brothers
Cumbernauld Transformers

Data Precision Corp. USA
Daturr
Datwyler AG
Delta Controls
Digital Equipment Corp.
Digitran Endevco
Doric Scientific
Dresser Europe SA
Druck
Duncan Electronics
Dunegan Endevco
Du Pont (UK)

E & D Graphics
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Electrical Contacts
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Feme SpA
Ferranti
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Fine Tubes
Flow Technology Inc.
Foreign Trade Co. Metronex
Foss Fasteners
Foster Cambridge
Fotherby Willis Electronics
Fothergill and Harvey
Frequency Devices Inc.

Gauges — Bourdon (GB)
General Eastern Corp.
Glenair International
Gould Advance
Grasslin (UK)
Green Electronic and Comms.
Guildline Instruments

Haefely Emile & Co.
Hamlin Electronics Europe
Helper Instruments Co.
Hemgstler GB
Hewlett-Packard
Hinchley Engineering Co.
Hitachi
Hoke International
Holledge (Instruments)
Hollingsworth Terminals
Howden, R. D. P.
Hunter Equipment Sales
Hutson Industries Inc.

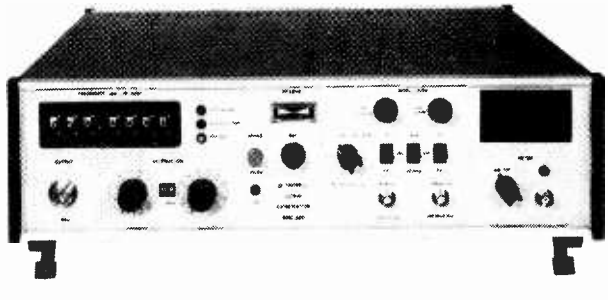
I.E.C. Electronique
IPC Electrical-Electronic Press
Icel SA
Imhof-Bedco
IMO Precision Controls
Inovan-Stroebe KG
Instagraphic Products
Instem
Institut, Reinhard Straumann
Insulation Systems Inc.
Introl
Iskra
Ivo Counters

KDG Instruments
Kappa Networks Inc.
Kaye-Dee
Keithley Instruments
Kenmeleon
Kent, George
Kent Automation Systems
Kent Instruments
Kent Meters
Kerry Ultrasonics
Klippon Electricals
Kovo
Krohnhite Corp.

L. A. Components
L. G. International
LNR Communications Inc.
L.T.H. Electronics
Landis & Gyr
Letromec Controls
Lee Engineering
Leeds and Northrup
Lemo (UK)
Lenco Italiana SpA
Licon Electronics
Light Soldering Developments
Litre Meter
Littelfuse (GB)
Littex
Loba
Lyons, Claude
Lyons Instruments

Machine Components Corp.
Mapco Inc.
Marden Electronic Systems
Markovits I.
Marvid European Electronics
McMurdo Instruments Co.
Measurement Technology
Medelec
Mentor GmbH

One of the products which will be on display at the Farnell stand. This signal generator, type SSG520, is synthesized and provides outputs from 10 to 520MHz. It has a resolution of 100Hz at maximum stability and a leakage of less than 0.2μV.



continued on page 87

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Logic design — 11

Design with m.s.i. — multiplexers and demultiplexers

by B. Holdsworth* and **D. Zissos†**

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The introduction of m.s.i. circuits is tending to result in the replacement of the old methods of logic design. Traditionally, the design engineer has developed a logic function as the solution to a particular problem. This function has then been minimized using the methods described earlier in this series and has been implemented using s.s.i. circuits. However when implementing logic functions with m.s.i. circuits such as the multiplexer, the Boolean function is used in its canonical form (i.e. each term in the Boolean function contains all the variables in the true or complemented form), and is implemented directly without minimization.

THE COST of a digital system is approximately proportional to the number of i.cs in the system, hence, to reduce the cost, the number of packages used should be minimized. The logic designer should therefore be looking for the replacement of a large number of s.s.i. circuits by one or more m.s.i. packages. It is frequently better to use a standard m.s.i. package even if this introduces redundant or unused gates rather than to design with s.s.i. circuits.

Data selector or multiplexer

The multiplexer selects one out of n lines where n is usually 4, 8 or 16. A block diagram of a data selector having 4 input lines, D_0, D_1, D_2 and D_3 and 2 output lines f and $\bar{f}$ is shown in Fig. 1(a). The device also has 2 control lines X and Y and may have an "enable" line E. The selector may be regarded as a single-pole switch which selects 1 out of 4 lines as shown in Fig. 1(b). The implementation of the multiplexer using gates is shown in Fig. 1(c).

In essence the circuit is an AND-OR-INVERT gate having complementary outputs. The Boolean function which represents the output of this circuit is: $f = \bar{X}\bar{Y}D_0 + \bar{X}YD_1 + X\bar{Y}D_2 + XYD_3$. Data lines can be selected by applying the appropriate binary coded signal to the control lines X and Y: when the control signal $\bar{X}\bar{Y} = 1$ the output of the circuit is D_0, and so on. Some multiplexers are provided with an input enable line as shown in Fig. 1(c). When the input to this line is logical 0 the four AND gates are enabled.

The number of data lines to be selected can be increased either by choosing a multiplexer with a larger number of data lines or alternatively by combining multiplexers. A combination of two data-selectors, which allows the selection of 1 out of 8 lines, is shown in Fig. 2, the enable signal in this case being used as an additional control signal. The data lines are sequentially selected with the aid of a binary counter, the control signals X and Y being clocked through the sequence 00, 01, 10 and 11, thus accessing the data

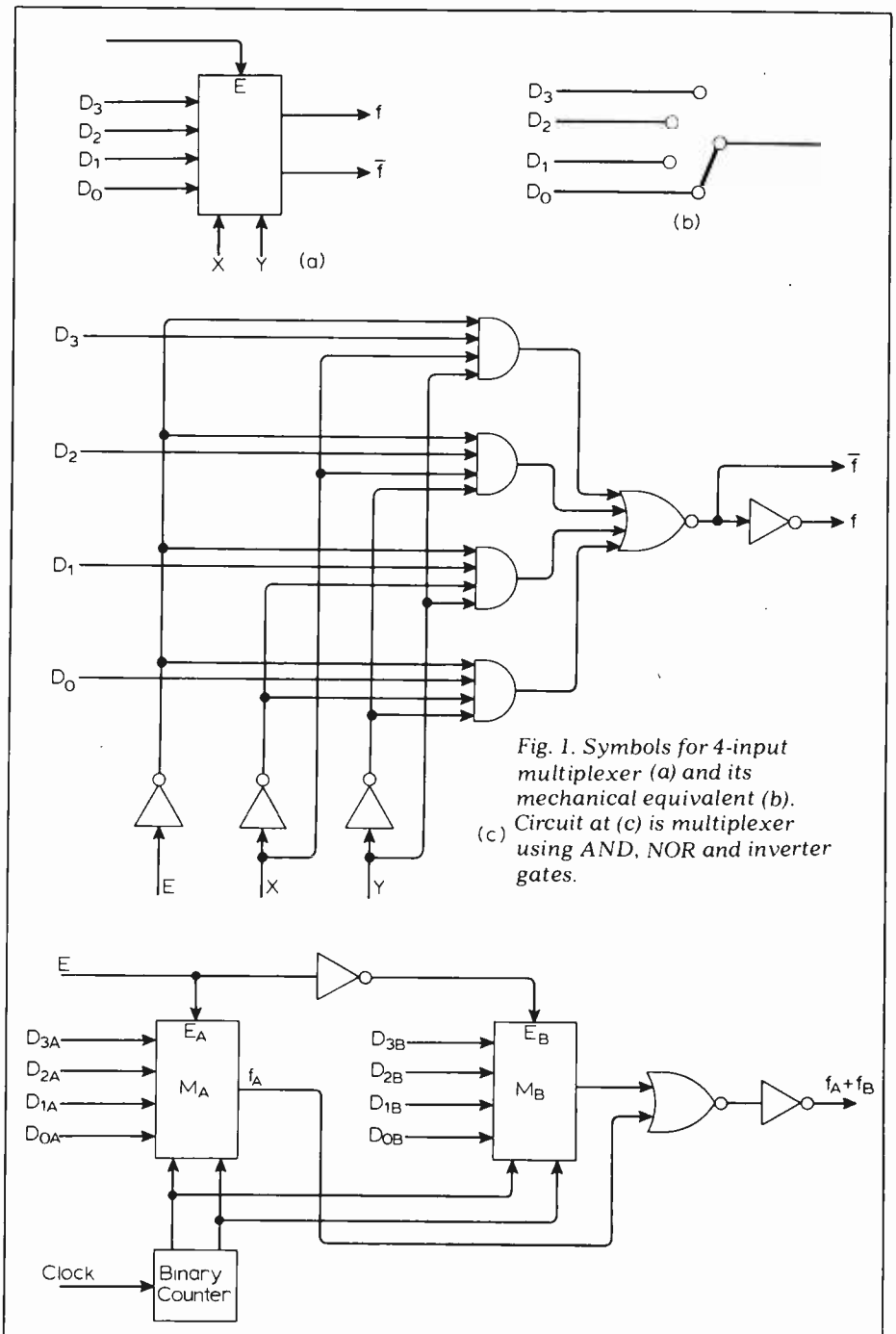

Fig. 1. Symbols for 4-input multiplexer (a) and its mechanical equivalent (b). Circuit at (c) is multiplexer using AND, NOR and inverter gates.

Fig. 2. Multiplexers can be combined to provide more inputs.

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lines in the order D_0, D_1, —D_7. A truth table for the circuit is shown in Table 1. This principle can be extended to allow the selection of a larger number of data lines. For example, the selection of 1 out of 64 lines can be achieved using nine 8-input multiplexers, as shown in Fig. 3, arranged in two levels of multiplexing.

An alternative way of looking at the multiplexer is to regard it as a device which converts parallel information into serial information. For example, in the arrangement shown in Fig. 2(a), the two multiplexers M_A and M_B can be presented with an 8-bit word on the 8 input lines in parallel form, and this can be taken off in serial form by using the sequential accessing technique.

Multiplexer as logic function generator

The equation for a multiplexer having four input lines is:

$f = \bar{A}\bar{B}D_0 + \bar{A}BD_1 + A\bar{B}D_2 + ABD_3$,

where the Boolean variables A and B are used as the signals for the control lines X and Y. Hence A and B can be factored out of any function of n variables, and the residue functions of n 2 variables can then be applied to the data lines. For example if n=3, four signals of one variable can be applied to each of the data lines. Assuming that the third variable is C the possible signals that can be applied to these lines are C, $\bar{C}$, 0 and 1. In all there are $4^4 = 256$ possible combinations of four input signals which can be applied to the 4-input lines; a multiplexer with 4 input lines can generate any of the 256 possible Boolean functions of 3 variables.

For the 4-input multiplexer there are three possible choices for the control variables – AB, AC and BC. These various combinations of the control variables can be associated with individual data lines as indicated in Fig. 4. For example, with control variables A and B, the input line D_0 is associated with those cells marked A=0 and B=0, that is the two top left-hand cells on the K-map of Fig. 4(a). In effect, the K-map for 3-variables has now been split into four 2-cell, 1-variable K-maps, each of these 2-cell maps being associated with a data line.

Table 1

E	A	B	E_A	E_B	
0	0	0	0	1	
0	0	1	0	1	M_B inhibited
0	1	0	0	1	
0	1	1	0	1	
1	0	0	1	0	
1	0	1	1	0	M_A inhibited
1	1	0	1	0	
1	1	1	1	0	

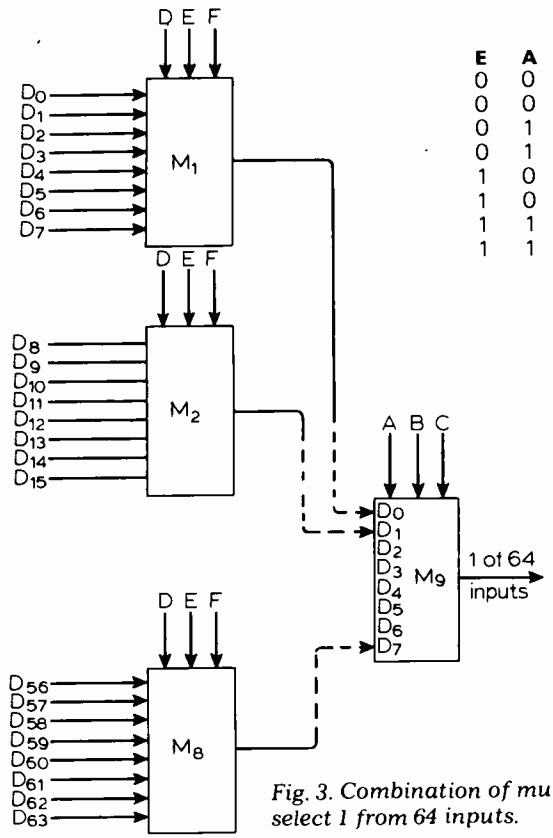


Fig. 3. Combination of multiplexers to select 1 from 64 inputs.

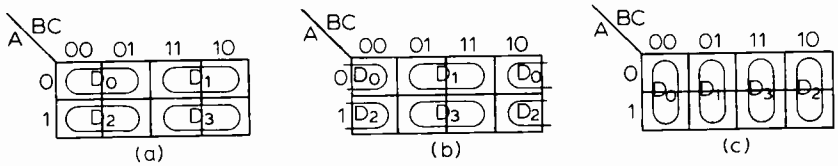


Fig. 4. Association of data lines with control signals for 4-input multiplexer. Control variables are A and B in (a), A and C in (b) and B and C in (c).

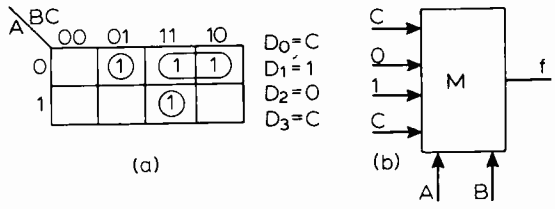
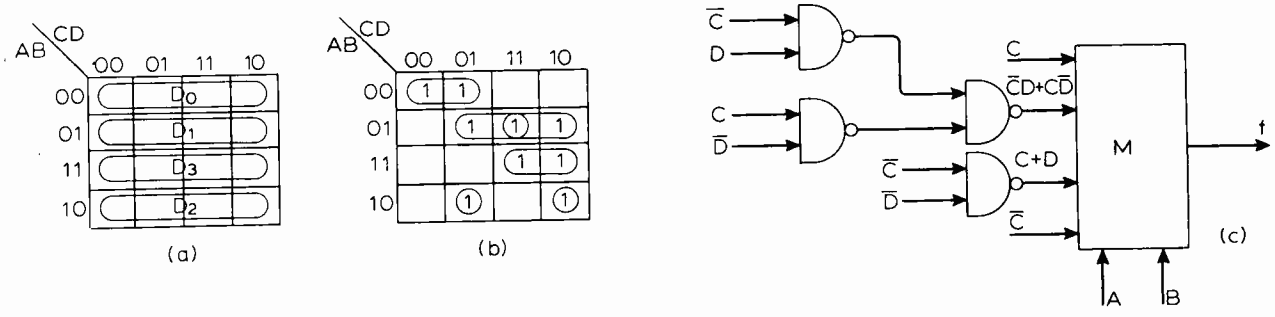


Fig. 5. Generation of $f = \bar{A}\bar{B}C + \bar{A}BC + A\bar{B}\bar{C} + ABC$ using a 4-input multiplexer.

Fig. 6. Generation of f = 0,1,5,6,7,9,10,14,15. Association of data lines with variable A and B is seen at (a) and the Karnaugh map is at (b). The diagram at (c) is the implementation.



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Example 1. Implement the 3-variable function

$$f = \bar{A}\bar{B}C + \bar{A}B\bar{C} + A\bar{B}\bar{C} + ABC$$

using a 4-input multiplexer.

Plot the function on a K-map as shown in Fig. 5(a) and make an arbitrary choice of control variables, say A and B. Next simplify the four 1-variable functions associated with each data line. For example, the two cells associated with D_1 are both marked with a 1, hence the input to data line D_2 is $C + \bar{C} = 1$. The remaining inputs are determined in the same manner and the implementation of the function is shown in Fig. 5(b).

Example 2 Implement the 4-variable function

$$f = \Sigma 0,1,5,6,7,9,10,14,15$$

using a 4-input multiplexer.

The function has been represented as the sum of a number of canonical terms, each term being represented as a decimal number. For example the term $A\bar{B}C\bar{D}$, represented in binary, is $0110 = 6$ in decimal.

Since a 4-input multiplexer is to be used, the application of two variables to its control lines will leave residue functions of two variables to be applied to the data lines. There are six possible ways of choosing the control variables – AB, AC, AD, BC, BD, and CD. These various combinations of control variables can be associated with the data lines as indicated previously in Fig. 4. It will be assumed in this example that A and B are chosen as the control variables and the K-map associating these control variables with the data lines is shown in Fig. 6(a). The 4-variable K-map has now been divided into four 4-cell, 2-variable maps and simplification can only take place within the confines of the 2-variable maps.

The K-map plot of the function is shown in Fig. 6(b) and the data line inputs obtained from the four rows of this map are:

$D_0 = \bar{C}$ address $\bar{A}\bar{B}$
$D_1 = C + D$ address $\bar{A}B$
$D_2 = \bar{C}D + C\bar{D}$ address $A\bar{B}$
$D_3 = C$ address AB

The implementation of the function is shown in Fig. 6(c).

It should be pointed out that it is useful to examine the various possible choices of control variables to ascertain whether there is a simpler solution. In this case it is left to the reader to show that a simpler solution is obtained if C and D are chosen as control variables.

As the number of variables associated with the Boolean function to be implemented increases, it becomes necessary to use more than one level of multiplexing and this technique is illustrated in the next example.

Table 2. Determination of the inputs to the 1st level multiplexer.

	$\bar{D}\bar{E}$	$\bar{D}E$	$D\bar{E}$	DE
$f = \bar{A}\bar{B}\bar{C}\bar{D}\bar{E}$	$\bar{A}\bar{B}\bar{C}$			
$+\bar{A}\bar{B}\bar{C}DE$		$\bar{A}\bar{B}\bar{C}$		
$+\bar{A}\bar{B}C\bar{D}E$				$\bar{A}\bar{B}\bar{C}$
$+\bar{A}B\bar{C}\bar{D}\bar{E}$	$\bar{A}B\bar{C}$			
$+\bar{A}B\bar{C}DE$		$\bar{A}B\bar{C}$		
$+\bar{A}BC\bar{D}E$				$\bar{A}B\bar{C}$
$+\bar{A}BCD\bar{E}$	$\bar{A}BC$			
$+\bar{A}BCDE$		$\bar{A}BC$		
$+A\bar{B}\bar{C}D\bar{E}$			$\bar{A}BC$	
$+A\bar{B}C\bar{D}\bar{E}$	$A\bar{B}\bar{C}$			
$+A\bar{B}C\bar{D}E$		$A\bar{B}\bar{C}$		
$+A\bar{B}CD\bar{E}$			$A\bar{B}\bar{C}$	
$+A\bar{B}CDE$				$A\bar{B}\bar{C}$
$+AB\bar{C}D\bar{E}$			$AB\bar{C}$	
$+AB\bar{C}DE$				$AB\bar{C}$
$+ABCDE$				ABC

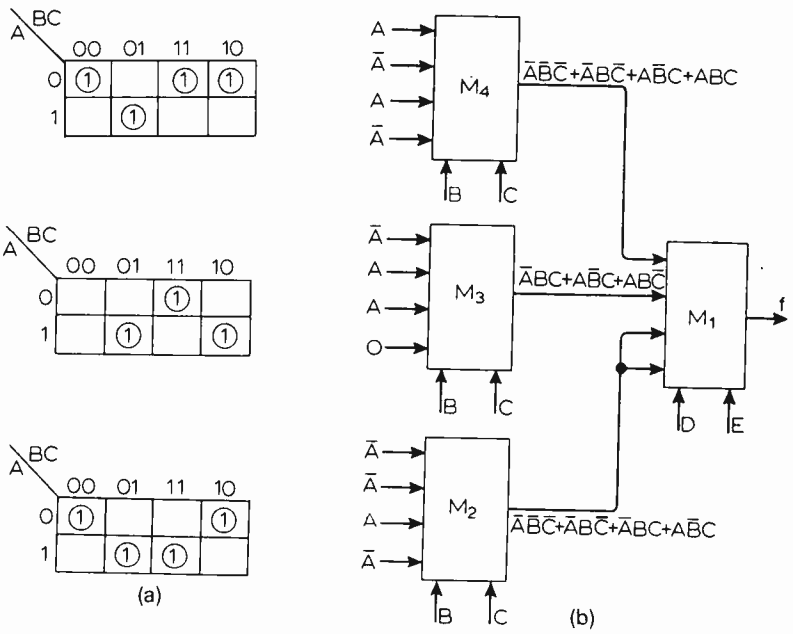
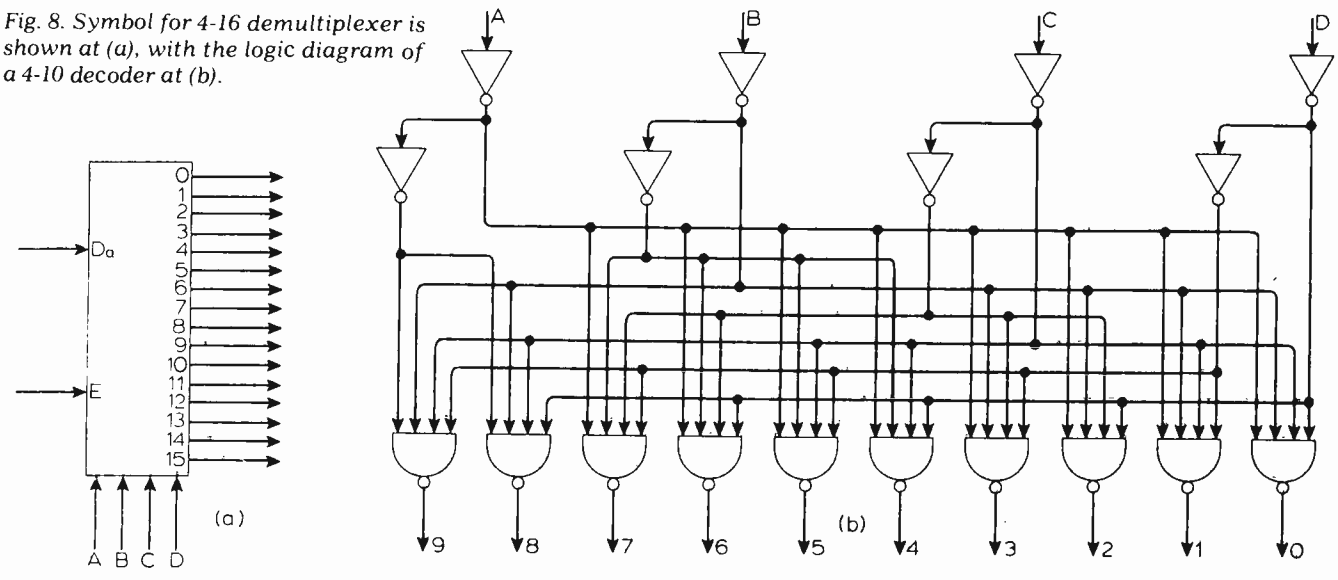


Fig. 7. Five-variable multiplexer circuit to produce the function of example 3.

Fig. 8. Symbol for 4-16 demultiplexer is shown at (a), with the logic diagram of a 4-10 decoder at (b).



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Example 3. Implement the 5-variable function

$f = \Sigma 0,1,3,8,9,11,12,13,14,20,21,22,23,26,31$

For the first level of multiplexing the control variables D and E have been arbitrarily chosen. The function is now listed at the left-hand side of Table 2, which contains four columns headed $\bar{D}\bar{E}$, $\bar{D}E$, $D\bar{E}$ and DE respectively. In the column headed $\bar{D}\bar{E}$ are listed all those terms of three variables A, B, and C which are associated with $\bar{D}\bar{E}$. For example, in the case of the term $\bar{A}\bar{B}\bar{C}\bar{D}\bar{E}$ the entry in the $\bar{D}\bar{E}$ column will be $\bar{A}\bar{B}\bar{C}$. This procedure is repeated for each term in the 5-variable function and an entry is made in the appropriate column in each case.

The input functions for the first level multiplexer are now seen to be:

$$D_{01} = \bar{A}\bar{B}\bar{C} + \bar{A}B\bar{C} + \bar{A}BC + A\bar{B}C$$
$$D_{11} = \bar{A}\bar{B}\bar{C} + \bar{A}B\bar{C} + \bar{A}BC + A\bar{B}C$$
$$D_{21} = \bar{A}BC + A\bar{B}C + AB\bar{C}$$
$$D_{31} = \bar{A}\bar{B}\bar{C} + \bar{A}B\bar{C} + A\bar{B}C + ABC$$

These three variable functions can be generated with 4-input multiplexers, as described in example 1, at the second level of multiplexing. However it should be noticed that $D_{01} = D_{11}$ and this function need only be generated once, hence only three second level multiplexers are required.

For the second level of multiplexing B and C have been chosen as the control variables. The K-maps for determining the inputs to the data lines for the second level multiplexers are shown in Fig. 7(a) and from these maps the various input signals are found to be:

$$D_{02} = \bar{A} \quad D_{03} = 0 \quad D_{04} = \bar{A}$$
$$D_{12} = A \quad D_{13} = A \quad D_{14} = A$$
$$D_{22} = \bar{A} \quad D_{23} = A \quad D_{24} = \bar{A}$$
$$D_{32} = \bar{A} \quad D_{33} = \bar{A} \quad D_{34} = A$$

The implementation of the function is shown in Fig. 7(b).

Decoders or Demultiplexers

A decoder or demultiplexer performs the opposite function to that of a multiplexer. A block diagram of the device is shown in Fig. 8(a). A single data input line can be connected to one of many output lines by the appropriate choice of signal on the control lines. With 4 control lines A, B, C, and D there are sixteen possible addresses and hence the maximum number of output lines that can be selected is sixteen.

A commonly used decoder has 4 input lines and 10 output lines. The logic diagram for this device is shown in Fig. 8(b). If A = 0, B = 0, C = 0 and D = 0, the output line marked 0 will be at logical 0 whilst all the other outputs will be at logical 1.

The device illustrated in Fig. 8(b) can be used as a decoder, but in a 4-to-16 line demultiplexer there are additionally enable and data lines as shown in Fig. 8(a). These are connected to the sixteen output gates via the circuit shown in Fig. 9 which is in effect a NOR gate. This input

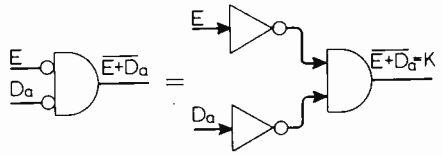

Fig. 9. Input data and enable arrangements.

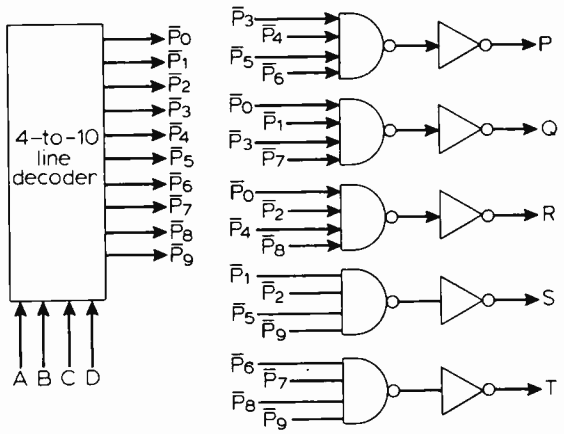

Fig 10. Natural binary-coded decimal to Lorenz converter.

arrangement allows of two modes of operation. In the first mode, if E = O & $D_a = 0$, K = 1, thus enabling all output gates. For any other values of E & D_a, K = 0, thus disabling all output gates.

In this mode the 4-to-16 line demultiplexer will act as a decoder allowing, for example, a b.c.d. input on lines A. B. C and D to be converted to a decimal output. Alternatively the circuit can be operated as a generator of the sixteen canonical terms of four Boolean variables. If $P_3 = \bar{A}\bar{B}CD$ is the input to the control lines then the output on line 3 = $\bar{P}_3$.

In the second mode E = 0, $D_a = 0$, hence K = 1. Control signal $P_2 = \bar{A}B\bar{C}\bar{D}$. The output on line $2 = 0 = D_a$.

E = 0, $D_a = 1$, hence K = 0. Control signal $P_2 = \bar{A}B\bar{C}\bar{D}$. The output on line $2 = 1 = D_a$.

In this mode the data on the data line is transferred to the output gate selected by the address applied to the control lines, in this case $\bar{A}B\bar{C}\bar{D}$.

Example 4 Using a 4-to-10 line decoder develop a circuit for converting n.b.c.d. to the Lorenz code.

The two codes are tabulated alongside each other in Table 3.

	NBCD				Lorenz				
	A	**B**	**C**	**D**	**P**	**Q**	**R**	**S**	**T**
P_0	0	0	0	0	1	0	0	1	1
P_1	0	0	0	1	1	0	1	0	1
P_2	0	0	1	0	1	1	0	0	1
P_3	0	0	1	1	0	0	1	1	1
P_4	0	1	0	0	0	1	0	1	1
P_5	0	1	0	1	0	1	1	0	1
P_6	0	1	1	0	0	1	1	1	0
P_7	0	1	1	1	1	0	1	1	0
P_8	1	0	0	0	1	1	0	1	0
P_9	1	0	0	1	1	1	1	0	0

From the tabulation:

$$P = P_0 + P_1 + P_2 + P_7 + P_8 + P_9$$
$$Q = P_2 + P_4 + P_5 + P_6 + P_8 + P_9$$
$$R = P_1 + P_3 + P_5 + P_6 + P_7 + P_9$$
$$S = P_0 + P_3 + P_4 + P_6 + P_7 + P_8$$
$$T + P_0 + P_1 + P_2 + P_3 + P_{-4} + P_5$$

Now $\bar{P} = P_3 + P_4 + P_5 + P_6$

Hence $\overline{\bar{P} = P_3 + P_4 + P_5 + P_6}$

and $\bar{P} = \overline{\bar{P}_3\,\bar{P}_4\,\bar{P}_5\,\bar{P}_6}$

Similarly $\bar{Q} = \overline{\bar{P}_0\bar{P}_1\bar{P}_3\bar{P}_7}$

$\bar{R} = \overline{\bar{P}_0\bar{P}_2\bar{P}_4\bar{P}_8}$

$\bar{S} = \overline{\bar{P}_1\bar{P}_2\bar{P}_5\bar{P}_9}$

$\bar{T} = \overline{\bar{P}_6\bar{P}_7\bar{P}_8\bar{P}_9}$

The implementation of the code converter is shown in Fig. 10.

The technique used in this example is useful where there are many functions of the same number of variables to be implemented. In comparison the multiplexer requires less additional gating, but one multiplexer at least is required to implement each function.

The second part of this article will deal with the applications of read-only memories.

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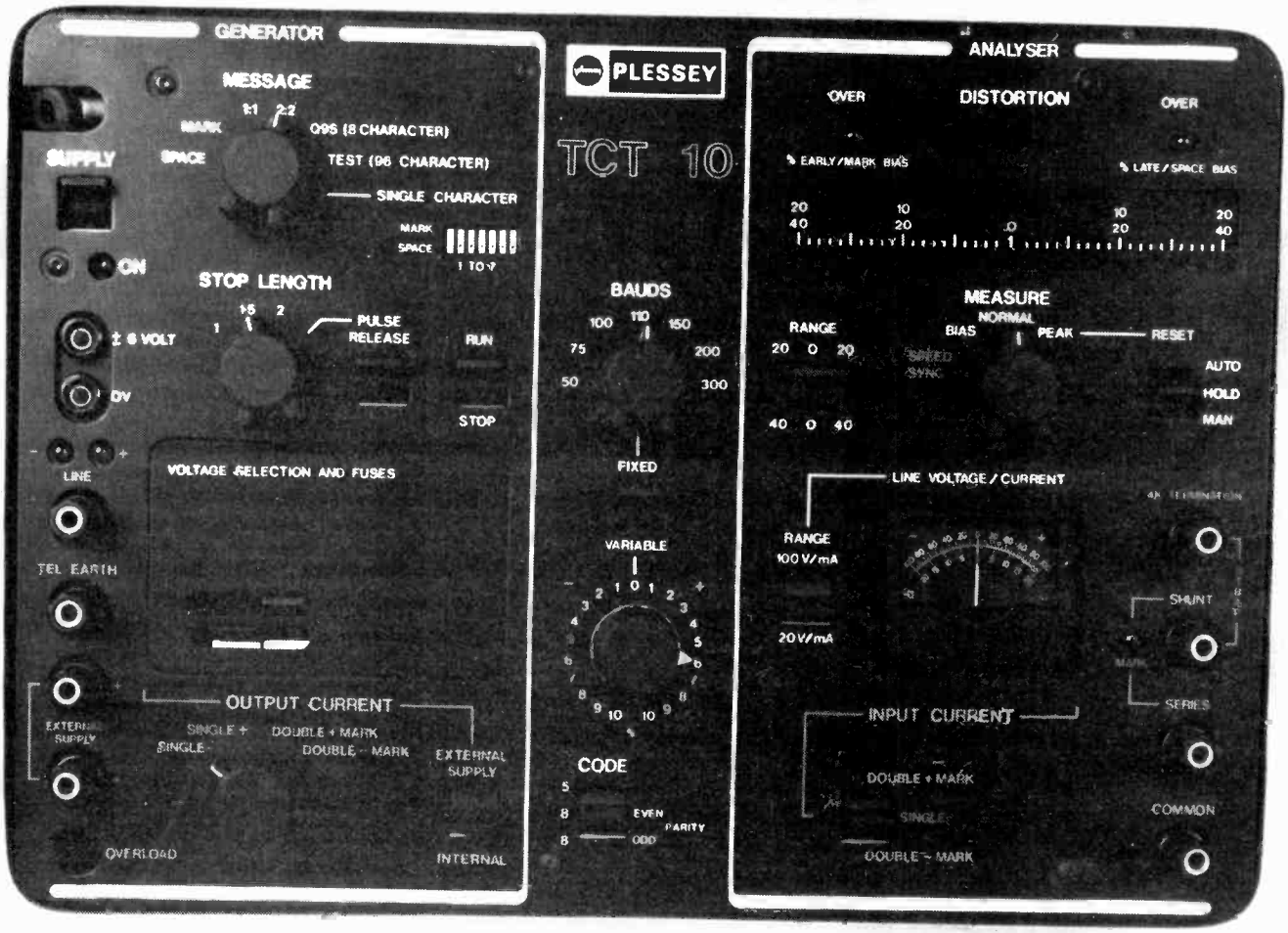

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LETTERS TO THE EDITOR

DIGITAL ELECTRONICS LACKS SOUND THEORY

THE digital electronics industry has sprung up so quickly in the past ten years that the theoretical foundation required has not developed at all. It is impossible to cross the line separating the analogue and digital worlds. The sine wave is a periodic, time varying, steady state phenomenon, whereas a digital signal is a fixed amplitude step (shock wave). Each change of state is a single event in time and cannot be correlated with any other change. A dubious connection, via Fourier analysis, is merely a mathematical arpeggio, guaranteed to be worth a few exam questions at least. A leading edge of a step is a shock wave, it is a transverse electromagnetic wavefront which travels at the speed of light. Of course, it is possible to take this single step and analyse it using Fourier analysis, but this would mean combining an infinite number of sine waves which exist from minus infinity to plus infinity. This can be easily seen to be quite absurd and of no practical use.

The hard and fast rules laid down for periodic sine waves must be cast aside and new rules developed for the shock wave. An obvious area to concentrate on is signal distribution. We must have a basic understanding of the mechanism by which a block or pulse of energy is transmitted in space. This leads us into electromagnetic field theory and it is here that the student will learn and ultimately understand the subject of digital electronics.

Unfortunately, nearly all the books written on e.m. field theory are concerned with steady state sine waves. There is no basic theory written today which concentrates on high speed digital techniques. How 1ns steps propagate is known to only a few people. Yet with the advent of emitter coupled logic and Schottky t.t.l. this electrical phenomenon is becoming widespread. Engineers today attempt to put together fast, complex logic systems which stand the risk of failure. The paper design might well be satisfactory but the problems that arise during testing and commissioning seem endless. The unfortunate engineer just cannot understand the "gremlins" that keep upsetting his system. Nowhere is he taught the important fundamental principles necessary for competent digital system development.

To have a complete understanding of high speed systems one must apply certain techniques which are not taught in any educational establishment in the country, nor written about in any text book. One must go back to the turn of the century to find any suitable material. Then the main subject was telegraph signalling, which is analogous to digital transmission today. A 10-millisecond risetime step travelling 1,000 kilometres (telegraphy) is based upon the same theoretical principles as a 1-nanosecond step travelling 10 centimetres (computers).

Around 1890-1910 Oliver Heaviside and his contemporaries Lodge, S. P. Thompson, Hertz and Maxwell had developed many theories which should be used today. By thinking of digital signals as small, discrete packets of "energy current" flowing at the speed of light between the wires (which merely act as a guide) many of the present-day design implementation problems could be solved. The advent of the telephone and wireless led to the predominance of sinusoidal time varying signals, so the concept of "energy current" was lost as new theories were developed to cope only with the periodic waveform. We have now turned a full circle and must look backwards before we can advance.

The practical problems of digital systems, such as cross talk (noise), power supply decoupling, signal termination and drive techniques, component pulse response, earthing, and mains borne interference, need to be studied. General models and original concepts based upon Heaviside's "energy current" idea can be used to tackle these problems, making it possible to design complex digital systems in an orderly, scientific fashion. Every practising engineer in digital electronics must stop attempting to use analogue ideas for digital systems: they will not work. Pattern sensitivity, noise, power supply problems are all raising their ugly heads, and all quite unnecessarily. By following clearly defined design rules, systems can be built which will work reliably and first time, without the usual 3-6 month commissioning troubles.

The design concepts that are used are not difficult. Although soundly based in theory, they do not involve exotic mathematics and are aimed specifically at practical problems of hardware development. They are tools of the trade to be used by all engineers and technicians.

Malcolm F. Davidson
CAM Consultants
South Mimms
Herts

ECONOMICAL TIME-MARK GENERATOR

I AM surprised that Mr Winder has apparently experienced trigger reliability problems with the oscillator circuit of the Time-Mark Generator (January letters), and also at his preoccupation with improvement of the rising edge of the output waveform. Perhaps it was a case of "missing the obvious", but the 7490 is triggered from the *falling* edge of the waveform, and the fall-time of my own circuit is better than 10ns, well inside the manufacturer's recommended 50ns maximum.

His advocation of a 10MHz frequency standard to enhance the capability of the generator is, of course, a sensible idea, but only echoes the same suggestion made in the article.

Mr Winder's suggested method of setting up the oscillator frequency to a high degree of accuracy is unnecessary. Even manufacturers of top-flight oscilloscopes rarely claim better than ±3% accuracy for their timebase ranges. There seems little point in going to the trouble of achieving better than about ±0.3% accuracy in the generator — amounting to a permissible error of ±3kHz in 1MHz! I very much doubt that a 1MHz crystal could be pulled off frequency by that amount by even the most strenuous efforts.

As to the question of how Fig. 3 of the article was achieved, the answer is quite simple. The "alternate" sweep mode of the dual-trace oscilloscope is chosen so the two frequencies are displayed separately in alternate sweeps, and the triggering is derived from each frequency alternately. In this way, two stable traces are obtainable and the measurement may be made with little difficulty.

A small drawing error did creep into the article, however, for which I must apologise. In the one-shot circuit, R_b is shown connected to pin 15, which does not, of course, exist. Pin 5 is the correct connection, and I am grateful to Mr Stewart Danks of Glasgow for pointing out the error.

S. Roberts
Sheffield

THE ULTIMATE FIDELITY TEST?

AS A humble amateur I would like to raise my voice for once in the discussion about the audibility of imperfections in sound reproducing equipment (November issue, p.63).

It struck me that the instrument for the ultimate measurement usually is a testperson's very subtle feeling of difference between two not simultaneously generated sounds. There are some "shrieking" sounds, such as the scraping of a piece of chalk on a blackboard at a certain angle, or the scraping of a knife-blade on a metal surface at a certain angle, that cause strong physical reactions, such as shivering or goose pimples, in people who are susceptible to this (one out of every ten, I would say).

Using this type of sound as programme material in a recording and reproducing system, its performance could be judged by its ability to cause shivering and goose pimples among a selected, susceptible group of testpersons. In this way the human psyche, including possible bias, is bypassed, as the final determining reaction comes from the nervous system, rather than from the conscious mind.

Although it's just an idea, and I am not in a position to work on it, I doubt whether there is much equipment that could pass such a fidelity test.

Hein E. Riegstra
Amsterdam
Netherlands

AUDIO MIXER DESIGN

A MINOR disadvantage of transistors compared with valves is that the output is not completely isolated from the input, even when an emitter follower is used. Thus if the output from, say, three emitter followers is to be mixed for further amplification, rather lossy T-networks must be interposed, with consequent worsening of signal-noise ratio. This drawback can be avoided if optoelec-

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tronic isolators are used, one for each audio input, or if desired an emitter follower for each audio input can terminate in an l.e.d., the illumination from which is picked up on a phototransistor for subsequent amplification. It would be possible to control levels and possibly also tone of the three signals mixed, by interposing optical filters between the l.e.ds and the phototransistor, which could well be cheaper and more compact than potentiometers. The method could be applied to the mixing of signals from microphones or to the mixing of various pitches and tones in electronic organs, and would obviate risk of intermodulation at the mixer stage.

K. J. Young
Derby

INTEGRATED CIRCUITS TOO SMALL?

THE article "Wiring by touch" in the January issue shows a level of determination which should be an example to all of us who have full sight. F or myself as I have grown older I have noted that components have shrunk in physical size to an alarming degree so that now, even with the benefit of glasses, and a midget iron, I find it quite hard enough to make the proper connections.

I am inclined to think that many experimenters would agree with me in thinking that integrated circuits are just too small for comfort and there is really no need in amateur construction for quite this degree of miniaturisation. I realise that commercially this is necessary, but there is a solution. There exists a standard circuit board for 0.15in pin spacing, so that if some enterprising small manufacturer could be persuaded to produce a socket accepting the standard 16-pin i.c. but with its own connection pins spaced at 0.15in this would, I feel, meet a very real need — and I am not at all sure that some of the development boys would not use this slightly larger scale for initial testing. I suggest a 16-pin socket as the other i.cs with 14 or fewer pins could still fit into the same socket.

I hope someone will take up this idea as I feel that Mr Jones, who wrote the fascinating January article and many others with limited sight, as well as thousands of other experimenters with normal human sized fingers, would find such a socket adaptor to be a boon.

B. R. Smith, G3NNM
Herne Bay
Kent

PHASE-FILTERING WITH TIME-REVERSAL

ONLY a subset of filtering operations that can be formulated are physically realisable (see reference 1). Further, only the subset of these known as minimum-phase filterings possess a true physically realisable inverse. If $Y(\omega)$ denotes the complex amplitude of a physically realisable filtering as a function of angular frequency ω, then $YY^{-1} = \exp(j\omega\tau)$, with $\tau = 0$ and Y^{-1} realisable if Y represents a minimum-phase filtering. Otherwise a realisable approximation $Y'(\omega,\tau)$ to the inverse of Y can be found only in the sense that $YY' \approx \exp(j\omega\tau)$ for non-zero time-delay τ. The tendency of phase-shift to 90° when the slope of the amplitude-response is 6dB/octave over a sufficiently large frequency interval, and what is usually called the phase-integral theorem[1], both belong to the domain of minimum-phase filterings.

Hansen & Madsen[2] have described an application to the investigation of aural phase detection of the method of Beauchamp[3] for cancelling the phasal part of a filtering operation. Essentially the method consists in recording with filtering $Y(\omega)$ and replaying the recording backwards through an identical filter Y. The time reversal of the recording has the effect of making the first filtering equivalent in real-time to $Y(-\omega) = Y^*(\omega)$, where the asterisk denotes complex conjugation. The combined effect of the two filtering operations acting in cascade therefore becomes $Y^*Y = |Y|^2$ with respect to the time-argument of the recorded signal. For eventual use, the backwards signal resulting from this process may of course be re-recorded and replayed with a further compensating time-reversal.

The purpose of this letter is to make two inferences of significant generality from the Beauchamp method. The first of these, which is the more philosophical, concerns the lapse of time between the original recording of the signal and the time at which the processed signal becomes available. Evidently the minimum possible interval is twice the duration of the recorded signal, and in practice will often be much greater. This interval is so long compared with the transient response-time of any likely filter as to effectively circumvent the restrictions of physical realisability. In this sense the Beauchamp method is just a way of ensuring that the delay τ is adequately large. In addition, of course, it provides a convenient technique for exploiting the freedom thus conferred. As we have seen, a phaseless amplitude filtering $|Y|^2$ results from including a filter Y in both the initial and the time-reversed steps, while any desired phase-filtering can be approximated by all-pass filtering in either or both of these steps. In practice of course the amplitude and all-pass filters would be concatenated and condensed together, so that in general the filtering would be different in the two steps.

The second general inference is more practical. Phase-shift (other than pure time-delay) between input and output of a signal-processing system is usually undesirable, and indeed is often called phase-distortion. Sometimes it may be useful however, and more frequently there is advantage in phase shift at intermediate stages that is afterwards compensated in whole or in part. For example relative phase shifts, usually of 90° and as accurately frequency-independent as possible in the working band, are employed in single-sideband modulators and processors, and in directional encoding of surround-sound on two or more channels[4].

Another application concerns overload limits of signal-handling equipment, and especially recording devices. In general there are overload points dependent on the signal-amplitude and on its time-derivatives and time-integrals of various orders. In power amplifiers, limitations on amplitude and its rate-of-change (slew rate) are of practical importance. In disc recording, groove spacing, the maximum slope that can be tracked, and the stylus radius set respective limits on the amplitude, slew-rate and acceleration of the signal that can be recorded satisfactorily. It is customary to use amplitude-filtering, adapted to the expected power spectrum of the signal, to mitigate the effect of these overload points; similar considerations apply, *mutatis mutandis* to other methods of recording, e.g. magnetic tape. Equally, knowledge of the phase character of the expected signal (e.g. that peaks are percussive) can be used to introduce phase-filtering which delays the onset of overloads of any order; "chirp" radar may be considered an example of this. Another use of phase-shift is to give to a signal characteristics which are distinct from those of expected errors, for example distinguishing digitally recorded bits from tape drop-out effects by recording them as impulse-equivalent signals.

The Beauchamp method provides a convenient technique for realising these various advantages without concomitant undesired phase effects in the final signal. Wideband 90° (or other) phase shifts between channels are normally obtained as the difference between frequency-dependent phase shifts of substantial amount affecting all channels; time-reversal recording enables these overall phase shifts to be compensated leaving only the required relative shifts. Similarly the the method enables "chirp" or other deliberate phase-shifts to be removed from the final signal after they have served their purpose.

The techniques that have been discussed above are unlikely individually to occasion any surprise, but they seem to have been exploited surprisingly little in view of their potentiality. This unified discussion has the aim of catalysing more systematic consideration of them by systems designers.

P. B. Fellgett
Department of Cybernetics
University of Reading

References

1. Bode, H. W. "Network analysis and feedback amplifier design" Van Nostrand, New York, 1949.
2. Hansen, V., and Madsen, E. R. "On Aural Phase Detection" *J. Audio Eng.Soc.* 22, 10-14, 783-788, 1974.
3. Beauchamp, J. W. "A simple method for phase compensation in tape copying with identical tape recorders". *J. Audio Eng. Soc.* 16, 112-113, 1968.
4. Fellgett, P. B. British Patent no. 1369813.

COMPETITION FOR VIEWDATA WELCOMED

VIEWDATA is no monopoly. The service which we will be offering in the market trial starting this June, and in the public service which we hope to start in 1979, involves the retrieval by customers of information held in remote computer data banks, using the telephone network as the transmission channel. Such services are already provided by the private sector, using conventional computer equipment. It is equally open to the private sector to establish and run computer centres, operating in Viewdata format. Any customer with a Viewdata-equipped television set could access these private data banks by dialling the appropriate telephone number, in the same way that he would access the Post Office Viewdata computers.

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In your February editorial "Viewdata needs encouragement" you called on the Government to provide an opportunity for an experiment in private operation of Viewdata-like computers. That opportunity already exists and we will welcome competition from the private sector. There is scope for competition not only in the running of the computer centres, but also in the provision of the terminal equipment, and the provision of information. Once a public Viewdata service is launched, any terminal equipment manufacturer will be able to supply suitably equipped television receivers to the public, subject only to technical and safety approval by the Post Office for attachment to the telephone system. Likewise it is open to any organisation to rent space in the Post Office's Viewdata computers.

We see the Viewdata project not as something under the sole charge of the Post Office, but as a co-operative venture, drawing equally on the resources of the Post Office and the private sector. Indeed much of the marketing of the service will be done by the tv set suppliers and the information providers. In short, the course we are pursuing is, I think, exactly the one you advocate, and I am very glad that you feel it to be right.

A. A. L. Reid
Viewdata Project Manager
Post Office Telecommunications
Headquarters

THE EAR IN PHASE AUDIBILITY

IN all these arguments about phase audibility and the experiments of Dr Shanefield (October issue) has anyone considered the organ of Corti and the information handling between it and the auditory cortex? Simple reference to this makes it unlikely that phase relations can be detected as such, unless there is an additional wavefront detector that we know nothing about. The ear transducer is a fluid-filled coiled tube containing stretched fibres of different lengths and tensions. Sound waves are pulsed through the fluid and each sensory fibre is attached to a cell which codes *amplitude* of vibration as *frequency* of nerve pulses. Intensity of stimulation is coded logarithmically, so that a small stimulus produces a small rise in frequency but a large stimulus produces progressively less and less change as it gets louder. The reason for this is that a nerve has appreciable capacitance and is in this respect like a transatlantic cable. It has an upper frequency response. The 20 Hz sound could have its wavefront represented by the first pulse down the nerve but at 8kHz several hundred cycles may have passed *at low intensity* before the first nerve pulse can be emitted.

It has to be admitted that surgical skill limits experimental work on nerves in the ear but it stands to reason that if the gap between pulse one and pulse two is to represent intensity then the system cannot be expected to keep the nerve cell in readiness to emit a pulse at wave peak on the first wave. What is more, the cochlea is a delay line. The sound wave progresses down it but is detected only as it passes its "resonant" element. This means that the nerve net ought to contain a compensating delay line. In the case of the electric eel, where exactly the same information problem is faced, compensating delay lines are found in the nerves that supply the electric organ. Informationally the problem of discharging all the little electrolytic capacitors in the electric organ is identical to preserving the phase relation of a wavefront. It can be done if an animal needs to do it. On the other hand, what use would phase coherence be to an animal like us? Wavefront difference between two ears is another matter as it can give direction in a creature with miserable little ear flaps. Even so it is hard to see how it is done.

In conclusion may I point out that in a television programme on famous violins where more great violins were gathered in one place than ever before, the tone analysis was only done by oscilloscope and the phase relations between different violins were the most noticeable feature. These may have simply been due to different bow strokes. The commentator was unaware that the shapes would reflect phase more than harmonic content.

Detecting equality is the best possibility of human performance. Dr Shanefield should try to dope the recorded sound until it produces equivalence and *does* take in the observer. He should try thumping damped objects as the tone is played to remove the possibility that sub-audible percussion is being picked up by the listener's body. If two violins can be made to give marked phase differences, he should try to see if people can distinguish them after their tone differences have been equalised. Two recorded sounds with phase differences are a fairer test than real and recorded sound, if the ability to hear phase is under investigation. The simple expedient of picking up a sound, feeding part of its harmonic structure into an amplifier and reissuing it should phase shift real sounds and this experiment should be quite conclusive.

F. C. Allen
Cambridge

WHAT Mr Naish says in September letters is undoubtedly true, but most of it, for example the exact shape of resonance curve and which part of a nerve carries which information. is not relevant to my suggestion.

Any amplitude to frequency converter working directly from the a.c. input is more likely to fire near peaks than near zero, unless one puts in extra complication to inhibit this. Even if the brain does not want the phase information there is no point in providing the extra complication.

The reversing phase experiment is interesting and demonstrates that a process of adding the inputs from the two ears takes place, a not surprising fact. When the signal is about the same level as the noise it is not surprising that a change in the relative pattern of the firings from the two ears causes one to detect the firings. This does not established that cognisance is taken of phase. There are many other possible explanations. For example, two firings, one from each ear, occurring together may be more easily detected than separate firings or perhaps a shorter time between firings after the adding process makes the signal easier to detect in low signal, high noise conditions. To what extent is it the sense of the two signals as distinct from phase that renders it audible in this experiment?

J. H. Asbery
Wembley
Middlesex

THE BLUMLEIN

YOUR news item about the unveiling of a plaque to honour the late A. D. Blumlein in the August 1977 issue prompted me to look up the account of his work by M. G. Scroggie in the September 1960 issue of your magazine. With the benefit of the passing of the years it is now possible to refute Scroggie's complaint of the non-commemoration of Blumlein's name in any "device, law or discovery . . ." He has achieved posthumously a place in the ranks of those like Watt, Joule, Mackintosh, Macadam, etc. whose names are used alone and not adjectively but with the unique distinction additionally of incorporating a pun. I refer of course to the "Blumlein", the reflective delay line invented by him to generate submicrosecond pulses. In the modern development of high power relativistic electron beam generators the Blumlein plays an important role in the form of three coaxial conductors and is frequently described in the literature as such.

J. W. Marks
The Weizmann Institute of Science
Rehovot
Israel

DIRECT PERCEPTION OF RADIO WAVES?

HAVING read Mr Wood's letter in the December 1977 issue, I would like to make some remarks on my own experience. When I was a child (maybe 7-10 years old) and I was lying in bed at night I often heard weak morse-like signals. My room, situated under the roof of my parents' house in a small town (5° 36′ East, 51° 08′ North), was very quiet and I could hear nothing but myself. I never asked anybody about this because I supposed they would not believe me. Later in my life I have several times had a similar experience but now I live in noisier surroundings and I fear my ears are too old.

Now I know there are radio stations transmitting that kind of slow morse at very low frequencies, where ultra-sound and radio meet and overlap each other. I do not know whether a military air base a few kilometres away transmitted something like that or whether the tram rails in front of our house could have acted as a sort of waveguide. I have only one explanation for the phenomenon: that waves of suitable frequency may be somehow transformed, perhaps rectified, in the inner ear.

Jan Smeets
Barcelona 9
Spain

DEKATRON R.I.P.

WITH reference to Mr R. E. Williams' letter in the January issue about the "Dekatron" tube. we have used the Texas integrated circuit TIL306 for several years. This device will count, latch. decode. drive and display an actual number (in seven-segment form) and, unlike the Dekatron, only needs five volts.

J. Baker
Department of Engineering
University of Warwick

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Broadcast stereo coder

Three decoders assessed, a reference decoder circuit, filters, and a v.h.f. oscillator

by Trevor Brook, Surrey Electronics

This article concludes the series on the high-quality stereo coder design with a low-distortion decoder circuit. Performance details of the coder, assessed using this decoder, were given in the October issue.

NEED FOR A REFERENCE DECODER for performance checks on the coder prompted an investigation of some commonly available types of decoder. Some decoders produce their best channel separation from a degraded multiplex signal, such as is likely to emerge from the demodulator of present receivers, and the crosstalk measured in Table 3 using an ideal signal is given as a guide to what to expect when testing decoders fed directly from a coder. The setting of the free-running frequency of the phase-locked loop i.c. decoders can also have a considerable effect on channel separation and the best readings obtained are given in Table 3. The 1310 used was the best of seven selected for low mono distortion. All were very similar in stereo but two of the seven gave mono distortion readings of 0.45% on one of their outputs.

The use of a low-pass filter preceeding the decoder is bound to reduce channel separation if it does not have a linear phase characteristic and low amplitude ripple and this effect can be seen in the Skingley and Thompson circuit (*WW* May 1974 page 124). Though a sacrifice in channel separation results, such simple filtering does achieve its purpose of dramatically reducing "birdy" interference from adjacent stations, which otherwise is subjectively far more irritating.

Two odd effects appeared when testing CA3090 decoders using the RCA data sheet circuit. The decoder would trip out of stereo if full level 15kHz M signal was fed into it and limiting of the audio outputs accompanied by large beat tones occurred with full S signal for 15kHz audio. These effects are presumably due to the 15kHz, or lower sideband of the S signal, confusing the 19kHz phase locked loop.

Finally tested was the Portus and Haywood decoder (*WW* Sept 1970). Needing principally lower harmonic and beat tone distortion, I devised the following modifications, included in the circuit of Fig. 14.

- Change Tr11 and Tr12, formerly BC108 types, for 2N2369, ZTX313 or any high-speed switching transistor.
- Change Tr14 and Tr15 for high-gain audio types, BC109C, ZTX109C, etc.
- Convert the input amplifier to a compound emitter follower, now with a lower emitter resistor and a gain potentiometer at the input. This can be done neatly on the original Integrex p.c. board using only one link. This modification is only suitable if the input amplifier is not required to provide any gain.
- Operate the decoder with only 1.4V at TP2, the pilot level test point, not 1.5V.

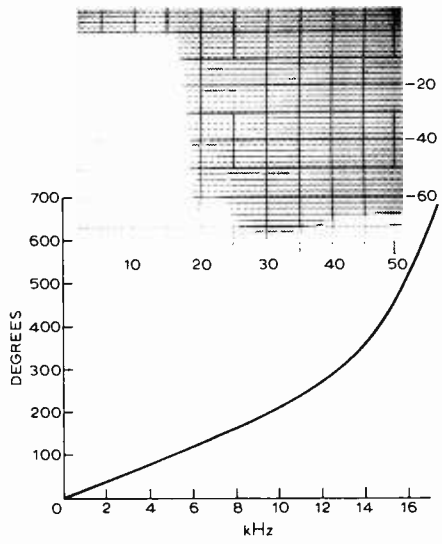

Fig. 13. Response of the audio filters in the coder and their measured phase response. The filters are two Toko BLR-2011-N units, each consisting of a modified π arrangement. Over 65dB rejection is provided at 19kHz and the ripple below 15kHz is less than 1dB.

These modifications brought the 1kHz distortion in stereo to 0.06% and, with the further suggestion by Mr Portus of fitting pull-up resistors R_{64}, R_{65} onto the bases of Tr14 and Tr15, gives the excellent figures in Table 3 with the only penalties a couple of dB lower audio output and higher switching waveform on the outputs. Low frequency channel separation is easily improved by paralleling 1000μF 10V electrolytics across C_5 and C_{18}. Though irrelevant for normal listening, good separation is desirable when measuring the coder's noise level.

All decoders proved sensitive to supply hum and noise and filtering along the lines shown, Fig. 15, is needed to reduce the noise output from i.c. voltage regulators to allow signal-to-noise measurements beyond 64dB or so.

Table 3. Stereo decoder comparison when fed with ideal multiplex signal.

	Input mV	Distortion (%) mono	Distortion (%) stereo 1kHz	Distortion (%) stereo 15kHz	Crosstalk dB 1kHz	Crosstalk dB 15kHz
MC1310 CA1310	300	0.09	0.09	0.67	40	37
1310 & filter	300	—	—	—	40	20
CA3090	180	0.17	0.18	1.7 L or R 3 S at −10dB	43	30
Portus & Hayward	600	0.05	0.38	1.3	—	—
P&H modified	600	0.04	0.04	0.35	30	31

Stereo distortion measured at full L, R, M or S level. Worst reading of two channels shown. By altering the pilot phase on the coder channel separation on the modified Portus and Haywood decoder will reach 54dB at 1kHz and 50dB at 15kHz. This has the same effect as adjusting the oscillator trimmers on the 1310 and CA3090 for best channel separation, not necessarily at a free-running frequency of exactly 76kHz.

VHF oscillator

A simple v.h.f. oscillator with a varicap arrangement which has low enough capacity along the multiplex path to avoid h.f. loss is shown in Fig. 16. The oscillator coil is printed on the p.c. board alongside a coupling link which gives roughly 70 ohms output impedance through R_6. Coupling is low en-

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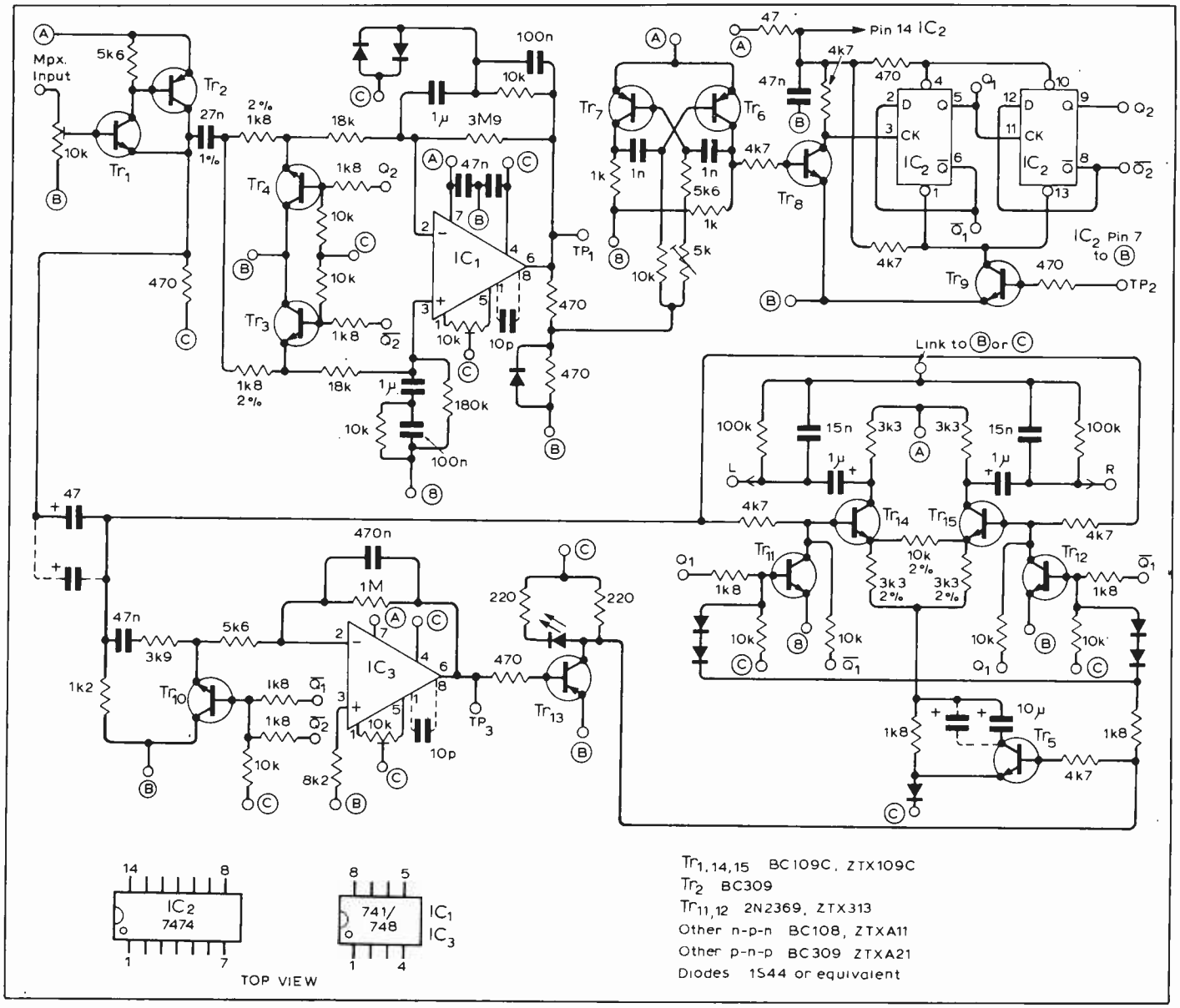
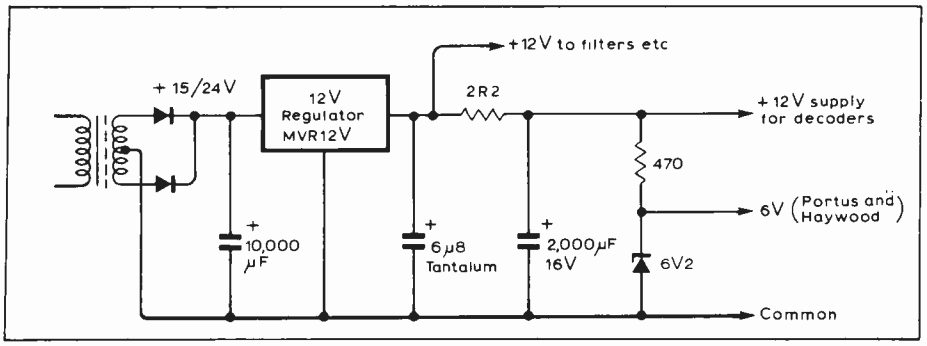


▲ *Fig. 14. Modifications to the Portus and Haywood decoder to improve both distortion and channel separation. Faster switching times and high gain transistors in the matrix with a different input amplifier arrangement give 1kHz distortion better than 0.04%. Voltage levels of points A, B and C can be either +12, +6 and 0V or +6, 0 and −6V respectively.*

ough to avoid frequency jumping with various loads. This device is only intended for use on a fixed frequency and there is no varicap sensitivity or linearity correction. Calculation for this circuit suggests distortion at full deviation of less than 0.5%. For a fully tuneable generator with calibrated attenuator the coder could be fed into the wideband modulation input of the Sound Technology FM1000 signal generator.

On stereo it is important for the deviation to be set correctly. Without an analyser or deviation meter the best way is to measure the pilot tone level before deemphasis when tuned to a BBC stereo station transmitting silence. They tune to the frequency selected for the oscillator and adjust its deviation to produce the same voltage. All the BBC stereo stations I can receive have pilot deviations within 1.5dB of Wrotham Radio 3. The output from the oscillator at around 60mV is adequate to feed a passive distribution system or with coaxial attenuators it can be used for receiver checking. Thirty decibels of attenuation (at 1.9mV) will still keep any reasonable f.m. receiver in full quieting on stereo while a further 6dB attenuation (685mV) will quieten a good tuner.

Fig. 15. Stereo decoders proved susceptible to noise on the supply line and filtering is needed to measure signal-to-noise ratios much above 60dB. Regulator should be mounted out of the transformer's magnetic hum field. 2000μF capacitor should have low internal resistance. ▼



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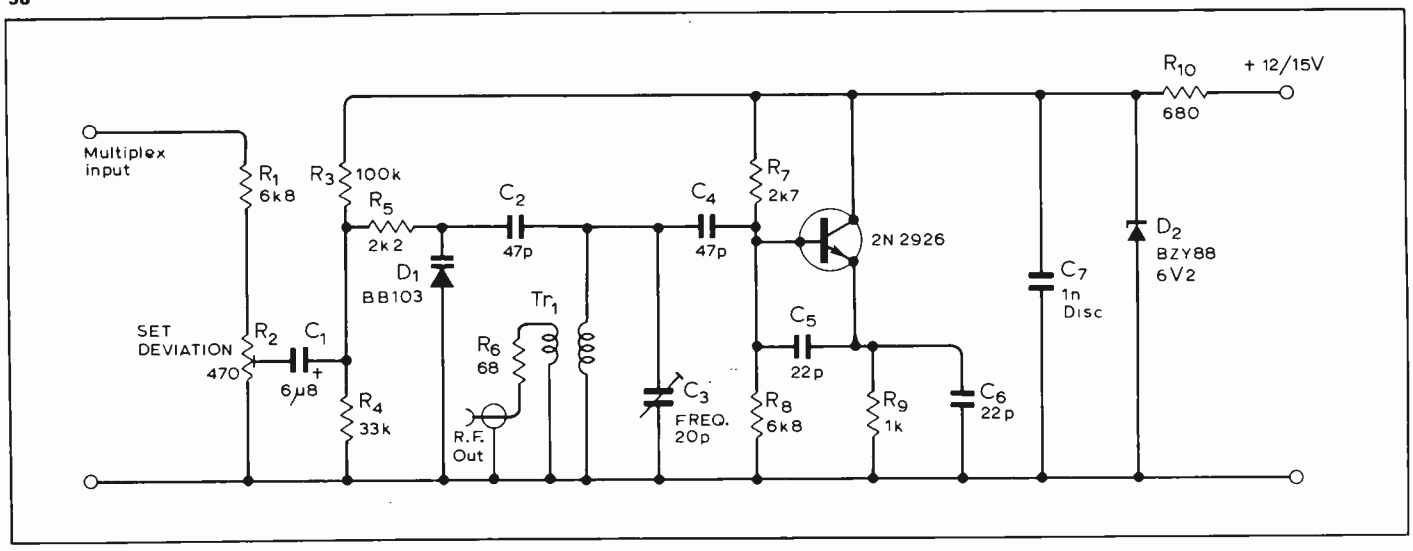


▲ *Fig. 16. Circuit of a v.h.f. oscillator using a printed coil and providing a simply repeatable output level. Output voltage into 75 ohms is 55mV at 108MHz and 65mV at 87.5MHz. Temperature stability over 20 to 57°C at 96.4MHz is 4kHz / deg C. Deviation sensitivity at 104MHz relative to 88MHz is +5dB.*

Fig. 17. The v.h.f. oscillator shown just fitting into the smallest diecast box available (RS Components 509-923). Coaxial attenuators provide lower signal levels for receiver alignment. ▼

The oscillator will run from either +12 or +15 volts so it can be run from the coder's supply or tapped from the receiver under test. The capacitor types used should be observed as they were chosen empirically to reduce the temperature drift. Wiring inside the box onto the p.c. board should use thin flexible wire with a slight slack left so that microphony is not transmitted from the input and output connectors onto the board.

The phase and amplitude mangling of the S signal which occurs in most receivers is so large that degradation is clearly visible on the demodulated composite signal even without any vertical magnification. Both low S amplitude and phase shift should be seen at 15kHz with S amplitude loss being predominant for 1kHz modulation. Oscilloscope synchronization will be helped by locking to the audio input to the coder or the deemphasized audio output from the receiver's active channel.

15kHz filter

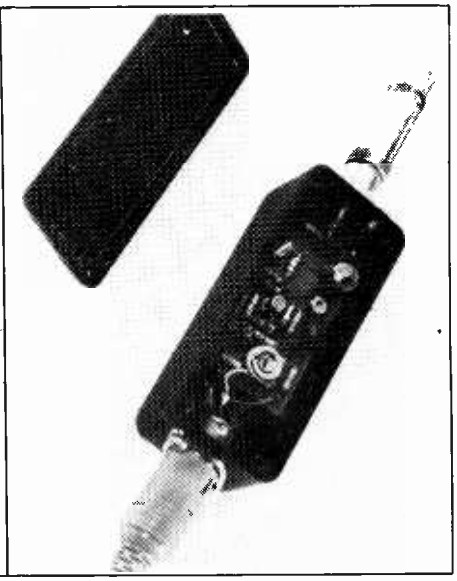
This is just a convenient p.c. board which runs from 12 volts and will remove switching frequencies at decoder outputs without introducing significant distortion, so allowing distortion and signal-to-noise measurements. The resistor from pin6 to supply draws a small current to stop the crossover distortion which 741s otherwise generate with only a 6-0-6V supply. To make distortion measurements below about 0.15% two such filters are needed to completely remove ultrasonic components.

I think the coder design presented here has reached a cost/performance plateau. Many of its identifiable deficiencies can be attributed to the balanced modulator i.c., and £80 or so spent on a precision multiplier will provide some further improvements. The lack of inductors and single p.c. board make for a repeatable unit with stable performance.

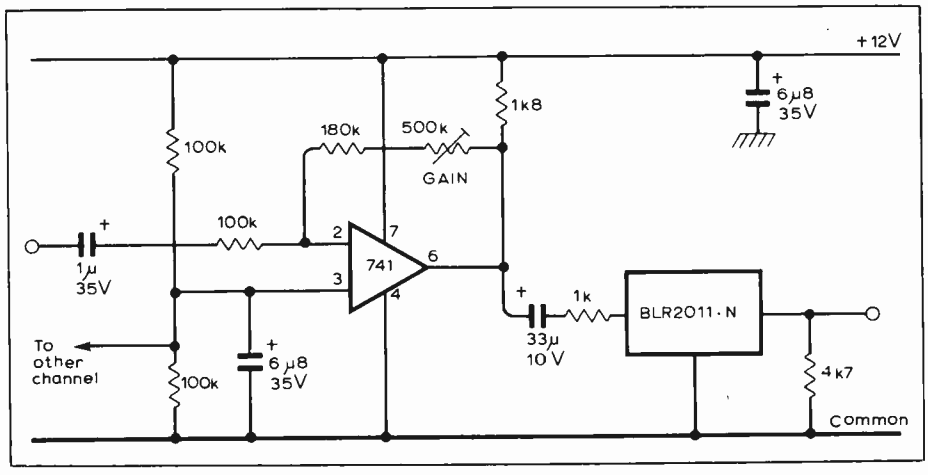
The work described forms the basis of stereo coders for broadcast transmission, outside broadcast radio links and test units. □

This series was written by . . .

Trevor Brook, who is keeping quiet for the time being about his latest idea, being a method of reducing noise in cassette tape machines he has decided to approach manufacturers with it first. But starting the electronic side of a new company to make film and tv equipment directly after leaving South London College (then Norwood Tech) must have convinced him that he could do the same sort of thing for himself, for he formed SurreyElectronics five years ago with a capital of £200. So we may see him making noise reduction modules as well as distribution and monitoring amplifiers, peak programme meters, and frequency shifters. His interests are not confined to audible frequencies. Acquiring a transmitting licence in 1966, he looked for good auroral openings by charting a tv sound channel from a transmitter 700km away, and heard a 20 watt repeater at Kilkeel over a 500km path "passing directly through Snowdon with unusual diffraction effects". With the aim of detecting sporadic-E backscatter and aurora he obtained a Home Office licence for an experimental pulse radar, but never quite overcame the problem of receiver blanking with a good noise figure.



▼ *Fig. 18. Circuit of a convenient filter for removing ultrasonic signals when making decoder measurements. Distortion at +11dB, 0.04%. Response −34dB at 19kHz, −45dB at 38kHz; ripple below 15kHz is less than 0.5dB. Crosstalk −80dB at 1kHz, −55dB at 15kHz. Noise −96 to −82dB over gain adjustment range of +4 to +14dB.*



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CIRCUIT IDEAS

Multiple station two-way intercom

This circuit shows a four-station, two-way intercom, where any station can communicate in privacy with any one of the others. Each two-station link-up is assigned a code, three bits being sufficient as there are six possible link-ups. The appropriate code is selected by Sw 1-4, and is generated at each station. All the station codes are "OR-ed" by IC_3 and decoded by IC_4 to drive a matrix of analogue switches which couple the appropriate audio inputs and outputs. Code 000 is allocated to a system-free status, indicated by l.e.ds 1 and 4 being on. A system-busy status is indicated by the l.e.ds flashing. When a code is selected, the station inhibit output is taken high and this forces the enable inputs on all other stations low, thus preventing any further codes being generated at the station outputs. However, if a station wishes to use the system and selects any of the other stations while the system is busy, it will flash a code for a time determined by CR thus interrupting the established link.

If the electronics are housed in one station, only two code wires are required to the other three. The system can be easily expanded up to six stations, where there are fifteen possible link-ups, by using a 4-bit code and a CD4514, 4-to-16 line decoder with an enlarged matrix of analogue switches.

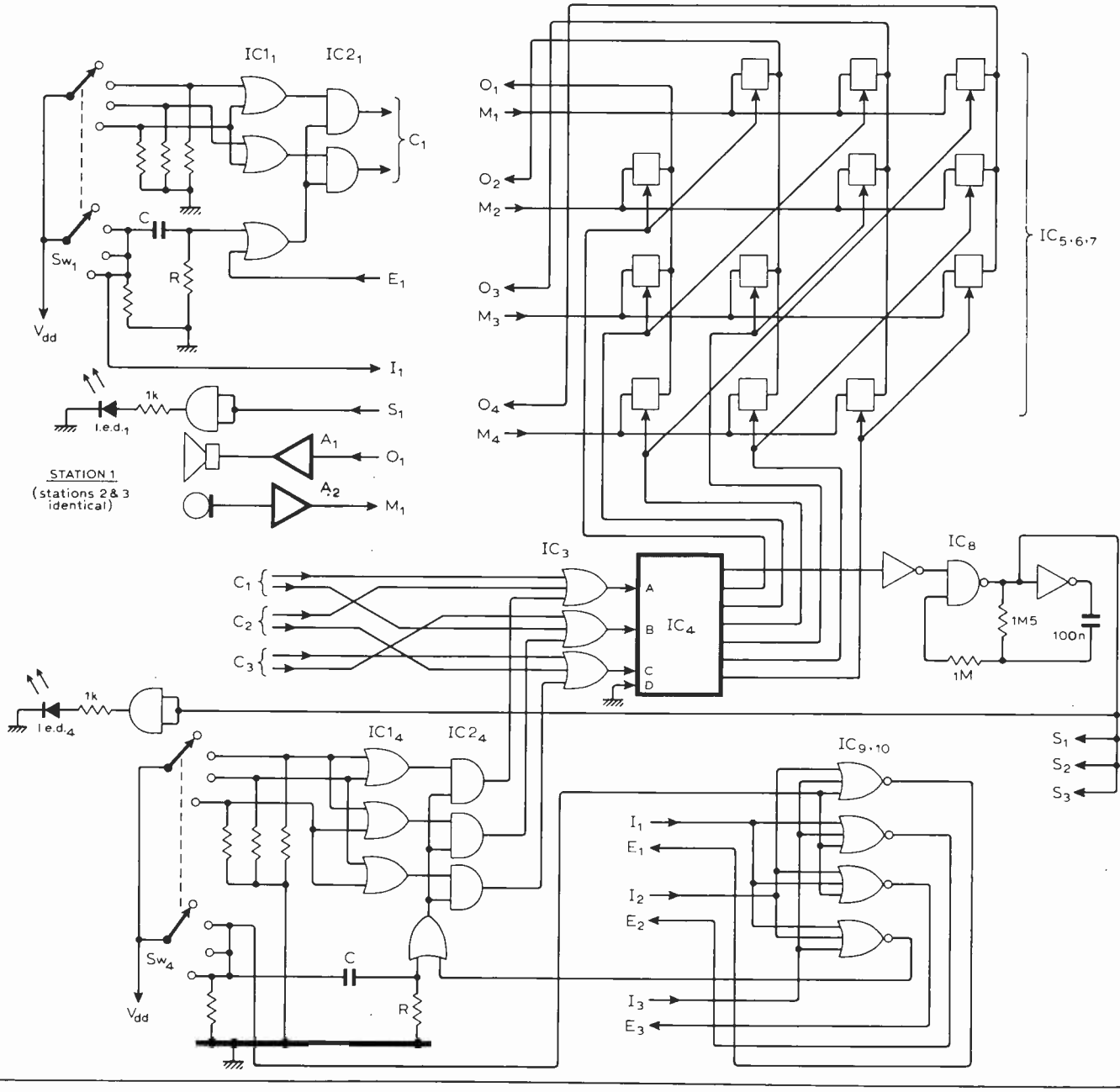
B. Voynovich,
Norwood,
Middx.

Components

IC_1	CD4071	IC_8	CD4011
IC_2	CD4081	$IC_{9,10}$	CD4025
IC_3	CD4075	A_1	LM380
IC_4	CD4028	A_2	741
$IC_{5,6,7}$	CD4016		

Station links	Code
1 to 2	001
1 to 3	010
1 to 4	011
2 to 3	100
2 to 4	101
3 to 4	110

Electronics housed in station 4 as all three bits are used.



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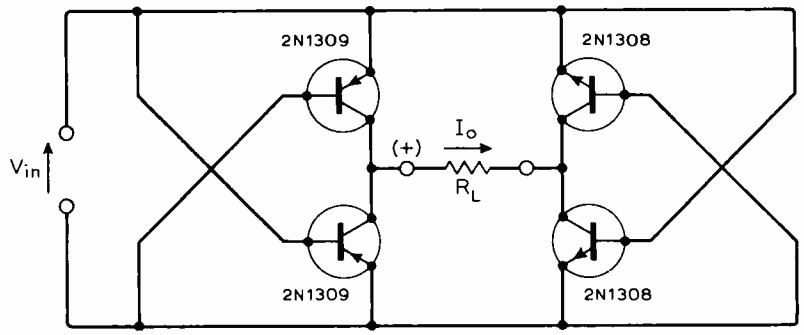
Cross coupled transistor bridge

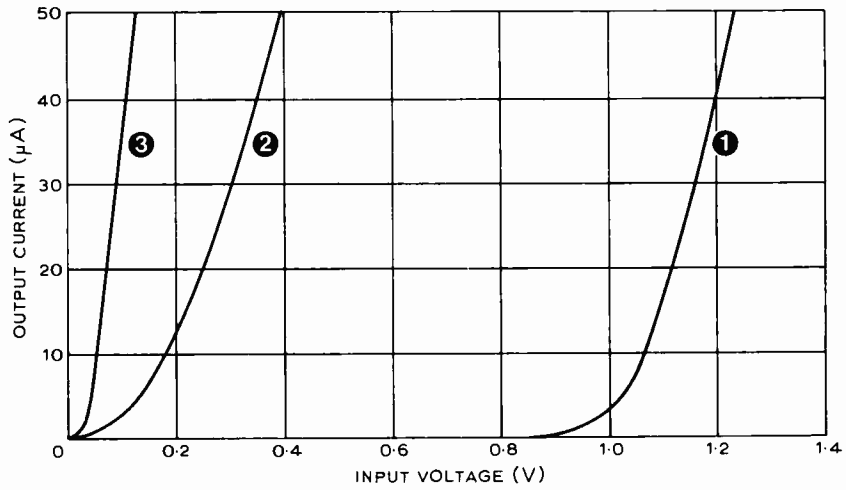
THIS circuit shows a full wave rectifying bridge which has an off-set voltage an order smaller than conventional diode bridges.

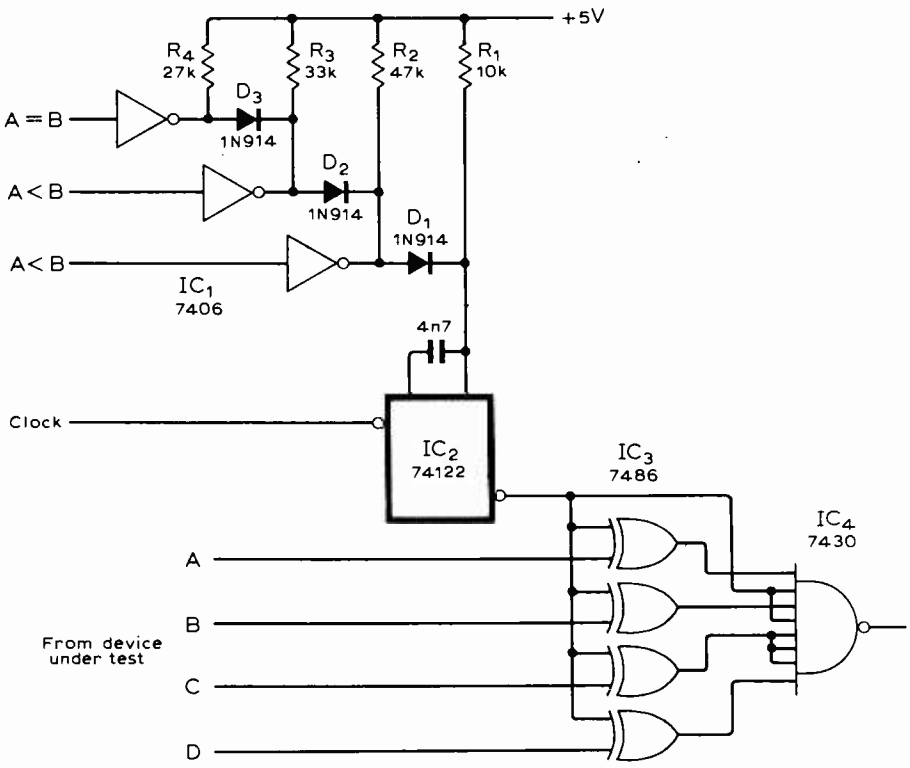
The graph shows transfer characteristics for a conventional full wave silicon diode bridge in curve 1, a germanium diode bridge in curve 2, and the cross coupled transistor bridge in curve 3. The off-set voltage of the transistor bridge is about 30mV with good linearity above the knee.

The circuit was developed for use in a simple but sensitive field strength meter. The meter is protected by the base-emitter junctions of the transistors. With the devices shown, the frequency response is up to 30MHz and the optimum value of R_L is about 2kΩ.

L. D. Thomas,
Burton on Trent,
Staffs.







Programmable strobe

WHEN using magnitude comparators to evaluate the dynamic operation of digital counters, the output data for A>B, A<B, and A = B is compared with a known conversion time for each bit by enabling exclusive OR gates with three separate strobe pulses. This circuit uses a monostable which, with the aid of three open collector inverting gates, will generate strobe pulses of 7.8μs, 10μs, 12μs, and a 15μs pulse to clear counters,etc.

The pulse widths can be increased or decreased by altering the value of C for the longest pulse and the three resistors in parallel for the three strobe pulses.

D. J. Greenland,
Cambridge.

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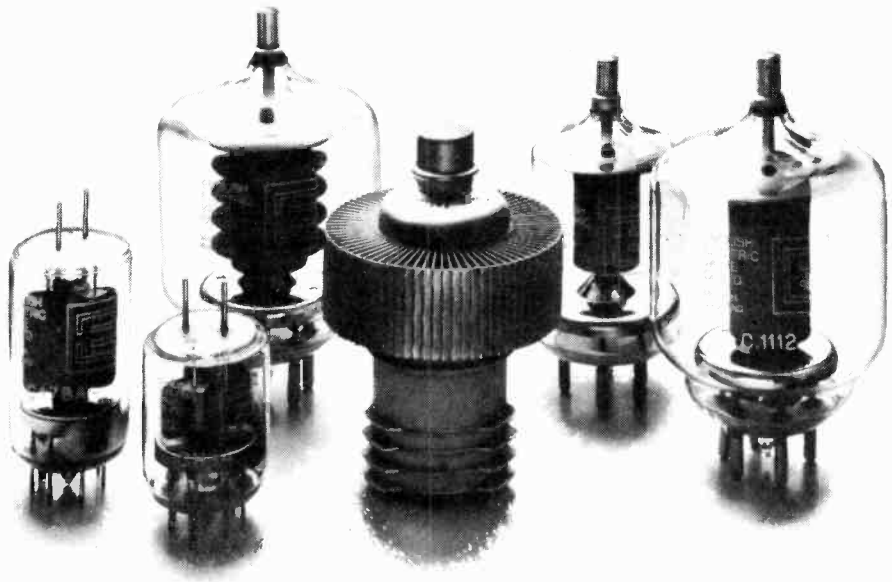

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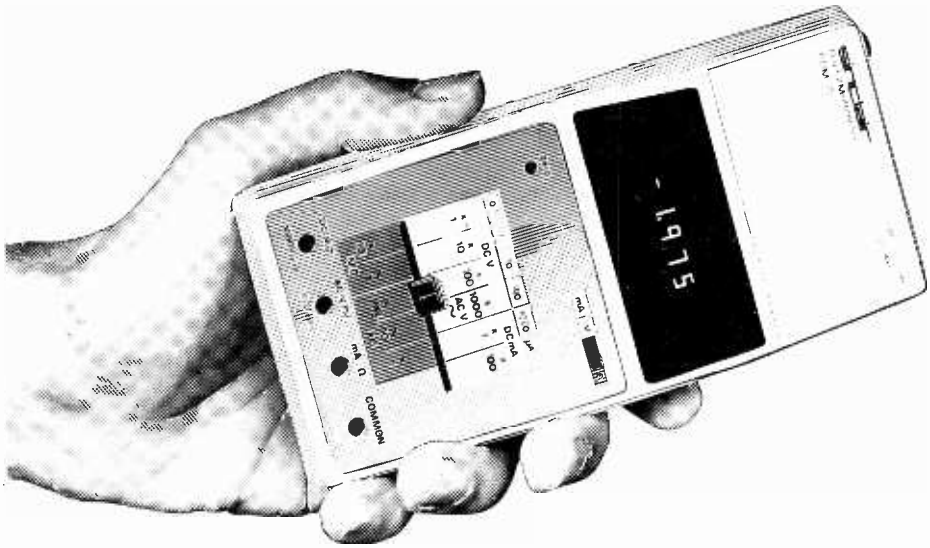

Now everyone can afford to own a digital multimeter

A digital multimeter used to mean an expensive, bulky piece of equipment.

The Sinclair PDM35 changes that. It's got all the functions and features you want in a digital multimeter, yet they're neatly packaged in a rugged but light pocket-size case, ready to go anywhere.

The Sinclair PDM35 gives you all the benefits of an ordinary digital multimeter – quick clear readings, high accuracy and resolution, high input impedence. Yet at £29.95 (+8% VAT), it costs less than you'd expect to pay for an analogue meter!

The Sinclair PDM35 is tailor-made for anyone who needs to make rapid measurements. Development engineers, field service engineers, lab technicians, computer specialists, radio and electronic hobbyists will find it ideal.

With its rugged construction and battery operation, the PDM35 is perfectly suited for hand work in the field, while its angled display and optional AC power facility make it just as useful on the bench.

What you get with a PDM35

3½ digit resolution.
Sharp, bright, easily read LED display, reading to ± 1.999.
Automatic polarity selection.
Resolution of 1 mV and 0.1 nA (0.0001 μA).
Direct reading of semiconductor forward voltages at 5 different currents.
Resistance measured up to 20 MΩ.
1% of reading accuracy.
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Industry standard 10 MΩ input impedance.

Compare it with an analogue meter!

The PDM 35's 1% of reading compares with 3% of full scale for a comparable analogue meter. That makes it around 5 times more accurate on average.

The PDM35 will resolve 1 mV against around 10 mV for a comparable analogue meter – and resolution on current is over 1000 times greater.

The PDM35's DC input impedance of 10 MΩ is 50 times higher than a 20 kΩ/volt analogue meter on the 10 V range.

The PDM35 gives precise digital readings. So there's no need to interpret ambiguous scales, no parallax errors. There's no need to reverse leads for negative readings. There's no delicate meter movement to damage. And you can resolve current as low as 0.1 nA and measure transistor and diode junctions over 5 decades of current.

Technical specification

DC Volts (4 ranges)
Range: 1 mV to 1000 V.
Accuracy of reading 1.0% ± 1 count.
Note: 10 MΩ input impedance.

AC Volts (40 Hz-5 kHz)
Range: 1 V to 500 V.
Accuracy of reading: 1.0% ± 2 counts.

DC Current (6 ranges)
Range: 1 nA to 200 mA.
Accuracy of reading: 1.0% ± 1 count.
Note: Max. resolution 0.1 nA.

Resistance (5 ranges)
Range: 1Ω to 20 MΩ.
Accuracy of reading: 1.5% ± 1 count.
Also provides 5 junction-test ranges.

Dimensions: 6 in x 3 in x 1½ in.
Weight: 6½ oz.
Power supply: 9 V battery or Sinclair AC adaptor.
Sockets: Standard 4 mm for resilient plugs.
Options: AC adaptor for 240 V 50 Hz power. De-luxe padded carrying wallet. 30 kV probe.

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Sinclair have pioneered a whole range of electronic world-firsts – from programmable pocket calculators to miniature TVs. The PDM35 embodies six years' experience in digital multimeter design, in which time Sinclair have become one of the world's largest producers.

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Analogue gate applications

The final background article in the series

by J. Carruthers, J. H. Evans, J. Kinsler and **P. Williams,** Paisley College of Technology

THE HAZY WORLD between analogue and digital systems is populated with a variety of strange and legendary creatures. One of these is the perfect switch, as hopelessly quested after as the Holy Grail as hunted as the Snark. As a long-time connoisseur of Boojums it has become obvious that we can hope for no better.

Good design is always a question of exploiting the behaviour of the available devices, of working within their limitations and not against them. The first step is to identify these limitations for the alternative devices, to see the implications and applications that follow. Consider first the on-off switch. This function can be duplicated by any device for which the resistance can be charged between two distinct levels. Ideally the resistance should be zero in one state infinite in the other and with no injected error voltages or currents. An adequate performance is possible provided the off-on resistance ratio is greater than 10^4, though useful results are obtained at ratios down to 10^2 while ratios above 10^6 are becoming commonplace.

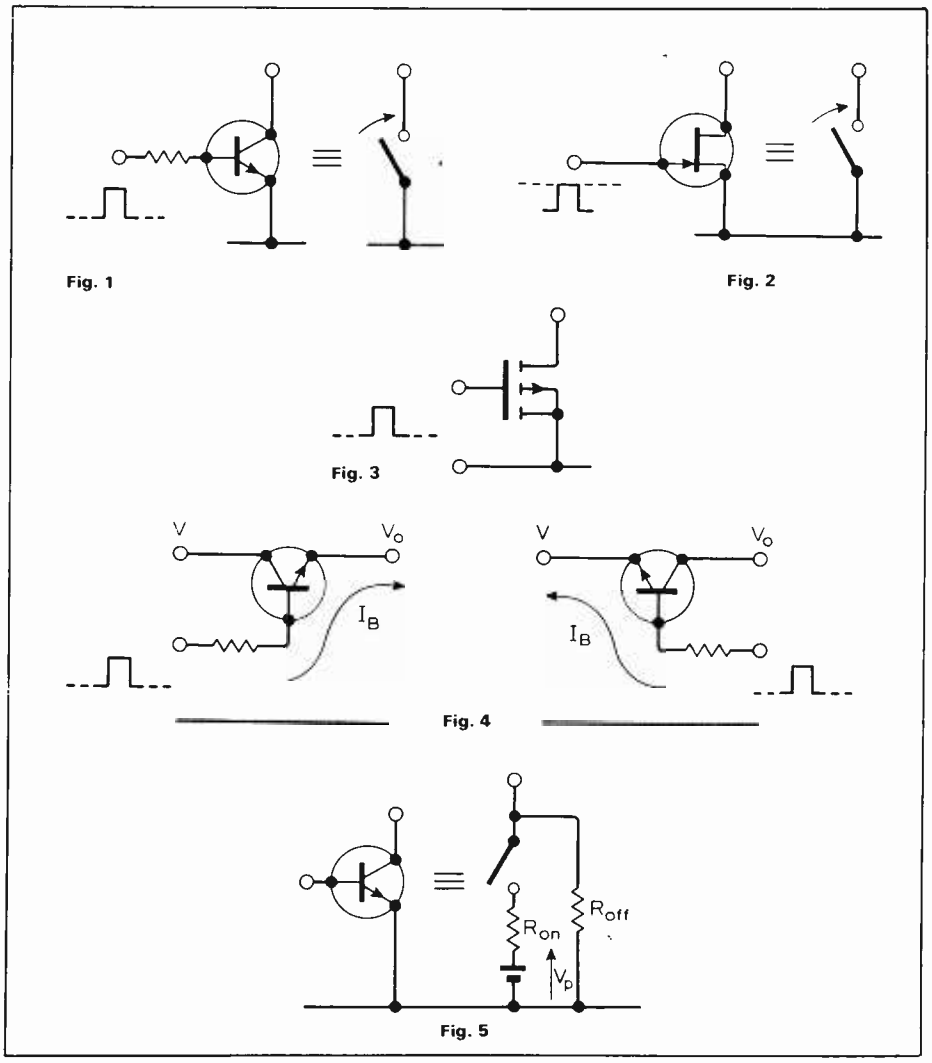
The changeover switch presents a different kind of problem. There is no direct electronic equivalent of such a switch, and it has to be synthesized by two separate on-off switches driven antiphase. This is not easy since if the conduction periods overlap then two different e.m.fs are placed temporarily in parallel. If there is a gap between the conduction periods problems arise with any current source that is open-circuited. The problem is clearly worse in multipole systems.

So far the switches, by implication, are able to operate between any pair of points regardless of their potentials. To bring ourselves down to earth (or ground) the transistor and f.e.t. switches of Figs 1, 2 and 3 illustrate the realities. Each can be switched from an off state where the resistance is very high to an on-state of moderately low resistance – anywhere between 10Ω and 1kΩ depending on the device. In the bipolar transistor the off-state is the normal one, with a forward bias voltage/current required to bring the collector-emitter path into conduction. This base current flows on through the emitter to the supply common line. For a junction f.e.t. which is a depletion-mode device the drain-source path is normally conducting and a reverse bias on the gate is needed to switch it off.

The enhancement-mode device of Fig. 3 requires the same sense of voltage drive as for the bipolar transistor to bring it into conduction, but the gate current is vanishingly small. The advantage is clearly seen by drawing the bipolar transistor switches with non grounded terminals as in Fig. 4. The base current then has to flow in either the source or the load. Further, the required drive voltage is affected by the magnitude and sign of the signal voltage, since at one extreme the device might receive excessive bias while at the other the signal might be sufficient to hold it permanently off.

This raises the question of how the drive voltage or current is to be derived. In the junction f.e.t., for example, the gate drive voltage is of opposite polarity to the normal drain source voltage and will normally require a dual supply system. The m.o.s.f.e.t. avoids the current requirements of the bipolar transistor and the reverse voltage needs of the junction f.e.t.

To summarize the imperfections that can exist Fig. 5 shows one equivalent circuit for a bipolar transistor in its switching mode. When the switch is open (no base current) the finite R_{off} still permits some current flow. When the switch is closed there is a voltage drop that depends in part on a resistive term R on, but includes a voltage V_p the



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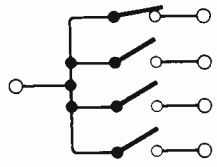

Fig. 6

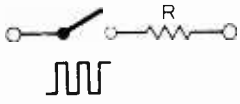

Fig. 7

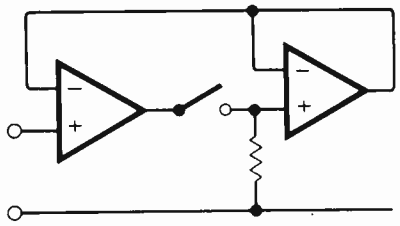

Fig. 8

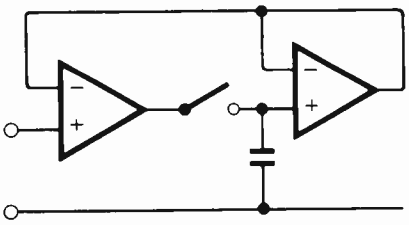

Fig. 9

pedestal voltage that is present even in the absence of current flow. This last term is absent from the equivalent circuits of both forms of f.e.ts making them preferable for low-voltage applications. The equivalent circuit is partial; it applies only to the static conditions, takes no account of the load presented to the switching voltage, and more important does not indicate the effects of the transients in the switching voltage. At high frequencies, low voltages or both these transients inject error currents into the output that can have the same overall effect as offset and drift voltages in operational amplifiers.

These limitations are very relevant to the process of multiplexing, of using a singlechannelto convey multiple sets of information. As a simple example, Fig. 6 shows a set of switches which can be used from left-to-right to transfer a single signal to one of a number of lines. Alternatively it can be used from right to left as a data selector i.e. transferring one out of a number of signals onto a single line.

A quite different application where transient properties are important is that of a switch that is periodically opened and closed (Fig. 7). If the rate at which this happens is very fast compared to any signal frequencies applied to the switch, then it is the fraction of the time for which the switch is closed that is significant. For a given voltage applied to the switch, the current remains inversely proportional to the resistance, but its average value is halved if the switch conducts for only 50% of the time; it is reduced to a quarter if the switch is closed for only 25% of the time and so on. The average current and hence the equivalent value of resistance is varied by the mark-space ratio of the switching waveform. This is an application of pulse width modulation to the control of circuit and system behaviour.

The examples quoted so far, have the switches used in open-loop systems. They can be very effective within feedback systems and two applications are shown in Figs 8 & 9. The first shows the switch at the location that would be occupied by a diode in a well-known form of precision rectifier. In fact if the switch is activated by a separate comparator that senses the input, it duplicates the function with some advantages. Replacing the resistor by a capacitor, creates a peak rectifier in the case of a diode, and a sample-and-hold circuit in the case of a switch. It is a testing application for the switch, since the speed of response should be high, the on-resistance low to allow the capacitor to sample rapidly, and the off-resistance should be high to avoid discharging the capacitor in the hold mode.

These are some of the areas in which analogue gates can be applied. Analogue gates are economically available in c.m.o.s. form. They have excellent performances in respect of drive input impedance which is virtually infinite, and an off-resistance which is also extremely large. Their on-resistance is less ideal though falling as new devices are introduced. The high-frequency behaviour is such as to permit operation to above 1MHz, while they are useful both as low-level choppers and as high-level switches. The gate-drive voltage is logic-level and the analogue signal may have any potential between the supply limits. It is for the flexibility that they add to circuit design that they are perhaps most welcome – no more need to waste time on special drive circuits, but instead use that time on applying them to a wide-range of useful functions. □

* * *

Twenty circuit cards devoted to analogue gate uses – sets 34 & 35 – concludes the Circards circuit information service. Individual back sets are available for £2 each (ten cards minimum) inclusive of UK and surface mail (ten sets are £18) and reprinted bound volumes of sets 11 to 20 are still available for £14.50.

Broadcast frequencies

Changes in broadcast frequencies, to take place on November 25th, 1978, are shown on the sticker presented in the U.K. edition of this issue of *Wireless World*.

The main changes are in the medium and long wave bands. **Radio 1** will achieve national coverage on 285m and 275m and will have an additional wavelength in the Bournemouth area of 202m.

Two medium wavelengths will carry **Radio 2** nationally — 433m and 330m.

Radio 3 is confined to a single frequency — 1215kHz, which is 247m.

Coverage of **Radio 4** will be obtained, in the main, by two long wavelengths — 1500m and 1322m. Ulster will be served by 417m, Scotland by 202m and 207m, the north-west by 202m and north-east by 498m.

Local radio in Leicester will change to 189m and in Bournemouth to 221m.

All medium-wave stations will have to change frequency by one or two kilohertz to comply with an international agreement, but most listeners will be unaffected by such a small change. Only push-button selectors may need to be reset. V.h.f./f.m. channels remain unchanged.

Frequency and wavelength

Multiplying frequency in megahertz (MHz) by wavelength in metres (m) gives the result 300. To convert from one to the other it is only necessary to divide the known quantity into 300. For example, the wavelength corresponding to 100 MHz is 300/100 = 3m. Similarly, the frequency of a 10m signal is 300/10 = 30MHz. The wavelength of Radio 4 on 200kHz (0.2MHz) is 300/0.2 or 1500m.

Units

1 Hz = 1 hertz = 1 cycle per second.
1 kHz = 1 kilohertz = 1000 cycles per second.
1 MHz = 1 megahertz = 1,000,000 cycles per second.

Abbreviations

a.m.	amplitude modulation
f.m.	frequency modulation
h.f.	high frequency (3-30MHz)
k.w.	short-wave (German)
l.f.	low frequency
l.w.	long-wave
m.f.	medium frequency (0.3-3MHz)
m.w.	medium wave
s.w.	short wave
u.h.f.	ultra-high frequency (300-3000MHz)
u.k.w.	v.h.f. (German)
v.h.f.	very high frequency (30-300MHz)

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Integrated-circuit memories — 1

A summary of techniques developed in the last ten years

by John Dwyer

Few sections of the electronics industry have seen such rapid increases in sales volume as that seen recently in semiconductor memories. In the first part of a two-part series the author gives a summary of developments in the fastest-growing part of memory technology, the random-access memory, and outlines what has led to that growth.

A MEMORY is any information-storage device. Its history goes back to the marks primitive man made in the sand, but the need for electrical storage of binary information did not arise until the first electrical calculating machines were developed towards the end of the second world war.

So many types of memory have been described, and even developed, since then that it would be impossible to name but a fraction of them. For the purposes of this brief summary of the current memory scene we must assume that readers are familiar with the better-known magnetic devices, such as drums, discs, tape and magnetic cores, and concentrate on the developments that have taken place in the last decade.

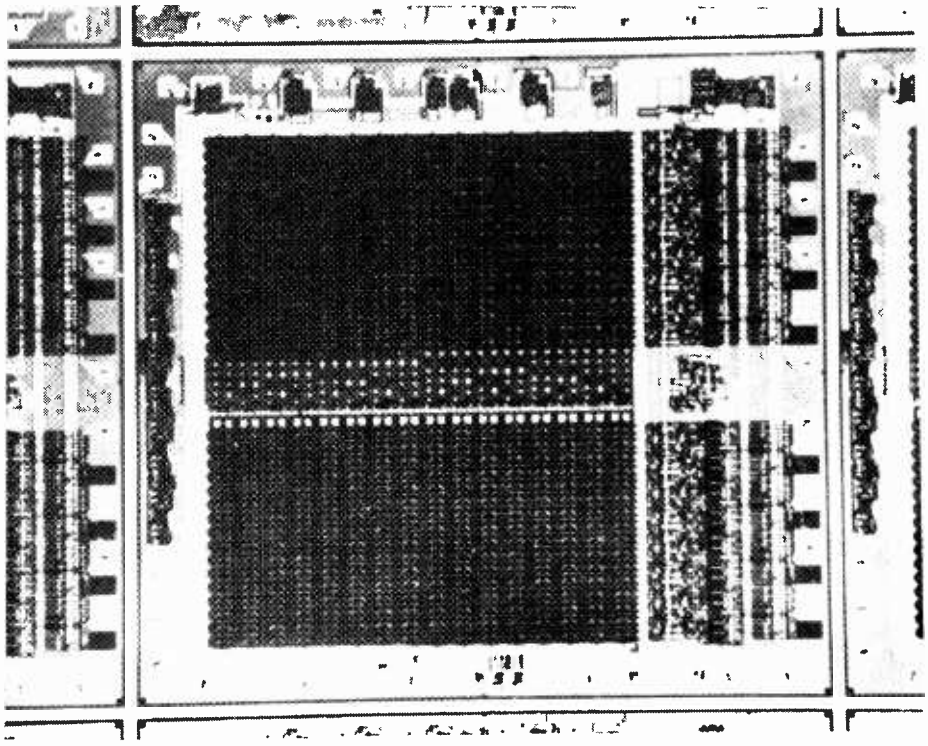
All these are still being used, and in increasing numbers, but their growth has been very slow compared with that of the semiconductor memory, which offers greater speed, greater capacity in a smaller space and is cheaper. Other magnetic devices may not surrender to new technology as quickly as the core has, partly because the drum and disc have different uses. The memories we will look at are mainly those within a computer as opposed to those storage devices which retain data in a library outside it and are brought to a peripheral device, such as a magnetic tape player, for reading into the computer.

Yet even these have a limited life once the storage capacity of non-mechanical systems becomes large enough. One reason is that discs, and the motors that drive them, wear out. A floppy disc lasts about three months. A more important reason is that these storage devices depend on human labour, and there will soon (five to ten years) be no need to depend on a man or woman bringing a tape to a machine when its contents can be called up from a store within the electronic reach of the computer. Technology is now dedicated to the elimination of human effort as too costly, and it may be that the devices about to be described will have greater social impact than anything since the steam engine.

Where peripheral devices are concerned, their slowness compared with the rapidity with which the data is operated upon within the computer, at sub-nanosecond gate speeds very often, has been taken for granted for years. The putting in and taking out of information is performed by humans or mechanical printers. This may change but until recently it affected the size and arrangement of the various parts of a computer, its "architecture." A computer was so expensive, and its input and output devices so slow, that users began to be concerned about how little of the computer's time was spent computing, as opposed to waiting for instructions and data to be read in and read out.

The solution, which came into general use around the mid-sixties, was to make greater use of the fact that a central processing unit, the part which performed the arithmetic functions, could deal with any calculation provided the instructions came with the data. The computers arranged their work in a queue, so that if the computer engaged on one task had to wait for a new piece of information it went on to another task, drawing new data and instructions from its memory, and on to others, then went back to the first. Time sharing made the use of the computer much more efficient and was partly necessary because the storage capacity of a computer was usually much greater than was needed for a single user. The reason for that was, and is, that the hand-made core memories then in general use only became cheap enough, per bit used, if they were large.

A development of the queueing idea was that of multiplexing data into the computer so that the tasks were handled continuously instead of continually. But computer-sharing met much



Motorola's 6810 128 x 8 bit static r.a.m. This n-channel device works from a single power supply and was the first of Motorola's memories to use depletion load techniques, reducing the area of the chip by around 40%. Chip size is 149 x 117 mils and access time is 500ns.

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greater resistance than had been predicted partly because of the fear of users that the information they put into the computer might find its way to someone who shouldn't see it. This may have been an imaginary fear, but it was an added stimulant to research into l.s.i. techniques that would allow computers, and their stores, to become small and cheap enough for everyone to have a computer of their own. It then followed that the uses of computers proliferated, making them even cheaper.

Their tasks are now so complicated that much routine calculation is performed by the terminals to which the central processor is connected, so-called intelligent terminals. The load on processors has become very high, and accounts for the emphasis on speed of processing as one instruction from one terminal rapidly follows another instruction from a different terminal. The video display units now in use, for example, are very hungry for data so much of the processing needed to present them with the information they need is done at the data terminal itself rather than by the processor. It follows, therefore, that the terminals will require some ability to store data.

Computers are not the only things that require memory, of course, especially with microprocessors about to come into more widespread use than pocket calculators now have, but they provide a convenient background for an account of the uses and development of various memory devices.

Before we look at the development of the newer devices there are certain terms which must be defined.

Access time: the time taken for a randomly-chosen computer word to be taken from the memory to the central processor or another memory.

Cycle time: the minimum time during which successive reading, writing, or reading and writing operations may occur. The cycle time is related to the access time depending on whether the memory cell is static or dynamic.

Dynamic memory: one in which the data has to be continually refreshed, usually 500 times a second or more.

Static memory: one which holds its data without the need to be clocked or refreshed.

Read-on memory (r.o.m.): once the memory is programmed no information can be read into it. It contains standing instructions which do not need to be altered, such as what bits to transmit when a letter on a keyboard is pressed.

Random-access memory (r.a.m.): strictly-speaking this should be called a read-write memory, since a r.o.m. may also be random-access. As normally understood, a r.a.m. is a device which data can be written into and read from at random, the access time being independent of its location in the memory. Some storage devices are continually circulating shift registers and data can only be taken out in the same order in which it was written in. This means access cannot be truly random, though they can be arranged to behave in a similar way.

Destructive read-out (d.r.o.); each time a number is read from a memory with destructive read-out it is lost unless replaced, as in the magnetic core. Semiconductor memories mostly have non-destructive read-out.

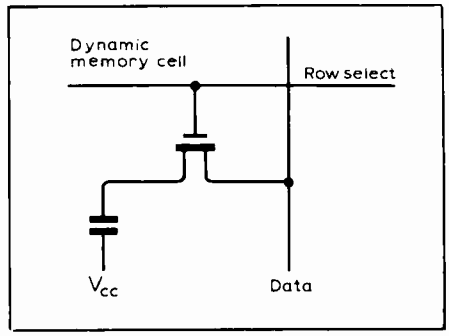
Volatile: a memory which loses its data when the power supply is removed is said to be volatile.

E.c.c.: error correction code. Most of the data going round in a computer contains at least one parity bit, a binary digit which checks automatically whether the accompanying number is correct. But now semiconductor memories sometimes contain, on the same chip as the memory itself, a set of circuits which checks the data that goes into a memory, and the data that comes out. A code, the error correction code, is added to the ingoing data, then the outcoming data and accompanying e.c.c. are checked. If an error has occurred the e.c.c. will identify not just that this has happened but where the error is, and will correct it. The e.c.c. is then removed before the data goes out to its destination.

A memory may have to do a number of tasks. It may have to store large amounts of data which are only required from time to time and thus for which speed of access is not a prime requirement as long as the cost of storing each bit is low. There may not be a great deal of calculation to be done so much as compilation, as in the case of personnel, bank records and so on.

On the other hand, a memory may have to store the results of a complex calculation ready to give the information out so that another part of the calculation can be performed.

Fig. 1. *Dynamic memory cells store the information as the charge on a capacitor. They now use one transistor where three used to be needed. The row select line turns on the transistor, allowing the capacitor either to charge up from the data line or discharge into it, depending on whether the operation is write or read.*



Memories which store these intermediate calculations need to work very fast indeed if they are not to slow down the calculation process.

A third type of memory may be required, when presented with a number at its input, to give out its square root, or square, or reciprocal, or log. This is a code conversion or table look-up operation which would be performed by a r.o.m.

In general the first type of memory is now more generally suited to tape or disc storage, and the second and third are where semiconductor memories have most to offer. At first, indeed, their use was confined to high speed 'scratchpad' and small buffer memories where, say, information had to be clocked in at one speed and clocked out at a different one.

Random-access memories

Bipolar semiconductor r.a.m. memories usually consist of t.t.l. or e.c.l. flip-flops. E.c.l. is inherently fast since the transistors are non-saturating, but t.t.l. can be made almost as fast by the use of Schottky diodes to clamp the collector-base junctions out of saturation. This technique was used by IBM in the 1K r.a.m. they put in their system 370 and System 7 computers introduced in 1973. IBM had produced a computer, the System 70, which used wholly-semiconductor memories as early as 1971. Bipolar access speeds in the mid-70s were less than 50ns, and are now under 10ns.

The first m.o.s. devices were p-channel, depending for their operation on holes as majority carriers instead of much more mobile electrons. The use of n-channel devices has improved access speeds, now under the 50ns mark that bipolars had reached two or three years ago. N-channel also allowed static m.o.s. r.a.m.s to have a single power supply, and all m.o.s. devices to have t.t.l.-compatible inputs and outputs.

Early semiconductor memories consisted of a matrix of storage cells. All the addressing, timing and control logic had to be made up from conventional integrated circuits mounted externally.

To improve their speed and cost, especially in large systems, dynamic memories have to be used. The data has to be re-entered each cycle, and since no reading or writing can take place during the refreshing period this means that cycle time is increased and efficiency, in terms of possible operating speed, reduced. In general, unlike static memories, dynamic memories cannot operate down to zero frequency. Efficiency is defined by

$$E = \frac{c - r.n}{c} \times 100$$

(about 98.3% for dynamics)

where c is the cycle time, r is the refresh duration and n is the number of refresh cycles needed in each cycle for all of the cells to be refreshed. Usually a number of cells are refreshed at once,

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and most of the refreshing circuits are now on-chip. Dynamic cells have a minimum operating frequency which, unlike that for static cells, does not extend to d.c. Dynamic cells also consume power each cycle, and power consumption in dynamic cells is sometimes quoted in mW/cycle, while static consumption may be expressed in mW/bit.

The normal dynamic cell is a m.o.s.f.e.t. whose gate capacitance stores the data as an electrical charge (see Fig. 1). At first bipolar r.a.ms were preferred because of their higher speeds. But m.o.s. is cheaper, needing fewer masks in the diffusion process, its speed is catching up that of the bipolar devices, and it also offers greater packing density and lower power consumption.

The need to refresh an m.o.s. dynamic cell arises because its capacitively-stored charge leaks away. The leakage can be reduced by introducing a layer of silicon nitride between the metal gate and the oxide insulator.

A static memory cell can be formed by cross-coupling two m.o.s.f.e.ts as flip-flops, but this usually means using four or more transistors and the number of cells available on a single chip is thus reduced. Dynamic r.a.m.s have reached densities of 16K (16,384 bits)/chip compared with 4K for a static r.a.m. The dynamic r.a.m. is also cheaper, though this effect is mitigated by the need to provide some external refreshing circuitry, and three power supplies.

M.o.s. used to suffer from the disadvantage that it needed an interface between the t.t.l. levels used by the logic and the 20V or so used by the memory. All these requirements for additional circuitry could only make sense if the required memory capacity was large enough to reduce the consequent additional cost per bit. Such interfacing is now on-chip, but it remains true that the greater packing density of dynamic r.a.ms only outweighs the need for more complex indirect or servicing circuitry if the system is a large one. An earlier analogy was that magnetic disc peripheral memory systems were economic for large systems once the cost of the drive motor could be spread over a great number of bits of information.

In an m.o.s. static memory the load resistor is replaced by another m.o.s. transistor with its gate connected to the drain to form a small-area non-linear resistor. The reason for using this is that it takes up less space on the chip, and enables more gates to be packed in. Yet Mostek have now introduced a 4K static memory, the MK4104, which uses resistors as loads to save space. This apparently backward step reduces space because the resistors are ion-implanted polysilicon devices which can be put almost on the same area as the drive transistors. Mostek say the device has the additional advantage of drawing only 1nA.

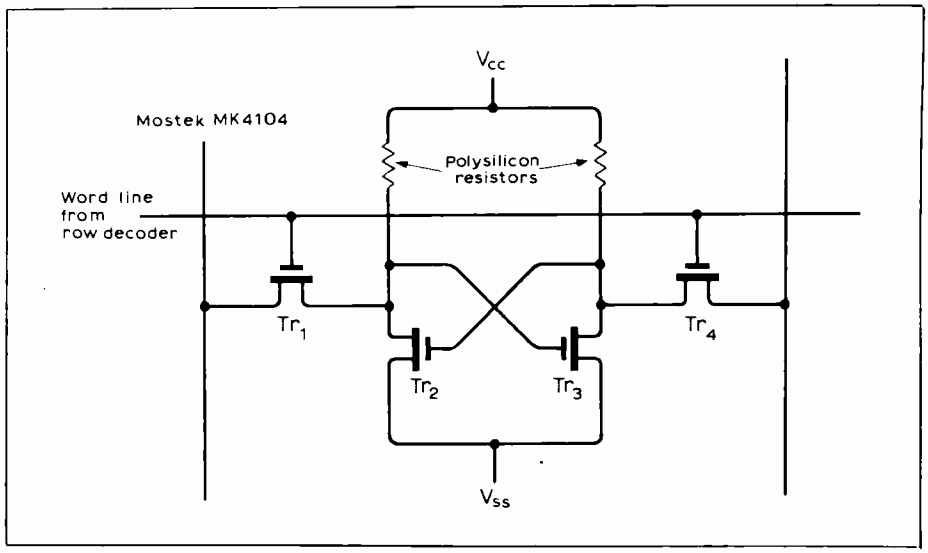

Fig. 2. *This device uses resistors where most devices have another f.e.t. The row line turns on Tr1 and Tr4, allowing the two column lines to sense the state of the flip-flop or during write, to change its state.*

In the c.m.o.s. technique the load resistor is replaced by a complementary transistor. Since, in theory, only one transistor of the complementary pair can conduct at one time the only current that flows is the leakage current through the top, load transistor. In non-complementary circuits power is continually dissipated through the load. Dissipation is thus very low in c.m.o.s. memories but they are slower, offering access times of around 500ns, compared with 150ns claimed for the 4104, and consume much more chip-space.

In practice the transistors do, for an instant, conduct together when the cell is changing state causing a power pulse. The reason for the slower operation is the parasitic capacitances that exist between the gate and the substrate and in reverse-biased p-n junctions, all of which have to be charged and discharged. These effects have been countered by the use of a sapphire substrate with the transistor built above it. The sapphire insulator allows the speed of the c.m.o.s. device to increase around four times, but the use of sapphire is never likely to be cheap enough to be practical.

A continuing disadvantage of semiconductor r.a.ms of whatever type remains, however, that they are volatile. The usual way round this is to provide a low-power or stand-by mode of operation, and this may entail the need for extra power supply connections to the chip which are disconnected when the device is on stand-by. The remaining power supply serves to keep the memory alive as programmed.

Another technique, used in Motorola's 6802, is to use an on-chip reservoir capacitor to sense a loss of power. When power does go down 32 bytes of information is transferred from wherever it was when the power went down to a part of the memory which is kept alive on batteries. Power consumption is reduced by turning off peripheral devices on the non-storage part of the chip. The 32 bytes that must be preserved are chosen in advance.

Another technique we reported in February 1977 (p.75) was that used by Toshiba, where charges are stored for up to a year in normally unused m.n.o.s. f.e.ts to which the date is transferred once a power failure has been sensed. This, though described as a non-volatile r.a.m, is a hybrid r.o.m/r.a.m. The number of transfers is limited to about 1,000 since there is a degradation of the ancillary f.e.t. switches each time they are used.

By 1974 it had become clear that i.c. memories had largely replaced core memories in new computer main memories. Western Electric had announced the development of a 4K n-channel r.a.m. to go into telephone switching the following year. The device had an access time of 250 ns, and a cycle time of 700ns. Bell were to phase out their core memories in favour of m.o.s. devices on grounds of cost.

That year a number of manufacturers offered 4K r.a.m. samples, including Siemens of Europe, whose S142 was t.t.l. compatible, with access and read-refresh cycles of 350 and 600ns. Altogether, about 50 semiconductor r.a.ms were being used in 1974 for every one in use only two years earlier, and 70% of new memories were being designed with semiconductors.

The responsibility for displacing the core has been attributed to the Intel 1103, a 1,024 bit dynamic r.a.m. which, though introduced in 1971, was still selling at a million a month world-wide last year, though in an improved form. In terms of cost per bit, core, with an access time of 1μs, became more expensive than the 0.5μs dynamic p-channel memory at the beginning of 1972, when they were both 0.7 cents/bit. Dynamic n-channel, also at 0.5μs, became cheaper at the beginning of 1974 (0.4 cents/bit) and static n-channel (1μs) at the beginning of last year. Yet

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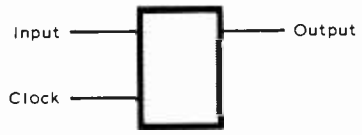

Fig. 3. *The memory cell. The information is not stored at the output until a clock pulse arrives to put it there.*

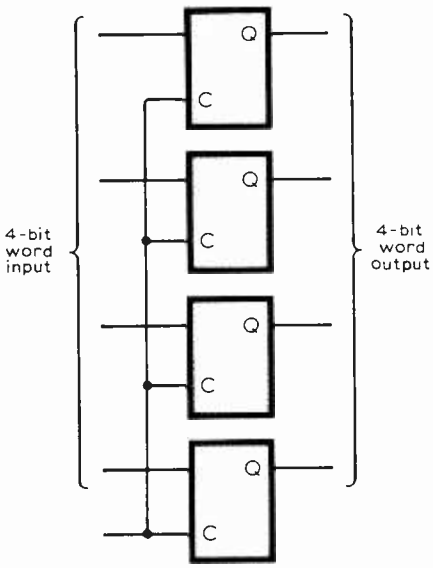

Fig. 4. *If four cells are used they can be arranged to store one word of four bits, as here, or four words of one bit, as in Fig. 5 and Fig 6. In the first case the four parallel bits are presented to the input and, when the clock signal arrives, the four-bit word is stored at Q.*

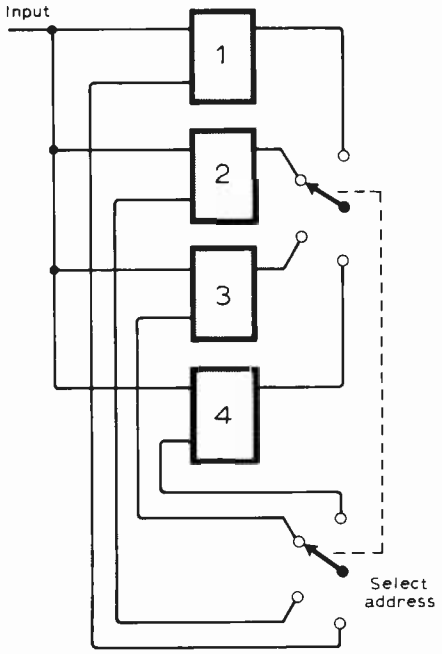

Fig. 5. *When four one-bit words are to be stored the clock and output lines are sent to whichever cell is to be written into or read from The incoming data is sent to all four cells, only entering the chosen one.*

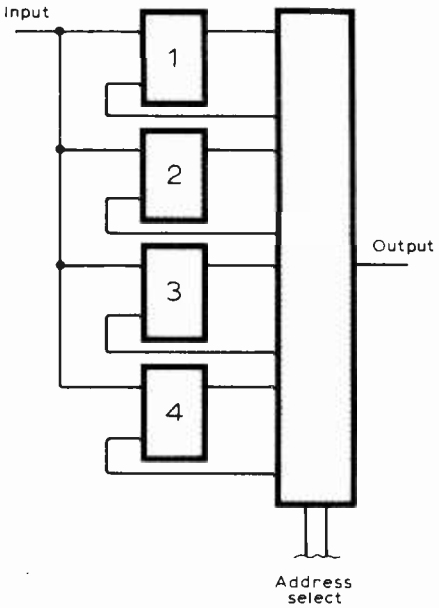

Fig. 6. *The four-position, two-pole selector is replaced by a gate circuit which has the address information sent to it on two address lines.*

core still appears to be selling fairly well, largely as a result of its non-volatility, and the above figures may reflect merely the huge growth in the demand for memory devices of all kinds. Nevertheless the core is slow and requires a great deal of interface and other peripneral circuitry.

By the middle of the decade the number of different types of semiconductor device had increased from two — the 64 and 256 bit bipolar array and the 1K p channel m.o.s. — to over a dozen, each suited to various tasks from the low speed, low power peripheral and terminal r.a.ms, with main memory applications inbetween.

Now the choice is even greater. In just two or three years we have seen improvements in e.c.l. and t.t.l. which have brought bipolar access times down to 7ns for e.c.l. and less than 50ns for t.t.l. Last year Intel claimed they had produced a m.o.s. r.a.m. which has an access time of around 25ns, which puts m.o.s. in the same class as bipolar for all but the very fastest applications. Users can choose from 4K and 16K dynamics, 4K fully and partially (clocked) static types, 1K and 4K fast statics, 4K and 16K integrated injection logic (I^2L) dynamic and static memories, as well as the newer c.c.d. and bubble memories, though these strictly speaking are serial memories, or recirculating shift registers. Texas are reported to be working on a 65K r.a.m. The variety of read-only memories is equally large.

The large number is mainly due to improvements in semiconductor fabrication techniques, particularly in m.o.s. technology; it has been said, indeed, that bipolar devices are less good than they could be if a little more research attention were paid to them. Recent m.o.s, polysilicon multi-layer processes, h.m.o.s. (a not-so-simple scaling down of existing circuits to one half or one third their previous size), electron beam etching, ion implantation, and depletion load techniques.

At the moment the rate of progress is about the same as it has been for the last ten years. Packing densities and speeds have about doubled their improvements every year or, more accurately, there have been fourfold improvements every two years. Memory capacities go up in powers of two and the capacity is normally a perfect square. Thus a 1K memory holds 1,024 bits which is 32^2.

The next logical step, therefore, is to go up to 4K (64^2) since it would take two years to design the device, and by that time users would be ready for a new device. Thus while there were a number of 2K memories about a year after the first 1K chips appeared, the biggest growth was the following year, when 4K chips were launched with bewildering frequency.

Equally bewildering was the number of packages available. Intel introduced the 2107 4K dynamic r.a.m. in 1973, followed closely by Texas Instruments. These were both 22 pin packages while the industry standard socket, and therefore the cheapest socket and the one easiest to fit, was 16 pin. In addition, the Intel and TI pin configurations differed from each other. Eventually Intel adopted the TI pin configuration but AMI and Motorola together produced a third 22 pin version which conformed to neither of the previous configurations.

Then Mostek produced a 16 pin 4K r.a.m. They did this by multiplexing the 12 address pins that had appeared on the 22 pin packages down to six. The six address pins are presented alternately with six-bit row and column addresses. Apart from offering cheaper packages and sockets for users, the device offers much greater packaging densities per memory board, though it means the designer now has to provide multiplexing circuits. TI then advocated an 18 pin package, and steadfastly refused to go to 16 pin address multiplex. The confusion was about complete.

Now that 16K dynamic r.a.ms have arrived, however, all the manufacturers agreed on the same pin configuration. Moreover, it is one which enables 16 pin 4K users to make one address line change and simply plug the new 16K memory straight in.

Memories can be organised in various ways. Let us consider a static memory cell as simply a flip-flop which, when presented with both a number (0 or 1) and a clock pulse, holds the number by switching into one of its two possible states. Looked at in another way, the arrival of the clock pulse transfers the input number to the output where it is stored until the next clock pulse arrives. (Fig. 1). The data is now written into the memory and will stay there as long as the power supply remains connected.

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By itself this flip-flop constitutes a one word, one bit (1 × 1) memory.

If the state-indicating output of the flip-flop and another line are connected as two inputs to an AND gate then the new line could act as a read line, only showing the output of the flip-flop when the read line goes to 1. This would provide a latched output. However, there is no need for two lines. If the read and write lines were both active at once the output during a read cycle might be changed in mid-cycle by the write line. One line is used, which is either read or write. The latched output to the cell is provided by a chip-select (CS) pin which shows the output of the cell if that cell on that chip has been selected and read has also been selected.

However, in some cases the cell can operate in read-while-write mode, where a binary digit stored in the cell can go out to the output within the specified access time, and then another bit can be read into the cell within the same cycle period.

If we had a chip with four memory cells, a typical size when the first semiconductor memories appeared in 1965, we could arrange it in a number of ways. We could connect it as 4×1, 1×4 or 2×2. The diagrams show the first two arrangements. In the first case there is a four bit parallel input, a common clock, or write line, and four separate outputs. If, however, we want to place the bits in the memory so that they were available serially, one at a time, we would need to arrange the memory cells as four words of one bit each. We would need to take each of the clock lines separately out to a selector, and each of the output lines would need to be selectable too. The arrangement is shown in the next fiagram.

This also means that each bit would need to be accompanied by the address for which it was destined. The address could be selected either by a multipole switch or, in reality, by logic routing. There are four possible addresses in this case, and the first four numbers could go to them in any order, provided each number was accompanied by a two-bit address which said where the digit was to go.

The more possible destinations the digit has, and the bigger the memory, the more the address lines that are going to be needed. The 1×4 memory needed none, the 4×1 memory needs two since those two address lines can define four states or addresses, and the 2×2 memory would need one, since this can define two states, or addresses which the two-bit number could go to.

In the case of a 16 bit memory arranged 4×4 the number of address lines needed is two (defining four possible addresses for the four bit number). A 16×1 r.a.m. would need four address lines since 2^4 is 16, while 1×16 needs none. In general terms, a z bit memory arranged as X×Y (where z=X.Y) will require $\log_z X$ address lines, where X is the number of words, and Y the number of bits per word. Y is also the number of input and output lines that are needed.

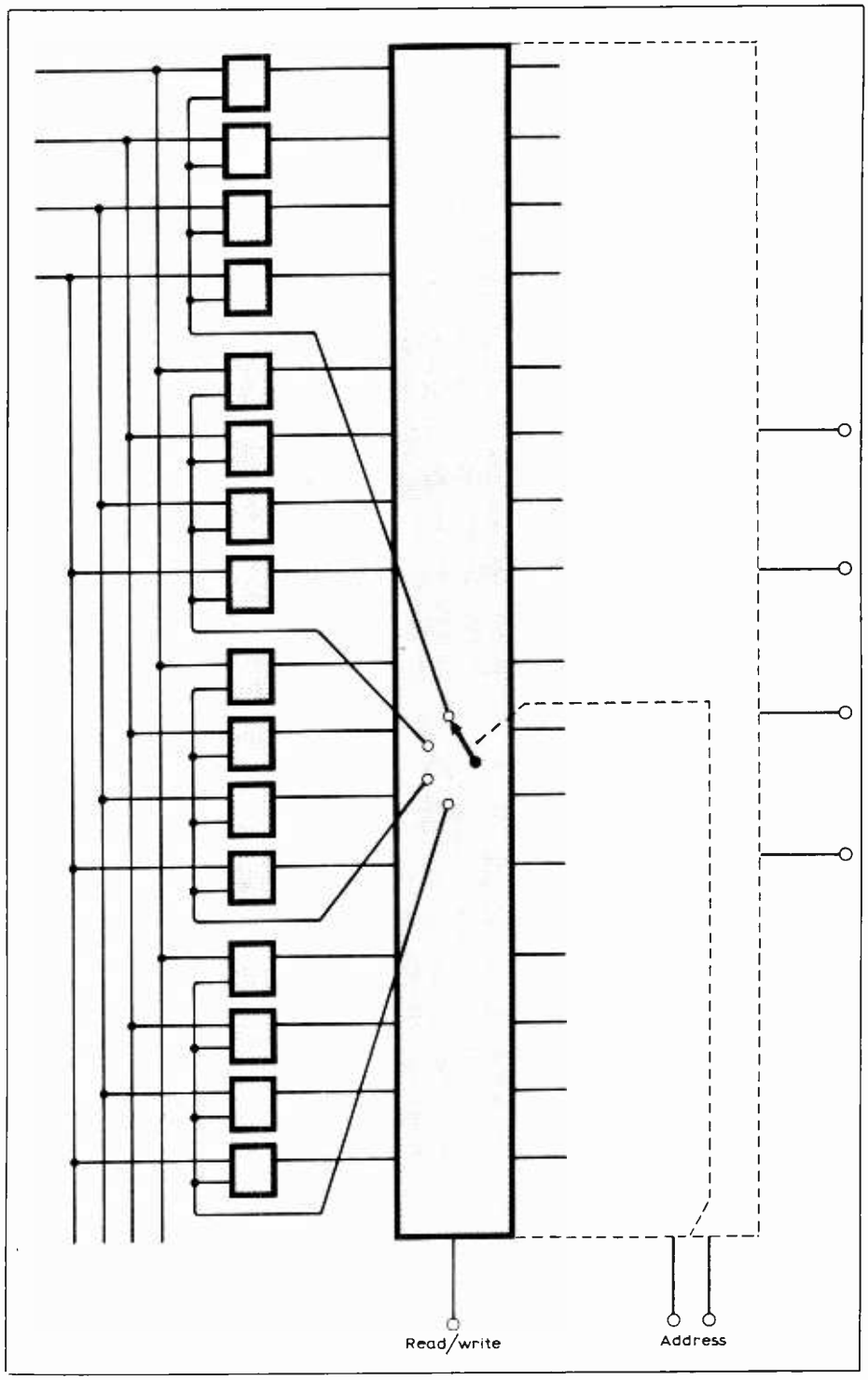

Fig. 7. *A 16-bit (4 × 4) memory. The four parallel bits coming in are each presented simultaneously to a group of four cells. The top bit, for example, goes to cells 1, 5, 9 and 13, and so on. But only one group of four cells will be clocked at one time, according to a write instruction being present and the correct address. The address connects the write signal to the correct group of cells, as selected in the shaded area. The outer dotted line corresponds to the block in the previous diagram which, when an address is selected for "read" delivers the appropriate word at the parallel output.*

In a practical case the 16 bit memory might be on one chip, or it might be spread among four chips. Chips are arranged in different ways, and for small amounts of memory the number of data in and data out lines can easily be provided on a conveniently-sized chip.

But as the amount that each chip can store goes up to 16K or more it is unreasonable to expect adequate addressing and data lines to be available for every configuration that might be required. Therefore the bigger the chip the more likely it is that it will have one data in and one data out line. If parallel outputs are required more than one chip has to be used.

In another case, not enough storage is available on a single chip, and data has to be addressed to one chip of a number. This is where the chip-select (CS) pin comes in. If the 16 bit memory men-

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tioned above had to be spread among four four-bit chips then only one chip would be selected at a time and the four chip selects would be decoded down to two lines just as the addresses on the 4×1 memory had been.

Thus if there are N chips, each with P address lines, D data input lines and Q data output lines, then the data-in lines are all connected to each other, the data-out lines are also commoned, and the address lines are also connected, giving P address lines for the group of chips. From each chip the CS line is taken to a decoder which selects one of N, and the number of lines which will come from this will be $\log_2 N$. Thus the total number of address lines needed for the collection of chips will be $P + \text{Log}_2 N$, which would write into, or read from, one chip at a time.

As the size of semiconductor memories has increased so has the number of pins. A 4K × 1 memory needs 12 address bits. With data in, data out, three power supplies for a dynamic memory, chip enable or select, and other pins this meant that the first 4K memories were designed with 22 pins.

The newer 16-pin dynamic memories still have data in and out and three power supplies (four pins) but the 12-bit addresses are multiplexed on to six pins. A row address select (RAS) pin is activated, the six row address bits are presented to the six address pins, then the column address select (CAS) is operated and the column address presented, at the same time as read or write are selected, and the cycle then continues.

This arrangement means the designer has to decode the address into rows and columns where this used to be done on the chip, and multiplex the two addresses onto the correct pins. But the use of standard 16-pin sockets has a great many advantages in cost and tooling. In addition, multiplexed memories can be doubled in speed for some applications by holding the row address low and feeding in successive column addresses without the need to supply the row address more than once. This is called page operation, and the application of successive column addresses is known as "strobing" the columns.

As already mentioned, some chips have latched outputs. The 4K chips on the market have latched outputs, the latch being provided by a combination of the chip select and column address lines. Most of the 16K memories, however, have unlatched outputs, partly because of the need to use the CS pin as another address. An exception is the Intel 2116.

Normally refreshing is done by putting a clock signal on the address lines, one row or column being refreshed at a time. A timer on the memory card sends a request to the clock circuit to carry out a refresh, and the memory cycle is halted until the refresh has taken place. A signal is then sent that the refresh has finished and the timer may start a new cycle.

There are normally a number of boards in a memory, and each of their timers, left to itself, might send a refresh request at a different time from all the others. Therefore one board is usually determined as the master, and its refresh clock determines the refresh times on all the other boards. It may be that a link is removed on all the boards except one.

In addition, many computers work in two phases, with one lot of boards going through a read or write cycle while the other lot of boards are being refreshed. Any card that is not in use during a cycle may have a refresh signal applied to it.

The high output impedance of m.o.s. circuits allows them to be connected together on the same output bus without the need for a buffer. T.t.l, on the other hand, will not, because, unlike m.o.s., it will drive a load. Whatever the device, if it is to be operated into a common bus it must have a three state output: high, low and floating. While an m.o.s. output would not be damaged by putting a 1 onto a bus that had a 0 on it from another device the bus needs to see the output of the one device along it that has been selected, with all the other outputs floating for the moment to that level. □

Continued from page 39

lutely forbidden for amateur stations to be used for transmitting international communications on behalf of third parties." The regulations even forbid the content of any messages to be conveyed to a third party, so that the television crew who recently filmed amateurs at work were technically in breach of the regulations.

Some countries have agreed between themselves to waive certain parts of the regulations, so that Brazil and the US, we understand, have mutually agreed that amateurs in those two countries can transmit third party messages. But no such agreement exists between Britain and the US, and so the Americans were, as the Home Office said, breaching the regulations.

If an amateur is talking to someone within his own country then he is subject to the laws of the national PTT, in our case the Home Office. In many countries there is no restriction on talking to third parties non-internationally, and that used to be the case here until 1954 when, because of abuses, "the syllabus for radio amateur licences was strengthened," according to a Home Office spokesman.

We did, however, discover one lophole in the Wireless Telegraphy acts which govern such matters. It appears that Crown property is exempt from the provisions of the Wireless Telegraphy Acts on the grounds that licences are granted by the Crown and the Crown could not logically license itself.

Whatever else may be said about the Home Office, the anniversary incident shows that at least they are consistent. It is, indeed, the bedrock of the British Constitution that the monarch is as subject to the law as anyone else.

That, at any rate, is the theory. At least two photographs exist of the Duke of Edinburgh, the Patron of the RSGB, at the microphone of an amateur radio station. He is not licensed. Oddly, the palace could not, when we asked them, recall any of these incidents.

● The Cornish amateurs have accepted the Home Office's attitude with good grace, though they confess to being disappointed. Their transmission wasn't too successful either. Supposed to be broadcast for 45 minutes on the hour every two hours from one until five on the great day, reception appears to have been poor. They planned to re-run Roosevelt's message, then a message from Marconi's daughter, then finally a message from Carter, in Morse. On the first transmission at one o'clock the first three-quarters of the Roosevelt message were heard through a lot of static but then the signal disappeared. Yet reports from other amateurs indicated that the Carter message had been picked up elsewhere. The Cornish amateurs would like to hear from anyone who copied any of the messages. As someone involved in the celebration remarked, "It's funny, they could do it in 1903 but not in 1978." □

Red faces all round

THE "DISAPPEARING BUILDING" in the computer simulation of Brussels airport, used during assessments of microwave landing systems, has caught up with the FAA, the US aviation authority. Interested parties in the UK, among them Plessey and the Civil Aviation Authority, who were a little downcast to hear that Lincoln Laboratories' simulation proved that the British Doppler system would suffer degradation in a Brussels-like scenario, were amazed to discover that the postulated seat of the trouble — a large hangar — simply did not exist. This was all the more puzzling in that exact dimensions of the "building" were used in the computer simulation.

It seemed clear to Plessey and the CAA that the FAA or the companies involved had tried to mislead and to gain some kind of advantage for the US scanning-beam system, and the House of Representatives Subcommittee has announced hearings, starting on January 31, to investigate the charges. Whether any conclusion will be reached in sufficient time to affect the final decision, in April, by ICAO on the system to be adopted is open to question, but a spokesman for the CAA told *Wireless World* that the results of tests so far conducted with British and US equipment at several "difficult" airports have not changed their opinion that Doppler is a much superior system.

One wonders why the Americans felt the need to cloud the issue at Brussels, if, in fact, they did so deliberately. □

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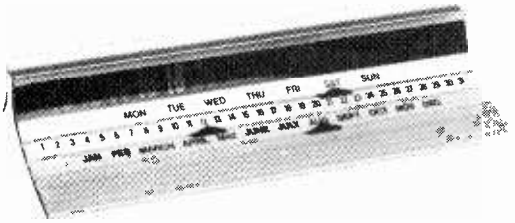

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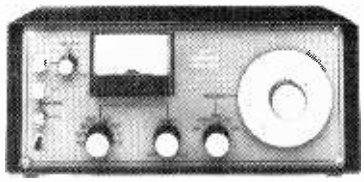

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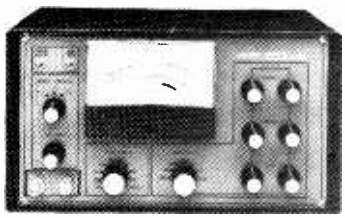

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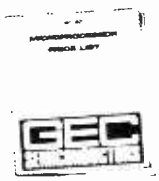

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Pickup-arm design techniques

History of the development of pickup arms, with a description of design methods used in a modern arm

by Tejinder Singh Randhawa VU2TSR

THE AUTHOR of this article has recently designed and constructed his own pickup arm based on the experience he gained on an earlier inferior design. The following text does not attempt to describe the constructional details of the new pickup arm, but instead concentrates on the methods employed in its design. In addition to attempting to remove some existing fallacies on the subject of pickup arms, the author has traced the history of their development from the end of the nineteenth century to the present day.

"Mary had a little lamb," history's first recorded phrase, squeaked out from the hill-and-dale recording of the tinfoil-layered cylinder of Edison's phonograph in 1877. The gramophone, which substituted wax for tinfoil, was patented by Chicester Bell and Charles Tainter in 1886. In the following year, the precursor of the modern record player — a gramophone using laterally-recorded discs — was developed by Emile Berliner, and in 1890 the English artist Francis Berraud painted the form of Nipper, quizzically peering into the reproducing horn of a gramophone, listening to "His Master's Voice".

It was to the credit of these older record reproducing machines that the sound box arm, a rough equivalent term to the present day 'pickup arm', was of substantial design and construction. With the introduction of electrical transducers came the early pickup arms of the simple stub type and, over the years, precision pickup arms have developed into the pleasingly intricate and technically perfected designs common today.

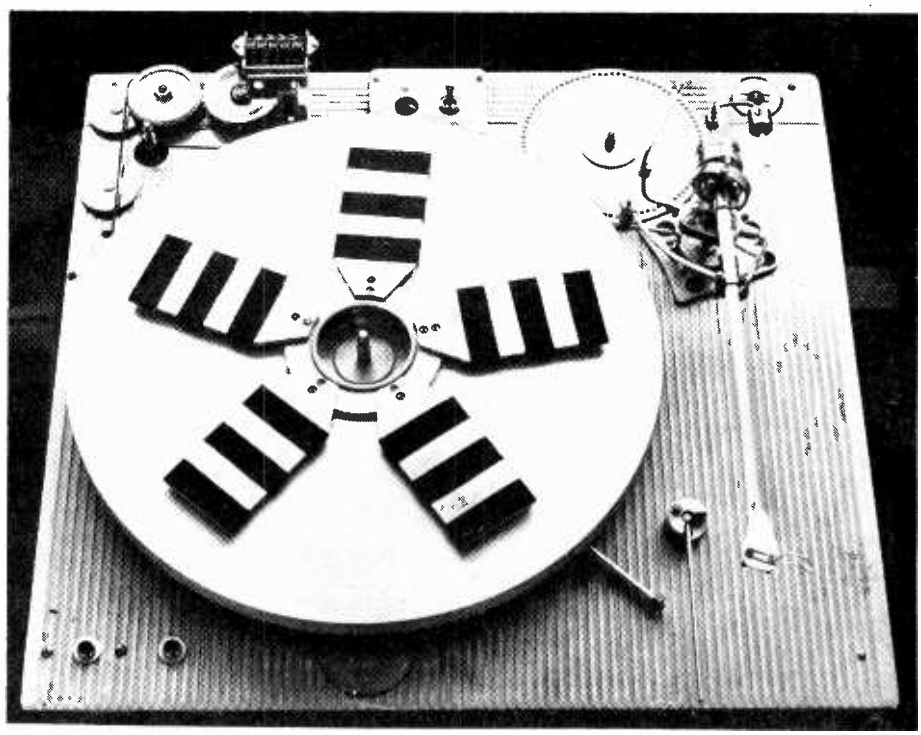
Tracking error

One of the first problems faced by pickup arm designers was tracking error, which is illustrated in Figs 1a and 1b. It was not the resulting distortion which brought the problem to their attention, but the excessive record wear. According to extracts from 1937 issues of the American magazine *Electronics*, it is probable that European and Australian audio firms were the first to benefit from the use of a bent arm to decrease tracking error, as follows: "A survey of the literature indicates that the situation has been thoroughly appreciated abroad. Notable examples of tone arms which correct for tracking angle can be found in the products of manufacturers in England, Continental Europe and Australia. All of these devices are of the bent arm type[1]." In October 1937, C. J. Lebel wrote[2], "the only fundamental improvement in pickup arms to appear in a long while is the use of the bent arm. This has been standard practice in England for some time. A consideration of the theory, as given by P. Wilson and G. W. Webb[3], shows that the reduction of needle tracking error is very great. . . . American manufacturers will undoubtedly change over as their dies wear out." When Lebel wrote this, the Wilson alignment protactor[4] was already being marketed in England by *The Gramophone*. A month later, B. Olney[5] recorded, "For several years past a feature of phonographs produced abroad has been some special arrangement of the pickup arm for minimizing the so-called tracking error, but it is only lately that such devices have made their appearance in this country. In 1930 the author became interested in this subject through an article published in a British journal *Wireless World*[6]..."

At about this time, in America, attention was drawn to the distortion produced by tracking error. In 1941, H. G. Baerwald carried out a rigorous mathematical analysis of tracking error and the resulting distortion[7], and derived the fundamental equation (Equation 1) relating tracking error distortion to recording variables. In a simpler analysis in 1945, B. Bauer[8] derived the two compact equations (Equations 2 and 3) to determine the optimum offset angle and overhang for a pickup arm. Bauer's equations held their ground until 1966 when J. K. Stevenson[9] derived new formulae, which gave results slightly nearer the optimum than Bauer's formulae because the approximation (Sin(X) = X Radians for small values of X) was not used.

Two years ago the author developed a 'direct' method which, by using a computer iteration method, gave marginally better results than the geometrical analyses employed in 1941, 1945 and 1966. The table shows the results obtained by the author's method. On the whole Stevenson's and the author's analyses give results which are slightly better

The author's record deck showing the turntable and pickup arm.



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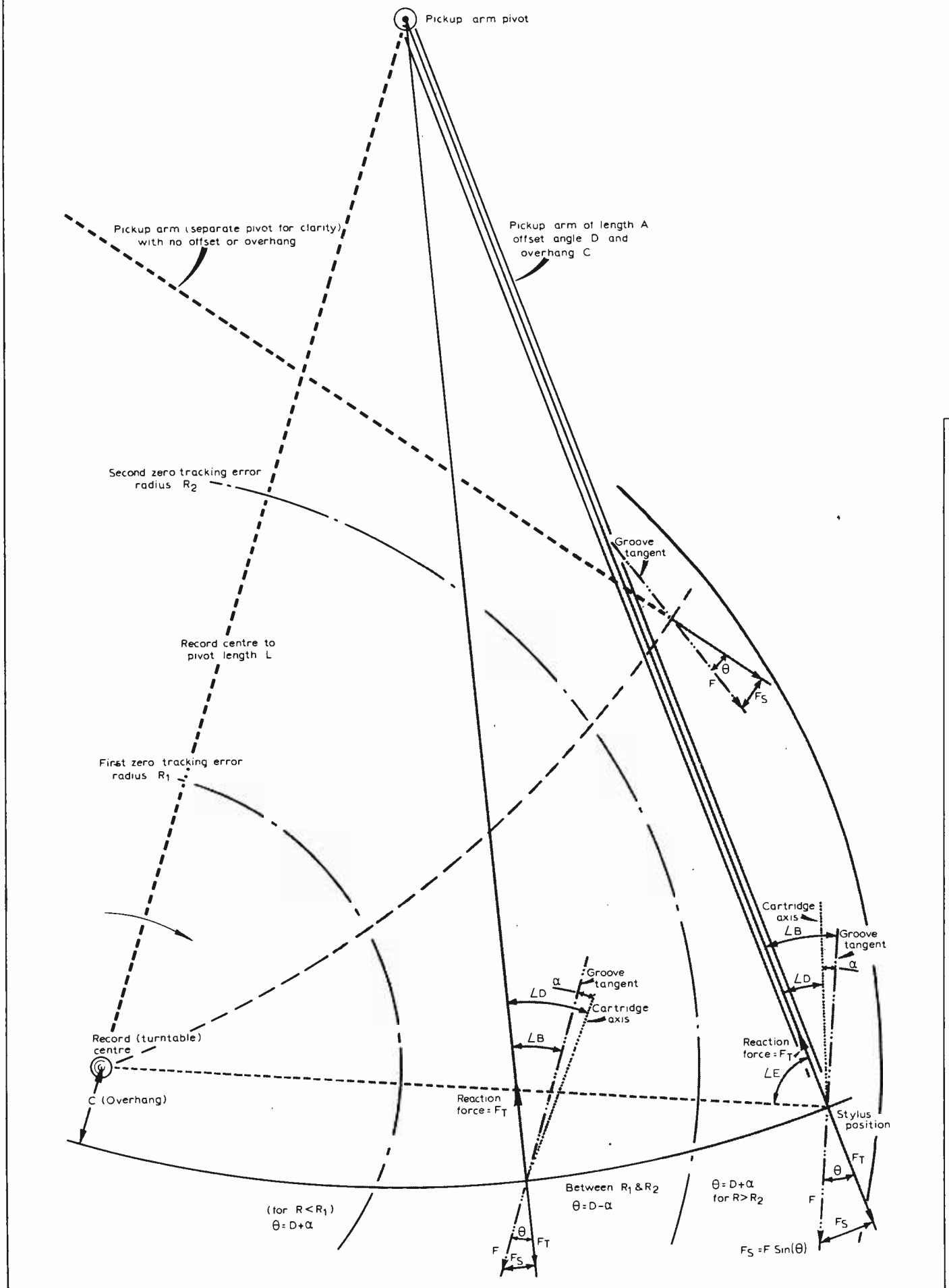

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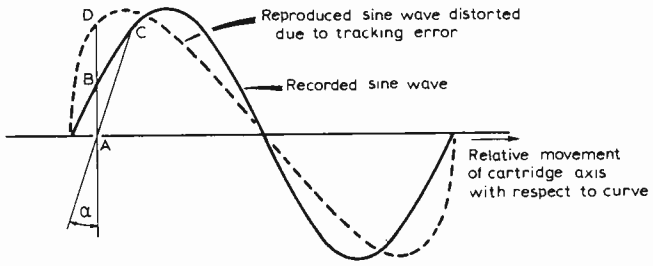

Fig. 1. *(a) illustrates tracking error distortion. Due to the error, angle α, the stylus moves from A to C, instead of B. Consequently, the reproduced signal amplitude is proportional to AD and not AB. The rest of the playback curve is produced in the same way. (b) Shows to scale, pickup arm positions relative to a record. The force triangles for skating force are shown for an optimum design and also for a straight arm having no overhang or offset angle. In the latter case the tracking error is equal to θ, which produces a considerable skating force. By applying the cosine law to the triangle at angle E, and remembering that Cos(E) is equal to Sin(B), the tracking error equation, Equation 4, can be derived.*

Equation 1: $D_2 = 100V_o\tan(\alpha)/S$

For recorded velocity equal to 10cm/s r.m.s., groove speed for 33⅓ rev/min, and correcting for a recording gain of 4dB/octave (by multiplying by $10^{-4/20}$ for playback) the above equation reduces to:

$$D_2 = 100.85\tan(\alpha)/R$$

$$= 100.85\alpha/R \text{ approx.}$$

Note that the term that requires minimizing is α/R, not just α. This means that more tracking error can be tolerated at a larger radii than at a smaller radii.

Equation 2: Offset angle (degrees)

$$D = R_a(1 + R_a/R_b)57.3/AB$$

where $B = 0.25(1 + R_a/R_b)^2 + R_a/R_b$

Equation 3: Overhang

$$C = (R_a)^2/AB$$

Equation 4: Tracking error (see Fig. 1b)

$$\alpha = \sin^{-1}(R/2A + (2AC - C^2)/2AR) - D$$

To get the zero tracking error points for a combination of C and D, insert the values in Equation 4, equate to zero and solve for R.

KEY

V_o is the peak recorded velocity, D_2 is the percentage second-harmonic distortion, α is the tracking error, S is the groove speed, R is the groove radius, R_a is the minimum recorded radius, R_b is the maximum recorded radius and A is the pickup arm length from pivot to stylus.

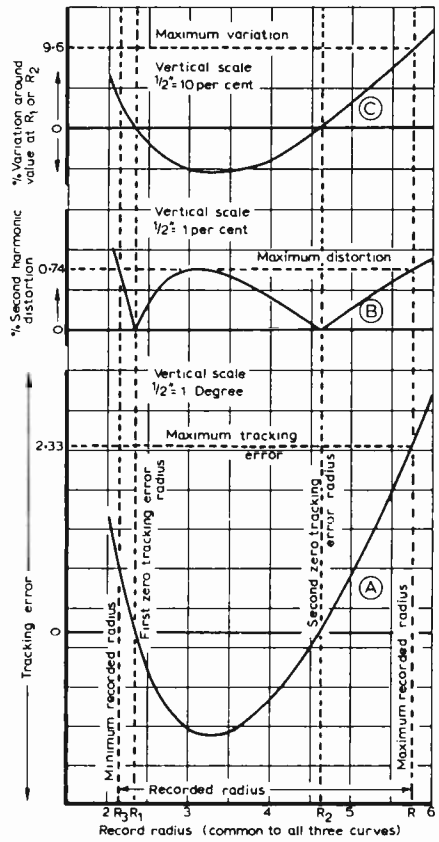

Fig. 2. *Design curves for a 9in pickup having optimum offset angle and overhang values. (a) Tracking error. (b) Tracking error distortion. (c) Variation of skating force with reference to the value at the zero tracking error points. Main radii are: the first and second zero tracking error radii, R_1 and R_2 at 2.32in and 4.62in respectively; the minimum recorded radius, R_3, at 2.125in; and the maximum recorded radius, R_4, at 5.75in.*

Table

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

Notes. (1) Do not compare values above with other computations without checking the values of minimum and maximum recorded radii used by them. (2) The minimum recorded radius on a 33⅓ rev/min LP record is 2.625in and on a 45 rev/min record it is 2.125in. The maximum recorded radius on a 33⅓ rev/min LP record is 5.75in. Design figures given in table are for R between 2.125in and 5.75in, and the differential speed between 2.125in and 2.625in has been accounted for. (3) Column 4 is for a recorded velocity of 10cm/s r.m.s. The last column is for an arm having the optimum offset angle and optimum overhang.

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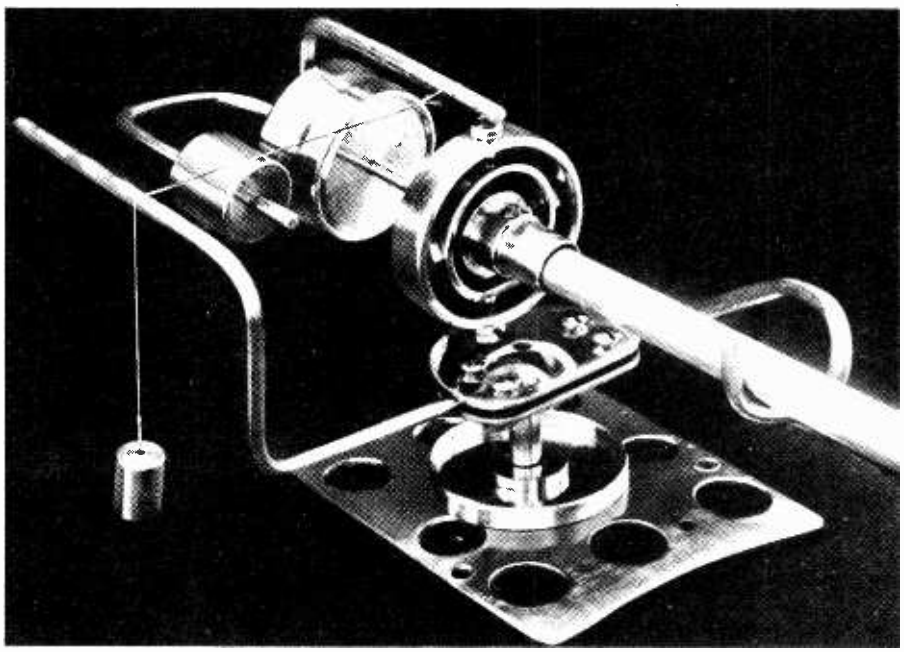


Front-side view of mounting post and weighting arrangements for author's pickup arm.

The next part of this article will include analyses of tracing error distortion, pick-up resonance, damping and skating force.

than Bauer's results, but when setting up an arm, mounting errors can often give rise to more distortion and nullify the effect of these accurate calculations. Bauer's equations can therefore safely be used for as near optimum results as possible.

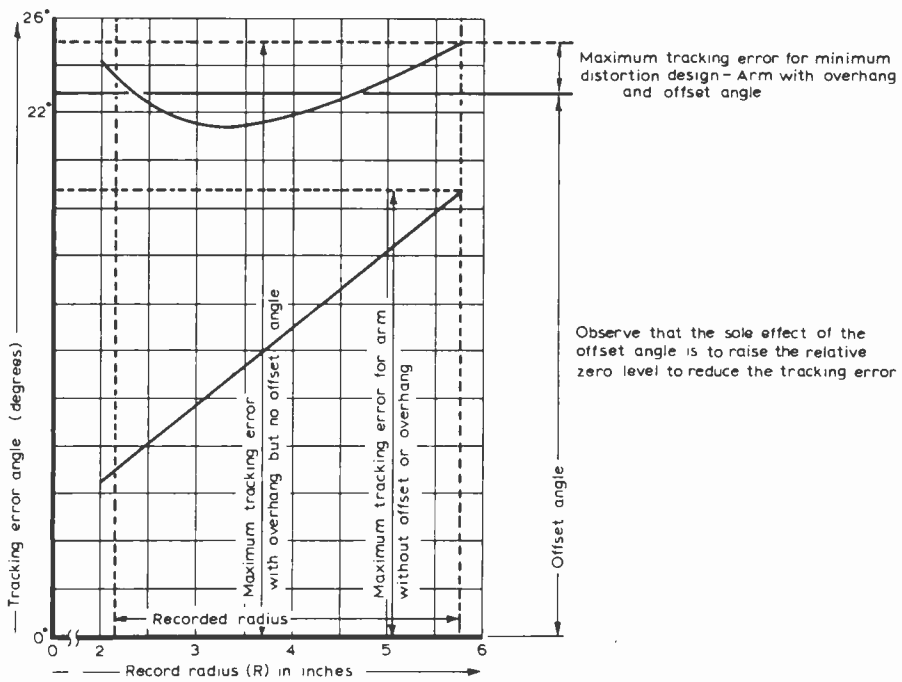
As can be seen from the table, a well designed and mounted 9in (effective length) pickup arm will give less than 1% harmonic distortion. These calculations are based on a worst case analysis – that is, for a completely monophonic lateral recording. In stereo (45-45) recordings, the corresponding distortion figures will be approximately divided by two. The introduction of 45-45 stereo brought the problem of vertical tracking error, and the resulting distortion, but helped in reducing distortion due to lateral tracking error. This indirect benefit comes because, in a 45-45 stereo recording, the total signal is the sum of a lateral and a vertical component (because the groove wall is at an angle of 45 degrees to the vertical) and the vertical component is not affected by lateral tracking error. As the vertical tracking angle is controllable there will be a net reduction in tracking error distortion. Vertical tracking error – the difference in angle between the vertical tracking angle of the cutting stylus and the playback stylus* — has now been eliminated because the vertical recording and reproducing angle has now been standardized at 15 degrees. Until recently this was a big source of distortion. The 15-degrees vertical tracking angle was recommended in 1961 by the Engineering Committee of the RIAA, but as late as 1965 vertical tracking angles of commercial pickups were measured[11] to be anything from 6 to 38 degrees.

*This is a very simple, idealized definition and in practice problems are created by the springback action of the record material which has to be accounted for. See reference 10 for details.

Design curves for a 9in pickup arm having an optimum offset angle and an optimum overhang are shown in Fig. 2. Each curve is plotted with respect to the radius of the recorded groove. Curve A is a plot of the tracking error and Curve B shows the percentage of second-harmonic tracking error distortion. Curve C indicates the percentage variation of the skating force with respect to the value at the zero tracking error points.

Figure 3 illustrates how the overhang and the offset angle combine to reduce tracking error.

Fig. 3. *Graphical illustration of how overhang and offset angle combine to reduce tracking error.*



References

1 Glover, R.P., A Record Saving Pickup, *Electronics*, Vol. 10, p31, Feb. 1937.
2 Lebel, C. J., Quality in Disc Reproduction, *Electronics*, Vol. 10, p25, Oct. 1937.
3 Wilson P. and Webb, G. W., Modern Gramophones and Electrical Reproducers, Cassel & Co., London, 1929.
4 Wilson, P., Needle Track Alignment, *The Gramophone*, p129, Sept. 1924.
5 Olney, B., Phonograph Pickup Tracking Error vs Distortion and Record wear, *Electronics*, Vol. 10, p19, Nov. 1937.
6 Chamberlain, E. A., Correct Pickup Alignment, *Wireless World*, Vol. 26, p339, Mar. 1930.
7 Baerwald, H. G., Analytic Treatment of Tracking Error and Notes on Optimal Pickup Design, J. Soc. Motion Picture Engrs., Vol. 37, p591, Dec. 1941.
8 Bauer, B. B., Tracking Angle in Phono Pickups, *Electronics*, Vol. 18, p110, Mar. 1945.
9 Stevenson, J. K., Pickup Arm Design, *Wireless World*, Vol. 72, p214-8 & 314-20, May & June 1966.
10 Bauer, B. B., The Vertical Tracking Angle Problem in Stereophonic Record Reproduction, IEEE Trans. on Audio, Vol. AU-11, p47, Mar.-Apr. 1963.
11 Redlich H. & Klemp, H. J., A New Method of Disc Reproduction for Reproduction with Reduced Distortion, J. Audio Engg. Soc., Vol. 13, p111, Apr. 1965.

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Microcomputer design — 5

Introduction to microcomputer programming

by Phil Pittman B.Sc in association with NASCO Ltd

A microcomputer is capable of storing information, controlling other devices, performing calculations, making decisions based on the results and completing a given task very rapidly. The processor cannot, however, perform these tasks without direction. Each step which the computer is to perform must first be worked out by the programmer.

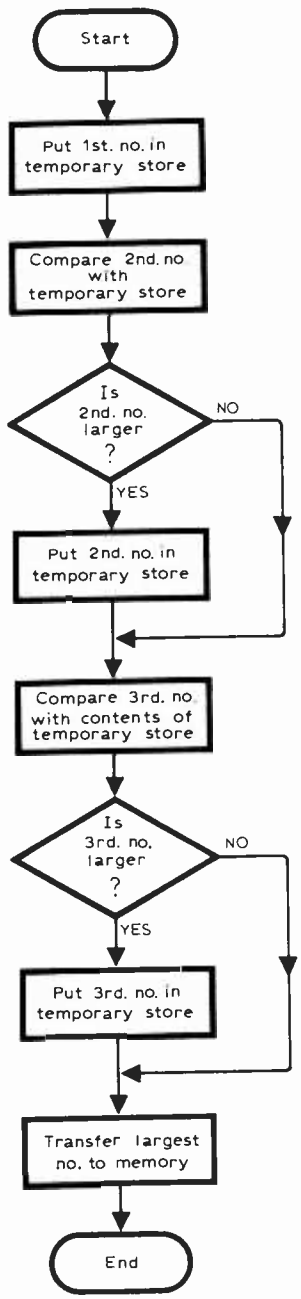


Fig. 1. *This flowchart is a preliminary to writing a programme for selecting the largest of three numbers. The programme itself is shown in Fig. 5.*

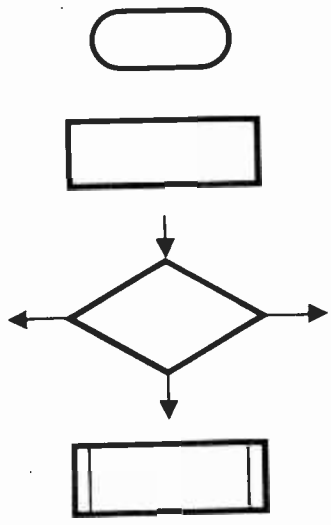
As explained in previous articles a programme is a list of instructions for the computer to follow in order to execute a given task. When a complex task has to be performed the programme may involve many steps, and writing it often becomes long and confusing. A method for solving a problem which is written in words, and possibly mathematical equations, is extremely difficult to follow, and compiling computer instructions from such a document would be equally difficult.

A technique called "flowcharting" is used to simplify the writing of programmes. A flowchart is a graphical representation of a given problem, indicating the logical sequence of operations that the computer is to perform. Having a diagram of the logical flow of a programme is a tremendous advantage to the programmer when he is determining the method to be used for solving a problem, as well as when writing the coded programme instructions. In addition, the flowchart is often a valuable aid when the programme checks the written programme for errors.

Fig. 1 is a flowchart which shows the sequence of operations for a programme which selects the largest of three numbers. The assumption is that the numbers are stored in consecutive memory locations and that the selected largest number is to be stored in the fourth consecutive location. To help with Fig. 1, Fig. 2 shows some common symbols used in drawing flowcharts. The rectangle represents an operation to be performed within the programme. The diamond shape is used to indicate a decision point where one of two or more paths is selected by the programme. There are other symbols for various other functions, but those shown are the most frequently used ones.

The flowchart of Fig. 1 clearly illustrates the method for selecting the largest of three numbers. Essentially, adjacent numbers are compared and the larger at each comparison is saved and used as one of the numbers for the next comparison. At the end of the sequence of comparisons the last "saved" value will be the largest from the group. By repeating the process the method may be extended to any number of values. For more complex problems the initial flowchart may not give as much detail about the operation of the programme as is shown in Fig. 1. For example, the task of selecting the largest of a group of numbers may be only a small part of a much larger item of software. Conse-

Fig. 2. *Common symbols used in flowcharts.*



Represents the start, the end, or an interruption of the programme depending on the word contained in the box.

Represents a given task accomplished by the programme, the description of the task being briefly indicated inside the rectangle.

Indicates that a test must be made to determine the subsequent path taken by the programme. The test is specified within the diamond and its results marked above the appropriate output paths.

Represents one or several operations which are not detailed on the flowchart in question but are detailed on another flowchart. A sub-programme is often represented in this way.

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quently, on a different flowchart this complete operation may be represented by a single box, as indicated in Fig. 3.

The very first flowchart for the operation of a microcomputer project may contain very little detail of the actual method by which the central processing unit will solve the problem. However, each block must then be broken down into smaller and smaller operations, probably resulting in several "levels" of flowchart, depending on the complexity of the problem, being generated along the way. Finally, as with the Fig. 1 example, the flowcharts will contain sufficient detail to be translated directly to machine instructions. By adopting this method of generating various levels of flowcharts, a more orderly solution to the software problem will result.

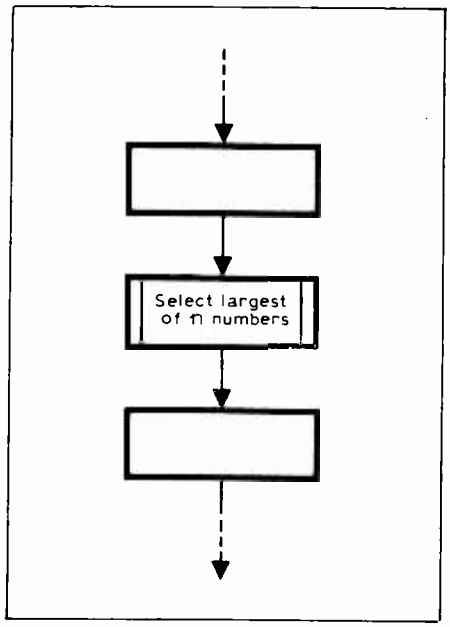


Fig. 3. *Example of a flowchart referring to a sub-programme.*

Programming models and instruction types

Flowcharts are generally "machine independent" in that identical flowcharts can be used as a basis for generating programmes for virtually any computer. However, in order to translate a flowchart into a programme for a particular machine, the programmer must be completely familiar with the instruction set of the c.p.u. (see December 1977 issue, p.56 and p.59) and know which registers within the c.p.u. are accessible by these instructions.

Fig. 4 shows what is called the programming model or internal register organization of the Z80 microprocessor chip. Before proceeding with a programming example it is necessary to study these aspects of the c.p.u. Note that some of the registers are duplicated in the Z80 and are referred to as the main and alternate registers sets. Within the Z80 there is a means for selecting one or other set for current working. The current discussion will be limited to considering the main set only, plus some of the other special-purpose registers. Each register has a particular significance in the overall operation of the c.p.u.

There is a register known as the accumulator. This 8-bit register, which is denoted by the letter A, is always used for one of the operands in any 8-bit arithmetic or logical operation, and as such is a very special and important register of the c.p.u. For example, if two 8-bit numbers are added, subtracted, compared, etc., one of them must reside in the accumulator and this is also where the result of the operation is left. Registers called B, C, D, E, H, L are general purpose 8-bit registers which may be used as stores in a similar way to any external memory locations. However, being part of the c.p.u. means that they may be accessed faster and more easily than external memory. In addition to being general purpose stores, registers B and C, D and E, and H and L may be used in pairs to form 16-bit registers for many types of arithmetic operations. Also, these 16-bit registers may be used to hold memory addresses for certain memory reference operations. This is particularly true of the H and L pair, which may be used to contain an address for many register-to-memory and memory-to-register data transfers, arithmetic and logical operations.

Register F in Fig. 4 is not really a register in the normal sense but is the collection of c.p.u. status bits which are affected by the a.l.u. operations and which may be tested by the conditional jump instructions.

Registers IX and IY are 16-bit registers used primarily for holding memory addresses for special "indexed" addressing operations. Arithmetic operations may also be performed, using these registers.

The SP or "stack pointer" register is another special purpose address register whose function will be explained in a later article. Register PC is the 16-bit programme counter which keeps track of the current instruction address in the programme memory.

Registers I and R have special functions which will also be explained in a later article.

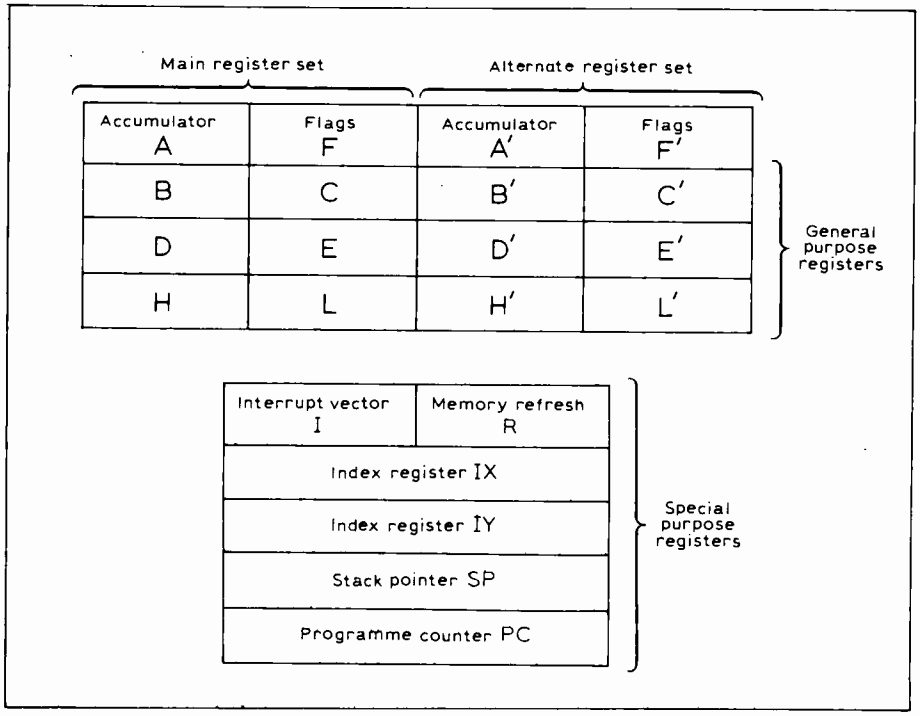
Instructions which operate on data within the above registers or memory locations may be classified into various groups. Any computer will have similar instruction groups, although the actual instructions within these groups are likely to differ between different designs of c.p.u.

The instruction set of the Z80 consists of 158 different instructions, which may be broken down into the following major groups.

Load and exchange
Block transfer and search
Arithmetic and logical
Shift and rotate
Bit manipulation
Jump, call and return
Input/output
Basic c.p.u. control

The load instructions move data internally between c.p.u. registers or between c.p.u. registers and external memory. All of these instructions must specify a source location from which the data is to be moved and a destination location. The exchange instructions can swap the contents of certain c.p.u. registers.

Fig. 4. *Diagram showing the organization of the internal registers of the Z80 microprocessor, known as a "programming model".*



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A unique set of block transfer instructions is provided in the Z80. With a single instruction a block of memory data of any size can be moved to any other area of memory. These instructions are extremely valuable when large strings of data must be processed. The block search instructions are also valuable for this type of processing. With a single instruction a block of external memory of any desired length can be searched for any 8-bit character. When the character is found, the instruction automatically terminates.

The arithmetic and logical instructions operate on data stored in the accumulator and other general purpose c.p.u registers or memory locations. The results of the operations are placed in the accumulator and the appropriate flags are set according to the result of the operation. This group also includes various 16-bit arithmetic facilities.

The shift and rotate instructions allow data in the accumulator or other 8-bit registers to be shifted or rotated in various ways, often including the carry flag as a ninth bit.

Bit manipulation instructions allow any bit in the accumulator, any general purpose register or any external memory location to be set, reset or tested with a single instruction. This group is especially useful in control applications and for controlling "software flags" in general purpose programming.

The jump, call and return instructions are used to transfer information between various locations in the user's programme. This group uses several different techniques for obtaining the new programme counter address from specific external memory locations. Programme jumps may also be achieved by loading the contents of registers H and L, IX or IY directly into the programme counter, thus allowing the jump address to be a complex function of the programme being executed.

The input/output group of instructions allow for a wide range of transfers between external memory locations or the general purpose c.p.u. registers and the external i/o devices.

Finally, the basic c.p.u. control instructions allow various options and modes including instructions for effecting the interrupt response.

Coding the programme

With the instruction set at his disposal, the programmer can begin to translate the detailed flowcharts into actual machine instructions. In the case of the "selection of largest number" programme, the flowchart of Fig. 1 is sufficiently detailed to give approximately a one-to-one correspondence between a flowchart block and a c.p.u. instruction. This will not always be true as problems get more complex and as the programmer becomes more proficient and confident. In Fig. 5 the flowchart has been translated into a list of programme instructions.

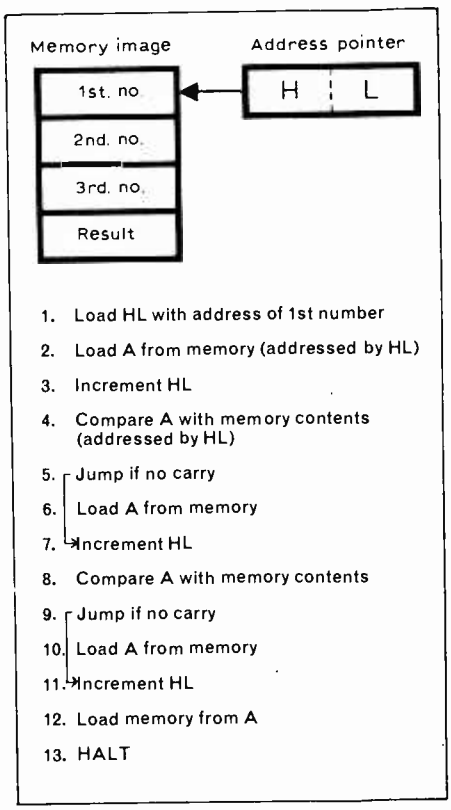

Fig. 5. *Actual programme to select the largest of three numbers.*

Notice that in order to address the sequential data memory locations it is convenient to use the 16-bit pair of registers H and L of the c.p.u. This is set up at the start of the programme (line 1 in Fig. 5) to contain the memory address of the first number in the data list. Consequently, as the other numbers have to be accessed the HL address pointer, as it is called, may be advanced by one each time with a suitable instruction (lines 3, 7 and 11 in Fig. 5). An alternative method would be to include the absolute address of each number as part of a suitable instruction at the relevant parts of the programme. However, in this case it would have resulted in a more inflexible programme and would require additional memory locations for the 16-bit address values to be stored in the programme.

The temporary store referred to in the flowchart has been chosen to be the accumulator register of the c.p.u. This is because in order to compare two numbers, one of them has to reside in this register. Therefore, unnecessary data movements can be avoided if this is used as the temporary store in this case.

Once the data address is set in the HL register, there are instructions available for loading the accumulator from memory address by HL (line 2) and vice versa (line 12). Also, other operations such as "compare A with memory" use the contents of HL as a memory address (line 4 and 8). Remember that the compare instructions work in a similar way to a subtraction, in that if the memory content is larger than the accumulator content then a carry (or borrow) will be generated, thereby setting the carry flag. The "jump if no carry" instructions will test this flag and decide whether the accumulator contains the larger value or whether it needs to be loaded into the accumulator from the currently addressed memory location. Consequently, before the execution of the instruction at line 7 or line 11, the accumulator will contain the largest value so far.

Instruction mnemonics

Programmes are rarely written as shown in Fig. 5 since it becomes very tedious to write out all the instructions in this form. The c.p.u. instructions are commonly abbreviated as shown in Table 1. Mnemonics are used for the various types of instruction, e.g. load — LD, compare — CP, jump — JP, increment — INC, etc. Also, the operands for the instructions are specified by suitable abbreviations for the storage locations in which they are held, for example A, HL, (HL).

These mnemonics are collectively known as the programming language. In particular they are the assembly language of the Z80 c.p.u. Some computer systems have an "assembler" which is a special programme for automatically translating the assembly language mnemonics into binary machine code.

Note that the parenthesis in the case of (HL) means that the operand is not actually the contents of the HL register but the contents of memory "addressed by" the contents of HL. Note also that

Table 1 — Mnemonic coded programme with comments

Line No.	Instruction	Comment
1	LD HL, 0900	Set data address in HL
2	LD A, (HL)	Get 1st data byte into accumulator
3	INC HL	Update address pointer
4	CP (HL)	Compare 2nd data with 1st
5	JP NC, LINE 7	Test carry flag
6	LD A, (HL)	Carry, so put larger in accumulator
7	INC HL	Update address pointer
8	CP (HL)	Compare 3rd data with accumulator
9	JP NC, LINE 11	Test carry
10	LD A, (HL)	Put larger in accumulator
11	INC HL	Update pointer
12	LD (HL), A	Store largest in memory
13	HALT	Halt c.p.u. at end of programme

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Table 2 — Machine coded programme listing

Line No.	Address	Machine	Instruction mnemonic
1	0800	21 00 09	LD HL, 0900H
2	0803	7E	LD A, (HL)
3	0804	23	INC HL
4	0805	BE	CP (HL)
5	0806	D2 0A 08	JP NC, LINE 7
6	0809	7E	LD A, (HL)
7	080A	23	INC HL
8	080B	BE	CP (HL)
9	080C	D2 10 08	JP NC, LINE 11
10	080F	7E	LD A, (HL)
11	0810	23	INC HL
12	0811	77	LD (HL), A
13	0812	76	HALT

for the jump instructions the addresses of the instructions at lines 7 and 11 would, in practice, need to be inserted as part of the jump instruction.

In order to make the programme more readable it is good practice to include comments as shown in Table 1, indicating how the programme operations relate to the task in hand.

Finally, before the programme can be entered into the computer's memory the instructions must be converted into the appropriate binary codes. This is done by referring to the c.p.u.'s instruction set details. At this stage it is also necessary to allocate memory addresses both for the programme and also for any data which must reside in memory.

The r.a.m. of the microcomputer kit (November 1977 issue, p. 45) starts at address 800 (hex), this being the beginning of the third 1K address block (December 1977 issue, Fig. 4). Consequently this would be a suitable address at which to store the programme. Four data memory locations are also required and so addresses 900 to 903 (hex) could arbitrarily be chosen for these.

We are now in a position to generate the machine code programme. Table 2 shows the resulting programme, indicating the relevant memory addresses for the instructions. Note that the hexadecimal number system has been used throughout. Where an instruction requires more than one memory location all the bytes of information have been shown on one line and the memory address of the next line is adjusted accordingly. The Z80 c.p.u. requires that whenever a 16-bit address is specified as part of an instruction, the least significant byte must be placed first in the memory, followed by the most significant byte.

Initially it is not possible to fill in the jump addresses at lines 5 and 9 until the memory addresses of the jump destinations (lines 7 and 11) have been established. So, on the first pass through, memory locations must be reserved for these values. Having established the memory locations required, one can then fill in the remaining memory references. For example, the jump instruction at line 5 must contain the address of line 7. Consequently the value 080A must reside in memory locations 0807 and 0808.

Running the programme

The following paragraphs illustrate how the above programme may be verified by running it on the microcomputer kit. A typical operational sequence is given, starting with the entry of the programme into the computer's memory, continuing with executing and verifying, and finally making a permanent record of the programme on cassette tape. In the discussion which follows the display listing produced by the kit is given. Those parts shown in bold characters are those which are typed by the user. The remainder is generated by the system. The reader should refer to Part 2 of this series (December 1977 issue) for a description of the system commands.

The first step is to type the programme into the memory using the M command. Each byte of machine code is entered starting from address 800. The M command responds with the current memory contents. The user must then type a space followed by the new value required. A carriage return then gives the contents of the next memory location on a new line and so on as shown below.

```
• M 800
0800  00  21
0801  00  00
0802  00  09
0803  00  7E
0804  00  23
0805  00  BE
0806  00  D2
0807  00  0A
0808  00  08
0809  00  7E
080A  00  23
080B  00  BE
080C  00  D2
080D  00  10
080E  00  08
080F  00  7E
0810  00  23
0811  00  77
0812  00  76.
•
```

The programme memory may be checked by using the "tabulate" command:

```
• T 800 812
0800 21 00 09 7E 23  BE D2 0A
0808 08 7E 23 BE D2 10  08 7E
0810 23 77 76
•
```

Three data values must be entered in addresses 900-902. These can be any convenient 8-bit numbers and may be entered with the M command:

```
• M 900
0900  00  12
0901  00  34
0902  00  0B•
```

Everything is now ready for the programme to be run. However, it is rarely advisable to try to run the whole of a new programme without any intervention by the operator at any point since even the simplest programme is likely to contain errors initially. It is therefore desirable to set a breakpoint at a convenient place, after a few instructions will have been executed. A suitable point is at line 7 (address 080A). A breakpoint here will cause the programme to stop before the INC HL instruction is executed. At his stage of the programme the accumulator should contain the larger of the first two numbers. The following print-out shows the setting of the breakpoint, the start of programme execution and the display of programme counter and accumulator contents when the breakpoint is reached.

```
• B 80A
• E 800
080A 34
•
```

See that the programme has stopped with the programme counter at address 80A as specified by the breakpoint instruction. This confirms that at least some of the programme has indeed been executed. The accumulator appears to have the value 34 which is the larger of the first two numbers. However, in order to check that the programme branches correctly it should be tried again with numbers of different relative magnitudes.

To check the next part of the programme a breakpoint could be set at address 812. This will ensure that the final c.p.u. register states will be preserved for examination if required. The following sequence sets the new breakpoint, continues programme execution from the previous breakpoint, and displays the final programme counter and accumulator contents.

```
• B 812
• E
08012 34
•
```

Continued on page 88

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The amazing, automatic Logic Monitor LM-1.

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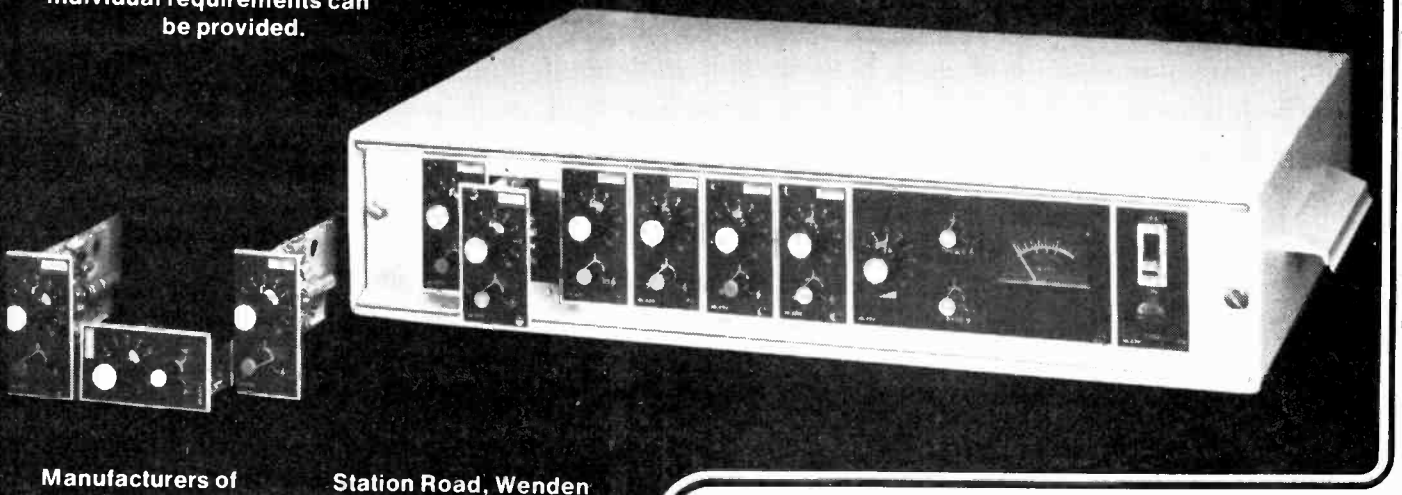

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A basic radio telescope — 2

Construction, performance and testing

by J. R. Smith

WHEN NO SIGNAL coherent with the square-wave generator is present the noise blocks are symmetrical about the zero line and the mean d.c. output is zero. If the signal and the square-wave are coherent the noise blocks are not symmetrical about the zero line and the d.c. output appears with a polarity dependent upon the phase of the noise blocks with respect the square wave. Integration of the output signal is carried out by a RC circuit. The time constant is adjusted by a variable 2MΩ resistor and the capacitor is selected for low leakage. The maximum time constant obtainable is 20 seconds. The d.c. amplifier consists of a bootstrapped pair of transistors with some carefully matched devices to provide an acceptable temperature stability. Field effect transistors are used for the input stage to provide a high input impedance which permits a long time constant. To obtain an equal mark-to-space ratio, an asymmetrical astable multivibrator is used to drive a divide-by-two monostable multivibrator, see Fig. 8. Buffer transistors provide low impedance outputs, and normal or inverted square-wave outputs at 1kHz are available as required. Early trials showed that these outputs require filtering to prevent radiation of r.f. fields. Values for r.f. chokes and capacitors are best found by trial and error, but excessive filtering degrades the shape of the square wave. The 12V power supply must be stable to within 5mV. As the total load current is about 55mA dry batteries can be used for short periods or a car battery for longer periods. With the last mentioned the voltage should be stable, after a charge, if it is partially discharged before use by about 5%.

The values of most of the components are not critical although high stability resistors are used in potential divider circuits and the d.c. amplifier. Radio frequency chokes are made by winding between twenty and thirty turns of enamelled wire on polythene tubing of 5mm in diameter. The i.f. chokes consist of twenty to thirty turns

Measured performance of various stages

Stage	V_d when I_n is 0	I_n to double	Noise factor	Noise figure	$\frac{I_n}{V_d}$	$\frac{dI_n}{dV_d}$	Stage gain	
	V	$\frac{V_d}{mA}$	No	dB	$\frac{mA}{V}$	mA per V	Absolute	dB
Aerial amplifier and coax	0.37	4.7	5.7	6.7*	$\frac{0.8}{0.1}$	8	16.2	12*
Frequency changer	0.15	14	15	11.5	$\frac{13}{0.1}$	130	11.3	10.5
Filter	0.12	–	–	–	$\frac{38}{0.03}$	1270	$\frac{1}{28}$	−14.5
I.f. amplifier	0.12	5	6	7.7	$\frac{4.5}{0.1}$	45	1.05×10^{3}	70.2

* A 3N140 f.e.t. should achieve a noise figure of 4dB. Some improvement in gain should also be possible.

V_d is the detector voltage. Output power is assumed to be proportional to V_d because a square law detector is used.

I_n is the diode anode current. The diode resistor is 50Ω and the voltage gain of the d.c. amplifier is 18.5 (absolute).

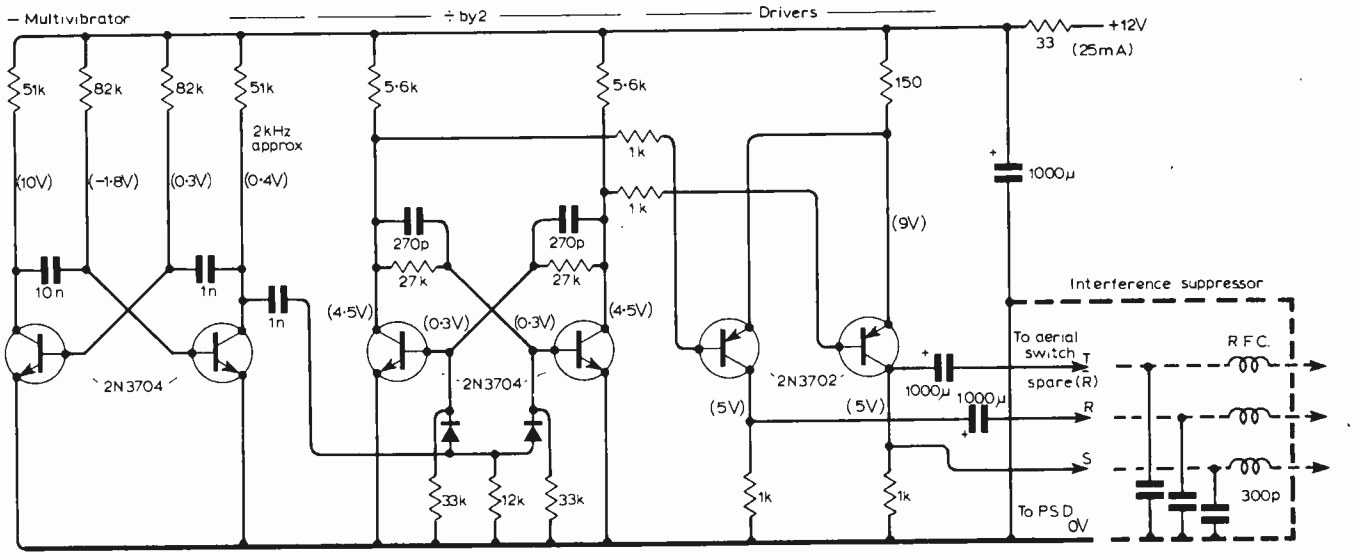

Fig 8. *Square-wave generator*

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wound and glued onto OBA ferrite slugs. A 1mA recorder that can be centred or end-of-scale zeroed is used with a chart speed of one inch per hour for most observations.

Noise diode

A valuable piece of test equipment is the valve noise diode, Fig. 9, which produces signals of a similar character and strength to a celestial radio source. The diode is modulated by supplying 240V a.c. to the anode while the detector output is fed to the *Y* plates of an oscilloscope. The *X* plates are fed from 240V a.c. through a phase adjuster. With the diode connected to the input of the correctly tuned aerial amplifier or i.f. amplifier a display similar to that shown in Fig. 9 is obtained. The left side of the trace corresponds to the receiver noise, and the right side to the receiver and diode noise. The system is adjusted to produce the largest difference between the two. The noise diode can also be connected to a dipole aerial which in turn can be placed near an aerial which requires adjustment for best performance. In this case, a pair of headphones is connected to the detector. The modulated noise can then be heard and adjustments made to produce the loudest buzz.

Because the noise diode operates at a high voltage, all exposed metal, including the dipole, must be correctly earthed. As the centre point of the folded dipole is at an r.f. voltage node, this point can be bonded to the earthed box without affecting the r.f. performance. All mains earthing leads must be made as secure as possible, and a one amp fuse should be placed in the mains line lead. Similar precautions are necessary for the transistor equipment when running from a mains operated power supply. Fig. 10 shows some typical results. The voltages given in the circuit diagrams were measured with a meter having a 100kΩ resistance. The i.f. amplifier gain was determined from the noise diode output corrected for the difference of the i.f. 4MHz bandwidth and the 0.5MHz filter bandwidth, divided into the change of the detector output power. □

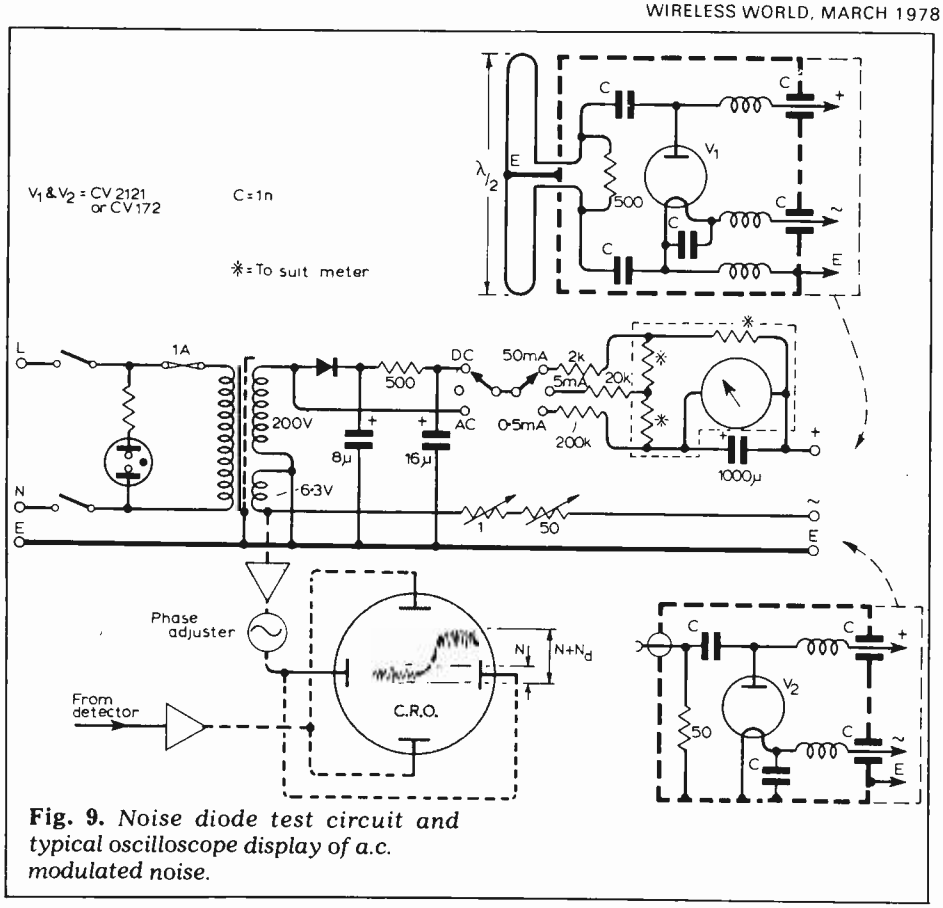
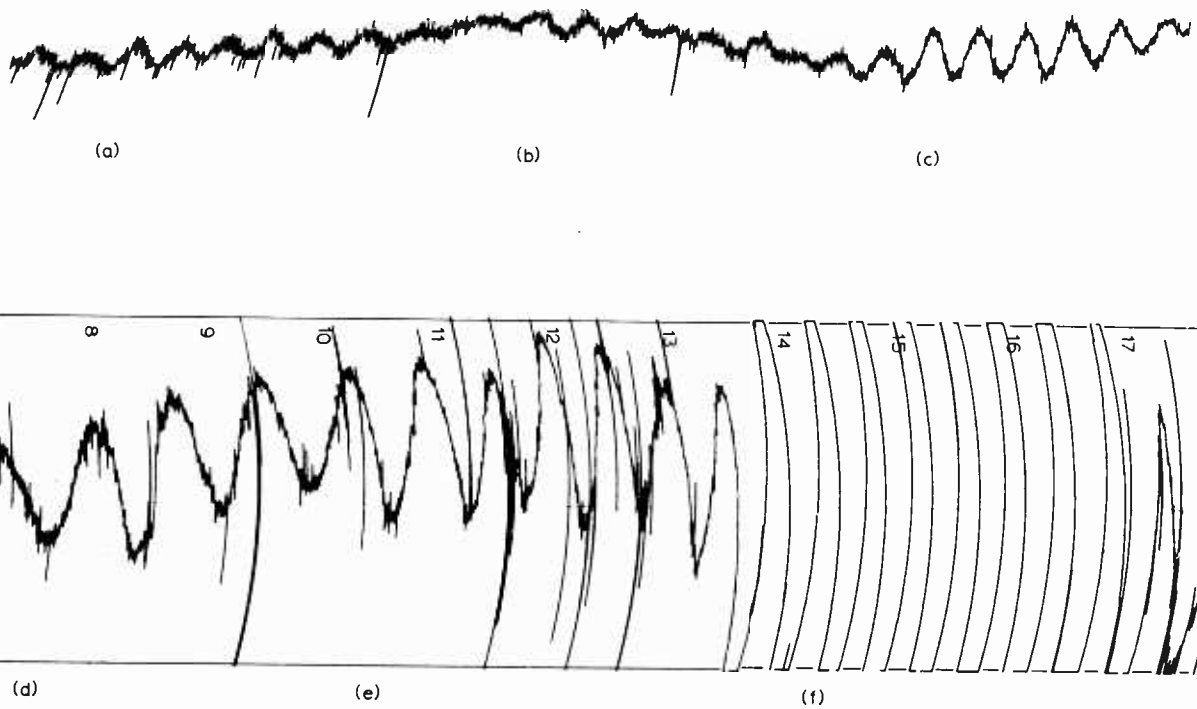


Fig. 9. *Noise diode test circuit and typical oscilloscope display of a.c. modulated noise.*

Fig. 10. *Pen recordings from the telescope used in the phase switched interferometer mode. Portion (a) shows Virgo A, galaxy M87. (b) Hercules A, a galaxy 1500 million light years distant. (c) Taurus A, Crab Nebula. (d) Cassiopeia A, a super nova reminent. (e) Cygnus A, a galaxy 600 million light years distant. (f) active sun.*



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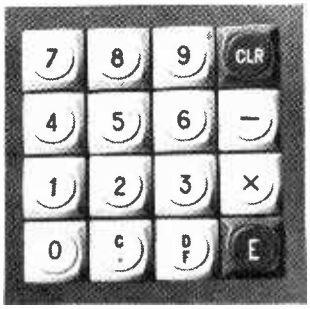
NEW PRODUCTS

Keyboard switches

Low-profile keyboard switches, from Osmor Moulded Products Ltd, are available individually or they can be supplied mounted as complete keyboards to customers' specifications. The switches, which have a life of 10 × 10^6 operations, are only 0.45in (11.45mm) high and they have



integral tops which are available in a range of colours. The switch contacts, s.p.s.t. n/o, are gold-plated phosphor bronze with cross-bar switching reliability and are rated at 2.5W (50V, 50mA). Osmor Moulded Products Limited, 75 Bensham Grove, Thornton Heath, Surrey.
WW 301

T.w.t. amplifier

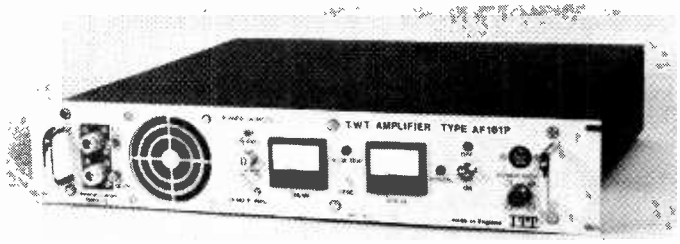
The AF161P is a travelling wave amplifier unit which has been designed for incorporation in ground-based microwave landing systems in the 5.00 to 5.25GHz frequency band. The unit uses an easily-replaceable miniature t.w.t., and together with the associated power supply, manual and remote control facilities, and monitoring and protection devices. This unit, which is designed to fit a standard 19in rack, meets all the requirements of both the Doppler and scanning beam systems specifications for military environments and has a c.w. output power of 20W. ITT Components Group, Electron Device Product Group, Brixham Road, Paignton, Devon.
WW 302

15MHz oscilloscope

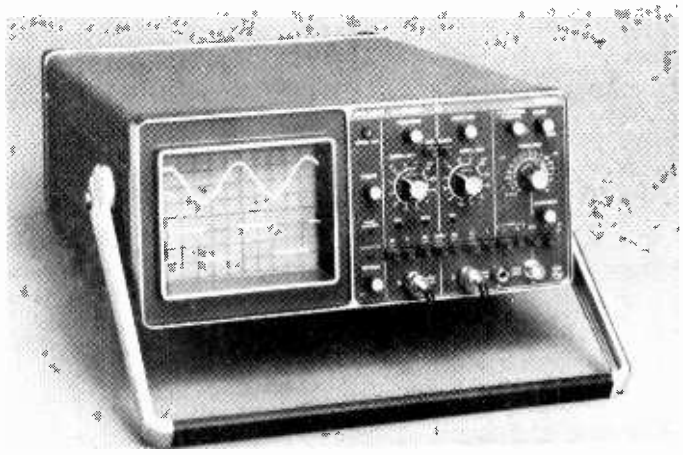
The PM3211 oscilloscope, from Philips, is a 15MHz, 2mV instrument having a 8 × 10cm screen. It is a compact unit, measuring only 300 × 135 × 445mm, and because of its construction and the use of i.cs in the amplifier stages, its down-time on maintenance and repairs is low. In common with other Philips oscilloscopes, the PM3211 meets the IEC standards 348 class II or VDE 0411. Consequently, no earth connection is required and measurements can be made in safety without earth loops and hum influencing the results. Triggering can be in an auto mode or in level-set modes and multisourced, eliminating the need to change probes. Channel B can be used as an X input or it may be inverted, giving an A-B mode, to allow maximum advantage to be taken of the 2mV sensitivity. Pye Unicam Limited, York Street, Cambridge.
WW 303

Microwave spectrum analyser

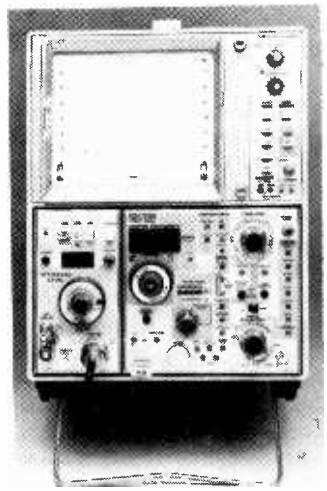
The 7L18 microwave spectrum analyser, from Tektronix, is claimed to offer a combination of exceptional performance and ease of operation. A high-stability phase-lock system yields a resolution of 30Hz at frequencies up to 12.5GHz, while external waveguide mixers extend the overall frequency range up to 60GHz. In addition, the 7L18 includes microprocessor-aided controls, a split digital-storage system, and y.i.g.-tuned filters for a spurious-free display from 1.5 to 18GHz. The instrument is a three-module wide plug-in unit for the Tektronix 7000 series of modular instruments. External waveguide mixers extend the frequency coverage to 60GHz with a response flatness specified at ±3dB or better. The stability resulting from the phase-lock circuitry, measured in terms of residual frequency modulation, is specified as 10Hz or less up to 4.5GHz (about four parts in 10^7). A split memory allows the comparison of a reference with an existing spectrum, or a calculated display of the difference between two spectra. The storage circuitry includes a maximum-hold capability that allows frequency



WW 302



WW 303



WW 304

or amplitude signal variations to be monitored. The mocroprocessor provides automatic resolution and sweeptime/division modes to optimise setting up the display and reduce operator errors. The instrument can also be converted to a high-quality microwave receiver for time-domain measurements by setting the frequency span to zero and using the calibrated time base. Tektronix UK Limited, Beaverton House, P.O. Box 69, Harpenden, Herts.
WW 304

Motorized potentiometers

Precision, motorized potentiometers, announced by F.S.G. (UK), are available in a variety of constructions enabling the drive motors, gears and potentiometer types to be selected to optimise performances for particular applications. Typical uses for the potentiometers would be found in slave systems for bridges and compensation circuits, in the measuring systems of indicators, recorders and signal converters and in analogue computing circuits. They can also be applied to signal stores and delay units. Accessories such as switches, wiper return mechanisms and impulse devices can also be fitted. F.S.G. (UK), 16 Conolly Road, London W7 3JW.
WW 305

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Low-cost soldering

The Adcola Unit 333 temperature-controlled soldering iron operates direct from an existing transformer or 24V alternating supply. It is a 50W iron, based on the Model 101, and it has a thermocouple sensor providing a temperature accuracy to within ±2% of the dial temperature, which ranges from120 to 420°C. The dial can be

WW 306

locked in any position for the desired iron temperature. Iron plated or copper soldering bits of the plug-in type are retained by a stainless steel shim. A pulsating neon light indicates when the operating temperature has been reached. Adcola Products Limited, Adcola House, Gauden Road, London SW4 6LH.
WW 306

Radio-telephone test set

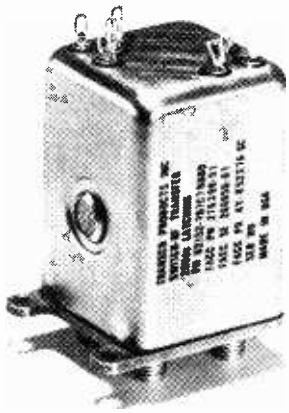
A compact, lightweight test set, the Teleset C, is intended for f.m. and a.m., v.h.f. and u.h.f. radio telephone systems. It provides facilities for high-accuracy measurements by incorporating the functions of a signal generator, a frequency counter, a modulation meter, an r.f. wattmeter, a digital a.c./d.c. voltohmmeter and an a.f. generator. The r.f. generator provides a high stability signal over the range 25 to 520MHz, and may be modulated internally or externally. Accurate i.f. testing is possible using three preset crystal-controlled frequencies which are push-button selected. The a.f. generator has a range from 30Hz to 30kHz and the counter covers a.f. and r.f. with a frequency range from 10Hz to 520 MHz. Direct reading measurements of r.f. power can be made over the range 0.1 to 25W on the standard equipment and up to 50W on an alternative version. Aspen Electronics Limited, 2 Kildare Close, Eastcote, Middlesex HA4 9UR.
WW 307

Precision wattmeter

The D4000 wattmeter, produced by Norma Messtechnik of Vienna, is now available in the UK. This instrument offers a wide range of power measurements combined with an overall accuracy of ±0.1% from 45 to 65Hz, and ±0.2% from 15 to 45Hz and 65 to 400Hz. The built-in current and voltage ranges are selected by switches on the front panel and measurements in the range 0.1W to 5.5kW can be made without additional accessories. The current ranges are protected up to 20A continuous and the voltage ranges up to 650V, with overloads being indicated by l.e.ds. The display is a 4½-digit, 12mm-high 7-segment l.e.d. showing both the sign and unit of measurement. Since the instrument is a double wattmeter, measurements of active power in both single and three-phase, unbalanced-loaded three-wire systems is possible. Current and voltage transformers are available for extending the measurement range. Cropico — Croydon Precision Instrument Company, Hampton Road, Croydon CR9 2RU.
WW 308

Coaxial switch

A high-reliability transfer switch introduced by Transco Products Inc., is suitable for the remote switching of coaxial r.f. lines carrying signals from 0 to 18GHz. The switch, which was designed to meet the environmental



WW 309

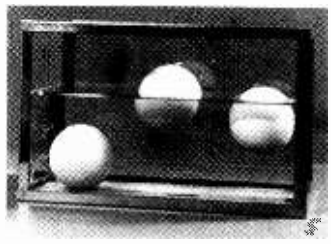
specifications for space applications, has a latching action and operates by means of a balanced rotor actuator having a current requirement of only 75mA at a direct voltage of 28V. It is fitted with SMA connectors, and has an insertion loss of only 0.2dB. The switch is capable of withstanding sinusoidal vibrations of up to 100g at frequencies from 100 to 1000Hz. Aspen Electronics Limited, 2 Kildare Close, Eastcote, Middlesex HA4 9UR.
WW 309

Helical antenna

The model ASO-1560A is a spiral helix antenna suitable for the frequency range 0.5 to 18GHz. It provides circularly polarized polar patterns over more than five octaves within a package which is only one-tenth of a wavelength in diameter at the lowest operating frequency. The antenna is suitable for airborne amplitude-comparison, direction finding systems, broadband dish feeds, or any other application where broad frequency coverage is required in a small package. American Electronic Laboratories Inc., P.O. Box 522, Lansdale, Pa. 19446, USA.
WW 310

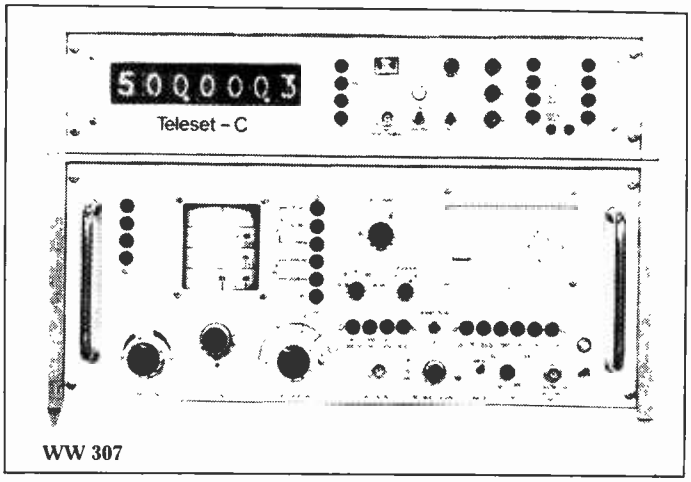
Low density resin

A very low density, single-part, casting resin, designated the Stycast 1091, has been formulated as a result of customer demand. The resin, from Emerson & Cuming, is supplied as a liquid which is cured, at an elevated temperature, into a tough, rigid



WW 311

solid. It has a good self stability and will withstand much higher temperatures (200°C) than other one-part systems, according to the makers. Typical applications for this material are encapsulation in airborne systems, and for providing buoyance in underwater systems. Since it is a syntatic foam, it has a very low water absorption rate, even at great depths. Other properties include: a specific gravity of 0.62, a thermal conductivity of 0.83 cal.cm/s.cm².°C, dielectric constant at 1MHz of 1.91 and a dissipation at 1MHz of 0.012. Emerson & Cuming (UK) Limited, Colville Road, Acton, London.
WW 311



WW 307

WW 308

Thumbwheel switches

Three ranges of thumbwheel switch, made by Digitran Endevco, have been introduced to offer users switches which incorporate l.e.ds for illumination. The switches have a minimum life of one million operations, and they are claimed to have a more uniform illumination level than switches with incandescent lighting. The 43000 series consists of 0.5in-wide rear-mounted switches, the 44000 series of rear-mounted 8mm-wide switches and the 45000 series of front-mounted 8mm-wide switches. The switches are available with "white" or red

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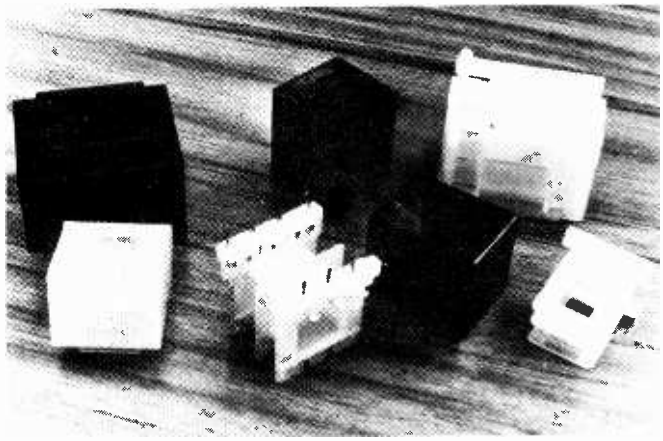
lighting, or no illumination at all. They have ten switch positions and include types for popular standard codes such as single-pole decimal, b.c.d., complement of b.c.d., b.c.d. true/not-true, s.p.d.t., nine's complement, complement of nine's complement and nine's complement true/not-true. The thumbwheel switches are rated at 28V, direct or alternating, 50mA resistive at 25°C. Contact resistance is less than 100mΩ. Digitran-Endevco UK Division, Back Road, Melbourn, Royston, Herts SG8 6AQ.
WW 312



WW 313

Transformer bobbins

The Michael range of high-insulation transfer bobbins and accessories from Germany, has been made available in the UK. These products include reinforced plastics bobbins and coil covers, solder tags and pins, and injection-moulded encapsulation covers. The basic range meets BS, DIN41.307 and VDE0551 specifications and, if the coil covers are used to totally enclose windings, it is claimed that these specifications can be greatly exceeded. Bobbin sizes available are suitable for miniature pulse transformers and transformers having VA ratings from 1 to 80VA. These products are available ex-stock from Albol Electronic & Mechanical Products Limited, 3 Crown Buildings, Crown Street, London SE5 0JR.
WW 313

WW 314

'Hot' mains plug

A 'hot'-condition, non-rewirable mains plug, designated the L1958, and a matching inlet, the L1957, both conform to IEC 320 requirements for use with electrical appliances such as kettles and heat trays. The units, from Belling & Lee, which are rated at 10A, 240V alternating, are available in p.v.c., silicone, and cotton-sheathed types. Both units can be supplied as separate components with cables cut to customers requirements. Belling & Lee Limited, Great Cambridge Road, Enfield, Middlesex EN1 3RY.
WW 314

Low-profile rotary switch

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WW 315

Continued from page 46

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Widney Dorlec
Wika Pressure Gauges (UK)
Williams, Henry

Zeal, G. H.
Zeiss Jena, Veb Carl
Zeta Research Inc.

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Continued from page 80

The accumulator contains the value 34, which suggests that the programme is working correctly since this was the largest of the three numbers.

To finally verify the correct operation, memory address 903 should be examined.

```
• M 903
0903 34 •
•
```

If for any reason the programme had required changing, this could be accomplished with the "modify" command again. For example, if we wish to select the smallest rather than the largest of the numbers, this can be achieved by changing the "jump if no carry" instruction to a "jump if carry." This involves changing the JP NC, . . . (op code D2) to JR C, . . . (op code DA), e.g.

```
• M 806
0806 D2 DA •
• M 80C
080C D2 DA •
•
```

The programme could now be executed again in a similar manner to that shown above.

Finally, to keep a permanent record of the programme it can be saved on tape by the "dump" command. This also produces a display of the saved information.

```
• D 800 812
0800 21 00 09 7E 23 BE DA 0A
0808 08 7E 23 BE DA 10 08 7E
0810 23 77 76
•
```

At a later time the programme may be quickly re-loaded into the memory with the "load" command.

```
• L
•
```

These examples have illustrated some of the fundamental principles and implications of writing programmes for a microcomputer or any other computer system. However, much more detail than can be given here is required in order to get a greater appreciation of the programming facilities offered by the c.p.u. and the techniques for exploiting these facilities. Future articles will go some way to explain these very important aspects of microprocessor system design.

Reference

The Z80 c.p.u. Technical Manual □

Owing to production difficulties the remainder of Dr Shelton's articles on microcomputer hardware have had to be postponed, but will be resumed as soon as possible.

All Finniston's persons

THE first meeting of the committee of inquiry into the engineering profession, chaired by Sir Monty Finniston, took place on December 20 at Great Smith Street, London. The names of its members, announced a few days before, were: Catherine Avent, careers guidance ILEA; W. Buckley, Warrington technical college; T. Crispin, T & GWU; H. Darnell, British Steel; J. Dawes, ex-Rolls Royce; J. Dickinson, North Staffs polytechnic; J. Horlock, Salford University; W. Howie, *New Civil Engineer;* B. Lindley, ERA; H. Macdonald Smith, Army; W. McCall, Institution of Professional Civil Servants; J. Menter, London University; H. Nelson, Ransome Hoffman Pollard; J. Powell, EMI; E. Sadler, Ove Arup Partnership; D. Weir, Scottish Business School; J. Wilson, Tayside Region.

The secretary to the committee is Mr M. V. Boxall, who will accept submissions at Abell House, John Islip Street, London SW1.

Dr Powell's career has led him to the Clarendon Laboratories, Oxford University, Ottowa's National Research Laboratory, Marconi, where he worked on semiconductors, and Texas Instruments, where he moved from engineering to management. He joined EMI in 1974.

An article in the journal of the Institution of Production Engineers points out that, surprisingly, none of their members is represented on the committee. "Apparently eschewing the talents of MIProdEs, the committee includes seven educationalists, a magazine publisher, a civil servant, a trade unionist and four industrialists." The list does, indeed, have the look of a fairly typical selection from the Book of the Great and the Good, and one would have thought the civil service is going to have quite enough influence on the committee's work without putting one of its members on the committee as well. □

Defence research spawns commercial success

THE 1977 MACROBERT award has gone to a team of five who developed a device, the Malvern correlator, which uses lasers to measure flow rates. The range of applications is said to extend from the flow of blood through the blood vessels at the back of the eye, the only non-invasive method of doing this, to the rate of flow of gases through an engine.

Four of the winners come from the Physics group of the Royal Signals and Research Establishment, Malvern, and the fourth is the managing director of the firm which produced a commercial version of the device, Malvern Instruments Ltd.

The instigator of the project was Dr Roy Pike, one of the RSRE team, who was engaged in a study of the structure of light. In particular, they wanted to study laser light. The laser had only just been invented and few uses had been found for it. They reasoned that once they understood the nature of what came out of the laser it might be put to practical, probably defence, use.

They began to concentrate on the measurement of the characteristics of laser photons. The flow measurement technique stems from that. A laser beam is split into two beams, which converge in the centre of the flow. The optical fringes formed by the interference of the two beams, when observed at the other side of the flow, are disturbed by the flow particles. This disturbance, or scattering, is caused by the photon pulses bunching together as the particles move through a light area of the optical fringes. The intensity distribution of the fringes therefore gives a guide to the particle velocity. The periodicity of the pulse train is measured by auto-correlation technique — multiplying the pulse train by many time-delayed versions of itself.

One of the team, Mr D. S. Trudgill, left RSRE in 1971 and with help from the NRDC, set about making a commercial version of the equipment. The firm of which he is now managing director, Malvern, started selling them in 1972 and last year won a Queen's Award. The firm has 35 employees compared with the six it had when it began. They have sold over 200 Malvern correlators.

The MacRobert award is the most prestigious in UK engineering. It is worth £25,000 and a day at Buckingham Palace, where Prince Philip presented the awards at a private ceremony just before Christmas.

The chairman of the CEI, which sponsors it, Sir Charles Pringle, reminded those who gathered after the presentation that no award had been made last year for lack of entries of a high enough standard. This year, however, there had been a number which would have been eligible, and the problem this year had been one of selection. Perhaps the absence of an award last year had given the MacRobert prize a shot in the arm. □

IN BRIEF

Marconi are to supply tv signal monitoring equipment for the studios broadcasting the 1980 Moscow Olympic Games.

Ferranti have bought linear i.c. makers Interdesign of California.

EMI have a new company, EMI Industrial Electronics, to co-ordinate the £50 million worth of business they conduct in that area.

Voice of America have installed a short wave dipole curtain aerial array at their Delano, California, relay station. The aerial operates at 250 to 500kW with 100% modulation on 49m, 40m and 31m. It was supplied by TCI. Satisfactory signals have been received in the Philippines.

The Ministry of Defence have bought 400 u.h.f. radio relays from Marconi, nearly four years after a £7.6 million order for the equipment. The present order, for Triffid transportable equipment, is worth £12 million. Triffid is a modification of a design by Siemens and AEG for the Netherlands, and will work in the Ptarmigan network (*WW* Sept. 77, page 49).

A contract to install 470,000 new lines to the Saudi Arabian automatic telephone system has been won by the Philips/Ericsson/Bell Canada consortium. The project will take three years. Philips and Bell will install the equipment, worth $2 million, and Bell will maintain it for five years.

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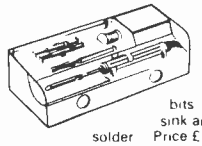

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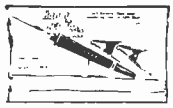
Model MLX KIT



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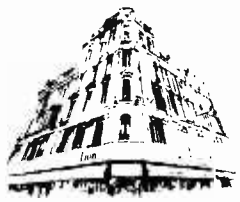

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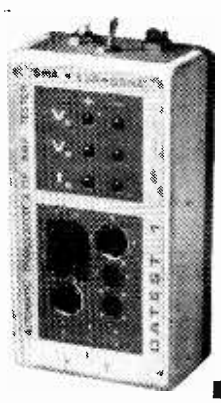

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1.5	4½p	5p	5½p	6p
2.2	4½p	5p	5½p	6p
3.3	4½p	5p	5½p	6p
4.7	4½p	5p	5½p	6p
6.8	5p	5½p	6p	7p
10	5p	6p	7p	9p
22	6p	7p	9p	13p
33	7p	8½p	10p	15p
47	8p	10p	12p	19p
100	10p	13p	18p	26p
150	11p	15p	20p	28p
220	12p	16p	22p	32p
330	14p	18p	26p	36p
470	16p	20p	29p	40p
680	18p	24p	35p	48p
1000	20p	29p	41p	
2200	24p	38p	60p	
4700	39p	52p	85p	

POLYESTER 100V Radial lead
001 0012 0015 0018 0022
0027 0033 0039 0047
0056 0068 0082 01 **.045**
012 015 018 022 **.05** 027
033 039 047 **.055** 056 068
.07 082 1 12 15 **.075** 18
22 27 **.09** 33 **.10** 39 **.11** 47 **.12**

7400 Series		7430	15p	7483	83p	74151	64p
TTL		7432	25p	7484	£1	74153	64p
7400	14p	7433	34p	7485	98p	74154	£1.17
7401	14p	7437	25p	7486	30p	74155	68p
7402	14p	7438	25p	7489	£2.45	74156	68p
7403	14p	7440	15p	7490	35p	74157	68p
7404	14p	7441	64p	7491	70p	74159	£2
7405	14p	7442	60p	7492	44p	74160	88p
7406	32p	7444	£1.10	7493	40p	74161	88p
7407	32p	7445	78p	7494	87p	74162	88p
7408	16p	7446	83p	7495	60p	74163	88p
7409	16p	7447A	74p	7496	69p	74164	£1
7410	15p	7448	68p	74100	94p	74165	£1
7411	20p	7450	15p	74107	30p	74166	£1.23
7412	21p	7451	15p	74109	50p	74170	£1.95
7413	28p	7453	15p	74121	25p	74173	£1.45
7414	60p	7454	15p	74123	60p	74174	99p
7416	30p	7460	15p	74125	50p	74175	74p
7417	30p	7470	30p	74126	50p	74176	99p
7420	15p	7472	25p	74132	75p	74177	99p
7421	35p	7473	30p	74135	68p	74179	£1.38
7422	20p	7474	30p	74141	60p	74180	99p
7425	20p	7475	30p	74145	72p	74181	£1.95
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7427	25p	7480	50p	74148	£1.58	74185A	£1.45
7428	35p	7481	98p	74150	£1.58	74190	£1.38

74191	£1.38	4025	19p	4072	23p	7805 TO220	£1.30
74192	£1.18	4026	£1.65	4075	23p	7812 TO220	£1.30
74193	£1.18	4027	60p	4081	19p	7815 TO220	£1.30
74194	99p	4028	86p	4093	80p	7905 TO220	£1.95
74195	95p	4029	£1.16	4501	20p	7912 TO220	£1.95
74196	99p	4030	55p	4502	95p	7915 TO220	£1.95
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74198	£1.80	4033	£1.50	4508	£2.84		
74199	£1.80	4034	£2	4511	£1.50	**LINEAR**	
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CMOS		4036	£2.40	4520	£1.26	TAA661B	£1.40
4000	15p	4037	99p	4527	£1.60	TBA120S	68p
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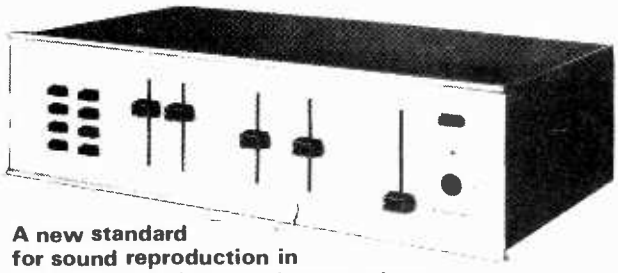
4006	£1	4041	86p	4555	85p	TBA810S	£1.16
4007	19p	4042	80p	4556	85p	TCA270SQ	
4008	98p	4043	95p	4583	80p		£2.21
4010	56p	4044	99p			TDA2020	£3.56
4011	19p	4046	£1.32	**OP AMPS**		380 14	£1
4012	19p	4047	96p	301A 8	35p	555 8	36p
4013	50p	4048	63p	709 14	46p	556 14	80p
4014	£1	4049	55p	741 8	22p	710 14	32p
4016	50p	4050	50p	741 14	20p	711 14	32p
4017	95p	4052	92p	741 TO99	48p	1310 14	£1.78
4018	£1	4053	95p	747 14	70p	2501B	£2.20
4019	52p	4054	£1.10	3900	50p	3045 14	45p
4020	£1.05	4060	£1.10	**VOLTAGE REGS**			
4021	95p	4066	50p	300	£1.25		
4022	95p	4069	24p	309K TO3	£1.30	**All Prices include V.A.T.**	
4023	19p	4070	38p	723 14	48p		
4024	75p	4071	25p				

WW—032 FOR FURTHER DETAILS

RADFORD HD250

High Definition Stereo Amplifier



A new standard for sound reproduction in the home! We believe that no other amplifier in the world can match the overall specification of the HD250.

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Maximum power output: 90 watts av. per channel into 5 ohms.

Distortion, preamplifier: Virtually zero (cannot be identified or measured as it is below inherent circuit noise.)

Distortion, power amplifier: Typically 0.006% at 25 watts, less than 0.02% at rated output (Typically 0.01% at 1 Khz)

Hum and noise: Disc,—83dBV measured flat with noise band width 23 Khz (ref 5mV); —88dBV "A" weighted (ref. 5mv)

Line —85 dBV measured flat (ref 100v) —88d BV "A" weighted (ref 100v)

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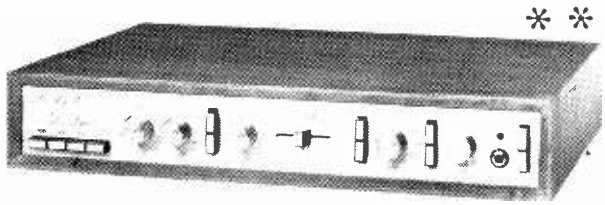
AUDIO KITS OF DISTINCTION FROM POWERTRAN

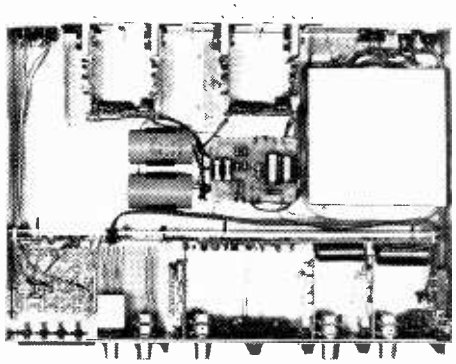
NEW! DE LUXE EASY TO BUILD LINSLEY-HOOD 75W AMPLIFIER



SPECIAL PRICE FOR COMPLETE KIT **£99.30**

Available as Separate Packs

Details in Free Catalogue



Internal view of De Luxe Kit

The standard model of our kit for Mr. Linsley Hood's 75 watt design has for a long time offered exceptional performance for a very modest cost (just look at prices for comparable high quality high power ready built units!) Features of the amplifier include very low distortion (less than 0.01%) 75W rms per channel power output rumble filter variable slope scratch filter variable transition frequency tone controls tape monitoring facilities and individually adjustable inputs. This model is based on 5 circuit boards which not having the controls mounted on them can if desired be effectively used separately in high performance audio systems not based on our metalwork.

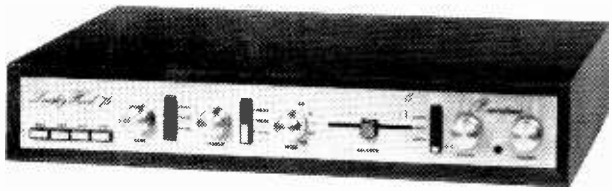
Our new De Luxe model uses 14 boards which interconnect with gold plated contacts and have the potentiometers and switches fitted to them. There are 3 boards for each power amplifier 1 board for the power supply and 7 boards for the stereo pre amplifier. This system almost eliminates internal wiring making construction delightfully straightforward and as each board can be easily removed in seconds from the chassis checking and maintenance is so simple that even newcomers to electronics will be able to cope competently with the kit. Additional features of our new model are inclusion of latest circuit improvements generously sized heatsinks for heavy duty use even in tropical climates and metal oxide resistors throughout for long-term stability and reliability.

PACK PRICES FOR STANDARD KIT

Pack	Price
1. Fibreglass printed circuit board for power amp	£1.15
2. Set of resistors, capacitors, pre-sets for power amp	£2.50
3. Set of semiconductors for power amp	£6.50
4. Pair of 2 drilled, finned heat sinks	£1.10
5. Fibreglass printed-circuit board for pre-amp	£1.90
6. Set of low noise resistors, capacitors, pre-sets for pre-amp	£4.10
7. Set of low noise, high gain semiconductors for pre-amp	£2.40
8. Set of potentiometers (including mains switch)	£3.50
9. Set of 4 push-button switches, rotary mode switch	£5.40
10. Toroidal transformer complete with magnetic screen/ housing primary: 0 117-234 V: secondaries: 33-0-33 V, 25-0-25 V	£10.95
11. Fibreglass printed-circuit board for power supply	£0.85
12. Set of resistors, capacitors, secondary fuses, semiconductors for power supply	£5.40
13. Set of miscellaneous parts including DIN skts., mains input skt., fuse holder, interconnecting cable, control knobs	£6.20
14. Set of metalwork parts including silk screen printed fascia panel and all brackets, fixing parts, etc.	£8.20
15. Handbook	£0.30
16. Teak cabinet 18.3" x 12.7" x 3.1"	£10.70

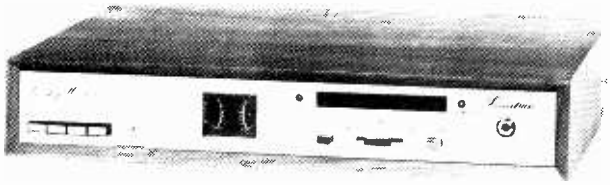
2 each of packs 1-7, 1 each of packs 8-16 inclusive are required for complete stereo amplifier. Total cost of individually purchased packs **£90.80**

STANDARD LINSLEY-HOOD 75W AMPLIFIER



SPECIAL PRICE FOR COMPLETE KIT **£79.80**

LINSLEY-HOOD CASSETTE DECK



SPECIAL PRICE FOR COMPLETE KIT **£79.60**

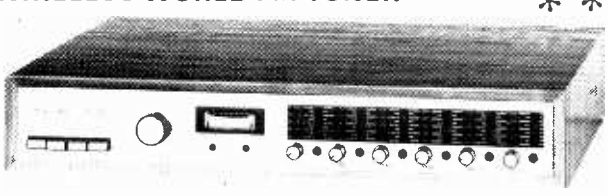
Pack	Price
1. Stereo PCB (accommodates 2 rep. amps. 2 meter amps. bias/erase osc. relay)	£3.35
2. Stereo set of capacitors, M.D. resistors, potentiometers for above	£7.95
3. Stereo set of semiconductors for above	£8.50
4. Miniature relay with socket	£2.90
5. PCB, all components for solenoid, speed control circuits	£3.80
6. Goldring-Lenco mechanism as specified	£18.50
7. Function switch, knobs	£1.90
8. Dual VU meter with illuminating lamp	£6.95
9. Toroidal transformer with E.S. screen prim. 0-117V, 234V. Sec. 15V	£4.90
10 Set of capacitors, rectifiers, I.C. voltage regulator for power supply (Powertran design)	£2.80
11. Set of miscellaneous parts, including sockets, fuse holder, fuses, interconnecting wire, etc	£3.40
12. Set of metalwork including silk screened fascia panel, internal screen, fixing parts, etc	£7.10
13. Construction notes	£0.25
14. Teak cabinet 18.3" x 12.7" x 3.1"	£10.70

One each of packs 1-14 inclusive are required for complete stereo cassette deck. Total cost of individually purchased packs **£83.00**

Matsushita WY 436 AZ head (optional extra) **£4.50**

Published in Wireless World (May June August 1976) by Mr. Linsley-Hood this design although straightforward and relatively low cost nevertheless provides a very high standard of performance. To permit circuit optimization separate record and replay amplifiers are used, the latter using a discrete component front-end designed such that the noise level is below that of the tape background. Push button switches are used to provide a choice of equalization time constants, a choice of bias levels and also an option of using an additional pre-amplifier for microphone use. The mechanism used is the Goldring-Lenco CRV a unit distinguished in its robustness and ease of operation. Speed control and automatic cassette ejection are both implemented by electronic circuitry. This unit which is powered by a toroidal transformer and uses metal oxide resistors throughout offers an excellent match for the Wireless World Tuner and the Linsley-Hood 75 Watt Amplifier. Circuit changes as published in February, 1978, follow-up article are included in the kit. A higher performance head (Matsushita WY 436 AZ) is offered as an optional extra.

WIRELESS WORLD FM TUNER



SPECIAL PRICE FOR COMPLETE KIT **£70.20**

Pack	Price
1. Fibreglass printed board for front end IF strip, demodulator, AFC and mute circuits	£2.15
2. Set of metal oxide resistors, thermistor, capacitors, cermet preset for mounting on Pack 1	£4.80
3. Set of transistors, diodes, LED, integrated circuits for mounting on Pack 1	£5.25
4. Pre-aligned front end module, coil assembly, three section ceramic filter	£8.50
5. Fibreglass printed circuit board for stereo decoder	£1.10
6. Set of metal oxide resistors, capacitors, cermet preset for decoder	£2.60
7. Set of transistors LED, integrated circuit for decoder	£2.90
8. Set of components for channel selector switch module including fibreglass printed circuit board, push-button switches, knobs, LEDs, preset adjusters, etc.	£9.40
9. Function switch, 10 turn tuning potentiometer, knobs	£5.80
10. Frequency meter, meter drive components, fibreglass printed circuit board	£10.35
11. Toroidal transformer with electrostatic screen, Primary: 0-117V 234V, secondary: 15V	£4.90
12. Set of capacitors, rectifiers, voltage regulator for power supply	£2.10
13. Set of miscellaneous parts, including sockets, fuse holder, fuses, inter-connecting wire, etc	£2.05
14. Set of metalwork parts including silk screen printed fascia panel, acrylic silk screen printed tuning indicator panel insert, internal screen, fixing parts, etc.	£8.30
15. Construction notes	£0.25
16. Teak cabinet 18.3" x 12.7" x 3.1"	£10.70

One each of packs 1-16 inclusive are required for complete stereo FM tuner. Total cost of individually purchased packs **£81.15**

Designed in response to demand for a tuner to complement the world-wide acclaimed Linsley-Hood 75W Amplifier this kit provides the perfect match. The Wireless World (Skingley and Thompson) published original circuit has been developed further for inclusion into this outstanding slimline unit and features a pre aligned front end module excellent a m rejection and temperature compensated varicap tuning which may be controlled either continuously or by push button pre-selection. Frequencies are indicated by a frequency meter and sliding LED indicators attached to each channel selector pre-set. The PLL stereo decoder incorporates active filters for birdy suppression and power is supplied via a toroidal transformer and integrated regulator. For long term stability metal oxide resistors are used throughout.

EXPORT A SPECIALITY!

Our Export Department can readily despatch orders of any size to any country in the world. Some of the countries to which we sent kits last year are shown in this advertisement. To assist in estimating postal costs our catalogue gives the weights of all packs and kits. This will be sent free on request by airmail together with our Export Postal Guide which gives current postage prices.

EXPORT ORDERS: No minimum order charge! Prices same as for U.K. customers but no Value Added Tax charged. Postage charged at actual cost plus 50p documentation and handling. Please send payment with order by Bank Draft, Postal Order, International Money Order or cheque drawn on an account in the U.K. Alternatively for orders over £500 we will accept Irrevocable Letter of Credit payable at sight in London.

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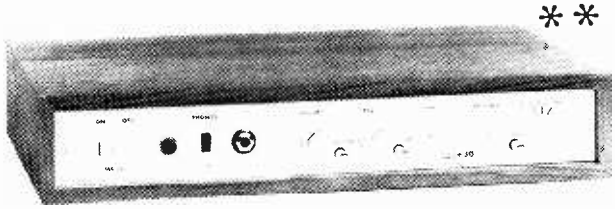
T20+20 AND T30+30 20W, 30W AMPLIFIERS



Designed by Texas engineers and described in Practical Wireless the Texan was an immediate success. Now developed further in our laboratories to include a Toroidal transformer and additional improvements, the slimline T20+20 delivers 20W rms per channel of true Hi-Fi at exceptionally low cost. The **easy to build** design is based on a single F/Glass PCB and features all the normal facilities found on quality amplifiers including scratch and fumble filters, adaptable input selector and headphones socket. In a follow-up article in Practical Wireless further modifications were suggested and these have been incorporated into the T30+30. These include RF interference filters and a tape monitor facility. Power output of this model is 30W rms per channel.

Pack	T20	T30
1. Set of low noise resistors	£1.60	£1.70
2. Set of small capacitors	£2.60	£3.40
3. Set of power supply capacitors	£2.20	£2.50
4. Set of miscellaneous parts	£3.50	£3.50
5. Set of slide, mains, P.B. switches	£1.50	£1.50
6. Set of pots., selector switch	£2.80	£2.80
7. Set of semiconductors, ICs, skts.	£7.25	£7.75
8. Toroidal transformer—240V prim. e.s. screen	£5.60	£7.20

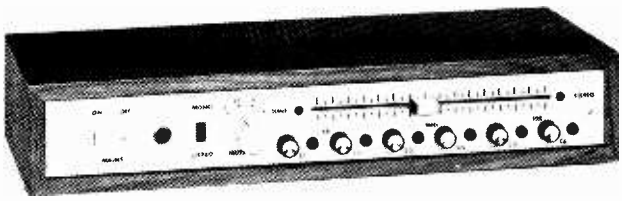
Pack	T20	T30
9. Fibreglass PCB	£3.50	£3.90
10. Set of metalwork, fixing parts	£5.20	£6.20
11. Set of cables, mains lead	£0.40	£0.40
12. Handbook	£0.25	£0.25
13. Teak cabinet 15.4" x 6.7" x 2.8"	£4.50	£4.50

One each of Pack 1-13 are required for complete stereo amplifier. Total cost of individually purchased packs T20+20 £40.90. T30+30 £45.60.

SPECIAL PRICES FOR COMPLETE KITS

T20+20 KIT PRICE £33.10 **T30+30 KIT PRICE £38.40**

WWII TUNER **

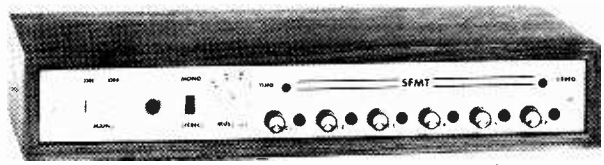


SPECIAL PRICE FOR COMPLETE KIT £47.70

AVAILABLE AS SEPARATE PACKS — PRICES IN OUR FREE CATALOGUE

Following the success of our **Wireless World FM Tuner Kit** this cost reduced model was designed to complement the **T20+20** and **T30+30** amplifiers and the cabinet size, front panel format and electrical characteristics make this tuner compatible with either. The frequency meter of the more advanced model has been omitted and the mechanics simplified, however the circuitry is identical and this kit offers most outstanding value for money. Facilities included are switchable afc, adjustable, switchable muting, LED tuning indication and both continuous and push-button channel selection (readily adjusted by controls on the front panel).

POWERTRAN SFMT TUNER **



PRICE FOR COMPLETE KIT £35.90

AVAILABLE AS COMPLETE KIT ONLY

The requirement was a simple, low cost design which could be constructed easily without special alignment equipment but which still gives a first class output suitable for feeding any of our very popular amplifiers or any other high quality audio equipment. Not finding a suitable published circuit, the requirement was met by design and development work in our own laboratories and this tuner, which uses a pre-aligned front end module can be set up with the aid of nothing more sophisticated than a multi-meter. A phase-locked-loop is used for stereo decoding and controls include switchable afc, switchable muting and push-button channel selection (adjustable by controls on the front panel). This unit matches well with the T20+20 and T30+30 amplifiers.

Wireless World Amplifier Designs. Full kits are not available for these projects but component packs and PCBs are stocked for the highly regarded Bailey and 20W class AB Linsley-Hood designs together with an efficient regulated power supply of our own design. Suitable for driving these amplifiers is the Bailey Burrows pre-amplifier and our circuit board for the stereo version of it features 6 inputs, scratch and fumble filters and wide range tone controls which may be either rotary or slider operating. For tape systems a set of three PCBs have been prepared for the integrated circuit based high performance stereo Stuart design. Details of component packs are in our free Catalogue.

30W Bailey Amplifier	
BAIL Pk 1 F/Glass PCB	£1.00
BAIL Pk 2 Resistors Capacitors Potentiometer set	£2.35
BAIL Pk 3 Semiconductor set	£4.70
20W Linsley-Hood Class AB	
LHAB Pk 1 F/Glass PCB	£1.05
LHAB Pk 2 Resistor Capacitor Potentiometer set	£3.20
LHAB Pk 3 Semiconductor set	£3.35
Regulator Power Supply	
60VS Pk 1 F/Glass PCB	£0.85
60VS Pk 2 Resistor Capacitor set	£2.20
60VS Pk 3 Semiconductor set	£3.10
60VS Pk 6A Toroidal transformer (for use with Bailey)	£8.80
60VS Pk 6B Toroidal transformer (for use with 20W LH)	£7.25
Bailey Burrows Stereo Pre-Amp	
BBPA Pk 1 F/Glass PCB (stereo)	£2.80
BBPA Pk 2 Resistor Capacitor Semiconductor set (stereo)	£6.70
BBPA Pk 3R Rotary Potentiometer set (stereo)	£2.85
BBPA Pk 3S Slider Potentiometer set with knobs (stereo)	£3.10
Stuart Tape Recorder	
TRRP Pk 1 Replay Amp F/Glass PCB (stereo)	£1.30
TRRC Pk 1 Record Amp F/Glass PCB (stereo)	£1.70
TROS Pk 1 Bias Erase/Stabilizer F Glass PCB (stereo)	£1.20

LINSLEY-HOOD LOW DISTORTION OSCILLATOR

A Wien bridge audio oscillator (10Hz 100KHz) with sine or square wave output (1mV-1V) published in Wireless World September, October 1977

Pack 1 Fibreglass PCB	£1.65
Pack 2 Capacitors, 2% metal oxide resistors	£2.60
Pack 3 Transistors IC, IC socket thermistor	£3.90
Pack 4 Potentiometers and switches	£2.80

ERIC F. TAYLOR PRE-AMPLIFIER

A low noise low distortion (0.005%) stereo pre-amplifier for use with magnetic pick-up (RIAA equalization)

Pack 1 Fibreglass PCB (Stereo)	£1.45
Pack 2 Metal oxide resistors, capacitors (Stereo)	£3.20
Pack 3 Transistors ICs IC sockets zeners (Stereo)	£4.20

SQ QUADRAPHONIC DECODERS

These state-of-the-art circuits described by CBS are offered as kits of superior quality with close tolerance capacitors metal oxide resistors and Fibreglass PCBs designed for edge connector insertion. Further information on these kits is given in our FREE CATALOGUE.

M1 Basic matrix decoder	£5.90
L1 Full logic decoder	£17.20
L2A Full logic decoder with variable blend	£22.60
L3A As L2A but with high performance discrete component front end (or with carbon film resistors)	£30.10 £25.90
SQM1-30 Decoder complete with 30W rear channel amplifiers. Complete kit matches T30+30 amplifier	£40.75

Value Added Tax not included in prices

UK Carriage FREE

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April issue on sale March 2nd

SERVICING FACILITIES: (Very rarely required for our kits) are available for all ** complete kits.

QUALITY: All components are brand new first grade full specification guaranteed devices. All resistors (except where stated as metal oxide) are low noise carbon film types. All printed circuit boards are fibreglass, drilled roller tinned and supplied with circuit diagrams and construction layouts.

FOR FURTHER INFORMATION PLEASE WRITE OR TELEPHONE FOR OUR FREE CATALOGUE

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Are proud to offer the only DESIGNER APPROVED kit for the

J. L. Linsley-Hood High Quality Cassette Recorder

Now offered with Super Quality Sendust Alloy Head at no extra cost, and incorporating noise reduction modifications given in the postscript article.

As these circuits are capable of such an excellent performance we feel that it is not sensible to sacrifice this potential by designing a kit down to a price. We have therefore spent a little more on professional hardware allowing us to design a very advanced modular system. This enables a more satisfactory electrical layout to be achieved, particularly around the very critical input areas of the replay preamps. These are totally stable with this layout and require no extra stabilising components. Many other advantages also come from this system which has separate record and replay amps for each channel plugging in to a master board with gold-plated sockets. The most obvious is the reduction of crosstalk and interaction which could cause trouble on a single plane board, with our modular system the layout is compact but there is no component crowding. Testing is very easy with separate identical modules and building with the aid of our component-by-component instructions is childishly simple, but the finished result is a unit designed not to normal domestic standards but tothe best professional practice.

All printed circuits are of glassfibre material, fully drilled with a tinned finish for easy and reliable soldering. Component locations are printed on the reverse side of the board and are arranged so that all identification numbers are still visible after assembly.

71x Complete set of parts for Master Board, includes bias oscillator relay controls, etc £9 83 + £1 23 VAT

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Total cost of all parts £83 58

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Reprint of 3 Linsley-Hood Cassette Recorder articles 45p post and VAT free.

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Super Quality Sendust Alloy R/P Stereo Head for replacement use £6 50 + 81p VAT

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4-track Cassette R/P Head, £7 40 + 93p VAT

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Blank Cassettes, reliable mechanics and Super Ferric Low Noise tape. C90, 80p inc VAT. C10, 35p inc. VAT.

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Farnell International Instruments Ltd, Sandbeck Way, Wetherby, West Yorkshire LS22 4DH Tel Wetherby (0937) 3541
T.E.R. Instrumemnts Ltd, Peel Lane, Astley, Manchester M29 7JH Tel: Atherton (05234) 2275 or 5611
Midlands Instrument Repair Centre, Thorn Automation Ltd, Armitage Road, Rugeley, Staffs Tel Rugeley (08894) 5151

SCOTLAND Falcon Electronics, 92 High Street, Johnstone, Scotland Tel Johnstone (0505) 23377

WALES Electro Services, 25 Chepstow Road, Newport, Gwent NPT 8BX Tel Newport (0633) 211243

LONDON INSTRUMENT REPAIR CENTRE

The manufacturers' joint service organisation.

WW—042 FOR FURTHER DETAILS

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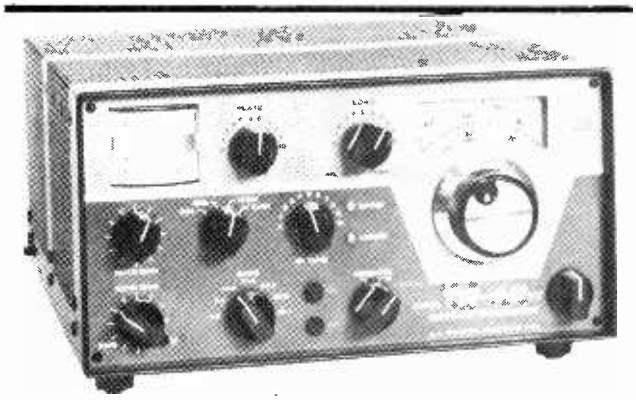

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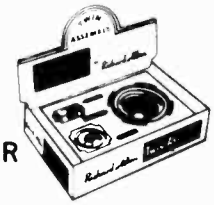

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Celestion G12H	£16.95
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Celestion G12/75 (d/cone)	£24.50
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Fane Pop 100	£35.95
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Richard Allan HD12T	£18.75
Richard Allan HD15	£29.95
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Kits include drive units, crossovers, BAF/Long fibre wool, etc. for pair of speakers. Carriage £3.50.

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Felt panels for PR09-TL	£5.50 + £1.50 p&p
Hifi Answers Monitor (Rogers)	£129.00
Hifi News State of the Art (Atkinson)	£161.00
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Popular Hifi Mini Monitor (Colloms)	£63.00
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Send 3 x 7p stamps for reprints/construction details of any of above designs

CARRIAGE & INSURANCE

Tweeters/Crossovers	40p each
Speakers up to 10"	75p each
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Mag. design kits	£3.50 pair

Prices per pair. Carriage £2.50.

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NEW PRODUCTS!

NRDC-AMBISONIC UHJ

SURROUND SOUND DECODER

The **first ever** kit specialy produced by Integrex for this British NRDC backed surround sound system which is the result of 7 years' research by the Ambisonic team. W.W. July, Aug., '77.
The unit is designed to decode not only UHJ but virtually all other 'quadrophonic' systems (Not CD4), including the new BBC HJ 10 input selections.
The decoder is linear throughout and does not rely on listener fatiguing logic enhancement techniques. Both 2 or 3 input signals and 4 or 6 output signals are provided in this most versatile unit. Complete with mains power supply, wooden cabinet, panel, knobs, etc.

Complete kit, including licence fee **£45.00** + VAT
or ready built and tested **£61.50** + VAT

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With Home Office Type approval
As in "Wireless World", designed by Mike Hosking. 240V ac mains operated and disguised as a hardbacked book. Detection range up to 30 feet.

Complete exclusive designer approved kit **£46.00** + VAT
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Wireless World Dolby™ noise reducer

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Featuring:
- switching for both encoding (low-level h.f. compression) and decoding
- a switchable f.m. stereo multiplex and bias filter.
- provision for decoding Dolby f.m. radio transmissions (as in USA).
- no equipment needed for alignment.
- suitability for both open-reel and cassette tape machines.
- check tape switch for encoded monitoring in three-head machines.

Typical performance
Noise reduction better than 9dB weighted.
Clipping level 16 5dB above Dolby level (measured at 1% third harmonic content)

Harmonic distortion 0.1% at Dolby level typically 0.05% over most of band, rising to a maximum of 0 12%

Signal-to-noise ratio. 75dB (20Hz to 20kHz, signal at Dolby level) at Monitor output

Dynamic Range >90db

30mV sensitivity

Complete Kit **PRICE: £39.90**+VAT

Also available ready built and tested . . . . . **Price £54.00**+VAT

Calibration tapes are available for open-reel use and for cassette (specify which) . . . . . **Price £2.20**+VAT *

Single channel plug-in Dolby™ PROCESSOR BOARDS (92 x 87mm) with gold plated contacts are available with all components . . . . . **Price £8.20**+VAT

Single channel board with selected fet . . . . . **Price £2.50**+VAT

Gold Plated edge connector . . . . . **Price £1.50**+VAT *

Selected FETs **60p** each+VAT, **100p**+VAT for two, **£1.90**+VAT for four

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

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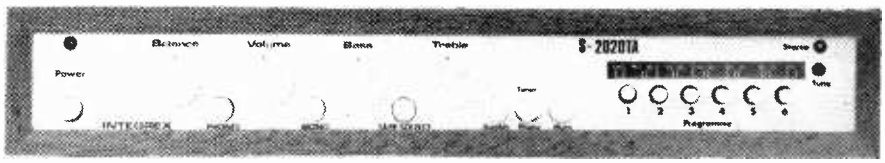
S-2020TA STEREO TUNER/AMPLIFIER KIT

SOLID MAHOGANY CABINET



A high-quality push-button FM Varicap Stereo Tuner combined with a 24W r.m.s. per channel Stereo Amplifier.

Brief Spec. Amplifier Low field Toroidal transformer, Mag, input, Tape In/Out facility (for noise reduction unit, etc.), THD less than 0.1% at 20W into 8 ohms. Power on/off FET transient protection. All sockets, fuses, etc., are PC mounted for ease of assembly. Tuner section uses 3302 FET module requiring no RF alignment, ceramic IF, INTERSTATION MUTE, and phase-locked IC stereo decoder. LED tuning and stereo indicators. Tuning range 88—104MHz. 30dB mono S/N @ 1.2μV. THD 0.3%. Pre-decoder 'birdy' filter.

PRICE: £58.95 + VAT

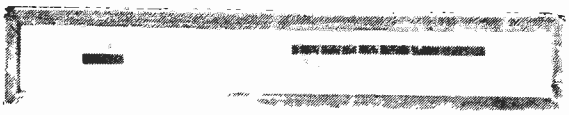
NELSON-JONES STEREO FM TUNER KIT

A very high performance tuner with dual gate MOSFET RF and Mixer front end, triple gang varicap tuning, and dual ceramic filter/dual IC IF amp.

Brief Spec. Tuning range 88—104MHz. 20dB mono quieting @ 0.75μV. Image rejection — 70dB. IF rejection — 85dB. THD typically 0.4%.
IC stabilized PSU and LED tuning indicators. Push-button tuning and AFC unit. Choice of either mono or stereo with a choice of stereo decoders.

Compare this spec. with tuners costing twice the price.

Mono £32.40 + VAT
With ICPL Decoder £36.67 + VAT
With Portus-Haywood Decoder £39.20 + VAT

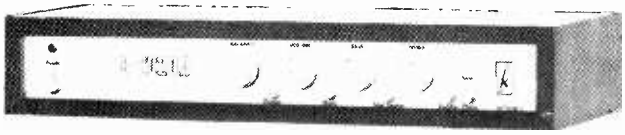


STEREO MODULE TUNER KIT

A low-cost Stereo Tuner based on the 3302 FET RF module requiring no alignment. The IF comprises a ceramic filter and high-performance IC Variable INTERSTATION MUTE. PLL stereo decoder IC. Pre-decoder 'birdy' filter Push-button tuning

Sens. 30dB S/N mono @ 1.2μV
THD typically 0.3%
Tuning range 88—104MHz
LED sig. strength and stereo indicator

PRICE: Stereo £31.95 + VAT



S-2020A AMPLIFIER KIT

Developed in our laboratories from the highly successful "TEXAN" design. PC mounting potentiometers, switches, sockets and fuses are used for ease of assembly and to minimize wiring

Power 'on/off' FET transient protection.

Typ Spec. 24+24W r.m.s. into 8-ohm load at less than 0.1% THD. Mag. PU input S/N 60dB. Radio input S/N 72dB. Headphone output. Tape In/Out facility (for noise reduction unit, etc.). Toroidal mains transformer.

PRICE: £33.95 + VAT

ALL THE ABOVE KITS ARE SUPPLIED COMPLETE WITH ALL METALWORK, SOCKETS, FUSES, NUTS AND BOLTS, KNOBS, FRONT PANELS, SOLID MAHOGANY CABINETS AND COMPREHENSIVE INSTRUCTIONS.

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CA3028A	1.01	LM388N	0.90	SN76008K	1.50	TBA510	2.21	C04009	0.64	TIC 47	0.67
CA30288	1.29	LM389N	1.00	SN76013N	1.30	TBA510Q	2.30	C04010	0.64	BST0246	1.35
CA3030	1.35	LM702C	0.75	SN76013NO	1.50	TBA520	2.21	C04011	0.24		
CA3036	1.10	LM709C	0.65	SN76018K	1.45	TBA520Q	2.30	C04012	0.24	**BRIDGE RECTIFIERS**	
CA3045	1.40	LM709N	0.45	SN76023N	1.45	TBA530	1.98	C04013	0.60	B40 C1500	0.48
CA3046	0.89	LM710C	0.60	SN76023NO	1.26	TBA530Q	2.07	C04014	1.15	2N929	0.25
CA3048	2.23	LM710N	0.60	SN76033N	2.20	TBA540	2.21	C04015	1.15	PW005	0.84
CA3049	1.80	LM723C	0.85	SN76110N	1.18	TBA540Q	2.30	C04016	0.64	PW01	0.86
CA3052	1.62	LM723N	0.75	SN76115N	1.51	TBA550	3.13	C04017	1.15	PW02	0.88
CA3053	0.60	LM741C	0.65	SN76116N	1.66	TBA550Q	3.22	**DIL SOCKETS**		PW04	0.98
CA3080	0.75	LM741N	0.40	SN76131N	1.20	TBA560Q	3.22	8 pin	0.15	PW08	1.18
CA3080A	1.88	LM7141-8	0.40	SN76226N	1.56	TBA570	1.29	14 pin	0.16	K005	2.10
CA3086	0.60	LM747CN	0.90	SN76227N	1.20	TBA570Q	1.38	16 pin	0.18	K01	2.16
CA3088	1.70	LM748-8	0.55	SN76228N	1.41	TBA641Q	2.70	18 pin	0.27	K02	2.48
CA3089	2.52	LM748N	0.55	SN76530N	0.75	TBA651	2.20	22 pin	0.30	K04	3.12
CA3090	4.00	LM1800	1.76	SN76582N	1.40	TBA700	1.52	24 pin	0.35	K06	3.86
CA3130	0.98	LM1808	1.92	SN76533N	1.20	TBA700Q	1.61	28 pin	0.45	BY164	0.57
LM307A	0.67	LM1828	1.75	SN76544N	1.44	TBA702Q	2.30	40 pin	0.55		
LM307N	0.40	LM3302N	0.85	SN76545N	1.65	TBA750	1.98			**RAMS**	
LM304	2.45	LM3307N	0.85	SN76546N	1.44	TBA750Q	2.07	**TRIACS**		MM2101-2N	3.00
LM307N	0.65	LM3401N	0.70	SN76550N	0.35	TBA800	1.25	Plastic		MM2102-2N	2.10
LM308N	0.85	LM3900	0.75	SN76552N	0.52	TBA810	1.25	400V 6A	0.70	MM2111-2N	3.00
LM309K	1.85	LM3905	1.60	SN76570N	1.65	TBA820	1.25	400V 8A	0.75	MM2112-2N	3.00
LM317K	3.00	LM3909	0.68	SN76620N	0.90	TBA920	2.90	400V 12A	0.85	MM74920D	12.57
LM318N	2.26	MC1035	1.75	SN76650N	1.10	TBA920Q	2.99	400V 16A	1.10		
LM323K	6.46	MC1327P	1.54	SN76660N	0.60	TBA940	1.62	400V 20A	1.70	**ROMS**	
LM339N	1.40	MC1330P	1.00	SN76666N	0.92	TCA160C	1.85	400V 25A	2.00	MM5214	26.95
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LM360N	2.75	MC1352P	1.10	TAA320A	1.00	TCA270	2.25	Plastic		**PROMS**	
LM370N	2.50	MC1433G	3.30	TAA521	1.00	TCA280A	1.30	100V 4A	0.35	DM74S287	5.33
LM371H	1.70	MC1435G	2.00	TAA522	1.90	TCA290A	3.13	200V 4A	0.40	MM5204Q	10.95
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LM377N	1.75	MC1455G	1.70	TAA611B	1.85	TCA750	2.30	200V 8A	0.49	**SC/MP CHIPS**	
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LM382N	1.25	SAS570	2.50	TB120	0.75	C04002	0.24	400V 12A	0.81	DP8228D	7.30
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LM386N	0.80	SN76001N	1.30	TBA500	2.21	CD4007	0.24	TIC 44	0.32		

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2N698	0.62	2N3791	3.10	AF125	0.65	BC258A	0.17	BF160	0.30	MJE340	0.58
2N706	0.28	2N3794	0.20	AF139	0.69	BC259B	0.18	BF166	0.40	MJE370	0.58
2N708	0.28	2N3820	0.38	AF200	1.20	BC262B	0.24	BF173	0.35	MJE371	0.60
2N718	0.27	2N3904	0.21	AF240	1.14	BC263C	0.30	BF178	0.25	MJE520	0.45
2N720A	0.80	2N4036	0.67	AF280	0.85	BC301	0.40	BF180	0.35	MJE2955	1.50
2N916	0.30	2N4058	0.20	BC108	0.15	BC303	0.50	BF182	0.35	MJE3055	0.95
2N929	0.25	2N4060	0.20	BC113	0.20	BC308	0.15	BF184	0.38	MP8111	0.35
2N1131	0.30	2N4062	0.18	BC115	0.20	BC309C	0.15	BF194	0.15	MP8112	0.40
2N1613	0.30	2N4289	0.20	BC116A	0.20	BC318	0.13	BF196	0.15	MP8113	0.45
2N1893	0.38	2N4920	0.75	BC117	0.22	BC328	0.19	BF198	0.18	MPF102	0.30
2N2218	0.33	2N4922	0.55	BC118	0.20	BC338	0.21	BF200	0.35	MPSA05	0.25
2N2219	0.35	2N5190	0.60	BC121	0.45	BC547	0.12	BF225J	0.15	MPSA05	0.25
2N2220	0.35	2N5192	0.75	BC134	0.20	BC548	0.12	BF244	0.35	MPSA12	0.40
2N2221A	0.26	2N5245	0.34	BC136	0.19	BCY30	1.00	BF246	0.75	MPSA55	0.25
2N2222A	0.25	2N5295	0.40	BC140	0.35	BCY31	1.00	BF255	0.24	MPSU05	0.50
2N2369	0.25	2N5298	0.40	BC142	0.30	BCY33	1.00	BF257	0.37	MPSU55	0.55
2N2645	0.75	2N5448	0.15	BC147	0.12	BCY38	2.00	BF258	0.45	TIP29A	0.45
2N2904	0.36	2N5457	0.32	BC149	0.14	BCY58	0.25	BF259	0.49	TIP29C	0.60
2N2905	0.37	2N5459	0.29	BC154	0.27	BCY59	0.25	BF459	0.50	TIP30A	0.49
2N2906	0.28	2N5486	0.38	BC158	0.14	BCY71	0.26	BFS21A	2.60	TIP30C	0.65
2N2907	0.25	2N6101	0.45	BC159	0.16	BD115	0.80	BFS28	1.38	TIP31C	0.66
2N2924	0.15	2N6109	0.50	BC160	0.35	BD116	1.20	FBS61	0.30	TIP32A	0.55
2N3019	0.55	2N6122	0.41	BC167	0.12	BD131	0.51	BFS98	0.30	TIP33A	0.80
2N3054	0.60	40361	0.50	BC169	0.12	BD135	0.37	BFX30	0.35	TIP34A	0.90
2N3390	0.20	40362	0.55	BC170	0.18	BD136	0.37	BFX84	0.35	TIP35A	2.50
2N3391A	0.20	40406	0.60	BC172	0.14	BD137	0.38	BFX87	0.30	TIP46A	2.80
2N3393	0.15	40407	0.52	BC177	0.20	BD139	0.40	BFX88	0.30	TIP41A	0.70
2N3939	0.88	40409	0.75	BC179	0.23	BD140	0.40	BFY50	0.25	TIP42A	0.80
2N3441	0.81	40410	0.75	BC182	0.11	BD239	0.40	BFY51	0.25	TIP42C	1.00
2N3638	0.16	40594	0.80	BC183	0.11	BD241	0.45	BFY52	0.30	TIP2955	0.65
2N3639	0.30	40595	0.90	BC183L	0.14	BD243	0.60	BFY53	0.34	TIS43	0.43
2N3702	0.13	AC126	0.45	BC184L	0.14	BD244	0.65	BRY39	0.50		
2N3704	0.15	AC127	0.45	BC207	0.16	BD245	0.65	BSX20	0.33		
2N3706	0.16	AC151V	0.40	BC212	0.14	BD529	0.45	BSX21	0.32		
2N3708	0.13	AC152V	0.50	BC212L	0.17	BD530	0.50	BU205	2.20		
2N3710	0.16	AC153K	0.55	BC213L	0.16	BDY20	1.00	ME0402	0.20		
2N3712	1.20	AC176K	0.65	BC214	0.16	BF115	0.38	ME0412	0.20		
2N3714	2.45	AC187K	0.60	BC237	0.14	BF121	0.55	ME4102	0.10		
2N3716	3.00	AD161	1.00	BC238	0.12	BF152	0.25	ME4104	0.10		
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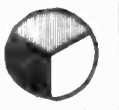
TV GAMES



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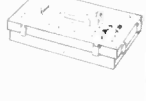

S-DeC **£2.23**. T-DeC **£3.98**. u-DeC-A **£3.97**. u-DeC-B **£6.67**. 16 dil adaptors — push in **99p**. With socket **£1.91**. New S-de kit **£4.95**.

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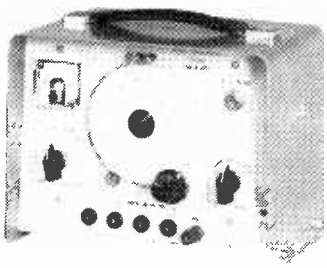

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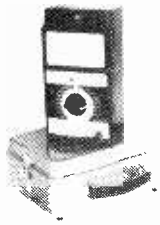

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Sensitivity A C	2,000 o p v	2,000 o p v
D C Current	60μA-1 5A	50μA-2 5A
A C Current	0 6mA-1 5A	0 5mA-2 5A
D C Volts	75m V-600V	75mV-1000V
A C Volts	15V-600V	1V-1000V
Resistance	1K-1M	300Ω-500kΩ
Capacity	0 5μF	0 5μF
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0A3	0.75	6J6	0.55	EY81	0.50	PY31	0.50
0B2	0.60	6L6GT	0.85	EY87	0.50	PY33	0.63
0C3	0.75	6SL7GT	0.70	EY88	0.55	PY80	0.60
1B3GT	0.65	6SN7GT	0.70	EY500A	1.50	PY81	0.70
1R5	0.50	12AL5	0.65	EZ80	0.50	PY82	0.55
1X2B	1.20	12AQ5	0.55	EZ81	0.50	PY83	0.70
5R4GY	1.10	12AT6	0.60	KT66	4.50	PY88	0.75
5U4G	0.60	12AT7	0.50	KT88	5.80	PY500A	1.30
5U4GB	0.95	12AU6	0.65	PC86	0.85	TT21	7.80
5V4G	0.60	12AU7	0.47	PC88	0.85	TT22	7.80
5Y3GT	0.65	12AV6	0.85	PC92	0.85	UABC80	0.58
5Z4GT	0.65	12AV7	1.00	PC96	0.50	UAF41	0.80
6AB4	0.55	12AX7	0.55	PC97	0.95	UAF42	0.70
6AJ5	0.65	12AY7	0.85	PCC84	0.50	UBC41	0.70
6AK5	0.55	12BA6	0.65	PCC85	0.60	UBC81	0.60
6AL5	0.40	12BE6	0.80	PCC89	0.75	UBF80	0.60
6AM6	0.70	12BH7	0.75	PCC189	1.00	UBF89	0.60
6AS5	0.75	12X4	0.50	PCF80	0.65	UCC84	0.75
6AS6	1.00	19AQ5	0.75	PCF82	0.45	UCC85	0.55
6AT6	0.75	35A3	0.70	PCF84	0.65	UCF80	0.75
6AV6	0.75	35B5	0.65	PCF201	1.10	UCH81	0.65
6AW8A	0.75	35C5	0.70	PCL81	0.65	UCL81	0.70
6AU6	0.50	35W4	0.70	PCL82	0.80	UCL82	0.75
6AV6	0.75	50C5	1.00	PCL84	0.75	UCL83	0.80
6BA6	0.45	EABC80	0.55	PCL86	0.85	UF41	1.00
6BE6	0.48	EAF42	0.70	PCL805	0.75	UF80	0.50
6BJ6	1.20	EAF801	0.70	PD510	3.35	UF85	0.50
6BN6	0.80	EBC41	0.75	PL36	1.10	UF89	0.55
6BZ6	0.65	EBC81	0.70	PL38	0.65	UL41	0.80
6BZ7	0.70	EBF80	0.50	PL81	0.80	UL84	0.85
6C4	0.55	EBF83	0.50	PL82	0.55	UM80	0.60
6CB6	0.55	EBF89	0.45	PL83	0.50	UM84	0.45
6CD6	2.20	EC86	0.75	PL84	0.75	UY42	0.60
6GK5	0.70	EC88	0.75	PL95	0.70	UY82	0.60
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ECC189	0.80	EF86	0.60
ECF80	0.60	EF97	0.70
ECF82	0.55	EF98	0.90
ECF86	0.80	EF183	0.70
ECF200	0.90	EF184	0.70
ECF201	0.90	EFL200	1.20
ECF801	0.95	EL36	0.95
ECF802	0.95	EL41	0.80
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ECH81	0.55	EL82	0.60
ECH83	0.60	EL83	0.60
ECH84	0.55	EL84	0.45
ECH200	0.80	EL86	0.75
ECL80	0.60	EL95	0.70
ECL81	0.75	EL504	0.80
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ECL83	1.15	EM81	0.60
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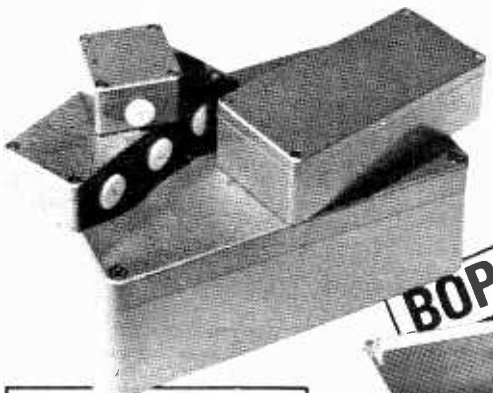

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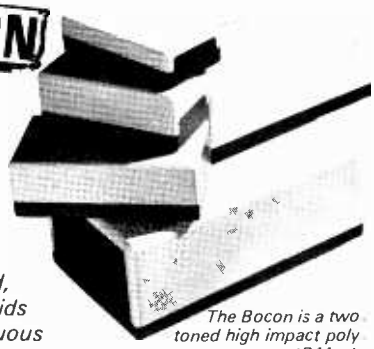
BOCON



BOPAL

All the Bopla range, with the exception of BOCON are to IP65 standard, being very accurately made. Their lids are sealed by a recessed continuous ring gasket, which will also resist petrol and oil. Fixing screws are outside the sealed chamber, but inside the case. Bopal are aluminium and Boplast either polycarbonate or glass polyester. Certain sizes can have clear covers.

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BOC 420	100	50	40	1.85
BOC 430	120	65	40	2.01
BOC 440	150	80	55	2.26
BOC 445	150	80	80	2.88
BOC 450	188	110	70	2.97
BOC 460	188	110	100	3.39

Aluminium

	L	B	H			L	B	H	
A100	50	45	30	2.47	A124	360	120	80	18.35
A101	58	64	34	3.54	A125	160	160	90	15.59
A102	98	64	34	4.16	A130	260	160	90	19.45
A103	150	64	34	5.64	A135	360	160	90	24.27
A105	75	80	57	5.18	A138	560	160	90	37.25
A110	125	80	57	6.76	A140	200	230	110	33.37
A115	175	80	52	7.70	A160	330	230	110	44.07
A117	250	80	52	10.85	A165	330	230	180	62.42
A120	122	120	90	11.78	A168	400	230	110	57.17
A123	220	120	90	14.27	A195	420	240	210	54.06

Polycarbonate

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M206	65	50	35	2.84	M240	250	160	90	10.23
M210	82	80	55	3.75	M240/1	240	160	90	10.23
M215	120	80	55	4.27	M241	250	160	120	13.73
M217	122	120	65	5.68	M242	240	120	100	9.00
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M223	200	150	75	9.00	M245	340	150	120	17.15
M225	82	80	85	4.27	M250	250	160	150	13.69
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M227	122	120	85	6.46	M253	300	230	85	17.19
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M231	160	80	65	5.57					

Glass Polyester

	L	B	H			L	B	H	
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P311	110	75	50	7.43	P327	230	75	75	11.86
P316	160	75	50	8.47	P328	190	100	90	15.55
P319	190	75	50	9.25	P330	160	160	90	20.01
P322	230	75	50	10.04	P333	260	160	90	24.77
P323*	55	55	58	5.95	P334	360	160	90	30.88
P324	110	75	75	8.35	P355	400	250	120	57.60
P325	160	75	75	9.10					

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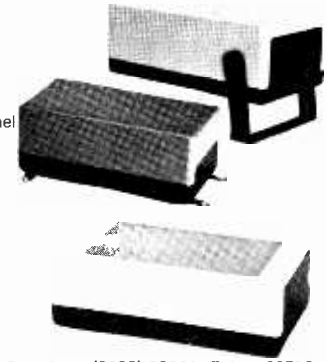
Bocon handles, mounting brackets and aluminium panel versions are also available



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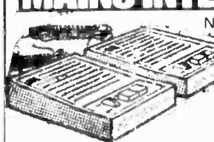

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153	350	16.28	1 84
154	500	19.15	2 15
155	750	29.06	OA
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106	4 0	10.70	1.50
107	6.0	14.62	1.64
118	8.0	17.05	2 08
119	10.0	21.70	OA

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79	1 0	3.57	96
3	2.0	5.27	96
20	3 0	6.20	1 14
21	4 0	7.44	1 14
51	5 0	8.37	1 32
117	6.0	9.92	1 45
88	8.0	11.73	1 64
89	10 0	13.33	1 84

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124	0 5	3.88	96
126	1.0	5.58	96
127	2 0	7.60	1 14
125	3.0	10.54	1 32
123	4 0	12.23	1 84
40	5 0	13.95	1 64
120	6.0	15.66	1 84
121	8 0	20.15	OA
122	10.0	24.03	OA
189	12.0	27.13	OA

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66	300	.. ..	7.75	1 14
67	500	.. ..	10.99	1.64
84	1000	.. ..	18.76	2.08
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207	500, 500	0-8-9, 0-8-9	2.59	71
208	1A, 1A	0-8-9, 0-8-9	3.53	78
236	200, 200	0-15, 0-15	1.99	38
239	50MA	12-0-12	1.99	38
214	300, 300	0-20, 0-20	2.56	78
221	700 (DC)	20-12-0-12-20	3.41	78
206	1A, 1A	0-15-20, 0-15-20	4.63	96
203	500, 500	0-15-27, 0-15-27	3.99	96
204	1A, 1A	0-15-27, 0-15-27	5.39	96
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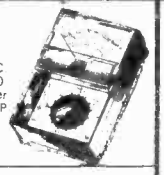

MULTI RANGE METERS Type MF15A. A.C./D.C. volts 10 50 250 500 1000 Ma 0·5 0-10 0-100. Sensitivity 2000V. 24 range, diameter 133 x 93 x 46mm. Price **£6.50** plus 50p P&P (**£7.56** inc. VAT & P)

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Raytheon tag symmetrical Triac. Type Tag 250/500v. 10 amp 500 prv. Glass passivated plastic triac. Swiss precision product for long term reliability **£1.25** P&P 10p (**£1.46** inc. VAT & P) (inclusive of date and application sheet). Suitable Diac **22p.**

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Double pole 15 amp 230AC. Contacts (no dial) **£1.50.** P&P 30p (**£1.94** inc. VAT & P)

MERCURY SWITCH

Size 27mm x 5mm. 10 for **£5.00** (inc. VAT **£5.72**) Min. quantity 10

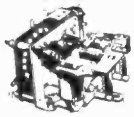
CONTACTOR

Mfg. by Hendrey Relays. type C2839 220/250 AC ops. Contact 4C/O at 20 amp at 440 volts AC. price **£6.00** P&P 75p (**£7.29** inc. VAT & P)

230 VOLT AC FAN ASSEMBLY

Powerful continuously rated AC motor complete with 5 blade 6½" aluminium fan. New reduced price **£3.00** P&P 65p (**£3.94** inc. VAT & P)

21-WAY SELECTOR SWITCH with reset coil



The ingenious electro mechanical device can be switched up to 21 positions and can be reset from any position by energising the reset coil. 230/240v. A.C. operation. Unit is mounted on strong chassis. Complete with cover. Price **£5.50** P&P 75p (**£6.75** inc. VAT & P)

VORTEX BLOWER AND VACUUM UNIT

Dynamically balanced to tally enclosed 9" rotor with max. air delivery of 1·5 cubic metres per min. Max. static pressure 600mm W.G. Suction or blow from 2 side-by-side 37mm I.D. circular apertures fitted to base of unit. Powerful continuously rated 115v.a.c. motor mounted on alloy base with fixing facilities. Dimensions: Length 22cm x width 25cm x height 25cm.

These units are ex-equipment but have had minimum use. Fully tested prior to despatch. Price **£12** + £1.50 P&P (**£14.58** inc. VAT & P). Suitable transformer for 230/240v.a.c. **£6** + £1 P&P (**£7.56** inc. VAT & P)

CENTRIFUGAL BLOWER

Mfg. by Smiths Industries 230/240v a.c. Miniature Model Series SE7200. Size 95mm x 82mm x 82mm. Aperture 38mm x 31mm. 12 c.f.m. **£2.75.** Post 50p (**£3.51** inc. VAT & P)

Smith type FFB 1906 022 220. 240v A.C. Aperture 10x4½cm overall size 16x14cm. Price **£3.75** p&p 75p (inc. VAT **£4.86**). Other types available phone for details.

NI-CAD BATTERIES

		Height (mm)	Width (mm)	Length (mm)
23 AH 1·2v Plastic Case	£4	214	79	27
35 AH 1·2v Metal	£6·50	219	75	29
40 AH 1·2v Plastic Case	£8	275	80	35

Postage 30p per unit

UNISELECTOR SWITCH

4 bank. 25 way 75 ohm coil. 36·48v D.C. operation. Ex **new** equipment. **£4.25,** P&P 75p. Total price inc. VAT. **£5.40.**

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12v. 11 way 4 bank (3 non-bridging, 1 homing). **£2.50** P&P 35p (**£3.08** inc. VAT & P)

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As illustrated but fitted with 1" Lever. 10 for **£2.00** P&P 30p (**£2.48** inc. VAT & P)

Sub-miniature Burgess type v 41 1. 10 for **£2.50** P&P 30p (**£3.02** inc. VAT & P)

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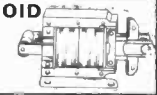
Type 3 115M 906T. 10 for **£2.50** post paid (**£2.70** inc. VAT & P)

Unimax USA. 10 for **£4.00** plus 50p P&P (min. order 10) (**£4.86** inc. VAT & P)

NEW HEAVY DUTY SOLENOID



Mfg. by Magnetic Devices. 240v A.C. Operation approx. 20lb pull at 1·25". Price **£7.00** P&P 75p (**£8.37** inc. VAT & P)

Similar to above approx. 10lb pull **£3.50** P&P 60p (**£4.43** inc. VAT & P)

230-250 VOLT A.C. SOLENOID

Similar in appearance to illustration. Approximately 1½lb. pull. Size of feet 1⅜" x 13/16". Price **£1.00** Post 25p (**£1.35** inc. VAT & P)

24 VOLT D.C. SOLENOIDS

UNIT containing **1 heavy duty solenoid approx. 25 lb. pull** at 1 in. travel. 2 solenoids of approx. 1 lb. pull at ½ in. travel. 6 solenoids of approx. 4 oz. pull at ½ in. travel. Plus 1 24V D.C. 1 heavy duty 1 make relay. Price. **£3.00** Post £1.00 (**£4.32** inc. VAT & P)

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240 A.C. SOLENOID OPERATED FLUID VALVE

Rated 1 p.s.i. will handle up to 7 p.s.i. Forged brass body, stainless steel core and spring ½ in. b.s.p. inlet outlet. Precision made. British mfg.

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Carriage extra

INPUT 230 v. A.C. 50/60

OUTPUT VARIABLE 0/260v. A.C.

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0.5 KVA (Max. 2½ Amp) .. **£15.00**

1 KVA (Max. 5 Amp) **£19.50**

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3 KVA (Max. 15 Amp) **£39.50**

4 KVA (Max. 20 Amp) **£60.00**

LT TRANSFORMERS

0-12v/24v at 1 amp **£2.50** p&p 50p (**£3.24** inc. VAT & P)

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0-6v/12v/17v/18v/20v at 20 amp. **£14.00** p&p £1·50 (**£16.74** inc. VAT & P)

0-6v/12v at 20 amp. **£11.85** p&p £1·00 (**£13.88** inc. VAT & P)

Other types in stock, phone in enquiries.

300 V.A. ISOLATING TRANSFORMER

115/230 screened primary, two separate or 115v for 115 or 230v. Secondary two 115v at 150 V.A. each for 115 or 230v output. Can be used in series or parallel connections. Fully tropicalised. Length 13·5cm., width 11cm., weight 15lbs. Special price **£6.00,** carr. £1·00 (**£7.56** inc. VAT & P)

COMPRESSOR,

precision built by Emerson USA. Horizontally opposed twin head diaphram type producing 20lbs. Plus P.S.I. per head 3·5 plus C.F.M. Output virtually pulse free. Powered by 110v A.C. motor size 30x23x15cm. weight 7 kilos. **Price £20** p&p £2·00 (inc. VAT **£23.76**). Suitable transformer for 230/240v A.C. **£8.00** p&p £1·00 (inc. VAT **£9.72**).

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HY-LIGHT STROBE KIT Mk. IV

Latest type Xenon white light tube. Solid state timing and triggering circuit. 230/240 volt A.C. operation. Speed adjustable 1-20 f.p.s. Designed for large rooms, halls, etc. Light output greater than many (so called 4 Joule) strobes. Price **£18.00** post £1 (**£20.56** inc. VAT & P). Specially designed case and reflector for Hy-Light **£8.25** Post £1·00 (**£9.99** inc. VAT & P).

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4ft. 40 watt £7.75 (callers only). **2ft. 20 watt £5.50.** Post 60p (For use in stan bi-pin fittings). Mini **12in. 8 watt £2.50.** Post 25p (**£2.97** inc. VAT & P). 9in. 6watt **£2.00** Post 25p (**£2.43** inc. VAT & P). 6in. 4 watt **£1.75** Post 25p) (**£2.16** inc. VAT & P).

Complete ballast unit. Either 6'', 9'' or 12'' tube 230V. A.C. op. **£3.50** plus P&P 40p (**£4.21** inc. VAT & P). Also available for 12V D.C. op. **£3.50** plus P&P 40p (**£4.21** inc. VAT & P)

XENON FLASH GUN TUBES

Range of Xenon tubes available from stock. S.A.E. for full details

RELAYS

Wide range of AC and DC relays available from stock. Phone or write in your enquiries.

230/240V A.C. Relays: Arrow. 2 c/o. 15 amp **£1.50** (**£1.84** inc. VAT & P)

T.E.C. open type 3 c/o. 10 amp **£1.10** (**£1.40** inc. VAT & P). Mag. Devices 2 c/o. 20 amp **£1.50** (**£1.84** inc. VAT & P). Omoron or Keyswitch 1 c/o. 7 amp **£1.00** (**£1.30** inc. VAT & P)

D.C. Relays: Open type 9/12V 3 c/o 7 amp **£1.00** (**£1.30** inc. VAT & P). Sealed 12V 1 c/o 7 amp octal base. **£1.00** (**£1.30** inc. VAT & P). Sealed 12V 2 c/o 7 amp octal base. **£1.25** (**£1.56** inc. VAT & P). Sealed 12V 3 c/o 7 amp 11-pin **£1.35** (**£1.67** inc. VAT & P). 24V. Sealed 3 c/o 7 amp 11-pin **£1.35** (**£1.67** inc. VAT & P) (amps = contact rating). P&P on any Relay 20p.

Other types available — phone for details

RESET COUNTER

230 volts AC 3 digits mfg. Veeder Root type LL7144L. **£1.75** P&P 25p (**£2.16** inc. VAT & P)

7 fig. 24v d.c. non set **£1.50** P&P 25p (**£1.89** inc. VAT & P)

6 fig. 24v d.c. resetable **£3.00** P&P 25p (**£3.51** inc. VAT & P)

BIG INCH

Tiny precision built 3 rpm USA motor size only 1 x 1·100 volt AC op. supplied with resistor for 230 volt AC price **£2.37** p&p 20p. 4 for **£5.40** post paid

INSULATION TESTERS (NEW)

Test to I.E.E. spec. Rugged metal construction suitable for bench or field work. constant speed clutch. Size L 8 in. W 4 in. H 6 in. weight 6 lb.

500 VOLTS 500 megohms

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100 R.P.M. 115 lbs. ins.!!

115 lb. ins. 110 volt, 50Hz, 2·8 amp, single phase, split capacitor motor. Immense power. Continuously rated. Totally enclosed. Fan cooled. In-line gearbox. Length 250mm. Dia. 135mm. Spindle Dia. 15·5mm. Length 145mm. ex-equipment tested **£12.00** Post £1·50 (**£14.58** inc. VAT & P). Suitable transformer 230/240 volt **£8.00** Post 75p (**£9.45** inc. VAT & P)

BODINE TYPE N.C.I. GEARED MOTOR

(Type 1) 71 r.p.m. torque 10 lb. in. **Reversible.** 1/70th h.p. cycle. 38 amp. This U.S.A. motor is offered in with transformer for 230/240v. A.C. input. Price type **£6.25** Post 75p (**£7.56** inc. VAT & P), or less transformer **£3.75** Post 65p (**£4.75** inc. VAT & P). (Type 3) 71 r.p.m. 230 volt A.C. Continuously rated. Non reversible **£6.50** Post 75p (**£7.83** inc. VAT & P)

FRACMO

50 rpm. 50lbs. ins. 240VAC. reversible. 0·7 amp. shaft length 30mm. dia. 1lb. ins. weight 6 kilos 600 grams. Price **£15.00** P&P 1·50 (**£17.82**). inc. VAT.

PARVALUX GEARED MOTOR

Type SD18 240v AC reversible 30 rpm 50lbs inch. Price **£15.00** P&P 1·50 (**17.82** inc. VAT).

A.E.G. WATER PUMP

200/240v a.c. motor. 2850 rpm. 480w approx. 1/3 hp. driving a centrifugal pump with 1½" inlet and outlet delivering approx. 40 galls. per min. at 10ft. head. Ideal for pumping or circulating any non corrosive light viscosity liquid. Dozens of uses in industrial labs. etc. Note this pump is not self-priming. Price **£15** + 75p P&P (**£17.01** inc. VAT & P)

CITENCO 19 RPM

FHP motor type C 7333/15 220/240v a.c. 19 rpm reversible motor. torque 14·5 kg. Gear ratio 144·1. Brand new. incl. capacitor. our price **£14.25** + £1.25 P&P (**£16.20** inc. VAT & P)

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General Electric 230v A.C. 1 600 r.p.m. 0·25 amp. Complete with anti-vibration mounting bracket and capacitor. O/A size 110mm x 95mm. Spindle 5/16" dia. 20mm long. Ex-equipment tested. **£3.00** Post 50p (**£3.78** inc. VAT & P)

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DC Amps type b5c5 0·2A 0·5A 0·20A 0·50A 0·100A. AC Amps type b2t2 0·1A 0·5A 0·50A. DC Volts type b5c5 0·15v 0·50v. AC Volts type b2t2 0·150v 0·300v. All at **£3.50** P&P 50p (**£4.32** inc. VAT).

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200/250V A.C. 2 on/2 off every 24 hrs. at any manually pre-set time. 36 hour spring reserve and day omitting device. Built to highest Electricity Board specification. Price **£7.75** P&P 75p (**£9.18**).

SANGAMO WESTON TIME SWITCH

Type S251. 200/250 v.a.c. 2 on 2 off every 24 hours. 20 amps contacts with override switch. diameter 4" x 3". price **£6.00** P&P 50p (**£7.02** inc. VAT & P). Also available with Solar dial.

A.E.G. TIME SWITCH

200/250V A.C. 1 on/1 off every 24 hrs. 80 amps contacts (ideal storage heater). spring reserve. Price **£10.00** P&P 50p (**£11.34**).

A.C. MAINS TIMER UNIT

Based on an electric clock with 25 amp. single-pole switch, which can be preset for any period up to 12 hrs. ahead to switch on for any length of time, from 10 mins. to 6 hrs. then switch off. An additional 60 min. audible timer is also incorporated. Ideal for Tape Recorders, Lights, Electric Blankets etc. Attractive satin copper finish. Size 135 mm x 130 mm x 60 mm. Price **£2.25.** Post 40p (Total inc. VAT & Post **£2.87**).

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New ceramic construction, vitreous enamel embedded winding, heavy duty brush assembly, continuously rated.

25 WATT 10, 25, 100, 150, 250, 500, 1k, 1·5k ohm **£2.40** Post 20p (**£2.81** inc. VAT & P) **50 WATT** 100, 500, 1k ohm **£2.90** Post 25p (**£3.40** inc. VAT & P) **100 WATT** 1, 5, 10, 25, 50, 100, 250, 500, 1k, 1·5k, 2·5k, 5k ohm **£5.50.** Post 35p (**£6.32** inc. VAT & P)

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AC126	0.25
AC127	0.25
AC128	0.25
AC141	0.20
AC141K	0.35
AC142	0.20
AC142K	0.30
AC176	0.25
AC187	0.25
AC188	0.25
ACY17	0.65
ACY18	0.65
ACY19	0.65
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AF186	1.50
AF239	0.45
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AFZ12	2.75
ASY26	0.45
ASY27	0.50
ASZ15	1.25
ASZ16	1.25
ASZ17	1.25
ASZ20	0.75
ASZ21	1.50
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AUY10	1.70*
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BA148	0.15*
BA154	0.10
BA155	0.12
BA156	0.13
BAW62	0.05
BAX13	0.07
BAX16	0.07
BC107	0.12
BC108	0.12
BC109	0.13
BC113	0.15*
BC114	0.18*
BC115	0.19*
BC116	0.19*
BC117	0.22*
BC118	0.16*
BC125	0.18*
BC126	0.25*
BC135	0.15*
BC136	0.19*
BC137	0.16*
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BC148	0.10*
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BC170	0.16*
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BC179	0.20
BC182	0.11*
BC183	0.11*
BC184	0.12*
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BC237	0.17*
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BC301	0.45
BC303	0.60
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BC308	0.18*
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BC328	0.18*
BC337	0.19*
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BCY30	1.00
BCY31	1.00
BCY32	1.00
BCY33	0.90
BCY34	0.90
BCY39	3.00
BCY40	1.25
BCY42	0.30
BCY43	0.32
BCY58	0.23
BCY70	0.18
BCY71	0.22
BCY72	0.17
BCZ11	1.50
BD115	0.60
BD121	1.50
BD123	1.50
BD131	0.51
BD132	0.54
BD135	0.35*
BD136	0.36*
BD137	0.37*
BD138	0.40*
BD139	0.43*
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BD144	2.00
BD181	1.38
BD182	1.48
BD237	0.80
BD238	0.85
BDX10	0.75
BDX32	2.25
BDY20	1.42
BDY60	0.75
BF115	0.39
BF152	0.25
BF153	0.25
BF154	0.25
BF159	0.35
BF160	0.30
BF167	0.39
BF173	0.30
BF177	0.38
BF178	0.45
BF179	0.48
BF180	0.45
BF181	0.45
BF182	0.45
BF183	0.45
BF184	0.39
BF185	0.37
BF194	0.12*
BF195	0.11*
BF196	0.13*
BF197	0.14*
BF200	0.32
BF224	0.20*
BF244	0.35*
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BF258	0.42
BF259	0.45
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BFX84	0.38
BFX85	0.41
BFX87	0.35
BFX88	0.32
BFY50	0.28
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BFY52	0.26
BFY64	0.30
BFY90	1.32
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BY126	0.14
BY127	0.15
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BZY88 Series	0.13
CRS1/05	0.45
CRS1/40	0.60
CRS3/05	0.45
CRS3/40	0.75
CRS3/60	0.90
GEX66	1.50
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GJ3M	0.75
GM0378A	1.50
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MJE370	0.65
MJE371	0.81
MJE520	0.65
MJE521	0.75
MJE2955	1.25
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NE555	0.45
OA5	0.75
OA7	0.55
OA10	0.55
OA47	0.14
OA70	0.30
OA79	0.30
OA81	0.30
OA85	0.30
OA90	0.08
OA91	0.08
OA95	0.08
OA200	0.10
OA202	0.11
OA210	0.75
OA211	0.75
OAZ200	0.65
OAZ201	0.65
OAZ206	0.65
OAZ207	0.65
OC16	1.25
OC20	2.00
OC22	2.50
OC23	2.75
OC24	3.50
OC25	0.90
OC26	0.90
OC28	2.00
OC29	2.00
OC35	1.50
OC36	1.50
OC41	0.50
OC42	0.50
OC43	1.50
OC44	0.50
OC45	0.50
OC71	0.45
OC72	0.45
OC73	1.00
OC74	0.75
OC75	0.60
OC76	0.50
OC77	1.20
OC81	0.75
OC81Z	1.00
OC82	0.75
OC83	0.55
OC84	0.60
OC122	1.50
OC123	1.55
OC139	2.25
OC140	1.95
OC141	2.25
OC170	0.75
OC171	0.75
OC200	1.00
OC201	1.50
OC202	1.25
OC203	1.25
OC204	1.25
OC205	1.75
OC206	1.75
OC207	1.25
OCP71	1.25
ORP12	0.83
R2008B	2.25*
R2009	2.25*
R2010B	2.25*
TIC44	0.36
TIC226D	1.30
TIL209	0.25
TIP29A	0.50*
TIP30A	0.60*
TIP31A	0.62
TIP32A	0.75
TIP33A	1.00
TIP34A	1.20
TIP41A	0.70
TIP42A	0.90
TIP2955	1.00
TIP3055	0.50
TIS43	0.35*
ZS140	0.25*
ZS170	0.12*
ZS178	0.54*
ZS271	0.22*
ZS278	0.56*
ZTX107	0.11*
ZTX108	0.10*
ZTX109	0.12*
ZTX300	0.12*
ZTX301	0.13*
ZTX302	0.17*
ZTX303	017*
ZTX304	0.19*
ZTX311	0.12*
ZTX314	0.20*
ZTX500	0.13*
ZTX501	0.14*
ZTX502	0.16*
ZTX503	0.17*
ZTX504	0.20*
ZTX531	0.20*
ZTX550	0.16*
1N914	0.07
1N916	0.07
1N4001	0.06
1N4002	0.07
1N4003	0.08
1N4004	0.09
1N4005	0.13
1N4006	0.15
1N4007	0.15
1N4009	0.15
1N4148	0.07
1N5400	0.14
1N5401	0.16
1S44	0.06
1S920	0.08
1S921	0.08
2G301	1.00
2G302	1.00
2G306	1.10
2N404	0.60
2N696	0.25
2N697	0.16
2N698	0.30
2N705	0.80
2N706	0.12
2N708	0.21
2N930	0.26
2N1131	0.26
2N1132	0.26
2N1302	0.37
2N1303	0.37
2N1304	0.45
2N1305	0.45
2N1306	0.50
2N1307	0.50
2N1308	0.60
2N1309	0.60
2N1613	0.33
2N1671	1.50
2N1893	0.33
2N2147	1.40
2N2148	1.65
2N2218	0.33
2N2219	0.42
2N2220	0.35
2N2221	0.22
2N2222	0.25
2N2223	2.75
2N2368	0.17
2N2369A	0.21
2N2484	0.21
2N2646	0.50
2N2904	0.35
2N2905	0.35
2N2906	0.25
2N2907	0.21
2N2924	0.15*
2N2925	0.17*
2N2926	0.13*
2N3053	0.25
2N3054	0.50
2N3055	0.65
2N3440	0.60
2N3441	0.80
2N3442	1.20
2N3525	0.90
2N3614	1.20
2N3702	0.15*
2N3703	0.15*
2N3704	0.15*
2N3705	0.15*
2N3706	0.14*
2N3707	0.18*
2N3708	0.14*
2N3709	0.15*
2N3710	0.14*
2N3711	0.15*
2N3771	1.60
2N3772	1.70
2N3773	2.65
2N3819	0.36*
2N3820	0.46*
2N3823	0.60*
2N3866	1.00
2N3904	0.21*
2N3905	0.22*
2N3906	0.22*
2N4058	0.20*
2N4059	0.15*
2N4060	0.20*
2N4061	0.17*
2N4062	0.18*
2N4124	0.17*
2N4126	0.17*
2N4286	0.20*
2N4288	0.25*
2N4289	0.25*
2N5457	0.35*
2N5458	0.35*
2N5459	0.35*
3N125	1.75
3N141	0.85
2S017	6.50
2S019	6.50
2S026	12.00
2S103	1.50
2S302	0.75
2S303	0.75
2S322	0.80
2S324	1.25
2S701	1.50
2S703	1.50
2S721	3.00
2S745A	0.35
2S746A	0.35

VALVES

A1834	6.00
A2087	10.48
A2134	4.81
A2293	4.10
A2426	8.20
A2521	8.53
A2900	4.85
A3343	18.43
AZ31	1.10*
AZ41	1.15*
BK448	62.70
BK484	84.70
BS90	27.25
BS810	27.75
BT5	31.15
BT17	55.64
BT19	19.00
BT29	169.70
BT69	173.65
BT75	72.25
BT95	66.80
CBL31	1.50*
CL33	2.00*
CY31	1.00*
C1K	10.00
C3A	10.00
C3JA	10.00
DA41	16.85
DA42	8.81
DA100	31.86
DAF91†	0.40*
DAF96	1.00*
DET22	15.12
DET24	41.00
DF91†	0.40*
DF96	1.00*
DK91†	0.55*
DK92	1.25*
DK96	1.10*
DL92	0.75*
DL94	1.20*
DL96	1.10*
DLS10	8.25
DLS15	8.25
DLS16	8.25
DLS19	8.25
DM70	1.25
DM71	1.25
DM160	1.50
DY86/7†	0.45*
DY802	0.80*
E55L	21.89
E80CC	4.97
E80CF	6.40
E80F	5.71
E80L	5.48
E81CC	5.76
E81L	5.75
E82CC	6.12
E83CC	6.23
E86C	8.93
E88C	5.38
E88CC†	1.00
E90CC	5.06
E90F	5.16
E91H	4.65
E92CC	4.97
E99F	5.51
E130L	16.85
E180CC	5.36
E180F	5.80
E182CC	5.71
E186F	7.90
E188CC	5.06
E280F	16.90
E283CC	7.85
E288CC	12.58
EA52	14.20
EA76	1.50
EABC80	0.40*
EAC91†	0.50*
EAF42	1.25*
EAF801	1.75*
EB41	1.75*
EB91†	0.30*
EBC33	1.75*
EBC41	1.25*
EBC81	1.10*
EBC90†	0.65*
EBF80	0.45*
EBF83	1.25*
EBF89†	0.40*
EBL31	2.50*
EC90†	0.40*
EC91†	2.80*
EC92	1.25*
EC157	208.00
ECC33	3.50*
ECC35	3.50*
ECC40	1.25*
ECC81†	0.50
ECC82†	0.47
ECC83†	0.55
ECC84†	0.50*
ECC85†	0.55*
ECC86	2.00*
ECC88†	0.75
ECC89	0.75*
ECC91†	0.55
ECC189	1.00*
ECC807	1.75
ECC808	2.25*
ECF80†	0.60*
ECF82†	0.60*
ECF86	0.75*
ECH35	2.00*
ECH42	1.15*
ECH81†	0.50*
ECH83	0.85*
ECH84†	0.85*
ECL80†	0.60*
ECL81	0.75*
ECL82	0.55*
ECL83	1.50*
ECL84	0.90*
ECL85	1.12*
ECL86†	0.65*
ECLL800	7.00*
EF37A†	1.60*
EF39†	1.60*
EF40	1.15*
EF41	1.20*
EF42	2.00*
EF50†	0.60*
EF54	5.00*
EF55	2.50*
EF80†	0.45*
EF83	1.75*
EF85†	0.50*
EF86†	0.45*
EF89	0.60*
EF91†	0.65*
EF92†	0.75*
EF93†	0.50*
EF94†	0.55*
EF95†	0.30*
EF98	1.25*
EF183†	0.50*
EF184†	0.50*
EF804S	6.50
EF805S	7.00
EH90	0.75*
EK90†	0.65*
EL32	1.50*
EL32	1.50*
EL33	3.50*
EL36	0.75*
EL41	1.25*
EL42	1.75*
EL81	1.10*
EL83	1.25*
EL84	0.45
EL86†	0.50*
EL90†	0.75*
EL91	3.85
EL95†	0.80*
EL156	16.25
EL360	2.75*
EL500/504	1.50*
EL509	2.16*
EL821	4.42
EL822	5.61
EM80	1.10*
EM81	1.00*
EM84	1.00*
EM85	1.25*
EM87	1.50*
EN32	15.66
EN91†	0.55
EN92	5.81
EY51†	0.75*
EY81	1.65*
EY83	1.75*
EY84	3.95
EY86†	0.50*
EY88	1.75*
EY500A	1.36*
EY802	0.82*
EZ35	0.55*
EZ40	1.25*
EZ41	1.25*
EZ80†	0.30*
EZ81†	0.35*
EZ90†	0.45*
FW4-500	2.50*
FW4-800	2.50*
G1-371K	15.00
G55-1K	9.50
G180-2M	12.90
G240-2D	11.75
G400-1K	13.50
GN4	4.50
GN4A	4.50
GS16	9.00
GT1C	6.95
GU50	9.66
GU51	9.80
GXU1	10.43
GXU2	17.20
GXU3	21.42
GXU4	21.94
GY501	1.32*
GZ32	0.75*
GZ33	4.00*
GZ34†	1.52
GZ37	4.00*
KT61	3.50*
KT66	4.00*
KT88	4.75*
KTW61	1.75*
KTW62	1.75*
KTW63	1.75*
M8079	8.40
M8080	3.80
M8081	6.33
M8082	4.65
M8083	5.61
M8091	7.71
M8096	3.75
M8097	3.56
M8098	3.20
M8099	5.20
M8100	5.92
M8136	6.12
M8137	6.23
M8140	4.50
M8141	4.85
M8142	4.00
M8144	3.75
M8149	5.10
M8161	5.76
M8162	5.75
M8163	4.50
M8190	4.60
M8195	3.70
M8196	3.40
M8204	3.50
M8212	8.63
M8223	2.30
M8224	2.80
M8225	2.60
M8248	6.72
MU14	1.00*
MX119	20.00
MX123	34.50
MX145	27.15
MX151	11.69
MX152	74.00
MX161	76.50
MX163	12.60
MX164	12.56
MX166	105.00
MX168	24.00
N78	7.50*
OA2†	0.45
OA3	1.10
OA4	1.10
OB2†	0.45
OB3	0.75
OC2	2.30
OC3†	0.45
OD3†	0.45
OZ4	0.75*
PC86†	0.85*
PC88†	0.85*
PC95	0.70*
PC97	1.08*
PC900†	0.75*
PCC84†	0.45*
PCC85	0.45*
PCC88	0.65*
PCC89†	1.05*
PCC189†	0.65*
PCC805†	0.95*
PCC806†	0.95*
PCE82†	1.72
PCF80	0.72*
PCF82†	0.50*
PCF86†	0.65*
PCF87†	1.00*
PCF200†	1.05*
PCF201†	1.05*
PCF801†	0.55*
PCF802†	0.88
PCF805	1.44*
PCF806	0.80*
PCF808	1.44*
PCL82†	0.50*
PCL83†	0.92*
PCL84†	0.50*
PCL85†	0.96
PCL86†	0.65*
PCL805/85†	0.80*
PD500	3.60*
PE06-40N	27.30
PFL200	1.12*
PL36†	1.12*
PL81	0.55*
PL81A†	1.12*
PL82	0.60*
PL83†	0.55*
PL84†	0.60*
PL504/505†	1.20*
PL508†	1.60*
PL509†	2.72*
PL519†	3.60*
PL801	1.10*
PL802†	2.16*
PY33	0.68*
PY81†	0.72*
PY82	0.45*
PY83	0.60*
PY88†	1.16*
PY500A†	1.60*
PY800/81†	0.92*
PY801	0.92*
QQV02/6	9.60
QQV03-10†	2.00
QQV03-20A†	10.50
QQV06-40A†	13.00
QQV07-50	36.70
QQZ03-20A	27.50
QQZ06-40A	42.60
QU37	11.00
QV03-12	3.00
OV04-7	2.50
QV08-100	85.60
QY3-65	42.80
QY3-125†	12.00
QY4-250	51.30
QY4-400	58.30
QY5-500	127.50
QY5-3000A	212.00
QZ06-20	18.40
R10	5.00
R17	1.65*
R18	3.95
R19	1.00*
R20	1.44
RG3-250	21.51
RG3-250A	23.28
RG3-1250	20.95
RG4-1250	27.50
RG4-3000	113.09
RR3-250	34.77
RR3-1250	62.37
S11E12	18.00
S130	2.00
S130P	2.50
STV80-40	10.00
STV280-80	20.00
SU41	2.50
SU42	9.00
TD03-10	15.00
TD03-10E	17.50
TD03-10F	17.50
TT15	22.00
TT21	7.00
TT22	7.00
TT100	37.50
TY2-125	40.20
TY4-400	56.10
TY4-500	73.20
TY5-500	160.00
TY6-800	145.00
TY6-5000A	198.00
TY6-5000B	206.00
TY6-5000W	178.00
TY7-6000A	216.00
TY7-6000W	175.00
TZ40	15.00
U18-20	2.50*
U19	8.11
U25	1.16*
U26	1.44*
U37	11.00
UABC80†	0.50*
UAF42	0.75
UB41	1.25*
UBC41†	0.75*
UBF89	0.50
UCC84	0.75*
UCC85†	0.50*
UCF80	0.75*
UCH42	1.20*
UCH81†	0.50*
UCL82†	0.50*
UCL83	1.44*
UF41	0.75*
UF42	1.25*
UF80†	0.50*
UF85†	0.50*
UF89†	0.50*
UL41	1.00*
UL84†	0.60*
UM80	1.00*
UY41†	0.75*
UY85†	0.65*
VL5631	8.22
XG1-2500	23.10
XG5-500	16.80
XG2-6400	64.95
XGQ2-6400	74.15
XR1-1600A	19.05
XR1-3200	54.00
XR1-3200A	54.00
XR1-6400	59.10
XR1-6400A	59.10
YD1120	206.00
YD1240	206.00
Z759	6.50
ZM1000	4.60
ZM1001	5.38
ZM1020	8.55
ZM1021	7.96
ZM1022	8.23
ZM1023	7.66
ZM1040	11.57
ZM1041	9.67
ZM1042	11.08
ZX1051	87.00
1B3GT†	0.55
1B24	10.00
1B35A	17.00
1B63	45.00
1R5†	0.55*
1S5†	0.40*
1T4†	0.40*
2A515	10.00
2C39A†	9.00
2C43	18.00
2D21†	0.55
2E26	3.00
2J42	60.00
2J55	175.00
2J70A	235.00
2J70B	250.00
2K25†	9.50
3-400Z	35.00
3-500Z	35.00
3A5	1.35
3B24	5.00
3B28†	4.00
3B29	10.00
3B-240M	15.00
3B241M	15.00
3C23	10.00
3C45†	6.00
3CX100A5	20.00
3E29†	5.50
3S4†	0.75*
3V4†	1.00*
4-65A	25.35
4-125A†	12.00
4-250A	36.00
4-400A	37.00
4B32	10.00
4C35	40.00
4CX250B	17.50
4CX350A	31.35
4CX150A	21.00
4X150D	25.00
5B-254M	11.25
5B-255M	11.25
5C22	40.00
5J-180E	495.00
5R4GY†	1.00*
5U4G	1.52
5U4GB	1.00*
5V4G†	0.65*
5Y3GT	0.85*
5Z3	1.50*
5Z4G	1.12
5Z4GT	1.00*
6-30L2	1.00*
6AB4	0.75*
6AB7	0.75*
6AC7	0.75*
6AF4A†	0.70
6AG7	0.75*
6AH6†	0.70*
6AK5†	0.30
6AK6	0.95*
6AL5†	0.30*
6AM4	2.30*
6AM5	3.85
6AM6†	0.65*
6AN5	2.50*
6AN8A†	0.70*
6AQ5†	0.75*
6AR5	0.70*
6AS6†	0.80*
6AS7G†	1.50*
6AT6†	0.65
6AU5GT	4.26*
6AU6†	0.55
6AV5GT	3.74*
6AV6†	0.50
6AX5GT	3.10*
6B7	0.75
6B8	0.75
6BA6†	0.50
6BA7	5.12
6BA8A	3.75
6BC4	3.71
6BE6†	0.45*
6BH6†	1.20*
6BJ6†	0.80*
6BK4	4.21*
6BL6	85.00
6BL7GT	3.86*
6BM6	85.00
6BN6	0.80*
6BQ7A	1.55*
6BR7	4.00*
6BR8†	1.20*
6BS7	4.00*
6BW6	3.75*
6BW7	1.40*
6BX7GT	4.96*
6BZ6	1.78*
6C4†	0.40*
6CB6A†	0.50*
6CD6GA	4.00*
6CG7	1.72*
6CH6	4.42
6CL6†	0.75*
6CW4	4.72*
6D2†	0.30*
6DK6	2.49*
6DQ6B	3.04*
6EA8	2.21*
6EB8	2.12*
6EW6	0.80*
6F6	0.75
6F23	1.60*
6F28	1.16*
6F33	10.75
6H1	8.00
6H2N	0.75*
6H3N	0.75*
6H6	0.75*
6J4†	0.75*
6J6†	0.55
6J7	0.75*
6K4N	0.75*
6K6GT	0.75*
6K7	0.75*
6K8	0.75*
6KD6	4.79*
6L6G	2.50*
6L6GA	1.50*
6L6GT	0.85
6L6GC	1.75*
6L7	0.75
6N2P	0.75
6N3P	0.75
6N7	0.75
6P25	3.60*
6Q7	0.80
6R7	0.80
6SA7	0.80
6SC7	0.80
6SF7	0.80
6SH7	0.80
6SJ7	0.80
6SK7	0.80
6SL7GT†	0.70
6SN7GT†	0.70
6SQ7	0.75*
6SR7	0.75*
6SS7	0.75*
6U5G	2.00*
6U8†	0.40*
6U8A†	0.55*
6V6GT†	0.60*
6X4†	0.45*
6X5GT†	0.55*
7B7	1.00*
7C5	1.75*
7C6	1.25*
7H7	1.00*
7R7	1.50*
7S7	2.25*
7Y4	0.75*
7Z4	0.75*
11E3	34.00
12AT6	0.45*
12AT7†	0.45*
12AU6	0.50*
12AU7†	0.45*
12AV6	0.60*
12AV7	2.84*
12AX7†	0.45*
12AY7†	0.82*
12B4A†	1.00*
12BA6	0.50*
12BE6	1.60
12BH7†	0.60*
12BY7†	0.80*
12E1	4.00
12E14	19.80
13E1	43.55
19H4	16.88
19H5	22.50
24B9	30.50
30C15	1.56*
30C17	1.56*
30C18	1.44*
30F5	1.60
30FL1/2	1.12*
30FL12	1.72*
30FL14	1.44*
30L1	0.84*
30L15	1.72*
30L17	1.72*
30P4	0.92*
30P19	1.12*
30PL1	1.32*
30PL13	1.72*
30PL14	1.68*
30PL15	1.72*
35W4	0.60*
50C5	0.70*
75B1	3.15
75C1	1.55
85A1	7.50
85A2	1.50
90AG	7.26
90AV	7.16
90C1	1.50
90CG	5.74
90CV	5.99
92AG	7.26
92AV	7.16
95A1	4.15
150B2	1.80
150B3	3.30
150C2	1.50
150C4	2.30
211	5.00
723AB†	8.00
803	10.00
805	20.00
807†	1.00
811A†	3.80
812A	7.25
813†	10.00
833A	30.00
866A	8.85
872A	11.40
922	4.36
931A	12.24
1624	1.25
1625	1.00
2050	2.50
4212E	118.95
4212H	118.95
5544	54.00
5545	59.00
5551A	62.70
5552A	84.70
5553A	225.30
5642	3.16*
5654	3.61*
5651	180*
5670	2.86*
5675	9.09*
5687	4.30*
5696	1.94*
5718	3.36*
5725	3.40*
5726	2.20
5727	3.50*
5749	3.30*
5751	2.93*
5763	3.12*
5814A	2.60*
5840	4.40
5842	6.90
5876A	9.38
5879	3.16*
5886	10.50
5963	1.87*
5965	2.36
6005	3.65*
6021	4.46
6057	6.23
6058	8.40
6059	4.00
6061	4.25
6062	3.75
6063	3.65
6064	5.60
6067	6.12
6072	3.77
6080	6.85
6097A × B × C	40.00
6146A	4.27
6146B	4.65
6159	6.00
6189	6.08
6201	4.84
6442	15.00
6883B	4.93
6973	2.61
7025†	1.20
7551	3.65
7586	6.79
7587	12.54
7609	31.80
7868	2.93*
7895	7.48
8005	25.00*
8068	5.50
8122	33.15
8136	1.54
8417	3.40
18042	5.31
18045	5.71

BASES

B7G unskirted	0.15
B7G skirted	0.30
B9A unskirted	0.15
B9A skirted	0.30
Int Octal	0.20
Nuvistor	0.25
Loctal	0.55
8 pin DIL	0.15
14 pin DIL	0.15
16 pin DIL	0.17
Valve screening cans all sizes	0.30

CRTs

2AP1*	8.50
2BP1*	9.00
3BP1	8.00
3DP1*	5.00
3EG1*	7.00
3FP7*	3.00
3GP1	6.00
3JP1*	8.00
3JP2*	8.00
3JP7*	10.00
3KP1*	15.00
3RP1*	35.00
4EP1	25.00
4EP7	25.00
4EP11	25.00
5ADP1	35.00
5BP1*	5.00
5CP1*	5.00
5CP1A	40.00
5FP15A	5.00
5UP7*	5.00
DG7-5	25.00
DG7-32	36.00
DH3-91	31.00
DH7-11	68.00
VCR97*	5.00
VCR138*	10.00
VCR138A*	12.50
VCR139A*	8.00
VCR517A*	3.00
VCR517B*	3.00
VCR517C	3.00

Tube Bases 0.75
* = Surplus
VAT 8%

INTEGRATED CIRCUITS

7400	0.20
7401	0.20
7402	0.20
7403	0.20
7404	0.26
7405	0.23
7406	0.55
7407	0.55
7408	0.28
7409	0.28
7410	0.20
7412	0.26
7413	0.45
7416	0.40
7417	0.40
7420	0.20
7422	0.25
7423	0.35
7425	0.35
7427	0.35
7428	0.50
7430	0.20
7432	0.36
7433	0.37
7437	0.42
7438	0.37
7440	0.22
7441AN	0.92
7442	0.78
7447AN	1.20
7450	0.20
7451	0.20
7453	0.20
7454	0.20
7460	0.20
7470	0.35
7472	0.36
7473	0.36
7474	0.40
7475	0.59
7476	0.42
7480	0.60
7482	0.85
7483	1.00
7484	1.00
7486	0.40
7490	0.52
7491AN	0.85
7492	0.60
7493	0.70
7494	0.80
7495	0.80
7496	0.90
7497	3.67
74100	1.75
74107	0.45
74109	0.86
74110	0.57
74111	0.86
74116	1.89
74118	0.95
74119	2.00
74120	1.10
74121	0.45
74122	0.60
74123	1.00
74125	0.80
74126	0.80
74128	0.80
74132	0.80
74136	0.68
74141	0.85
74142	3.00
74143	3.00
74144	3.00
74145	1.00
74147	2.45
74148	2.00
74150	1.75
74151	0.90
74154	2.00
74155	0.90
74156	0.90
74157	0.90
74159	2.50
74170	2.60
74172	5.00
74173	1.75
74174	1.57
74175	1.00
74176	1.10
74178	1.65
74179	1.65
74180	1.65
74190	1.48
74191	1.48
74192	1.25
74193	1.25
74194	1.25
74195	1.10
74196	1.20
74197	1.00
74198	2.25
74199	2.25
76013N	1.75*
TAA570	2.30*
TAA630S	3.50*
TBA480Q	1.84*
TBA520Q	2.30*
TBA530	1.98*
TBA540Q	2.30*
TBA550Q	3.22*
TBA 560CQ	3.22*
TBA673	2.19*
TBA700	1.52*
TBA720Q	2.30*
TBA750Q	2.07*
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TCA270Q	2.99*
TCA760A	1.38*

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BRAND NEW — FULLY GUARANTEED

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
AC107	25p	BC177	12p	BF194	9p*	TIP32C	36p	2N1893	28p
AC126	14p	BC178	12p	BF195	9p*	TIP41A	34p	2N2218	15p
AC127	16p	BC179	12p	BF196	12p*	TIP41B	35p	2N2218A	18p
AC128	16p	BC182	9p*	BF197	12p*	TIP41C	36p	2N2219	15p
AC128K	24p	BC182L	9p*	BF200	25p	TIP42A	36p	2N2219A	18p
AC176	16p	BC183	9p*	BFX29	22p	TIP42B	37p	2N2221	15p
AC176K	24p	BC183L	9p*	BFX84	18p	TIP42C	38p	2N2221A	16p
AC187	16p	BC184	9p*	BFY50	12p	TIP2955	65p	2N2222	15p
AC187K	26p	BC184L	9p*	BFY51	12p	TIP3055	42p	2N2222A	16p
AC188	16p	BC212	10p*	BFY52	12p	ZTX107	6p*	2N2369	10p
AC188K	26p	BC212L	10p*	MPSA05	22p*	ZTX108	6p*	2N2904	14p
AD161		BC213	10p*	MPSA06	22p*	ZTX109	7p*	2N2904A	15p
162MP	80p	BC213L	10p*	MPSA55	22p*	ZTX300	7p*	2N2905	14p
AF139	30p	BC214	10p*	MPSA56	22p*	ZTX301	7p*	2N2905A	15p
AF239	30p	BC214L	10p*	OC44	12p	ZTX302	9p*	2N2906	12p
BC107	6p	BC251	10p*	OC45	12p	ZTX500	8p*	2N2906A	14p
BC108	6p	BCY70	12p	OC71	9p	ZTX501	10p*	2N2907	12p
BC109	6p	BCY71	12p	OC72	12p	ZTX502	12p*	2N2007A	13p
BC118	10p*	BCY72	12p	OC75	10p	2N696	10p	2N2926G	8p*
BC147	8p*	BD115	40p	OC81	14p	2N697	10p	2N2926Y	7p*
BC148	8p*	BD131	35p*	TIP29A	35p	2N706	7p	2N3053	12p
BC149	8p*	BD132	37p*	TIP29B	36p	2N706A	8p	2N3055	35p
BC154	16p*	BF115	17p	TIP29C	38p	2N708	8p	2N3702	7p*
BC157	9p*	BF167	19p	TIP30A	36p	2N1302	12p	2N3703	7p*
BC158	9p*	BF173	20p	TIP30B	37p	2N1303	15p	2N3704	6p*
BC159	9p*	BF180	25p	TIP30C	38p	2N1304	15p	2N3903	11p*
BC169C	10p*	BF181	25p	TIP31A	32p	2N1307	18p	2N3904	11p*
BC170	6p	BF182	25p	TIP31B	33p	2N1308	22p	2N3905	11p*
BC171	6p*	BF183	25p	TIP31C	34p	2N1309	22p	2N8906	11p*
BC172	6p*	BF184	25p	TIP32A	34p	2N1613	15p		
BC173	7p	BF185	25p	TIP32B	35p	2N1711	15p		

DIODES

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
AA119	5p	BAX16/		BYZ17	28p	OA91	7p	IN5401	11p
AAZ13	4p	OA202	5p	BYZ18	28p	OA95	7p	IN5402	12p
BA100	6p	BY100	15p	BYZ19	28p	IN34	5p	IN5404	13p
BA115	5p	BY127	10p*	OA47	5p	IN60	6p	IN5406	16p
BA144	5p	BYZ10	32p	OA70	5p	IN914	4p	IN5407	17p
BA148	10p	BYZ11	32p	OA79	7p	IN4148	4p	IN5408	19p
BA173	10p	BYZ12	32p	OA81	7p	1S44	3p		
BAX13		BYZ13	30p	OA85	7p	IN5400	10p		
OA200	5p	BYZ16	30p	OA90	6p				

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No 1502	Green 125"	18p each
No 1505	Green 2"	18p each
No 1503	Yellow 125"	18p each
No 1506	Yellow 2"	18p each
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No 16134	50 750mA Si top hat Rects	40p
No 16135	20 3 amp Si stud Rect	40p
No 16136	50 400mw Zeners D O 7 case	40p
No 16137	30 NPN Plastics trans like BC107 8	40p*
No 16138	30 PNP Plastic trans like BC177 8	40p*
No 16141	25 NPN Trans like 2N697 2N1711 TO 39	40p
No 16140	25 PNP Trans like 2N2905 To 39	40p
No 16141	30 NPN Trans like 2N706 To 18	40p
No 16143	30 NPN Plastic trans like 2N3906	40p*
No 16144	30 PNP Plastic trans like 2N3905	40p*
No 16145	30 PNP Germ trans like OC71	40p
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16195	6 x 47K LOG Single	40p*
16194	6 x 47K LIN Single	40p*
S27	6 x 100K LIN Single	40p*
S28	6 x 100K LOG Single	40p*
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S9	5 x 2.5mm Chassis Sockets (Switched)	25p*
S10	4 x Metal Std Chassis Switched Jack Sockets	50p*
S11	2 x Stereo Jack Sockets with instruction leaflet for Headphone connection	50p*
S12	5 x 5-pin 180 Din Chassis Sockets	40p*
S13	8 x 2-pin Din Chassis Sockets	50p*
S14	6 x Single Phono Sockets	40p*

AUDIO LEADS

Order No		
117	A.C. Mains connecting lead for cassette recorders and radios Telefunken type	45p*
118	5-pin Din Headphone Plug to stereo socket	78p*
119	2 x 2-pin Plug to inline stereo socket for headphones	60p*
123	20ft of coiled guitar lead	£1.15*
124	3-pin to 3-pin Din Plug	50p*
125	Audio Lead 5 pin Plug to 5 pin Din Plug	50p*
126	Audio Lead 5-pin Din plug to tinned open ends	50p*
127	Audio Lead 5-pin Din plug to 4 phono plugs	90p
129	Audio Lead 5-pin Plug to 5-pin Din Plug — mirror image	70p*
130	5 Meter Lead 2-pin Din plug to 2 pin Din inline socket	45p*
132	10 Meter Lead 2-pin Din plug	65p*

HEAVY GAUGE BLACK PLASTIC BOX

With aluminium lid and fixing screws
Size 6¼" x 3¾" x 2"
Order No S16 **Only 75p**

74 SERIES TTL ICs

TYPE	QUANTITY 1	QUANTITY 100	TYPE	QUANTITY 1	QUANTITY 100	TYPE	QUANTITY 1	QUANTITY 100
	£p	£p		£p	£p		£p	£p
7400	0.09	0.08	7448	0.70	0.68	74122	0.45	0.42
7401	0.11	0.10	7450	0.12	0.10	74123	0.65	0.62
7402	0.11	0.10	7451	0.12	0.10	74141	0.68	0.65
7403	0.11	0.10	7453	0.12	0.10	74145	0.75	0.72
7404	0.11	0.10	7454	0.12	0.10	74150	1.10	1.05
7405	0.11	0.10	7460	0.12	0.10	74151	0.65	0.60
7406	0.28	0.25	7470	0.24	0.23	74153	0.70	0.68
7407	0.28	0.25	7472	0.20	0.19	74154	1.20	1.10
7408	0.12	0.11	7473	0.26	0.22	74155	0.70	0.68
7409	0.12	0.11	7474	0.24	0.23	74156	0.70	0.68
7410	0.09	0.08	7475	0.44	0.40	74157	0.70	0.68
7411	0.22	0.20	7476	0.26	0.25	74160	0.95	0.85
7412	0.22	0.20	7480	0.45	0.42	74161	0.95	0.85
7413	0.26	0.25	7481	0.90	0.88	74162	0.95	0.85
7416	0.28	0.25	7482	0.75	0.73	74163	0.95	0.85
7417	0.26	0.25	7483	0.88	0.82	74164	1.20	1.10
7420	0.11	0.10	7484	0.85	0.80	74165	1.20	1.10
7422	0.19	0.18	7485	1.10	1.00	74166	1.20	1.10
7423	0.21	0.20	7486	0.28	0.26	74174	1.10	1.00
7425	0.25	0.23	7489	2.70	2.50	74175	0.85	0.82
7426	0.25	0.23	7490	0.38	0.32	74176	1.10	1.00
7427	0.25	0.23	7491	0.65	0.62	74177	1.10	1.00
7428	0.36	0.34	7492	0.43	0.35	74180	1.10	1.00
7430	0.12	0.10	7493	0.38	0.35	74181	1.90	1.80
7432	0.20	0.19	7494	0.70	0.68	74182	0.80	0.78
7433	0.38	0.36	7495	0.60	0.58	74184	1.50	1.40
7437	0.26	0.25	7496	0.70	0.68	74190	1.40	1.30
7438	0.26	0.25	74100	0.95	0.90	74191	1.40	1.30
7440	0.12	0.10	74104	0.40	0.35	74192	1.10	1.00
7441	0.60	0.57	74105	0.30	0.25	74193	1.05	1.00
7442	0.80	0.70	74107	0.30	0.25	74194	1.05	1.00
7443	0.95	0.90	74110	0.48	0.45	74195	0.80	0.75
7444	0.95	0.90	74111	0.75	0.72	74196	0.90	0.85
7445	0.80	0.75	74118	0.85	0.82	74197	0.90	0.85
7446	0.80	0.75	74119	1.30	1.20	74198	1.90	1.80
7447	0.70	0.68	74121	0.28	0.26	74199	1.80	1.70

Devices may be mixed to qualify for quantity price Data is available for the above series of ICs in booklet form **price 35p**

CMOS ICs

Type	Price	Type	Price	Type	Price	Type	Price
CD4000	£0.14	CD4018	£0.85	CD4035	£1.40	CD4056	£1.15
CD4001	£0.16	CD4019	£0.45	CD4037	£0.78	CD4069	£0.32
CD4002	£0.16	CD4020	£0.95	CD4040	£0.78	CD4070	£0.32
CD4006	£0.80	CD4021	£0.85	CD4041	£0.68	CD4071	£0.20
CD4007	£0.17	CD4022	£0.80	CD4042	£0.68	CD4072	£0.20
CD4008	£0.80	CD4023	£0.18	CD4043	£0.78	CD4081	£0.20
CD4009	£0.50	CD4024	£0.64	CD4044	£0.78	CD4082	£0.20
CD4010	£0.50	CD4025	£0.18	CD4045	£1.15	CD4510	£1.10
CD4011	£0.18	CD4026	£1.85	CD4046	£0.95	CD4511	£1.25
CD4012	£0.17	CD4027	£0.48	CD4047	£0.75	CD4516	£1.10
CD4013	£0.42	CD4028	£0.80	CD4049	£0.46	CD4518	£1.10
CD4015	£0.80	CD4029	£0.95	CD4050	£0.46	CD4520	£1.10
CD4016	£0.42	CD4030	£0.46	CD4054	£0.95		
CD4017	£0.80	CD4031	£1.80	CD4055	£1.60		

AUDIO MODULE SALE

Type	Description	Normal Price	Sale Price
AL30A	10W RMS Power AMP	~~£3.65*~~	£2.95*
AL60	25W RMS Power AMP	~~£4.35*~~	£3.55*
AL80	35W RMS Power AMP	~~£6.95*~~	£5.95
AL250	125W RMS Power AMP	~~£15.95*~~	£14.45
SPM80	35V Power Supply	~~£3.75*~~	£3.10*
PS12	20-30V Power Supply for AL30A	~~£1.30*~~	£1.15*
PA12	Stereo Pre Amp for AL30A	~~£6.70*~~	£5.95*
PA100	Stereo Pre-Amp for AL60/AL80	~~£13.75*~~	£12.45*
S450	Stereo F.M. Tuner	~~£20.45*~~	£18.65*
MPA30	Magnetic-Ceramic Pre Amp	~~£2.85*~~	£2.55*
Stereo 30	Complete Audio Chassis 7W + 7W RMS	~~£16.25*~~	£14.95

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GE 100 NINE CHANNEL MONO-GRAPHIC EQUALIZER MODULE £19.50

The GE100 has nine 1 octave adjustments using integrated circuit active filters Boost and Cut limits are ± 12dB Max Voltage handling 2 V RMS T H D 0.05% input impedence 100 K Output impedence less than 10 K Frequency response 20 Hz 20 KHz (3dB) The nine gain controls are centred at 50 100 200 400 800 1 600 3 200 6 400 and 12 800 Hz The suggested gain controls are 10 K LIN sliders (not supplied with the module) See Paks S31 and 16192

SG30 POWER SUPPLY BOARD FOR GE100 15 0-15 VOLT **£4.50**

SEND S.A.E. FOR TECHNICAL DATA ON ALL AUDIO MODULES

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Add 25p for postage and packing unless otherwise shown Add extra for airmail Min order £1

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Order No	Quantity	
16164	200 approx Resistors mixed values (Count by weight)	40p*
16165	150 approx Capacitors mixed values (Count by weight)	40p*
16167	80 ½W Resistors mixed values	40p*
16168	5 pieces Assorted Ferrite rods	40p*
16169	2 pieces Tuning gangs MW LW	40p*
16170	50 metres Single strand wire assorted wire	40p
16171	10 Reed switches	40p*
16172	3 Micro switches	40p*
16176	20 Assorted electrolytics Trans types	40p*
16177	1 pack Assorted hardware nuts bolts etc	40p
16179	20 Assorted tag strips and panels	40p
16180	15 Assorted control knobs	40p*
16184	15 Assorted Fuses 100mA 5 amp	40p
16188	60 ½W Resistors mixed values	40p*
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½ PRICE BARGAIN!

£4 worth (min. Value)

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£2 per bundle†
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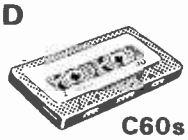

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Order No 829 **£1.40***

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ANTEX SOLDERING IRONS

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1931	X25 25watt LOW LEAKAGE Usually ~~£3.40~~	Sale Price £2.95
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1939	ST3 Soldering Iron Stand, suitable for either Iron	£1.20

NEW Siren Alarm Module

American Police screamer powered from any 12 volt supply into 4 or 8 ohm speaker. Ideal for car burglar alarm, freezer breakdown and other security purposes. Order No. S15 **Only £3.50**

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Cyanocrylate adhesive Bonds — plastic rubber Transistors Components in Seconds

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Auto or Manual. A high quality unit backed by BSR reliability with 12 months' guarantee. A.C 200/250V. Size 13½-11¼in
3 speeds. Above motor board 3¾in. Below motor board 2½in with Sonotone V100 magnetic cartridge
BSR P128 with magnetic cartridge Balanced arm Cueing device Bias Compensator **£24.50.** Post £1

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Modern design. Rexine covered
Vynair front grille Chrome fittings
Size 17 x 15 x 8in approx **£4.50** Post 75p
Motor board cut for BSR or Garrard deck

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With P V C. Cover Cut out for most BSR or Garrard decks Silver grey finish **£6.50** Post £1 50
Model "A" Size 12½ x 14¾ x 7½in **£7.50**
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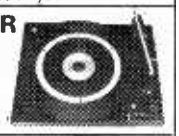

Ideal replacement or disco deck with cueing device and stereo ceramic cartridge. 3 speeds Large turntable, modern design
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Dual cone plastic roll surround Large ceramic magnet. 50-16,000 c/s. Bass resonance 40 c/s. 8 ohm impedance
10 watts. RMS **£5.95** Post 35p

SMITH'S CLOCKWORK 15 AMP TIME SWITCH
0-6 HOURS £3.30 Post 35p

Single pole two-way Surface mounting with fixing screws Will replace existing wall switch to give light for return home, garage, automatic anti-burglar lights, etc. Variable knob. Turn on or off at full or intermediate settings. Brand new

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R.C.S. "MINOR" 10 watt AMPLIFIER KIT
This kit is suitable for record players, guitars, tape playback, electronic instruments or small P A systems Two versions available. Mono, **£11.25;** Stereo, **£18.** Post 45p Specification 10W per channel; input 100mV; size 9½ x 3 x 2in. approx S.A.E. details. Full instructions supplied. AC mains powered

VOLUME CONTROLS
5kΩ to 2MΩ. LOG or LIN L/S **35p.** D.P. **60p.** STEREO L/S **85p.** D.P. **£1.** Edge 5K. S P Transistor **45p.**

80 Ohm Coax 8p yd.
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Ideal 625 and colour PLUGS **10p.** SOCKETS **10p.** LINE SOCKETS **18p.** OUTLET BOXES **50p.** 300 ohm FEEDER **5p** yd

ELAC 9 × 5in HI-FI SPEAKER TYPE 59RM £3.45 Post 35p
This famous unit now available 10 watts 8 ohm

E.M.I. 13½ x 8in. SPEAKER SALE!

With twin tweeter and crossover. 10 watt. 3 or 8 ohm
£7.95 Post 45p

Ditto 15 watts. 8 ohm
£10.50 Post 65p

With tweeter and crossover 20 watt. Bass res. 25 c p.s. Flux = 11,000 gauss. **£11.50** Post 75p
8 or 15 ohm. 20 to 20,000 c.p.s.

Bookshelf Cabinet Teak finish. For EMI 13 x 8 speakers **£8.50** Post £1 00

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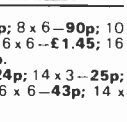

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Kit of parts to build a 3 channel sound to light unit 1,000 watts per channel **£17** Post 35p.
Easy to build. Full instructions supplied. Cabinet **£4.**
Will operate from 20MV to 100 watt signal

R.C.S. LOW VOLTAGE STABILISED POWER PACK KITS
£2.95 Post 45p
All parts and instructions with Zener diode, printed circuit rectifiers and double wound mains transformer. Input 200/240V a.c
Output voltages available. 6 or 7 5 or 9 or 12V d c up to 100mA or less. Size 3 x 2½ x 1½in Please state voltage required.

R.C.S. POWER PACK KIT
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12 VOLT, 750mA Complete with printed circuit board and assembly instructions.
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For use with valve or transistor equipment
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20V 3 amp	£2.45	10V, 30V, 40V 2 amp	£2.75
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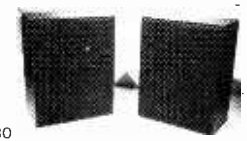

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50 to 14,000 cps.
8 watts rms 8 ohms
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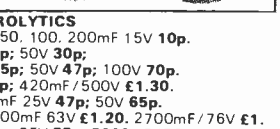
These little marvels of modern sound reproduction are ideally suited for today's domestic audio set-up Two of these smart spheres, each with 5 watt deep throated ceramic magnets, will produce superb stereo reproduction
The globe shaped cases in high gloss mouldings of red or green, are finished with chrome frontal trim and provided with screw-on rubber inset protective bases In addition, 2½ metres of strong lead already fitted with phono plug is supplied.
Frequency Response 100-20,000 Hz
Impedance 8 ohms
Power Capacity 5 watts



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1 5V d c operation over 300 hours continuous on SP2 battery, fully adjustable swing and speed Ideal displays teaching electro magnetism or for metronome, strobe, etc **95p** Post 30p

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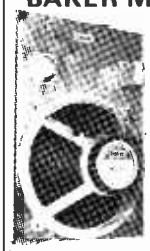

30-14,500 c/s, 12in double cone, woofer and tweeter cone together with a BAKER ceramic magnet assembly having a flux density of 14,000 gauss and a total flux of 145,000 Maxwells. Bass resonance 40 c/s. Rated 25W. NOTE 4 or 8 or 16 ohms must be stated

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Please state 4 or B or 16 ohms.

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'Group 25'	'Group 35'	'Group 50/15'
12in 30W **£12.00** 4 or 8 or 16 ohm	12in. 40W **£14.00** 4 or 8 or 16 ohm	15in 75W **£26.00** 8 or 16 ohm

BAKER LOUDSPEAKER, 12 INCH. 60 WATT. GROUP 50/12, 4 OR 8 OR 16 OHM HIGH POWER. FULL RANGE PROFESSIONAL QUALITY RESPONSE 30-16,000 CPS MASSIVE CERAMIC MAGNET WITH ALUMINIUM PRESENCE CENTRE DOME **£21.00** Post £1 60

TEAK VENEERED HI-FI SPEAKERS AND CABINETS
For 12in. or 10in speaker 20x13x12in **£14.50** Post £2
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Horn tweeters 2-16kc/s. 10W 8 ohm or 16 ohm **£3.60.**
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All purpose transistorised
Ideal for Groups, Disco and P A 4 inputs speech and music 4 way mixing Output 4 8/16 ohms a c Mains Separate treble and bass controls Master volume control. Guaranteed Details S A E **£75** £1 50 carr.

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volume, treble, bass controls 500 M V or 1 volt input Four loudspeaker outputs 4 to 16 ohm All transistor **£59**

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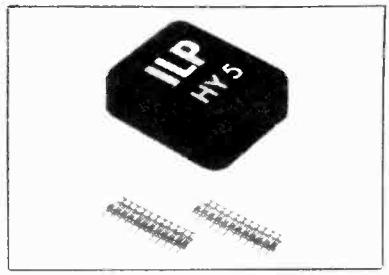
HY5
Preamplifier

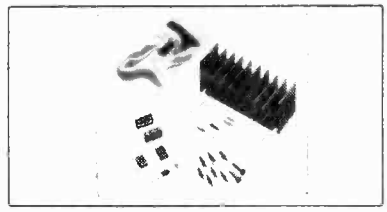
The HY5 is a mono hybrid amplifier ideally suited for all applications. All common input functions (mag Cartridge, tuner etc.) are catered for internally, the desired function is achieved either by a multi-way switch or direct connection to the appropriate pins. The internal volume and tone circuits merely require connecting to external potentiometers (not included). The HY5 is compatible with all I.L.P. power amplifiers and power supplies. To ease construction and mounting a P.C. connector is supplied with each pre-amplifier.

FEATURES: Complete pre-amplifier in single pack — Multi-function equalization — Low noise — Low distortion — High overload — two simply combined for stereo.
APPLICATIONS: Hi-Fi — Mixers — Disco — Guitar and Organ — Public address.
SPECIFICATIONS:
INPUTS: Magnetic Pick-up 3mV. Ceramic Pick-up 30mV. Tuner 100mV. Microphone 10mV. Auxiliary 3-100mV. Input impedance 47kΩ at 1kHz.
OUTPUTS: Tape 100mV. Main output 500mV R.M.S.
ACTIVE TONE CONTROLS: Treble ± 12dB at 10kHz. Bass ± at 100Hz.
DISTORTION: 0.1% at 1kHz. Signal/Noise Ratio 68dB.
OVERLOAD: 38dB on Magnetic Pick-up. SUPPLY VOLTAGE ± 16-50V.
Price £5.22 + 65p VAT P&P free.
HY5 mounting board B1 48p + 6p VAT P&P free.



HY30
15 Watts into 8Ω

The HY30 is an exciting New kit from I.L.P. it features a virtually indestructible I.C. with short circuit and thermal protection. The kit consists of I.C., heatsink, P.C. board, 4 resistors, 6 capacitors, mounting kit, together with easy to follow construction and operating instructions. This amplifier is ideally suited to the beginner in audio who wishes to use the most up-to-date technology available.
FEATURES: Complete kit — Low Distortion — Short, Open and Thermal Protection — Easy to Build.
APPLICATIONS: Updating audio equipment — Guitar practice amplifier — Test amplifier — Audio oscillator.
SPECIFICATIONS:
OUTPUT POWER 15W R.M.S. into 8Ω. DISTORTION 0.1% at 15W.
INPUT SENSITIVITY 500mV. FREQUENCY RESPONSE 10Hz-16kHz — 3dB.
SUPPLY VOLTAGE ± 18V.
Price £5.22 + 65p VAT P&P free.

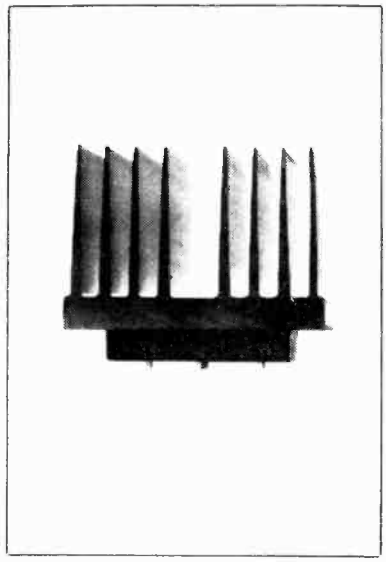


HY50
25 Watts into 8Ω

The HY50 leads I.L.P.'s total integration approach to power amplifier design. The amplifier features an integral heatsink together with the simplicity of no external components. During the past three years the amplifier has been refined to the extent that it must be one of the most reliable and robust High Fidelity modules in the World.
FEATURES: Low Distortion — Integral Heatsink — Only five connections — 7 Amp output transistors — No external components.
APPLICATIONS: Medium Power Hi-Fi systems — Low power disco — Guitar amplifier.
SPECIFICATIONS: INPUT SENSITIVITY 500mV.
OUTPUT POWER 25W RMS in 8Ω LOAD IMPEDANCE 4-16Ω. DISTORTION 0.04% at 25W at 1kHz.
SIGNAL/NOISE RATIO 75dB. FREQUENCY RESPONSE 10Hz-45kHz — 3dB.
SUPPLY VOLTAGE ± 25V. SIZE 105.50.25mm.
Price £6.82 + 85p VAT P&P free.

HY120
60 Watts into 8Ω

The HY120 is the baby of I.L.P.'s new high power range, designed to meet the most exacting requirements including load line and thermal protection, this amplifier sets a new standard in modular design.
FEATURES: Very low distortion — Integral Heatsink — Load line protection — Thermal protection — Five connections — No external components.
APPLICATIONS: Hi-Fi — High quality disco — Public address — Monitor amplifier — Guitar and organ.
SPECIFICATIONS:
INPUT SENSITIVITY 500mV.
OUTPUT POWER 60W RMS into 8Ω LOAD IMPEDANCE 4-16Ω. DISTORTION 0.04% at 60W at 1 kHz.
SIGNAL/NOISE RATIO 90dB. FREQUENCY RESPONSE 10Hz-45kHz —3dB. SUPPLY VOLTAGE ±35V.
Size 114 x 50 x 85mm.
Price £15.84 + £1.27 VAT P&P free.

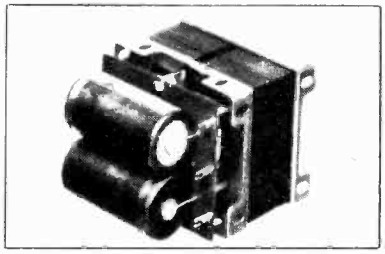


HY200
120 Watts into 8Ω

The HY200 now improved to give an output of 120 Watts, has been designed to stand the most rugged conditions, such as disco or group while still retaining true Hi-Fi performance.
FEATURES: Thermal shutdown — Very low distortion — Loadline protection — Integral Heatsink — No external components.
APPLICATIONS: Hi-Fi — Disco — Monitor — Power Slave — Industrial — Public address.
SPECIFICATIONS:
INPUT SENSITIVITY 500mV.
OUTPUT POWER 120W RMS into 8Ω LOAD IMPEDANCE 4-16Ω. DISTORTION 0.05% at 100W at 1kHz.
SIGNAL/NOISE RATIO 96dB. FREQUENCY RESPONSE 10Hz-45kHz — 3dB. SUPPLY VOLTAGE ±45V.
SIZE 114 x 100 x 85mm.
Price £23.32 + £1.87 VAT P&P free.

HY400
240 Watts into 4Ω

The HY400 is I.L.P.'s "Big Daddy" of the range producing 240W into 4Ω! It has been designed for high power disco or public address applications. If the amplifier is to be used at continuous high power levels a cooling fan is recommended. The amplifier includes all the qualities of the rest of the family to lead the market as a true high power hi-fidelity power module.
FEATURES: Thermal shutdown — Very low distortion — Load line protection — No external components.
APPLICATIONS: Public address — Disco — Power slave — Industrial.
SPECIFICATIONS:
OUTPUT POWER 240W RMS into 4Ω LOAD IMPEDANCE 4-16Ω. DISTORTION 0.1% at 240W at 1 kHz.
SIGNAL/NOISE RATIO 94dB. FREQUENCY RESPONSE 10Hz-45kHz — 3dB. SUPPLY VOLTAGE ±45V.
INPUT SENSITIVITY 500mV. SIZE 114 x 100 x 85mm.
Price £32.17 + £2.57 VAT P&P free.



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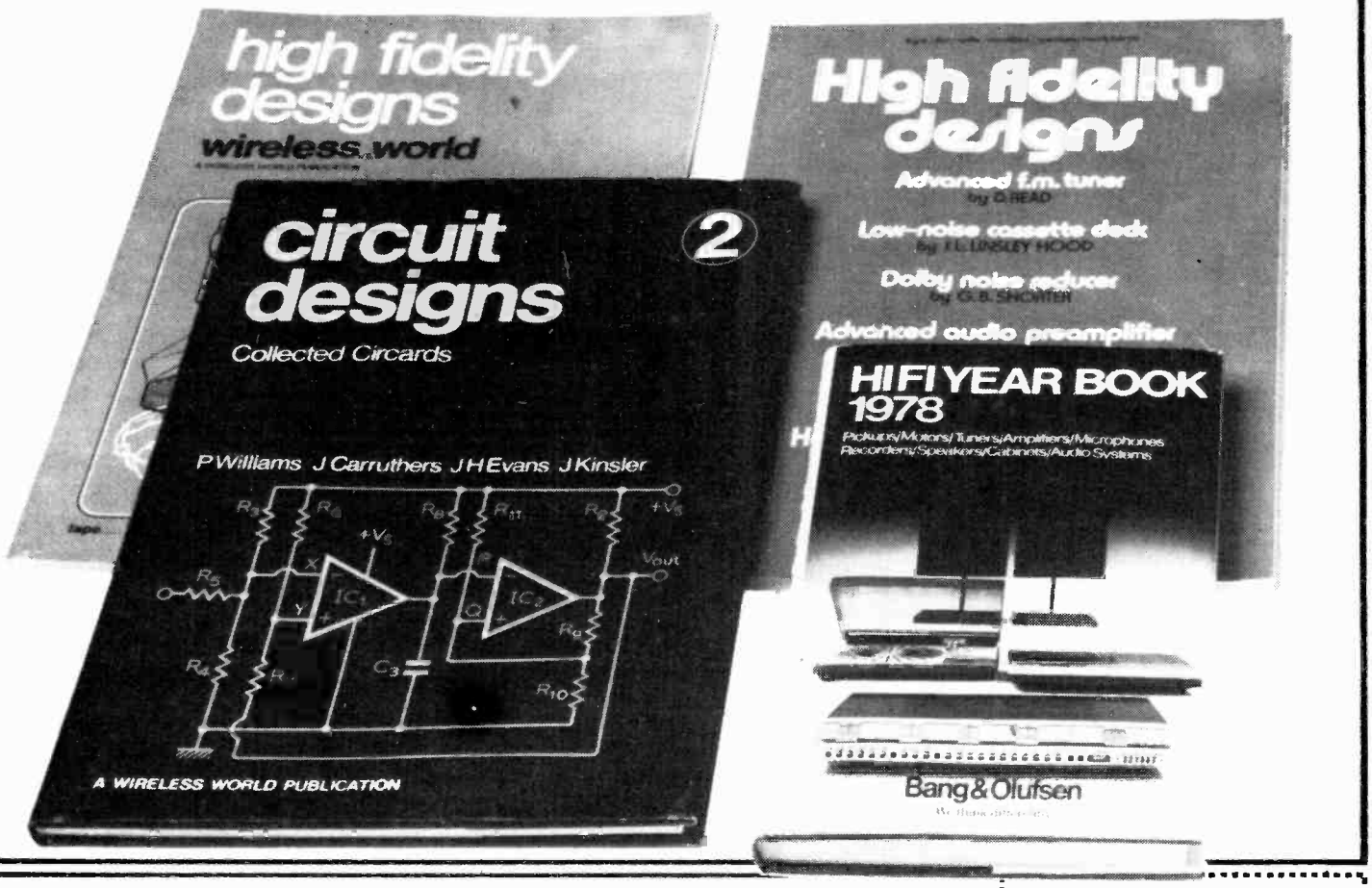

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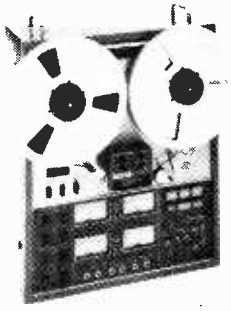

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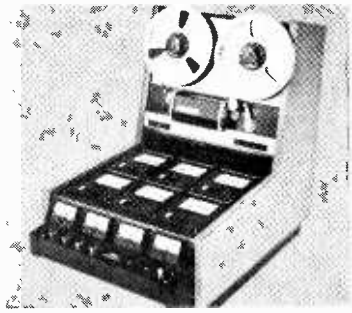

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100mA TO92

+5V	70p
+12V	70p
+15V	70p
−5V	80p
−12V	80p

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OP. AMPS

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CA3160	Int. Comp.	8 pin DIL	110p
LM318N	High speed	8 pin DIL	200p
LM324N	Quad. Op. Amp.	14 pin DIL	120p
LM348N	Quad. Op. Amp.	14 pin DIL	125p
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ICL8038CC	VCO Fun. Gen	14 pin DIL	370p
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LM377N	Dual 2W Aud. Amp	14 pin DIL	175p
*LM380	2W Audio Amp	14 pin DIL	99p
*LM381	Stereo Preamp	14 pin DIL	175p
*LM389N	Aud. Amp + 3 Trs. Array	18 pin DIL	160p
LM3911N	Temp Controller	8 pin DIL	150p
*MC1310P	FM Stereo Dec.	14 pin DIL	190p
*MC1351P	Lim/Det. Aud Preamp	14 pin DIL	97p
MC1495L	Multiplier	14 pin DIL	450p
*MC1496L	Bal. Mod/Demod.	14 pin DIL	100p
*MC3340P	Electronic Attenuator	8 pin DIL	160p
*MC3360P	¼W Audio Amp.	8 pin DIL	160p
NE555	Timer	8 pin DIL	40p
NE556	Dual 555	14 pin DIL	100p
NE561	PLL with AM Demod.	16 pin DIL	425p
NE562	PLL with VCO	16 pin DIL	425p
NE565	PLL	14 pin DIL	200p
NE566	PLL Fun. Gen.	8 pin DIL	200p
NE567	PLL Tone Dec.	8 pin DIL	200p
RC4151	Vol to Fre. Converter	8 pin DIL	400p
SN72710	Diff. Comparator	14 pin DIL	50p
*SN72733	Video Amp.	14 pin DIL	120p
*SN76003N	Pwr. Aud. Amp with int. HS	16 pin DIL	245p
*SN76008	10W Amp in 4 ohms	5 pin Plastic	250p
*SN76013N	Pwr. Aud. Amp with int. HS	16 pin DIL	140p
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*SN76033N	Pwr. Aud. Amp with int. HS	16 pin DIL	230p
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*TAA621A	Aud. Amp for TV	QIL	225p
*TAA661B	FM IF Amp. Limiter/Det.	QIL	120p
*TBA641B	Audio Amp.	QIL	250p
*TBA651	Tuner & IF Amp.	16 pin QIL	200p
*TBA800	5W Audio Amp.	QIL	90p
*TBA810	7W Audio Amp.	QIL	100p
*TBA820	2W Audio Amp.	QIL	80p
*TCA940	10W Audio Amp.	QIL	200p
*TDA2020	20W Audio Amp.	QIL/OIL	325p
ZN1034E	Precision Timer	14 pin DIL	200p
*ZN414	TRF Radio Receiver	TO-18	110p
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AC128	25p	BFY90	90p	*2N3565	30p	75182	200p
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AC187	25p	*BU105	140p	*2N3703	12p	75451	72p
AC187K	30p	BU108	250p	*2N3704	12p	75452	72p
AC188	25p	*BU205	200p	*2N3705	12p		
AC188K	30p	*BU208	300p	*2N3706	12p		
AD149	49p	*MJE340	65p	*2N3707	12p		
AD161	45p	MJ481	175p	*2N3708	12p		
AD162	45p	MJ491	200p	*2N3709	12p		
AF114	30p	MJ2501	225p	2N3773	300p		
AF115	30p	MJ2955	120p	2N3866	90p		
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BF115	22p	2N697	22p	**FETs**			
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*BF197	15p	2N1308	75p	*2N5458	40p		
BF200	32p	2N1309	75p	*2N5459	40p		
BF257	32p	2N1613	25p	*2N5460	70p		
BF258	36p	2N1711	25p	*2N5485	40p		
BF259	45p	2N1893	30p				
BF337	30p	2N2102	55p	**MOSFETs**			
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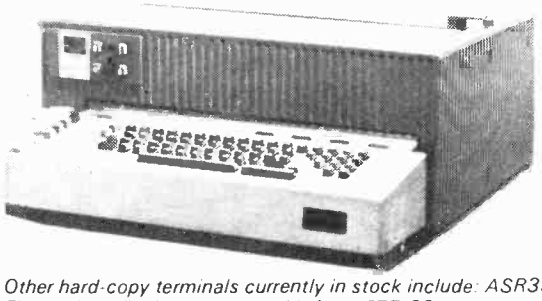

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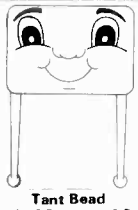

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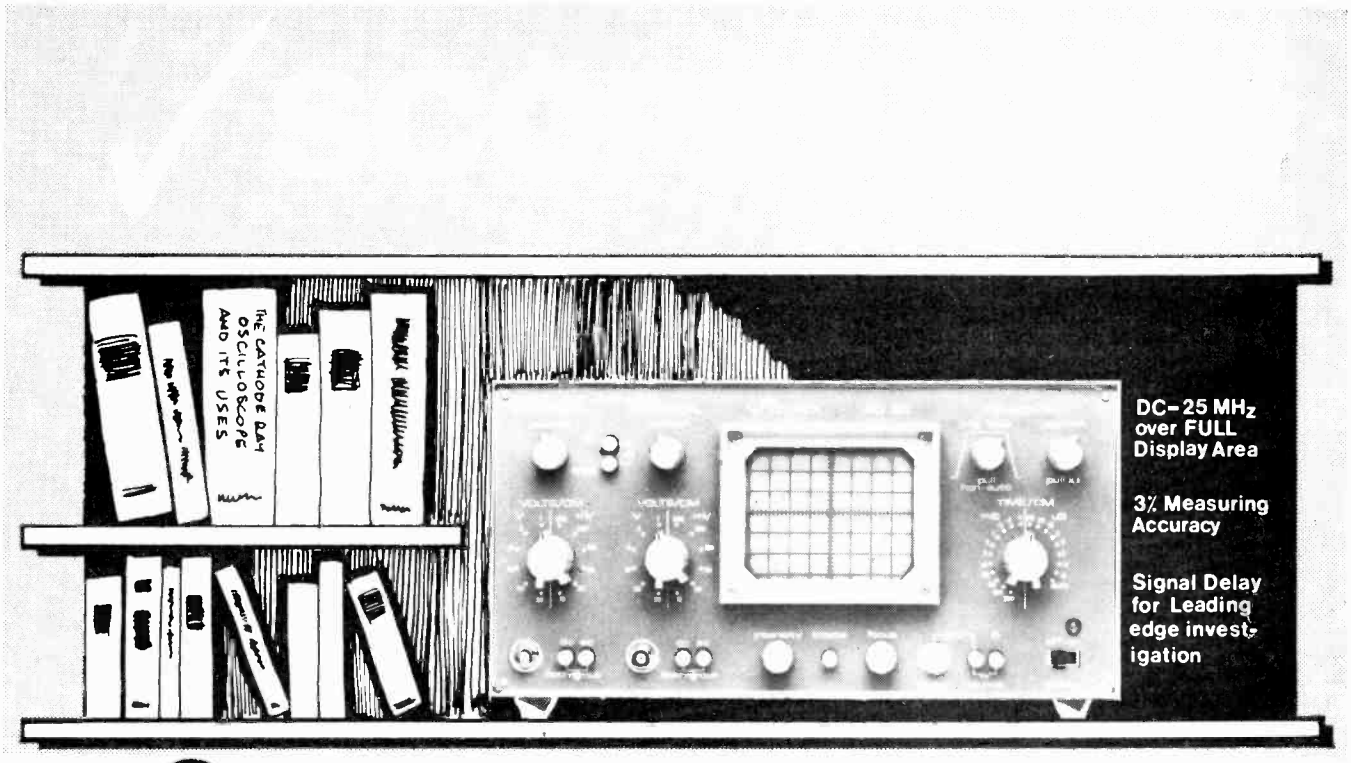

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MK14–the only low-cost keyboard-addressable microprocessor!

The new Science of Cambridge MK14 Standard Microprocessor kit

Just £39.95 (+ £3.20 VAT, and p&p)

The MK14 National Semiconductor Scamp-based Microprocessor Kit gives you the power and performance of a professional keyboard-addressable unit – for less than half the normal price! For less than £44.00 you can have your own microprocessor. One with a specification that makes it perfect for the engineer who needs to keep up to date with digital systems, or for use in school science departments. It's ideal for hobbyists and amateur electronics enthusiasts, too.

But the MK14 isn't just a training aid. It's been designed for practical performance, so you can use it as a working component of, even the heart of, larger electronic systems and equipment.

MK14 Specification

* Hexadecimal keyboard
* 8-digit LED display
* 512 x 8 Prom, containing monitor program and interface instructions
* 256 bytes of RAM
* 4MHz crystal
* 5V Stabiliser
* Single 6V power supply
* Space available for extra RAM and RAM I/O

Free Manual

Every MK14 Microprocessor kit includes a free Operation Manual. It contains operational instructions and examples for training applications, and numerous programs including math routines, timing, general purpose sequencing, games, etc.

Designed for fast, easy assembly

Each 31-piece kit includes everything you need to make a full-scale working microprocessor, from 14 chips, a 4-part keyboard, display interface components, to PCB, switch and fixings.

The MK14 can be assembled by anyone with a fine-tip soldering iron and a few hours' spare time, using the step-by-step illustrated instructions provided.

Tomorrow's technology – today!

"It is not unreasonable to assume that within the next five years...there will be hardly any companies engaged in electronics that are not using microprocessors in one area or another."

Phil Pittman, Wireless World, Nov. 1977

The low-cost computing power of the microprocessor is already being used to replace other forms of digital, analogue, electro-mechanical, even purely mechanical forms of control systems.

The Science of Cambridge MK14 Standard Microprocessor Kit allows you to learn more about this exciting and rapidly advancing area of technology. It allows you to use your own microprocessor in practical applications of your own design. And it allows you to do it at a fraction of the price you'd have to pay elsewhere.

Getting your MK14 Kit is easy. Just fill in the coupon below, and post it to us today, with a cheque or PO made payable to Science of Cambridge. And, of course, it comes to you with a comprehensive guarantee. If for any reason, you're not completely satisfied with your MK14, return it to us within 14 days for a full cash refund.

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Telephone: Cambridge (0223) 311488

To: Science of Cambridge Ltd; 6 Kings Parade, Cambridge, Cambs., CB2 1SN.

Please send me an MK14 Standard Microprocessor Kit. I enclose cheque/money order/PO for £43.55 (£39.95 + 8% VAT and 40p p&p).

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Address *(please print)* _____

Allow 21 days for delivery.

Science of Cambridge

WW/3

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THERMOSTATS

Refrigeration. As illustrated with 36" capillary **£1.62.**
Limpet Stat. Must be mounted in close contact calibrated 90 -190° F 15 amp contacts **£1.62.**
Appliance Stat. Fix like a volume control — 15 amp contact 30 -80° F **85p.**
Ditto but for high temps **£1.25.**
Over Stat. With sensor and capillary **85p.**

MAINS OPERATED SOLENOIDS

Model 772 Small but powerful 1" pull — approx. size 1½ x 1½ x 1¼" **£2.00.** Model 4001 — ⅞" pull. Size 2¾ x 2 x 1½". **£2.50.** Model TT10 — 1¼" pull. Size 3 x 2½ x 2" **£4.50.** Prices include VAT & postage.

DELAY SWITCH

Mains operated — delay can be accurately set with pointers knob for periods of up to 2½ hrs. 2 contacts suitable to switch 10 amps — second contact opens few minutes after 1st contact **95p.**

MOTORISED DISCO SWITCH

With 10 amp changeover switches, multi-adjustable. Switches are rated at 10 amp each so a total of 200w can be controlled and this would provide a magnificent display. The motors are 50V, but they are of such a low wattage, only 2 watts, that they can be driven by a resistor or condenser voltage dropper. 8 Switch model **£5.25.** 10 Switch model **£5.75.** 12 Switch model **£6.75.**

SMITHS CENTRAL HEATING CONTROLLER

push-button gives 10 variations as follows (1) continuous hot water and continuous central heating (2) continuous hot water but central heating off at night (3) continuous hot water but central heating on only for 2 periods during the day (4) hot water and central heating both on but day time only (5) hot water all day but central heating only for 2 periods during the day (6) hot water and central heating on for 2 periods during the day time only — then for summer time use with central heating off (7) hot water continuous (8) hot water day time only (9) hot water twice daily (10) everything off. A handsome looking unit with 24-hour movement and the switches and other parts necessary to select the desired programme of heating. Supplied complete with wiring diagram. Originally sold we believe at over **£15** — we offer these, while stocks last at **£7.50** each including VAT & Postage.

LOW R.P.M. MOTORS

Made by Crouzet — Smiths — SAIWA — Venner and similar famous companies — all supplied ready for 230/240v 50Hz mains working, all **£2.75** each. Following speeds in stock when preparing this advertisement

1 rev per day	6 revs per day	1 rev per hour
12 revs per hour	½ rev per min	1 rev per min
2 rpm 1½ rpm	5 rpm 15 rpm	16 rpm 20 rpm 25 rpm
30 rpm		

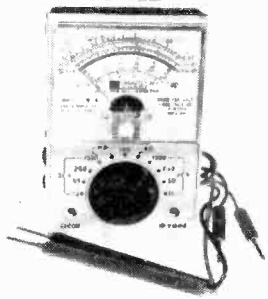
EXTRACTOR FAN

Ex-computers made by Woods of Colchester, ideal for fixing through panel — reasonably quiet running — very powerful 2500 rpm. Choice of two sizes 5" or 6½" dia. **£5** and **£6.**

FLUORESCENT INVERTOR

For camping — car repairing — emergency lighting from a 12v battery you can't beat fluorescent lighting. It will offer plenty of well distributed light and is economical. We offer invertor for 21" and 13 watt miniature tube for only **£3.75** with tube and tube holders as well.

MINI-MULTI TESTER

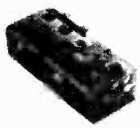


Amazing, deluxe pocket size precision moving coil instrument — jewelled bearings — 1000 opv — mirrored scale
11 Instant ranges measures —
DC volts 10, 50, 250, 1000
AC volts 10, 50, 150, 1000
DC amps 0-1 mA and 0-100 mA
Continuity and resistance 0-150K ohms
Complete with insulated probes, leads, battery, circuit diagram and instructions.
Unbelievable value only **£5.50** + 50p post and insurance.

FREE

Amps ranges kit enable you to read DC current from 0-10 amps directly on the 0-10 scale. It's free if you purchase quickly but if you already own a mini tester and would like one send £1.50.

HUMIDITY SWITCH



American made by Ranco, their type No. J11. The action of this device depends upon the dampness causing a membrane to stretch and trigger a sensitive microswitch adjustable by a screw, quite sensitive — breathing on it for instance will switch it on. Micro 3 amp at 250V a.c. Overall size of the device approx. 3⅜in. long 1in. wide and 1⅛in. deep. **75p.**

MICRO SWITCH BARGAINS

Rated at 5 amps 250V, ideal to make a switch panel for a calculator and for dozens of other applications. Parcel of 10 for **£1**. VAT and post paid.

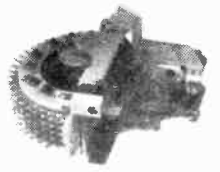
ROTARY PUMP

Self priming, portable, fits drill or electric motor, pumps up to 200 gallons per hour depending upon revs. Virtually uncorrodable, use to suck water, oil, petrol, fertiliser, chemicals, anything liquid. Hose connectors each end. **£2** post paid.

MULLARD UNILEX

A mains operated 4 + 4 stereo system. Rated one of the finest performers in the stereo field, this would make a wonderful gift for almost anyone in easy-to-assemble modular form and complete with a pair of Plessey speakers this should sell at about £30 — but due to a special bulk buy and as an incentive for you to buy this month we offer the system complete at only **£15** including VAT and postage.

UNISELECTORS



These are pulse operated switches as used in automatic telephone switchboards etc. The pulse moves the switch arm through one position. Except where indicated the selectors are 25 position types and 50v Coil is standard. 24v or 12v operation extra at **£2** per switch.

3 pole	**£4.80**
4 pole	**£5.94**
5 pole	**£7.02**
8 pole	**£9.72**
10 pole	**£10.80**
12 pole	**£12.96**
3 pole 50 way	**£10.58**
4 pole 50 way	**£12.74**

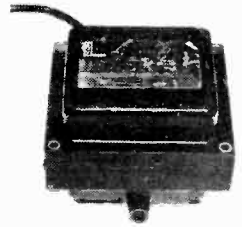
24 HOUR TIMERS

The one illustrated is the 'E' control, this uses the Smiths mechanism as in their autoset. 2 on/off's per 24 hours, 13 amp contacts, override switch **£6.50.**
Smiths 100 amp model one on/off per 24 hours **£10.50,** extra contacts **£1.00** per set.
AEG 60 amp model with clockwork standby, one on/off per 24 hours **£9.50,** extra contacts **£1.00** per set.

INDUCTION MOTORS

One illustrated is our reference MM11 made for ITT ¾" stack 1½" spindle **£2.25.** ½" stack model **£1.75.** 1" stack **£2.75.** 1½" stack **£3.25.**

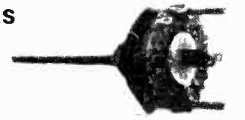
MAINS TRANSFORMERS



20v ½ amp **£1.50**
18v ¼ amp **£1.75**
6.3v 2 amp **£1.75**
25v 1½ amp **£2.25**
24v 2 amp **£2.50**
50v 2 amp **£4.50**
9v 1 amp **£1.50**
8.5v-0-8.5v ½ amp **£1.50**
100w auto 230-115v **£2**
8.5kv **£9.50**

MANY OTHERS — REQUEST LIST

WAFER SWITCHES



6 pole	2 way	12 pole	2 way	18 pole	2 way
5 pole	3 way	10 pole	3 way	15 pole	3 way
4 pole	4 way	8 pole	4 way	12 pole	4 way
3 pole	5 way	6 pole	5 way	9 pole	5 way
3 pole	6 way	4 pole	6 way	6 pole	6 way
2 pole	8 way	4 pole	8 way	6 pole	8 way
1 pole	10 way	4 pole	9 way	6 pole	9 way
1 pole	12 way	2 pole	10 way	3 pole	10 way
all **£1.32** each		all **£2.41** each		all **£3.12** each	

Multi bank switches up to 72 pole 2 way — to 12 pole 12 way, quickly made to special order.

THIS MONTH'S SNIP

Japanese made FM tuner and matching decoder. Two items for less than average price of the tuner only — £11.20 the two. Don't miss this — stocks will not last long.

RELAYS

12 volt two 10 amp changeover plug in **95p.** 12v three 10 amp changeover plug in **£1.28.** 12v two changeover miniature wire ended **95p.** 12 volt open single screw fixing two 10 amp changeovers **85p** 12 volt open three 10 amp changeovers **£1.25.** Latching relay mains operated 2 c/o contacts **£2.11.** Mains operated three 10 amp changeovers open type one screw fixing **£1.25.** Many other types with different coil voltages and contact arrangements are in stock, enquiries invited.

TANGENTIAL HEATER UNIT

A most efficient and quiet running blower-heater by Solatron — same type as is fitted to many famous name heaters — Comprises mains induction motor — long turbo fan — split 2 kw heating element and thermostatic safety trip — simply connect to the mains for immediate heat — mount in a simple wooden or metal case or mount direct onto base of say, kitchen unit — price **£4.95** post £1.50. control switch to give 2kw, 1kw cold blow or off available 60p extra.

TERMS:
Prices include Post & VAT, but orders under £6.00 please add 50p to offset packing etc. Bulk enquiries please phone for generous discount 01-688 2833.

J. BULL (ELECTRICAL) LTD.

(Dept. WW)
103 TAMWORTH ROAD
CROYDON CR9 1SG

IT'S FREE!

Our monthly Advance Advertising Bargains List gives details of bargains arriving or just arrived — often bargains which sell out before our advertisement can appear. — It's an interesting list and it's free — just send S.A.E. Below are a few of the Bargains still available from previous lists.

FM Tuner and decoder, 2 very well made (Japan) units, nice clear dial, excellent reproduction **£11.20** the pair.

12 Volt Heavy Duty Relay, plug in type has three pairs of 10 amp changeover contacts. Transparent dust cover, price **£1.08,** suitable 11 pin base **45p.**

4 Changeover Relay, upright mounting, 4 sets of 10 amps changeover contacts, mains voltage coil **£1.72.**

12 Volt Pump. Designed we believe as a bilge pump, this is 12 volt AC/DC motor coupled by a long enclosed shaft to a submersible pump. Suitable for water or most any fluids. Price **£12.50.**

Just arrived. Fruit machines, working order, very impressive choice of several but very heavy so you must collect, **£50.**

High Load 24 Hour Clock Switch, made by the famous AEG Company for normal mains but with clockwork reserve has load capacity of 80 amps at 240V 50HZ. Therefore suitable for dealing with large loads of say shop lighting, water heating, storage heaters etc. etc. Has triggers for on and off once per 24 hours but extra triggers will be available. Price **£1.50** per pair. Size of clock approximately 8" x 5" x 5", totally encased but has lift up flap for ease of altering switching times. Price **£7.50.**

Enclosed 24 Hour Clock, with contacts for breaking 10-12 amps at 240 volts. This one has two sets of on/off per 24 hours, price **£7.00.**

Light Dimmer, our timer module with small mods makes an excellent light dimmer. Contains a 4 amp 400V SCR so it should be suitable for loads approaching 1KW. Price of module and instructions **£2.25.**

Push Pull Solenoids, mains operated solenoids which will push as well as or instead of pull. Very heavy duty, estimate this at 20lbs push or pull. 1¾" x 3⅛" x 4" made Magnetic Devices Co. **£7.50.**

Flashing Lights, chasing lights, random flashes, strobe effects etc. etc. can easily be achieved using our disco switches. These switches are ex-equipment but guaranteed perfect and supplied suitable for mains working. To get some idea of the loading number, each switch is 10 amp. For the light pipe or Catherine Wheel effect order the 12 switch model with light pipe data model; interconnecting the switches to give fastest speed. 6 Switch model **£5.** 9 Switch Model **£9.75.** 12 Switch model **£6.20.**

Reed Switches, standard 60 watt glass type. Normal open contacts glass lengths 2", diameter 3/16". 10 for **£1.** 100 for **£8.** 64p. 1000 for **£70.**

Flat Reed Switches, for stacking, greater quantity in confined space. Price **50p.**

Single Ended Types for jobs where it is not easy to bring a lead to each end. **75p** each. All these switches are normally open, but can be biased to a normally closed position by fitting a magnet adjacent. The reed switch would then be opened by a magnet of opposite polarity being bought up to it.

Ceramic Magnets suitable for operating reed switches, central fixing hole. 10 for **£1.**

Music Centre Transformer 12-0-12 at 1 amp and 9 volt at ½ amp. Normal primary, uprighting, impregnated and varnished for quiet operation. Price **£3.50.**

'W' Shaped Fluorescent Tubes for porch light, box signs or where you want light evenly spaced over a confined area of approx. 10" x 10". 30 watts, made by Philips price **£2.24.**

Extension Speakers 8 ohm 4-5 watts handling power. We have 5 or 6 different models in stock, cheapest being the Partytime at **£3.95** each, again only really a bargain for callers as postage is **£1.50p** per speaker.

T.V. Monitors, an item for callers, believed to be in good working order, switchable thro' 405-525 & 625, 21" tube line systems, normal controls, volume, brightness, contrast, width etc. Price **£16.20,** 12" model **£18,** suitable for conversion into special purpose scope, etc.

Auto Transformers for working American tools and equipment, completely enclosed in sheet metal case with American type flat output socket made for computer so obviously first class. 500 watts. With carry handle, offered at about half price only **£15.** These may be a bit soiled but are fully guaranteed. Similar but 1000 watt **£29.50.**

Car Starter Charger Kit. New version. We supply two 10 amp rectifiers, 250V transformer and the start charge switch with instructions, price **£9.75.** This is probably one of the most useful pieces of equipment you can have in your garage. Sooner or later you or someone will leave something on and you will have a flat battery, this starter will get you away usually in less than 5 minutes.

Resettable Counter by Veederoot Company. 230/240V mains operated. Intended for surface mounting has a fixing flange at the bottom. Price **£2.16.**

12V Drip proof Relay. Specially designed for going under the bonnet of a car, made by one of our big manufacturers, this really has a removable semi hard rubber cover. Contacts look suitable for up to 10 amps so this could be the right one if you are thinking about making an anti-thief device. Price **£1** + 8p.

High Speed Uniselector. As many customers know, we have a very comprehensive stock of uniselectors as used in automatic telephone exchanges, light flashing device etc. etc. Just arrived, however, is a high speed model made by famous Plessey, this is 2 pole 32 way with make before break wipers, overall size approx. 4" x 3" x 2½", price **£3.50** + 28p. Post 40p + 4p.

Pneumatic Ram for lifting, thrusting, pulling etc. etc. has 2¾" travel, looks large enough to open doors, lift, staircase, ventilators etc. Price **£7.00.** Post 80p.

Solder Gun Bargain. The ETP, this is 100 watt solder gun, a very well made tool with lamp to illuminate work, has double insulated mains transformer and is built into the shockproof thermoplastic case. Comes complete with spare tips. Mains operated of course. Price **£4.50.**

Interested in Tape Control. American made tape punches, really beautiful units full of sophisticated parts, designed we believe to automatically operate typewriters and they can of course be used to operate other punch tape controlled machines. Reference number is NCR Class 461-2 reference 205 H8 R56. We believe these are 8 bit paper tape punches, powered from 115V 50HZ in very good condition with tape **£16.00,** carriage is £3.20.

Memories. The memory units which work with these tape punches, again by N.C.R. are in very good condition and we believe in working order. Price and details on request.

Tangential Blowers. 12" long with powerful induction motor ideal for blowing heaters or general air extraction or circulation, offered at low price of **£2.70.** The motors are 110V so you will have to work them in pairs or through a dropper or mains transformer. Post £1.08 for one or two.

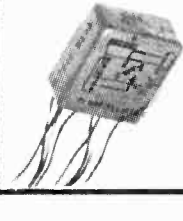
Digital Panel made for the G.P.O. for incorporation, we understand, in push button dialling units, this has the usual 10 digits, each of which when depressed operated a two pole changeover switch. Really beautifully made size approximately 4" square. Price **£3.78.**

250 watt Mains Transformers — 40v secondary, made up of four 10v sections, all the ends of which are brought out to the tag panel, so they can be separated if required — also the 10v coils are all a very heavy gauge wire, thick enough to take 25 amps, so any one of these coils can be loaded up to the full 250 watts, or this wattage can be spread over two or more coils. We can recommend this transformer for heavy duty battery charging — high power amplifier — plastic sealing — soil heating — light welding and dozens of other jobs. Price only **£6.50.**

Save Yourself A Fortune. Build your own rechargeable batteries, using our ex-Home Office nickel cadmium cells — these cells are German made, ref. NCB 22M, which we understand are ¼ amp hour rating. Normally, these cells retail at about £1.00 each, but a special purchase enables us to offer them at only **30p** each, or four for **£1.08.**

Free Gift: All those who purchase 12 cells will receive, free of charge, a mains operator ni-cad charger unit. DON'T miss this offer.

Self Repairing Fuses — not exactly, but our magnetic circuit breakers do the same job and are a boon for the test bench, saving valuable time. In the event of a short, they trip almost instantly, before the fuse can blow. They are rated at 1.5 amps (enough for the average repair bench). Simply wire it in parallel with your bench switch — you would then use the circuit breaker to switch bench supply on, but keep your normal switch for loads over 1.5 amps — a real bargain at **£1.08.**



MINIATURE RELAY

12v dc operated with two sets of changeover contacts. The unique feature of this relay is its heavy lead out wires. These provide adequate support and therefore the relay needs no fixing. On the other hand there is a fixing bolt through one side so if you wish you can fix the relay and use its very strong lead outs to secure circuit components — an expensive relay, we are offering them at only 87p each.

Don't miss this exceptional bargain.

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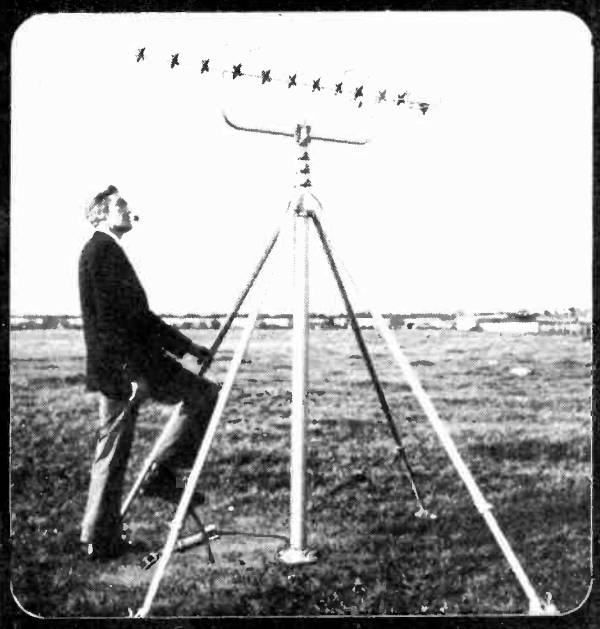
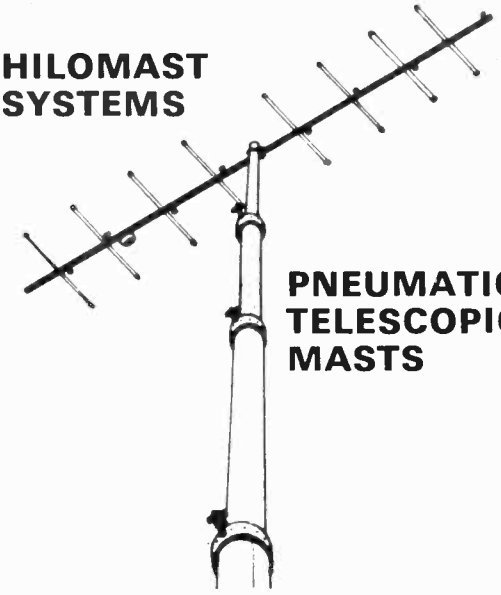


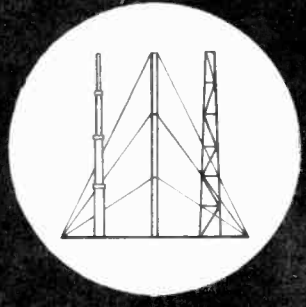
Hilomast Ltd

HILOMAST SYSTEMS



PNEUMATIC TELESCOPIC MASTS

Pneumatic and winch operated telescopic masts and towers. Vehicle, field and wall mountings available. Many standard models ex-stock.



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NEW BOOK

Newnes Radio and Electronics Engineer's Pocket Book
15th Ed.

Edited by Halvor Moorshead

This is a true pocket book containing masses of facts, figures and formulae, indispensable to all interested in radio and electronics. This is a major revision and updating of the previous edition, including new material relating to recent developments in radio and electronics. New tables include TTL, CMOS and logic

Early 1978 192 pages £2.55 approx

A selection of other useful titles

ELECTRONICS ENGINEER'S REFERENCE BOOK – 4th Edition
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Continuing rapid development has made it necessary for the fourth edition to be almost completely rewritten. A new format has also been adopted to greatly improve ease of reference. The whole field of electronics is dealt with: physical aspects; materials; basic theory and descriptions of devices and circuits; and finally, a wide range of electronic applications is described in detail.
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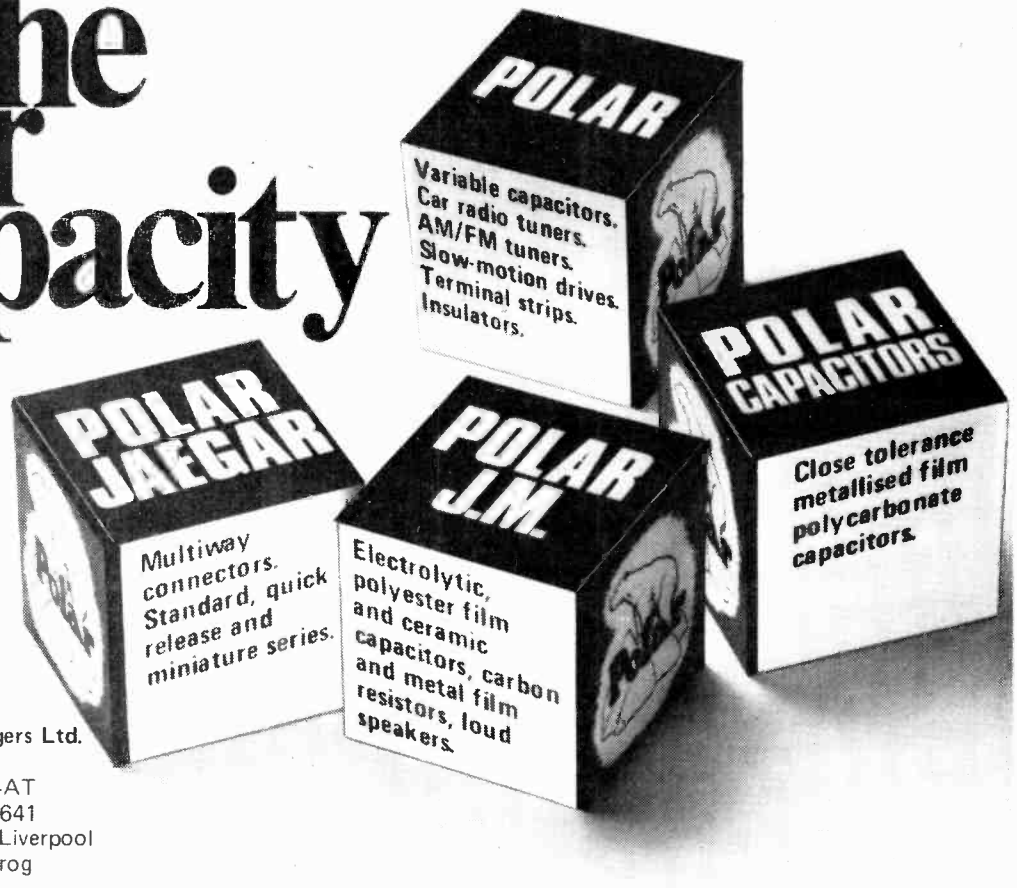
The Polar capacity



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A1065	1.25	EL82	0.60	PY88	0.65	35L6GT	0.80
AR8	0.60	EL86	0.60	PY500A	1.35	35W4	0.60
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ATP4	0.50	EL91	1.60	QQV03-10	2.00	50C5	0.70
B12H	3.00	EL95	0.70	QQV06-40A		50CD6G	1.20
DAF96	0.60	EL504	0.80		14.00	5FP7	10.00
DET22	12.85	EL821	3.00	QV03-12	2.00	88J	9.00
DF96	0.60	EM31	0.75	R19	0.80	25L6GT	0.80
DK96	0.80	EM80	0.55	S104/1K	2.50	75	1.00
DL92	0.50	EM81	0.60	SC1/400	4.00	75C1	0.80
DL96	0.70	EM84	0.40	SC1/600	4.00	76	0.80
DY86/87	0.45	EM87	1.00	SP61	0.85	78	0.75
DY802	0.45	EV51	0.45	1T21	6.50	80	0.75
E55L	7.50	EY81	0.45	U25	1.00	85A2	2.20
E88CC/01	1.30	EY86/87	0.50	U26	0.85	723A/B	9.00
E180CC	1.30	EY88	0.50	U27	1.00	803	6.00
E182CC	3.50	EZ40	0.60	U191	0.75	805	18.00
E810F	6.00	EZ41	0.75	U801	0.80	807	1.00
EA50	0.45	EZ80	0.30	UABC80	0.50	813	6.50
EA76	2.00	GZ32	0.85	UAF42	0.75	829B	5.50
EABC80	0.40	GZ33	4.00	UBC41	0.60	832A	4.50
EAF42	0.70	GZ37	2.50	UBF80	0.50	866A	2.80
EB91	0.30	KT66	4.00	UBF89	0.50	931A	6.00
EBC33	1.00	KT88	5.00	UBL1	1.00	954	0.50
EBC41	0.75	MH4	1.00	UBL21	0.75	956	0.50
EBF80	0.45	ML6	1.00	UCC85	0.50	957	0.90
EBF83	0.45	OA2	0.55	UCF80	0.80	1625	1.00
EBF89	0.40	OB2	0.60	UCH42	0.80	1629	0.70
EC52	0.40	PABC80	0.40	UCH81	0.50	2051	1.00
ECC81	0.45	PC86	0.65	UCL82	0.45	5763	2.00
ECC82	0.40	PC88	0.65	UCL83	0.70	5933	3.00
ECC83	0.40	PC92	0.65	UF41	0.75	6057	0.85
ECC84	0.35	PCC84	0.45	UF80	0.40	6060	0.85
ECC85	0.45	PCC85	0.50	UF85	0.50	6064	0.85
ECC86	1.25	PCC89	0.55	UF89	0.50	6065	1.20
ECC88	0.55	PCC189	0.65	UL41	0.75	6067	1.00
ECC189	0.80	PCF82	0.40	UL84	0.50	6080	3.50
ECF80	0.45	PCF84	0.65	UM80	0.60	6146	3.80
ECF82	0.45	PCF86	0.65	UY21	1.50	6146B	4.20
ECF801	0.75	PCF201	0.90	UY41	0.55	6360	2.00
ECH42	0.85	PCF801	0.55	UY85	0.50	8020	5.50
ECF81	0.45	PCF802	0.65	VR105/30		9001	0.40
ECH84	0.50	PCF806	0.85		1.25	9002	0.55
ECL80	0.60	PCF808	1.00	VR150/30		9003	0.70
ECL82	0.40	PCH200	0.80		0.50	9004	0.40
ECL83	1.20	PCL81	0.60	X61M	1.50		
ECL86	0.55	PCL82	0.45	X66	0.75		
EF36	0.75	PCL83	0.70	Z800U	3.00		
EF39	2.90	PCL84	0.70	Z801U	3.50		
EF40	0.70	PCL86	0.65	Z900T	1.50		
EF41	0.75	PCL805/85		1A3	0.60		
EF80	0.35		0.60	1L4	0.30		
EF83	1.50	PD500	2.25	1R5	0.55		
EF85	0.45	PFL200	0.85	1S4	0.40		
EF86	0.45	PL36	0.60	1S5	0.40		
EF89	0.35	PL81	0.75	1T4	0.40		
EF91	0.65	PL82	0.50	1X2B	0.80		
EF92	0.75	PL83	0.50	2X2	0.80		
EF95	0.45	PL84	0.50	2D21	0.55		
EF183	0.55	PL504	0.95	2K25	9.00		
EF184	0.40	PL508	0.95	3A4	0.60		
EF804	2.00	PL509	2.00	3E29	5.50		
EFL200	0.75	PL802	2.50	3D6	0.40		
EH90	0.60	PY33	0.60	3S4	0.50		
EL32	0.60	PY80	0.60	3V4	0.85		
EL34	2.20	PY81/800		5B/254M	5.50		
EL37	3.00		0.55	5B/255M	5.50		
EL41	0.80	PY82	0.45	5B/258M	5.50		
EL81	0.60	PY83	0.50	5R4GY	1.10		

PLUMBICON TUBES TYPE XQ.1020R

Mullard—£150 each

5U4G	0.60	6SJ7	0.60	5FP7	10.00
5V4G	0.65	6S37GT	0.50	88J	9.00
5Y3GT	0.65	6SK7	0.60	25L6GT	0.80
5Z3	1.00	6SL7GT	0.55	75	1.00
5Z4G	0.70	6SN7GT	0.55	75C1	0.80
5Z4GT	0.75	6SQ7	0.65	76	0.80
6AB7	0.60	6V6GT	0.60	78	0.75
6AC7	0.60	6X4	0.60	80	0.75
6AH6	0.75	6x5G	0.45	85A2	2.20
6AK5	0.45	6X5GT	0.55	723A/B	9.00
6AK8	0.40	6Y6G	0.95	803	6.00
6AL5	0.30	6Z4	0.65	805	18.00
6AL5W	0.65	6.30L2	0.90	807	1.00
6AM5	1.60	7B7	0.80	813	6.50
6AM6	0.65	7Y4	0.80	829B	5.50
6AN8	0.85	9D2	0.60	832A	4.50
6AQ5	0.50	9D6	0.75	866A	2.80
6AQ5W	0.85	11E3	11.00	931A	6.00
6AS6	0.80	12A6	0.60	954	0.50
6AT6	0.65	12AL5	0.70	956	0.50
6AU6	0.40	12AT6	0.45	957	0.90
6AV6	0.80	12AT7	0.45	1625	1.00
6AX4GT	0.80	12AU7	0.40	1629	0.70
6AX5GT	1.00	12AV6	0.70	2051	1.00
6B7	0.75	12AX7	0.40	5763	2.00
6BA6	0.40	12BA6	0.50	5933	3.00
6BE6	0.45	12BE6	0.60	6057	0.85
6BG6G	1.00	12BH7	0.60	6060	0.85
6BJ6	0.75	12C8	0.55	6064	0.85
6BQ7A	0.60	12E1	4.25	6065	1.20
6BR7	2.30	12J5GT	0.40	6067	1.00
6BW6	2.80	12K7GT	0.60	6080	3.50
6BW7	1.00	12K8GT	0.70	6146	3.80
6C4	0.40	12Q7GT	0.50	6146B	4.20
6C6	0.55	12SC7	0.55	6360	2.00
6CB6	0.50	12SG7	0.55	8020	5.50
6CH6	3.00	12SJ7	0.55	9001	0.40
6CL6	0.75	12Y4	0.40	9002	0.55
606	0.50	14S7	1.00	9003	0.70
6EA8	0.80	19AQ5	0.75	9004	0.40

Add 12½% for V.A.T.

6F8G	0.75	19G3	10.00	9006	0.40
6F12	0.65	19G6	6.00	**C.R. TUBES**	
6F17	1.00	19H5	17.00	DG7-5	15.00
6F33	4.20	20P3	0.60	DG13-2	22.00
6H6	0.45	20P4	1.10	MW13-35	
6J4WA	1.75	30C15	1.00		35.00
6J5GT	0.55	30C17	1.10	VCR139A	10.00
6J6	0.35	30C18	1.10	38P1	8.00
6J7	0.70	30F5	1.00	**SPECIAL VALVES**	
6J7G	0.50	30FL2	1.50	BR189	250.00
6K7	0.55	30FL12	1.20	M503 2J42	
6K7G	0.35	30FL14	1.00		65.00
6K8GT	0.55	30L15	1.00	K301	7.00
6L6M	1.90	30L17	1.00	KRN2A	6.00
6L6GT	0.60	30P12	1.00	725A	25.00
6L7	0.65	30PL1	1.00	2J/52A	75.00
6SA7	0.55	30PL13	1.10	CV2339	45.00
6SG7	0.60	30PL14	1.10		

POSTAGE: £1-£2 20p, £2-£3 30p, £3-£5 40p, £5-£10 60p, over £10 free.

VIDEON TUBE TYPE P863B
English Electric—£20

MARCONI SIGNAL GENERATORS

TF 1066 B from 10 to 470MHz FM up to 400kHz AM up to 50%
TF 2005 R 20Hz to 20kHz
TF 2400/1 Frequency Converter up to 510MHz
TF 894 A Audio Tester 50cs to 27kHz 2W into 15 3Ω
791 D Deviation Meter Freq from 4MHz to 1024MHz Deviations up to ±125kHz
AIRMEC
MODULATION METER 210A. 2·5-300MHz AM 0-100%FMD+100kHz in 4 ranges
HF WAVE ANALYSER 853 from 30kHz to 30MHz
VHF WAVE ANALYSER 248 Freq from 5MHz to 300MHz
TF 801 D/1/S SIGNAL GENERATOR. Range 10-485MHz in 5 ranges R.F. output 0·1 V-1V Source C.M. 50Ω output impedance Internal modulation at 1KHz at up to 90%
TF 801 B/2. Spec as for 801D but minor circuit differences Few only left
TF 995 A/1 or A/2 or A/2M or A5 SIGNAL GENERATORS. Very high class AM/FM 1·5MHz to 220MHz Detailed spec and price on application
TF 995/3S with additional amplifier to give extra high output between 1·5 and 6 Mc/s
TF995 B2 SIGNAL GENERATOR as 995A but later model
TF 144 H SIGNAL GENERATOR
HIGH FREQUENCY SPECTRUM ANALYSER. MARCONI TYPE 1094A/S Basic Freq. range 3 to 30 Mc/s and with LF unit from 100Hz to 3 MHz Measures relative amplitudes up to 60dB
TF1041 B VALVE MULTIMETER. DC voltage from 300mV to 1 000V AC voltage from 300mV to 300V at up to 1 000MHz
TF1370 R.C. OSCILLATOR FOR SQUARE & SINE WAVE. Freq —31 6V rms **TF1066 FM/AM SIGNAL GENERATOR.**
LEVEL OSCILLATOR TYPE REL 3W29. Frequency from 0·3 to 1200Kc/s. Mod ext output from +16dB to —60dB Impedance output 75, 140, 600 ohms
36' AERIAL MASTS consisting of 6 sections 6' 8" × 2¼" dia Complete with all accessories to erect and instal
AVO CT 160 VALVE TESTER
LOW RESISTANCE HEADPHONES TYPE CLB £1.50. 40p postage VAT 12½%
AR88 D & LF SPARES. We hold the largest stock in UK Write for list
RF METERS. 0 to 8 amps 2¼" dia USA brand new **£1.50.** P&P 25p
TELEPHONE TYPE "J" tropicalised
10 LINE MAGNETO SWITCHBOARDS
CABLE LAYING APPARATUS No. 11. New production P O A

FOR EXPORT ONLY

TRANSMITTER RECEIVER. Transmitter Type M9 receiver Type M17 with fixed frequency Range 240MHz
RCA ET4336, 2 Mc/2-20 Mc/s 350W, also modified version of increased output to 700W
Collins 231D 4·5kW 3MHz-24MHz 10 channel Auto or manual tuning
53 Transmitter
Mullard C11, High power installation, 1000W Technical details and prices available on request

A lot of these valves are imported and prices vary for each delivery so we reserve the right to change prices for new stock when unavoidable

VALVES AND TRANSISTORS

Telephone enquiries for valves transistors etc retail 749 3934 trade and export 743 0899

RHODE & SCHWARZ

Z-g DIAGRAPH TYPE ZDU 30-420MHz 50Ω Directly measures multiterminal networks, phase shift, phase angle with complementary POWER SIGNAL GENERATOR TYPE SMLM high freq resolution internal external mod up to 3v out
FREQUENCY SYNTHESIZER TYPE XUA. 30Hz-30MHz with FREQUENCY INDICATOR TYPE FKM 15-30MHz 30-100MHz
UHF SIGNAL GENERATOR TYPE SMLM from 30 to 303MHz
UHF SIGNAL GENERATOR TYPE SLSD from 300 to 300 940MHz
FREQUENCY INDICATOR TYPE FKM from 30 to 1 000MHz

TEKTRONIX

545A. Bandwidth DC to 30MHz
570 CHARACTERISTIC CURVE TRACE
517A OSCILLOSCOPES wide band high voltage cathode ray oscilloscope designed for observing and photographically recording wave form having extremely short rise times
DANA EXACT FUNCTION GENERATOR MODEL 121. Frequency range 0·2Hz to 2MHz (7 ranges) voltage controlled to 10V sweep generator 1ms to 10 sec
TEXSCAN ELECTRONIC SYSTEM ANALYZER MODEL 9990. Frequency range 10MHz to 300MHz with market controls
FURZEHILL SENSITIVE VALVE VOLTMETER TYPE V200A full scale from 10mV to 1000V in 6 steps with output amplifier
TRAINING SET for Radio Operators with 10 key terminals and control frequency and volume
EDDYSTONE COMMUNICATIONS RECEIVER MODEL 730/1A. Frequency from 500kc/s to 28Mc/s
HIGH VACUUM VARIABLE CAPACITORS — ceramic envelope — UC 100A 20, 150 = VMMHC 1000 60 1000μF 20kv 150A RF max = 27MHz
TEST SET FT2 for testing Transceivers A40 A41 A42 and CPRC26
UNIVERSAL WIRELESS TRAINING SET No 1 Mk 2 YA 8316 to train 32 operators simultaneously on key and phone Complete installation consists of 3 kits packed in 3 special transit cases
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EXTRA SPECIAL OFFERS

MARCONI INSTRUMENTS TF2333 M.F. TRANSMISSION MEASURING SET

Freq. range 30Hz-550 KHz (5 ranges)
Attenuator Range 70dB in 10 dB and 1 dB steps
Level Measurement +25 to −70 dBm
Measures response of active and passive transmission networks

REFURBISHED AND RECALIBRATED TO SPEC.

LIST PRICE £900 + **£600.00**

MARCONI INSTS TF893A A.F. POWER METER

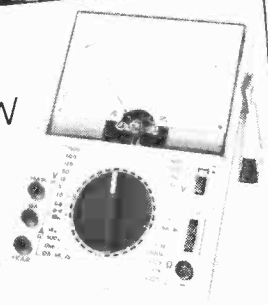
FREQ. RANGE 20Hz to 35KHz.
5 power ranges 1mW to 10W.
Impedance 2.5 ohms to 20Kohms in 48 steps. Balanced or unbalanced inputs. Direct calibration in watts and dBm.

REFURBISHED AND RECALIBRATED TO SPEC.

NEW LIST PRICE £260.00 **£155.00**

WIDE RANGE MULTIMETER UM11

BRAND NEW



SPECIAL LOW PRICE FOR LIMITED PERIOD ONLY:
38 ranges. High input impedance.
★ DC Volts 150mV to 1500V f.s.d. @ 100K Ohms/V
★ AC Volts 1.5 to 1500V f.s.d. @ 31.6KOhms/V
★ DC Current 10μA to 15A f.s.d.
★ AC Current 15A
★ Mirror scale, rugged taut-band suspension, dB scale, diode and fuse protection
★ Supplied complete with test leads and leather carrying case
★ 3 months' warranty

NORMAL PRICE £39.50

£29.50

BRAND NEW FUNCTION GENERATORS

Special Low Prices for Limited Period while Stocks last

G.430
(Illustrated)
★ Frequency 1 Hz to 1 MHz ★ Output Sine-wave, 0-10V r.m.s. from 600. Square-wave 0.20V p.p. from 600. ★ 0-60 dB step attenuator

£59.50

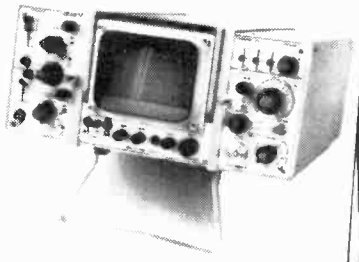
G.432
★ Frequency 1 Hz to 1.1 MHz. ★ Sine, square and triangle. ★ 5V from 0-60 dB 50 attenuator. ★ Also simultaneously 10V from three independent 600 outputs. ★ D.C. offset

NORMAL PRICE £115.00

£79.50

6 MONTH WARRANTY

DYNAMCO MODEL 7100 PORTABLE DUAL CHANNEL OSCILLOSCOPE



Supplied with plug in units 1X2 and 1Y2
New condition
DC to 30MHz
Rise Time: 12nS
10mV/div. also X10 gain provides 1mV/div. (10Hz-5MHz)
Comprehensive sweep delay timebase
Full spec. on request

TODAY'S VALUE £500 PLUS

UNUSED

£350.00

HEWLETT PACKARD 332A DISTORTION ANALYSER

Fundamental Frequency Range 5Hz-600 KHz
Distortion levels of 0.1%-100% are measured full scale in 7 ranges
A.M. Detector facility

REFURBISHED AND RECALIBRATED TO SPEC.

OUR PRICE **£495.00**

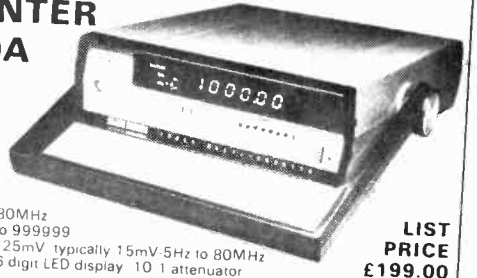
RACAL RA117 H.F. COMMUNICATIONS RECEIVER

FREQ.: 1-30MHz
TUNING: Effective scale length of 145 feet i.e. 6" corresponding to 100KHz
CALIBRATION: 100KHz signal derived from 1MHz Xtal oscillator accuracy 5 parts in 10^6 provides check points at 100KHz intervals
SENSITIVITY: A1 reception b.w. 3KHz 1μV for 18dB signal to noise ratio. A2 reception 30% mod. b.w. 3KHz 3μV for 18dB signal to noise ratio. Intermodulation −100dB down. Selectivity 6 i.f. bandwidths are obtained by means of a selector switch. Full Spec. on request. Completely refurnished and recalibrated

TODAY'S VALUE AT LEAST £600.00

SUPERB CONDITION **£350.00**

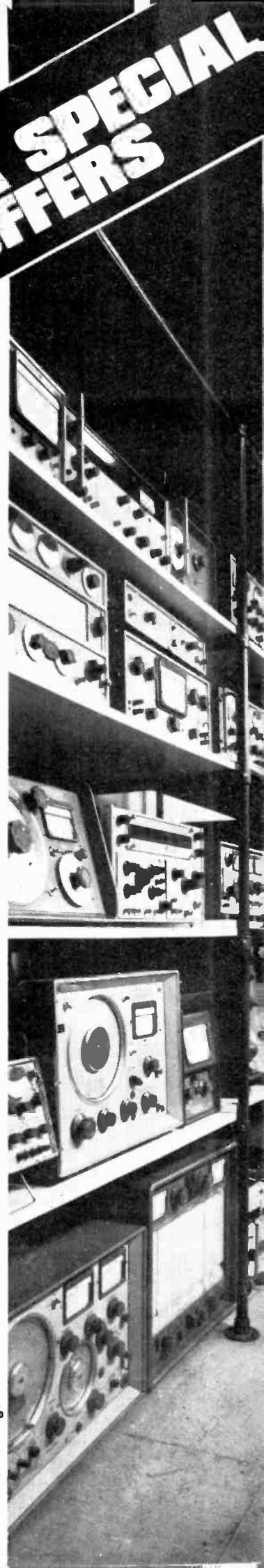
FLUKE MULTIFUNCTION COUNTER 1900A



FREQ. 5Hz-80MHz
TOTALIZE 1 to 999999
SENSITIVITY 25mV typically 15mV 5Hz to 80MHz
Autoranging 6 digit LED display. 10:1 attenuator

LIST PRICE £199.00

BULK PURCHASE *BRAND NEW* **£175.00**



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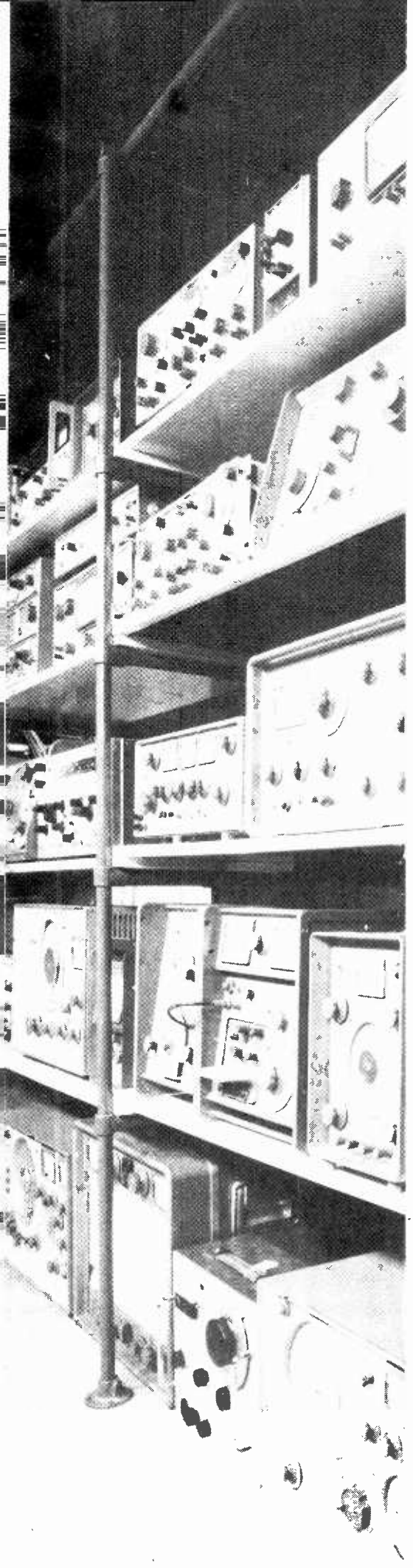

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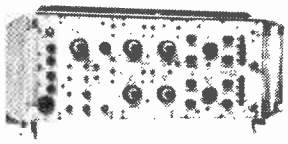
SIGNAL SOURCES

ADVANCE

V H F Square wave Generator SG21 10 KHz-100MHz Max o/p 2V **£50.00**

H1E Audio Signal Generator Sine & Square Wave 15Hz-50KHz 200V to 20V (Sine) Distortion 1% 1 4mV to 140V (Square) Brand new condition **£75.00**



Type PG59 Pulse Generator 2 Channel double pulse Functions Frequency, Width Rise & Fall Time, Amplitude Offset, Delay, Prepulse & Gate Repetition Freq 1Hz to 10MHz (20 MHz in double pulse mode) Delay & Width 25 nsecs/1sec Full specification on request **£595.00**

Type SG67A Wide Range Oscillator Freq Range 1Hz-1MHz Sine or Square Output Amplitude up to 2 5V Battery operated **£95.00**

R F Signal Generator B4B7 30KHz-30MHz Output Z — 75 Int Mod 400Hz 0-80% Provision for Ext Mod Audio o/p 0-10V at 400 Hz into 600Ω **£165**

SG68A Low Distortion Oscillator 1-5Hz-150KHz c/w BE2 battery pack New condition **£200.00**

HEWLETT PACKARD

10515A Frequency Doubler **£75.00**

F M / A M Signal Generator 202H F M A M C W & pulse coverage 54 to 216MHz R F o/p 0 1μV-0 2V 50ohms Impedance **£495.00**

612A-U H F Signal Generator 450-1230MHz 0 1μV-0 5V (50ohms) A M Internal & external Pulse mod facilities SUPERB CONDITION **£1250.00**

606A A M Signal Generator 50KHz 65MHz **£550.00**

MARCONI INSTRUMENTS

TF1060 U H F Signal Generator 450-1250MHz Sine wave and pulse a m **£400.00**

Signal Generator **TF867**, 15KHz-30MHz o/p 0 4μV-4V Int & Ext mod Supplied with Terminating unit **£185.00**

Solid State Generator 6058B Freq range 8-12 5GHz Int & Ext mod freq Stab 0 003% 50Ω impedance **£530.00**

A M Signal Generator TF801D/1S Military version 10-485MHz **£450.00-£800.00**

R C Oscillator TF1370A 10Hz-10MHz Square Wave up to 100KHz High Outputs up to 31 6V **£225.00**

Phase/A M Signal Generator TF 2003 0 4 12MHz **£150.00**

A M Signal Generator TF801D/1 Freq range 10-470MHz R F output 0-1μ 1V Piston attenuator 50ohms Impedance Signal Generator TF144H/4 Later models in super condition **£500.00 to £650.00**

TF995B/5 F M / A M Signal Generator 200KHz-220MHz **£675.00**

TF1101 R C Oscillator 20Hz-200KHz 600ohm impedance Output variable 1mV-20V **£105.00**

TF2000 A F Signal Source 20Hz-20KHz 111dB Attenuator in 0 1 dB steps Low distortion **£325.00**

TF2005R Two Tone Signal Source 2 identical oscillators 20Hz-20KHz <0 1% distortion for intermodulation measurements on high quality A F equipment **£415.00**

PHILIPS

50MHz Pulse Generator PM5712 **£495.00**

Pulse Generator PM5775 **£800.00**

Pulse Generator PM5776 **£900.00**

L F Generator PM5105 10Hz-100KHz Sine & Square Wave 2V(R M S) Stabilised o/p Low Distortion <0 8% (10Hz-100KHz) **£156.00**

RADIOMETER

SMG1C Stereo Signal Generator **£350.00**

DIGITAL VOLTMETERS AND MULTIMETERS

AVO

Test leads **£4.00**

Multiminor Mk 4 c/w carrying case and leads **£14.00**

Model 7x **£40.00**

Heavy Duty Mk 5 (with case) **£40.00**

AVO Model 8X **£53.00**

AVO Model 9 or Test Set No 1 **£55.00**

DATA PRECISION

D.M.M 4½ digit battery operation AC/DC current and voltage + ohms **£150.00**

DYNAMCO

Digital Voltmeter DM 2023 c/w DC ranging unit C1 Scale 99999 0 001% F S D DC Accuracy 10μV-1Kv DC **£450.00**

FLUKE

DC Digital Voltmeter 8200A 4½ digit 60% overanging, autoranging, push button range and function selection full guarding and a selectable input filter Many options can be obtained for expanding the 8200A capabilities **£595.00**

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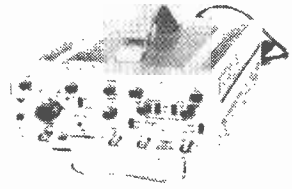

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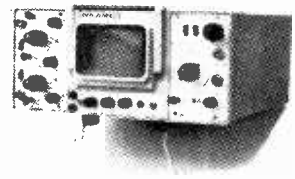

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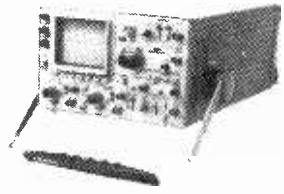

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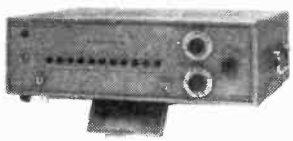

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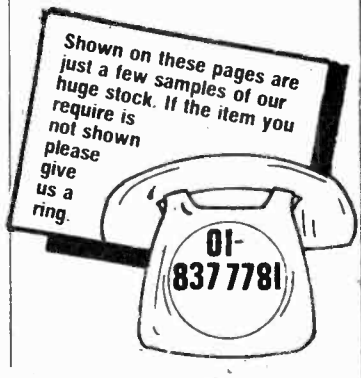

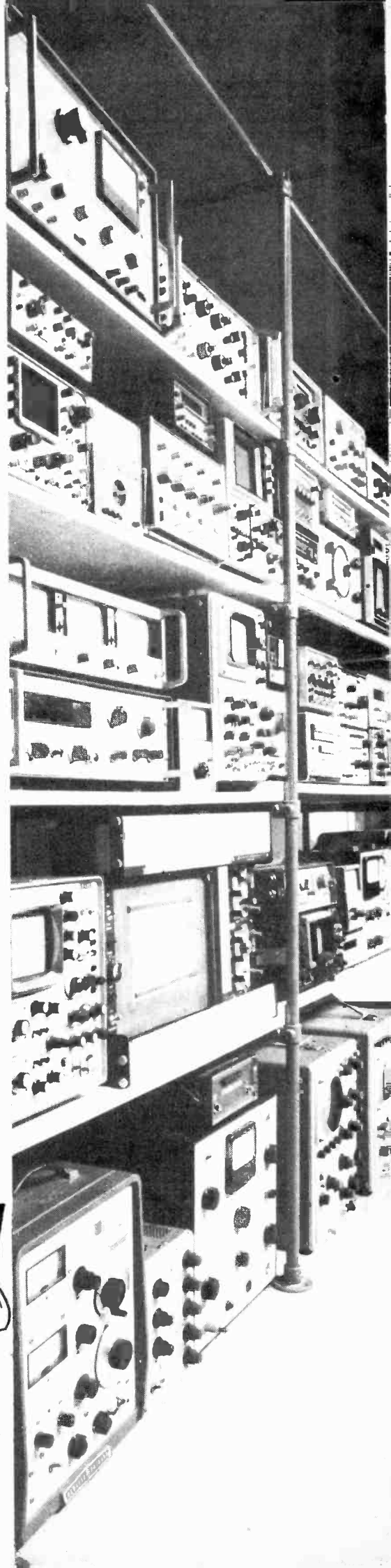

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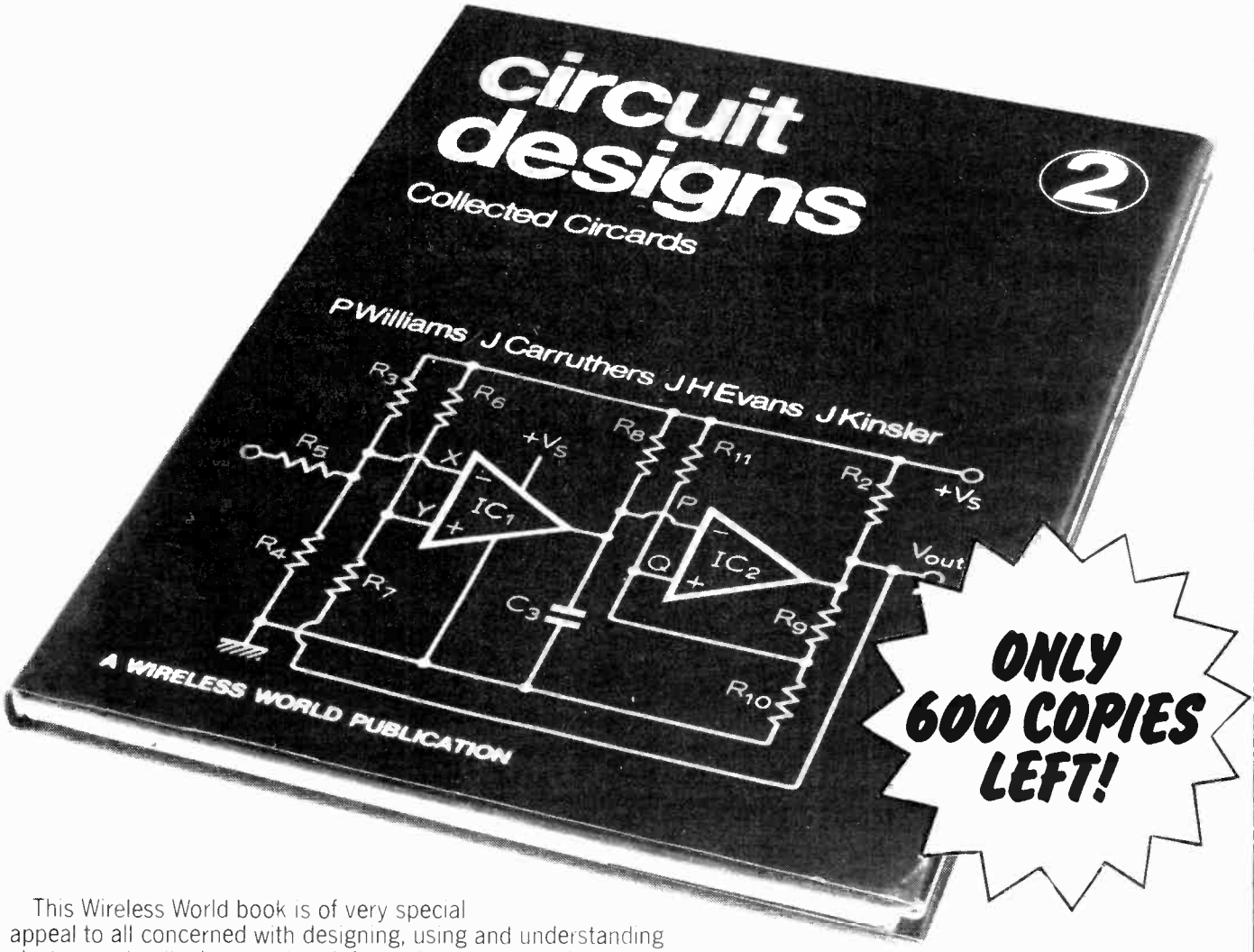

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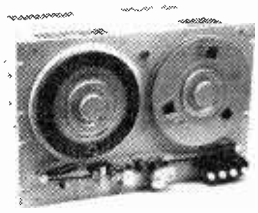

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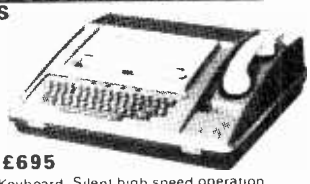

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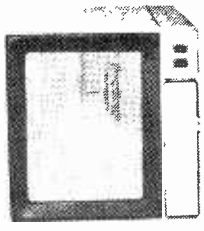

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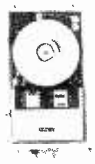

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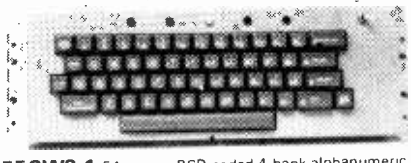

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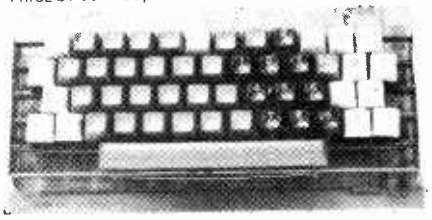

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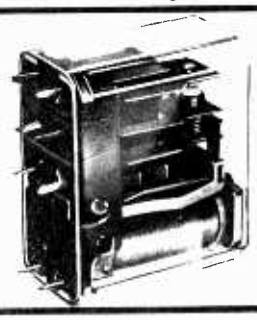

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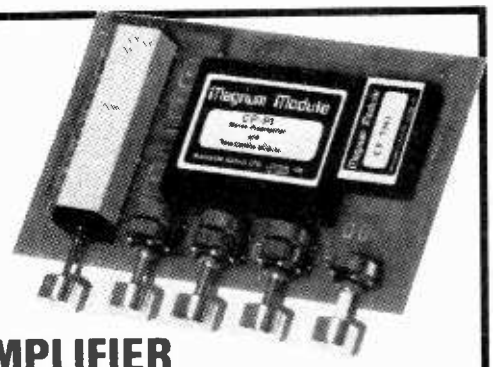

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0C3	0.50	6BA6	0.65	6L19	2.00	12AX7	0.52	35A3	1.00	CY31	1.00	EC88	0.84	EL360	2.50	PC88	0.80	PY83	0.60	U17	1.00	X142	1.00	AF102	1.04	BYZ15	2.03	OC44	0.12
0Z4	0.55	6BC8	0.90	6LD12	0.48	12BA6	0.50	35C5	0.80	D1	0.50	EC90	0.50	EL506	2.00	PC92	0.65	PY88	1.12	U18/20	2.50	X150	1.00	AF106	0.58	CG12E	0.23	OC45	0.13
1A3	0.60	6BE6	0.70	6LD20	0.80	12BE6	0.85	35D5	0.90	D63	0.50	EC92	1.00	EL509	2.50	PC95	1.00	PY301	0.50	U19	4.00	X719	0.55	AF114	0.30	CG46H	0.23	OC65	1.31
1A5GT	0.55	6BG6G	1.00	6N7GT	0.70	12BH7	0.55	35L6GT	0.80	DAC32	0.80	EC97	0.75	EM80	1.00	PC97	0.75	PY500	1.56	U22	0.85	Z145	0.67	AF115	0.30	FSY11A	0.26	OC70	0.14
1A7GT	0.60	6BH6	1.10	6PL12	0.60	12BY7	1.15	35W4	0.55	DAF91	0.35	EC32	1.00	EM81	1.00	PC900	0.65	PY500A	1.56	U25	1.00	Z152	0.40	AF117	0.23	FSY41A	0.26	OC71	0.13
1B3GT	0.55	6BJ6	0.75	6P15	0.48	12E1	3.50	35Z3	0.80	DAF96	1.00	EC33	2.00	EM83	1.00	PCC84	0.39	PY800	0.80	U26	0.90	Z329	0.70	AF121	0.35	GD4	0.38	OC72	0.13
1C2	1.00	6BK7A	0.85	6Q7G	0.75	12J5GT	0.40	35Z4GT	0.70	DC90	0.70	EC35	2.00	EM84	1.00	PCC85	0.47	PY801	0.80	U31	0.50	Z719	0.40	AF124	0.36	GD5	0.32	OC74	0.26
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1G6	1.00	6BQ5	0.48	6Q7M	0.75	12K5	1.50	50B5	0.95	DF33	0.75	EC81	0.52	EM87	1.45	PCC89	0.49	QP21	1.10	U35	1.75	Z749	1.00	AF139	0.76	GD8	0.23	OC76	0.18
1H5GT	0.80	6BQ7A	1.40	6R7G	0.70	12K7GT	0.50	50C5	0.70	DF91	0.30	EC82	0.52	EMM803	2.50	PCC189	0.60	QQV03/10		U37	2.00	Z759	6.50	AF178	0.79	GD9	0.23	OC77	0.32
1L4	0.25	6BR7	1.00	6R7(M)	1.00	12K8	0.75	50CD6G	4.00	DF96	1.00	EC83	0.52	EY51	0.80	PCC805	0.75		2.00	U45	1.20	Transistors		AF180	0.56	GD11	0.23	OC78	0.13
1LD5	0.70	6BR8	1.25	6SA7	0.70	12Q7GT	0.50	50EH5	0.85	DH63	0.75	EC84	0.50	EY81	1.50	PCC806	0.70	QS75/20	1.00	U47	1.00	and Diodes		AF186	0.64	GD12	0.23	OC78D	0.18
1LN5	0.70	6BW6	3.50	6SC7GT	1.00	12SA7GT	0.75	50L6GT	1.00	DH76	0.50	EC85	0.50	EY83	1.50	PCF80	0.80	QS95/10	1.00	U49	0.90	1N1124A	0.61	AF239	0.44	GD14	0.58	OC79	0.47
1N5GT	0.75	6BW7	0.65	6SG7	0.70	12SC7	0.50	66KU	1.00	DH77	0.60	EC86	2.00	EY86/7	0.45	PCF82	0.45	QS150/15	1.80	U50	0.65	1N4744A	0.16	ASY27	0.50	GD15	0.47	OC81	0.13
1R5	0.50	6BX6	0.40	6SH7	0.70	12SG7	0.55	72	0.70	DH81	1.00	EC88	0.72	EY88	1.00	PCF84	0.70	QV03/12	2.75	U52	1.00	1N4952	0.58	ASY28	0.38	GD16	0.23	OC81D	0.13
1S4	0.40	6BY7	0.45	6SI7	0.70	12SH7	0.50	77	0.45	DK32	0.60	EC89	0.35	EY500A	1.45	PCF86	0.57	QV04/7	3.00	U76	0.70	2N404	0.21	ASY29	0.58	GET119	0.30	OC82	0.13
1S5	0.35	6BZ6	1.50	6SK7	1.00	12SJ7	0.80	85A2	1.40	DK40	1.00	EC189	1.00	EZ35	0.50	PCF87	0.90	QV06/20	4.70	U78	0.95	2N966	0.61	BA102	0.53	GET573	0.44	OC82D	0.13
1T4	0.30	6C4	0.50	6SK7GT	0.70	12SK7	0.80	85A3	1.40	DK91	0.50	EC800	0.90	EZ40	1.00	PCF200	1.35	R10	5.00	U81	0.80	2N1756	0.58	BA115	0.16	GET587	0.50	OC83	0.23
1U4	0.70	6C6	0.45	6SN7GT	0.75	12SN7GT	0.75	90C1	1.50	DK92	1.00	EC807	2.80	EZ41	1.00	PCF201	1.00	R11	1.00	U150	1.00	2N2147	0.99	BA116	0.21	GET872	1.11	OC84	0.28
1U5	0.85	6C9	2.00	6U4GT	1.00	12SQ7	0.80	90CV	5.50	DK96	1.00	ECF80	0.65	EZ80	0.42	PCF800	1.00	R16	2.00	U153	0.60	2N2297	0.26	BA129	0.14	GET873	0.18	OC123	0.26
2D21	0.55	6C10	1.00	6U7G	0.55	12SQ7GT	0.80	108C1	0.40	DL63	0.70	ECF82	0.50	EZ81	0.45	PCF801	0.49	R17	1.50	U191	0.50	2N2369	0.16	BA130	0.12	GET882	0.58	OC140	1.11
2GK5	0.75	6CB6A	0.65	6U8	0.50	12SR7	0.75	150C2	1.20	DL82	1.00	ECF86	0.80	EZ90	0.95	PCF802	0.80	R19	0.75	U192	0.40	2N2613	0.45	BA148	0.29	GET887	0.26	OC169	0.50
2X2	0.70	6C12	0.55	6V6G	0.50	13D8	2.00	215SG	0.60	DL92	0.65	ECH35	2.00	FC4	1.00	PCF805	2.25	R20	0.90	U193	0.60	2N3053	0.38	BA153	0.18	GET889	0.26	OC171	0.40
3A4	0.55	6CD6G	4.00	6V6GT	1.00	14H7	0.75	303	1.20	DL94	1.00	ECH42	1.00	FW4/500	2.50	PCF806	0.70	R52	0.75	U251	1.00	2N3121	2.90	BCY10	0.53	GET896	0.26	OC172	0.41
3B7	0.55	6CG8A	0.90	6X4	0.95	14S7	1.00	305	1.20	DL96	1.00	ECH81	0.55	FW4/800	2.50	PCH200	1.00	RK34	1.00	U281	0.75	2N3703	0.23	BCY12	0.58	GET897	0.26	OC201	1.00
3D6	0.40	6CL6	0.75	6X5GT	0.50	18	1.25	807	1.10	DM70	1.25	ECH83	1.00	GY501	1.25	PCL82	0.62	SP4	1.50	U282	0.70	2N3709	0.23	BCY33	0.23	GET898	0.26	OC204	0.50
3Q4	0.80	6CL8A	0.95	6Y6G	0.95	19AQ5	0.85	956	0.50	DM71	1.75	ECH84	0.75	GZ30	0.75	PCL83	0.75	SP13C	0.75	U291	0.50	2N3866	1.16	BCY34	0.26	GEX113	0.21	OC206	1.05
3Q5GT	0.70	6CM7	1.00	6Y7G	1.25	19BG6G	1.00	1625	2.50	DW4/350	1.15	ECL80	0.55	GZ32	1.00	PCL84	0.48	TH4B	1.00	U301	1.00	2N3988	0.58	BCY38	0.26	GEX36	0.58	ORP12	0.61
3S4	0.65	6CS6	0.65	7A7	1.00	19G6	6.50	1821	1.00	DY51	2.00	ECL82	0.60	GZ33	4.00	PCL85	1.00	TH233	1.00	U329	1.00	2S323	0.58	BCY39	0.26	GEX45	0.38	SFT237	0.50
3V4	1.00	6CU5	0.90	7B6	1.00	19H1	4.00	5702	1.20	DY87/6	0.52	ECL83	1.50	GZ34	2.25	PCL86	0.85	TP2620	1.00	U339	0.50	AA119	0.18	BC108	0.14	GEX55	0.87	SM1036	0.58
4CB6	0.75	6D3	0.75	7B7	1.00	19Y3	0.40	5763	2.75	DY802	0.50	ECL84	0.90	GZ37	4.00	PCL88	1.50	TP22	1.00	U381	0.70	AA120	0.18	BC109	0.14	GT3	0.30	ST1276	0.58
4GK5	0.75	6DE7	0.90	7D6	2.00	20D1	0.70	6057	2.00	E80CC	4.75	ECL85	0.80	HABC80	0.80	PCL800	1.30	TP25	1.00	U403	0.90	AA129	0.18	BC113	0.30	MI	0.18	SX1/6	0.21
4CG8	0.75	6DT6A	0.85	7F8	2.00	20D4	2.50	6060	2.00	E80CF	6.00	ECL86	0.64	HL13C	0.60	PCL801	1.25	SP4	1.50	U404	0.75	AAZ13	0.21	BC115	0.18	MAT100	0.45	U14706	0.30
5R4GY	1.00	6EW6	0.85	7H7	1.00	20F2	0.85	6067	2.00	E80F	5.50	ECL1800		HL23	0.70	PCL805/85		TH4B	1.00	U709	0.45	AC107	0.18	BC116	0.30	MAT101	0.50	XZ30	0.30
5T4	2.00	6E5	1.00	7R7	2.00	20L1	1.20	6146	4.70	E81CC	2.00		10.00	HL23DD	0.68		0.65	TH233	1.00	U801	1.00	AC113	0.30	BC118	0.26	MAT120	0.45	Y543	0.21
5U4G	1.00	6F1	0.80	7V7	2.00	20P1	1.00	6463	2.00	E82CC	2.00	EF22	1.00	HL41DD	1.00	PEN4DD	2.00	TP2620	1.00	U4020	1.00	AC114	0.47	BF154	0.30	OA9	0.14	Y728	0.21
5V4G	1.00	6F6G	0.70	7Y4	0.80	20P3	1.00	7025	2.00	E83CC	2.00	EF40	1.00	HL42DD	1.00	PEN45	1.00	TP22	1.00	VLS492	9.50	AC126	0.14	BF158	0.21	OA47	0.12		
5Y3GT	0.65	6F12	0.70	7Z4	0.80	20P4	0.84	7193	0.60	E83F	3.50	EF41	1.00	HN309	1.70	PEN45DD	1.00	TP25	1.00	VP2	1.50	AC127	0.20	BF159	0.30	OA70	0.18		
5Z3	1.40	6F14	0.90	9D2	0.50	20P5	1.50	7475	1.20	E88CC	1.25	EF73	1.75	HVR2	1.00	PEN46	1.00	UBL21	2.00	VP4(5)	2.00	AC128	0.26	BF163	0.23	OA73	0.18		
5Z4G	0.75	6F15	0.85	9D8	0.52	25A6G	1.00	9002	0.55	E92CC	4.50	EF80	0.40	HVR2A	1.00	PEN453DD		UBC92	0.50	VP13C	0.60	AC132	0.23	BF173	0.44	OA79	0.11		
5Z4GT	1.00	6F16	1.00	9BW6	0.90	25L6G	1.00	9006	0.45	E180CC	5.00	EF83	1.70	HVR4	2.00	PENDD/		UCC84	0.90	VP23	0.65	AC154	0.30	BF180	0.35	OA81	0.11		
6/30L2	0.90	6F18	0.80	9D7	0.70	25Y5	0.80	A1834	1.50	E180F	5.50	EF85	0.45	HY90	0.55	4020	1.00	UCC85	0.45	VP41	0.90	AC156	0.23	BF181	0.47	OA85	0.11		
6A8G	1.40	6F23	1.00	9U8	0.45	25Z4G	0.50	A3042	6.00	E182CC	5.50	EF86	0.52	KT8	3.00	PFL200	1.12	UCF80	0.80	VR105	0.50	AC157	0.30	BF185	0.47	OA86	0.23		
6AC7	0.70	6F24	0.80	10C2	0.70	25Z5	0.75	AC2PEN	1.00	E188CC	4.50	EF89	0.55	KT32	1.00	PL33	1.00	UCH21	2.00	VR150	0.75	AC165	0.30	BF250	0.26	OA90	0.14		
6AG5	0.35	6F25	1.00	10C14	0.52	25Z6G	0.80	AC2PENDD		E280F	12.50	EF91	0.70	KT41	1.00	PL36	0.80	UCH42	1.00	VR1A	0.75	AC166	0.30	BF251	0.23	OA91	0.11		
6AG7	0.70	6F25	0.45	10D1	1.00	28D7	2.00		1.00	E1148	0.60	EF92	0.70	KT44	1.00	PL81	0.48	UCH81	0.52	VU111	1.00	AC168	0.44	BF252	0.23	OA95	0.11		
6AH6	0.70	6F28	0.85	10D1/2	0.80	30A5	0.75	AC6/PEN	1.00	EA50	0.40	EF93	0.65	KT61	1.70	PL81A	0.75	UCL82	0.70	VU120	1.00	AC169	0.68	BTX34/400		OA200	0.11		
6AJ5	0.70	6F32	1.00	10F1	0.67	30C1	0.80	AC/P4	1.50	EA76	1.30	EF94	0.62	KT66	3.00	PL82	0.50	UCL83	1.00	VU120A	1.00	AC176	0.64		2.31	OA202	0.12		
6AJ8	0.55	6G6G	1.00	10F9	0.65	30C15	1.00	AC/PEN(7)		EABC80	0.48	EF95	0.45	KT81	2.00	PL83	0.50	UF80	0.40	W76	0.50	AC177	0.32	BY100	0.21	OC19	1.46		
6AK5	0.45	6GH8A	0.80	10F18	0.65	30C17	0.90		1.20	EAC91	0.55	EF97	0.90	KT88	6.75	PL84	0.50	UF85	0.50	W81M	1.20	AC179	0.35	BY101	0.18	OC22	0.44		
6AK6	1.50	6GK5	0.75	10L14	0.45	30C18	2.25	AC/THI	1.00	EAF42	1.00	EF98	0.90	L63	0.65	PL95	1.00	UF89	0.52	W107	1.00	AC20	0.30	BY105	0.21	OC23	0.44		
6AK8	0.48	6GK6	2.00	10LD11	0.75	30F5	0.70	AL60	1.50	EAF801	1.50	EF183	0.50	L65	0.65	PL302	0.90	UL41	0.90	W719	0.45	AC21	0.30	BY114	0.21	OC24	0.44		
6AL5	0.25	6GU7	0.90	10LD12	0.45	30L1	0.39	ARP3	0.80	EB34	0.50	EF184	0.50	LN119	0.70	PL504/500		UL46	1.00	W729	1.20	AC22	0.18	BY126	0.18	OC28	0.69		
6AM6	0.70	6H6GT	0.50	10PL12	0.70	30L15	0.75	ATP4	0.50	EB91	0.25	EF804	6.25	LN152	0.55		1.05	UL84	0.65	WD709	1.00	AC28	0.21	BY127	0.21	OC29	0.73		
6AM8A	0.70	6J5GT	0.65	10P13	0.80	30L17	0.70	AZ1	0.50	EBC41	1.00	EH90	0.65	LN309	0.75	PL505	2.55	UM80	1.00	XE3	0.60	AC29	0.18	BYY23	1.16	OC36	1.00		
6AN8	0.70	6J6	0.35	10P14	2.50	30P4MR	0.98	AZ31	1.00	EBC81	1.00	EK90	0.70	LZ319	0.80	PL508	1.60	UR1C	1.00	XFY12	0.60	AC30	0.30	BYZ10	0.30	OC38	0.50		
6AQ5	0.75	6J7G	0.50	10P18	0.65	30P12	0.74	AZ41	0.50	EBC90	0.60	EL32	1.00	LZ329	0.80	PL509	3.10	UU5	1.15	XH15	0.60	AD140	0.50	BYZ11	0.30	OC41	0.58		
6AQ8	0.50	6J7M	0.65	12A6	1.00	30P19/		B36	0.75	EBC91	0.65	EL35	3.00	M8083	3.00	PL519	3.75	UU9	1.00	XSG15	1.20								
6AR5	1.05	6JU8A	0.90	12AC6	0.80	30P4	0.90	B719	0.50	EBF80	1.00	EL37	3.00	M8136	2.00	PL801	0.74	UU12	0.45	X41	1.00								
6AS7	1.50	6K7G	0.50	12AD6	0.80	30P16	0.50	B729	0.90	EBF83	0.45	EL41	1.00	M8137	2.00	PM84	0.75	UY41	0.70	X61	2.00								
6AT6	0.60	6K8G	0.50	12AE6	0.80	30P18	0.50	BL63	2.00	EBF89	0.40	EL81	1.00	M8162	2.00	PY31	0.50	UY42	0.70	X63	1.40								
6AU6	0.62	6K8GT	0.55	12AT6	0.45	30PL1	1.25	CL33	2.00	EBL21	2.00	EL83	1.00	MHL4	1.00	PY33/2	0.50	UY85	0.70	X65	2.00								
6AV6	0.65	6L1	2.50	12AT7	0.52	30PL12	0.62	CV6	0.60	EC52	1.00	EL84	0.48	MHLD6	0.99	PY80	0.50	U10	1.00	X66	2.00								
6AW8A	1.15	6L7(M)	1.50	12AU6	0.50	30PL13	1.30	CV63	1.00	EC53	1.00	EL86	0.60	P61	0.60	MKT4	1.20												

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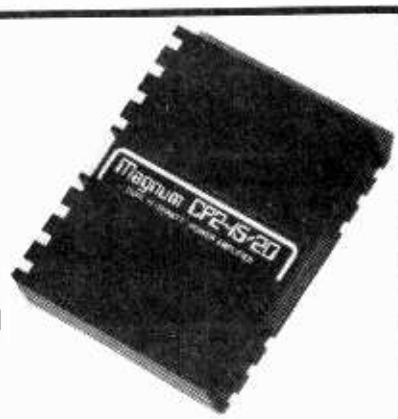

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Duties (mostly overseas) include the operation and first line maintenance, installation and repair, of MF, HF and VHF sound broadcasting equipment and receiving and studio equipment, operation and maintenance of TV equipment including video-tape recorders, vision mixers, slide scanners and character generators.

Candidates (preferably aged 22-30) must have ONC in Engineering **or** an appropriate C & G Certificate **or** an equivalent qualification. They should have received appropriate training and have at least 2 years' relevant experience together with a knowledge of the fundamental principles of the PAL colour TV system.

Starting salary will be between £3945 and £5095, depending on qualifications and experience, plus generous overseas allowances. Promotion prospects. Non-contributory pension scheme.

For further details and an application form (to be returned by 9 March 1978) write to Civil Service Commission, Alencon Link, Basingstoke, Hants, RG21 1JB, or telephone Basingstoke (0256) 68551 (answering service operates outside office hours). *Please quote T/9718.*

Ministry of Defence (Army Department)

(7896)

Technical Sales

ELECTRONIC EQUIPMENT

We feel that we can offer outstanding opportunities to a person in their young twenties in the marketing of electronic equipment for the control of industrial machines, cranes and locomotives and for a wide variety of applications in materials handling.

We have the dynamism of a comparatively small company, and have securely established world leadership in our fields.

The work would commence in our internal sales activity, providing familiarisation with our engineering and marketing techniques, and it is our wish to engage someone who will be able to develop their career to incorporate, firstly, responsibilities in publicity and in exhibition work, and later in field sales engineering.

The commencing salary will depend upon the current capabilities of the chosen applicant. Telemotive is a good employer. It looks for people who are likely to be exceptional in their particular functions, and it treats them accordingly.

Please forward details of experience and interests in electronics and in marketing to:

Telemotive UK Limited

TELEMOTIVE HOUSE, 100 HIGH ROAD
BYFLEET, WEYBRIDGE, SURREY
BYFLEET 47117

7904

www.americanradiohistory.com

Calling all professional Electronics Engineers and amateur electronics enthusiasts

The Electronics Industry has always been a breeding ground of professional talent, particularly within the specialist areas. At EMI, we have always attracted talented people, graduates and specialist engineers with valuable experience to contribute.

We're a flexible company, which is undoubtedly one of the attractions to professional people. We're also an acknowledged major force in the industry. Our training is excellent, our products ahead of the field. Our expertise has changed the face of electronics time and time again.

People joining us at any level rapidly acquire a great deal of knowledge and experience which puts them on a steady path to promotion. And right now, we have a very special need for a limited number of men and women as Semi-Conductor Consultant Engineers within our Engineering Standards Group.

We are extending our invitation to both experienced Electronics Engineers and men and women who have a particular interest, though not necessarily experience, in electronics as a hobby.

Your role with EMI Electronics will be to advise engineers, production personnel, buyers and Q.A. staff on various aspects of semi-conductor and micro-processor products, to liaise with suppliers and initiate/draft standards. You will also be expected to undertake laboratory testing, evaluate devices and be responsible for seeking out new products.

These varied duties require people with at least HNC qualifications but probably more important for this work, is the right personality. You must enjoy resolving technical problems and yet be capable of confident and effective communication with a wide and varied range of people. Knowledge of passive components, the foreign components markets and a working fluency in a European language, would be very useful though is not absolutely essential.

The men and women we envisage joining us will be aged between 20 and 35 and will be looking for a challenging and rewarding career with one of the major forces in international electronics.

For further information, please contact:
Neil Robotham, Personnel Department, EMI Limited, 135 Blyth Road, Hayes, Middlesex.
Telephone 01-573 3888 or Record-a-call anytime on 01-573 5524.

EMI Electronics Ltd.

A member of the EMI Group. International leaders in music, electronics and leisure

(7910)

EMI

Technical Authors

are required to work on a variety of interesting projects in our new offices in Wokingham. Other vacancies exist for authors to work on contracts on our clients premises.
Previous experience is desirable but applications will be considered from engineers with a detailed knowledge of digital techniques, radar or communications.

Apply Brian Goodenough
Engineering & Technical Publications Ltd
No 12 Shute End
Wokingham, Berks
Tel: Wokingham 790123

(7937)

BBC

SENIOR LABORATORY TECHNICIAN

The BBC requires a Senior Laboratory Technician in its Communications Department, London to assist engineers with the construction and development of a wide range of communications equipment.

He/She must have the ability to make simple electronic and mechanical designs and will also be expected to carry out first line maintenance, alignment and calibration of apparatus in all laboratories used by Communications Department.

Candidates must have some experience of workshop practice and the ability to work from verbal instructions, rough sketches and drawings and be able to convert the basic design into practical equipment of high standard.

A Higher National Certificate or equivalent qualifications is required but training is available for those not yet qualified.

Requests for application forms to The Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA, quoting reference number 78 E 2021 WW and enclosing a self-addressed envelope at least 9" x 4". Closing date for completed application forms is fourteen days after publication.

(7949)

www.americanradiohistory.com

ELECTRICAL/ ELECTRONIC ENGINEERS

Design unique computer/ communication systems

This is an opportunity to design, plan and manage the implementation of a wide range of interesting and unique computer/communication systems. The computer systems range from the use of microprocessors for specific applications, through mini computers to large main frame systems employing the whole range of peripheral devices. The communication systems range from line communications through the full spectrum of radio communications including satellite communications.

Most posts are designated project officer/manager, and involve the interpretation of internal customer requirements, and the preparation of project studies, designs and plans which provide technical solutions and define and cost all resource requirements to implement the solution.

Candidates must have passed, or been exempted from, examinations qualifying them for corporate membership of IEE or IERE, and have an aggregate of at least 5 years' recognised study, professional training and experience. Project management experience in the computer/communication field an advantage.

Starting salary between £3950 and £5240, depending on qualifications and experience. Promotion prospects. Non-contributory pension scheme.

For further details and an application form (to be returned by 9th March, 1978) write to Civil Service Commission, Alencon Link, Basingstoke, Hants RG21 1JB, or telephone Basingstoke (0256) 68551 (answering service operates outside office hours). Please quote T(8) 851.

(7946)

GCHQ Cheltenham

Digital Electronics Design Engineers

Invest your future with us!

As Europe's largest exporter of two-way radio systems, we are actively engaged in designing modern digital telecommunications systems for radio and line applications.

Join Pye Telecom, and you'll join exciting development projects concerned with all aspects of computer-based interactive systems. You could be working on high-speed high-capacity digital signalling for automatic control, encoders/decoders using advanced coding strategies, speech synthesis and modern data display equipment.

Some of these projects require experience in computing techniques, including programming in machine code and assembler languages. We are also working on projects employing custom L.S.I. microcircuits, and these require experience in the design of digital and analogue circuits.

If you have a BSc or an HND, and at least three years' good, relevant experience, we want you!

Upon joining us, you will enjoy a good salary, + a generous relocation allowance, and good career prospects. You will also discover an extremely attractive working environment and the most modern laboratory facilities available.

Men or Women, if you want to apply your innovative abilities in an expanding field, apply now, quoting reference WW, to Alan Depauw, Pye Telecommunications Ltd., Newmarket Road, Cambridge. Tel: 0223 61222.

7860

Pye Telecommunications Ltd
Newmarket Road Cambridge England CB5 8PD
Tel: Cambridge (0223) 61222 Telex: 81166 PYETELECOM CAMBGE

A member of the Pye of Cambridge Group

STUDIO MANAGER

£5389-£5692 Farnham

For the Department of Audio Visual Studies at West Surrey College of Art and Design, The Hart. To be responsible under the Head of the Department, for a newly constructed studio complex, including initial installation and subsequent maintenance and development of colour TV equipment. The successful applicant, male or female, will be required to manage the day-to-day operation of the complex ensuring its optimum use including commercial hire, with the assistance of a team of technicians.

Candidates should hold an electronic engineering qualification, preferably at Degree level or equivalent and should also have good practical experience in commercial TV studios or a large educational TV installation and should be familiar with the technical and administrative problems associated with the management of a television complex.

Application form and further details from the Chief Administrative Officer, Mr J. Nice. Tel: Farnham 22441.

SURREY COUNTY COUNCIL

7895

audix

PRODUCTION MANAGER

In line with our new building extensions and production programme we require an experienced person to fill the position of Production Manager.

The applicant should have had experience in the electronics industry, preferably associated with industrial audio production. The duties would entail the supervision of approximately 70 staff, arrange production programmes and work closely within a management team.

The appointment would carry a salary commensurate with experience, together with a production commission. Excellent prospects are available for full establishment in the company for a person with drive and initiative.

Write or telephone for further details and an appointment to:

Audix Limited

Station Road, Wenden
Saffron Walden, Essex CB11 4LG
Tel: Saffron Walden (0799) 40888

(7898)

www.americanradiohistory.com

LONDON BOROUGH OF HOUNSLOW

EDUCATION DEPARTMENT

TECHNICIAN

T.2/3 £3126-£3879 plus Stage II supplement of up to a maximum of £4 a week, required at the Visual and Aural Aids Centre, Hanworth Road, Hounslow. To be responsible for the maintenance of a wide variety of audio-visual equipment involving fault finding, repair and sometimes modification of mechanical, electrical and electronic items. It is highly desirable that candidates should have some experience of language laboratory maintenance, and experience in the maintenance of video equipment would be an advantage. Duties will also include the ordering and storage of spares.

Current driving licence essential. Application forms from Director of Education, Civic Centre, Lampton Road, Hounslow TW3 4DN. Tel. 01-570 7728, ext. 3632. Closing date: 28th February, 1978.

(7892)

UNIVERSITY OF BATH
SCHOOL OF MATHEMATICS

Technician/ Trainee

A vacancy exists for a Technician to assist mainly in servicing and developing DIGITAL and ANALOGUE computing devices. Candidates should have at least an ONC or equivalent qualification and considerable experience in electronics and be competent in elementary mechanical skills.

Salary in the range £2955-£3402 according to qualifications and experience.

Alternatively a Trainee aged around 18 could be appointed. Training and day release facilities would be provided. Applicants should have at least 4 relevant 'O' levels and a keen interest in electronics.

Salary at 18, £1824 per annum.

Application forms obtainable from the Personnel Officer, University of Bath, Claverton Down, Quoting reference number 78/12.WR.

Closing date will be February 28, 1978.

7875

CAPITAL APPOINTMENTS LTD.

FREE JOBS LIST
for
FIELD SERVICE ENGINEERS
BASIC SALARIES TO £5,000 + CAR

(7707)

30 Windmill Street, London, W1
01-637 5551

Several interesting opportunities have arisen with one of Britain's most successful electronics companies, at an attractive rural location in new premises on the border of East Anglia and the East Midlands. These positions offer secure and prosperous careers, full on-the-job training on our Client's products, progressive salaries with regular reviews, good fringe benefits, plus full assistance with relocation where justified.

SYSTEMS TEST ENGINEERS

Suitable applicants will have had 1-5 years' practical experience of testing, modifying and repairing electronic systems. A knowledge of computers, analogue and digital electronics is required. In addition, an understanding of optics and photographic mechanical equipment would be an advantage.

UNIT TEST ENGINEERS

A minimum qualification of O.N.C. in Electronics, together with 1-5 years' practical experience of testing using oscilloscope and sophisticated test equipment, fault finding, modifying and repairing electronic units, are the necessary parameters of this challenging post.

Please telephone or write for an application form to:
A W Tyler, Personnel Manager,
Crosfield Electronics (Westwood) Limited,
Bretton Way, Bretton,
Peterborough PE3 8YG,
telephone: Peterborough (0733) 267504.

(7897)

Crosfield Electronics — A De La Rue Company — 1973 1976

T.V. Studio Engineer

The Road Transport Industry Training Board has in operation at its Wembley Headquarters, a 3 camera broadcast-quality colour television studio with full telecine and video recording facilities which includes RCA TR50-2" also 1" Helical Scan systems. We now wish to appoint an experienced studio engineer to join a small team working on the production of training and educational television programmes.

Applicants, aged not less than 24 years, should have a good working knowledge of the above equipment.

The starting salary will be in the region of £5700 depending on qualifications and experience: other benefits include four weeks' holiday, contributory pension and life assurance scheme.

Please send relevant personal history stating how the above requirements are met, and quoting reference ZH. 553 to: Mrs. H. M. Brown, Manager, Personnel Administration, Road Transport Industry Training Board, Capitol House, Empire Way, Wembley, Middlesex HA9 0NG. Tel. 01-902 8880.

(7925)

www.americanradiohistory.com

PROFIT BY WORKING WITH ARAMCO IN SAUDI ARABIA

£9,600 TO £13,000

TAKE HOME PAY PER CONTRACT YEAR

COMMUNICATIONS ENGINEERS

are required in the following 3 categories:

1. Microwave/Multiplex systems 1-11GHZ equipment 120-1200 channel design.
2. Telephone inside plant central offices PABX systems. ESS/step by step design.
3. VHF/UHF land mobile marine air ground systems.

Applicants should have at least 10 years experience and a wide background of consulting and system engineering rather than manufacturing experience.

Salaries (paid net) plus local allowances, end of contract bonus and excellent paid leave, especially for married men, fares paid. Low cost air-conditioned shared living accommodation provided. Contracts, one year, renewable. Single status. Free medical care.

Valid driving licence essential.

Interviews will be held regionally in main centres at which you will be given all detailed information.

Write giving brief career details for an application form quoting reference WW/2 to:

PMC MANAGEMENT SERVICES LIMITED
5, East Parade, Harrogate, North Yorkshire HG1 5LF.

(7868

Synthesiser Engineer

for advanced electronic component development

The Quartz Crystal Division of ITT Components Group Europe, one of the largest electronic component manufacturers in the UK, is developing, producing and marketing a wide range of high technology products and is a major innovator in materials technology. The range of products is geared specifically to meet the constantly changing needs of industry and the Division is, therefore, able to offer engineers considerable scope to apply their skills to advanced development projects.

This appointment, at the Company's Harlow headquarters, is for a creative engineer, man or woman, to develop a range of surface acoustic wave devices, synthesisers and crystal oscillators as applied to digital circuitry and radio systems.

A degree is desirable but more important is good relevant experience plus, ideally, a knowledge of programming.

An excellent starting salary will be offered plus an attractive range of benefits including assistance with relocation, where appropriate. Promotion prospects are first class.

Write with full personal and career details to: R. J. Coster, ITT Components Group Europe, Quartz Crystal Division, Edinburgh Way, Harlow, Essex. Telephone: Harlow 26811. Ext. 2562 or 2526.

Components ITT QUARTZ CRYSTAL

(7879)

DECCA NAVIGATOR, one of the Decca Group of Companies specialising in sophisticated avionic navigation systems, require experienced

ENGINEERS

for repair and overhaul of airborne communication and airborne equipments. To be based West of London.

Applications will be considered from engineers with experience of complex Electronic equipment.

These positions provide a support to customers both in UK and abroad and successful applicants may be required to travel within the UK and for short visits overseas.

Generous remuneration depending upon experience and qualifications.

Please write, giving details of age, experience and present salary, to:

Mis B. J. Eatly-Hunt
DECCA NAVIGATOR COMPANY LIMITED
Spur Road, Feltham, Middlesex

7906

Ministry of Defence Air Force Department

RADIO TECHNICIANS

The Ministry of Defence has vacancies for Radio Technicians to work on RAF radar and radio equipment at

RAF Sealand Deeside Clwyd

Applicants must be experienced technicians in the radio field.

Starting pay according to age up to £2905 per annum (at age 25) rising to £3385 per annum plus pay supplements totalling from £443 to £522 per annum.

5-day week — good holidays — prospects of promotion — pension scheme.

Applicants must be United Kingdom residents.

Write for details to:

Officer Commanding
No. 30 Maintenance Unit
RAF Sealand, Deeside, Clwyd CH5 2LS

(7952)

www.americanradiohistory.com

SENIOR AUDIO ENGINEER

Dixserve, the service company within Dixons Photographic, the world's largest retailer of Hi-Fi and Photographic equipment have a vancancy for a Senior Audio Engineer at our Service Centre in Camberley.

If you are a fully skilled, experienced engineer looking for the opportunity to take on increased responsibility and gain supervisory experience, this could be the vacancy for you.

Reporting to the Service Manager you would be responsible for a small audio section on a day-to-day basis and in particular the training and development of staff.

We'll pay you a good salary for a 40 hour week (no Saturdays). In addition there are generous discounts on Dixons products and all the benefits you would expect from a large international company.

Interested? Then contact:

Bill Singleton, Dixserve Ltd.,
Doman Road, York Town Trading Estate,
Camberley, Surrey. Tel: Camberley 21282.

7865

Dixons

LABORATORY TECHNICIANS

There are opportunities for versatile Laboratory Technicians, male or female, at the BBC Equipment Department, Chiswick, to do interesting and varied work, testing BBC designed equipment, newly manufactured in small batches. This equipment covers most aspects of colour television and stereo broadcasting and includes techniques in audio, video, digital and radio frequency. Suitable technicians will have had at least one year's experience of testing small batches of electronic equipment and will be qualified to Final City and Guilds or O.N.C. standard.

Senior Technicians will have had two years' experience and be qualified to F.T.C. City and Guilds or H.N.C. standard.

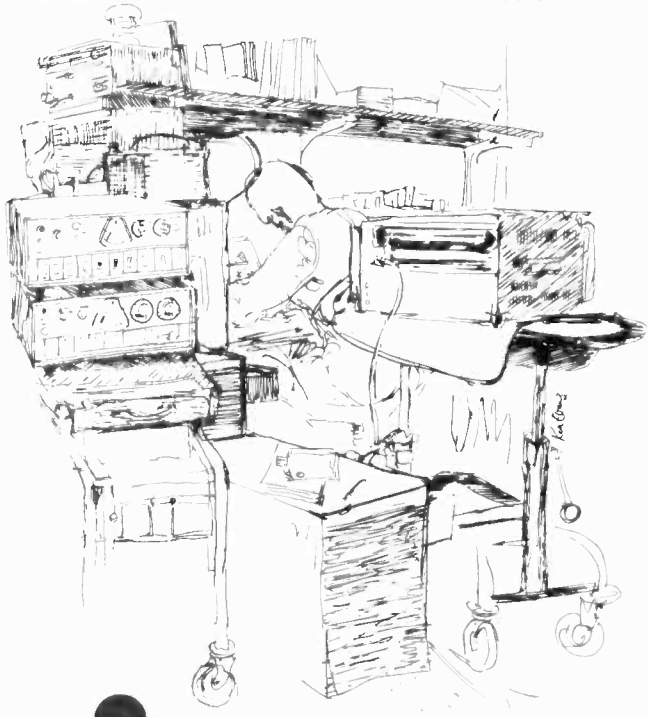
Starting salary for Senior Technicians is in the range £3,535 to £3,835 rising by increments to £4,285. Laboratory Technicians start between £3,230 and £3,490, rising to £3,880. Less qualified technicians may start at a lower rate.

Request for application form to the **Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA,** quoting reference 78.E.4008/WW and enclosing foolscap envelope. Closing date for completed application forms is fourteen days after publication.

BBC

7862

Marconi Instruments



ELECTRONIC TECHNICIANS

Opportunities for the experienced and sometimes inexperienced in St. Albans and Luton.

Work situations range from fault finding on PCB's and components, to batch product testing of equipment that utilise very advanced techniques including microprocessors and the repair/calibration of all manner and types of test instruments.

Attractive salaries and, where appropriate, relocation are offered for the right candidates.

Further information may be obtained in confidence from John Prodger

Marconi Instruments Limited,
Longacres, St. Albans, Herts. tel: St. Albans, 59292

A GEC-MARCONI ELECTRONICS COMPANY

(7918)

mi

www.americanradiohistory.com

PRODUCT EVALUATION ENGINEER
c.£5000 p.a.

Dixons Photographic, the World's largest retailer of Hi-Fi and photographic equipment is looking for an Audio/Hi-Fi Engineer to be based in Edgware, Middlesex.

We need an experienced engineer who has practical knowledge of a wide range of audio and electronic products.

The job entails accurately assessing the specifications and performance of new, and often as yet untried products. A close liaison will be necessary between the Product Evaluation Engineer and our Quality Control Department at Stevenage. Some knowledge of current safety specifications in relation to consumer electronic products would be useful.

This is a senior engineering appointment and preference will be given to those candidates who possess a City and Guilds (Full Tech. Certificate), ONC or HNC qualification.

Salary will not be a restricting factor to the right candidate. We offer first class working conditions which include a contributory pension and security scheme. Employees are also eligible for substantial discounts on all Dixons products.

If you feel you meet our requirements write or phone now to:

Ron Irving, Personnel Manager,
Dixons Photographic UK Limited,
Prinz House, 54-58 High Street, Edgware, Middlesex.
Tel: 01-952 2345 Ext. 341.

7907

Dixons

Electronics Technicians

The essence of job satisfaction for a technician must surely be the opportunity to work on and keep up to date with all the latest in techniques and technology.

We have vacancies for men and women to work with our R and D Engineers on colour television and related systems like Ceefax, Oracle and Viewdata. The jobs entail making up experimental rigs, carrying out validation tests, taking precise electrical measurements and generally providing skilled technical support to the project engineers.

We are looking for a blend of formal qualification and job experience. Being long on one could make up for being a little short on the other. For example, City and Guilds Final in Telecomms would be good. HND/C even better. ONC, plus several years in a similar job could be equally acceptable. The possible permutations of training, qualification, practical experience and age are quite wide – all we would look for is evidence from your career record to convince us that you could cope with the work.

Whilst, in the first instance, engagements will be on temporary terms, good opportunities exist for suitable candidates to transfer to permanent employment where this is desired, and where conditions are mutually acceptable.

Salaries are good and vary with the jobs. Benefits include generous sick pay and holiday entitlements, social club, subsidised canteen, discount purchase arrangements etc.

A satisfying and absorbing job with plenty of work to prevent you becoming bored!

Write or phone for an application form:- George Greaves, Personnel Officer, ITT Consumer Products (UK) Ltd., Theaklen Drive, Hastings, E. Sussex. Tel: 437061.

TV Radio Stereo **ITT**

Microcomputer Shop Manager

READING

Sintrom Electronics is a fast-growing young computer company based in Reading. We market our own rapidly-developing range of microcomputers and also act as UK and European agent for a number of leading American peripherals manufacturers.

We are establishing the first UK retail shop for microcomputers and peripherals, and need a young and enthusiastic manager to set up and run this exciting new venture.

We are looking for someone with retail management experience, perhaps in radio, and a working knowledge of computers.

In addition, we require Assistants for this new shop – people used to retailing electronic components.

To learn more about the post please phone, or write, with full details of your career to, Mrs. Jay Dee at:

SINTROM ELECTRONICS LIMITED

Sintrom Electronics Limited, 14 Arkwright Road, Reading Berkshire, RG2 0LS. Telephone Reading (0734) 85464

7919

AMPEX

BROADCAST TELEVISION SERVICE ENGINEER
(based in Switzerland)

Ampex, a leading manufacturer of professional broadcasting equipment, is seeking a qualified Service Engineer to be based in its Fribourg (Switzerland) office.

The Engineer to be appointed will have considerable experience in the maintenance of modern electronic equipment. Knowledge of Ampex VTR equipment would of course be advantageous. Some knowledge of colour cameras, and of a European language, is desirable, although not essential. Specific product training will be given.

The job offers an attractive salary and the opportunity for international travel. Applications, with C.V., should be sent to the

Product Manager (Broadcast Products)
Ampex
72 Berkeley Avenue
Reading

(7921)

www.americanradiohistory.com

Communicate with Racal

Radio Communications Systems Planning Engineers

Racal Communications Systems Limited pleasantly situated in Bracknell, Berkshire, is a member of the highly successful Racal Electronics Group and a world leader in H.F./S.S.B. telecommunications techniques.

Racal design a wide range of systems from small networks to major radio communications projects, which include Point-to-Point, Ground-to-Air and Shore Ship complexes. With the continued growth in demand for Racal communications systems there has resulted a need for Engineers, at all levels, to undertake the planning of radio systems in many parts of the world.

The Engineers selected will be capable of accepting responsibility for the systems from inception to final implementation, and have experience, both operationally and technically, in H.F. radio systems and associated ancillary equipment. They will be required to liaise on a technical basis with customers, at all levels, throughout the world, and this will necessitate overseas travel of limited duration from time to time.

For these positions Racal offers competitive salaries, over 4 weeks annual holiday, and a first class pension and free life assurance scheme.

If you are interested in, and wish to be considered for these positions, please write stating age, experience and present salary, for an application form to:

RACAL

The Personnel Manager,
RACAL COMMUNICATIONS SYSTEMS LTD.,
Western Road,
Bracknell, Berks.

7915

THE QUEEN'S UNIVERSITY OF BELFAST

COMPUTER MAINTENANCE ENGINEER

The Computer Centre

The Computer Centre provides batch and on-line computing services to teaching and research staff of the University. Two I.C.L. machines, a 1906S and a 1904A, are operated, as well as a number of remote job entry stations and minicomputers. Equipment maintained by the engineering staff includes visual display units, teletypewriters, graph-plotters, minicomputers, data links, converters and acoustic couplers.

Applications are invited from Maintenance Engineers with experience of digital circuitry and its application in the device types detailed above. Experience of visual display unit and minicomputer maintenance is particularly relevant.

Salary scale (under review) £2,904-£4,811. Assistance with removal expenses is available.

The above position is open to both male and female applicants.

Application forms are available from the Personnel Department, The Queen's University of Belfast BT7 1NN, Northern Ireland.

(7926)

LABORATORY TECHNICIANS

BBC Engineering Designs Department requires technicians for Central London laboratories to assist engineers with the development, construction and testing of sound and television broadcasting equipment.

Vacancies exist both for people with experience of this type of work and for trainees.

LABORATORY TECHNICIANS
Successful candidates will probably be in their 20's and have a keen interest in, and a minimum of two years' practical experience of, electronics. They will have at least ONC or City & Guilds Part 2 or equivalent. Salary according to qualifications and experience in the range £3,230-£3,535 rising to £4,285.

JUNIOR LABORATORY TECHNICIANS
Successful candidates will probably be aged 18-20 and have a keen interest in electronics. They will either be recently qualified to ONC or City & Guilds Part 2 (T4) standard or have started the final year of such a course. Salary according to qualifications in the range £2,950-£3,170. Excellent opportunities for promotion.

Requests for application forms to **The Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA,** quoting Reference Number 77. E. 4095/WW, and enclosing a self addressed envelope at least 9" x 4," or telephone 01-580 4468, Ext. 2675. Closing date for completed application forms is 14 days after publication.

BBC

7864

UNIVERSITY OF SALFORD

ELECTRONICS TECHNICIAN/ ENGINEER

Required in the Department of Electrical Engineering. Able on own initiative to design, develop and construct equipment, to service and maintain wide range of instrumentation (including minicomputers and associated electromechanical peripheral equipment) and to give advice on such matters as part of Electronic Workshop team. HNC (or equivalent) and some years' relevant, practical experience normally required. Desire to widen experience essential.

Salary scale £3654-£4365 (£3186-£3720 if experience limited) Local Government Superannuation.

Letters of application from persons of either sex stating age, qualifications and experience together with the names and addresses of two referees should be sent to the Registrar, University of Salford M5 4WT by March 2, 1978, quoting reference E/190/WW.

(7948)

APPOINTMENTS IN ELECTRONICS

Take your pick of the permanent posts in

MISSILES — MEDICAL
COMPUTERS — COMMS
MICROWAVE — MARINE
HARDWARE — SOFTWARE

For expert advice and immediate action on career improvement, 'phone, or write to, Mike Gernat BSc.

Technomark
Engineering and Technical Recruitment

11 Westbourne Grove
London W2 01-229 9239.

7958

Midland Bank Limited

TELEVISION STUDIO ENGINEER

We have an immediate vacancy for a technical engineer/operator to work with a minimum of supervision in a non-broadcast monochrome T.V. studio at our Management College near Dorking. The studio is equipped with ancillary colour equipment including a sophisticated electronic editing suite.

Applicants should have an interest in electro-mechanical engineering related to video-tape recorders, and some industrial or commercial experience would be helpful.

The job is varied and secure with a non-contributory pension scheme.

Please apply in writing, giving details of age, education, technical qualifications and practical experience, to The Manager, Audio/Visual, Midland Bank Limited, Residential College, Sandy Lane, Betchworth, Surrey RH3 7AA.

(7945)

www.americanradiohistory.com

ENGINEER VACANCIES

AT

Television Centre, London
Broadcasting House, London
Regional Radio & Television Studio Centres
BBC Receiving Station, Caversham, Nr. Reading
Communications Department, London
Studio & Transmitter Capital Projects Departments based in London

Candidates, male or female, who must have normal hearing and colour vision, should be qualified, or be qualifying this year, with a degree in electronic engineering or applied physics awarded by a British university or polytechnic. Those with an appropriate HNC or HND or with a City and Guilds Full Technological Certificate (Telecommunications) also considered.

At studio centres, engineers are concerned with the maintenance, and in some cases the operation, of the electronic equipment used in the origination of programmes. At Caversham they will be working on an elaborate radio receiving installation used for the monitoring of radio broadcasts. Shift working is involved with these posts for which generous allowances are paid.

Engineers in Communications Department, which is located in Central London, are involved in the maintenance and operation of modern communications equipment handling audio, video and digital signals.

The Capital Projects Departments are concerned with the planning, installation and commissioning of new equipment in various parts of the country. Engineers working in these departments will travel away from base a good deal.

The starting salaries for these posts are £3535 to £3835 p.a. in London, £3085 to £3385 p.a. elsewhere. Engineer grades are currently under review.

Requests for application forms to The Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA quoting reference 78.E.4002/WW and enclosing an addressed envelope at least 9" by 4".

BBC

7863

UNIVERSITY OF BATH
SCHOOL OF ELECTRICAL ENGINEERING

TECHNICIAN

A vacancy has occurred for an electronics technican to assist on a mobile radio research project supported by the Wolfson Foundation for a period of two years initially.

The duties will be primarily concerned with the construction and development of VHF/UHF single sideband mobile radio equipment.

Applicants must be qualified at least to ONC or equivalent and have several years of relevant experience.

Salary in the range £2955-£3402 per annum, according to qualifications and experience.

Application forms are obtainable from the Personnel Officer, University of Bath, Claverton Down, Bath, quoting reference number 78/31 WW. Closing date will be 24th February, 1978.

7908

UNIVERSITY OF ST. ANDREWS
DEPARTMENT OF PSYCHOLOGY

TECHNICIAN GRADE 5 (ELECTRONICS)

Applications are invited for the above post in the Electronics Workshop of the Psychology Department. Applicants should have a good electronics background together with practical experience in the development and construction of digital equipment and the design of computer interfaces.

The person appointed will work together with other members of the technical staff on the development of on-line experimental facilities using the Department's two Data General computers and a DEC GT40 Graphics Display Terminal. Experience with small general purpose digital computers and a knowledge of programming languages is desirable. The duties will also involve the use and maintenance of other electronic equipment in the Department.

Salary on scale £3,186-£3,720 (Technician Grade 5). Applications, with full details of career to date and the names of two referees, should be sent to the Establishments Officer, The University, College Gate, St. Andrews, Fife, by February 28, 1978.

7867

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(7916)

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CITY OF LONDON POLYTECHNIC

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The person appointed will be involved with the development and construction of electronic equipment for research and teaching purposes. This is an opportunity to gain experience in current developments in analogue and digital circuitry within an active department.

Applicants should be familiar with standard test equipment and its use, and hold relevant qualifications (O.N.C. or equivalent).

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Further information and application form can be obtained from **The Department of Psychology, City of London Polytechnic, Old Castle Street, London, E1 7NT, or telephone 01-283 1030, ext. 513.**

7870

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(7947)

Roxland

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7920

Dixons

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£3349-£4910

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ilea

For further details and application forms contact the Chief Technician at the College. Tel. 01-789 6533

(7927)

THE CITY UNIVERSITY

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Applicants should have experience in one or more of the following fields: Microwaves, Digital Systems and Microprocessors, General Electronics. Appropriate C. & G. or O.N.C. level qualifications are desirable but this does not exclude applicants with adequate relevant experience; minimum age 21.

Salary will be within the range £3153 to £3525 per annum inclusive, 37½ hour week, 29 days' annual leave.

To apply, please contact by letter or telephone Mrs. S. E. Simpkins, Personnel Officer, The City University, St. John Street, London EC1V 4PB (Telephone 01-253 4399, extension 334) not later than 31st January, 1978, quoting reference EED 78/1.

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Swaziland

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(7885)

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(7893)

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7873

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(7876)

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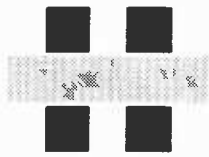

For an application form please telephone or write to: Bob Ferdinand, Personnel Manager, Heathrow Hotel, Bath Road, Heathrow, Hounslow, Middlesex. Tel. 01-897 2419 or 01-897 6363.

(7871)

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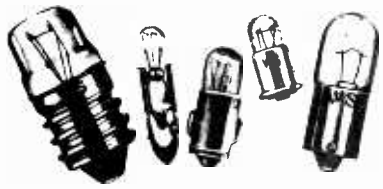

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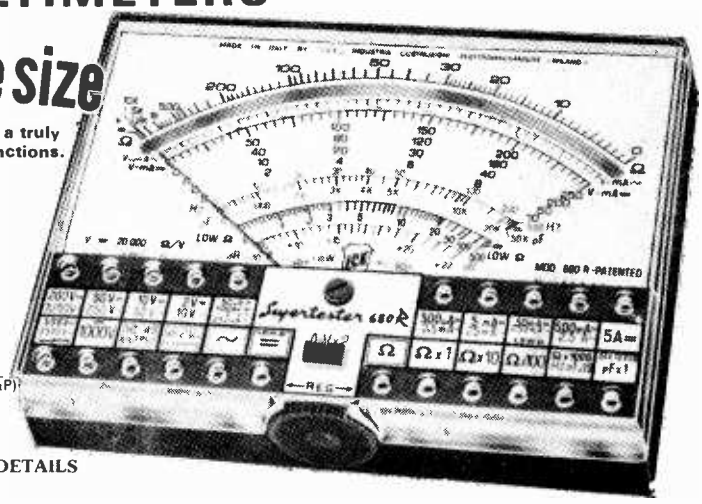

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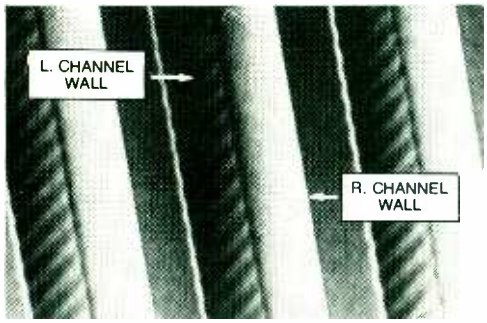
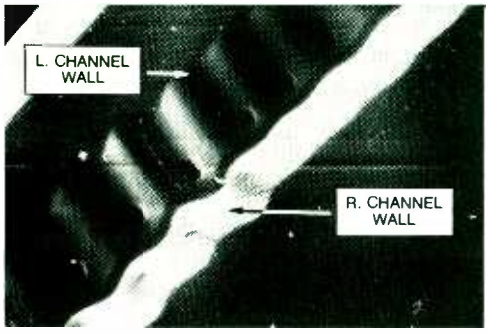
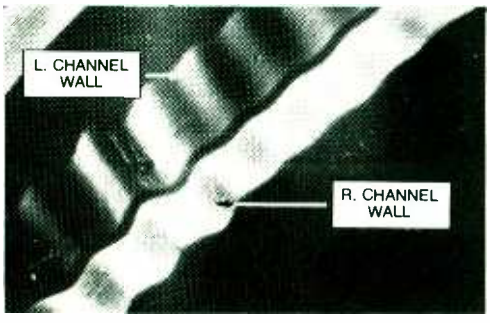
fact: one mistrack damages grooves more than 25...50...even 100 plays.



CBS STR 100 Played 75 Times With a V15 Type III Cartridge.



Mistracking Damage
A Commercial Recording After Just One Play With Top-of-the-Line Name Brand Cartridge at 1.0 Gram Tracking Force. Mistracking — Critical Damage.



The Same Commercial Recording After 50 Plays With Shure V15 Type III Cartridge at 1.0 Gram Tracking Force. Normal (Inaudible) Wear — Excellent Tracking.

The Optimist's View:

The cartridge that tracked the grooves shown in the top photomicrograph caused no PERCEIVABLE wear after 75 plays. But because these grooves are cut at relatively low velocities and have a continuous 20 kHz signal (only on one channel), they don't present a very challenging test. As a matter of fact, any reasonably good cartridge should produce the same results. However, under greater magnification these same grooves would probably reveal some amount of record wear (although not enough to alter sound quality). That's because record wear is a gradual but constant phenomenon . . . like tyre wear every time you drive.

The Terrible Truth:

The middle photomicrograph shows a record of musical material cut at today's "hotter" velocities after only one play with a well-known competitive cartridge at its rated tracking force. This cartridge mistracked the record. Clearly, critical damage resulted. Notice the deep gouge marks on the groove walls.

A single mistrack can result in MORE damage than 25, 50 or even 100 plays of a record! Continuing our tyre analogy, a mistrack is like a blowout. Once your cartridge mistracks a record passage, the damage has been done and that passage will never sound the same. TRACKABILITY is the single most meaningful yardstick by which to measure cartridge performance. That's because TRACKABILITY encompasses virtually every performance factor by which a cartridge is judged . . . including velocity of the recorded signal, frequency, compliance, and effective mass.

The bottom photo shows the same groove played 50 times with a V15 Type III at a record- and stylus-saving force of only one gram. Clearly, there is no cartridge you can buy — for any amount of money — that will protect your record collection more from the damage of mistracking than the Shure V15 Type III.

Shure V15 Type III

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...Bib keeps it playing

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Universal Tape Head Maintenance Kit

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Patent Pending.

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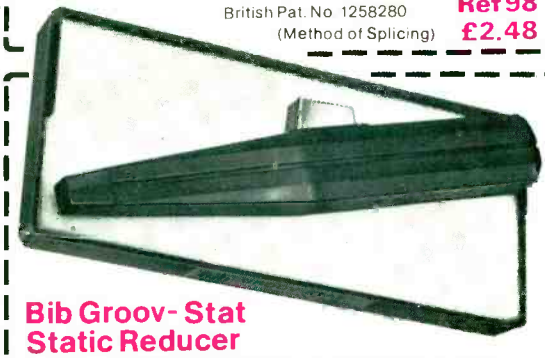

Bib Groov-Stat Static Reducer

Neutralises in seconds the static charge that attracts harmful dust to record surfaces. Safe and simple to use.

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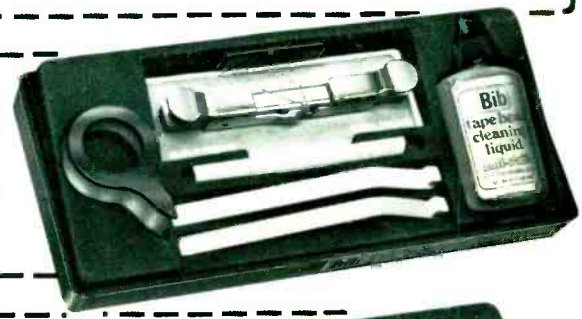

¼" Tape Care Kit

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