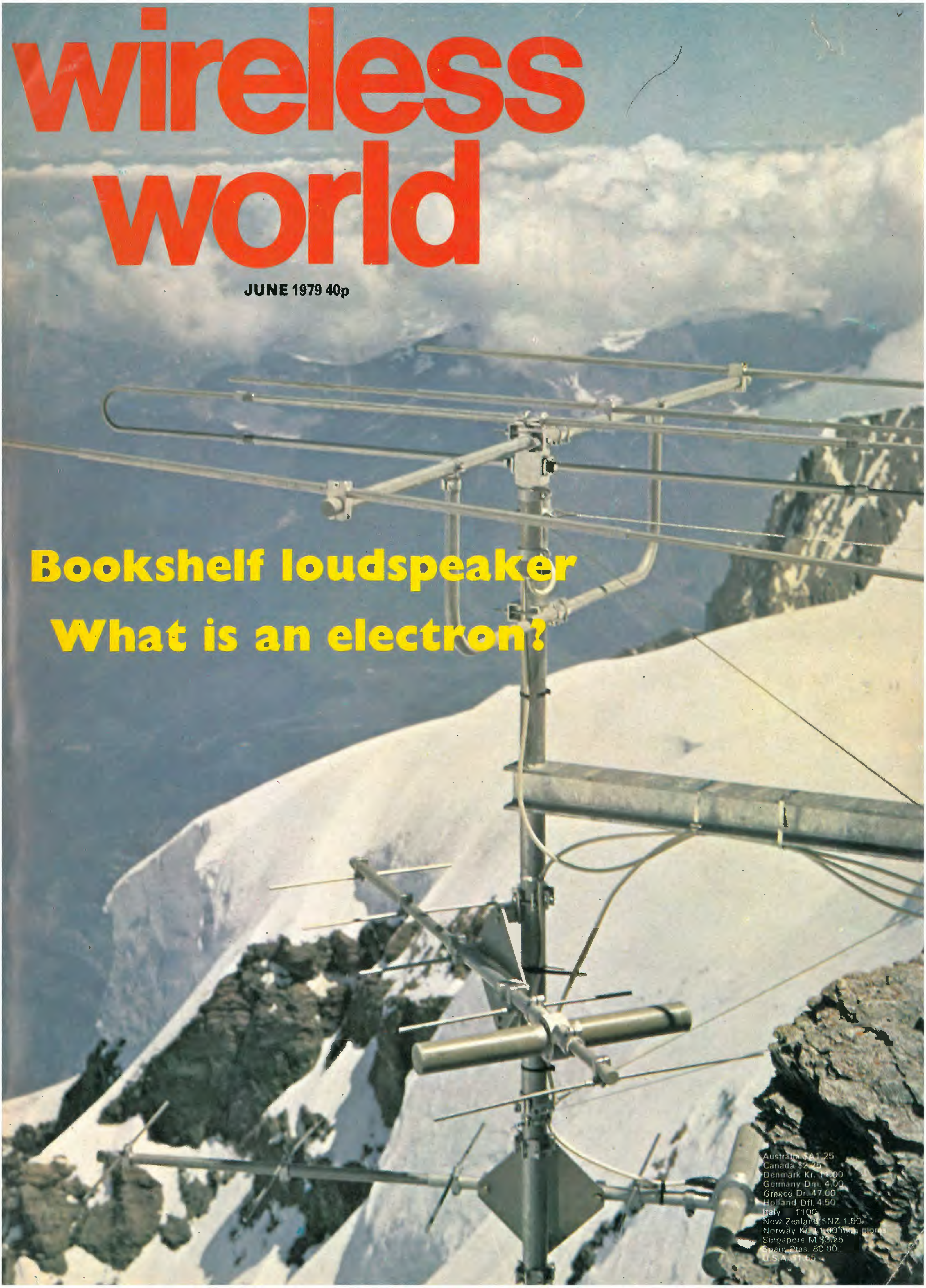
wireless world

JUNE 1979 40p



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WW—001 FOR FURTHER DETAILS

Front cover shows receiving aerials of Swiss "+ PTT" on top of the Jungfrau. Transmitters are in line-of-sight. Photo: The Hamer-Smith Swiss collection.

IN OUR NEXT ISSUE

***Loop aerials,* ousted by the ferrite rod, have been unjustly neglected. Modern methods of designing loops to improve broadcast band reception.**

***Distortion meter.* Construction of a spot-frequency type which measures harmonic distortion down to 0.00001 per cent.**

***Simple digital filters* for control systems. Designing them in software using simple rules that avoid the usual z-transform theory.**

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Editorial & Advertising offices: Dorset House, Stamford Street, London SE1 9LU.
Telephones: Editorial 01-261 8620. Advertising 01-261 8339.
Telegrams/Telex: Wiworld Bisnespres 25137 BISPRS G. Cables: Ethaworld, London SE1.
Subscription rates: 1 year: £7.00 UK and $23.40 overseas ($24 USA and Canada).
Student rate: 1 year, £3.50 UK and £4.50 overseas ($11.70 USA and Canada).
Distribution: 40 Bowling Green Lane, London EC1R ONE. Telephone 01-837 3636.
Subscriptions: Oakfield House, Perrymount Road, Haywards Heath, Sussex. RH16 3DH. Telephone 0444 59188, Please notify a change of address.
USA mailing agents: Expediters of the Printed Word Ltd, 527 Madison Avenue, Suite 1217, New York, NY 10022, 2nd-class postage paid at New York.

ISSN 0043 6062

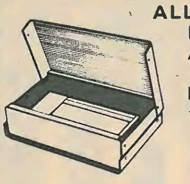
wireless world

ELECTRONICS/TELEVISION/RADIO/AUDIO

JUNE 1979 vol 85 No 1522

YOUR COMPLETE RANGE OF ELECTRONIC HARDWARE...

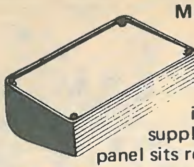
BIMENCLOSURES



ALL METAL BIMCASES

Red, Grey or Orange 14swg Aluminium removable top and bottom covers. 18 swg black mild steel chassis with fixing support brackets.

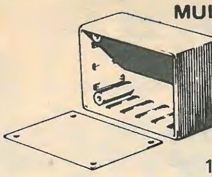
BIM 3000
(250x167.5x68.5mm)
£14.58



MINI DESK BIMCONSOLES

Orange, Blue, Black or Grey ABS body incorporates 1.8mm pcb guides, stand-off bosses in base with 4 BIMFEET supplied. 1mm Grey Aluminium panel sits recessed with fixing screws into integral brass bushes.

BIM 1005 (161 x 96 x 58mm) £2.18
BIM 1006 (215 x 130 x 75mm) £3.05



MULTI PURPOSE BIMBOXES

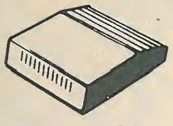
Orange, Blue, Black or Grey ABS with 1mm Grey Aluminium recessed front cover held by screws into integral brass bushes. 1.8mm pcb guides incorporated and 4 BIMFEET supplied.

BIM 4003 (85x56x28.5mm) £1.18
BIM 4004 (111x71x41.5mm) £1.62
BIM 4005 (161x96x52.5mm) £2.19

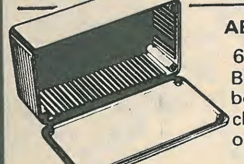
ALL METAL BIMCONSOLES

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 panel for excellent cooling. See latest catalogue for new styles and sizes

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



15° Sloping Panel	30° Sloping Panel	
BIM7151 (102x140x51[28] mm)	BIM7301 (102x140x76[28] mm)	£10.67
BIM7152 (165x140x51[28] mm)	BIM7302 (165x140x76[28] mm)	£11.44
BIM7153 (165x216x51[28] mm)	BIM7303 (165x183x102[28] mm)	£12.61
BIM7154 (165x211x76[33] mm)	BIM7304 (254x140x76[28] mm)	£13.82
BIM7155 (254x211x76[33] mm)	BIM7305 (254x183x102[28] mm)	£15.36
BIM7156 (254x287x76[33] mm)	BIM7306 (254x259x102[28] mm)	£16.67
BIM7157 (356x211x76[33] mm)	BIM7307 (356x183x102[28] mm)	£17.58
BIM7158 (356x287x76[33] mm)	BIM7308 (356x259x102[28] mm)	£18.55

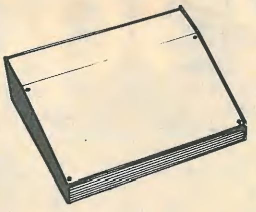


ABS & DIECAST BIMBOXES

6 sizes in ABS or Diecast Aluminium. ABS moulded in Orange, Blue, Black or Grey. Diecast Aluminium in Grey Hammertone or Natural. All boxes incorporate 1.8mm pcb guides, stand-off supports in base and have close fitting flanged lids held by screws into integral brass bushes (ABS) or tapped holes (Diecast).

	ABS		Diecast	Hammertone	Natural
(50x50x31mm)	N/A		BIM5001/11	TBA	£1.02
(100x50x25mm)	BIM2002/12	£0.96	BIM5002/12	£1.46	£1.19
(112x62x31mm)	BIM2003/13	£1.13	BIM5003/13	£1.78	£1.46
(120x65x40mm)	BIM2004/14	£1.35	BIM5004/14	£2.24	£1.82
(150x80x50mm)	BIM2005/15	£1.52	BIM5005/15	£2.84	£2.28
(190x110x60mm)	BIM2006/16	£2.37	BIM5006/16	£3.94	£3.33

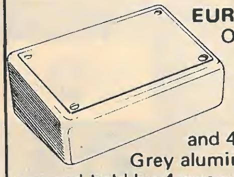
Also available in Grey Polystyrene with no slots and self-tapping screws
BIM 2007/17 (112x61x31mm) £1.00



LOW PROFILE BIMCONSOLES

Orange, Blue, Black or Grey ABS body has ventilation slots as well as 1.8mm pcb guides and stand-off bosses in base. Double angle recessed front panel with 4 fixing screws into integral brass bushes. 4 BIMFEET supplied.

BIM 6005 (143 x 105 x 55.5 [31.5] mm) £2.37
BIM 6006 (143 x 170 x 55.5 [31.5] mm) £3.08
BIM 6007 (214 x 170 x 82.0 [31.5] mm) £4.12

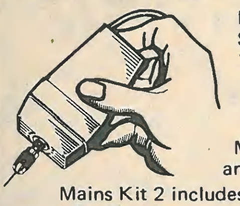


EUROCARD BIMCONSOLES

Orange, Blue, Black or Grey ABS body accepts full or ½ size Eurocards, with bosses in the base for direct fixing. 1.8mm wide pcb guides incorporated and 4 BIMFEET supplied. 1mm Grey aluminium lid sits flush with body top and held by 4 screws into integral brass bushes.

BIM 8005 (169x127x70[45] mm) £4.12
BIM 8007 (243x187x103[66] mm) £6.10

BIMTOOLS + BIMACCESSORIES



MAINS BIMDRILLS

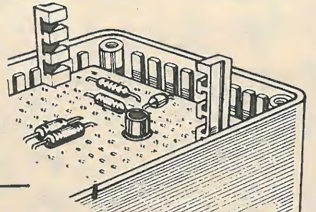
Small, powerful 240V hand drill complete with 2 metres of cable and 2 pin DIN plug. Accepts all tools with 1mm, 2mm or .125" dia. shanks Drills brass, steel, aluminium and pcb's. Under 250g, off load speed 7500 rpm. Orange ABS, high impact, fully insulated body with integral on/off switch £10.53

Mains Accessory Kit 1 includes 1mm, 2mm, .125" twist drills, 5 burrs and 2.4mm collet £2.48

Mains Kit 2 includes Mains BIMDRILL as above, 20 assorted drills, mops, burrs, grinding wheels and mounted points, 1mm, 2mm, 2.4mm and .125" collets. Complete in transparent case measuring 230x130x58mm £22.14

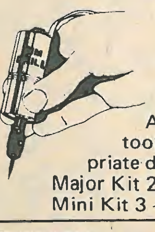
BIMDAPTORS

Allows pcb's to be flat mounted sandwich fashion in BIMBOXES, BIMCONSOLES, and all other enclosures having 1.5mm wide vertical guide slots. One plastic BIMDAPTOR on each corner of pcb(s) enables assembly to be simply slid into place. 54mm long, 10 slots on 5mm spacing and can be simply snipped off to length. £1.08 per pack of 25.



BIMFEET

11mm dia. 3mm high, grey rubber self-adhesive enclosure feet.
£0.77 per pack of 24



12 VOLT BIMDRILLS

2 small, powerful drills easily hand held or used with lathe/stand adaptor. Integral on/off switch and 1 metre cable.

Mini BIMDRILL with 3 collets up to 2.4mm dia. £ 8.10
Major BIMDRILL with 4 collets up to 3mm dia. £13.60

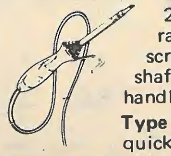
Accessory Kits 1 have appropriate drills and collets as above plus 20 assorted tools. Mini Kit 1 – £15.12, Major Kit 1 – £19.44. Accessory Kits 2 have appropriate drills, collets plus 40 tools and mains-12V dc adaptor. Mini Kit 2 – £34.02, Major Kit 2 – £39.42. Accessory Kits 3 as appropriate Kits 2 plus stand/lathe unit. Mini Kit 3 – £45.36, Major Kit 3 – £50.76.

BIMPUMPS

2 all metal desoldering tools provide high suction power and have easily replaceable screw in Teflon tips. Primed and released by thumb operation with in-built safety guard and anti-recoil system.

BIMPUMP Major (180mm long) £7.99
BIMPUMP Minor (150mm long) £6.80

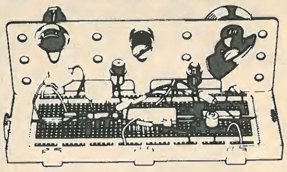
BIMIRONS



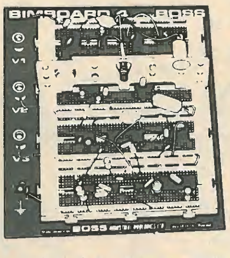
Type 30 General Purpose 27 watt iron with long life, rapid change element, screw on tip, stainless steel shaft and clip on hook. Styled handle with neon. £4.05

Type M3 Precision 17 watt iron, quick change tip, long life element, styled handle with clip on hook. £4.43

BIMBOARDS



DIL COMPATIBLE BIMBOARDS



Accept all sizes (4-50 pin) of DIL IC packages as well as resistors, diodes, capacitors and LEDs. Integral Bus Strips up each side for power lines and Component Support Bracket for holding lamps, switches and fuses etc. Available as single or multiple units, the latter mounted on 1.5mm thick black aluminium back plate which stand on non slip rubber feet and have 4 screw terminals for incoming power.

BIMBOARD 1 has 550 sockets, multiple units utilising 2, 3 and 4 BIMBOARDS incorporate 1100, 1650 and 2200 sockets, all on 2.5mm (0.1") matrix.

BIMBOARD 1 £ 8.83
BIMBOARD 2 £21.01
BIMBOARD 3 £29.84
BIMBOARD 4 £38.79

DESIGNER PROTOTYPING SYSTEM

1, 2, or 3 BIMBOARDS mounted on BIM 6007 BIMCONSOLE with Integral Power Supply (±5 to ±15Vdc @ 100mA and fixed +5Vdc @ 1A) All O/P's fully isolated. Short circuit and fast fold back protection. Power rails brought out to cable clamps that accept stripped wire or 4mm plug.

DESIGNER 1 £55.62
DESIGNER 2 £61.02
DESIGNER 3 £66.42

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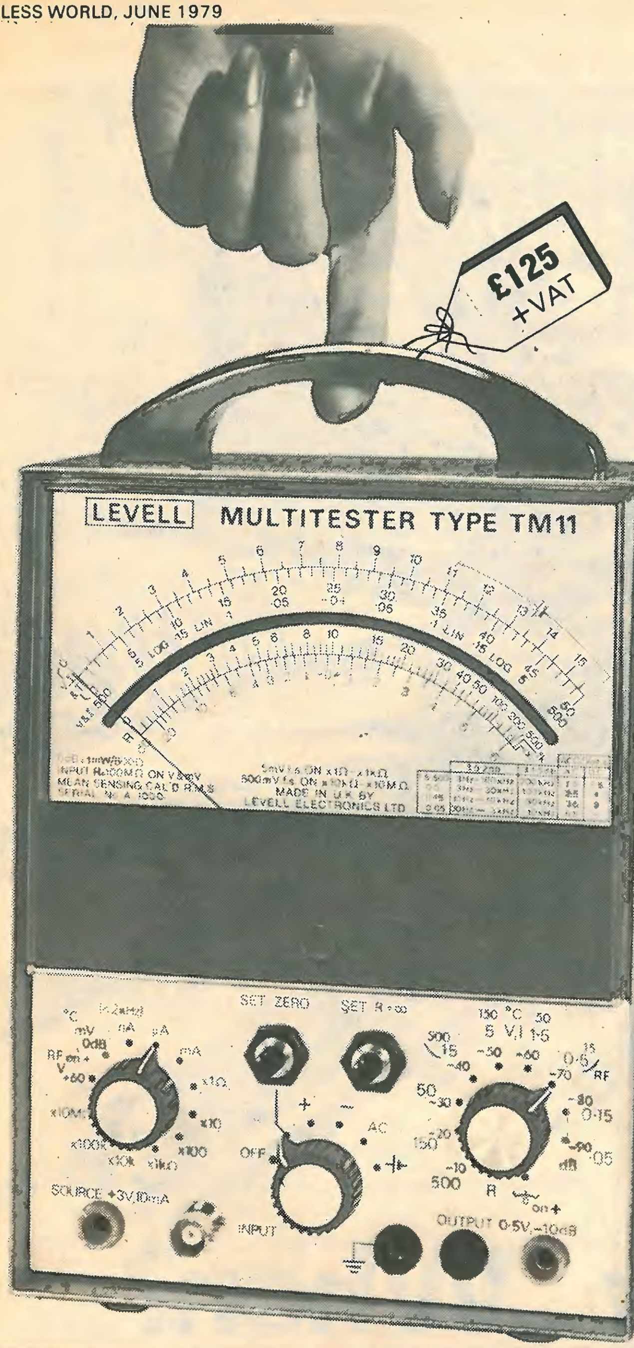

VERSATILE ELECTRONIC MULTITESTER

120 BASIC RANGES

AC V, I & dB	:	50µV/500V fsd, 50pA/500mA fsd, -90dB/+50dB mid scale. Acc.±1.5% fsd above 500µV & 500pA. Response 3Hz/200kHz above 500µV and 500nA. Input R = 100MΩ on volts.
DC V, I & NULL	:	150µV/500V fsd, 150pA/500mA fsd, polarity reversible. Acc.±1.5% fsd above 500µV & 500pA. Input R = 100MΩ on volts. 5 Null ranges have centre zero lin/log scale covering ±4 decades.
RESISTANCE	:	0.2Ω/10GΩ in 7 ranges, polarity reversible. Low test voltage for solid state circuits.
LEAKAGE at 3V	:	Uses 3V source with current ranges to test capacitors, diodes and resistance up to 100GΩ.
VOLT DROP at 10mA	:	Uses 10mA source with voltage ranges to test diodes, LED's and resistance down to 10mΩ.

30 OPTIONAL RANGES

RF VOLTS	:	0.5V/500V fsd, 10kHz/1GHz, using RF Probe. Price £26 + VAT.
HIGH VOLTS	:	1.5kV/50kV fsd, AC/DC, using HV Probe. Price £19 + VAT.
HIGH CURRENT	:	1.5A/50A fsd, AC/DC, using Current Shunt. Price £18 + VAT.
TEMPERATURE	:	-150°C/+500°C fsd in 7 ranges using Temperature Probe. Price £43 + VAT.

The instrument operates from a 9 volt battery, life 1000 hrs., or, AC mains when optional Power Supply Unit is fitted. Size is 240mm x 150mm x 80mm. Weight is 1.75 kg. Meter scale length is 140mm. Leather case is available at £16 + VAT.

LEVELL ELECTRONICS LTD.

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TEL: 01-449 5028/440 8686

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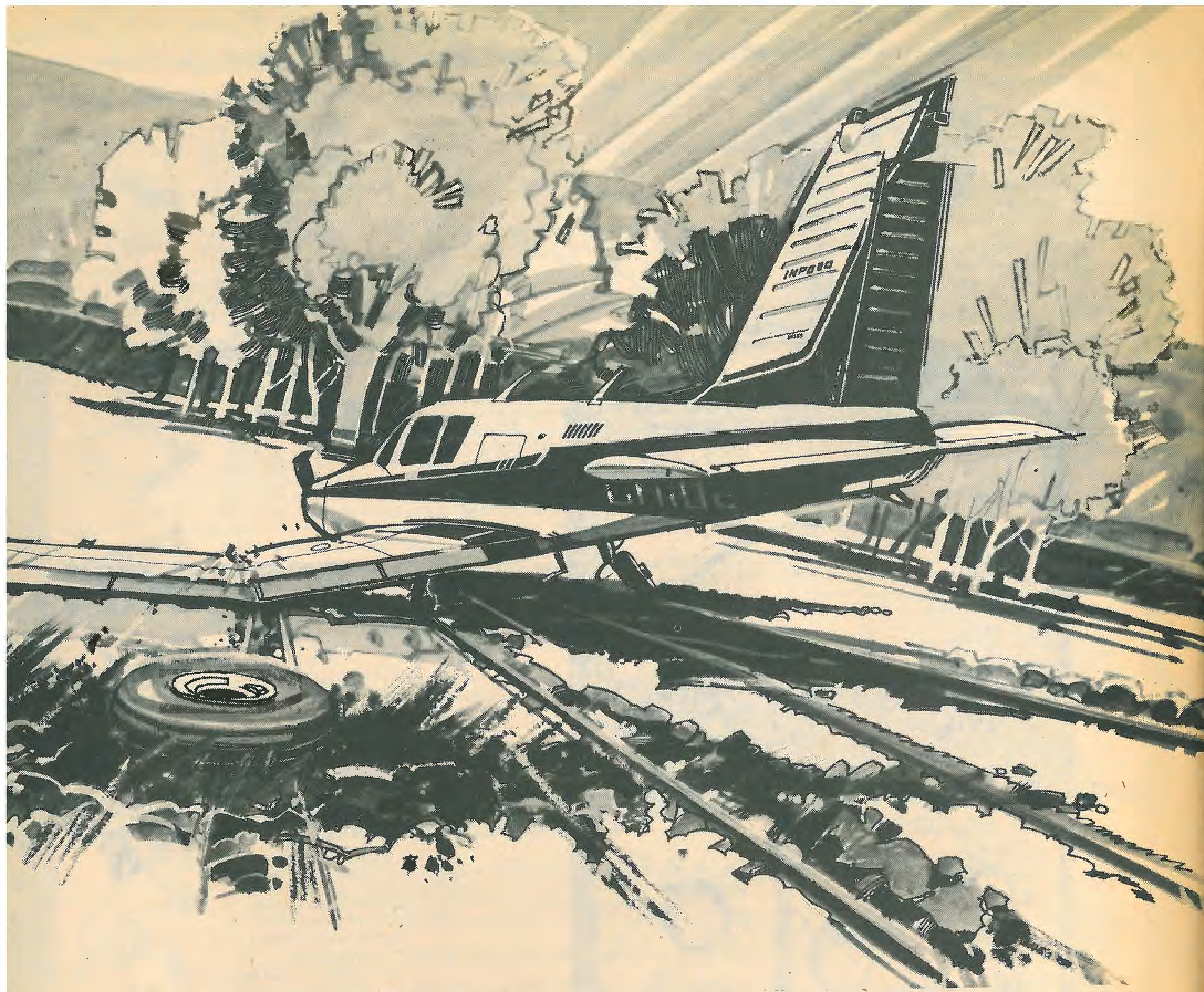

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Distress calls are made every day–hundreds each year, and in every case questions are asked. Questions which require accurate, up-to-the-minute answers. Answers that can only come from reliable and immediately accessible communications recordings.

When police, ambulance, fire, local ATC and other services are called upon, either by radio or telephone, they often receive hasty, garbled messages–sometimes several at a time. In such instances a positive need for communications recording arises–a need for a system with instant message trace and replay–at the touch of a button–and at any speed to assist intelligibility.

All these facilities, and more, are available in the Racal Recorders 'Callstore' cassette recorder/reproducer. Actuated either by incoming audio signals or by local or remote control, Callstore uses four cassette transports, each giving up to four separate channels, including a search control track which is cued at the beginning of each message.

For details write to:

Racal Recorders Limited
Hardley Industrial Estate
Hythe, Southampton,
Hampshire, SO4 6ZH
Telephone: 0703 843265.
Telex: 47600.

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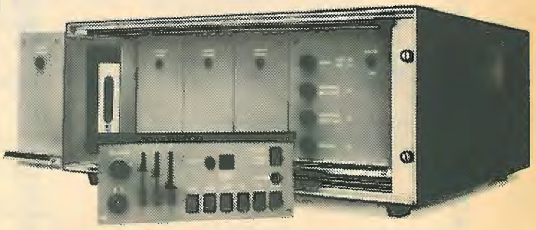


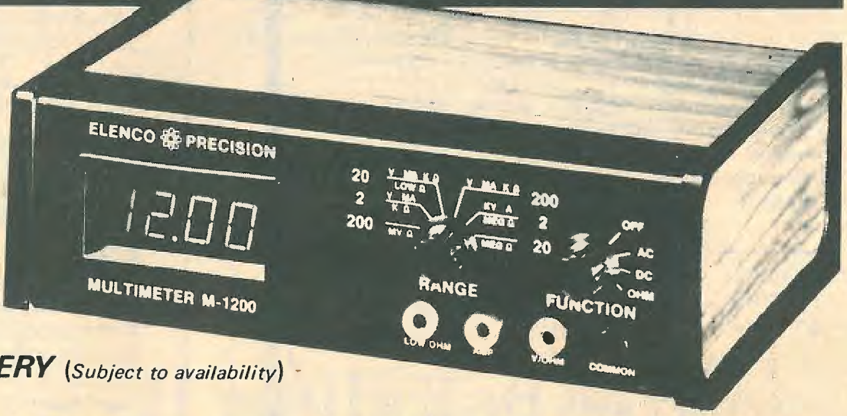
Callstore, from **Racal Recorders,** answers all the questions.

WW — 011 FOR FURTHER DETAILS

Measure Resistance to 0.01Ω ...
At a Price that has no resistance at all

New ELENCO PRECISION USA Digital Multimeter M1200B

ONLY £55 (+£3 p&p + VAT £4.64 = £62.64)



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METAL CASE

EX STOCK DELIVERY (Subject to availability)

THE ULTIMATE IN PERFORMANCE - MEASURES RESISTANCE TO 0.01 OHMS, VOLTAGE TO 100 MICROVOLTS, CURRENT TO 1 MICROAMPS AT LOWEST EVER PRICE!

FEATURES

- 3½ digits 0.56" high LED for easy reading
- 100μV, 1μA, 0.01Ω resolution
- High input impedance 10 Megohm
- High accuracy achieved with precision resistors, not unstable trimpots
- Input overload protected to 1000V (except 200mV scale to 600V)
- Auto zeroing, autopolarity
- Mains (with adaptors not supplied) or battery operation-built-in charging circuitry for NiCads
- Overrange indication
- Hi Low power ohms, Lo for resistors in circuit, Hi for diodes

SPECIFICATIONS:

DC Volts	Range 200mV, 2V, 20V, 200V, 1000V
	Accuracy 1% ± 1 digit, Resolution .1mV
	Overload protection 1,000 volts max
AC Volts	Range 200mV, 2V, 20V, 200V, 1000V (Response 45Hz to 5KHz)
	Accuracy 1.5% ± 2 digits, Resolution .1mV
	Overload protection 1000V max, 200mV scale 600V
DC Current	Range 2mA, 20mA, 200mA, 2amp.
	Accuracy 1% ± 1 digit, Resolution 1 Microamp
	Overload protection -- 2 amp fuse and diodes
AC Current	Range 2mA, 20mA, 200mA, 2 amp
	Accuracy 1.5% ± 2 digits, Resolution 1 Microamp
	Overload protection – 2 amp fuse and diodes
Resistance	Range 20, 200, 2K, 200K, 2 Meg. 20 Meg.
	Accuracy 1% ± 1 digit, Resolution .01 ohms
Environmental	Temp coefficient 0°to 30°C ± .025%°C
	Operating Temp 0° to 50° C Storage – 20° to 60° C
General	Mains adaptor: 6 - 9 Volts @ 200mA (not supplied)
	4C size batteries (not supplied)
	Size 8¼ x 5¾ x 2¼ Weight 2½ lbs.

At £55, M1200B is the best buy among DMM's currently available. Its 0.01 ohms resolution allows you to detect shorted windings in coils, transformers or motors. It is also useful in checking low contact resistance in switches, relays or connectors. Poor solder connections can also be spotted. The low power ohms function permits accurate measurements of in circuit resistance without forward biasing semiconductor junctions.

You have been waiting a long time for a digital multimeter with all these features at a price like this. Now its yours.

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Please send me ________ DMM M1200B
@ £62.64 inc. p & p + VAT (overseas £60).

I enclose cheque/P.O./Bank Draft for £ ____

Name ____________
Address ____________ (BLOCK LETTERS PLEASE)
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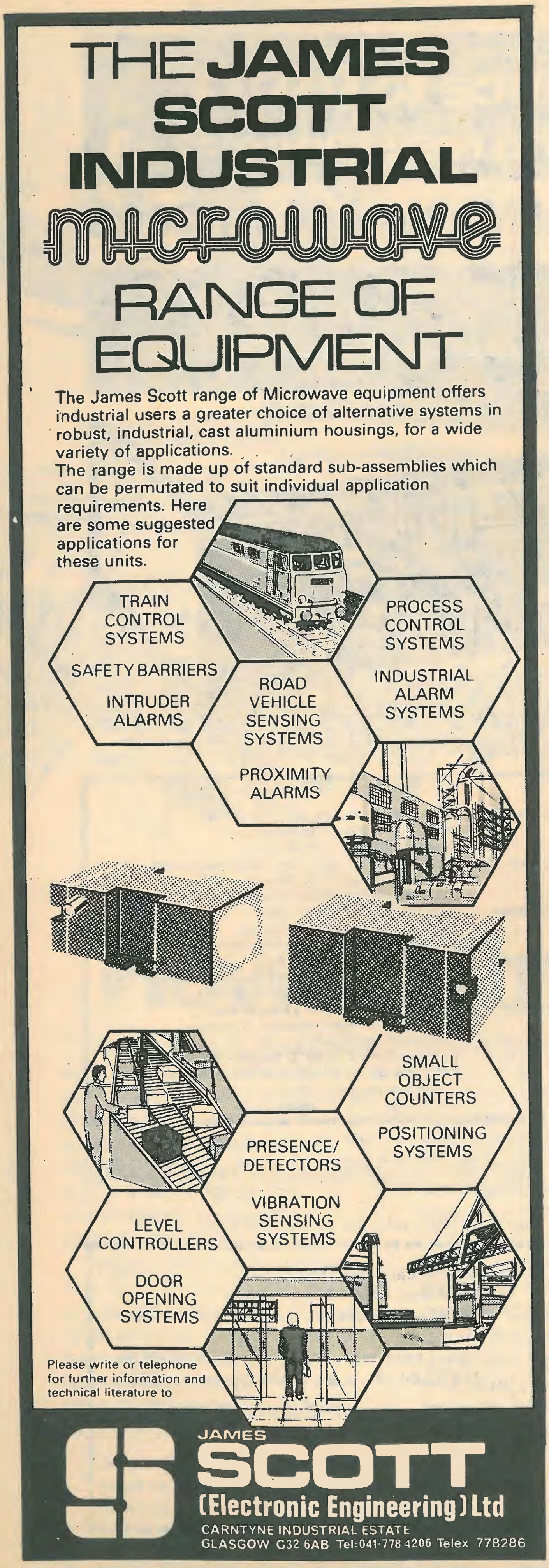

THE JAMES SCOTT INDUSTRIAL MICROWAVE RANGE OF EQUIPMENT

The James Scott range of Microwave equipment offers industrial users a greater choice of alternative systems in robust, industrial, cast aluminium housings, for a wide variety of applications.
The range is made up of standard sub-assemblies which can be permutated to suit individual application requirements. Here are some suggested applications for these units.

Please write or telephone for further information and technical literature to

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WW — 038 FOR FURTHER DETAILS

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Luton: B & B Hi-Fi – Coventry Radio – D. P. Hobbs

Berkshire
Bracknell: Sewards (Electrical) **Newbury**: Povey & Wade **Reading**: B & B Hi-Fi – L. J. Gale – Reading Cassette & Hi-Fi Centre **Wokingham**: Sewards (Electrical).

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QUAD is a Registered Trade Mark

WW—021 FOR FURTHER DETAILS

If walls had ears?

"We can't possibly use an output condenser, it must cut the bass mustn't it? And what about the damping?"
"And no output transformer, what with all that hysteresis and iron distortion."
"Pentodes? Tetrodes?"
"No, No, nothing but triodes will do."
"Triodes then, but wait, we can't have all that accumulated Miller effect."
"Transistors then?"
"Oh no, this year's crop are all hard and brittle."
"And that see-saw phase splitter, it's asymmetrical; if we fed a square wave . . . "
"But what have square waves to do with programme?"
"Shut up, that's irrelevant."
"Class B? But doesn't that always produce crossover distortion?"
"Ah! Feedback will cure all;"
"No, No, we've read that too much feedback causes TID or something."

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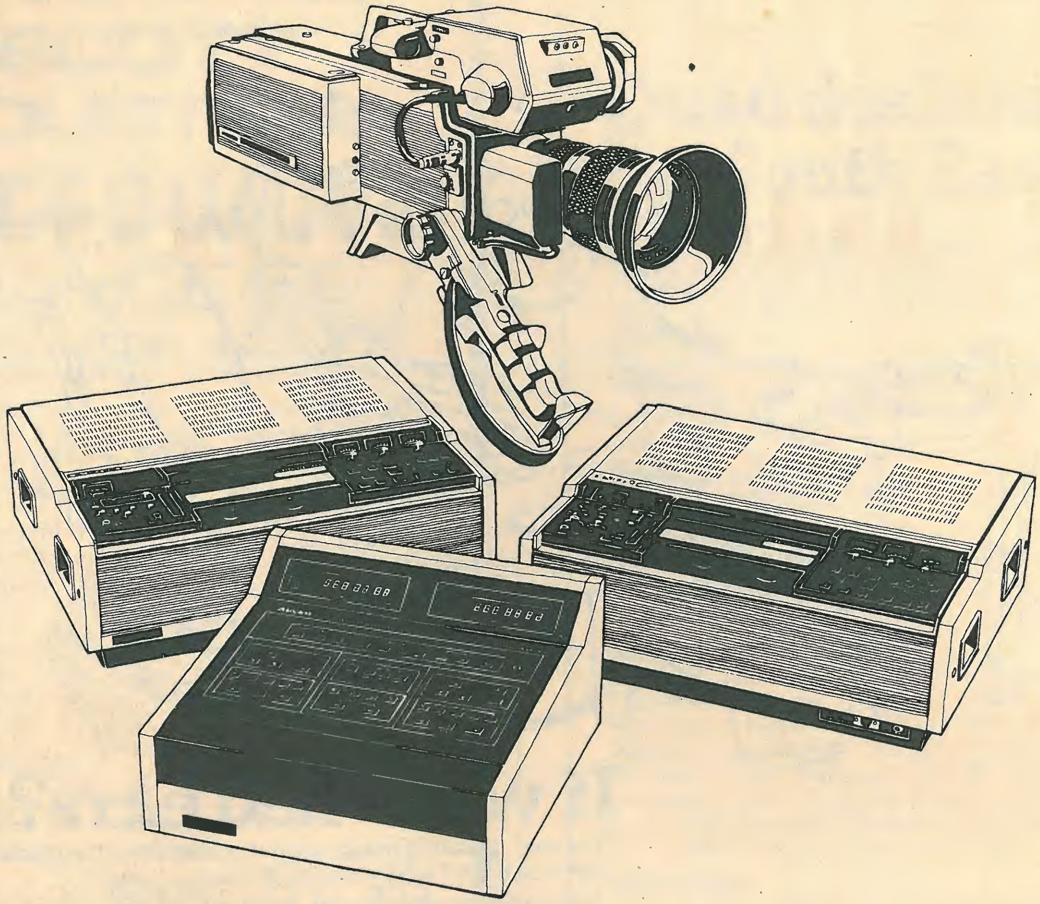

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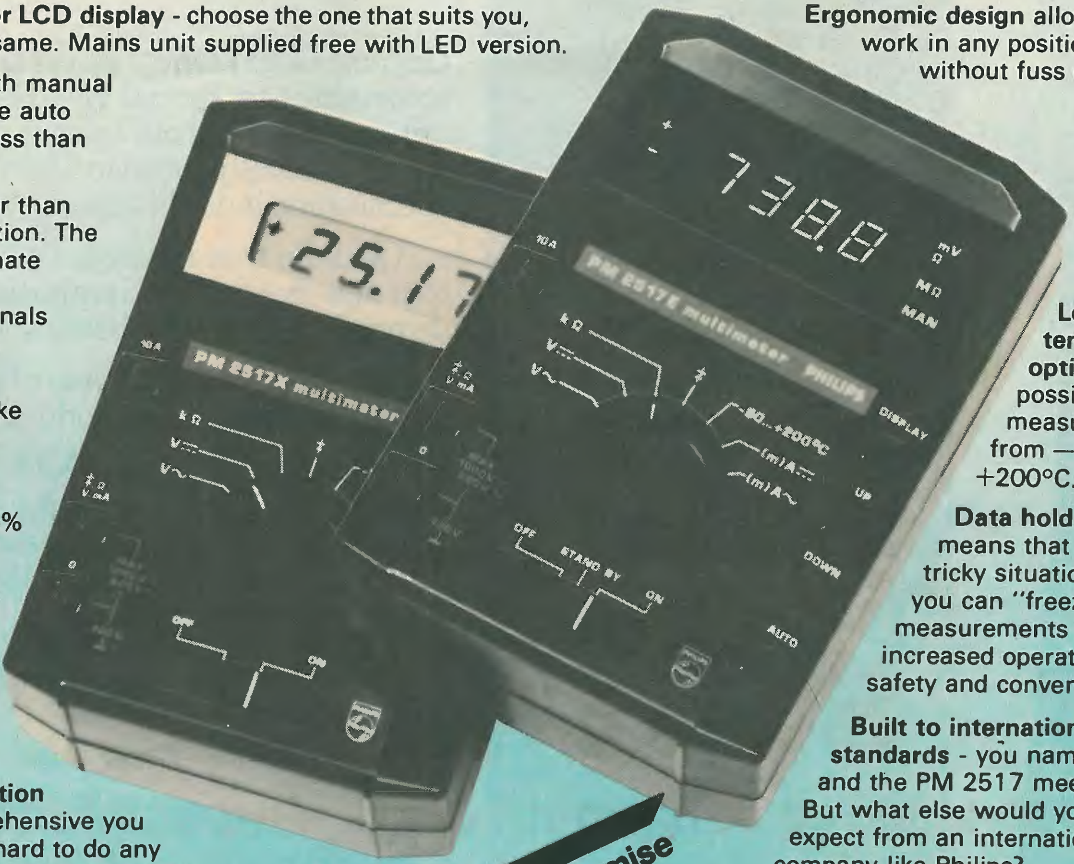

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It can also be purchased from the U.K. marketing organisation -

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Illustration actual size.

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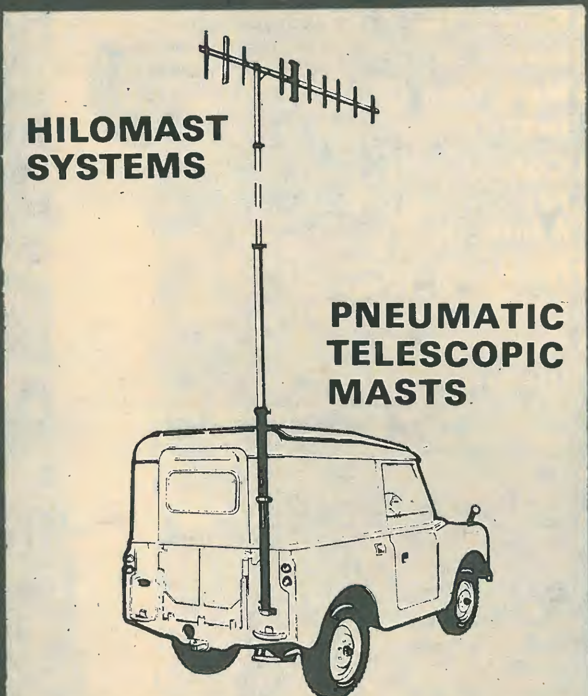

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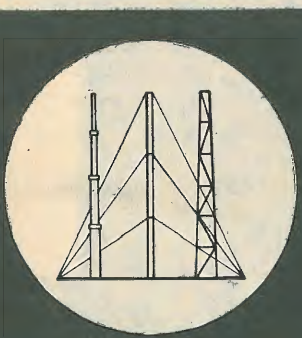

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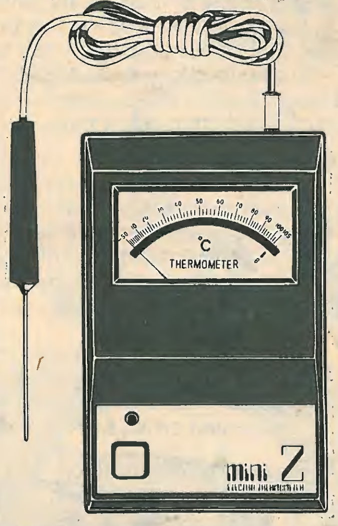

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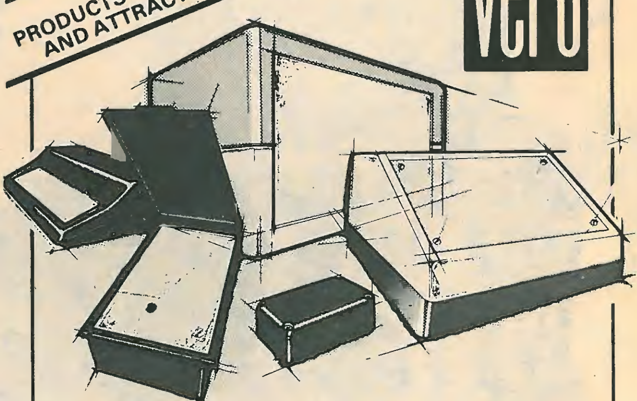

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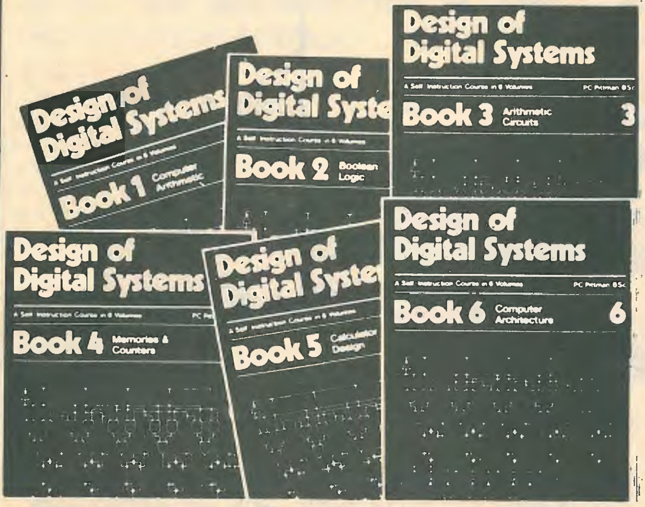
Understanding Digital Electronics

New teach-yourself courses



Design of Digital Systems is written for the engineer seeking to learn more about digital electronics. Its six volumes — each A4 size — are packed with information, diagrams and questions designed to lead you step-by-step through number systems and Boolean algebra to memories, counters and simple arithmetic circuits, and finally to a complete understanding of the design and operation of calculators and computers.

The contents of Design of Digital Systems include:

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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.
Book 6 Central processing unit (CPU); memory organisation; character representation; program storage; address modes; input/output systems; program interrupts; interrupt priorities; programming; assemblers; computers; executive programs; operating systems and time sharing.

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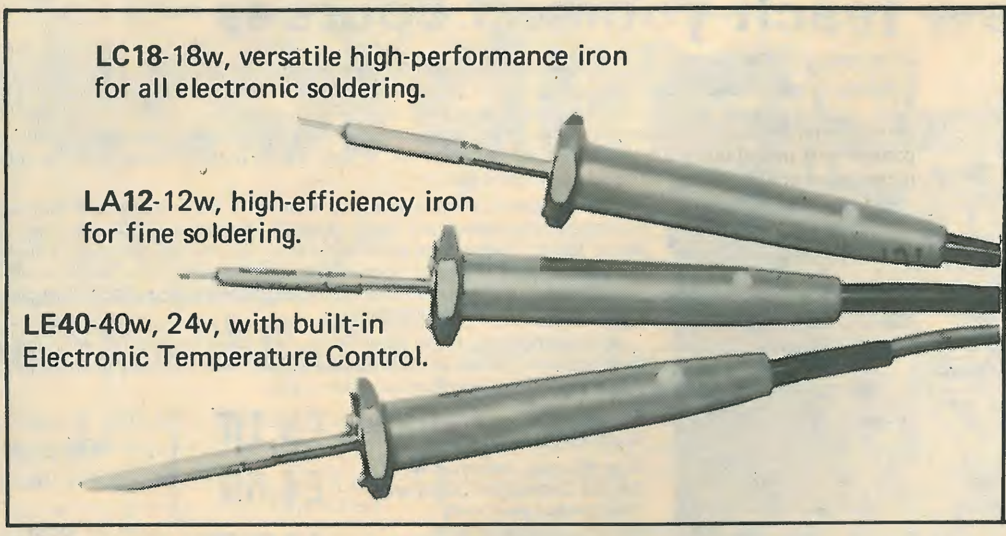

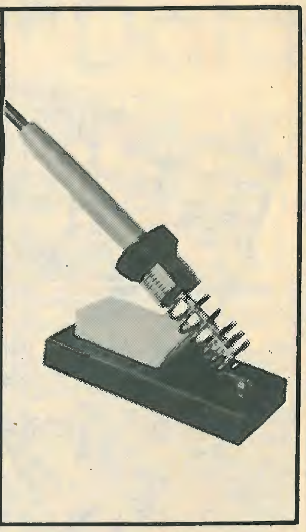

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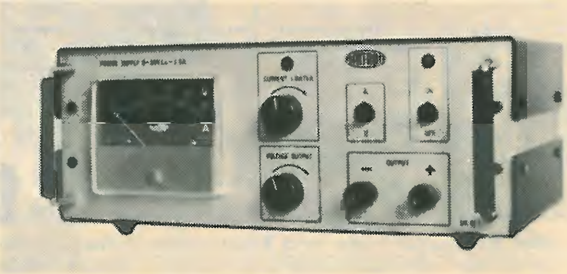

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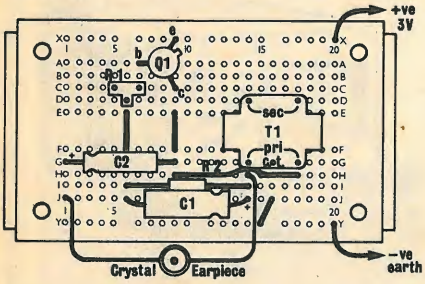
NOW YOU HAVE FISH'N'CLIKS



YOU WILL NEED

B1, B2 – 2xl.5V AAA batteries
C1, C2 – 50 uF, 12-VDC electrolytic capacitor
E1 – Crystal earphone
Q1 – Motorola HEP-230 pnp transistor
R1 – 5000-ohm pot
R2 – 27000-ohm, ¼ watt resistor
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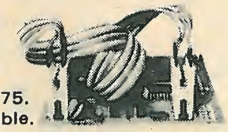

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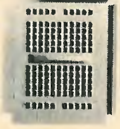

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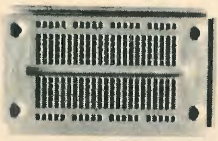

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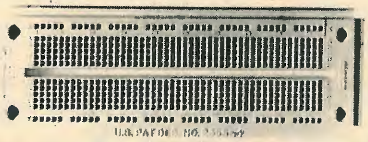

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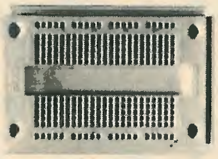

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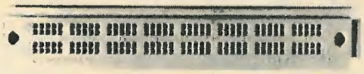

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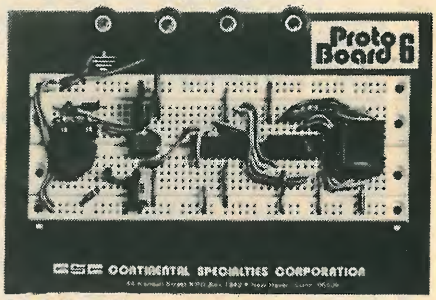

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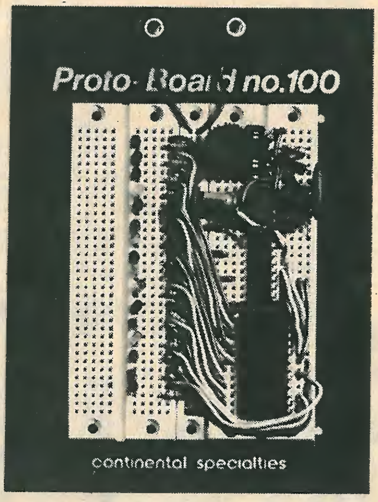

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Overshoot:	less than 3%
Sweep time:	100 nS/cm - 0.5S/cm
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Trigger bandwidth:	DC - 40 MHz
Trace rotation:	Electrical
Phosphor:	P31
Power:	AC 100/120//220/240V 50/60 Hz 40W
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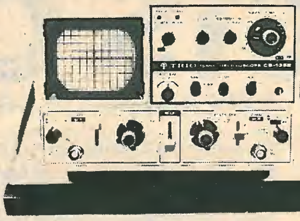

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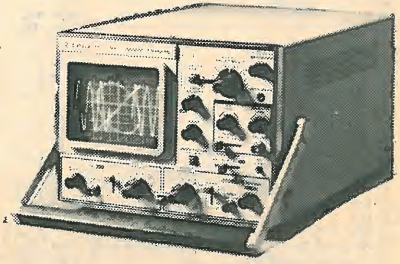
The CS1352 oscilloscope offers you not only dual trace, 15MHz bandwidth operation at sensitivities down to 2mV/cm but also use from 100-240 Vac mains **and** portable operation using the optional rechargeable battery pack. Automatic charging is carried out when the CS1352 is plugged into a mains supply. Now you can have top performance both on the bench and out in the field — and at an affordable price.

CS1575 DUAL TRACE 4 FUNCTION



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

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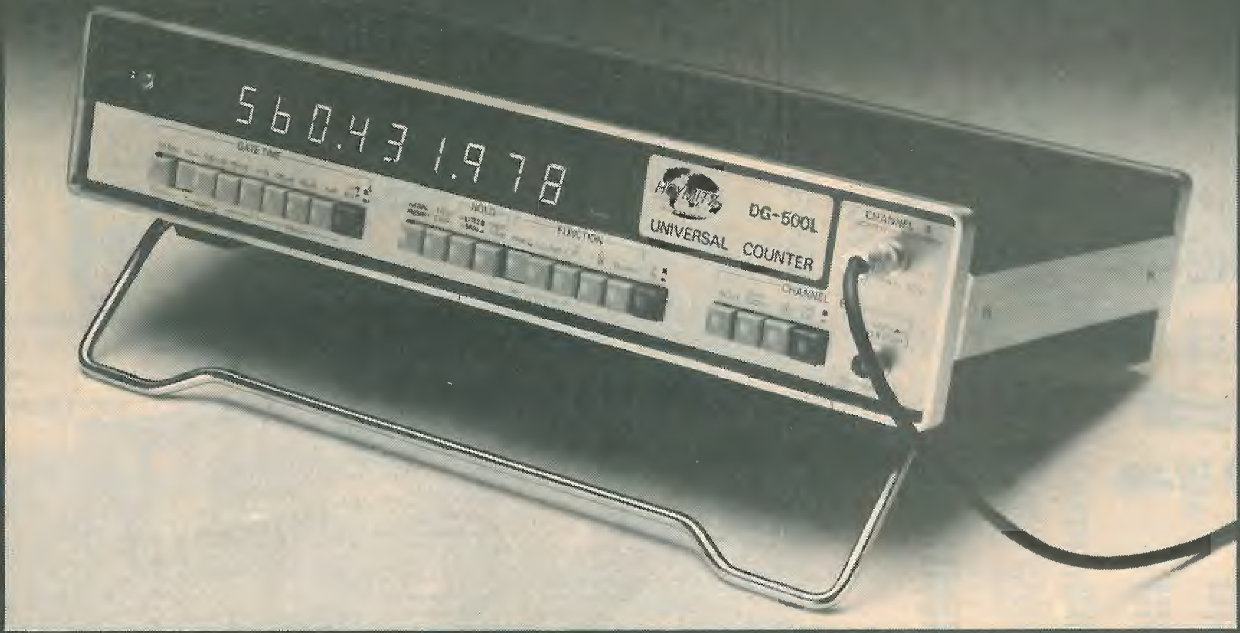

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24 hour stability	3 parts 10^7	1 part 10^8	5 parts 10^{10}
Stability, after a warm up time of 20 minutes	1 part 10^7	3 parts 10^8	1 part 10^8
Crystal Type	5 MHz Fundimental	5 MHz Third Overtone	5 MHz Fifth —
Oven Temperature	+75°C	+80°C	+80°C
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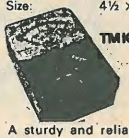

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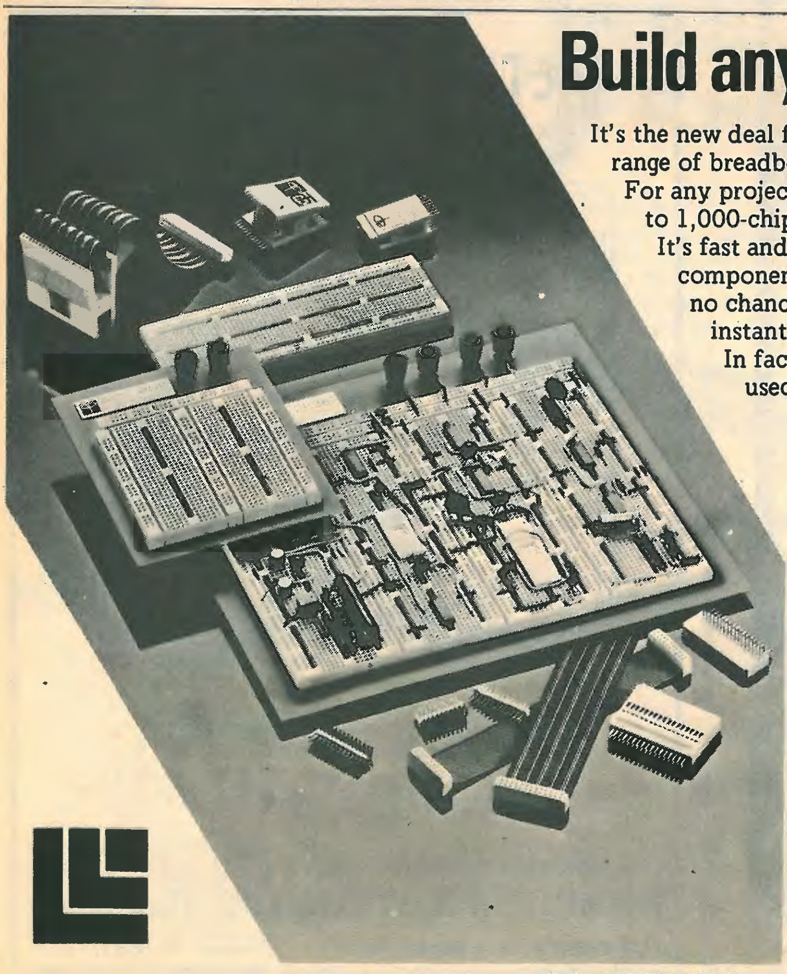

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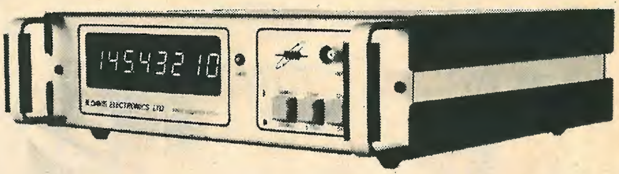

Model HFC600-D 1HZ=600MHZ Frequency Counter fitted with XTAL Oven 8 digit .5" LEDs driven to high brightness.

Ranges=1HZ - 60MHZ=60 - 600MHZ.

Gate = XTAL 5.24288MHZ 1.0 or .1 sec. by pushbutton selection.

Input Imp=50Ω at 60 - 600MHZ 1MΩ par with 15PF at 60MHZ.

Typical Sensitivity = 10mV = 50MHZ. 20mV = 200MHZ. 150mV = 500MHZ.

Resolution = 1Hz=0.60MHZ. 10 HZ=60-600MHZ.

Typical Stability = 3 parts 10 per °C after 1 min. warm-up time.

Power=100-240V A.C. 40-60HZ=9-16V D.C.

Size=H.68mm W=263mm D=216mm. (Provision for int. batt pack). Anodized aluminium cabinet.

Price £145.00 + VAT

7 HUGHENDEN ROAD, HASTINGS, SUSSEX, TN34 3TG ENGLAND. Telephone: (0424) 428131

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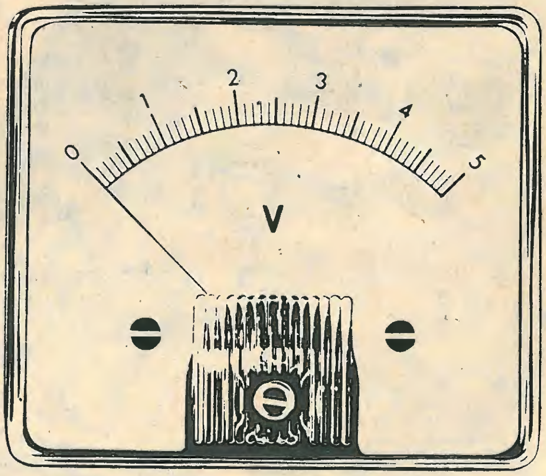
METER PROBLEMS?



137 Standard Ranges in a variety of sizes and stylings available for 10-14 days delivery. Other Ranges and special scales can be made to order.

Full Information from:

HARRIS ELECTRONICS (London)

138 GRAYS INN ROAD, W.C.1 Phone: 01/837/7937

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Put Fluke to the Test

A Digital Multimeter on 14 days approval

If you've ever wanted to challenge the claim of a leading instrument manufacturer then here is your chance.

Fluke are so confident that you will appreciate the fine qualities of their multimeters that we would invite you to put them through their paces.

Simply select either the handheld or bench models at the special low price, complete and clip the coupon. We then pay the VAT, postage & packing and despatch the instrument on 14 days approval.

If during the 14 day period you're not completely satisfied with its performance, return it to us and your money will be refunded.

Are you going to put us to the test?

8010A/8012A
Both models include: ■ 3½ digit LCD readout ■ True RMS measurements ■ 0.1% Accuracy + 1 digit ■ Current ranges from 200μA to 2A (8012A) or 10A (8010A) ■ Diode test facility ■ 100μV resolution ■ 3 conductance ranges for leakage test ■ Fully overload and transient protected.

■ **2 year warranty on parts and labour**

FLUKE 8020A HANDYMETER

- ■ Large easy to read 3½ digit LCD display.
- ■ 26 measurement ranges for AC/DC volts, amps, ohms and conductance.
- ■ 0.25% VDC accuracy over 1 year.
- ■ High power and low power ohms capability.
- ■ Measures to 10,000 MΩ using two conductance ranges.
- ■ Fully protected to 250V on all ranges.
- ■ Protected against transients up to 6KV for 10 μsecs.

Access

BARCLAYCARD

To: Fluke International Corporation, Colonial Way, Watford, Herts WD2 4TT. C

Please send me: ☐ 8020A DMM(s) at £112.00 ☐ 8012A DMM(s) at £199.00
☐ 8010A DMM(s) at £159.00 ☐ Short Form Catalogue–FREE
All prices are fully inclusive.

I enclose my cheque/postal order for £ or please debit my Access/Barclaycard

No Signature

Name (BLOCK LETTERS PLEASE)

Address

THIS OFFER MUST CLOSE 30th SEPTEMBER 1979. ALLOW 2 WEEKS FOR DELIVERY.

Offer applies to U.K. Mainland and Channel Isles. For Northern Ireland & Eire contact EURO ELECTRONIC INSTRUMENTS, 32 Brews Hill, Navan, County Meith, EIRE. *Official company orders, duly authorised, will be accepted with corresponding credit arrangements if required.

FLUKE

Fluke International Corporation
Colonial Way, Watford, Herts. WD2 4TT
Telephone: (0923) 40511 Telex: 934583

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ASTRA-PAK

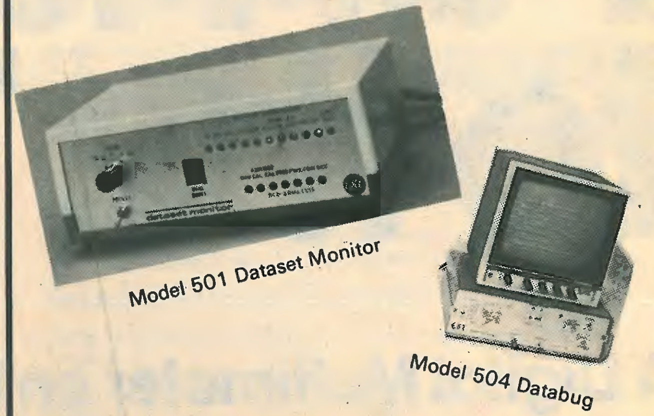
92 GODSTONE ROAD
WHYTELEAFE SURREY CR3 0EB

All prices include V.A.T. Add 25p for P&P (Extra for overseas). **Discounts** over £10 less 5%, over £20 less 5%, over £20 less 10%, over £50 less 15%, over £100 less 20%.
Send SAE for complete list of components.

7400	0.12	7495	0.54	74190	1.05	74LS113	0.36	4007	0.16	4085	0.72
7401	0.12	7496	0.60	74191	0.99	74LS114	0.36	4008	0.92	4086	0.76
7402	0.12	7497	2.38	74192	0.99	74LS123	0.82	4009	0.45	4089	1.55
7403	0.12	74100	0.94	74193	1.05	74LS124	2.45	4010	0.48	4093	0.65
7404	0.13	74104	0.40	74194	0.90	74LS125	0.44	4011	0.15	4094	1.80
7405	0.13	74105	0.40	74195	0.84	74LS126	0.44	4012	0.16	4095	1.10
7406	0.28	74107	0.28	74196	0.90	74LS132	0.69	4013	0.42	4096	1.10
7407	0.28	74109	0.45	74197	0.90	74LS136	0.40	4014	0.80	4097	3.50
7408	0.14	74110	0.46	74198	1.48	74LS138	0.53	4015	0.77	4098	1.12
7409	0.14	74111	0.70	74199	1.48	74LS139	0.53	4016	0.42	4099	1.90
7410	0.13	74116	1.60	74221	1.50	74LS151	1.05	4017	0.77	4404	1.00
7411	0.18	74118	0.82	74273	2.15	74LS153	0.50	4018	0.87	4412	0.30
7412	0.21	74119	1.30	74279	1.25	74LS154	1.20	4019	0.42	4428	0.80
7413	0.25	74120	0.82	74283	1.70	74LS155	0.86	4020	0.92	4445	1.50
7414	0.54	74121	0.25	74284	6.85	74LS156	0.86	4021	0.82	4449	0.30
7416	0.27	74122	0.40	74293	1.35	74LS157	0.47	4022	0.82	4501	0.17
7417	0.27	74123	0.53	74298	1.92	74LS158	0.53	4023	0.15	4502	0.88
7420	0.13	74125	0.44	74390	1.92	74LS160	1.22	4024	0.66	4507	0.50
7421	0.28	74126	0.45	74393	2.12	74LS161	0.69	4025	0.15	4508	2.25
7422	0.17	74128	0.62	74LS00	0.19	74LS162	1.22	4026	1.28	4510	1.05
7423	0.25	74132	0.68	74LS01	0.19	74LS163	0.69	4027	0.50	4511	0.98
7425	0.20	74135	0.68	74LS02	0.19	74LS164	1.20	4028	0.67	4512	0.92
7426	0.25	74136	0.75	74LS03	0.19	74LS168	2.00	4029	0.86	4514	2.85
7427	0.25	74137	0.94	74LS04	0.20	74LS169	2.00	4030	0.48	4515	2.80
7428	0.34	74141	0.58	74LS05	0.20	74LS170	1.76	4031	2.34	4516	1.02
7430	0.13	74142	2.00	74LS08	0.19	74LS173	1.05	4033	1.25	4518	0.99
7432	0.24	74143	2.00	74LS09	0.19	74LS174	1.12	4034	2.00	4519	0.50
7433	0.32	74144	2.00	74LS10	0.19	74LS175	1.05	4035	1.00	4520	1.05
7437	0.24	74145	0.84	74LS11	0.19	74LS189	2.85	4036	2.40	4521	2.00
7438	0.24	74147	1.30	74LS12	0.19	74LS190	0.81	4037	0.99	4522	1.35
7440	0.13	74148	1.18	74LS13	0.46	74LS191	0.81	4038	1.00	4527	1.60
7441	0.52	74150	0.99	74LS14	1.10	74LS192	1.80	4039	2.80	4528	0.92
7442	0.55	74151	0.60	74LS15	0.19	74LS193	1.80	4040	0.88	4529	1.10
7443	0.90	74153	0.60	74LS20	0.19	74LS195	1.12	4041	0.77	4536	3.56
7444	0.90	74154	1.05	74LS21	0.19	74LS196	1.20	4042	0.72	4553	4.20
7445	0.70	74155	0.63	74LS22	0.19	74LS197	1.20	4043	0.82	4555	0.85
7446	0.70	74156	0.63	74LS26	0.24	74LS221	1.12	4044	0.82	4556	0.85
7447A	0.64	74157	0.63	74LS27	0.40	74LS247	0.97	4045	1.40	4558	1.25
7448	0.60	74159	1.70	74LS30	0.19	74LS248	0.97	4046	1.32	4566	1.40
7450	0.13	74160	0.80	74LS32	0.25	74LS249	0.97	4047	0.96	4583	0.75
7451	0.13	74161	0.60	74LS37	0.27	74LS251	1.00	4048	0.60	4585	1.03
7453	0.13	74162	0.80	74LS38	0.27	74LS253	1.05	4049	0.42		
7454	0.13	74163	0.80	74LS40	0.19	74LS257	1.05	4050	0.42		
7460	0.13	74164	0.89	74LS42	0.53	74LS258	1.05	4051	0.84		
7470	0.28	74165	0.89	74LS47	0.97	74LS266	0.39	4052	0.84		
7472	0.22	75166	0.99	74LS48	0.97	74LS273	2.50	4053	0.84		
7473	0.26	74167	2.70	74LS49	0.97	74LS279	0.50	4054	1.10		
7474	0.26	74170	1.68	74LS51	0.19	74LS283	1.00	4055	1.00		
7475	0.30	74172	4.00	74LS54	0.19	74LS289	2.85	4060	0.98		
7476	0.26	74173	1.18	74LS55	0.20	74LS293	0.90	4066	0.48		
7480	0.45	74174	0.89	74LS73	0.30	74LS298	1.60	4067	3.50		
7481	0.90	74175	0.68	74LS74	0.34	74LS352	0.92	4068	0.24		
7482	0.80	74176	0.68	74LS75	0.45	74LS353	1.05	4069	0.17		
7483	0.72	74177	0.88	74LS76	0.32	74LS365	0.50	4070	0.17		
7484	0.90	74178	1.20	74LS78	0.32	74LS366	0.50	4071	0.17		
7485	0.88	74179	1.10	74LS83	0.78	74LS367	0.50	4072	0.17		
7486	0.26	74180	0.90	74LS85	0.90	74LS368	0.50	4073	0.17		
7489	2.00	74181	1.92	74LS86	0.35	74LS386	0.37	4075	0.17		
7490	0.35	74182	0.75	74LS93	0.95	74LS670	2.00	4076	1.05		
7491	0.65	74184	1.20	74LS95	1.10	4000	0.14	4077	0.46		
7492	0.44	74185A	1.20	74LS107	0.36	4001	0.15	4078	0.22		
7493	0.40	74186	7.20	74LS109	0.36	4002	0.16	4081	0.17		
7494	0.80	74188	2.70	74LS112	0.38	4006	0.92	4082	0.20		

WW—102 FOR FURTHER DETAILS

TWO LOW COST METHODS OF MONITORING YOUR DATA CIRCUITS



Model 501: Dataset Monitor. Checks asynchronous modem circuits or DCE-3 telex auto-dial circuits. Code and speed transparent. Displays number being dialled on telex circuits. Connection for VDU or printer for both-way data monitoring.

Model 504: Databug. Video display based monitor for asynchronous or synchronous data at speeds up to 9600 bps. Utilises well-proven and reliable Intel 8080 microprocessor. 8-level ASCII and 5-level Baudot codes as standard. Video and UHF outputs for video monitor or TV set.

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Telephone Lancing (090-63) 4608

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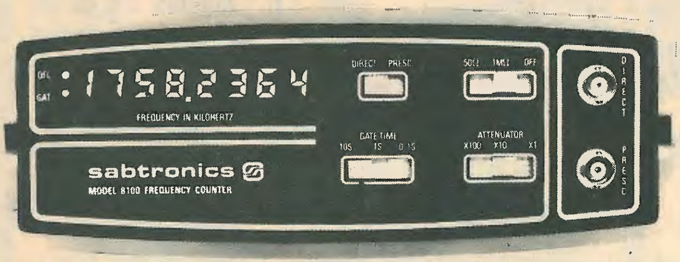
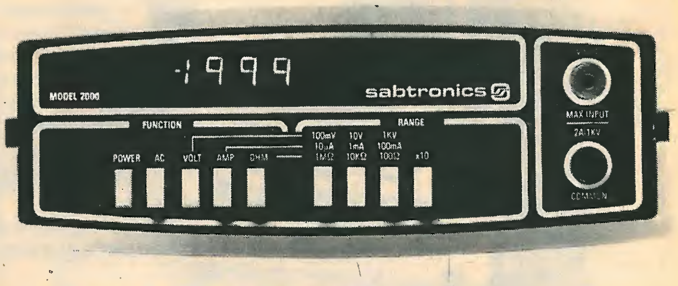


sabtronics

Model 2000 3½ Digit DMM
Kit £ 49.95
assembled: £ 69.95
(plus p.p. £ 3.00 and VAT at 8%)

Model 8100 Frequency counter
Kit £ 69.95
assembled tested: £ 84.95
(plus p.p. £ 3.50 and VAT at 8%)



The Winners

These two products are our best sellers!

The two products shown above from Sabtronics are our best selling products. Both these products compare with similar equipment selling for atleast £ 150.00. Is there more to these products than value? Let's take a closer look.

The Frequency Counter Model 8100
It employs LSI Technology, has the performance and characteristics you demand, guaranteed frequency range of 20 Hz to 100 MHz; selectable hi/lo impedance; superior sensitivity; selectable resolution and selectable attenuation. Plus an accurate time base with excellent stability. An 8 digit LED Display features floating decimal point, leading zero suppression and overflow indicator.

Brief specifications:
Frequency Range: 20 Hz to 100 MHz guaranteed, (10 Hz to 130 MHz typical) – Sensitivity: 10 mV RMS, 20 Hz to 50 MHz (5 mV typical); 15 mV RMS, 50 MHz to 100 MHz (10 mV typical) – Selectable impedance: 1 MΩ/25 pF or 50Ω – Attenuation: X1, X10 or X100 – Accuracy: ± 1 Hz plus time base accuracy – Aging Rate: ± 5 ppm/yr – Temperature Stability: ±10 ppm, 0° to 50° C – Resolution: 0.1 Hz, 1 Hz, 10 Hz selectable – Display: 8-digit LED, floating DP, overflow indicator – Overload Protection – Power Requirement: 9-15 VDC.
Optional prescaler will be available from around March 1979.

The DMM Model 2000
The model 2000 is all solid-state, incorporating a single LSI circuit and high quality components. It has five functions and a total of 28 ranges. Input overload protection, auto polarity and auto zero are provided on all ranges and a basic DCV accuracy of 0.1% ± 1 digit.

Brief specifications:
DC volts in 5 ranges: 100 μV to 1 kV – AC volts in 5 ranges: 100 μV to 1 kV – DC current in 6 ranges: 100 nA to 2A – AC current in 6 ranges: 100 nA to 2A – Resistance: 0.1Ω to 20 MΩ in 6 ranges – AC frequency response: 40 Hz to 50 kHz – Display: 0.36" (9,1 mm) 7-segment LED – Input impedance: 10 MΩ – Size: 8" W×6.5" D×3" H (203×165×76 mm) – Power requirement: 4 "C" cells (not included).

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S 500D — dual channel
up to 500W/RMS per
channel DC-20 KHZ

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The H|H 'S' range is designed to handle heavy industrial usage in the fields of vibrator driving, variable frequency power supplies and servo motor systems.

S 500D
Dual Channel
19" rack mount 3½" high
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0.005% harmonic distortion (typical) at 300w r.m.s. into 4 ohms at 1 KHZ
3KW dissipation from in-built force cooled dissipators

S 250D
Single Channel
19" rack mount 3½" high
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Retro-convertible to dual channel
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Full short and open circuit protection
Drives totally reactive loads with no adverse effects

A complete range of matching transformers and peripheral equipment for closed loop, constant current and voltage use are available.

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FRANCHISED COMMERCIAL AND INDUSTRIAL AGENTS FOR H|H ELECTRONIC

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*PROVISION FOR LIGHT PEN ATTACHMENT.

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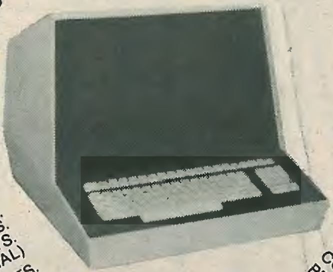

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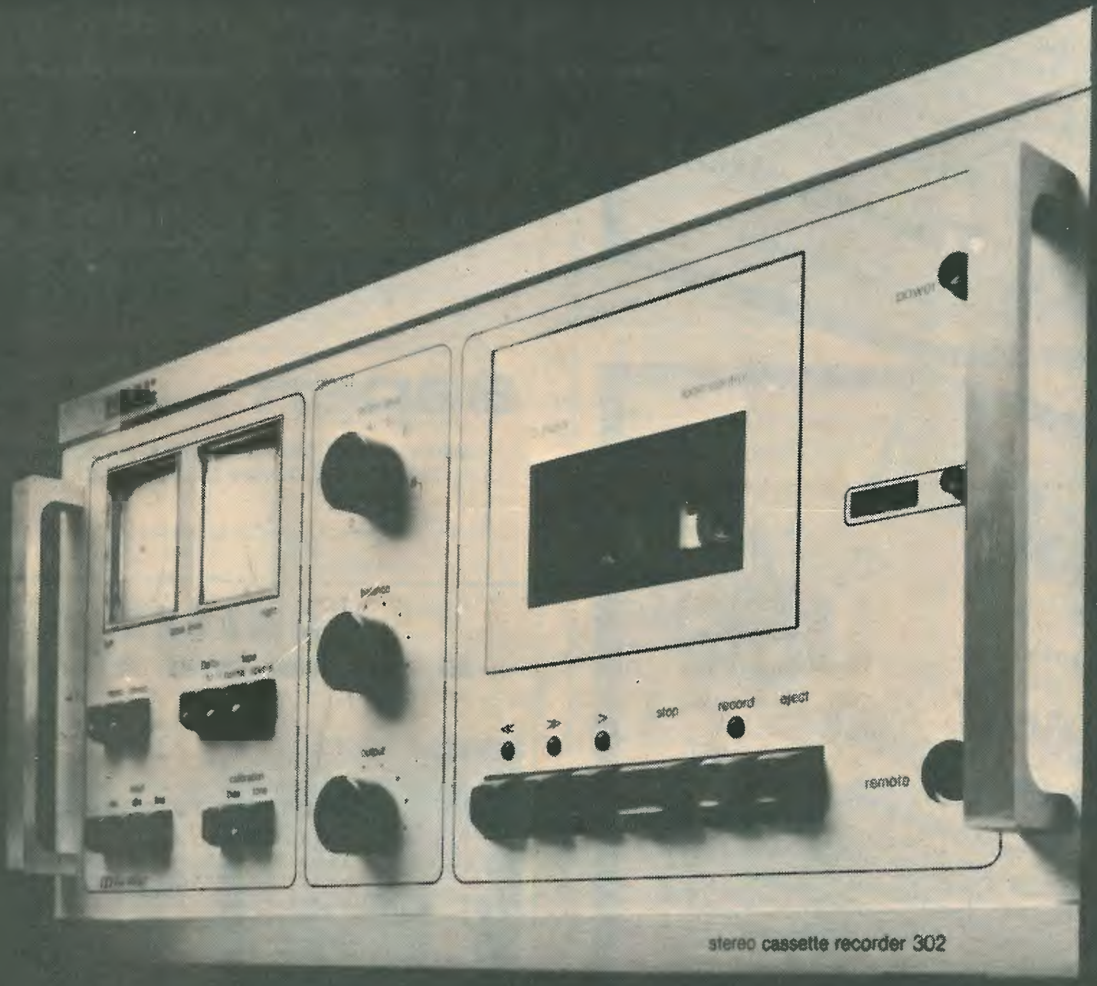

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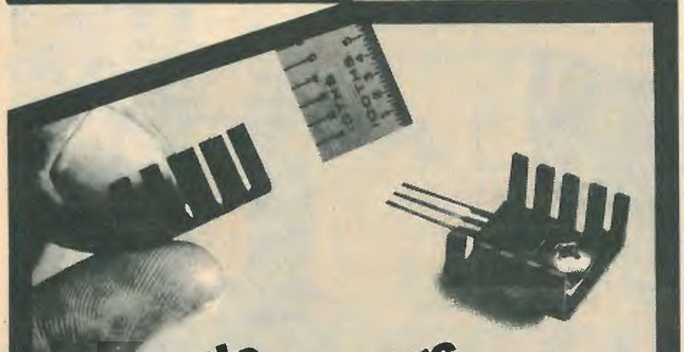
Clip and Save

Clip-on Thermalloy "Slip Clip" heat sinks and save assembly time, board space, and heat sinks costs. They require no mounting hardware, PC board drilling, or adhesives, and clamp firmly to the device for maximum heat transfer. "Slip Clips" are available for TO-202, TO-220, TO-126, Motorola case 90 and most other popular case styles.

Thermalloy

Number one in Semiconductor Accessories



Plastic Power Coolers

New low profile heat sinks save board space

The 6073B requires only 750" board space and is just 375" tall – the right heat sink for 500" centreline PC board applications. Cools SCR's and transistors in TO-220. Motorola Case 70 and Case 90 packages. Dissipates 21°C/watt in natural convection. Available in Black Anodized and Pre-Black Anodized finish.

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0.45-2300 MHz / 0.1-10,000 watts

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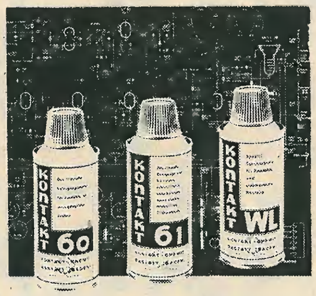
KONTAKT 60

EUROPE'S LEADING CONTACT CLEANING SPRAY



Kontakt products 60-61 and WL provide an unsurpassed cleaning capability for contacts and switchgear.

KONTAKT 60

Safely dissolves oxides and sulphides and disposes of resinated contact greases and dirt, but does not attack plastics or any standard production materials.

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WW—049 FOR FURTHER DETAILS

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1613 Octave filter set couples directly to 2203 & 2204	250
CEL	
112 LEQ meter-digital readout	575
Bridges	
CAMBRIDGE	
43379 Decade resistance bridge	75
MUIRHEAD	
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B601Z RF bridge to 5 MHz SR268 Source for B601Z	475
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MARCONI	
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HEWLETT PACKARD	
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	Prices from £
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	Prices from £
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DANA	
5230 119999 FSD AC/DC	175
FLUKE	
8300A 119999 FSD DC only	150
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HEWLETT PACKARD	
3474/2 9999 FSD AC/DC/Ω	215
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Perfect testgear for circuit perfection

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Automatic Telex Test Set, ATTS10

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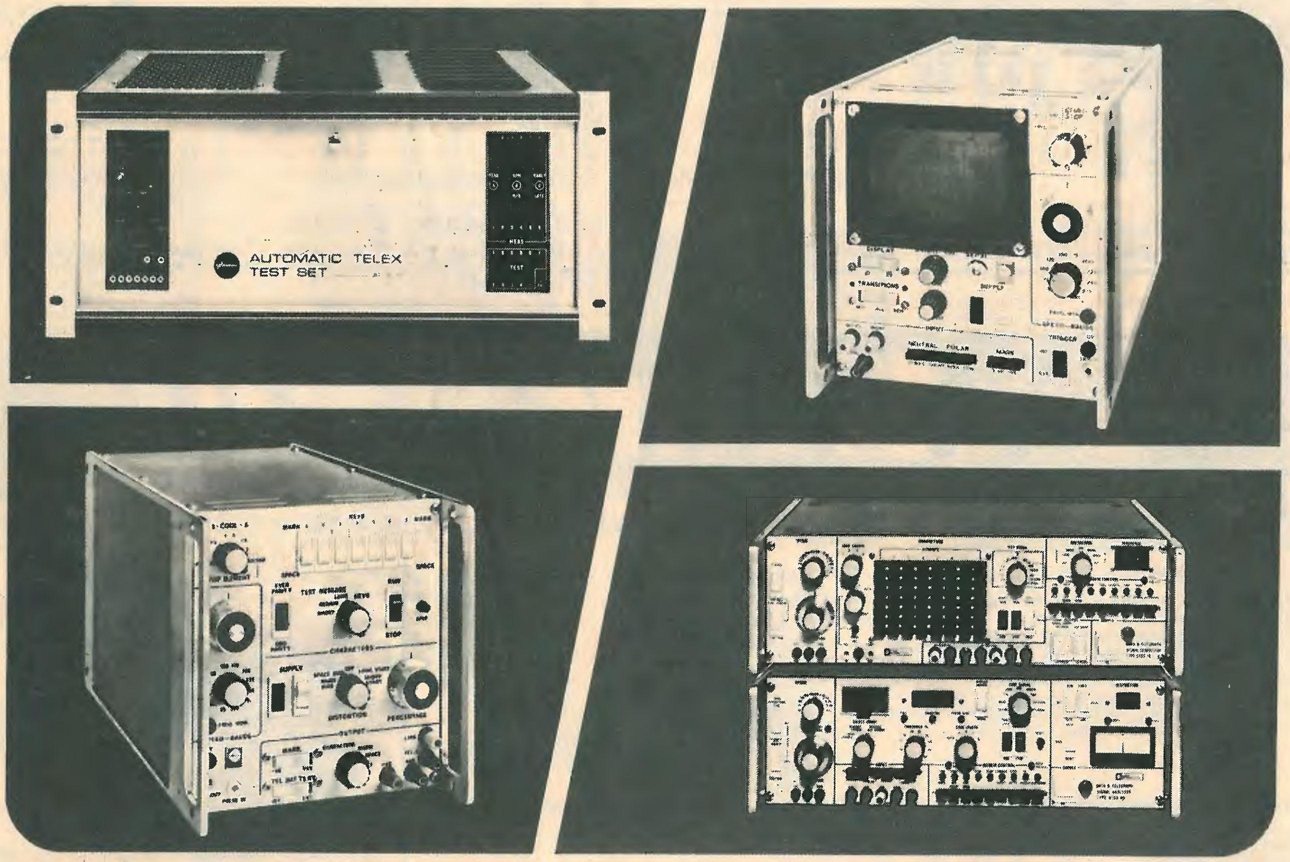
The perfect monitor for 5 and 8 unit code telegraphic transmission problems. An easy to use instrument, covering the speed range 25-330 bauds. All measurements shown on large CRT raster display. A useful companion to the TSG40.



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A precise signal generator covering CCITT recommendations for testing 5 and 8 unit codes, with or without distortion. Speed range 25–330 bauds, calibrated in bauds. Internal signalling supply and TTL logic outputs. A sensible addition to the TDMS80.

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Compact and versatile, the DTSG10 (Generator) and DTSA10 (Analyser) provide comprehensive telegraph and data testing facilities for Simplex and duplex operation of 5, 6, 7 and 8 unit codes. Speed range is 40-12,000 bits/sec. LED numeric displays show peak distortion, speed character, bit and block errors together with modem interface.

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AU113	1.88	1.79	1.37
BC107	.12	.11	.09
BC107A	.12	.11	.09
BC107B	.12	.11	.09
BC108	.12	.11	.09
BC108A	.12	.11	.09
BC109	.12	.11	.09
BC109B	.12	.11	.09
BC109C	.12	.11	.09
BC142	.24	.22	.17
BC143	.26	.24	.19
BC172B	.08	.075	.06
BC177B	.13	.12	.10
BC179	.14	.13	.10
BC187	.22	.20	.16
BC300	.23	.22	.17
BC301	.23	.22	.17
BC441	.27	.25	.20
BC461	.27	.25	.20
BCY58	.15	.14	.11
BCY59	.15	.14	.11
BCY70	.18	.17	.13
BCY71	.18	.17	.13
BD131	.36	.34	.26
BD132	.37	.35	.28
BD142	.69	.65	.51
BD242	.33	.32	.24
BF257	.23	.22	.17
BF259	.25	.24	.19
BF337	.24	.23	.18
BFY50	.21	.20	.16
BFY51	.21	.20	.16
BFY52	.21	.20	.16
BFX84	.21	.20	.16
BFX85	.21	.20	.16
BFX86	.21	.20	.16
BFX87	.23	.22	.17
BFX88	.23	.22	.17
C1509	.30	.28	.26
MJE340	.71	.67	.52
R2008B	1.35	1.26	1.00
R2010B	1.15	1.08	.85
TIP29A	.32	.30	.24
TIP29C	.35	.33	.26
TIP30A	.32	.30	.24
TIP30C	.35	.33	.26
TIP31A	.32	.30	.24
TIP31C	.35	.33	.26
TIP32A	.32	.30	.24
TIP32C	.35	.33	.26
TIP33A	.56	.53	.41
TIP33C	.67	.64	.50
TIP34A	.62	.59	.46
TIP34C	.75	.71	.56

Transistors	1+	25+	100+
TIP35A	1.24	1.18	.92
TIP35C	1.49	1.41	1.10
TIP36A	1.35	1.27	.99
TIP36C	1.62	1.53	1.19
TIP41A	.46	.44	.34
TIP41C	.52	.49	.38
TIP42A	.48	.45	.35
TIP42C	.52	.49	.38
TIP48	1.38	1.32	1.00
TIP2955	.56	.54	.42
TIP3055	.56	.54	.42
2N918	.35	.33	.25
2N1131	.24	.23	.18
2N1132	.23	.22	.17
2N1893	.33	.31	.24
2N1613	.19	.18	.14
2N1711	.24	.23	.18
2N2102	.34	.33	.25
2N2218A	.21	.20	.16
2N2219A	.21	.20	.16
2N2221A	6	.15	.12
2N2222A	.14	.13	.10
2N2368	.16	.15	.12
2N2369	.18	.17	.13
2N2646	.37	.35	.27
2N2904A	.22	.21	.17
2N2905A	.22	.21	.17
2N2906A	.15	.14	.11
2N2907A	.15	.14	.11
2N3053	.20	.19	.15
2N3054	.60	.57	.45
2N3055	.61	.58	.45
2N3442	1.30	1.23	.96
2N3771	1.87	1.77	1.38
2N3772	1.88	1.79	1.39
2N3823	.60	.57	.44
2N4036	.23	.22	.17
2N4059	.10	.09	.07
2N4061	.10	.09	.07
2N4236	.28	.26	.21
2N4239	1.19	1.12	.87
2N5294	.42	.40	.31
2N5296	.37	.35	.27
2N5492	.49	.47	.36
2N5494	.46	.44	.34
2N5496	.51	.48	.37
3N128	.83	.80	.62
3N201	.53	.50	.39
3N204	.55	.52	.41
40366	.36	.34	.27
40406	.37	.35	.28
40407	.37	.35	.28
40411	.80	.76	.59

TTL 7400 series			
7400	.15	.14	.11
7401	.17	.16	.13
7402	.15	.14	.11
7403	.17	.16	.13
7404	.15	.14	.11
7405	.18	.17	.14
7406	.24	.23	.18
7407	.24	.23	.18
7408	.15	.14	.11
7409	.18	.17	.14
7410	.15	.14	.11
7412	.19	.18	.14
7413	.29	.28	.22
7416	.22	.21	.16
7417	.22	.21	.16
7420	.15	.14	.11
7422	.18	.17	.14
7423	.18	.17	.14
7425	.19	.18	.14
7426	.19	.18	.14
7427	.19	.18	.14
7428	.19	.18	.14
7430	.15	.14	.11
7432	.16	.15	.12
7433	.21	.20	.15
7437	.19	.18	.14
7438	.19	.18	.14
7440	.15	.14	.11
7442	.25	.24	.19
7443	.40	.37	.29
7444	.40	.38	.30
7445	.19	.18	.14
7446	.45	.43	.33
7447	.36	.34	.27
7448	.45	.43	.33
7450	.17	.16	.13
7451	.17	.16	.13
7453	.17	.16	.13
7454	.17	.16	.13
7460	.17	.16	.13
7470	.30	.29	.23
7472	.30	.29	.23
7473	.23	.22	.17
7474	.23	.22	.17
7475	.19	.18	.14
7476	.28	.26	.21
7480	.33	.31	.24
7481	.52	.40	.38
7482	.52	.49	.38
7483	.28	.26	.21
7484	.40	.38	.30
7485	.42	.40	.31
7486	.16	.17	.13
7489	2.20	2.08	1.62

TTL	1+	25+	100+
7490	.18	.17	.14
7491	.18	.17	.14
7492	.28	.27	.21
7493	.18	.17	.14
7494	.36	.34	.27
7495	.21	.20	.16
7496	.31	.30	.23
7497	.94	.89	.69
74100	.65	.61	.48
74104	.65	.61	.48
74105	.78	.74	.57
74107	.32	.30	.24
74109	.32	.30	.24
74110	.38	.36	.28
74111	.25	.23	.18
74116	.25	.23	.18
74118	.81	.77	.60
74119	.54	.51	.40
74120	.54	.51	.40
74121	.35	.33	.26
74122	.40	.38	.29
74123	.38	.36	.28
74125	.38	.36	.28
74126	.38	.36	.28
74128	.40	.38	.30
74132	.55	.52	.41
74136	.22	.21	.18
74137	.23	.21	.17
74141	.22	.21	.16
74142	1.34	1.27	.99
74145	.33	.31	.24
74147	.65	.61	.48
74148	.67	.64	.50
74150	.40	.38	.30
74151	.26	.25	.20
74153	.26	.25	.20
74154	.63	.60	.46
74155	.25	.24	.19
74156	.33	.31	.24
74157	.26	.25	.19
74159	.70	.66	.52
74160	.33	.31	.24
74161	.33	.31	.24
74162	.36	.34	.27
74163	.33	.31	.24
74164	.33	.31	.24
74165	.33	.31	.24
74165	.47	.45	.35
74167	1.15	1.09	.85
74170	.99	.94	.73
74172	1.88	1.78	1.39
74173	.65	.61	.48
74174	.49	.47	.36
74175	.76	.72	.56

TTL	1+	25+	100+
74176	.35	.33	.26
74177	.35	.33	.26
74180	.36	.34	.27
74181	.90	.85	.66
74182	.36	.34	.27
74184	.85	.80	.63
74185	.85	.80	.63
74190	.28	.27	.21
74191	.28	.27	.21
74192	.33	.31	.24
74193	.33	.31	.24
74194	.45	.43	.33
74195	.24	.23	.18
74196	.35	.33	.26
74197	.35	.33	.26
74198	.54	.51	.40
74199	.33	.31	.25
74221	.82	.78	.61
74H00	26	.24	.19
74H05	.29	.28	.22
74H10	.26	.24	.19
74H11	.26	.24	.19
74H20	.26	.24	.19
74S10	.28	.27	.21
74LS11	.19	.18	.14
74LS21	.19	.18	.14
74LS153	.46	.44	.34

CMOS	1+	25+	100+
4000	.15	.14	.12
4001	.15	.14	.12
4002	.15	.14	.12
4007	.15	.14	.12
4011	.15	.14	.12
4012	.15	.14	.12
4013	.26	.25	.21
4015	.76	.72	.60
4016	.28	.26	.19
4017	.57	.54	.45
4018	.65	.62	.51
4020	.67	.63	.53
4021	.67	.63	.53
4022	.65	.62	.51
4023	.15	.14	.12
4024	.48	.45	.38
4025	.15	.14	.12
4027	.31	.29	.24
4028	.54	.51	.42
4029	.70	.66	.55
4040	.65	.62	.51
4042	.53	.50	.42
4043	.57	.54	.45
4044	.57	.54	.45
4046	.82	.78	.65
4047	.95	.90	.75
4049	.28	.27	.22
4050	.31	.29	.24
4051	.51	.48	.40
4052	.51	.48	.40
4053	.51	.48	.40
4060	.94	.88	.74
4066	.33	.31	.26
4068	.15	.14	.12
4069	.15	.14	.12
4070	.15	.14	.12
4071	.15	.14	.12
4072	.15	.14	.12
4073	.15	.14	.12
4075	.15	.14	.12
4076	.73	.68	.57
4077	.15	.14	.12
4078	.15	.14	.12
4081	.15	.14	.12
4082	.15	.14	.12
4093	.39	.37	.31

DIL Sockets			
8 pin	.12	.11	.09
14 pin	.13	.12	.10
16 pin	.14	.13	.11
18 pin	.20	.19	.15
20 pin	.21	.20	.16
22 pin	.23	.22	.17
24 pin	.24	.22	.18
28 pin	.31	.30	.23
40 pin	.44	.42	.33

Triacs T0220	1+	25+	100+
2A 200v	.42	.40	.31
2A 400v	.45	.43	.33
8A 400v	.51	.48	.38
8A 200v	.47	.45	.35
10A 200v	.76	.72	.56
10A 400v	.82	.78	.61

Thyristors T0220			
3A 400v	.37	.35	.28
5A 600v	.46	.43	.34
7A 400v	.51	.48	.38
10A 200v	.57	.54	.42

Bridge Rec	1+	25+	100+
2A 50v	.34	.33	.26
2A 100v	.38	.36	.28
2A 200v	.42	.39	.31
2A 400v	.54	.51	.40

Voltage regs T0220 1A			
7805	.67	.63	.49
7812	.67	.63	.49
7905	.78	.74	.56
7912	.78	.74	.56

Diodes	
IN914 100s only	.013
IN4001 100s only	.034
IN4002 100s only	.036
IN4003	.037
IN4004	.04
IN4005	.04
IN4006	.044
IN4007	.047
IN4148	.013
BAX13	.014

LEDS	1+	25+	100+
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710	.40	.38	.29
741	.20	.19	.15
747	.35	.33	.25
748	.33	.31	.24
CA3130E	.81	.77	.59
CA3130T	.89	.84	.64
CA3140E	.36	.34	.26
LM301AN	.24	.23	.17
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MC1310P	.80	.76	.58
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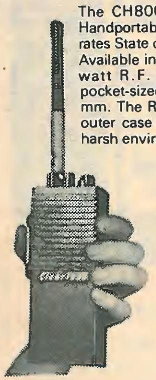
The CH800 is a miniature sized VHF/FM Handportable Radiotelephone which incorporates State of Art Technology. Available in the 148-174 MHZ Band with a 2 watt R.F. output the equipment is truly pocket-sized with dimensions of 151 x 45 x 62 mm. The Ranger is housed in a rugged Lexan outer case which provides protection against harsh environment.



The unit is available in 4 or 6 channel versions and local or remote facilities are provided as standard.
Rechargeable Ni-cads provide 8 hrs. operation and a full range of re-charging facilities are available.
The Ranger is easy to service, with all circuits located on one side of a PC Board, and an access to a multitude of test points permit unprecedented ease in circuit trouble shooting.

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The Commando 331 is a dash mount FM mobile radiotelephone available in all VHF bands.
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The performance of the 331 mobile makes it suitable for a variety of applications, its physical strength, lack of specialised components and case of service makes it particularly suitable for operation in remote areas.
The unit is supplied complete with all installation items and is available with a complete range of selective signalling accessories.
The 331 series is available in local base and transportable mode.

The Commando AM mobile series 235 provides new standards of convenience, flexibility and performance. Available to cover 150-174/66-88 MHZ. Channel spacing 12.5KHZ or 25KHZ. The 235 mobile is direct operated by simple controls with LED indicators, the package small and shaped to fit under dash, where it can be seen and operated comfortably. Series 235 is rugged, unaffected by vibration and shock, tough yet retaining style to blend unobtrusively into any vehicle interior.

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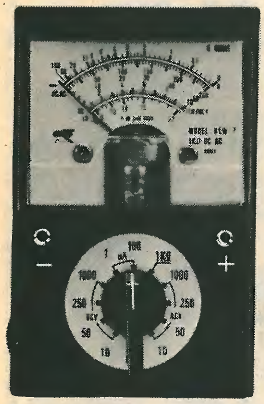

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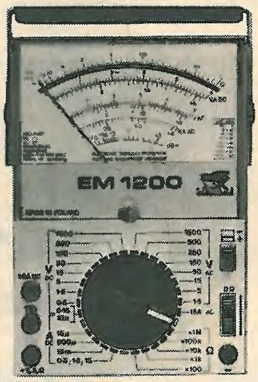

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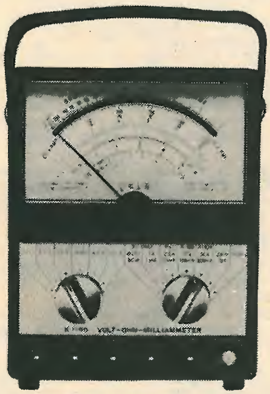

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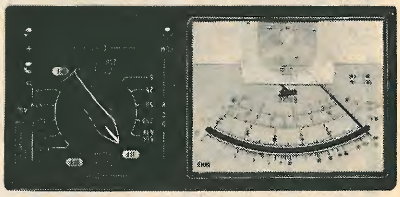

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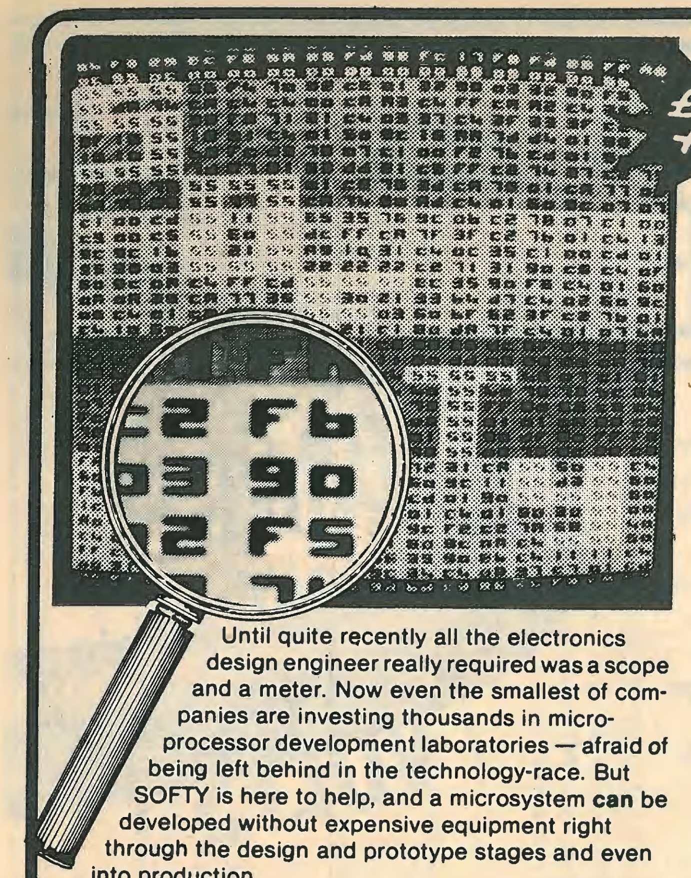

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- IT COPIES MEMORY DEVICES (ROMs &c) presenting the data as an address-mapped hexadecimal display on the screen of a monitor or TV set.
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- IT RECORDS PROGRAMS on ordinary cassette tape using an ordinary cassette recorder at ultra-high-speed — around 2000 baud equivalent!
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SOFTY can be assembled in a couple of hours. No extras are required except for a power supply providing +5, +12 & —5 volt rails and +30 volts for the EPROM programmer. The kit includes sockets for all the 23 ICs, UHF modulator for TV use, 4MHZ crystal, DIN socket and lead for cassette interface, 21 key keyboard, a quality double-sided PCB of fibreglass with solder mask and component overlay and a comprehensive manual covering assembly and use.

A DEVELOPMENT KIT is also available which includes all of the above and a lever-operated ZERO INSERTION FORCE SOCKET for the EPROM programmer, 43 way card edge connector, ribbon cable and 24 pin header (for connection to the system under development as firmware) and a spare 2708 EPROM.

It is not possible to present a full technical specification in the space available here. We will therefore send you a SOFTY on the understanding that you may examine it and read the literature and, if you wish to do so, return the goods for a complete refund within 14 days.

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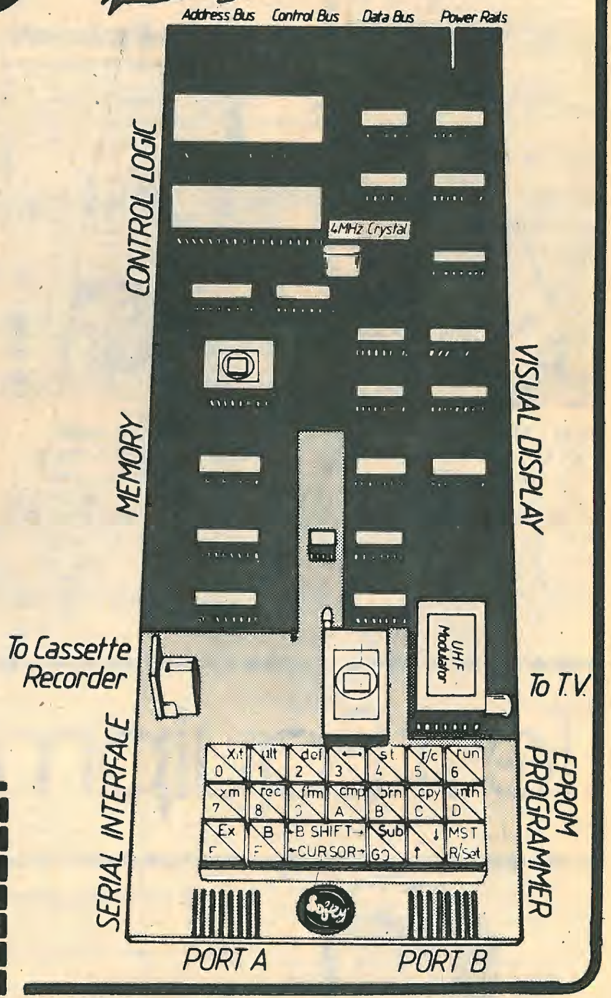

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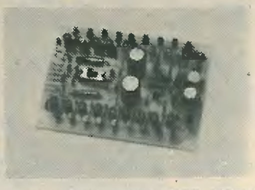
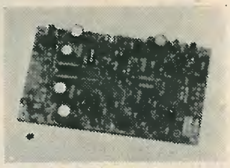

MC 1


CPR 1

CPR 1 — THE ADVANCED PRE-AMPLIFIER. The best pre-amplifier in the U.K. The superiority of the CPR 1 is probably the disc stage. The overload margin is a superb 40dB, this together with the high slewing rate ensures clean top, even with high output cartridges tracking heavily modulated records. Common-mode distortion is eliminated by an unusual design. R.I.A.A. is accurate to 1dB; signal to noise ratio is 70dB relative to 3.5mV; distortion <.005% at 30dB overload 20kHz.

Following this stage is the flat gain/balance stage to bring tape, tuner, etc. up to power amp. signal levels. Signal to noise ratio 86dB; slew-rate 3V/uS; T.H.D. 20Hz—20kHz<008% at any level.

F.E.T. muting. No controls are fitted. There is no provision for tone controls. CPR 1 size is 138x80x20mm. Supply to be ± 15 volts.

MC 1 — PRE-PRE-AMPLIFIER. Suitable for nearly all moving-coil cartridges. Sensitivity 70/170uV switchable on the p.c.b. This module brings signals from the now popular low output moving-coil cartridges up to 3.5mV (typical signal required by most pre-amp disc inputs). Can be powered from a 9V battery or from our REG 1 regulator board.

XO2:XO3 — ACTIVE CROSSOVERS. XO2 — two way, XO3 — three way. Slope 24dB/octave. Crossover points set to order within 10%.

REG 1 — POWER SUPPLY. The regulator module, REG 1 provides 15-0-15v to power the CPR 1 and MC 1. It can be used with any of our power amp supplies or our small transformer TR 6. The power amp kit will accommodate it.

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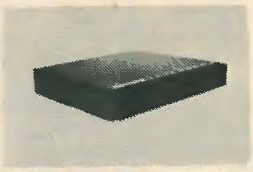

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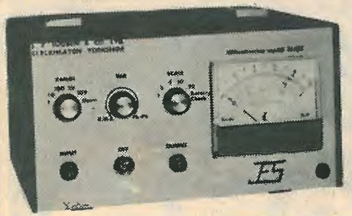

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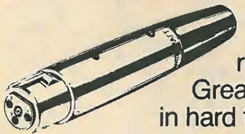

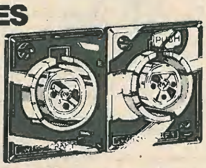

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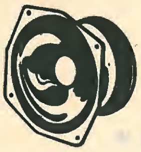

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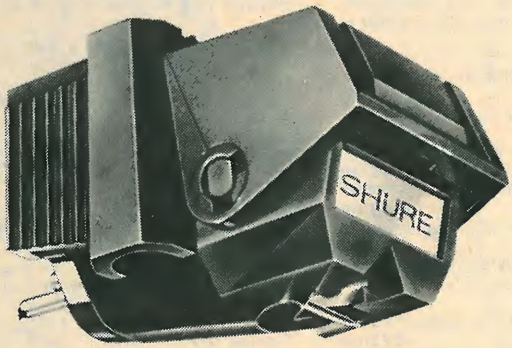

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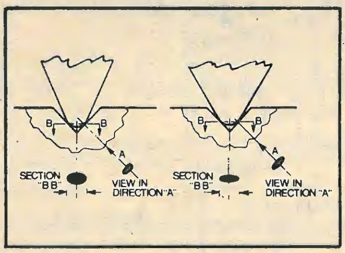

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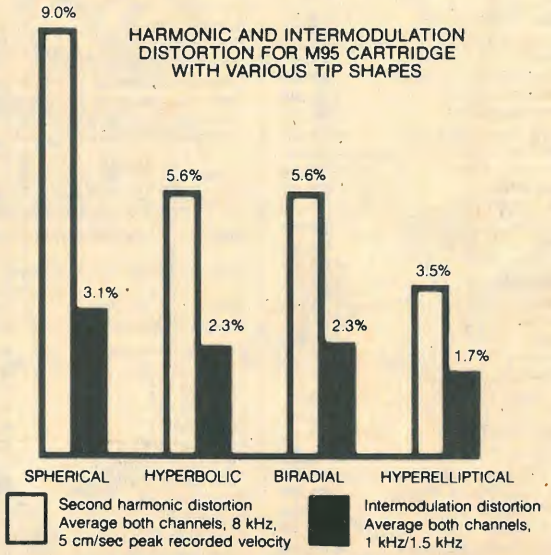

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TOM IVALL, M.I.E.R.E.

Deputy Editor:
PHILIP DARRINGTON
Phone 01-261 8435

Technical Editor:
GEOFFREY SHORTER, B.Sc.
Phone 01-261 8443

Projects Editor:
MIKE SAGIN
Phone: 01-261 8429

Communications Editor:
RAY ASHMORE, B.Sc., G8KYY
Phone 01-261 8043

Drawing Office Manager:
ROGER GOODMAN

Production & Design:
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Suppressing the converted

In October of last year a young technical journalist, charged under the provisions of the Wireless Telegraphy Act of 1949, was convicted of manufacturing and operating a home built walkie-talkie without a licence. He was fined £300 with £45 costs but, rather than prompting a strong negative response, this heavy fine served to spur him into doing the right thing. He studied for the Radio Amateurs' Examination, passed with credit and applied to the Home Office for the licence to which he was now entitled, first having signed the statutory undertaking to comply totally with the provisions of the licence.

The result was a curt refusal from the Home Office to issue a licence. They said they felt that the necessary clauses of the Act would not be complied with, and suggested that application be made again in 12 months' time.

Reading the Act and the licence shows that, although there is provision for the Secretary of State to close down a station which is being operated improperly, refusal to issue a licence in the first instance is purely discretionary (Section 4, sub-section 3 of the Act). The Home Office's negative reaction therefore amounts to the imposition of a penalty *before* a licence-related offence has been committed, and it must surely be implicit in the advice to "apply again in 12 months" that offenders are not automatically considered undesirable. It would seem, in fact, that to refuse a licence under such conditions represents an arbitrary administration of additional punishment, standing outside the main body of punitive principles followed by the judiciary – although why offenders should take exactly a year to see the error of their ways is difficult to understand.

Such action strikes at the very spirit of constructive regulation, inevitably discouraging the worthwhile aims of the applicant. It could well make the radio enthusiast doubt the value of conforming to regulations which can depend on a mere opinion about the way a licensed operator is likely to behave. It could even stimulate aggressive acts of illegal transmitter operation.

In the current state of conflict between the Home Office and the advocates of citizens' band, the former's case is not helped by such a heavy-handed demonstration of retribution. Where an individual has discharged his legal debt after an offence, and has satisfied all the technical conditions, it surely must be right – and make sense psychologically – to demonstrate good faith by issuing a licence forthwith. In any case the operation of licensed equipment is that much easier to check. On the other hand, if the regulations had been infringed after a licence had been granted the Home Office's actions would have been perfectly acceptable.

There is certainly more than a hint of the perverse in the Home Office's action here. Had the applicant been told that he would be barred from holding a licence for a full year after conviction, he presumably would not have bothered to apply until the end of that period. At the very least, this detail should have been pointed out at the time of legal proceedings.

According to information we have received, a generally similar case resulted in an amateur's licence actually being re-issued after he had been convicted of an offence against the Wireless Telegraphy Act, suggesting that it is not simply the offence which dictates a refusal. When questioned by an RSGB representative, an official of the Home Office said it was their policy that once the punishment had been meted out and served the offender was regarded as having a clean record. Judging from this total divergence in approach, either the decision is made on a hit-and-miss basis or an official double standard is being applied.

What is an electron?

A new model: the phase-locked cavity

by R. C. Jennison, B.Sc., Ph.D., F.I.E.E., F.R.A.S., F. Inst.P., F.R.S.A.

Electronics Laboratories, University of Kent at Canterbury

What is an electron beyond being just a unit of charge? Why do we have to push an electron, or a car, with a specific force to make it move? Why does it carry on moving after we stop pushing? Why, in the limit, is the push quantised? Three-quarters of the way through the twentieth century there was no satisfactory answer to these questions but recent research in the Electronics Laboratories of the University of Kent at Canterbury may have provided the answers.

THE electrical or electronic engineer can often get by without considering all the properties of the electron and frequently regards it simply as a unit of electrical charge. Occasionally he may encounter a problem in electron optics or physical electronics where he has to recognise that the electron has a mass, a magnetic moment and quantised angular momentum and he will accept that it obeys the quantum laws and Fermi-Dirac statistics. Electrons have become so useful that their properties in all sorts of circumstances are very well known and rules for their behaviour are fully documented. By the very nature of these rules many of them are *ad hoc;* they were propounded to explain the idiosyncrasies of the electron, and sometimes matter in general, in order to provide working rules to account for its behaviour in all manner of circumstances. Thus the quantum theory has gradually incorporated further rules to account for more sophisticated observations and these rules have become an accepted part of physics. They work, and for many people that is sufficient, so why bother to question why nature obeys these rules if the rules enable us to achieve all the technological wonders of the age?

The same applies to Newton's laws; they are usually accepted as basic laws of physics yet they are only rules, laid down by Newton to account for the observation of the behaviour of matter. There has to be a reason for Newton's laws, just as there has to be a reason for the quantum theory, the charge on the electron and all its other properties. Really what we have is a wonderful computer programme that has evolved over the ages and to which we may refer for the solution of nearly all of our problems. The curious thing is that we don't, or at least didn't, know *why* the programme works.

Why have a few people worried about why it works? Let me give you an analogy. In these days of integrated circuits it is very easy to build quite complicated electronic systems by plugging integrated circuits together in a rational manner and relying on the fact that the manufacturers have done a good job in specifying the overall parameters and transfer function of each unit. It is not necessary to know precisely what goes on inside each integrated circuit provided that we stick to the rules. Or is it? There are vast possibilities open to the current range of integrated circuits, microprocessors and the like, but who would suggest that we stop all further research into physical electronics and simply accept the present state of the art for all future applications? It is only by digging down into the fundamentals that we are likely to achieve a really major break-through in the future.

Until very recently, in order to explain the electron, its inertia, its detailed quantised behaviour, its charge and its other properties as a particulate entity, at least half a dozen separate postulates were required. Some of these postulates are embodied in the separate rules comprising the quantum theory, and quantum mechanics has six postulates (Van der Waerden, 1973). Other postulates like those concerning inertia and charge are even more mysterious for these properties have assumed such a traditional place in our teaching that their existence is automatically accepted without question. Einstein always seemed content to accept Ernst Mach's postulate for the origin of inertia (that its origin was in the influence of the distance masses in the Universe) but he had considerable reservations about the quantum postulates. Werner Heisenberg (1973) commented: "I had a discussion with Einstein about this problem in 1954, a few months before his death. It was a very nice afternoon that I spent with Einstein but still when it came to the interpretation of quantum mechanics I could not convince him and he could not convince me. He always said: 'Well, I agree that any experiment the results of which can be calculated by means of quantum mechanics will come out as you say, but still such a scheme cannot be a final description of Nature'." It is clear that Einstein had a fundamental conviction in the basic beautiful simplicity of Nature. To Einstein the quantum theory was simply a succession of *ad hoc* solutions with the greater truth hidden somewhere underneath. It is surprising how this echoes the earlier difference of conception on the nature of photons where Planck and Bohr held on to simple classical concepts and Einstein, on that occasion, was the radical, postulating a complication in an otherwise simple conception of light.

Heisenberg's views on electrons, photons and other particles were very complicated and caused considerable dissension in his audience. Dirac, who was present when Heisenberg read a paper, was not entirely happy: "I wonder whether the electron should not be considered as an elementary particle. It may be that I am prejudiced because I have had some success with the electron and no success with other particles. I would like to hear Heisenberg's view on that." Heisenberg's reply well illustrates the attitude of a whole school of thinkers who are devoted to the extreme quantum picture of corpuscular particles, to the possible exclusion of a simple underlying theme which, in the same breath, they state may well exist: "I cannot see that one could consider the electron as an elementary particle in the old sense, because an electron can produce light quanta. Light quanta can produce baryons. So actually the electron is connected with this world of baryons and hadrons and so on. So I don't see that you can separate it out. As soon as an electron has these interactions, then, of course, it is surrounded by a cloud consisting of all these other things". The rigidity of Heisenberg's thinking is illustrated beautifully by his use of the phrase "of course" in the last sentence. It is probably worth noting that Heisenberg lost on points in the discussion which followed.

It is generally acknowledged that the quantum theory cannot solve the mystery of the electron for it starts too far up the scale and uses as its postulates the properties which are already embodied in the electron. The quantum description of an electron therefore properly agrees with these properties but it tells us nothing of the substance from which it is made or how it is held together. A good account may be found in Rohrlich (1973) and see also Feynman (1964).

Most of the attempts to model the electron have relied basically on classical concepts, a distribution of electric charge held together by unknown forces named Poincaré stresses after their propounder. Problems arise with this model for if the bits of charge move in the field of the particle as a whole they are acted upon by a Lorentz force and it has not been possible to establish a model which satisfies the observed features of the particle. In particular the 'electromagnetic mass' of these models differs slightly from the rest mass derived from relativity theory.

The discovery that electrons have an intrinsic spin presented further difficulties with this model, for the angular momentum turned out to be almost exactly half that which would be given by classical physics. Furthermore, the ratio of magnetic moment to angular momentum for an electron about its own axis turned out to be twice that which applied when the electron was in orbit about a nucleus.

This 'plum pudding' model of the electron assumes that electric charge is fundamental, for it in no way accounts for it, and it further requires that the charge can be spread throughout the electron. This implies that the unit of charge can be broken up into many separate bits of unknown substance. The electric field, in line with traditional electromagnetism, is assumed to arise from the charge and is therefore thought of as a secondary phenomenon. This leads to a further difficulty with this model, for measurements show that the electron appears as a point charge, and yet this implies an infinite energy for the field at at the centre. Attempts to avoid this difficulty never seem to agree with the observed facts; for example, the 'classical radius' of the electron may be calculated for the model and turns out to be 2.8×10^{-13}cm. When measurements are made on the electron it does not seem to have any particular radius, certainly not 2.8×10^{-13}cm, and the effective radius given by the quantum theory is 137 times larger.

A very few authors have endeavoured to avoid the problems of the plum-pudding electron by postulating whirls of electromagnetic waves which might arise from non-linear solutions of Maxwell's equations. On the whole these theories have been looked upon as curiosities for they by no means accounted for the properties of an electron, but they did remove one variable by attributing the charge to a condensation of the electric field.

Radiation and electrons

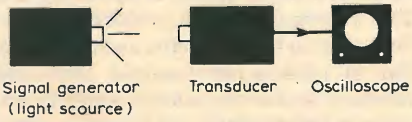
What is the connection between radiation and electrons? Clearly we can only detect radio waves by utilising their interaction with electrons or protons and we have to be very careful not to confuse the properties of the radiation with those of the electron and vice-versa. Nevertheless there are two remarkable phenomena which show that at certain precise frequencies the connections between electromagnetic waves (or photons) and electrons is absolute – they completely transform into each other. Before we consider these phenomena let us look at the way it is possible to conceive of radio waves as photons.

According to the photon concept radio waves consist of a very large

Radio waves or photons? — historical background

In his famous treatise on optics Newton stated that light consisted of corpuscles and his authority was such that his opinion dominated scientific reason until, nearly a hundred years later (1801), Thomas Young showed that the interference of light was a wave phenomenon.

In the mid nineteenth century James Clerk Maxwell showed theoretically that there should be electromagnetic waves, that light fitted this description and that there ought to be a spectrum of such waves from the lowest electrical frequencies to far above the frequency of visible light. Some years later Hertz demonstrated the existence of radio waves and the wireless transmission of telegraphic messages became a reality. Then the bombshell came: the discovery of the photo-electric effect. No one could explain how electromagnetic waves could eject electrons from metal surfaces, for the onset of emission depended upon the *frequency* of the waves. Below a certain critical frequency no electrons were ejected, irrespective of the amplitude or intensity of the waves. In 1904 Einstein accounted for this by proposing that energy and frequency were related by the now famous formula $E=h\nu$. The interpretation that he put on this formula was that light consisted of discrete bundles of energy (later called photons). The energy given by this formula had to exceed the energy binding the electron in the surface before it could be ejected. The reason why Einstein and many of his contemporaries assumed that the interpretation of $E=h\nu$ was that the light only was quantised was because they considered the electron simply as a point or a ball of charge, and, as such, it appeared that it could have none of the properties of a simple system. A macroscopic analogy could take the form of a large scale opto-electrical transducer in the form of a black box, an optical signal generator in the form of another black box and an oscilloscope to observe the output of the transducer (see figure). If then we observed that the oscilloscope registered pulses when the optical generator was applied to the transducer, it would be reasonable to assume that the generator was emitting pulsed light. This was Einstein's interpretation. But are there other possibilities? It is an elementary exercise in electronics to make a transducer with delayed feedback which will give a pulsed response from a continuous wave input, so that in the analogue case this is clearly another solution. One further possibility remains, that *both* the light and the transducer response are pulse-like, so that, going back to the interpretation of $E=h\nu$ there are three possibilities; (i) all light is quantised (photons). (ii) all light is electromagnetic waves and the response of the electron is quantised, (iii) both the light and the electron are quantised.



An unspecified light source and an unspecified opto-electrical transducer coupled to an oscilloscope. If the oscilloscope exhibits a pulsed waveform, does this imply that the light is pulsed, that the transducer has a pulse-like transfer function, or both?

It is interesting that Max Planck, the founder of the quantum theory, and Niels Bohr, the founder of modern atomic physics, would not accept the concept of Einstein's photons, especially if this implied that light was corpuscular, and they hoped for some other explanation of the effect. Planck himself had revolutionised physical concepts by postulating the quantum of action, *h*, to explain the laws of black body radiation, but he held on to the belief that the radiation itself was simple waves of the Maxwell-Hertz type. Bohr's attitude is recorded by Leon Rosenfeld (1973): "As to the photon or light quantum concept, introduced by Einstein, Bohr regarded it as a useful but auxiliary concept, one which he later called symbolical, meaning thereby that it was not an aspect of the radiation phenomenon which could be directly observed as such."

Despite his remarkable contribution to quantum theory Einstein was never happy with the quantum concept and in particular with the surrender of deterministic physics which seemed to defy the very basis of the classical principles upon which he built up the principles of relativity. Twenty years later Compton investigated the behaviour of free electrons when radiated with electromagnetic waves of very high frequency and explained their behaviour by a billiard-ball like collision process between a photon and an electron, and the concept of photons as simple short wave-trains here seemed less applicable than the corpuscular bullet-like concept. Shortly afterwards Dirac welded together the quantum theory and relativity in such a way that the behaviour of electrons in general could be properly accounted for and his theory also predicted a positively charged twin to the electron, the positron, which was discovered a few years later in cloud chamber tracks of cosmic rays.

number of low energy photons which statistically behave as though they are Hertzian waves. Although no one knows what a photon looks like, it is assumed by one school that a single photon is some form of particle or corpuscle and by another school that it is a short burst of waves which nevertheless behaves as though it is purely monochromatic. The first point of view is clearly exhibited in the listing of the photon in tables of fundamental particles, despite the fact that its properties under relativistic transformations are quite different.

Photon energies at radio frequencies are extremely small, so the energy of a powerful radio signal comes from having a vast number of photons and, because there are a vast number, the statistical combination of all the photons synthesises the electromagnetic waves propounded by Maxwell. Radio astronomers can receive spectral line signals at v.h.f. which originate in the very low energy transitions between, say, the 250th and 251st Bohr orbits of the hydrogen atom (conditions in interstellar space are so tenuous and collisions are so rare that these remarkable transitions can actually take place). Is one receiving corpuscular photons or simple Hertzian waves? The quantum theory tells us nothing for it avoids the issue by simply identifying the frequency ν with the energy $E=h\nu$ between the respective orbits. The emission of a photon is postulated but the mechanics of its formation and the structure of the photon remain a mystery.

If two oppositely charged spheres on the ends of a rod are spun about the centre point, then it is fairly easy to comprehend how this gives rise to very low frequency radio waves in terms of oscillating electric and magnetic fields moving outwards at the velocity of light. It is also easy to picture the situation as the rotational speed is reduced to zero for we are just left with a static dipolar electric field. If we endeavour to interpret this situation in terms of corpuscular photons it is far less easy to comprehend and becomes anomalous when we reduce the rotational speed to zero. One has either to accept the static electric field as a separate system in its own right, endowed with the ordinary field properties of Maxwell's equations or one has to preserve an entirely photon concept by postulating the existence of virtual photons to explain the properties of the system at zero frequency.

It is probably apparent that the corpuscular photon concept is not very helpful at radio frequencies although the concept of a multitude of short wave trains is not unreasonable. For example, the analysis of an open-ended resonant cavity, even when the radiation is infinitesimally weak, does not pose a problem to the radio engineer using the concept of electromagnetic waves, but try arguing it out when it is inhabited by one bullet-like photon! Similarly, feedback problems using corpuscular photon concepts are a conceptual nightmare.

It may appear from the foregoing that photons are bit of a red herring and that, apart from the photo-electric effect and various atomic phenomena, classical electromagnetic waves consisting of simple fluctuating fields are far more satisfactory. Really the problem is more fundamental and concerns the interplay of radiation and matter. Which is the more fundamental – the photon or the electromagnetic field wave? the charge or the associated electric field? It is currently fashionable to consider that all electromagnetic waves are an assembly of photons and therefore to infer that it is impossible for a photon itself to be composed of electromagnetic waves. If one considers photons to be little balls of some form of light then, clearly, the statement is logical. If, on the other hand, the photons are simply limited trains of electromagnetic waves which can add together according to Fourier principles, then the statement is quite untrue – the photons *are* composed of electromagnetic waves and the electromagnetic fields and not the photons are the more fundamental. But then, if electromagnetic fields come initially from moving charges, it would appear that the charges are really the most fundamental and the fields secondary or tertiary according to one's choice of the two viewpoints. As we shall see later, we can question this argument on similar logical grounds. If we can form the unit of charge (the electron) from electromagnetic fields then we may reduce the number of variables and simplify our conception of the universe by requiring only the existence of time varying electric fields.

About thirty years ago I constructed the first intensity interferometer. With this I had been able to measure for the first time the shapes of the radio stars Cassiopeia A and Cygnus A. (In those days there were only three radio stars, Cassiopeia, Cygnus and Taurus!) The original concept of the intensity interferometer was due to R. Hanbury Brown but he gave me a very free hand in its realisation as he was much occupied with work on the original Jodrell Bank 218ft telescope. It was quite unlike a conventional interferometer for it did not make use of the direct correlation of coherent signals but of the *fluctuations* of those signals. The correlation was performed after detection so that it might at first appear that all correlation was lost. However, random fluctuations from the various parts of the distant source beat together at the output of two detectors spaced apart by many miles on the earth's surface. The modulation is therefore cross-correlated and provides information about the source.

The intensity interferometer produced some excellent results although it had the drawback of being rather insensitive and incapable of determining the phase of the source distribution. It immediately raised the question "if it works for radio waves will it work for light waves or photons?" I had thought up a new and entirely different interferometer technique which proved much better for further work in radio astronomy for it solved many of the problems of working on very long baselines (it is now known as "phase closure" and is used over baselines of thousands of miles) so I reluctantly declined an invitation from Hanbury Brown to work on an optical version of the intensity interferometer. Hanbury Brown tried it for himself and with theoretical help from Richard Q. Twiss finally established that there was a correlation in the light from a laboratory source, and later, from starlight.

The success of these experiments caused quite a lot of re-thinking in theoretical physics at the time for, in the words of Hanbury Brown, "It appeared to show that one little photon knew what another little photon was doing!" Certainly if one looks at the situation from the point of view of fluctuating electromagnetic fields, as in the radio case, there is no problem. The important lesson which we learned at the time was this: though we may consider that in the emission and detection processes light, or a radio signal, behaves as photons, in the propagation process between source and observer it behaves as electromagnetic waves.

Are there any experiments where the wave concept fails completely? Apart from the photo-electric effect the shining example was the Compton Effect. In 1924 Compton showed that when very high frequency electromagnetic radiation (γ rays) fell on an electron, the electron immediately shot off as though it were hit by a bullet and simultaneously emitted a burst of radiation of somewhat lower frequency than that of the incident radiation. Usually the electron shot off at an angle from the direction of the original radiation and the re-emitted radiation shot off at another angle. All attempts to explain this classically failed; it really looked as though light must consist of bullet-like photons and Compton was able to account for the phenomenon entirely in terms of a billiard ball type collision of a photon incident with energy $h\nu$ and reflected with energy $h\nu'$ from a billiard ball type electron of rest mass m_0 which shot off with the kinetic energy given by the difference between $h\nu$ and $h\nu'$. Surely this was proof that photons must be particles and not just short wave trains? Last year I was able to show that it can be explained quite simply as an electromagnetic wave phenomenon provided that we identify the electron with a simple phase-locked cavity of radiation.

Earlier on we referred to two remarkable phenomena by which electromagnetic waves and electrons completely transform into each other. These are known as annihilation and pair production. Annihilation occurs when a negative electron bumps into its opposite number, a positive electron (or positron). Both particles completely disappear and from the point in space where they collided two photons of identical frequency but opposite polarisation move off at the speed of light. The frequency of these photons is such that it corresponds to the exact conservation of energy in the transformation. The rest energy of the electron is $E = m_oc^2$ where m_o is the rest mass of the electron and c is the velocity of light. The rest energy of the positron is similarly m_oc^2. If the two particles idly bump into each other we therefore get two photons each with a frequency given quite simply by equating the energy $E = h\nu$ with the energy $E = m_oc^2$ *and* therefore the frequency $\nu = m_oc^2/h$ which is 1.25×10^{20}Hz and corresponds to a wavelength of 2.4×10^{-10}cm. The fascinating feature of annihilation is that it represents a perfect transformation from particles of matter (electrons) to electromagnetic waves (photons); there are no other ingredients required for this transformation, it is complete and perfect.

Pair production is the opposite process, the formation of an electron and positron from electromagnetic radiation. Curiously, the process is not quite the reciprocal of annihilation. Two photons do not combine to form the two particles, they are formed from a single photon of twice the annihilation frequency when the photon bumps into a catalyst, such as a heavy nucleus, which simply absorbs the excess momentum of the photon. This is really quite extraordinary. Imagine a super radio transmitter that will tune over the whole range of the electromagnetic spectrum. Starting at v.l.f. we tune it through the radio frequency band, the infra red band, the optical spectrum, the ultra violet spectrum, X rays and finally gamma rays. Nothing very remarkable happens throughout this whole range of frequencies until we reach a frequency of about 2.5×10^{20}Hz when – bingo! – two particles, a positron and an electron, appear before our eyes, formed only from the radio waves at that frequency – no pepper, no salt, no green cheese – just an electromagnetic wave and nothing else forming two particles of matter.

It is clear that, over three-quarters of a century after the discovery of the electron, no model had been suggested which could account for more than one or two of its many properties. Its greatest property had no quantitative explanation whatsoever, for its greatest property is its inertia and the only suggestion to explain this, that due to Ernst Mach, was entirely a qualitative hypothesis which could not account for the precise observations of inertial mass and inertial force.

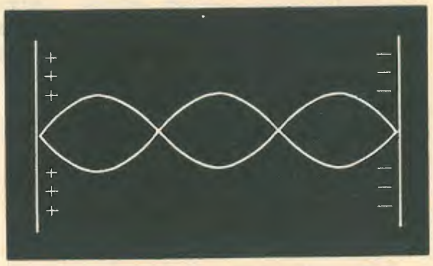


Fig. 1. *A simple phase-locked cavity with nodes at the end. The position of the boundaries in a phase-locked system is determined entirely by the wave system and not by rigid supports.*

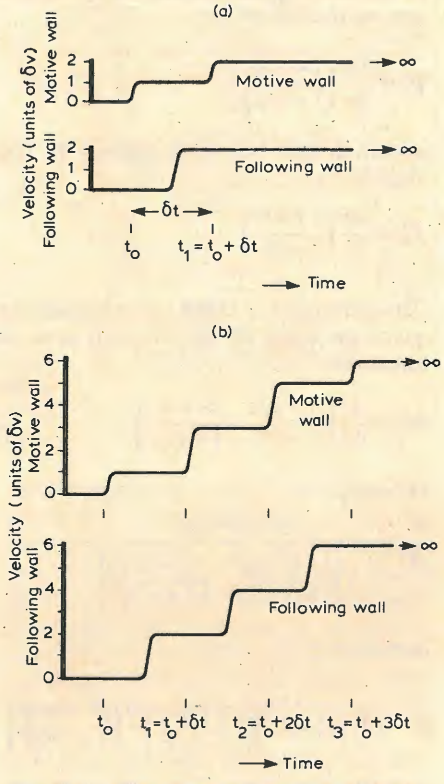


Fig. 2. *(a) The effect of maintaining a constant motive force for precisely the interval, δt, taken by the radiation to complete one round trip in a cavity such as that in Fig. 1. The cavity continues to move forward at a velocity 2δv. (b) The staircase of velocity produced by a motive force maintained constant for a time 3δt. In the limit, for a very large number of steps, the staircase approximates to classical linear acceleration.*

Phase-locked cavities

For about a decade a small research group at the Electronics Laboratory of the University of Kent had been trying to understand the electron, and, as a first step, they made it their job to clarify what happens when systems rotate. One might have expected that everything was known about rotating observers but this was far from the case. In the course of this research it was necessary to consider what happened to the units of length and time when they were accelerated, for only in this way could one express the measurements made by a rotating observer – everything that he measured had to be in terms of his local units. The question then arose that no one had solved the problem of the accelerated measuring rod; how did it maintain its length?

W. H. McCrea had gone part of the way towards the answer when he showed in 1952 that the rod would have to be made of a substance in which the velocity of sound was equal to the velocity of light. In a private conversation at a dinner in Oxford in 1972 he suggested that this might require impossible molecules but rejected the author's suggestion that the measuring rod would be simply a standing electromagnetic wave on the grounds that this would have no rest mass. I was concerned that McCrea's magic molecules could not be applied to the electron so I took up McCrea's challenge and within a few days I was able to show that a trapped standing wave not only had rest mass, it possessed the intrinsic property of inertia – once it had started moving it could only be stopped by applying a restraining force.

The physical mechanism is really very simple. Fig. 1 shows a macroscopic system in which a standing wave is trapped between two plates carrying equal and opposite charges of such a magnitude that they precisely balance the radiation pressure of the wave. If the left boundary is given a small velocity to the right, the wave reflected from it has a slightly higher energy and its wavelength is shorter. The shorter wavelength is reflected from the far end where it exerts a small excess pressure on the boundary, causing it to move to the right. The wave is then reflected back to the original end, closing the feedback loop; but a simple calculation shows that when it comes back from the moving boundary on the right it is redder and less energetic than the original wave in the cavity so that it *pulls* the left hand boundary. If the original motive force is now removed the whole system has no option but to continue moving to the right. It has gained energy relative to the laboratory but to an observer moving with it on the boundary it still has the original energy and original length, for it is still the same trapped standing wave. Thus the system has acquired inertia entirely from its own properties and without help from the distant masses of the universe. The effects of this are legion, for inertia affects our daily lives even more than gravity.

Newton's Second Law ($F = ma$) and also the Einstein relation $E = mc^2$ fall out from the above but it turns out that Newton's law is very slightly modified. The force has to be applied for the whole time that it takes for the excess radiation to complete the feedback loop, otherwise the excess is radiated back into space. Furthermore, if the push is applied for a considerably longer time the cavity accelerates by progressing up a 'staircase' of velocity (Fig. 2). It accelerates in little jerks because the transfer function of the system is, quite classically, quantised by the feedback loop and it acts as a simple integrator to attain the final velocity. If external radiation in the form of a c.w. signal falls upon a phase-locked cavity the delay in the feedback loop causes it to respond in the manner of the transducer in the "Radio waves or photons?" box and to register the quantum jumps of Fig. 2. Are the quantum jumps the right size? If the little cavity is filled with the electromagnetic wave that we associate with the annihilation of the electron, then the quantum jumps are precisely Planck's quantum of action. It looks as though, at last, we may be on the right track to solve the mystery of the electron. Are there any other idiosyncrasies of the electron that are shared by a phase-locked cavity?

Since the mid nineteen-twenties it has been known that the electron spins but that its angular momentum about its own axis is only half that to be expected from classical mechanics. Let us see if a phase-locked cavity exhibits the same feature. Fig. 1 shows that if we are to analyse a complete phase-locked cavity system then the total energy consists of the sum of the trapped wave energy and the potential energy required to hold the system together, i.e. the stored energy of the capacitor. The configuration shown in Fig. 1 cannot be applied to the electron, for the maximum of the electric field at the centre leads to severe difficulties if the system is rotated about the centre point. We therefore consider the 'push-pull' standing wave shown in Fig. 3. Let it be of unit cross-sectional area and let it be held together by a source of potential energy maintaining the dotted boundaries to either side. These boundaries may be formed quite naturally from spinning the system and we will not specify them further until we have completed our analysis.

Using similar units to Einstein (1905) the energy density of the travelling waves in the cavity at rest is $A^2/8\pi$ where A is the amplitude of either the electric or magnetic field. If the central node is caused to move, the energy density and the volume occupied by the wave system are both relativistically transformed. The cross-sectional area does not change but, as we are considering a phase-locked system, the length of the system to each side of the node is the effective length of the total travelling wave packet on each side.

We now consider that the central node is moved to the right at velocity v. Both of the component travelling waves to the right of the node have more energy and both of those to the left have less energy than when at rest since the boundaries at each end redirect the radiation within the time taken to complete the feedback loop. Thus the total energy E'_T of the system to an observer on the moving node is given by the transformed potential energy E'_p plus the transformed energy density times the transformed total wave length to the right, E'_{WR}, plus the transformed energy density times the total transformed wave length to the left, E'_{WL}:

$$E'_T = E'_P + E'_{WR} + E'_{WL}$$

$$= E'_P + \frac{A^2}{8\pi}\left(\frac{1+v/c}{1-v/c}\right)\frac{\lambda}{2}\left(\frac{1-v/c}{1+v/c}\right)^{1/2} +$$

$$\frac{A^2}{8\pi}\left(\frac{1-v/c}{1+v/c}\right)\frac{\lambda}{2}\left(\frac{1+v/c}{1-v/c}\right)^{1/2}$$

$$= E'_P + \frac{A^2\lambda}{16\pi}\left[\left(\frac{1+v/c}{1-v/c}\right)^{1/2} + \left(\frac{1-v/c}{1+v/c}\right)^{1/2}\right] \quad (1)$$

The radiation pressure (Einstein 1905) at the moving node from the wave system on the left is

$$P'_L = \frac{2A^2}{8\pi}\left(\frac{1-v/c}{1+v/c}\right)$$

and that from the wave system on the right is

$$P'_R = \frac{2A^2}{8\pi}\left(\frac{1+v/c}{1-v/c}\right)$$

The difference in these two expressions gives the force $\delta F'$ on the unit area at the node

$$\delta F' = \frac{A^2}{4\pi}\left(\frac{1+v/c}{1-v/c} - \frac{1-v/c}{1+v/c}\right) \quad (2)$$

From (1)

$$\frac{A^2}{4\pi} = \frac{4\,(E'_T - E'_P)}{\lambda\left[\left(\frac{1+v/c}{1-v/c}\right)^{1/2} + \left(\frac{1-v/c}{1+v/c}\right)^{1/2}\right]}.$$

Therefore

$$\delta F^1 = \frac{4}{\lambda}\left(E'_T - E'_P\right)\left[\left(\frac{1+v/c}{1-v/c}\right)^{1/2} - \left(\frac{1-v/c}{1+v/c}\right)^{1/2}\right]$$

$$= \frac{8\,(E'_T - E'_P)}{\lambda(1-v^2/c^2)^{1/2}} \cdot \frac{v}{c} \quad (3)$$

We may replace λ by $2c\delta t$ where δt is the time taken by a wave to complete the feedback loop by travelling out from the node and back again.

The force that we have established is of enormous magnitude, even at 1 metre per second when v^2/c^2 is only 10^{-17}, so we may drop the expression $(1-v^2/c^2)^{1/2}$ and state to first order

$$\delta F = \frac{2}{c^2}\,(E_T - E_P)\,.\,\frac{2v}{\delta t}$$

But $2v/\delta t$ is the acceleration over a complete feedback cycle, hence

$$\delta F = \frac{2}{c^2}\,(E_T - E_P)\,.\,a \quad (4)$$

But, in the rest state, the wave energy equals the binding energy and they together comprise the total energy, hence

$$\delta F = \frac{E_T}{c^2}\,a = m_o a\,. \quad (5)$$

Thus we derive Newton's Second Law and $E = m_o c^2$ at the same time. It would have been possible to derive these relations quite simply by ignoring the second order terms at the outset, but this analysis is enlightening in that eq. (4) shows that only half of the total energy comprising the inertial mass contributes actively to the inertial force. The law of inertia would be twice as efficient ($\delta F = 2m_o a$) if the potential energy also contributed to the inertial force of a phase-locked cavity, i.e. if the transformation of E_P had a first order component. Thus if a particle is formed entirely from an electromagnetic wave, half of the wave system actively produces the inertial phenomenon, whilst the other half is equally essential but plays a passive role. Once a complete particle has been formed as a phase-locked system, it can interact with external forces completely in accordance with the laws of mechanics; in particular, its total mass is available to produce reaction to an impressed force. In contrast, if we apply the inertial laws *within* a closed loop wave packet then we do not have a situation where the waves act on existing particles and we may only employ half of the wave energy in establishing the active component.

Thus, for entirely classical reasons, some laws of mechanics break down when applied *within* elementary phase-locked systems though they are perfectly valid for the external behaviour of the complete systems. The concept of moment of inertia is based upon the concept of inertial mass as it appears in Newton's law. If the concept is applied internally to a rotating phase-locked cavity, then only half of the energy is actively operational, thus: *The moment of inertia of a phase-locked cavity about its own axis is half that which is given by the classical mechanics of an externally equivalent system composed of particulate component masses.*

If we identify an electron with a phase-locked cavity formed entirely from electromagnetic waves and we wish to establish its internal angular momentum, then we must reserve half of the total internal energy for the passive role so that the internal angular momentum is therefore only half that which would be given by considering the total energy of the system.

It is suggested that this is the classical origin of the (anomalous) spin angular momentum of the electron and other fundamental particles. Furthermore, a comparison of the magnetic moment of an electron with its internal angular momentum should give a value which is twice that observable for the behaviour of the complete phase-locked particle in motion around a distant nucleus. It is suggested that this is the origin of the anomalous magnetic moment of the electron.

Apart from accounting for the enormous forces of inertia which affect our daily lives, the analysis shows that the principle of the phase-locked cavity

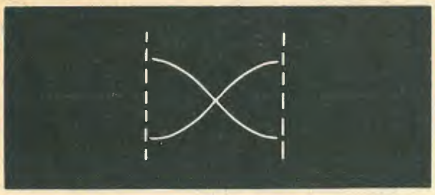
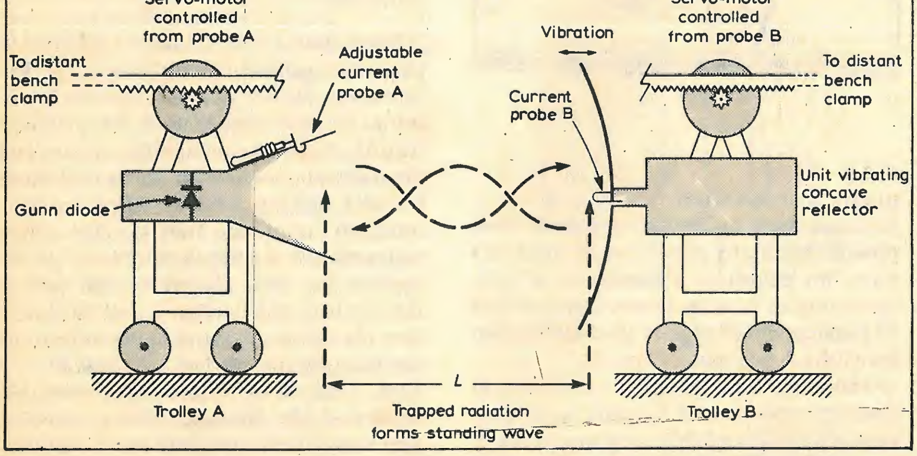


Fig. 3. *A $\lambda/2$ standing wave with zero electric field at the centre. An electron may consist of two such systems at right angles rotating about the central node.*

Fig. 4. *The freely floating phase-locked cavity. The distance L is maintained constant by independent sensing and control on each trolley. This effectively amplifies the very weak control exerted by the normal boundary conditions although the speed of response is degraded. The independent trolleys accelerate and move as though they were a single solid body upon the application of a horizontal force applied to one trolley only. Upon removal of the force the system coasts at the terminal velocity, still maintaining L constant.*



appears to reconcile many of the differences between the classical and quantum behaviour of matter. A phase-locked cavity has a transfer function which reproduces the quantised relationship between an external influence and an elementary mass; furthermore it has an anomalous equivalent mass for the application of the classical laws of mechanics to its internal properties. In particular, if one accepts that there is a unique wavelength (the Compton Wavelength) at which electromagnetic waves can lock into a closed loop system, then a particle can be formed which has all the following properties of an electron: inertia; quantised transfer function; rest mass; angular momentum (half classical); electric field equivalent to a localised charge; magnetic moment (including the anomaly); preservation of the proper units of length and time when accelerated to a different frame; indeterminacy arising from lack of knowledge of the phase of the internal waves.

We cannot, of course, see an electron. Any attempt to do so causes the electron to move smartly out of the way in accordance with the principles that we have just established, but we can, on the basis of this analysis, set up a model which would have the required characteristics. This tentative model would consist of two spinning standing waves, somewhat like that in Fig. 3, set at right angles and electrically in phase quadrature. Preliminary investigations suggest that relativistic aberration renders this system equivalent to two travelling wave systems of double the frequency rotating in an annular manner around the centre as seen from the laboratory. The electric fields of the waves would give a static but spinning electric field pointing either inwards or outwards according to the sense of rotation, and the magnetic fields of the waves combine to form a dipole field through the centre.

At the moment we need just one postulate to apply a model such as this, that, at the annihilation wavelength, nature permits such a configuration to lock in perfect equilibrium. This one postulate then dispenses with all the separate postulates required for other descriptions of the electron, inertia and the quantum theory. What does this tell us about the photon concept? A phase-locked cavity will respond in a quantised manner to either a short train of waves or a continuous signal but, when it surrenders its excess energy, this appears in simple short wave trains of radiation which may then mix with other free wave trains perfectly in accordance with the superposition property of Fourier theory. The photon is quite classical!

Is it possible to make a macroscopic phase-locked cavity? We have made two in the Electronics Laboratories at the University of Kent, one using laser light and the other using radio waves. The radio wave version is shown in Fig. 4. Though this is by no means a perfect analogue, it clearly demonstrates a system which maintains the same number of wavelengths between the boundaries. With care it may be set up so that the frictional losses are cancelled and a slight push at one end then causes the two trolleys to move freely as a single particle. Small noise perturbations are rather amusing for they cause the system to have a mind of its own and to perform unpredictable little dances in the manner of one-dimensional macroscopic Brownian motion. It is possible to make this system from a cheap intruder alarm Gunn diode assembly feeding the horn on the left and a 2½ inch loudspeaker carrying the reflector on the right. A tiny two-turn loop in the plane of the reflector feeds a crystal diode, the output of which goes to an audio amplifier, synchronous detector and power amplifier feeding a small motor on the same trolley. A similar arrangement is associated with a crystal diode and detector loop mounted through the wall of the horn on the left trolley and it is advisable to include an isolator or attenuator between the Gunn diode assembly and the horn in order to reduce pulling of the oscillator by the reflector on the opposite trolley. The loudspeaker is driven with a very small amplitude at about 120Hz and the synchronous detectors are referenced to the same 120Hz source.

It is possible to construct analogues of many aspects of this work but demonstrations of inertia are all around us. The next time you stub your toe or hold on to your seat belt remember to blame all the little feedback loops forming your elementary particles. Without feedback none of this would be possible; if we could form a stable self-contained particle entirely from static fields we might be able to have energy without inertia but there would be no phase-locking principle to regulate its size and give it quantisation. Would it also defy gravity? This analysis is reassuring in that it preserves Einstein's Principle of Equivalence and does not reduce it to a Principle of Identity between gravitational and inertial forces.

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WORLD OF AMATEUR RADIO

World records tumble

From Doug Hutchinson, ZR6JH come details of a new 144MHz transequatorial two-way record set up on February 13 between David Larsen, ZS6DN on behalf of the Pretoria Tessa Group and Costas Fimerelis, SV1DH in Athens: a great-circle distance of about 7100km. ZS6DN runs 140W into a 4 by 12-element widespread Yagi aerial (measured gain 19.5dB). The aerial at SV1DH is a 14-element Parabeam. Following the initial contact there have been fairly regular TEP openings over this very long path at around 1800GMT and SV1AB, Athens and ZS6LN in South Africa have joined this 'net' on occasions. The Tessa group includes Dr Fred Anderson, ZS6PW, John McCoy, ZS6JM and Doug Hutchinson. Attempts are being made to measure the transit time of signals to determine actual path length.

In Australia a new 1296MHz world record was established on December 29, 1978 with a contact between VK6KZ/P, Walpole in south-west Western Australia and VK5MC about 300km south-east of Adelaide: a distance of 2109km. VK6KZ/P used about 3W output to a 1-metre dish aerial; VK5MC 45W output to a 6.5m dish.

Following many reports of the reception during January, February and March of signals from North and South America and southern Africa comes news of a new two-way 50MHz record contact between LU8AHW Argentina and HL9TG in Korea. On the evening of March 20, SV1AB and SV1DH in Athens, Greece positively identified signals from the 432MHz beacon station ZE2JV, Salisbury, Rhodesia — only the second reported example of long-distance transequatorial propagation at u.h.f.

Encouraging more c.w.

To a substantial minority of amateurs, the essence of enjoyable h.f. operating is the use of manual Morse (c.w.). Many consider this to be the most effective means of communicating information between amateurs of different countries, often with no common language except 'telegraphese'; it permits the use of relatively simple equipment (though presenting its own technical challenges) and low-cost aerials; and offers the most economical use of the radio spectrum.

Not everyone, of course, shares these views and some bolster up their impatience with the tedious and time-consuming process involved in becoming a proficient c.w. operator by shrugging off this mode as 'old-fashioned' and by pointing to the growing popularity of s.s.b., slow-scan tv, r.t.t.y. and even automatic electronic conversion of Morse into visual displays. The abandonment of the short-lived post-war regulations that made c.w. obligatory in the UK for the first year and the subsequent introduction of Class B v.h.f. licences with no Morse required have meant that many present-day amateurs have no practical experience of c.w. operating or no experience beyond that of passing the 12 w.p.m. Post Office test for Class A licences.

Although there is still a great deal of c.w. activity on the h.f. bands (and some on v.h.f.) much of this is by amateurs in countries still imposing an obligatory c.w. period or those who have held licences for a considerable time or have come into the hobby with a background of military or commercial operating. In recent months, however, there have been new moves to encourage greater use of c.w. in the UK and Europe. A "European CW Association" has been formed by several clubs such as "Tops", the G-QRP-Club and Swedish and German "CW Activity" groups. The aims are to encourage c.w. operating, to ensure adequate c.w. training and to bring c.w. operators together in regular sessions. The Association is currently investigating potential support among other amateurs for a "novice" c.w.-only licence to be introduced into the UK and Region 1, basically similar to those already available in North America, Australia etc. (e.g. simple technical examination, 5w.p.m. Morse test, 10W crystal-controlled transmitter for segments of some h.f. bands).

The G-QRP-Club has begun issuing a 'Worked All Continents' award to amateurs who make contact with all six continents using no more than 5 watts input c.w. or 3.6 watts p.e.p. on s.s.b.

Secrets of RSS

After almost 40 years of silence, long-guarded secrets of the work carried out between 1939-45 by British radio amateurs enrolled as Voluntary Interceptors into the Radio Security Service or as members of Special Communications Unit No 3 have been revealed in a BBC East of England television programme. This follows some two years of research by Paul Wright, G3SEM, of BBC Norwich. The programme, which may later be networked, traces the origins of radio interception and signals intelligence in World War I and its growth into an effective and highly fruitful branch of intelligence during World War II. RSS, set up by MI5 to listen for beacon signals to aircraft, was transferred to MI6 to keep track of the elaborate networks of German military intelligence (Abwehr) communications that spread out all over Europe, North Africa and the Middle East, and North and South America.

More than 1,000 volunteers listened in their own homes to the signals passing between the centres in Berlin, Hamburg, Vienna and Wiesbaden and the hundreds of out-stations, including clandestine links with spies and busy circuits linking Abwehr offices. Interception of this traffic not only represented a unique source of intelligence but also played a vital role in deception strategy, including the Double-Cross playback of controlled German agents in the UK and Middle East. Few of the VIs ever learned the nature of the messages they received, and many believed they were listening to Resistance traffic. Only one major breach of security occurred when in February 1941 a report headlined "Spies tap Nazi code" appeared in the *Daily Mirror* describing the VI system, though there is no evidence that this slip was spotted by the Germans.

From the end of 1941 a considerable number of the VIs were recruited for full-time interception duties at Hanslope Park and Forfar and a network of d.f. stations was largely manned by them, as a separate intelligence organisation to the "Y" service which copied German service traffic. The VI logs were sent by post to Box 25, Barnet and the messages decoded at Bletchley Park. Although many of those concerned with the setting-up and running of RSS, including Brigadier Gambier-Parry and Lord Sandhurst, have since died, the BBC recorded interviews with some of the many people involved in this work, including Colonel 'Ted' Maltby, Colonel Hornsby, Professor Hugh Trevor-Roper, Robin Addie (G8LT), 'Dud' Charman (G6CJ), Arthur Watts (G6UN), Louis Varney (G5RV), Eric Chambers (G2FYT), Dr Gee (G2UK), Pat Hawker (G3VA), 'Gerry' Openshaw (G2BTO) Norman Sedgwick (G8WV), the late George Edwards (G2UX) and Hugo Lawley.

Prof. Hugh Trevor-Roper revealed that the activities of "Cicero", the German spy in the British Embassy in Turkey, were fully known to British Intelligence through these intercepts.

PAT HAWKER G3VA

Bookshelf loudspeaker Mk II

Improvements to the October 1977 design

by **Jim Wilkinson,** Sony Broadcast

Following the publication of the original loudspeaker article[1] KEF ceased production of the T15 tweeter used in the design. Although existing stocks would meet the initial demand, in order to ensure the usefulness of the loudspeaker for several years to come an alternative tweeter had to be found. A unit which meets the performance criteria is the Audax HD13D34H. This unit is now being fitted to several new commercial designs and thus is going to be around for some time to come. Introducing this new unit initiated further rounds of measurements which revealed some shortcomings in the original theory and this article reveals the details of the new design.

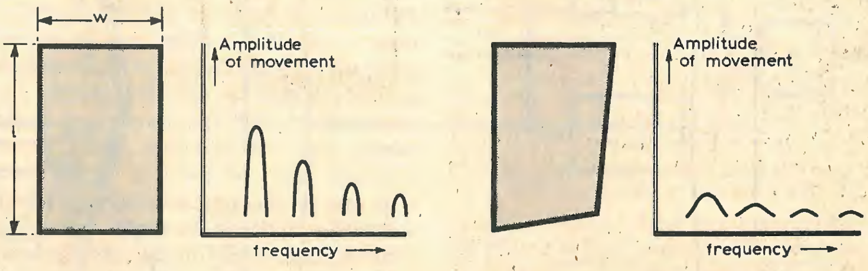


Fig. 1. *Cabinet resonance factors, comprising the effects of parallel and non-parallel sides*

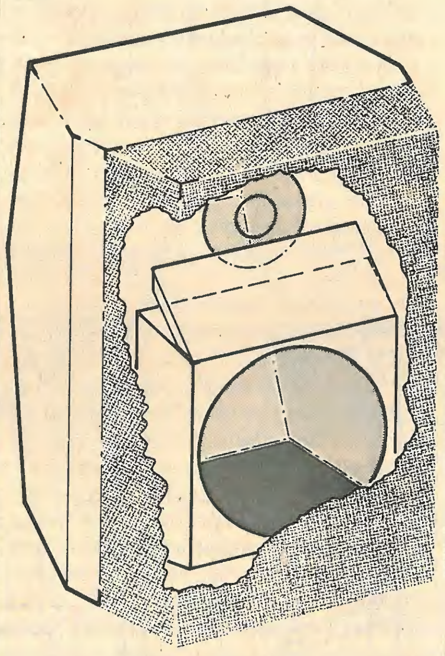


Fig. 2. *Shape of the completed cabinet*

THE ORIGINAL loudspeaker included a number of features which are retained, one of these being the use of the 4th order crossover network. The high rate of cut-off (24dB per octave) ensures that the response of each unit does not have to be maintained more than one octave beyond the crossover frequency. Unlike the more common 3rd order Butterworth filter, the 4th order network is instrumental in obtaining a symmetrical vertical polar pattern, by ensuring that the phases of signals fed to the bass and treble units are identical and independent of frequency. Although the crossover network is one of the most complex available today, the trend towards more involved networks is continuing as designers realise that simpler networks cannot achieve the same performance. Even so, the total cost of one network is less than the cheaper drive unit. This particular network also has the advantage of being exceptionally easy to drive.

Another retained feature is that of staggered drive units. This method is the second stage in obtaining a totally symmetrical polar pattern. Essentially required to align the voice coils of bass and treble units, the time shift must also account for any additional errors introduced by these units. It is accepted that a high quality loudspeaker should have a wide (and symmetrical) horizontal dispersion for realistic performance. It follows, therefore, that such a loudspeaker should also have a wide and symmetrical vertical dispersion and since even the 4th order crossover is active over a frequency range of two octaves then inserting the correct time delay is essential. Finally, the technique of diagonal bracing of the cabinet walls is retained. There are essentially two methods for building a cabinet. The first is to make the box as rigid (which includes as much mass) as possible and the second is to use light walls which are heavily damped with thick felt panels. This latter method allows some antiphase sound to be radiated but attenuates panel resonances significantly.

The approach in this design is to adopt the rigid box method using a combination of techniques (diagonal bracing being one) to reduce panel resonances.

The cabinet design

The internal dimensions of the original cabinet were 440 × 270 × 180mm which results in a system resonance of 55Hz. No change is required in the enclosure volume, but considerable thought has been given to the internal shape.

A simple box with rectangular sides and parallel walls quite readily allows a whole series of resonant modes. The formation of standing waves in such a cabinet is well documented and it is normal to fit large amounts of acoustic wadding to absorb the energy, thus attenuating the standing waves. Solutions to the cabinet wall resonances commonly involve bracing techniques but often they only succeed in raising the frequencies of the resonant points rather than attenuating the level of vibration. A mathematical study of the modes of vibration is complex but a useful starting point is given in ref. 2. The modes of vibration of a panel of length l, and width w, are a function of these two dimensions and give rise to preferential frequencies of vibration proportional to $1/l$ and $1/w$. There is no practical way of eliminating panel vibrations for a cabinet of this size. On the other hand, if these modes could be distributed over a band, then the Q of each resonance would be lowered. Consequently, the panel frequencies would be more evenly distributed and this can be achieved by using non-rectangular cabinet walls.

A cabinet which employs non-parallel sided walls will, in a like fashion, lower the Q of each standing wave. By combining these two techniques, a significant improvement in cabinet resonances can be achieved. Some considerable time was spent creating and

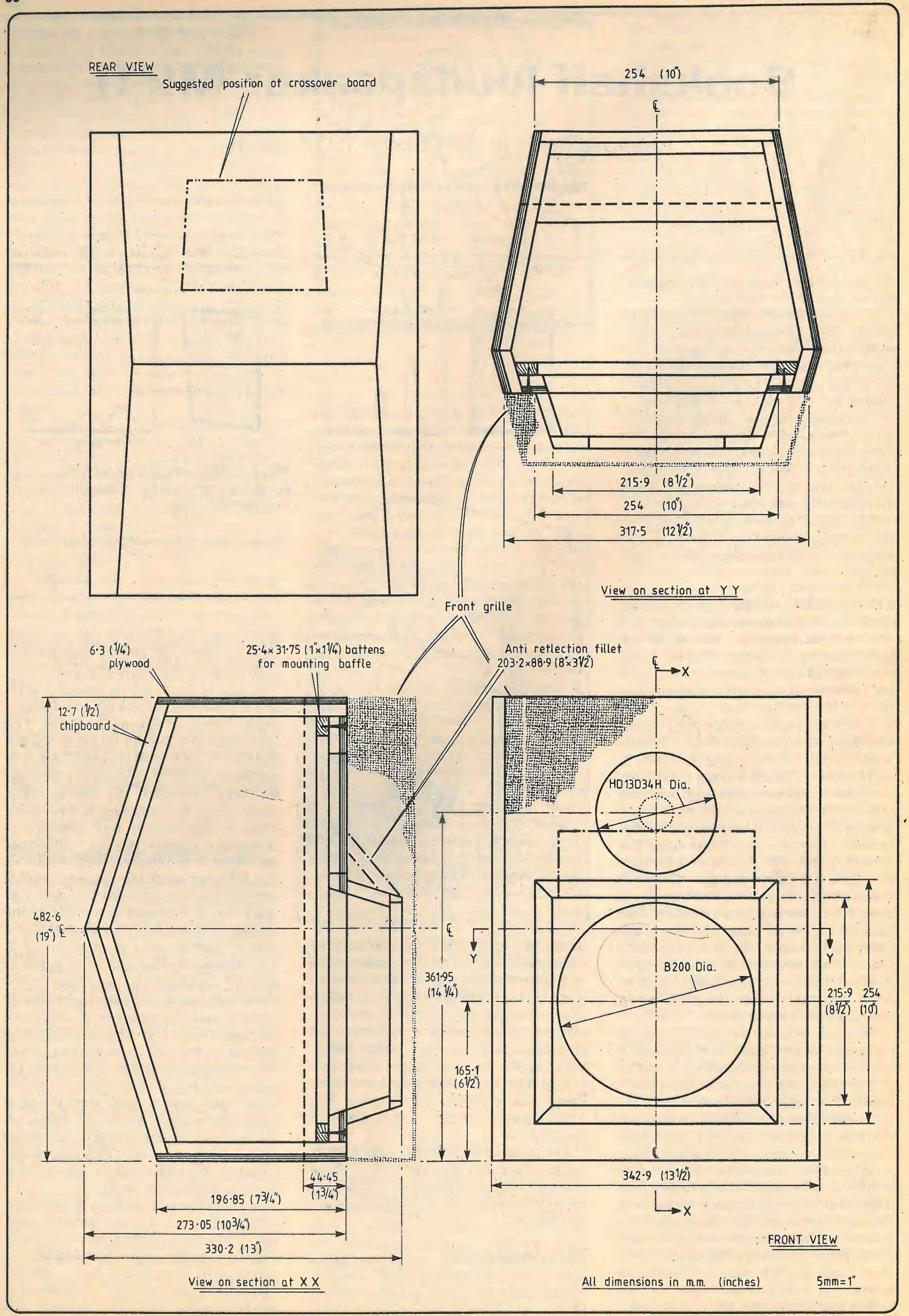

REAR VIEW
Suggested position of crossover board
254 (10")
℄
215·9 (8½")
254 (10")
317·5 (12½")
View on section at Y Y
Front grille
6·3 (¼") plywood
25·4×31·75 (1"×1¼") battens for mounting baffle
Anti reflection fillet 203·2×88·9 (8"×3½")
12·7 (½") chipboard
482·6 (19")
℄
℄
X
HD13D34H Dia.
361·95 (14¼")
Y
Y
B200 Dia.
215·9 (8½")
254 (10")
165·1 (6½")
℄
44·45 (1¾")
196·85 (7¾")
273·05 (10¾")
330·2 (13")
342·9 (13½")
X
FRONT VIEW
View on section at X X
All dimensions in m.m. (inches)
5mm=1"

Fig. 3. *Full engineering drawing of cabinet (see left)*

evaluating various cabinet shapes, concentrating on those which could be build by the amateur and which would be pleasing to the eye. Further points of consideration are cabinet diffraction effects and the need for staggered drive units. The only rectangular panel is the baffle but here the drive units themselves break up the standing wave patterns. The chamfered corners at the front of the cabinet help reduce acoustic reflections which naturally occur at sharp boundaries.

A cabinet based on this shape was built and compared directly against the original. The latter cabinet never showed any signs of boxiness, indeed the triangular bracing and extra thick rear wall should have eliminated any such possibility. The new cabinet definitely sounds better and experiments have shown that it is not a simple diffraction effect. The difference seems particularly audible on male speech, the new cabinet being slightly more mellow in character. Interchanging the drive units and crossover proved that the cabinet itself was providing the difference. NB: Those readers who wish to retain the original cabinet whilst updating the tweeter can easily do so provided, of course, the new crossover network is installed. The improvement is still worthwhile.

Construction of the cabinet is much the same as the original design, but the use of non-rectangular joints means that a multi-angled power saw and circular sander are almost mandatory. The overall method of construction is essentially the same as the original article. There is, however, an additional bracing piece which is placed between the centres of the two side walls of the cabinet, these two walls being the weakest. This bracing piece should be a tight fit which is glued prior to hammering into place. The internal walls of the cabinet are coated with a layer of car underseal (or Rubberoid mastic, available from builders merchants), then about 75% of the available wall area is further damped by pinning on bitmus felt panels. The recommended acoustic wadding consists of two rolls of 2in BAF, each roll formed from a piece 3ft × 9in (914mm × 228mm). The rolls are fitted into the top and bottom halves of the cabinet, separated by the centre brace.

When the drive units are fitted to the baffle a new piece of timber (12mm thick) is fitted to present a continuous surface between the bottom of the tweeter diaphragm and the top edge of the bass unit, which functions as an anti-reflection fillet. This prevents unwanted acoustic reflections from the top of the bass unit sub baffle (Fig. 4).

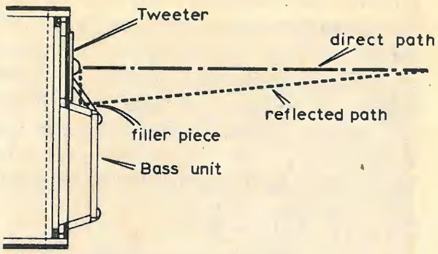


Fig. 4. *Location and effect of filler piece*

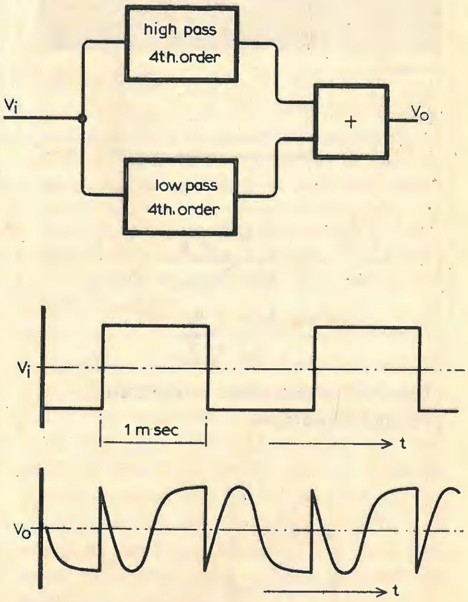


Fig. 5. *Active filter network showing typical 4th order waveform distortion*

The crossover circuit

This is the most complex area of any loudspeaker design and is in this case the result of considerable thought. Over the past few years, several manufacturers have produced loudspeakers which preserve waveform fidelity, claiming that waveform distortion is audible. The 4th order crossover network produces gross waveform distortions (Fig. 5) which should be audible were the ear sensitive to phase shifts. A simple test was arranged in order to make listening tests of this distortion and an active network of the type shown in **Fig. 5** was built to simulate the effect of such a circuit. This was inserted into the feed to a studio monitor loudspeaker via a switch. By switching the network in and out, this waveform could be introduced. The loudspeaker used in the test had its own minor waveform distortion, but further distortion should still show up as a difference. None of the three listeners (all experienced hi-fi enthusiasts) could detect any difference using either music or white noise sources, although, when a square wave at 500Hz was applied a slight tonal change could be heard. Further tests showed that there was a 0.25dB gain difference between the high and low pass filters. This error was corrected and the tests resumed. Now no difference could be heard at all with any type of source, emphasing just how carefully any test should be controlled before attaching significance to the result.

At least one other designer has arrived at the same conclusion for the 4th order crossover network. This in no way implies that phase distortion of any kind cannot be heard since gross errors have been proved audible, but that the level introduced by this type of crossover is inaudible.

One of the most important parts of any crossover network is the method of compensating for drive unit deficiences. Early theoretical work showed that the on-axis pressure response of a direct radiator would rise with increasing frequency (tending towards 6dB/octave), this being coupled with a reduction in the radiation angle. The exact frequency at which this effect starts to become significant is a complex function of the effective cone diameter, the shape of the cone and the velocity of wavefront propagation across the cone surface. The rising response is coupled with cone resonance effects (the drum effect, also known as "bell modes," is explained mathematically in ref. 2), cabinet diffraction effects, roll surround reflections, the voice coil inductance and the high frequency cut-off between the voice coil and the cone. All these effects will combine to produce an on-axis pressure response which is complex and difficult to understand.

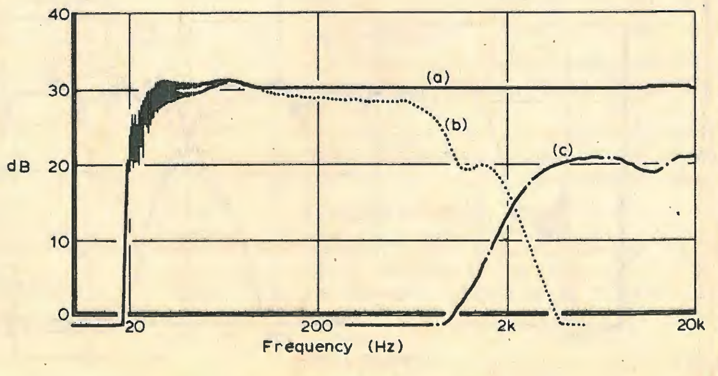
Any practical crossover will attempt to compensate for the overall effect rather than for individual effects, and

Fig. 6. *The signals applied to the B200 and HD13D34H*

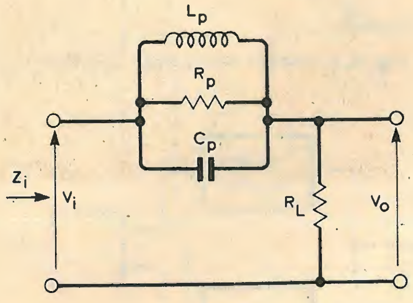
(a) signals to crossover

(b) signal to B200

(c) signal to HD13D34H



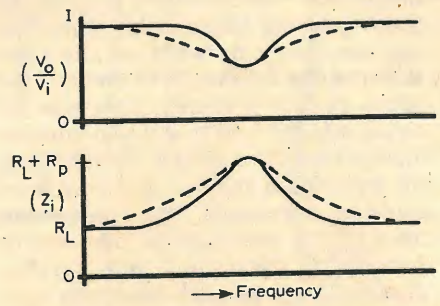
no single network has been found which will give the desired response. However, a combination of two cascaded functions helps to solve the problem. The first is the addition of a suckout filter, the second a modification of one of the Butterworth low pass filter sections. The crossover frequency has been set at 2.2kHz, but one of the low pass Butterworth filters has been lowered to give a −3dB point at 1.3kHz. This results in the voltage applied to the terminals of the bass unit emerging as shown in the left-hand response of Fig. 6. The tweeter needs only one compensating network for a peak of 3.5dB at 11kHz. The suckout is evident from the right-hand response of Fig. 6 which is the signal applied to the tweeter.



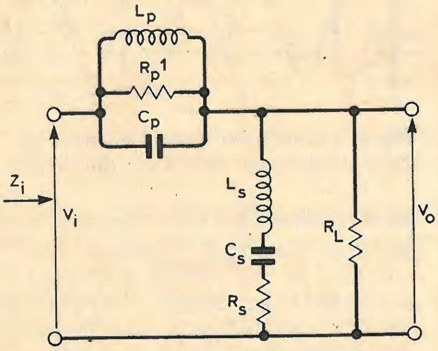
$$\frac{V_o(s)}{V_i} = \frac{s^2 + s/C_pR_p + 1/L_pC_p}{s^2 + s/C_pR_x + 1/L_pC_p}$$

where $R_x = \frac{R_L R_p}{R_L + R_p}$

Fig. 7. *Suckout filter circuit and related equations*



The principle of cascading 2nd order Butterworth filters to produce the 4th order high and low pass filters was explained in the original article. However, in this network there is a requirement for cascading the Butterworth filters with the suckout filter and the basic suckout filter is shown in Fig. 7, the related equations being in the 's' domain. The dotted line shows the effect of increasing the value of the inductance (the capacitance being decreased by the same factor). The response showing the input impedance of the network displays clearly that this is far from resistive and is, therefore, unsuitable for cascading. Adding a second tuned circuit can completely solve this problem provided the set network conditions are met (Fig. 8). This network is used to compensate for a broad peak (at 1.2kHz) in the bass unit response. A simple network based on Fig. 6 is used to compensate for this response anomaly in the tweeter. Figs. 9 and 10 show four pressure response curves for the loudspeaker. All were measured on a dry, warm day. A framework, some 3m high, supported the loudspeaker, with the microphone supported on its tripod. Some reflections are bound to occur at this height and cancellation effects can be seen at 120Hz, 170Hz and 260Hz. Fig. 9 shows the on-axis response of the bass unit, which also indicates the effectiveness of the compensation networks. Fig. 10, parts a, b and c show the response of the completed loudspeaker on axis, 30° horizontally off axis and 45° horizontally off axis respectively. Lowering the crossover frequency from 3kHz to 2.2kHz has ensured a wide horizontal response which is evident from these readings.



(1) $\text{Loss}_{(max.)} = \frac{R_sR_L}{R_p^1(R_s+R_L)+R_sR_L}$

(2) $R_p^1 + \frac{R_sR_L}{R_s+R_L} = R_L$

(3) $C_s = \frac{L_p}{R_L^2}$ (4) $L_s = C_pR_L^2$

Fig. 8. *1.2kHz filter circuit and network conditions*

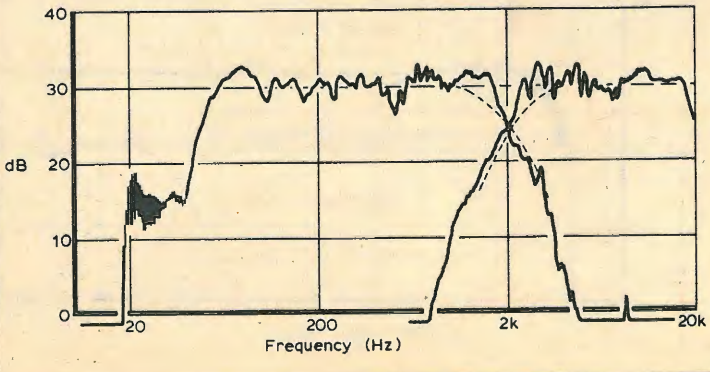


Fig. 9. *Pressure response of B200 unit with filter included – the dotted line shows the ideal response*

One point which could cause trouble is that, in lowering the crossover frequency, the tweeter could possibly run into frequency doubling problems.

The power to the tweeter is reduced by a factor of 0.25 so that it matches the sensitivity of the bass unit. This means that the loudspeaker can accept at least 25W at any frequency. A level of 25W was applied, sweeping the frequency over the full audio range. With the bass unit replaced by a load resistor, no obvious frequency doubling occurred in the tweeter.

The suggested amplifier power rating is 25 to 100W r.m.s. into 8Ω. A higher power amplifier can actually be safer for the tweeter since the onset of distortion in a lower power amplifier produces high levels of harmonics which can easily destroy a tweeter, although in this particular design there is sufficient power headroom to make this eventuality extremely unlikely.

As one of the design objectives of this loudspeaker was to produce a symmetrical vertical polar response, it is possible to measure the phase error between the two units. Such a measurement has been performed and indicates that, for ±0.5 of an octave either side of the crossover frequency, the phase difference between the two drive units is better than 30°. Measurements beyond ±0.5 of an octave are difficult as the level of one signal becomes unusable. The complete crossover network is shown in Fig. 11 and three values of attenuator for the tweeter are given. If required, a simple switch can be used to give two variations on the nominal setting. Note that no Zobel network is needed for the tweeter as this has a very well controlled impedance over the frequencies of interest. To obtain the best performance from the crossover network, high grade 5% tolerance components should be used throughout. Some leeway is permissible on the components marked with an asterisk.

The resistor power ratings allow for a continuous 25W to be applied to the loudspeaker. No significant distortion (in the general sense) is introduced by the network at this power level at any

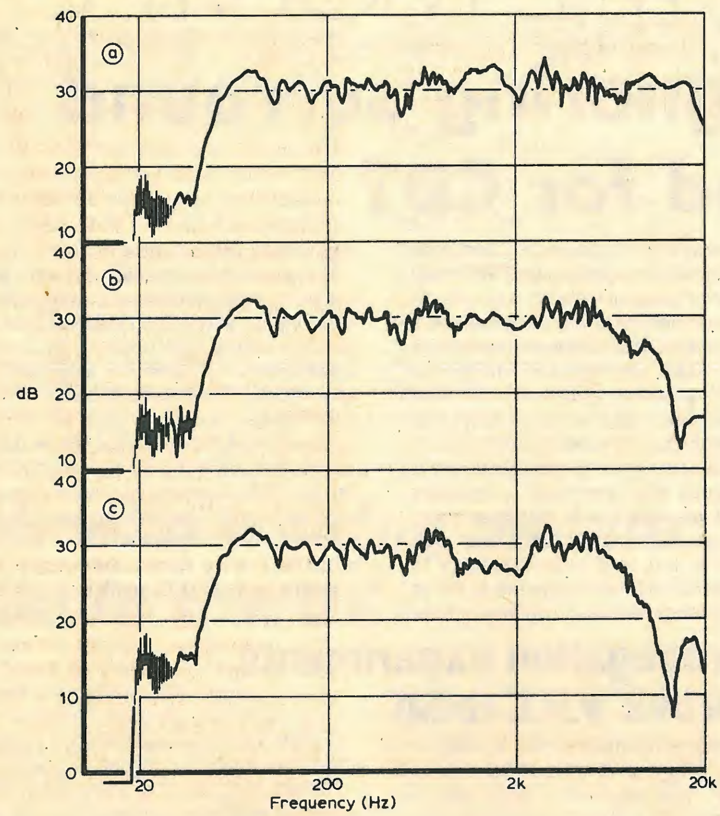
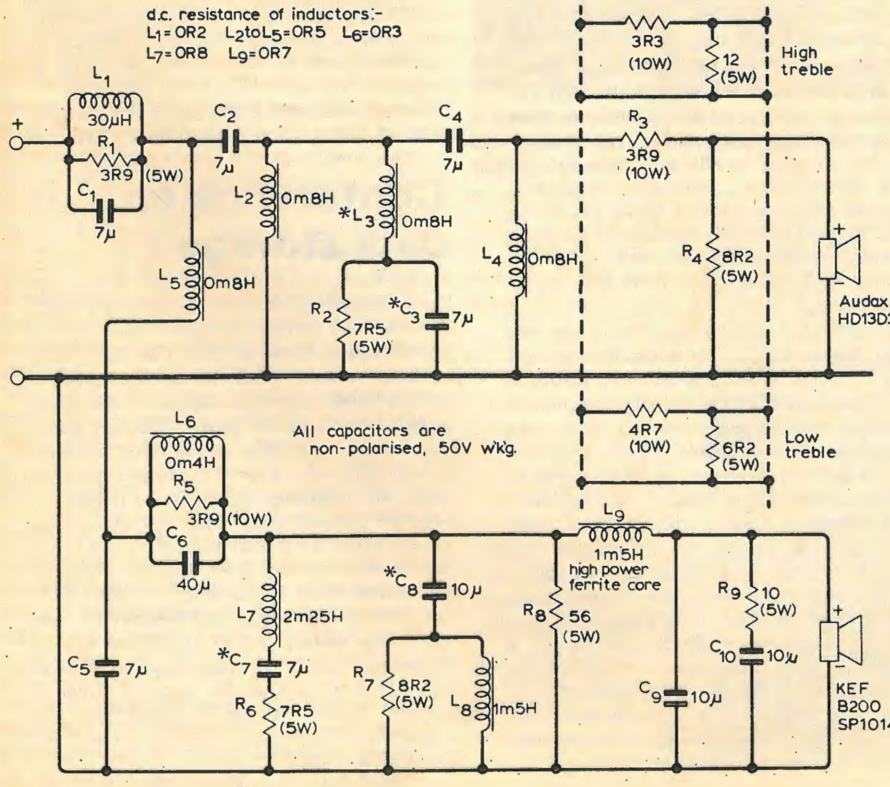


Fig. 10. *Three pressure responses of the complete loudspeaker*

(a) on axis (b) 30° off axis (c) 45° off axis

Fig. 11. *Full schematic of the cross-over network*



Jim Wilkinson studied at Sheffield Polytechnic prior to joining Marconi Elliott Avionics where he worked on raster-based avionic display systems. Subsequently he joined the IBA, working for over four years on digital video equipment, specialising in phase-locked-loops and differential p.c.m. coders. He is currently a project engineer in the advanced development laboratories of Sony Broadcast.

frequency in the audio band, using inductors from the recommended supplier. The network's design accounts for each inductor's resistance and the use of air-cored inductors is not recommended unless similar resistance values could be achieved. Further, the effect of using an active crossover network has been simulated and no real advantage emerged over the use of passive components apart from a slight improvement in the damping of the system resonance. Furthermore, the cost penalty for using an active network is quite high and does not have the flexibility of a passive network.

The author recorded the terminal impedance between 100Hz and 20kHz, which emerged as 8Ω (+3Ω or −1Ω) and 0° ±10° for magnitude and phase respectively, showing that the loudspeaker is easily driven by any amplifier.

Frequency traces were made using a Brüel and Kjaer frequency response recorder. The materials for acoustic damping of the cabinet comprise three bitumenised felt panels, approximately 9in by 7in and two pieces of BAF wadding, 36in by 9in. Where difficulties are experienced in obtaining the specified components and materials, these are all available from Falcon Acoustics, Tabor House, Norwich Road, Mulbarton, Nr. Norwich, or any of this company's suppliers.

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2. Kreyszig, Erwin. Advanced Engineering Mathematics, Wiley International, pp.440-453.

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Schroeder, Manfred R. "Models of Hearing," *Proc. I.E.E.E.*, Vol. 63, No. 9, September 1975.

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NEWS OF THE MONTH

Are Philips ignoring surround sound for CD?

Philips Compact Disc, first announced last May (WW August 1978, p. 39), is a miniature (115mm) version of the 30cm optical video disc recently test-launched by Philips Magnavox in the USA. Whereas the Japanese companies favour the idea of a single high-density player, capable of reproducing either video discs when connected to a colour television set or digital audio discs when connected to an audio system, Philips favours two players, one for video and one for digital audio. The accent is on miniaturization and Philips reject even the idea of a special player to handle both disc sizes.

The Compact Disc will be laser scanned while rotating at constant tangential velocity. This means a change of rotational speed from an initial 500 rev/min as the laser scans the centre tracks, decreasing to 215 rev/min as it moves to the outer edge. Coding is by 14-bit p.c.m. with a sampling frequency of 44.33kHz and parity bits for error correction. Left and right channels for stereo are encoded in time multiplex fashion, i.e. left and right-channel words introduced sequentially and alternately into the digital stream.

On paper, results from the CD system are predictably impressive; frequency response from 20Hz to 20kHz and a signal-to-noise ratio of 85dB without pre-emphasis and 92dB with pre-emphasis. Unfortunately a recent demonstration at Eindhoven, Netherlands, gave no real opportunity to confirm these figures by ear. The recordings played were lifted from analogue tapes and reproduced without any comparison with analogue originals or analogue pressings. Also the digital-to-analogue converters, a crucial link in the chain, were bulky beasts under the table on which the undeniably compact (cassette player size) CD player sat. Philips say there is no problem with miniaturization by large scale integration when – or if – the CD standard is adopted by record companies and hardware manufacturers around the world.

The biggest question marks concern pressing quality and compatibility with the future. The disc is single sided, and can offer one hour of uninterrupted stereo programme. To achieve this packing density the tracks are 1.66 μm apart and the pits are of variable length but a constant 0.6 μm in width. The disc is pressed from PVC, coated first with a reflective material and then with a protective transparent surface. The laser is auto-focused on the bottom of the pits. Thus warps and sticky fingers should present no problem. But will Western world pressing plants manage to press discs sufficiently blemish-free to play without problems? Only time will tell but there are already reports of a few of the first US video discs failing to track properly, apparently due to pressing faults.

Wireless World readers may also wonder about the one hour stereo capacity of the 115mm disc. Because encoding is sequential by time multiplexing any attempt to encode further channels of information, e.g. for three and four-channel surround-sound formats, will reduce the playing side to as little as half-an-hour uninterrupted per disc. This seems quite unacceptable for a system destined for the 21st century. The Philips engineers talking about Compact Disc displayed remarkable ignorance of surround sound developments by talking only vaguely of "no plans currently for quadraphonics". It was also argued that improved technology may extend playing time. Shorter wave lasers and tighter track pitching may well prove possible, but is it really sensible to launch a system with what appears to be an inherent deficiency and then rely on technology to take up the slack?

The question is especially relevant because just a few centimetres on the disc size would very readily solve the problem. But Philips seem unwilling and unlikely to consider a larger disc. At 115mm the Compact Disc is only slightly larger than a compact cassette and Philips envisage cars of the future equipped with CD players. If the disc were larger the player could not readily fit into current DIN standard car radio and cassette player mounts. Reading between the lines, it seems that the European habit of worshipping DIN with something approaching religious fervour still persists.

Adrian Hope

BBC propagation experiments to improve v.h.f. radio

A series of test transmissions on 90.3MHz from London's Crystal Palace station are providing BBC engineers with information which will hopefully be used to assist in the planning of improvements to the UK's v.h.f. radio service. These improvements are to be implemented in the next few years. The test transmissions are to continue for several months and will carry Radio 3 programmes*, with interruptions from time to time for announcements and other test signals.

The engineers are particularly interested in assessing the different types of polarization which can be used in built up areas. In the 1950's when the present v.h.f. network was planned, the most common type of receiver was a fixed mains set using an external antenna and consequently the transmitters, most of which were completed before 1960, used horizontally-polarized antennas. Since that time, however, v.h.f. portables and car radios have become available and are now widely used and in some parts of the country the v.h.f. signal is hardly adequate for the much less efficient, normally vertically polarized antennas, which these receivers utilize. In most cases the mobile and portable receivers are therefore receiving the spurious signals resulting from the cross-polarization.

Originally, the power output from the test transmitter was 1kW, but when this proved to be stronger than the normal Radio 3 transmissions in the local vicinity complaints were received from listeners and it was dropped to its present 250W. The transmitter antenna at Crystal Palace can be changed to provide circular, slant, vertical and horizontal polarizations so that the engineers can assess their effects and the differences between them when received on mobile, portable and home hi-fi receivers. A family car with a receiver and a magnetic-mount antenna is used to study the effects on a typical mobile radio and a 3/6dB yagi mounted 10m high on another vehicle is used to simulate the typical home hi-fi set-up for that part of the study. Portable experiments will also be carried out eventually.

In particular, the engineers are looking for differences due to multipath propagation.

For example, there is a concensus of opinion that multipath propagation can adversely affect stereo receivers, which for true separation require the correct phase reference across the band, but so far there is no strong evidence to support this. Two advantages with using vertical polarization are that firstly, most cars already use vertical antennas which are both simple and omnidirectional, and secondly, vertical field strengths are stronger than horizontal field strengths at ground level because there is much less ground reflection, and therefore less cancelling due to antiphasing. However it is suggested, but not proved, that vertical reflections result from vertical obstructions such as trees, pylons and buildings and cause more distortion to vertical waves than to horizontal waves.

* The normal Radio 3 service in the London area will continue unchanged on 91.3MHz.

Conference on data storage

An international conference on "Video and Data Recording" is to be held by the IERE from July 24 to July 27 at the University of Southampton. Since the previous conference in 1976, the area of activity has expanded to include developments in digital techniques in signal processing in both video and audio matters and especially storage and retrieval of data. Forty-five papers are to be presented under six headings which are "Theory of Recording Processes", "Magnetic Recording Techniques and Hardware", "Coding, Modulation and Signal Processing", "Digital Audio and Video Recording", "Information and Archival Storage and Retrieval", and "New Recording Techniques". Working equipment will be demonstrated in a small exhibition alongside the lecture theatre. Further details can be obtained from the Conference Registrar, IERE, 99 Gower St., London, WC16AZ.

Growth in European mobile radio market

According to a report by an international market research company, Frost & Sullivan Inc, the European market for mobile radio equipment of all kinds will increase by 60% in "real US dollar terms", at an average annual rate of 5.5% over the next ten years. The report gives a market figure for 1978 of $350 million (about £167 million) and predicts that this will reach $560 million (about £267 million) by 1987. The company's analysis shows that the annual growth rate in the first five years will be 7% and will significantly outpace the 4% growth rate in the latter five years.

Three quarters of the total West European market will, they say, be accounted for by four countries, West Germany, Britain, France and Sweden. Their cumulative contributions to the market over the ten year period are forecast as $2,300m (£1095m), $930m (£443m), $470m (£224m) and $860m (£410m) respectively, amounting to more than a $4.5 billion (£2.14 billion) market overall.

The report gives an analysis of the types of equipment in the market and this shows that private mobile radio systems will account for 75% of the total market; paging systems 13%, public correspondence systems 7% and citizens' band radio 5%. However, the report adds, "these percentages show market variations when analyzed by country."

In the **private mobile radio (p.m.r.)** sector, replacement equipment will take an increasing share of the market as p.m.r. becomes more complex. Anticipated regulatory changes and user demand for higher performance equipment will, according to the report, result in new developments such as selective calling, especially in congested channels. In addition, the ratio of mobile units to base stations will increase, particularly in Britain, though this trend may reverse over the longer terms as "small" users account for a greater market share.

The **public correspondence** sector, which includes all mobile radio equipment capable of being connected directly to the public network, is described in the report as "a relatively young market," with most countries planning to update from their current manual systems to fully-automatic, multichannel systems.

The faster growing sector in the mobile radio market is that for **pagers.** The number of units in use is expected to triple by 1987, with the value of equipment shipments increasing at a 7% annual rate. As modern v.h.f. and u.h.f. techniques are coming into use, says the report, once-popular inductive loop systems are becoming less and less important. In particular, the analysis showed that Eurosignal pagers, recently introduced into France and Germany, are very much in demand.

On the subject of **citizens' band equipment** the report points out that, although Japanese and UK companies currently dominate the market place, other suppliers are finding successful "niches" by specializing in products aimed at particular communities.

Other findings of the study indicate that imports will become increasingly important, especially in Britain, foreign vendors are switching to f.m., and France, described as an "attractive market to outside suppliers", is expected to double its expenditure on mobile radio over the ten year period.

- The possibility of operating land mobile radio communication systems with a channel spacing of only 5kHz by the use of s.s.b. has been privately demonstrated by Pye Telecommunications Ltd to people in the UK industry and potential users (see page 95). The use of s.s.b. for narrow band working has also been field tested by Dr Bruce Lusignan of Stanford University, USA, for the FCC in the States (News of the Month, June 1978, p.48).

Look who is using mobile radio in the UK

Without having to look at the national figures for mobile radio equipment sales, we can see from the many snippets of information coming into the *Wireless World* office whether or not the demand for such units is high. Last year we learned that hand-portable and mobile radios were being used by people like, and including, Harrods in London, for security purposes, by keepers in zoos, to enable them to summon help should they find themselves in the unfortunate situation of being mauled by one or more wild animals, and increasingly by farmers and council workers, among others, for keeping in touch with their colleagues when they are working in remote areas.

This year we can again conclude that the demand for mobile radio equipment is high because the snippets of information are even more numerous and the users of the equipment are just as varied. For example: Motorola Electronics have been selling selective-calling mobile radios to an emergency windscreen-replacement company in Swindon, whose vehicles operate in various UK counties. Pye Telecommunications have been providing mobile radio systems for the Isle of Wight ambulance service, Findus sales representatives, Lord and Lady Montague, to solve their communications problems at their National Motor Museum in Beaulieu, and Electricity Board cash collectors to protect them from thefts. They have also been showing horticulturists and farmers how radio communications can have a vital role to play in agriculture.

Pagers are Multitone Electric's speciality, and they have been providing them for Shell International's sports and recreation club, to keep members in touch with the clubhouse, Saville Colliery in Yorkshire, and the Grampian Fire Brigade. They have also supplied systems for the BP oil terminal in Fulham, London, and for the administration at the Brighton Centre, Brighton, for security purposes. Some of these pages are "bleeper" types but many are "pagephone" transceivers which permit some two-way communications.

Despite Burndept Electronic's recent problems (see p75, March 1979 issue) they have been supplying the Home Office with personal radios for the police, fire and prison services in England and Wales. In the six years up to the end of 1978 the total number of sets supplied to the Home Office was around 35,000. Their two-way radios are also helping to bring home the harvest in Chichester by ensuring that combine harvesters are in the right place at the right time.

A Multitone two-way pocket paging system aiding security at the Brighton Centre, Brighton.

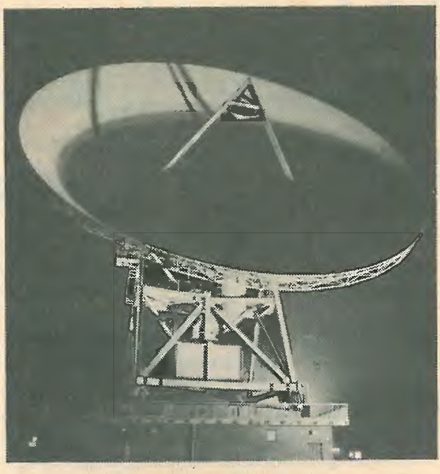
A Pye Telecommunications mobile radio system in use with the Isle of Wight ambulance service

PO's largest satellite earth terminal operational

The first earth terminal at the Post Office's new satellite earth station at Madley near Hereford was inaugurated by Mr Peter Benton, the PO's Telecommunications MD, on April 11. This terminal, Madley 1, is the second in six months to be handed over to the Post Office by Marconi Communication Systems Ltd, the prime contractors. The previous terminal, which became operational towards the end of last year, was Goonhilly 4 in Cornwall (see p.63, Dec. 1978 issue).

Unlike Goonhilly 4, which operates in the 11/14GHz bands to the test satellite OTS-2, Madley 1 operates in the 4/6GHz bands, currently to Intelsat IVA** over the Indian Ocean. It is one of the largest earth terminals operating in the Intelsat system and can be used with Atlantic satellites as well as Indian Ocean satellites. Madley 1, with its 32m antenna, which is almost twice the size of that on Goonhilly 4, has actually been in operation since Nov. 19, 1978, and provides a large capacity for telephone, telex and television traffic. With 55 chains of receiving equipment, 14 chains of transmitting equipment and ten high-power amplifiers, Madley 1 is capable of communicating with about 40 countries simultaneously and Marconi is already manufacturing equipment to extend this capacity.

Contracts have already been placed and work started for a second Madley antenna, which is to come into service next year, and another is to follow in 1981. According to the Post Office, Madley will eventually have up to six antennas and Goonhilly, which already has four operational antennas, is likely to get another four in the early 1980's. It is foreseen that Madley 1 will be used with the next generation of international telecommunication satellites, Intelsat V. This would double the system capacity.



Madley 1, the Post Office's largest dish antenna (32m diameter). It can carry up to 2000 phone, telex or computer data calls, as well as tv pictures, between Britain and East Africa, the Middle and Far East, India, Australia and New Zealand.

Marconi Communication Systems coordinated the efforts of an international team of sub-contractors, which included Mitsubishi Electric Corporation in Japan, Comtech in the USA, who provided the low-noise amplifiers, and IDC Ltd, Marconi themselves supplied the radio and communications equipment.

The complete station is built in modular form from a number of individual subsystems. The largest of these is the steerable parabolic antenna, supplied by Mitsubishi. The antenna building, housing the steering and control equipment, contains the high-power transmitter amplifiers, low-loss combiners, i.f./s.h.f. transmit drives, with their associated control logic, and the low-noise, cyrogenically-cooled broadband receivers. A central P.O. building houses the ground communication part of the system which includes the s.h.f. branching, s.h.f./i.f. downconverters, demodulators, modulators and base-bands equipment. This building also holds the cross-site make-up amplifier operating at the s.h.f. receiver frequency, fixed station test facilities and all associated control and monitoring equipment.

The new station will help the Post Office to meet the dramatic growth in international telephone services. At the present time there are 12 million phone calls to and from Britain every month and this is doubling every four or five years. Telex and computer data are also growing at a similar rate. Intercontinental calls to and from places beyond Europe account for 4 million a month, and six out of every ten of these go by satellite via Madley 1, or through the station at Goonhilly. Madley 1 presently carries one million calls a month between Britain and 40 other countries via Intelsat IVA and calls to some of these countries have been growing at 30% per year. At any one time it can carry more than 2000 calls — twice the capacity of Goonhilly 1 which previously carried the Indian Ocean satellite traffic. However, Goonhilly 1, the first terminal to carry satellite signals across the Atlantic in 1962, is still in use. It has been turned back to the Atlantic to provide extra capacity for the world's busiest satellite route between Britain and the USA.

The introduction of the new terminal coincides with the transfer of all the Indian Ocean earth stations from Intelsat IV, which has 4000 telephone circuits, to Intelsat IVA, which is capable of carrying 6000 calls simultaneously. Intelsat V, having twice the capacity of Intelsat IVA, is expected to be launched next year and within the next two years all the existing IVA satellites will be augmented by four Intelsat V systems — two over the Atlantic and two over the Indian Ocean.

IDC Ltd of Stratford-upon-Avon was appointed as contractor for the design and construction of the stations buildings and undertook the civil engineering work related to the antenna foundations and steelwork. There is no doubt that the antenna is a fine example of a product which is the result of many engineering skills and sciences.

** Intelsat IVA, 22,300 miles out in space, has 6000 phone circuits, television circuits and SPADE (a demand assigment system which permits greater flexibility and more efficient use of the satellite capacity). If used only for television the satellite has a capacity of 20 channels. It has 20 transponders permitting 20 channels each 36MHz wide.

Transmitter hijacking no joke

An IBA advertisement in the appointments section of *Wireless World* (p.137, April issue) was clearly an April fool's joke – an expensive one for the journal and a somewhat embarrassing one for the IBA – but nonetheless it has interesting undertones. The advertisement referred to a vacancy for an engineer to lead a team researching into operating procedures to protect the IBA's transmitters from being electronically hijacked (replacement of the ingoing programme signal with a private signal). Incidentally it also appeared in the April issue of *Broadcasting Systems and Operations*, the new broadcasting journal, and coincidentally found itself on the same page, number 137.

At first one might think "what fools the ad-men at these two journals are"; but no, the whole thing was very carefully planned, the timing was perfect and the "placer" had the required knowledge, relating to the advertisement procedures and copy dates of both journals, to carry it off without a hitch. The ads were placed initially by 'phone, confirmed by official purchase order on or very near the final copy date, and were already professionally prepared in photoset.

The advertiser knew that the IBA normally placed ads through an agency, even though the agency name used was different, and that such an ad placed at this late stage would not be suspect. *BSO* and *WW* received identical official purchase orders, they even had the same order number, 1171, and both came supposedly from Industrial Appointments Consultants at a London address (which turned out to be a printer's establishment). The telephone number was for a Croydon exchange and was a spare line. The wordings were identical and the initial phone call was supposedly made by Robert C. Jones in both cases.

Why did they go to so much trouble? One reason may be that they were drawing attention to their own hijacking successes in the past. For example, on April 1, 1976, a John Peel radio programme was interrupted when a BBC transmitter was hijacked – the advertiser signed the official purchase order "J. Peel". Some time later another BBC transmitter was hijacked. This time the transmission was supposed to be coming from the world's first broadcast satellite, K-sat – the reference given in the ad is "KS/AT".

So where does the IBA fit in? Well, towards the end of November 1977 a *News at Ten* programme was interrupted with "voices from outer-space" when the IBA's Hannington transmitter was hijacked. At the time this was not too difficult to do because the Hannington transmitter, like many others, is a rebroadcast link which receives audio and visual signals, on separate carriers, at one frequency near the broadcast frequency and re-transmits on the broadcast frequency. All the hijackers had to do was swamp the input "audio" frequency with a transmission on the same frequency near the Hannington site. The IBA did monitor the sound output at that time but for one reason or another this was missed. However, since then the transmitters have been fitted with extra protection circuits. Could it be that the hijackers in this electronic war are now frustrated by these defence tactics and are attempting to get their kicks another way?

POLICE COMMUNICATIONS

A news item in our April 1979 issue (p.82) pointed to an enlargement of the relationship between the Post Office, the Home Office and the police, centred on the introduction of a microprocessor-controlled police communications headquarters in Leicestershire. One or two details were inaccurate, according to a Department of Transport contact. While it is possible for a police patrol car driver to check immediately on the name and address of the *keeper* of any car, the age of a driver or keeper cannot be ascertained by such direct means. This data is apparently stored on files not immediately accessible to the police, although it is available via the daily up-date on driver and vehicle details which the department sends to what is believed to be the police computer in Hendon, and not to any police establishment in Swansea as suggested in our news item. The relevant phrase should therefore have read "through the carrier-operated main station to the Department of Transport computer in Swansea," and not "to the national police computer in Swansea."

Our Department of Transport contact suggested that the facility extended to the police via centres such as that in Leicestershire only permits the police to check on limited details of vehicles, and that there is no direct liaison between the department and the police.

NEWS IN BRIEF

A recently signed **franchise agreement links Semiconductor Specialists and Westcode Semiconductor,** the semiconductor division of Westinghouse Brake and Signal Co, Chippenham. This extends the range of semiconductor manufacturing companies distributed by Semiconductor specialists to eight, among which are General Instruments, Plessey, Siliconix and Thomson-CSF. The distribution will be carried out from Semiconductor Specialists' West Drayton base. Westcode manufactures heavy duty thyristors and rectifiers in ranges carrying up to 3000 amps and voltages up to 4kV, and a full range of silicon power transistors including 250 amp single diffused and 500V triple diffused types.

Akai has just announced the setting up of its first UK subsidiary, which, apart from the US, is its only major subsidiary to be established outside Japan. With 90% of the parent company's annual sales being made outside Japan the British base of operations is a rational step in the service follow-up. Akai UK, which was born in Cricklewood in February, will shortly move to a modern complex next to Heathrow Airport.

The **eighth Imeko Congress,** entitled "Measurements for Progress in Science and Technology," is to be held in Moscow from May 21 to 29, according to the Institute of Measurement and Control, a UK member organisation of Imeko. Further information from IMC, 20 Peel St., London, W8 7PD.

Air Call Ltd has entered into an **agreement** to become the national distributor for the commercial sector of the Mobile Radio Division of **Marconi Communication Systems,** Ltd.

British industry supporting UOSAT

The University of Surrey's project to build Britain's first amateur satellite is now being backed by British industry. Racal (Slough) Ltd have announced that they will support the project both financially and in other ways as it progresses over the next two years. Jim Crerar, managing director at Slough, said "This project by the University of Surrey is an extremely worthwhile and ambitious exercise and we are pleased to be involved. Although it is strictly an amateur satellite venture, I have been very impressed with the professional approach the University has taken. As the project unfolds over the next two years there will be several areas where we can mutually assist each other and so increase general knowledge of satellite communications."

The company is leading Racal's expansion into satellite communications and is currently undertaking a contract to supply the MoD Procurement Executive with a number of transportable satellite communications earth stations. So far, in addition to the financial aid — the company does not wish to disclose the amount – Racal has made test equipment available to the project team.

The project team is working in conjunction with the Radio Amateur Satellite Corporation (AMSAT) and the university's electronic engineering department towards a launch date in 1981-2. The spacecraft, to be known as UOSAT before launch, will be quite different from the present AMSAT Oscar satellites, which so far have specifically provided improved long-distance v.h.f./u.h.f. communications for amateur operators. UOSAT is intended to complement the Oscar series as an experimental and scientific amateur spacecraft, and its mission objectives are threefold. Firstly, "to provide radio amateurs with a readily available tool for the study of the propagating medium through which they communicate and to enable the amateur satellite service in particular to evaluate the suitability of novel methods and new frequencies for use in later amateur communications satellites". 'Secondly, "to stimulate a greater degree of interest in space sciences in schools, colleges and universities by active participation," and lastly, "to study the problems associated with an inexpensive spacecraft project in the UK and to establish an active body in this country contributing flight hardware to the AMSAT programme"—(ref. p.230, Radio Communication, March 1979). It has been proposed that UOSAT should provide the h.f. amateur with a facility for gathering real-time information on prevailing ionospheric conditions and also encourage more widespread interest and activity in microwave communication, at the same time evaluating these frequencies to see if they will be suitable for future AMSAT Oscar spacecraft.

There are three main groups of experimental modules proposed for UOSAT's payload. The ionospheric studies experiment is the first and is to include phase-referenced h.f. beacons on 7, 14, 21 and 28MHz (the main h.f. amateur bands), a magnetometer, and radiation counters. The second is an "education" experiment which will comprise an earth-pointing slow-scan tv camera, and a synthesized voice telemetry system. "Future systems" experiments modules will include s.h.f. beacons on 1.296 and 10.47GHz, an expanded CODESTORE system, a microprocessor housekeeping system and a two-axis stabilization system.

While most of the satellite's modules will be built at the university there will be opportunities for other amateur groups to contribute specific modules such as the s.h.f. beacons, the voice telemetry unit and the slow-scan unit. To support personnel, components and travel a sum of £85,000 has been raised and at a meeting in February this year the RSGB also agreed to support the project financially up to a limit of £2000.

Martin Sweeting G3YJO, the UOSAT project manager has stressed that there is a long way to go before the satellite reaches the launch pad and it may even evolve along different lines to those described and carry a "much-modified payload".

Home office publishes WARC proposals for the UK

United Kingdom proposals for the World Administrative Radio Conference to be held in Geneva from Sept. 24 to Nov. 30 were published on April 10. The proposals are in two parts. The first part comprises more than 300 pages and consists largely of the detailed changes the UK would wish to see made in the international Radio Regulations to cater for developments over the next 20 years. The second part, comprising 40 pages, contains a set of supplementary proposals of a more technical nature that take into account the results of a recent meeting of the International Radio Consultative Committee.

UK proposals for the international table of frequency allocations follow fairly closely the outlines given in the report issued by the Home Office in April last year – Preparation for the World Administrative Radio Conference 1979, see p.47, July 1978 issue. By transferring many of the world's international communications onto satellites (using earth terminals similar to Madley 1, see News story in this issue) the UK hopes to increase allocations in the h.f. bands for broadcasting services, maritime communications and for amateurs. The proposals seek to inject a greater degree of flexibility into the allocations in the h.f. bands when black-and-white tv has been phased out, and they also want an upward extension of the f.m. sound-broadcasting band. Again, to provide flexibility it is proposed that there be a degree of sharing between broadcasting and mobile services — spread spectrum methods could be used here.

In the u.h.f. and s.h.f. ranges the UK proposes numerous changes to cope with increases in satellite service requirements and to provide flexibility in future space or terrestrial services.

Broadly, according to the Home Office, the proposals seek to bring the radio regulations up to date and to cater for future frequency requirements as far as they can be foreseen.

AES European Convention

Highlights from the papers presented at Brussels

by a correspondent

WITH OUR involvement in the European Community growing almost daily, it seemed fitting that the 1979 Convention of the Audio Engineering Society should be held in one of the governmental centres, Brussels. Delegates attending came from unusually far afield and included three from the People's Republic of China! There were eight sessions in all. Those papers referred to are listed as references at the end of the article.

Locating items on cassettes

The topic of paper B-O was a digital technique for locating programme items on a recorded cassette and methods of automatically controlling the cassette machine functions.

A low frequency, 5Hz, signal is selected for the recorded code since, when recorded at −10dB below 250nWb/m, it would be inaudible at normal tape speeds. A separate magneto-resistive head is used to read the code, as it can be designed to obviate long-wavelength interference due to pole tip dimensions. By recording the code in anti-phase on the left and right tracks of the tape, signal-to-noise performance can be improved by noise cancelling in the head. The code may be read either in the 'play' mode, or in the fast wind modes either forward or reverse. For this reason identical synchronisation signals are necessary at the beginning and end of the code. These sync signals provide both a starting point and timing for the decoder.

Synchronisation is given by three cycles of a 5Hz sine wave, the frequency being identified by taking the mean of the first two cycles. A total of thirteen bits is allowed for the complete code, six of which are used for synchronisation and an additional four bits used for sync correction. The correction bits are located at positions 5, 6, 8 or 9 in the sequence. Of the remaining combinations, a full set of 'ones' is barred on the grounds that it might be confused with other extraneous l.f. signals. The remaining combinations offer a total of 71 addresses. Codes one to fifty are assigned to addresses, 51 is reserved to indicate the last item on either side of the tape and the remainder are given to special functions, possibly including slide projector control.

To allow for the inertia of the tape and mechanism in the fast wind mode, the code is recorded such that a 2-second gap is left between the end of the code and the beginning of the next programme item. Adjustment of the tape to bring the playback head into this space is achieved by first stopping the tape with the playback head in the tail of the previous item and then switching to play mode, but with the replay amplifier muted. This allows the tape to be moved forward at low speed for about 4.5 seconds, bringing the playback head into the correct location on the tape. This requires that the code be superimposed on the tail of the previous recorded item.

Detection of the signal prior to the microprocessor stage is achieved by the simple circuit of Fig. 1. Additional suppression of audio or other interference signals on the tape is obtained by locating the magneto-resistive head some 0.4mm from the tape. This has the effect of a wavelength dependent low-pass filter.

Microprocessor controlled cassette recorder

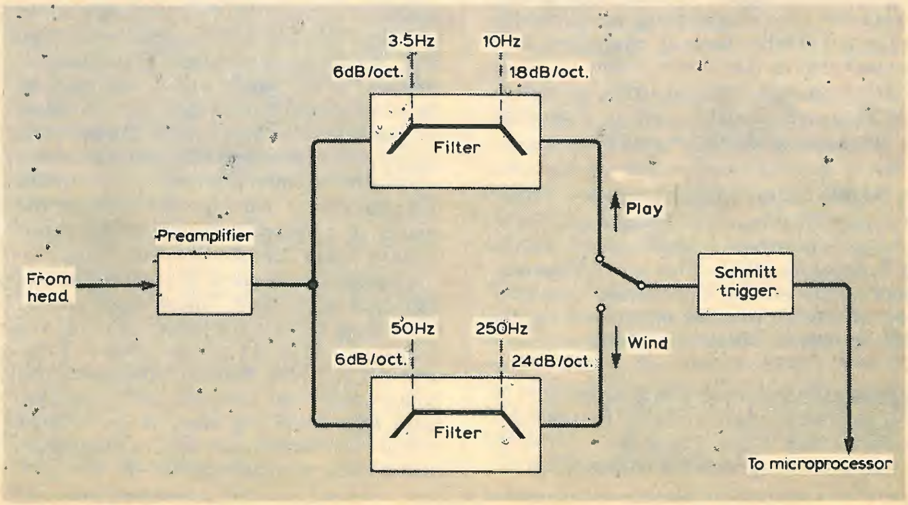
A microprocessor controlled system of optimising bias, record preemphasis and record amplifier gain of a cassette recorder having only a single combined record and replay head was described in a paper presented by the chief engineer of the JVC tape recorder division (B-1). The record amplifier gain adjustment is required to ensure the correct working points for the compander noise reduction system.

The design is best described by the sequence of events leading to the optimisation of the record channels. A blank tape is inserted in the machine and the type of tape selected using two front-panel keys. These switch the replay amplifier to the correct time constant and set the record amplifier to conditions suited to specified recommended tapes.

Further 'fine tuning' of the record system is obtained, if desired, by operating the 'start' key on the microprocessor control panel which initiates the following sequence. The tape is wound in the 'fast forward' mode for 2.5 seconds, to skip the tape leader. Then the machine switches to the 'record' mode and proceeds without recording any signal for 2.5 seconds. This space permits some positioning errors in subsequent rewinding and play operations. An indexing tone burst signal is then recorded, followed by a 1kHz reference and a series of 32 sections of a 6.3kHz test tone. At each of the sections, the bias signal is altered by a small amount. The total recording time for this sequence is about 2 seconds.

The tape is then rewound and the recorded section replayed. Using analogue-digital conversion, the level of each 6.3kHz section is compared with that of the 1kHz reference. The correct bias is assumed to be when the two

Fig. 1. Detection circuit for locating items on cassettes.



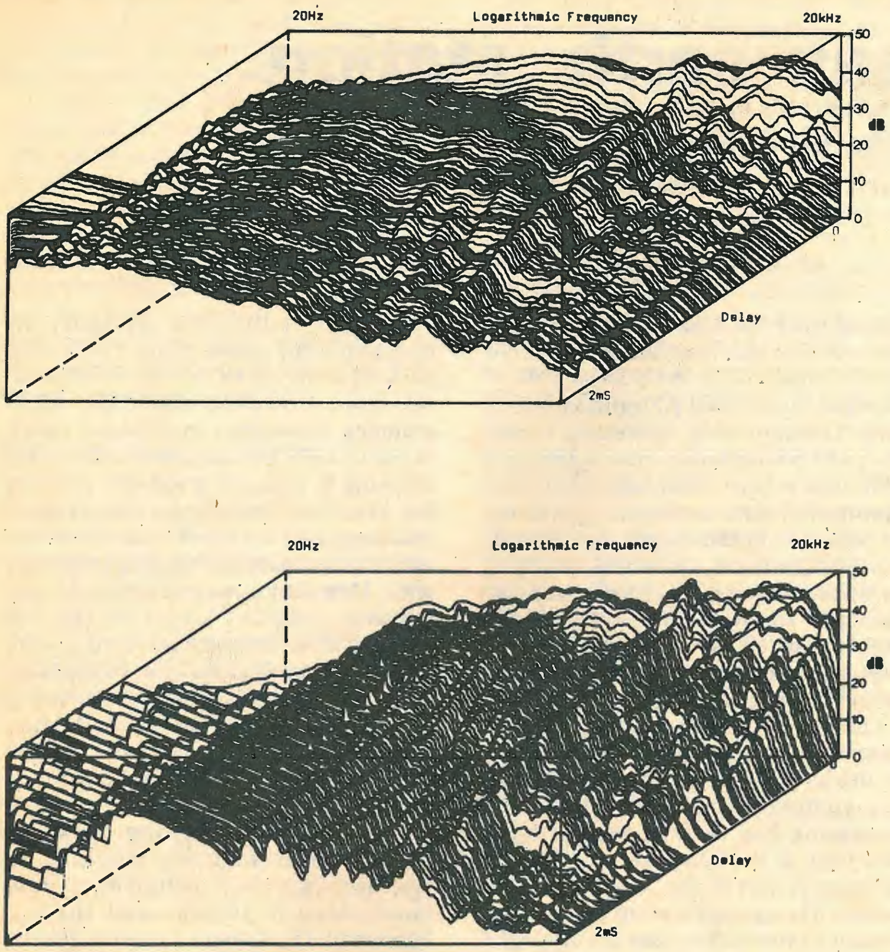


Fig. 2. Three-dimensional displays of decay spectra of loudspeakers, with logarithmic frequency scale of 20Hz to 20kHz: (top) impulse analysis; (bottom) tone burst analysis.

signals are equal. At this point, the microprocessor sets the appropriate bias and switches the machine to the record mode.

After a further 2.5 seconds blank, the indexing tone is again recorded, followed by a 1kHz reference and a series of 18 steps of a 10kHz test tone. During this, the record pre-emphasis is increased, first in the left and then in the right channel, through 8 discrete values. Finally, a 1kHz signal is recorded while the record amplifier gain is switched through 16 steps. The tape is rewound and replayed to determine the correct values of pre-emphasis and record amplifier gain, these values being successively set by the microprocessor.

At the end of each of these sequences, l.e.ds light to indicate successful completion. Errors due to drop-outs or malfunction of the tape transport cause an error lamp to flash and the sequence to halt, pending the operation of either the 'reset' button or the 'start' key.

3D loudspeaker measurements

In a brilliant though extremely rapid presentation (D-4), Peter Fryer and Gareth Millward of Rank Hi-Fi (Wharfedale), described some elegant solutions to the problems of measuring decay spectra in loudspeaker components and systems.

The Fast Fourier Transform method of obtaining cumulative decay spectra is well known and has been pioneered by KEF Electronics. This paper describes an alternative method of obtaining identical information using impulses or tone bursts and a simple detection system designed at the Wharfedale laboratories. A further advantage is that the 'three-dimensional' display can be produced with a logarithmic frequency axis, improving the resolution at low frequencies (Fig. 2). The disadvantage of this system when compared to the FFT digital method is that an anechoic chamber is required to ensure adequate signal to noise discrimination.

Digital audio discs

Digital audio discs are very much a subject of popular and current concern, since development is being temporarily arrested pending international agreement on standards. The prototype systems shown or discussed during the digital audio session represented proposals put forward by JVC, Sony and Philips respectively. At this stage the most complete proposal has been made by Philips (described elsewhere in this issue) with JVC and Sony putting foward ideas which are clearly at an earlier stage of development.

The JVC audio digital disc system (Paper G-1) is the only proposal which relies on a non-optical method of scanning. Like the Sony disc, it is a modification of their video disc, the only changes being in the speed of rotation (half NTSC video speed, 1800 r.p.m.), 900 r.p.m.

The disc is a standard diameter plastic pressing, similar to a conventional audio disc and capable of being pressed by a standard audio pressing plant. The plastic is conductive, since the pick-up system relies on capacitance principles. Fig. 3 shows a magnified view of the modulation, which consists of a train of pits comprising the audio or video signal, and a secondary series of longer pits between, which provide tracking signals to assist in servo-control of the pick-up assembly.

Since there are no grooves in the disc,

Continued on page 64

References (by paper number)

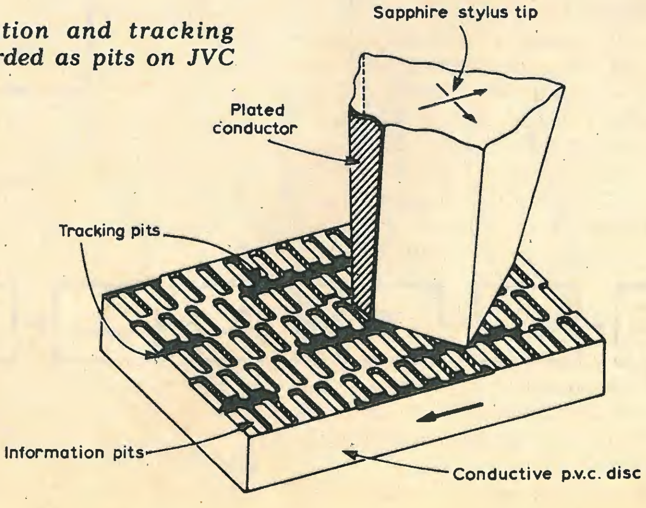
B-0. Simons, H. "Computer coded search system for compact cassettes."

B-1. Kitamura, M *et al.* "Automatic characteristics setting in the compact cassette player."

D-4. Fryer, P. A. and Millward, G.P. "Analogue loudspeaker measurement with '3-D' display."

G-1. Inoue, T *et al.* "Digital audio disc (AHD) system."

Fig. 3. Information and tracking modulation recorded as pits on JVC audio digital disc.



Meteosat earth station

A low-cost receiver for meteorological facsimile pictures

by M. L. Christieson

The geostationary satellite of the European meteorological community, Meteosat, is providing user stations with data far in advance of previous meteorological satellites, both in quality and quantity. It is located over the equator at zero longitude in an orbit such that it appears nearly stationary as seen from the earth. The satellite was developed by the European Space Agency (ESA) and was placed in orbit on November 23, 1977, by NASA. This article describes an earth station which can be used to receive Meteosat picture transmissions. The satellite's high orbit permits pictures of the whole globe to be obtained instead of just a slice of Europe.

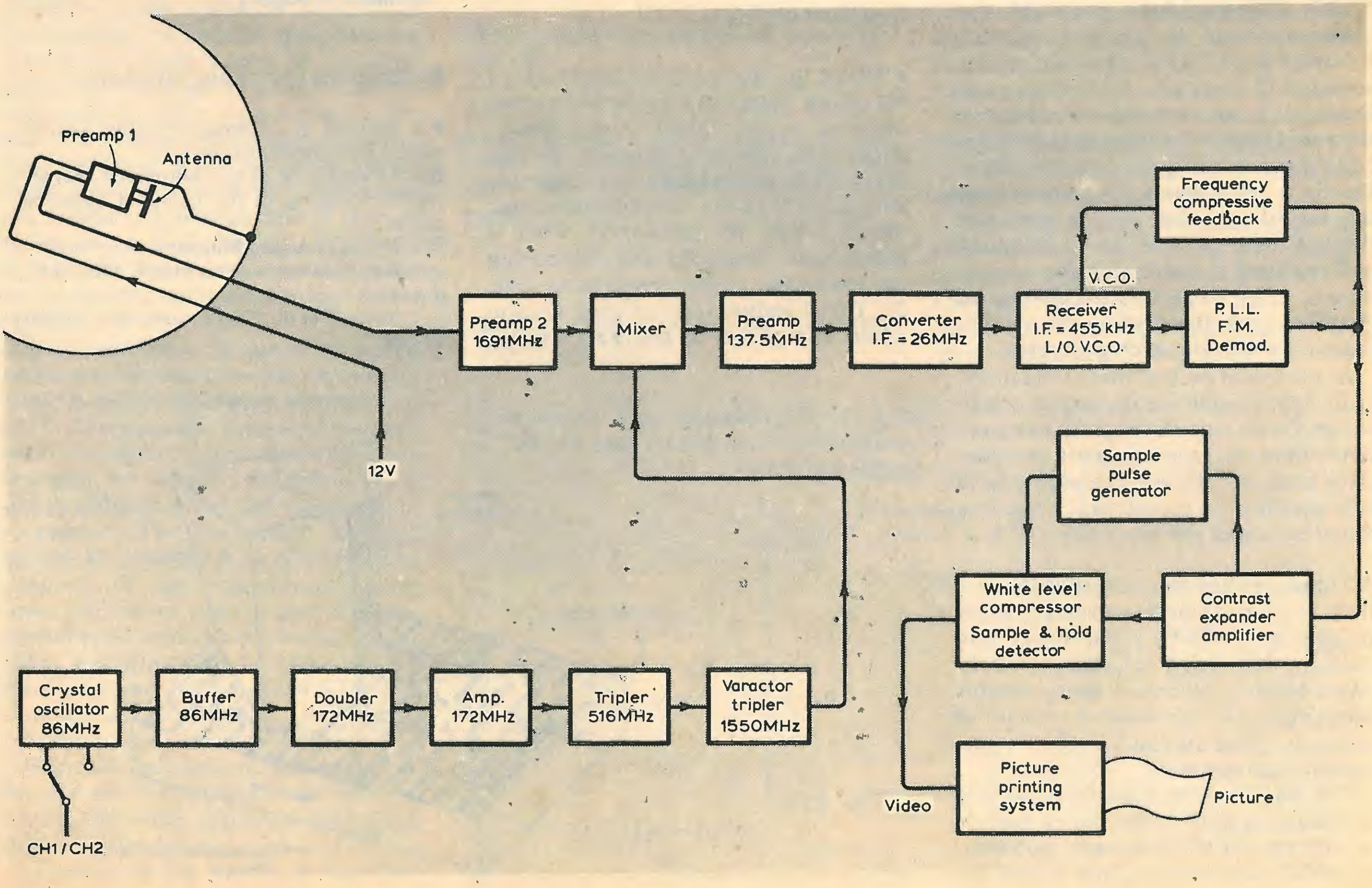
METEOSAT is more than just a simple picture-taking platform. It is an essential link in a meteorological data collection and dispersal system. It takes pictures of the earth in visual, infrared and water vapour light every half hour, extending nearly 70 degrees great circle, and then transmits these to the ESA operation centre (ESOC) at Darmstadt, Germany, in digital form on a channel in the S band. After optical correction and dissemination at ESOC, the pictures are relayed daily via Meteosat to user stations in Europe amd Africa on two further channels in the S band both in analogue mode (WEFAX) and as digital data. Transponders, operating in the u.h.f. and S bands, also interrogate and relay information from land-based environmental data collection platforms for collection at Darmstadt. In addition, selected pictures from the GOES E satellite, which performs a similar function to Meteosat over South America, are relayed by Meteosat via a receiving station at Lannion in Brittany for use in Europe.

The data relayed on the two dissemination channels are convenient for use by low-cost stations as much of the complex and thus high cost processing has been done by ESOC. ESA regards the computer at ESOC as an integral part of the satellite optical system. The ground station operated at present by the author uses the analogue signals and is referred to as a "secondary data user station" (SDUS). The possibility of using the higher resolution digital data is being investigated.

The author had a system, based on previously published designs, in operation for some time receiving pictures from the NOAA series of polar satellites. However, when the v.h.f. scanning radiometer in NOAA-5 failed in March 1978, he was prompted to start thinking in terms of a suitable receiver for Meteosat. Standard v.h.f. designs had been used for the NOAA series but with the necessity of changing to S band with Meteosat a new approach was required.

The carrier frequencies used in the S-band transmissions are 1694.5MHz and 1691.0MHz on channels 1 and 2 respectively, each frequency modulated by a 1200Hz subcarrier, with a peak deviation of 9kHz. The subcarrier is amplitude modulated with 80% modulation representing a white picture level and 5% modulation representing a black picture level. Base band video is 1600Hz and the r.f. bandwidth (by Carson's rule) is 26kHz. It can be seen from this that the type of modulation used with Meteosat is the same as that used with the SR

Fig. 1. *Block diagram of Meteosat earth station.*



(Scanning Radiometer) pictures from the NOAA series and the APT (Automatic Picture Transmission) pictures from ESSA-8 and ATS-3.

A three-second, 300Hz tone signal is transmitted at the start of the picture and this is followed by a five-second phasing signal of white level, containing 12.5ms of black level, which indicates the start of each line. The picture is transmitted in 200s and comprises 800 lines, produced at the rate of 240 lines per minute, each of 800 pixels (horizontal picture points). A five-second, 450Hz tone indicates the end of the picture signal.

Low-cost receiver systems

A block diagram of the Meteosat earth station is shown in Fig. 1. To reduce image noise^2 an intermediate frequency of 100MHz or above is recommended for converters of this kind and the author's existing system, which could receive the NOAA-5 frequency of 137.5MHz, therefore made a convenient first i.f. stage.

At these frequencies the most suitable antenna is the parabolic dish. However, the one used in the station being described is only some four feet in diameter, and is much smaller than the size recommended by ESA. If the dish was still smaller it would result in a poor signal-to-noise ratio. The feed is a simple dipole and reflector with a pre-amplifier mounted at the dish focus. A balun was not used because the author did not have the test equipment required for its adjustment. The r.f. amplifiers are identical in design and construction and use the same type of transistor. The amplifier's schematic diagram is shown in Fig. 2. The tuning elements are striplines fabricated on double-sided 1/16in G10 glass fibre board. The copper is left intact on the reverse side and provides the ground plane for the striplines. The transistors operate with their emitters grounded so the bias is critical even though some degree of d.c. negative feedback is used. Small trimmer capacitors tune the lines to resonance and are adjusted on test.

Fig. 3 shows the mechanical design of the antenna pre-amplifier, complete with its antenna and reflector assembly, and Fig. 8 shows the second amplifier which is bolted on to the mixer. The boxes for these assemblies are also made from copper clad board and it is very important when constructing them to maintain a good earth connection from the earth plane to the box sides which connect to the r.f. sockets. The only difference between the two amplifiers is the value of the bias resistance in the antenna pre-amp required to give the best signal-to-noise ratio on test. In pre-amp 1 this is a 2.2kΩ preset and in pre-amp 2 it is a fixed resistor. The supply voltage to the antenna pre-amp is carried out to the dish on a separate cable, and the output of the pre-amp is carried to the amplifier in the converter by a short length of UR67 coax (not more than 10 feet).

When the system was first tested using two BFR34A transistors, which are quite inexpensive, the pictures received showed considerable noise.

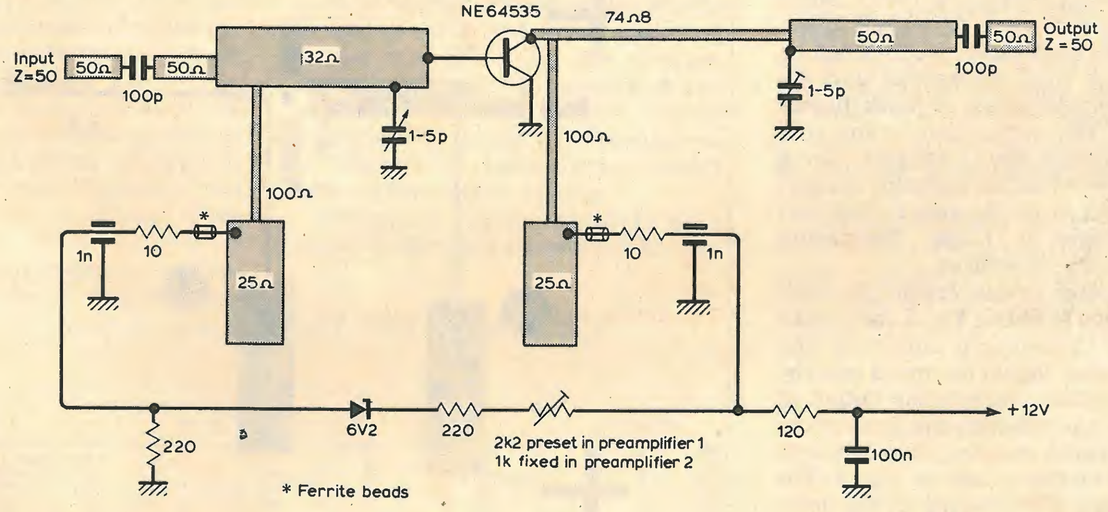


Fig. 2. *Schematic diagram of pre-amplifier circuit.*

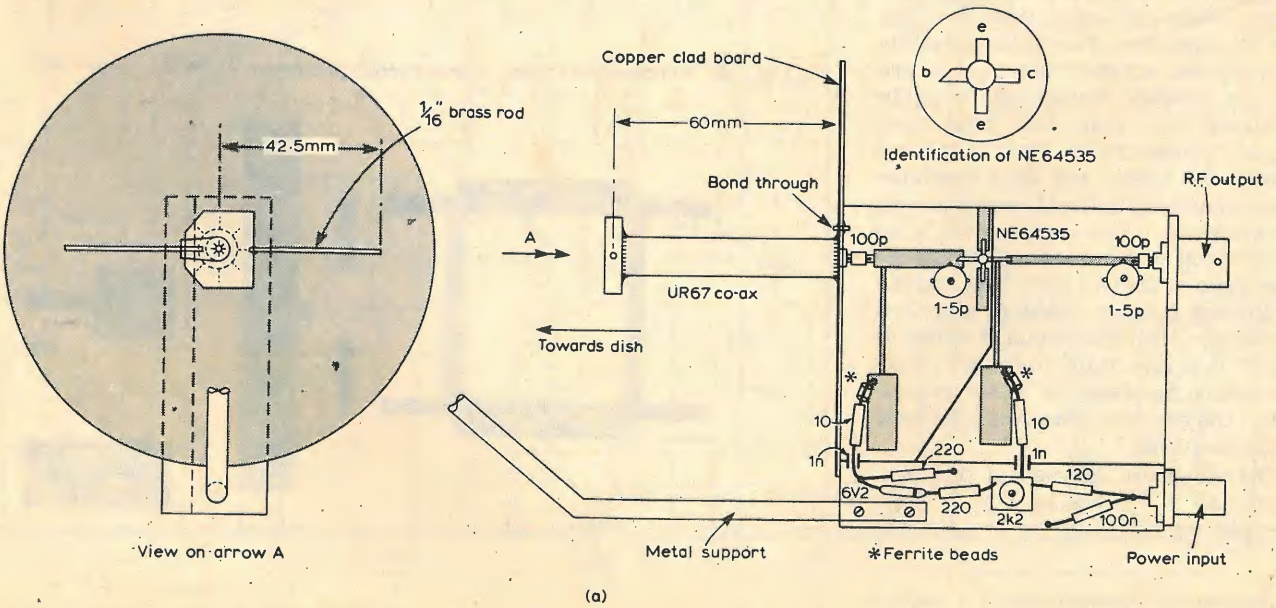


Fig. 3. *Mechanical design details for antenna and pre-amp 1. Scale is half full size.*

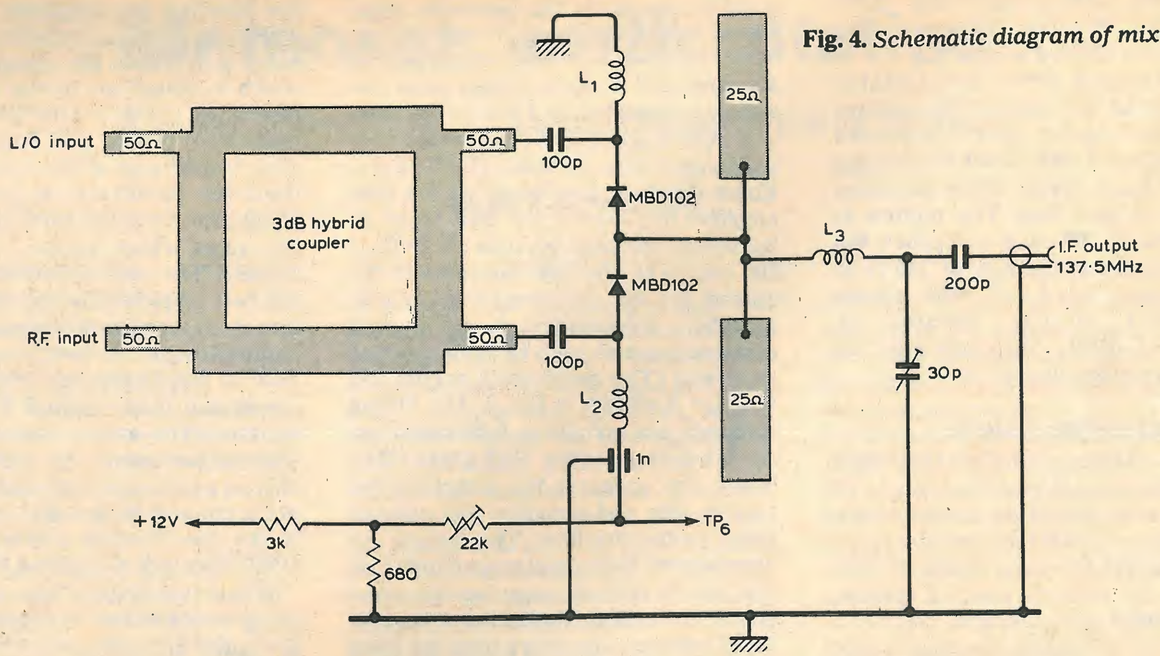


Fig. 4. *Schematic diagram of mixer.*

Two better types, NE64535s made by the Nippon Electric Company, were therefore obtained. Although these devices are more expensive they can be obtained in small quantities* and the pictures produced are of much higher quality. The important transistor characteristics are as follows: For a frequency of 1.6GHz, collector current of 8mA and V_{cc} of 8V, gain is 12dB and noise factor is 1.6dB. Maximum collector current is 65mA.

The printed circuit layout for both amplifiers is shown in Fig. 5 and for the receiver to function correctly the stripline sizes should be copied exactly. A 50Ω stripline connects the output of the second amplifier to one input of the mixer hybrid coupler. A schematic diagram for this shown in Fig. 4. The other input is connected to the local oscillator chain output. Two hot carrier diodes, MBD102 types, were used in the mixer. These performed very well and are inexpensive. The 22kΩ preset is initially set so that the diodes are slightly forward biased and is again adjusted on test for the best signal-to-noise ratio. Two r.f. shorts remove the carrier and local oscillator before matching to the i.f. output via an L network. The mixer is also constructed on the same type of copper clad board as the two pre-amps, and the earth plain is again retained. A printed circuit layout for this circuit is shown in Fig. 6. It is important to ensure direct connection between the mixer ground plane, the amplifier plane and the local oscillator plane.

The schematic diagram of the local oscillator is shown in Fig. 7. Two crystals are necessary to provide the

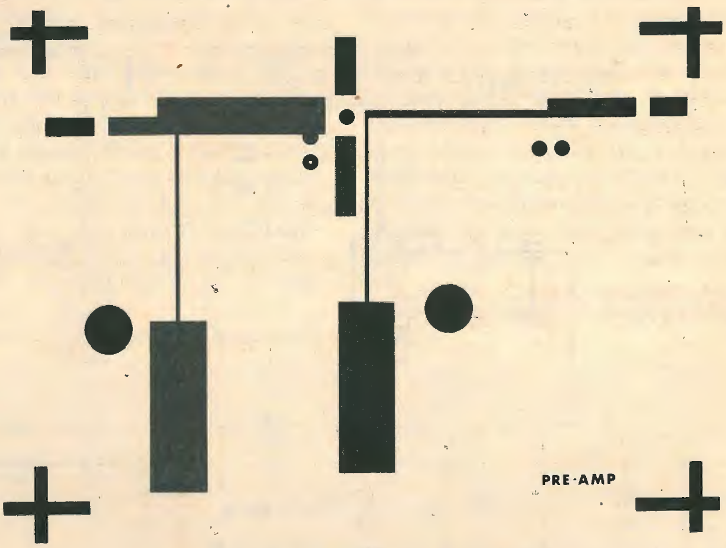


Fig. 5. *Printed circuit layout for pre-amps 1 and 2.*

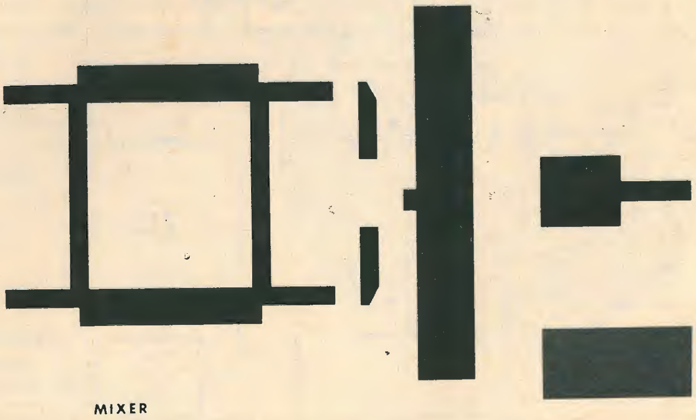


Fig. 6. *Printed circuit layout for the mixer.*

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*Available at approximately £13 each in small quantities from Auriema Ltd, Microwave and Electronic Instruments Division, 442 Bath Road, Slough, Berks, SL1 6BB.

two frequencies on which the satellite operates. Switching is achieved by using two d.i.l. reed relays, but diode switching could be used if preferred. The output of the oscillator, which operates in the fifth overtone mode at approximately 86MHz, is amplified by a buffer. Any tendency towards self oscillation is prevented by a resistor connected from collector to ground. The value of this resistor can be varied and for best results the largest value which gives stable operation should be used. A frequency doubler stage follows, bringing the frequency to 172MHz. This is amplified and then used to drive a tripler, producing 516MHz. This is a stud type transistor mounted upside down by the emitter straps. A small heatsink is bolted to the upward facing stud. The collector circuit is coupled to a varactor tripler and matching is achieved by a capacitor combination with L_6. A second harmonic idler circuit is formed by L_7, feeding the varactor, a 1N5139. The correct frequency is selected by a filter comprising L_8 and L_9 which are both tuned to 1550MHz and are mounted next to each other. A small length of 50Ω stripline feeds the output to the mixer. Test points for monitoring the current in each stage are used for adjustment, and the final filter tuning is achieved by monitoring the mixer diode current at TP_6. There is more power available at 516MHz than is really necessary, but this gives a large margin of error when tuning the system.

The entire chain is constructed on the top surface of a copper clad board, using further pieces of board mounted vertically as interstage screens. The mechanical construction of the converter is shown in Fig. 8.

Converter adjustment

Initial alignment of the oscillator chain can be achieved without an antenna. The mixer bias should be set to minimum and all capacitors set to about half their maximum values. Power is then applied to the converter from a stabilized 12V supply capable of providing up to 750mA. The output of the crystal oscillator should be checked using a frequency counter or an absorption wavemeter. The buffer collector circuit should then be adjusted for maximum current in the doubler, measured at TP_3. The doubler can then be resonated, as indicated by maximum current in the amplifier at TP_4 and the current taken by the tripler can be checked by measuring the voltage at TP_5 with respect to the 12V line. This voltage should be peaked by the amplifier collector circuit, the tuning capacitor, and the variable coupling capacitor. These are interactive. At this point an absorption wavemeter should be used to check that all the preceding stages are tuned to the correct frequencies and all re-peaked for maximum current in the tripler transistor. L_5 should be resonated to 517MHz and this should also be checked with a wavemeter or counter.

Preliminary adjustment of the final tripler is achieved by monitoring the voltage at TP_6. This should be approximately 0.7V with no oscillator drive and should decrease to almost zero when the chain is correctly aligned. It is very easy to tune the tripler to the wrong harmonic and the only sure way is to use a microwave meter or a signal generator tuned to the satellite frequency and loosely coupled to the r.f. amplifier while listening to the 137.5 MHz output. At this frequency most of the capacitors are near or at their minimum value and the drop in voltage at TP_6 is quite sharp. A receiver set to 137.5MHz on the i.f. output should show an increase in noise when the chain is adjusted correctly.

In the absence of a suitable signal generator, a u.h.f. television tuner can be used by setting the u.h.f. local oscillator in the region of channel 68, as seen on another television set, and extracting the oscillator output. Sufficient level of second harmonic, which is approximately the satellite frequency, is available for tuning the r.f. amplifier and checking the converter local oscillator chain. Another increase in noise at the i.f. should be detected when the r.f. amplifier is tuned.

Table 1 shows the voltages at all the test points measured on the prototype. These should be compared with those obtained during the adjustment procedure. The collector currents of the pre-amplifiers should be approximately 10mA.

The antenna assembly (without the dish) should then be connected to the length of cable that will eventually be used to feed the dish. Once the collector current has been set to 7mA the

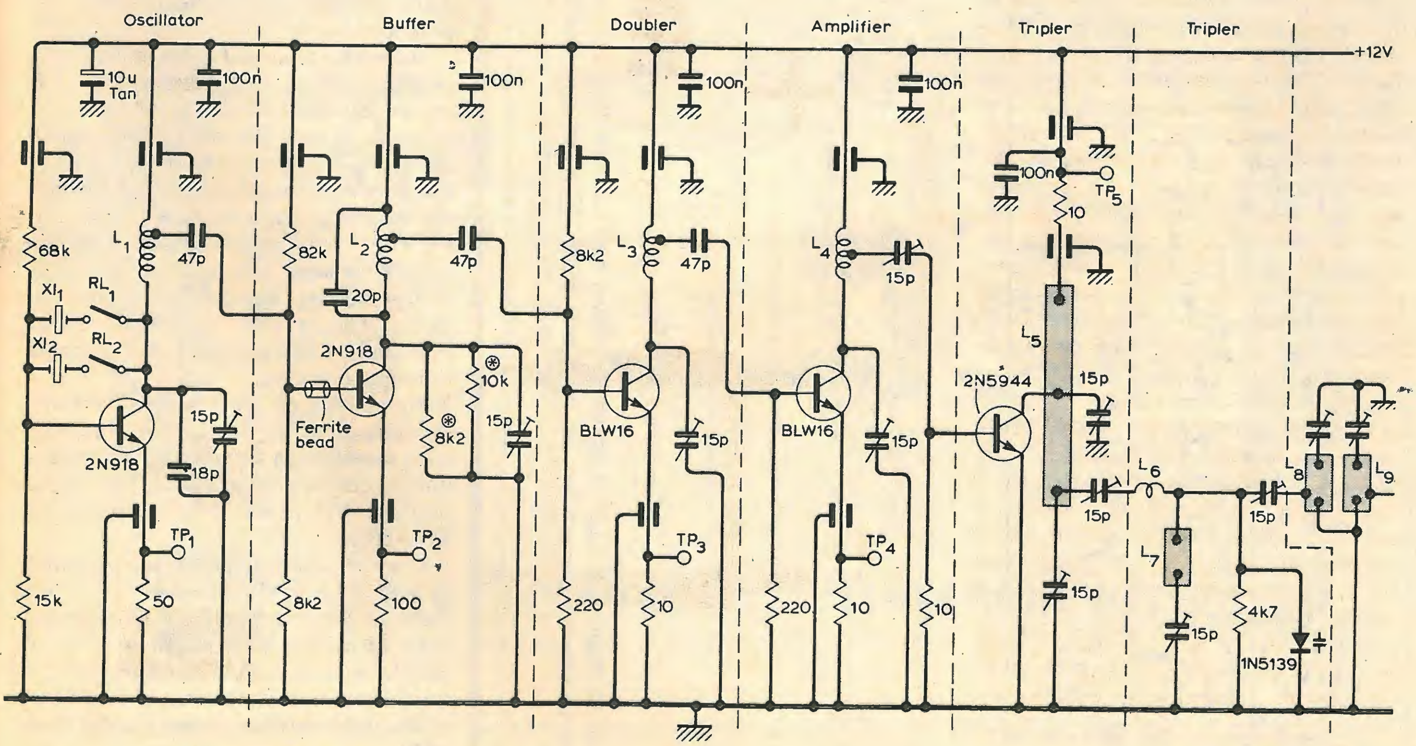

Fig. 7. *Local oscillator circuit.*

All feedthroughs: 1n
Dotted lines show the position of screens
Xl_1: 86·500MHz
Xl_2: 86·3055MHz } HC18/U 5th overtone crystals
⊛ As required – see text
Output: 1550MHz, 50Ω

pre-amp can be adjusted either for maximum noise at i.f. or by using the signal generator very loosely coupled to the antenna. When tuned, the system should be very sensitive to the signal generator output from several feet away.

The next step is to align the dish in the correct position. This of course depends on the user's location and can be obtained from the satellite position. From southern England its position is due south at an elevation of approximately 30°. The dish must have an unobstructed view of the sky in this direction and a small amount of directional adjustment must be possible. The antenna assembly should then be installed in the dish focus, with the dipole horizontally polarised. The system can then be switched on.

Although transmissions are quite regular, the satellite is not on all the time and the schedule is subject to change, so some period of monitoring may be necessary before a signal is heard. The signal may be recognised by the switching-on tone and the characteristic throbbing 2.4kHz subcarrier at line rate (see picture characteristics). Once a signal has been received the whole system can be re-adjusted for maximum signal.

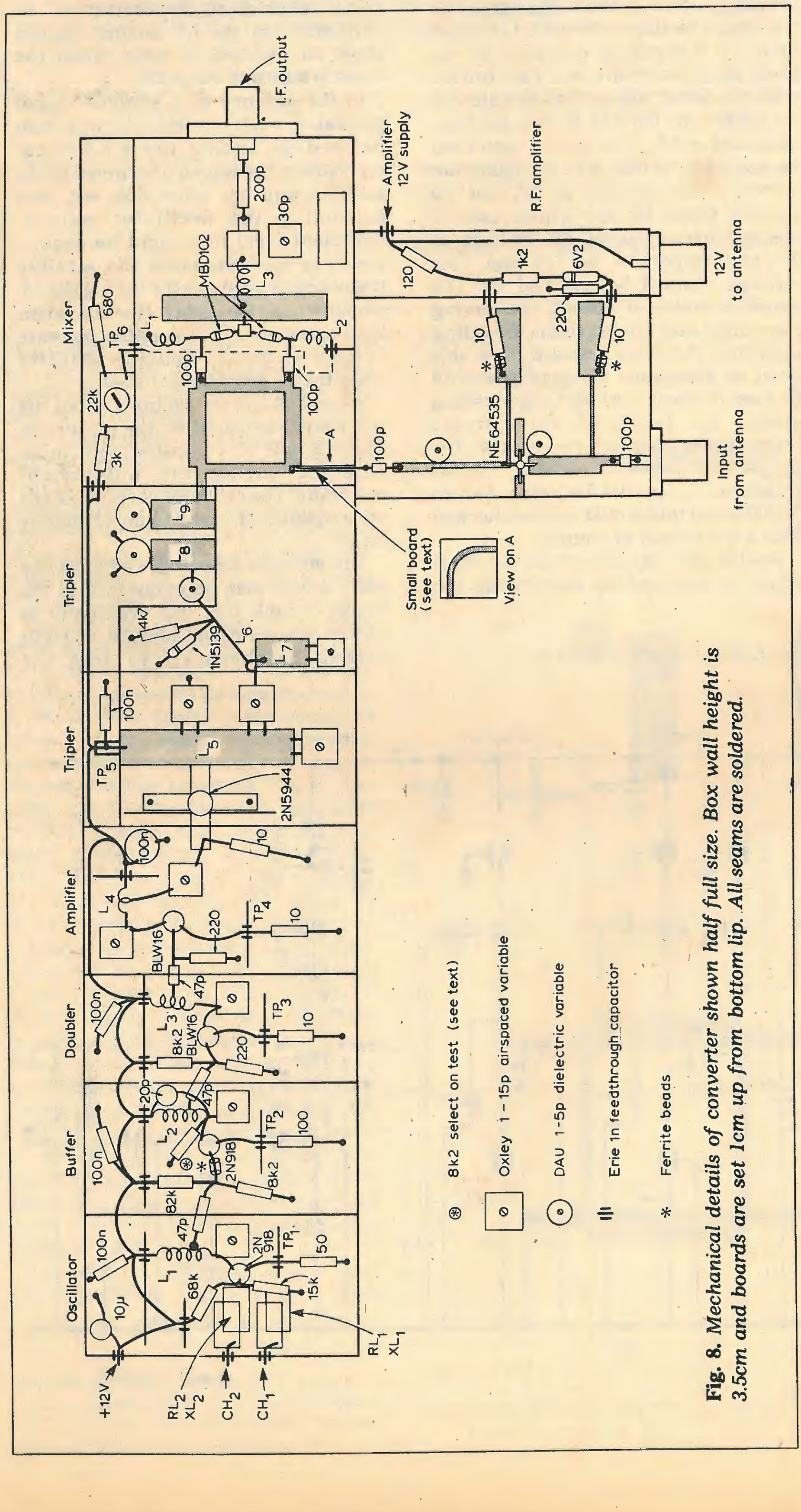

Fig. 8. *Mechanical details of converter shown half full size. Box wall height is 3.5cm and boards are set 1cm up from bottom lip. All seams are soldered.*

Table 1

Test point	Oscillator on	Oscillator off	
1	0·50	0·66	With respect to earth
2	0·47	0·39	
3	0·21	0·00	
4	0·48	0·00	
5	−1·97	0·00	With respect to +12V line
6	0·08	0·71	With respect to earth

Supply voltage : 12·01V
Oscillator disabled by selecting neither crystal

References

1. Vollhardt, D., Mixer and pre-amplifier noise, *V.h.f. Communications*, Winter 1976.

(To be continued)

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continued from page 59

the 'stylus' actually consists of a block of sapphire with a flat base which rides on the surface with very little wear. The trailing edge of the stylus is plated with a thin conductor which, with the material of the disc, acts as the two plates of a capacitor. The capacitance of this system varies as the dielectric constant changes, with the presence or absence of a pit.

The stylus is mounted on quite a long (approx. 2.5mm) cantilever which is driven by motors along its axis and laterally across the disc. These small servo motors compensate for minor tracking errors and correct for timebase errors that might arise due to disc flutter. The whole cantilever is mounted on a pick-up arm which itself traverses across the disc. Random access and, for video, stop or slow motion is readily provided by the addition of a separate random access unit.

Modulation on the disc is video frame synchronised f.m. carrier with a pulse code modulation decoded by a separate unit. Quantisation is a 14 bit non-linear process with a sampling frequency of 44.056kHz.

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Aspects of the Sony digital audio disc system will be published in a continuation of this report.

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Putting an arrow on TV

Design and construction of a movable pointer for positioning on a television screen

by **M. K. Cook,** B.Sc., G6AMB/T, University of Salford

The arrow used by television broadcasters as a pointer on monitor screens was thought to be useful in closed-circuit television. In lecturing for example when the camera is connected to a microscope objects of interest can easily be indicated. It has proved ideal in the author's amateur television station. And with the advent of home video recording this device could be a handy addition to the camera.

A TELEVISION PICTURE is generated by an electron beam scanning across the phosphor-coated face of a cathode ray tube in a zig-zag fashion from top to bottom to give a raster. To build up a picture on the screen the brightness of the trace must be varied and the receiver raster must be in synchronism with the picture source. To achieve this, line and frame sync pulses are produced from the picture source at the end of each line and frame. These sync pulses are used to synchronize the arrow generator to the picture source with which it is mixed. They can be obtained from a simple test circuit, described at the end of this article. Monostable circuits, triggered from the sync pulses, are used to control the position on the raster where the arrow will appear, Fig. 1. The arrow pattern is produced by a character generator.

The first frame sync pulse triggers the vertical monostable delay; when the correct vertical position is reached on the scan, the horizontal monostable delay is enabled, triggered by the next line sync pulse, at the end of which the clock is started. The first line of the arrow appears at the video output. The clock is then stopped until the same point on the next line when it is started and the second line of the arrow produced. This continues every line until the whole arrow has been produced. The horizontal delay is then inhibited until the same process recurs on the next frame.

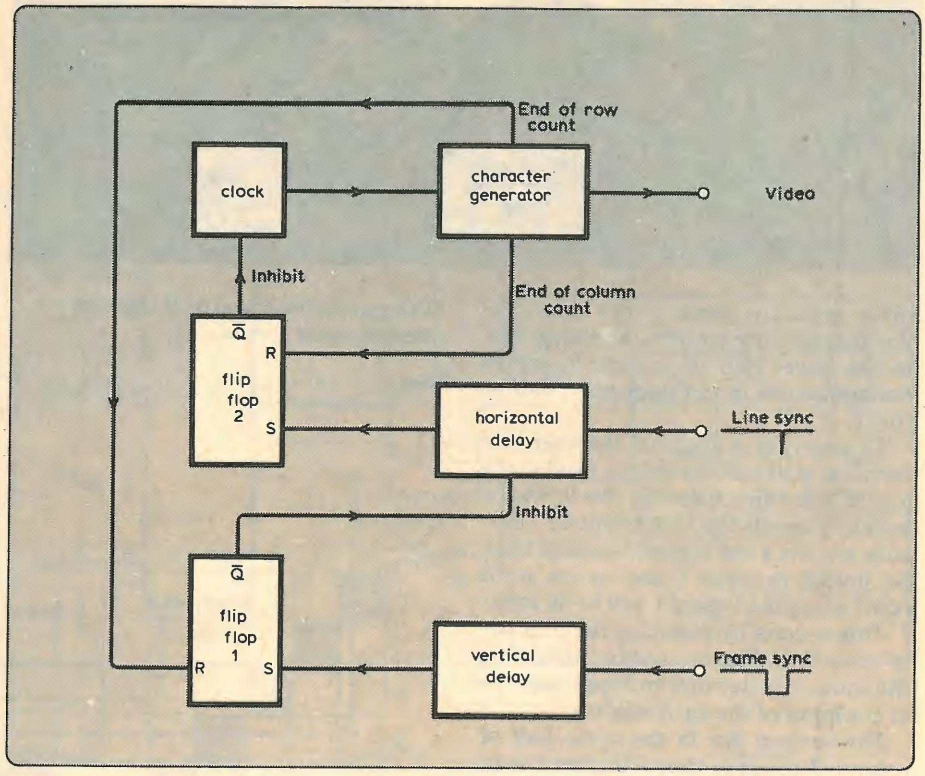


Fig. 1. *Monostable circuits triggered from sync circuits control arrow position.*

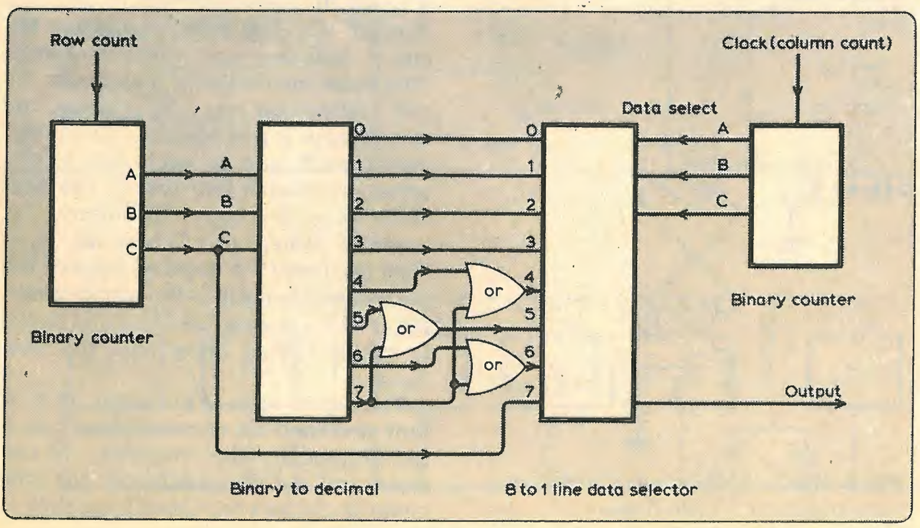


Fig. 2. *Character generator uses data selector i.c. instead of shift register so that arrow quadrant can be changed by simply switching inverters.*

Character generator

The video output is produced by looking in turn at each one of the eight data inputs using a SN74151 eight-to-one line data selector, Fig. 2. The data line selected is controlled by a three-bit binary number provided by a counter, connected to the clock, producing a column count and so the input lines are scanned sequentially. If, for example, a logical 1 was on input 3 and the rest of the inputs were at logical 0 all the time, the trace would brighten at column 3 on each row and a vertical line would be displayed.

The pattern to be generated must be produced a row at a time on the inputs of the data selector, and this pattern is shown in Fig. 3. It can be split up into

The generated arrow as it appears on the television screen.

three separate parts — the diagonal line between the corners, a vertical line in the lower half of column 7, and a horizontal line in the right-hand half of row 7.

To generate a diagonal between the corners, it is necessary to produce a logical 1 on input 0 during row 0, with a logical 0 on all the other inputs. Similarly on row 1 the logical 1 should then be shifted to input 1 and so on, until row 7 when the logical 1 will be on input 7. This is done by counting the number of rows on a binary counter, decoding the count into decimal and applying this to the input of the data selector.

The vertical line in the lower half of column 7 requires that a logical 1 is at input 7 during rows 4, 5, 6 & 7. This is achieved by connecting the most significant bit, C, of the binary row counter to input 7.

Finally, the horizontal line in the right-hand half of row 7 is achieved by placing a logical 1 on inputs 4, 5 & 6 during row 7, with OR gates. Thus an arrow is formed pointing "down right" as in Fig. 3.

If the data selector is scanned in reverse order, the arrow would be pointing "down left". All that has to be done is to avert each of the outputs from the column count. Similarly, if the row count is inverted the arrow points "up right". Finally, if both circuits are inverted the arrow points "up left". This flexibility simply using inverters was why a data select i.c. was chosen as the output device instead of a parallel-in serial-out shift register, usually used in character generator circuits.

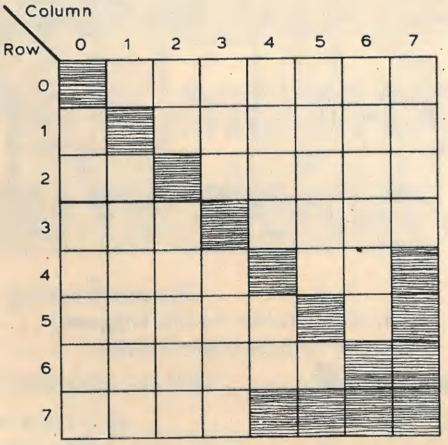


Fig. 3. *Diagonal is generated by counting the number of rows on a binary counter, decoding the count into decimal, and applying to the data selector*

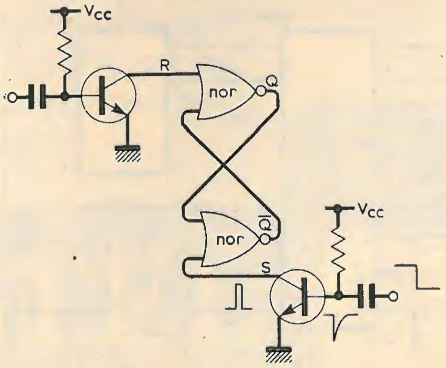


Fig. 4. *Monostable acts as a negative edge-triggered RS flip-flop.*

Flip-flops

Two cross-coupled NOR gates as edge-triggered RS flip-flops inhibit the horizontal delay monostable and the clock. Assume Q, R and S are at 0 and Q=1. If a 1 is applied momentarily to S nothing happens. However, if a 1 is applied momentarily to R then Q goes to 0 and as Q and S are at 0, Q changes to 1. If R again goes to 1 nothing happens. If a 1 is now placed momentarily on S the circuit flops back into its previous state.

The transistors on the inputs are normally on due to the current supplied to each base by its associated resistor, thus putting a 0 on the input of the gates. If the potential of the other end of the capacitor goes from low to high, nothing happens but if it goes from high to low the base of the transistor follows it to a negative potential. Subsequently, the base potential rises as the capacitor charges, and on reaching V_{be} the transistor turns on again. During the time the transistor has been off the gate input can float up to 1. Pull-up resistors on the collector of the transistor are not needed. Thus the circuit in Fig. 4 acts as a negative edge-triggered RS slip-flop.

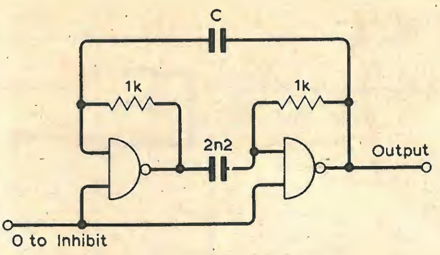
The clock must always stop in one state. When started it has to produce its first pulse a fixed time after the start command. Therefore a free-running oscillator whose output is gated is not suitable. The long-term stability is not important however as the oscillator is stopped after about eight cycles, and the complete arrow is generated in 64 cycles, so that any long-term drift only shows up as an imperceptible change in the width of the arrow. I found that the circuit using NAND gates in Fig. 5 works well but the exact value of C depends on many factors and is best adjusted on test. The oscillator is inhibited by placing a 0 on the unused inputs and stops with the output potential high.

Complete circuit

In the complete circuit for a "down right" pointing arrow, shown in Fig. 6, the frame sync pulses fire the monostable IC_1, its Q output immediately goes high and after the set time determined by R_{12}, goes low. This triggers flip-flop 1 and puts 1 on pins 2 & 3 of IC_2 monostable. This allows IC_2 to be fired on the next line sync pulse, and after a time determined by R_{13} its Q output goes low and fires flip-flop 2. The oscillator then starts, the data selector is enabled, and the oscillator feeds the column count IC_{10} which scans the input of the data selector IC_5. The most significant bit, pin 11, falls to 0 and resets flip-flop 2. This stops the oscillator and clocks the row counter on one. (In practice, the row counter is preceded by a divide-by-four circuit, and so each row of the arrow is repeated four times.) The next line sync pulse triggers IC_2 and row 2 is scanned. When all of the rows have been produced the negative edge of the most significant bit of the row counter, pin 11 of IC_3, resets flip-flop 1 and so IC_2 is inhibited from firing until the next frame.

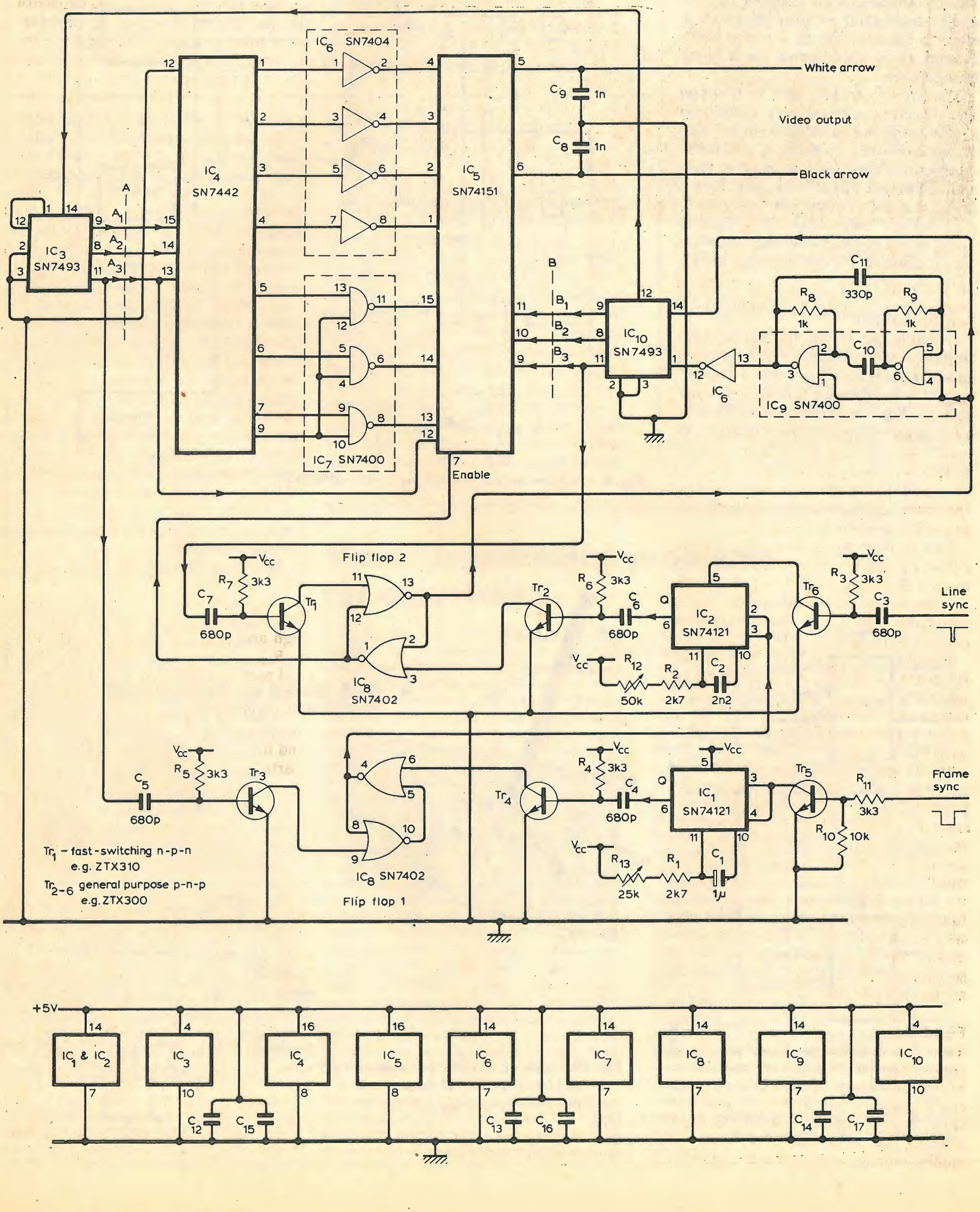
The aspect ratio of the arrow, that is, how stretched out or compressed it is, is determined by the frequency of the clock and the division before the row count is clocked on. Clock frequency is adjusted by altering the value of C_{11}; this controls the width of the arrow. The height is controlled by the number of lines of raster scan per row counter increment. In this circuit it is four, but it can be reduced to two by connecting pin 14 on IC_3 to pin 14 on IC_5. This produces an arrow half as high and C_{11} will have to be adjusted to get the correct aspect ratio.

Transistor Tr_1 needs to be a fast switching transistor, for if there is a delay here an output of column 0 will be



◀ **Fig. 5.** *Long-term drift produces imperceptible change in arrow width. Adjust capacitor C on test.*

Fig. 6. *Arrow direction is altered by using spare gates in IC_9 and IC_7 as inverters in each of three connections across broken lines A or B – see Figs. 7 & 8.* ▼



displayed at the end of column 7 until flip-flop 2 is reset and inhibits the output from the data selector. Due to the non-synchronous counting of the SN7493 column count certain spurious outputs can occur taking the form of narrow lines in the arrow pattern. This could be overcome by using synchronous counters, but they are expensive. As the spikes are very sharp they can be simply filtered out without affecting the rest of the pattern by placing capacitors C_8 and C_9 across the output. The data selector has an output and an inverted output, and by taking one of these the result is either a black arrow on a white background, or a white arrow on a black background.

The arrow can be made to point in any direction without any additional i.cs by using the spare gates in IC_9 and IC_7 as invertors in each of the three connections crossing the broken lines labelled A or B. For an "up right" arrow invert at A; for a "down left" invert at B. If an "up left" pointing arrow is required invert at A and swap over the following connections on IC_5 — 4 and 12, 3 and 13, 2 and 14, 1 and 15.

Pointer control

To switch the arrow in two or four directions extra circuitry will have to be added at point A or B or both. The most elegant way of doing this is to use the circuit in Fig. 7 employing two SN74H87 4-bit true/complement circuits. A

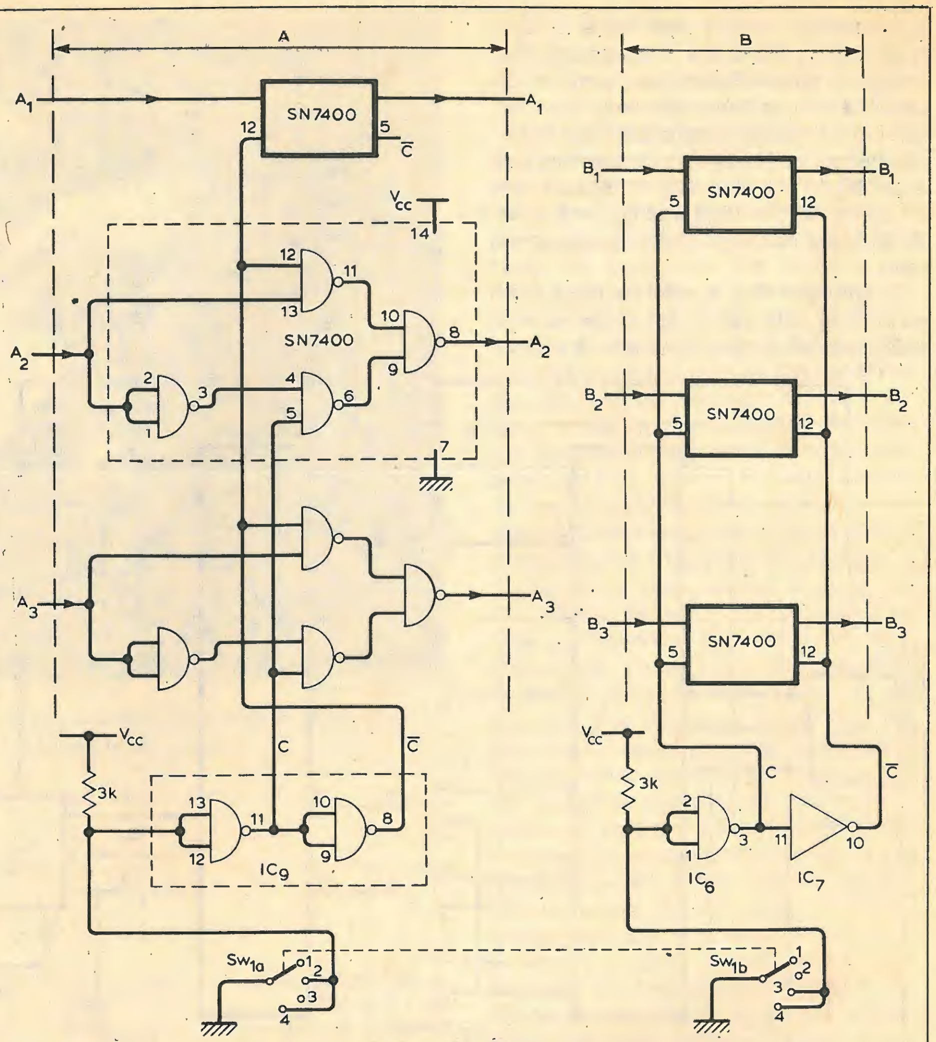


Fig. 8. *Cheaper way of switching arrow direction.*

Switch position	
1	Down right
2	Up right
3	Down left
4	Up left

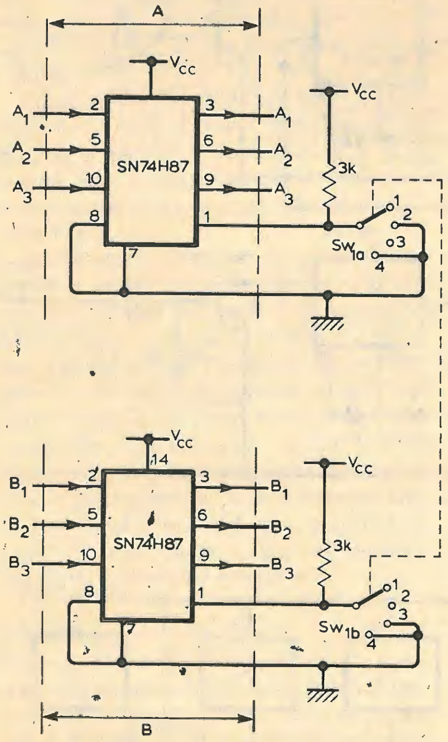
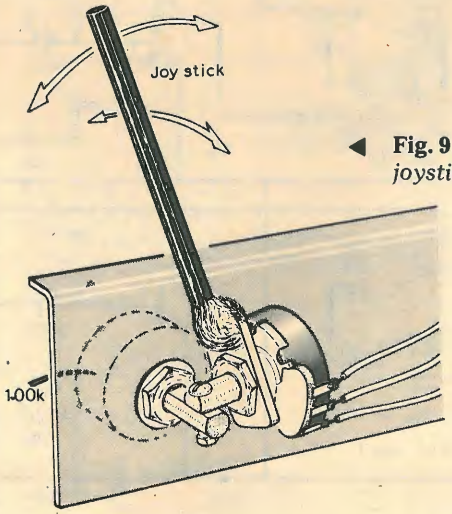


Fig. 7. *One way of switching arrow direction; A & B refer to Fig. 6.*



◀ **Fig. 9.** *Simplest and cheapest form of joystick control (plan view).*

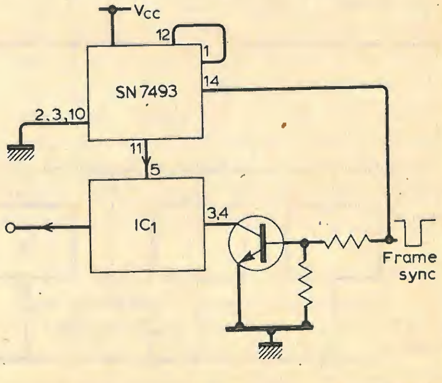


Fig. 10. *Flashing at different rates by counting the frame sync pulses and enabling the monostable for half the time.* ▶

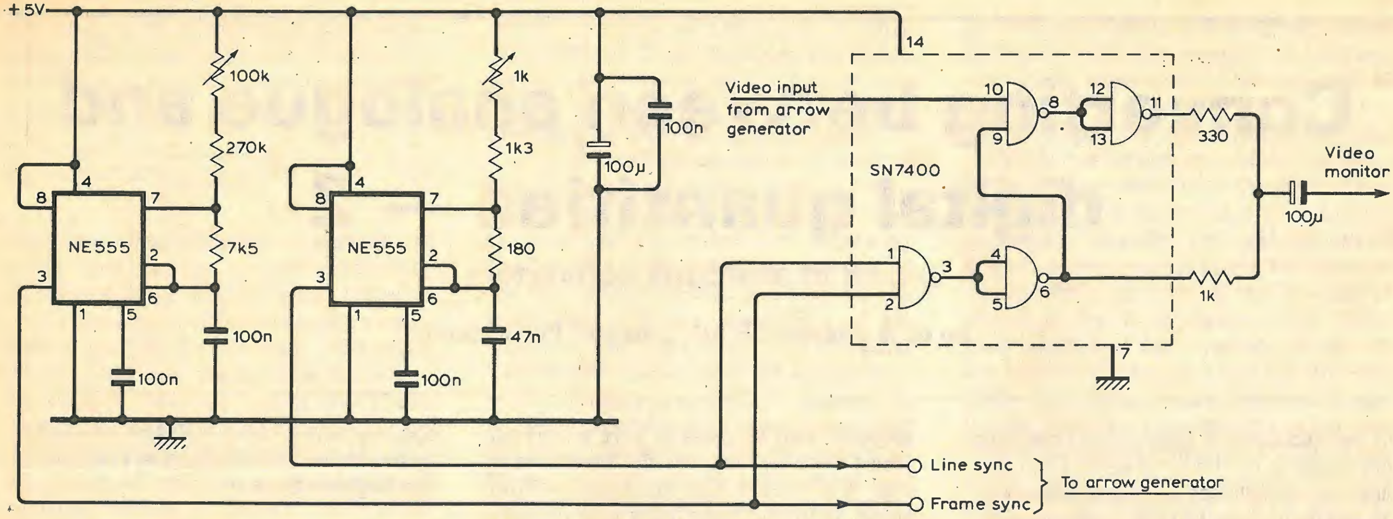


Fig. 11. *Simple sync generator and mixer for testing.*

cheaper way is shown in Fig. 8, using an SN7400 in each line to be inverted. The control lines C and C can be generated by the spare gates in the rest of the circuit.

The position controls can be left as two potentiometers, but this requires two hands and a good deal of practice to operate. Perhaps the simplest and cheapest method of "joystick" construction is shown in Fig. 9. This involves bolting two potentiometer shafts together at right angles. The body of one potentiometer is attached to a base via a mounting bracket, and the body of the other is attached to the joystick control. The potentiometers are then wired so that the direction of movement on the joystick corresponds to the direction of movement on the television screen. For full coverage of the screen the potentiometers must cover a range of 25 and 50kΩ respectively; as the full track of the potentiometers is not used, the values must be 50k and 100kΩ.

Flashing arrow

If the delay on IC_1 is greater than the frame period then the arrow will only appear every other frame. This gives a flashing effect that might be desirable in certain applications. Flashing at different rates can be achieved by counting the frame sync pulses and enabling the monostable for only half the time, Fig. 10. This is done by connecting the most significant bit to the inhibit of the monostable. If pins 3 & 4 of IC_1 are connected to ground then the modification in Fig. 10 produces an arrow one frame in every 16, i.e. every 0.4 seconds. If the interval is made larger by using more counting stages, a "subliminal" effect may be achieved where attention is drawn to where the arrow is pointing without the arrow being consciously visible. This needs to be the subject of further experiment before any rate of flashing can be suggested. The period of IC_1 cannot be extended to achieve this as the inaccuracies in timing produce jitter in the position of the arrow.

Test circuit

This arrow generator is essentially part of a larger system that provides sync pulses and mixes the arrow with other material. It is useful for test purposes to have a simple sync generator and a video/sync mixer to produce a composite video signal of the arrow only. The simple circuit used in the development of this arrow generator is shown in Fig. 11. It uses two NE555 timers as oscillators having duty cycles similar to that of the line and frame sync pulses. These oscillators are not locked together and so a random interlace occurs. An SN7400 mixes these pulses and adds them to any digital video information. When the output is terminated in 75Ω there is just under a volt of composite video signal which is sufficient to drive most monitors. The oscillator frequencies can be adjusted by locking the monitor onto a TV transmission and then connecting it to the circuit in Fig. 11. The two preset potentiometers are adjusted until lock is obtained.

The layout appears to be non-critical, and the prototype was made on a piece of 4 x 4½ in matrix board and included the arrow direction control of Fig. 8. As there are a lot of i.cs, attention must be paid to decoupling. If the spare gates on IC_9 are used it must be decoupled as close to the supply pins as possible, otherwise it might not oscillate reliably. □

More compatibility problems for cassettes

It is now two years since Philips announced its intention to show a cassette containing tape coated with pure iron dust rather than magnetic iron or chromium oxide, at the 1977 Berlin Funkaustellung. But shortly before the Berlin show Philips curtly told all those journalists who had by then written at length about the impending launch that it was, after all, off. As a result of the late date of this about-face, some magazines carried lengthy reports on the new tape, followed by a couple of hastily inserted lines effectively advising readers to ignore everything they had just read. Since then there has been a deafening silence from Eindhoven on the metal tape front and at a recent Eindhoven press conference a company spokesman gallantly tried to re-write history by denying that it had ever talked of a Berlin launch in 1977. All that we know for sure is that commercial production of the tape, two years ago, ran into "problems", probably relating to the coating techniques necessary to prevent the iron dust from turning to non-magnetic rust. Alternatively Philips may have found to its cost that finely divided metal powder has a nasty habit of exploding.

While Philips has been solving its production problems a string of competitors, including BASF, 3M and TDK have also developed iron powder tapes. Coercivity hovers around 1000 oersted ($10^6/4\pi$ A/m) but there is as yet no standardization. Philips has settled for 950 oersted (75,000 A/m) but 3M and TDK have talked of coercivities of 1000 oersted and above. Thus the poor long-suffering cassette-using consumer is faced with yet another problem. Not only will existing tape decks hopelessly under bias any metal powder tape (pushing up the high frequency end to uncomfortable peaks) but a machine biased for one metal tape may well not exactly match the competition. But perhaps, just once, the companies can get together before it is too late and agree on a one coercivity, one bias standard, right from the word go. We shall see.

Perhaps the most worrying aspect of the new metal powder tapes, which at £5 for a C90 will cost around four times the price of an ordinary cassette of similar length, is that they look generally similar to conventional oxide cassettes. It is thus a forgone conclusion that a customer asking in a shop for the "best tape" is likely in the future to be sold an iron powder tape which will actually produce far worse results on a conventional machine than an oxide cassette at quarter the price. In its press release Philips claimed "good results" from metal tape on conventional recorders set for chromium tape bias. When pressed to defend this claim a spokesman said it depended on what one meant by "good results".

Adrian Hope

Converting between analogue and digital quantities — 2

Digital to analogue converters

by **G. B. Clayton,** B.Sc., Liverpool Polytechnic

In the discussion of conversion principles presented so far the function of a d.a.c. has been established as that of providing an analogue output signal in response to a digitally coded input signal. The basic circuit principles underlying the implementation of this function are not difficult to understand and can be readily demonstrated in a simple but convincing manner.

CONNECT UP, or simply consider, the circuit arrangement given in Fig. 3. It consists of a reference voltage source and a set of binary weighted resistors, each resistor having an associated switch. Switch positions are taken as representing values of binary inputs. If a switch is in the state designated 1,V_{ref} causes a current to flow through the resistor associated with that switch. The sum of all switched current contributions is the short circuit output current of the network; it can be measured by a low-resistance milliameter to give an analogue reading corresponding to the binary-coded digital input – the switch positions.

The m.s.b. (bit1) switch makes a contribution V_{ref}/R to the short-circuit output current, bit 2 contributes $V_{ref}/2R$ and bit 3, which in Fig. 3 is the l.s.b., makes a contributes $V_{ref}/4R$. Using $V_{ref}=10V$ and $R=5k\Omega$ makes the l.s.b. contribution 10/20 = 0.5mA, and with all bits 'on' (binary input 111), the short-circuit output current is 3.5 mA (⅞ full scale where normalized full scale is 4mA).

A digital-to-analogue conversion involving a digital input word with more than three bits can be implemented using the principles outlined above by simply adding an extra switch and resistor for each extra bit. Thus an *n*-bit, natural-binary d.a.c. would require *n* binary-weighted resistors values *R*, 2*R*, 4*R* ... $2^{n-1}R$. The expression for the short-circuit output current developed by such a network is:

$$I_{o(sc)}=2V_{ref}/R[x_1 2^{-1}+x_2 2^{-2}+ x_3 2^{-3}+ ... +x_n 2^{-n}]$$

where $x_i=1$ if S_i is switched to the high state,

or $x_i=0$ if S_i is switched to the low state.

There is a variety of possible techniques for reading the analogue output signal produced by a binary-weighted resistor network. An operational amplifier can be used to give a current sum-to-voltage conversion, as shown in Fig. 4(a) where the analogue output signal is in the form of a low output-impedance voltage, which can be scaled by choice of R_f. The output voltage is determined by the relationship:

$$V_o=(-2V_{ref}/R) R_f[x_1 2^{-1}+ x_2 2^{-2}+x_3 2^{-3}+x_n 2^{-n}]$$

The analogue output polarity in this case is negative, and goes more negative as the value of the digital input word is increased.

As an alternative, an operational amplifier can be used in the high input-impedance follower configuration as in Fig. 4(b). This arrangement allows the open-circuit output voltage produced by the resistor network to be read out at low impedance as

$$V_o=\frac{2^n}{2^n-1}.V_{ref}.$$
$$[x_1 2^{-1}+x_2 2^{-2}+x_3 2^{-3}+ ... +x_n 2^{-n}]$$

Loading the binary network with a load resistor R_L, as shown in Fig. 4(c), gives rise to an output voltage developed across the load:

$$V_o=\frac{2^n}{2^n-1}.V_{ref}.\frac{R_L}{R_o+R_L}.$$
$$[x_1 2^{-1}+x_2 2^{-2}+x_3 2^{-3}+ ... +x_n 2^{-n}]$$

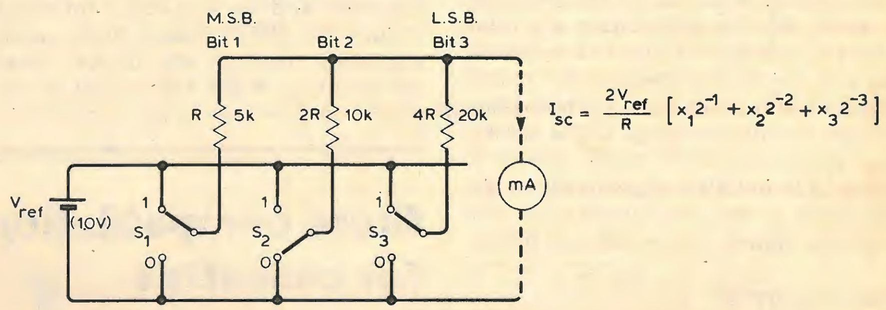
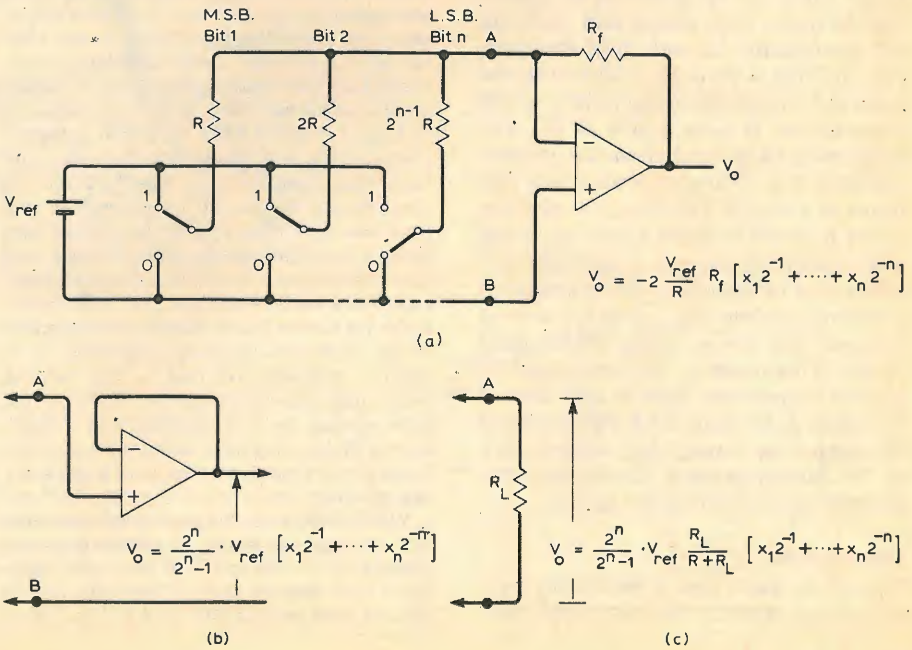


Fig. 3. *Digital to analogue conversion with binary weighted resistors.*

Fig. 4. *Read out of analogue output signal.*



(a)

(b)

(c)

where R_o is the effective output resistance of the binary network, which is the resistance of all the weighting resistors in parallel.

$$R_o = \frac{2^{n-1}}{2^n - 1} \cdot R \simeq \frac{R}{2} \text{ for } n > 4$$

Note that when the resistor network is loaded any change in load inevitably influences the analogue output signal.

In concept, weighted-resistor networks provide the simplest and most direct method of performing a d.-to-a. conversion. However, when many bits of digital information are involved, the weighted resistor network has the disadvantage of requiring a large range of resistor values. A ten-bit converter would require resistor values in the range 2^9:1, (512:1) and the m.s.b. resistor would need to be of very close tolerance if it were not to introduce errors as big as the l.s.b. value. In a ten-bit converter the size of the l.s.b. is only $1/2^9 \times 100\% \sim 0.2\%$ of the m.s.b. The m.s.b. resistor value would need to be accurate to better than ±0.2% if it were not to introduce an error as big as the l.s.b.

The difficulties associated with a requirement for a wide range of precision binary weighted resistors is overcome in many practical converters by the use of a resistor ladder network of the form shown in Fig. 5. The network maintains a binary weighting of bit currents but uses only two resistor values, and is called an R-2R ladder network. A three-stage R-2R network is considered for the sake of simplicity but the principles involved in the action of the network are readily extended to any number of stages. First notice that, regardless of the number of stages, the effective output resistance of the network (looking back to the left in the Fig. (5) is R. The output resistance, looking back into the circuit at point C, is $2R//2R = R$, and at point B is $R + R$ (in series) in parallel with $2R$, namely $2R//2R = R$ and so on, regardless of the number of stages.

The output voltage produced by the network can be derived, using the principle of superposition, as the sum of the effects of the individual bits acting separately. The effect of each bit at the output is most readily found by deriving its Thévénin equivalent; the process is shown in Fig. 6. In deriving the Thévénin equivalent for a particular bit, all bit switches except that for the bit under consideration are imagined in the 0 state. It can be seen that the m.s.b. (bit one) makes a contribution $V_{ref}/2$ to the open circuit output voltage, bit two makes a contribution $V_{ref}/4$ and bit three $V_{ref}/8$.

In the more general case of an R-$2R$ network with n stages used for an n-bit d.-to-a. conversion, the expression for the open-circuit output voltage is

$$V_{o(oc)} = V_{ref}\,[x_1 2^{-1} + x_2 2^{2} + \ldots + x_n 2^{-n}]$$

The short circuit output current is:

$$I_{o(sc)} = (V_{ref}/R)\,[x_1 2^{--1} + x_2 2^{-2} + \ldots + x_n 2^{-n}]$$

The output voltage of the network where loaded by a resistor R_L is

$$V_o = V_{ref} \cdot \frac{R_1}{R + R_L} [x_1 2^{-1} + x_2 2^{-2} + \ldots + x_n 2^{-n}]$$

If the analogue output voltage must be available at a low output impedance an operational amplifier can be used as shown previously in Figs. 4(a) and 4(b).

R-2R ladder networks, because of their symmetry, can be used in a variety of circuit configurations. In the arrangement shown in Fig. 7 the reference input and output lines of Fig. 5 are interchanged: a change of switch state in Fig. 7 causes very little change in the voltage level at the switch. The short-circuit output current produced by the simple three-bit arrangement is determined by the relationship

$$I_{o(sc)} = I_{ref}\,[x_1 2^{-2} + x_2 2^{2} + x_3 2^{-3}]$$

The R-2R network divides the input current $I_{ref} = V_{ref}/R$ into binarily-related bit-current components which the switches steer to either the output line or earth. Notice that a current increment equal in value to the l.s.b. current flows through the terminating 2R resistor to earth. The number of bits can be

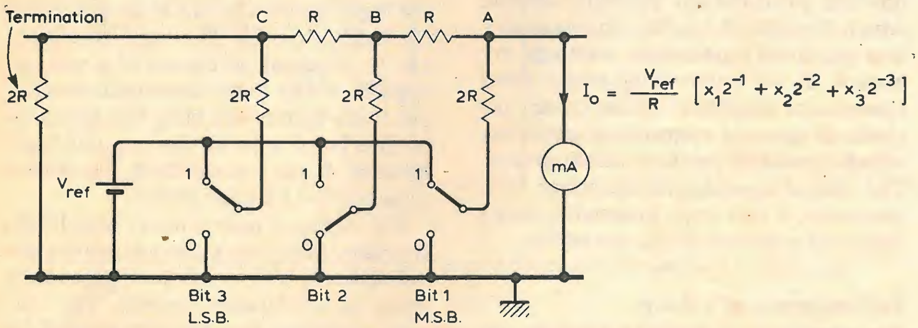
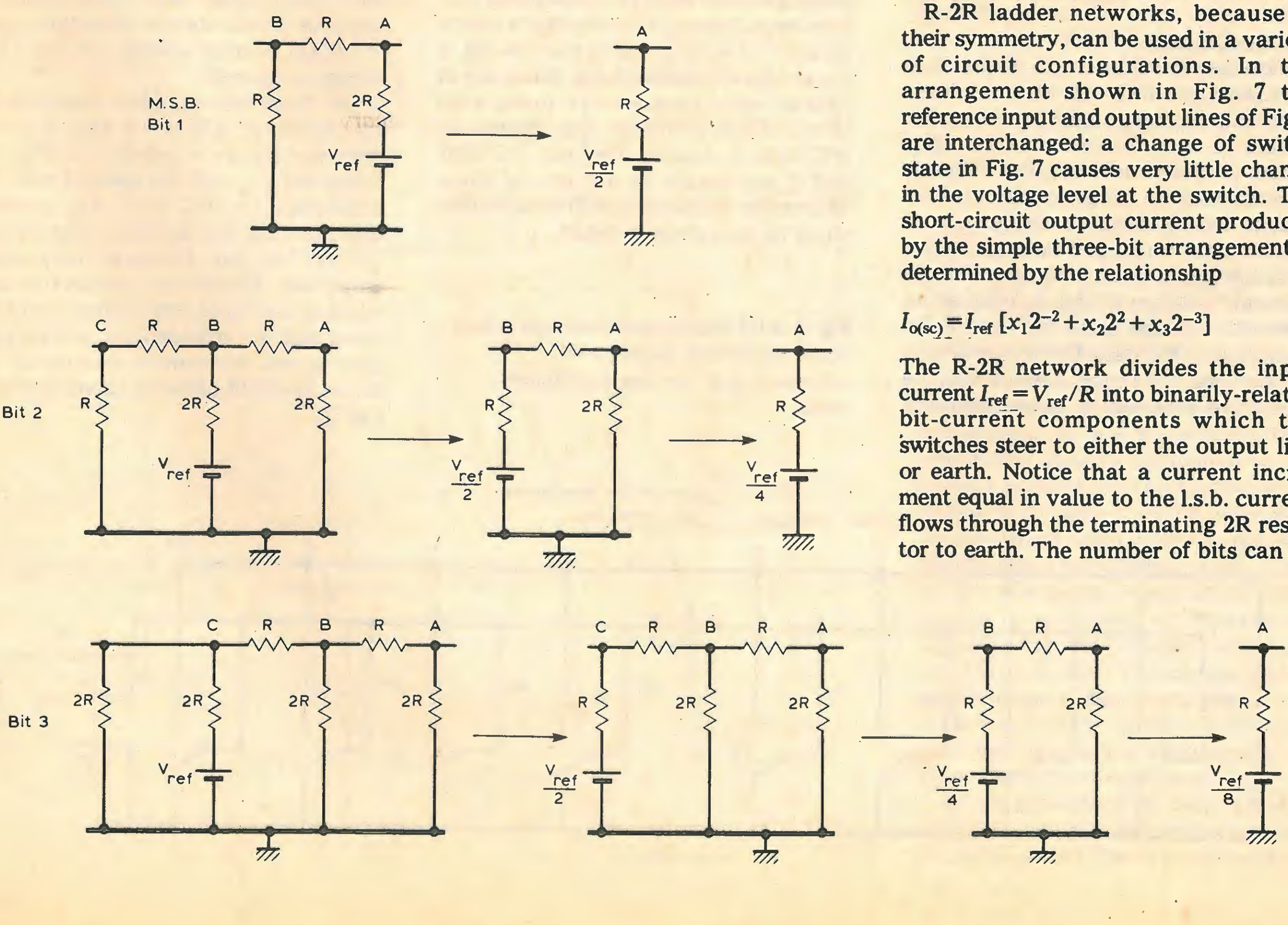


Fig. 5. *R-2R ladder network gives binary bit weighting.*

Fig. 6. *Thevenin equivalents for each separate bit in Fig. 5.*



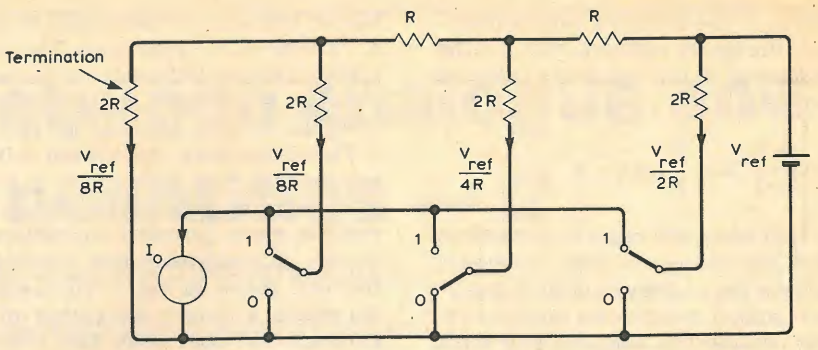
increased by simply adding extra sections to the R-2R ladder.

The foregoing treatment of resistor weighting networks has by no means covered all the techniques which are employed in the practical converters. The R-2R ladder is probably the most frequently used network for bit weighting but an alternative approach which is adopted in some converters is to use binary-weighted resistor quads (*R*, 2*R*, 4*R*, 8*R*) with appropriate attenuation between the quads. The quad approach allows the proper relative quad weighting for b.c.d. conversion to be obtained by adjustment of this inter-quad attenuation. A circuit configuration illustrating the use of binarily related resistor quads is given in Fig. 8.

The subject of resistor weighting is not pursued further since from the d.a.c. user's point of view, a general knowledge of the basic ideas underlying the subject is all that is required. Commercially available d.a.c.s contain resistor weighting networks, but the devices can be used effectively without a detailed knowledge of the design of these networks. Practical d.a.c.s do not, of course, use mechanical switches; they employ electronic switches which are activated in response to the high or low voltage levels which are applied to their logic inputs. Current switching techniques based upon the circuit configuration of Fig. 7 (because they involved very little change in switch voltage), provide faster operation than the voltage switching of Fig. 4. Bipolar transistor current switches are used in many converters but the detailed circuitry involved in such switching arrangements need not concern the d.a.c. user.

Practical d.a.cs

A wide variety of d.a.cs are available in both integrated circuit and modular form, ranging from modest, six-bit converters to very accurate 16 bit converters. Available devices differ in speed; accuracy and the range of performance options which they provide (types of digital code, analogue polarity, etc.) Some devices include their own built-in reference voltage, whilst in others the reference voltage must be externally connected by the user. Devices in which the external reference voltage can be varied are referred to as multiplying d.a.cs, since in these devices the analogue output signal is proportional to the product of the variable reference voltage and the input digital number. Some devices produce an output current which, if required, can be converted to a low output-impedance voltage by means of an externally-connected operational amplifier, whilst others include an internal operational amplifier which is used to perform this function. The output operational amplifier in a converter, if it is used, invariably slows down the response of the converter.



$$I_o = \frac{V_{ref}}{R}\left[x_1 2^{-1} + x_2 2^{-2} + x_3 2^{-3}\right]$$

Fig. 7. *R-2R network in current switching configuration.*

Performance of a d.a.c.

An experimental learning exercise on d.a.cs is best performed with a device which allows a range of different operating conditions and thereby permits the experimenter to more fully investigate the factors influencing performance. Precision Monolithic's multiplying d. to a. converter, type DAC08, is chosen for discussion here; there are of course other inexpensive integrated circuit d.a.cs available, e.g. Motorola, MC1408L-8, Analog Devices AD7520, and if you decide to use one of these alternative devices you will need to first study its data sheet in detail.

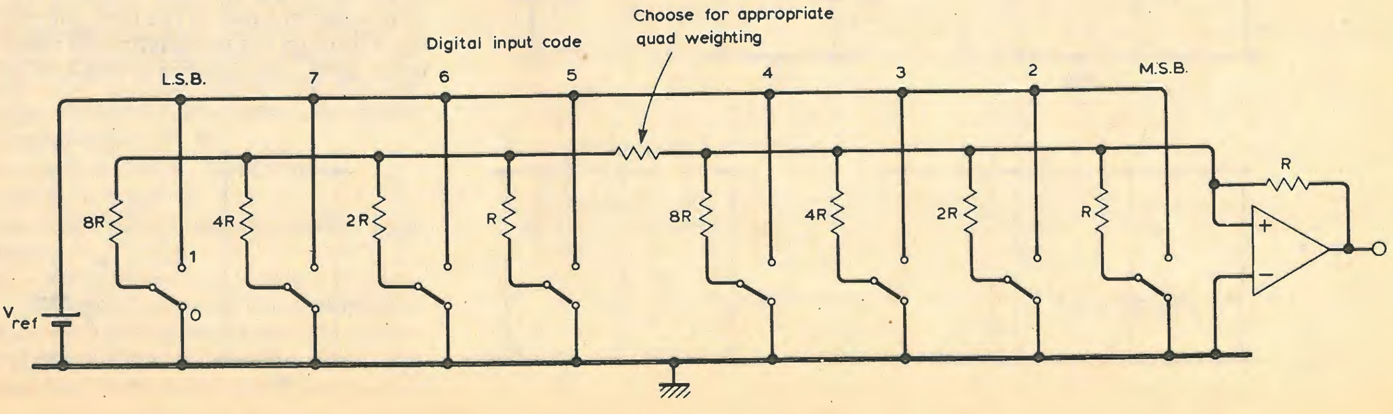


Fig. 8. *8-bit d-to-a converter using two equal resistance quads with attenuation of the less-significant quad.*

The DAC08 is an eight-bit, integrated-circuit, multiplying d.a.c. It is fast, it provides a range of flexible operating conditions and is inexpensive. In Fig. 9, which is extracted from the manufacturers' data sheet, the device pin connections and simplified equivalent circuit are shown. Pins 5 to 12 are the logic inputs, the m.s.b. on pin 5 and the l.s.b. at pin 12. The logic threshold can be adjusted by means of a voltage applied to the logic threshold control, pin 1, this feature enabling the device to be interfaced with all the popular logic families. If pin 1 is earthed, the device responds to t.t.l. logic levels.

An internal operational amplifier, together with an external reference voltage and resistor, is used to set the value of a reference current. The current is divided into binarily-related bit currents by an R-2R ladder network and the bit currents are supplied to current switching transistors. The simplified equivalent circuit of Fig. 9 does not show the detailed switching circuitry nor does it indicate the technique used to obtain correct scaling of the l.s.b. current increment.

The reference amplifier connections for positive, negative and bipolar reference inputs are shown in Fig. 10. Transistor Tr_1 and the current sink bit transistors Tr_1, Tr_2, $\text{Tr}_3 \ldots \text{Tr}_8$, share a common base line driven by the output voltage of the integral reference amplifier. Transistor collector and emitter currents are approximately equal and the voltage $I_{ref}.R$ which appears across the emitter resistor of Tr^1 drives the R-2R network (compare with Fig. 7).

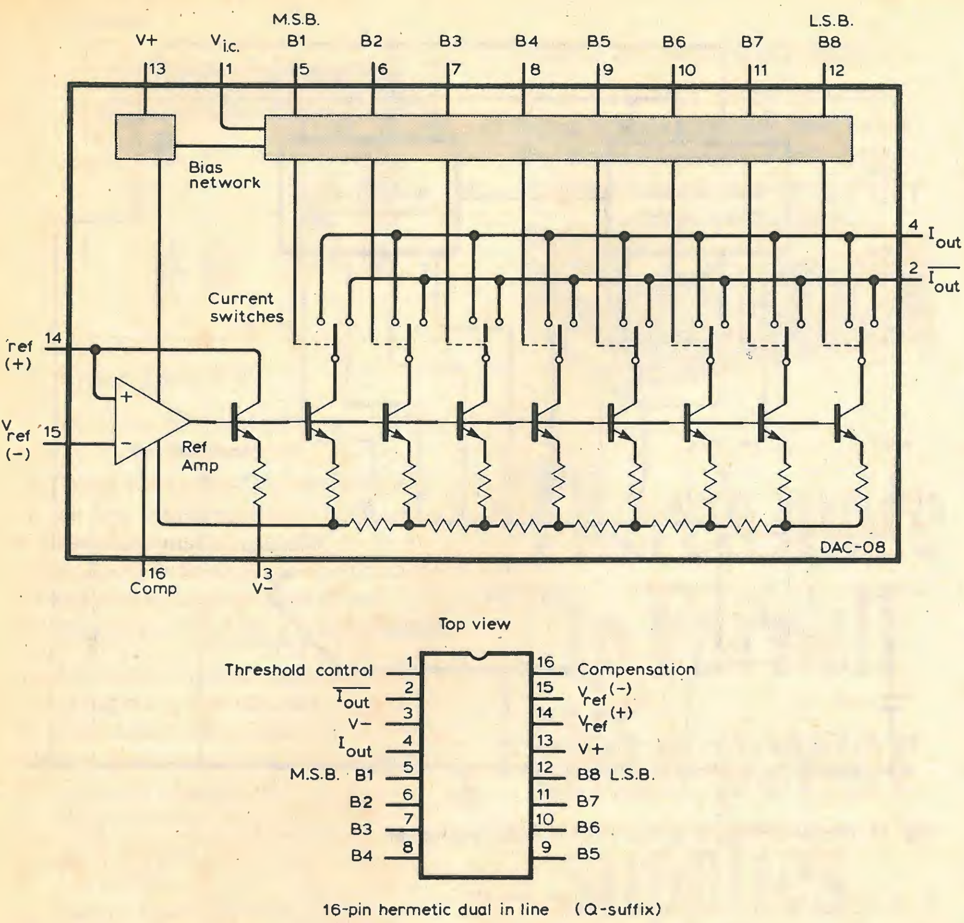
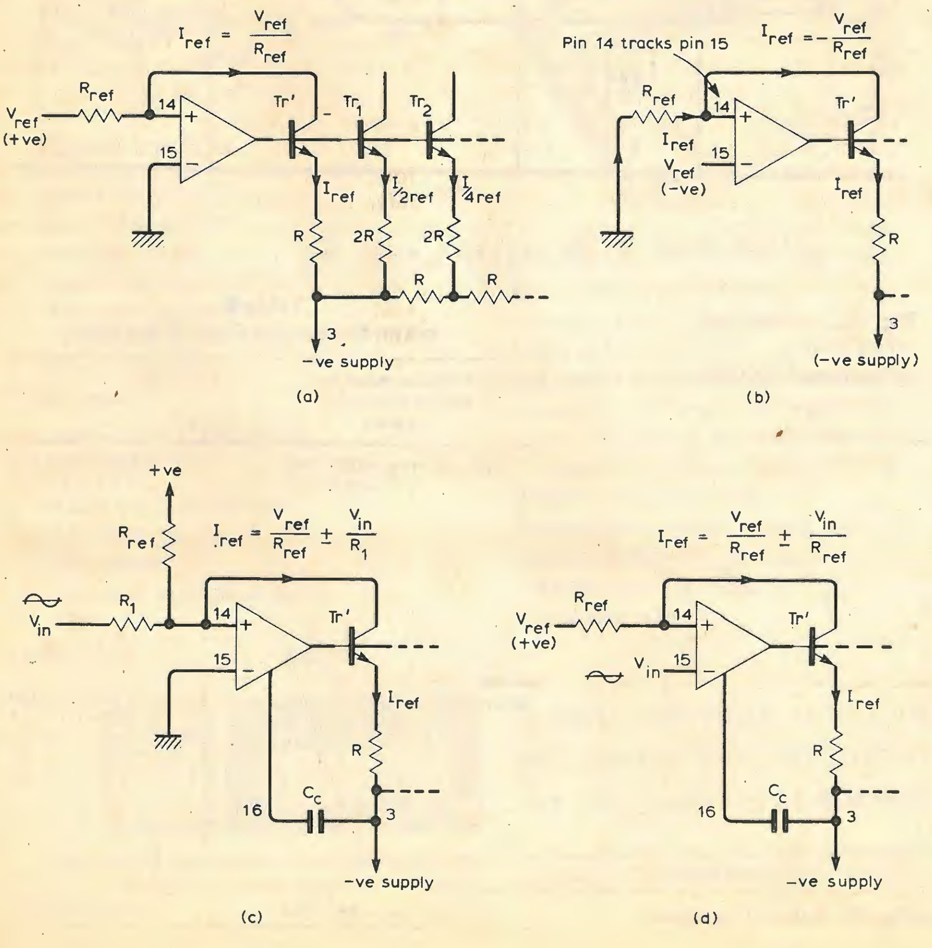


Fig. 9. *Precision monolithic DAC08 pin connections and simplified functional schematic.*

Fig. 10. *Reference amplifier connections (DAC08).*



Feedback round the reference amplifier is returned to its non-inverting input terminal, this connection giving negative feedback because of the signal phase inversion between the base and collector of transistor Tr_1 Assuming the reference amplifier behaves like an ideal operational amplifier, all current arriving at pin 14 is made to flow as the collector current of Tr_1 and the voltage levels at pins 14 and 15 are forced to equality. The negative reference connection of Fig. 10(b) in effect applies series negative feedback to the reference amplifier and is thus characterized by a high input impedance. Connections for use with variable bipolar reference inputs are obtained by d.c. offsetting the current into pin 14 and are shown in Figs. 10(c) and 10(d); values used must ensure that the current direction is always into pin 14. In multiplier applications when an alternating reference signal is applied a capacitor, C_c, must be connected between pin 16 and pin 3 (the negative supply) in order to frequency compensate the reference amplifier. The value required for C_c depends upon the value used for R_{ref}; the minimum recommended values are 15 pF, 37 pF and 75 pF for R_{ref} values 1 kΩ, 2 kΩ and 5 kΩ respectively.

A feature of the DAC08, not commonly found in other devices, is that it provides two output currents, the current I_o at pin 4 and the current $\bar{I}_o$ at pin 2, into the output terminals. Bit currents, instead of being switched between a single output line and earth are switched between the I_o and $\bar{I}_o$ lines. A bit current is switched to the I_o line when its input logic terminal is in the state 1 and to the $\bar{I}_o$ line when the logic terminal has the state 0.

Output currents have values which are determined by the relationships:

$$I_o = I_{ref}[x_1 2^{-1} + x_2 2^{-2} + \ldots + x_8 2^{-8}] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

and

$$\bar{I}_o = I_{ref}[\bar{x}_1 2^{-1} + \bar{x}_2 2^{-2} + \ldots + \bar{x}_8 2^{-8}]$$

Note that $I_o + \bar{I}_o = I_{FS}$ where I_{FS} is the actual full scale output current determined by the relationship

$$I_{FS} = 255/256\, I_{ref}$$

Both output currents can be used simultaneously, but if one output is not required it must be connected to earth or to a current point capable of supplying the current I_{FS}. Both outputs can be converted into voltage signals by simply using an external load resistor or, if a low output impedance voltage signal is required, an operational amplifier can be used as a current to voltage converter. The outputs have a wide voltage compliance, which is the maximum voltage which can be applied to an output terminal without changing the value of the output current.

As an experimental familiarisation exercise it is suggested that you connect the d.a.c. logic inputs to the parallel outputs of an eight-bit binary counter; a suitable arrangement is shown in Fig. 11. Note, in Fig. 11, that the 12V positive supply line is used as the d.a.c. reference voltage; in a practical application a separate reference voltage would normally be used for greater accuracy.

Set the clock frequency to a convenient value (say 100kHz), and observe the analogue output signal (at pin 4) with an oscilloscope. The traces given in Fig. 12 show you what you should expect to see.

There are many other aspects of the d.a.c. performance that you can investigate. Connect a second 2.2k kΩ resistor between the $\bar{I}_o$ output, (pin 2) and earth and simultaneously observe both outputs. Change the value of the reference current (by changing the value of R) but do not exceed $I_{ref} = 3mA$. Try the effect of setting the counters in the count down mode by applying a logical 1 insead of 0 to the counter pins 5.

Offset binary operation

In some applications d.a.c.s are required to produce a bipolar output signal, which is often accomplished by offsetting the analogue output of the d.a.c. by an amount equal to half the unipolar output of the d.a.c. The conversion relationship between the digital input word and the analogue output is then the offset binary code (See Table 6). The I_o and I_o outputs of the DAC08, together with an external operational amplifier, allow a symmetrical offset binary operation. A suitable circuit arrangement is given in Fig. 13.

The operational amplifier is configured as a current-different-to-voltage converter and, assuming ideal action, its output voltage is determined by the relationship:

$$V_o = [I_o - \bar{I}_o] R_2$$

$$\text{But } \bar{I}_o = I_{fs} - I_o$$

$$\text{Thus } V_o = [2I_o - I_{fs}] R_2 \quad \ldots\ldots\ldots\ldots\ldots (2)$$

where $I_{fs} = 255/256\ I_{ref}$ and I_o is determined by Equation (1)

Equation (2) may be used to obtain the conversion code which is shown in Table 6. Note that the analogue output states are symmetrical about zero and there is no value of the digital input for which the analogue output is identically zero. ☐

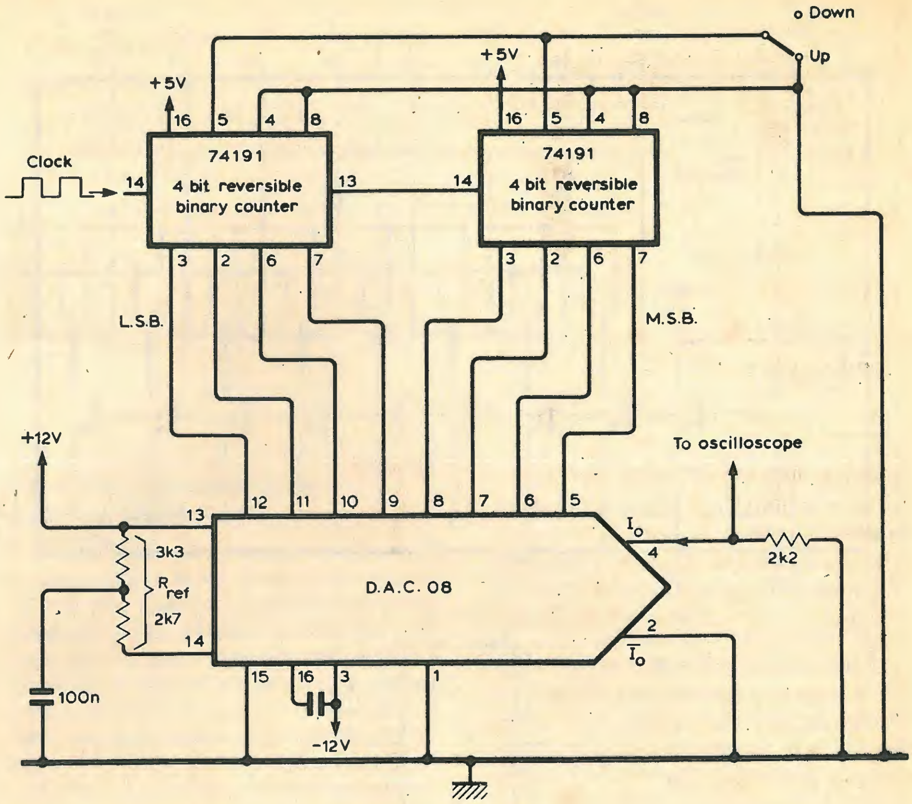
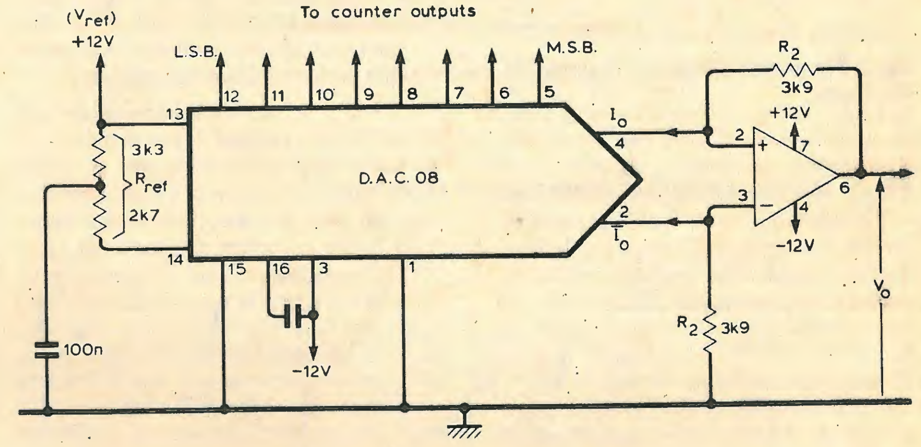


Fig. 11. *Incrementing a d.a.c. with a binary counter.*

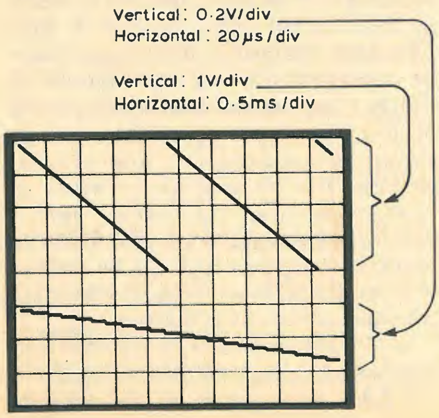


$$V_o = \left[2I_o - I_{fs}\right] R_2 ,\ I_{fs} = \frac{255}{256} \cdot \frac{V_{ref}}{R_{ref}}$$

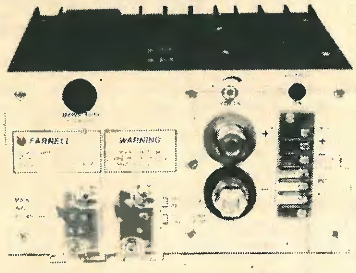
Fig. 13. *Symmetrical offset binary operation of DAC08.*

Table 6
Eight Bit Symmetrical Offset Binary Code

Analogue values as fraction of nominal full scale	Digital code
Full scale +ve +255/256	1 1 1 1 1 1 1 1
+253/256	1 1 1 1 1 1 1 0
⋮	⋮
+ 3/256	1 0 0 0 0 0 0 1
Nominal zero scale (+ve) + 1/256	1 0 0 0 0 0 0 0
Nominal zero scale (—ve) — 1/256	0 1 1 1 1 1 1 1
— 3/256	0 1 1 1 1 1 1 0
⋮	⋮
Full scale —ve —255/256	0 0 0 0 0 0 0 0



◀ **Fig. 12.** *Output from d.a.c.*



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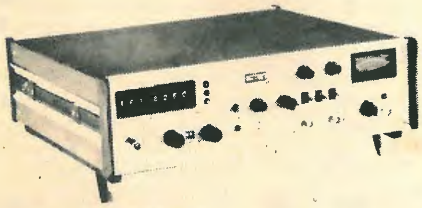

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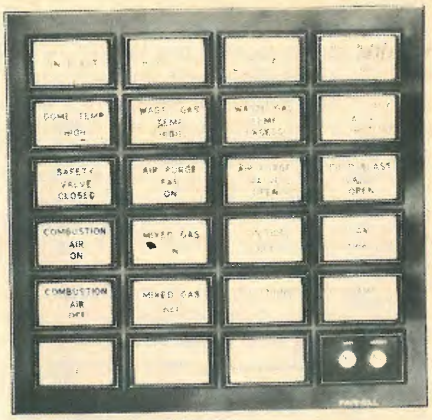

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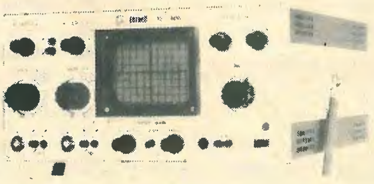

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LETTERS TO THE EDITOR

MICROELECTRONICS REVOLUTION

The editorial in your April issue sets up the microelectronics revolution as a recipe for disaster. It shows all the signs of a body of opinion left behind in the wake of a new technology performing what could be described as a "Custer's last stand".

I take issue on several points. Initially the government intends to put up some £70 million over the next five years. Surely we should not knock this golden opportunity but attempt to capitalise on it for the benefit of all. To consider the microcomputer quantitatively as another number crunching equivalent of its larger predecessor is a narrow viewpoint. It shows a lack of understanding of the concept. To those of us who have worked on software development I say that for the first time we can write high- and low-level software of considerable complexity on machines costing less than £2,000. This including editors, assemblers and the like. It will without doubt lead to a large number of software engineers and a *reduction* in the cost of software at least in relative terms.

At present there is considerable interest in the application of this new technology in industry, particularly in labour intensive environments. To drop loaded statements about labour relations and propaganda can do nothing but harm to this very sensitive problem area. Equally it is no reason to run away from the issue. It has been said elsewhere that at first man used his muscle power to earn a living. With the advent of the Industrial Revolution steam power replaced this, so that man had only to control his new source of energy to accomplish his work. Perhaps the micro revolution will see a similar change in the working environment, where man is no longer employed to control the machine power. In the industry of the future the industrial wealth will still be with us, provided, that is, that we are not left behind in technology. Surely of far greater significance will be the re-distribution of wealth from our industries — a problem which is more soluble when viewed from a position of strength.

G. J. Frost
University of Warwick Business School
Coventry

AN OVERSIGHT IN COSMOLOGY?

Answering the question "Has there been an oversight?" raised by A. Jones in your April issue, elementary a.c. theory shows that randomly phased radiation covering a wide waveband, such as that of light reaching us from stars and the observable limits of the Universe, is linearly additive in energy or power.

Heinrich William Olbers in 1826 was justifiably puzzled not to find the night sky infinitely bright, and to this day the red shift is the only adequate explanation of the paradox.

The electric or magnetic field will of course average to zero, but luminance is electromagnetic power proportional to *E* squared or *H* squared which cannot have negative value at any time so cannot cancel in summation.

The radius of the Universe, suggested by Hubble's constant which relates red shift to distance of the light source, is of the order of 13 thousand million or 10^{10} light years, and certainly not 10^{20} light years.

V. B. Hulme
Chichester
Sussex

TELETEXT FOR DEMOCRACY

May I suggest a use for teletext which could raise it to the position of an indispensable aid to democracy? It could be used as a public noticeboard on which to display our questions to ministers and the ministers' replies. This would help to overcome the lack of communication between citizen and government which was recognised as a serious problem by the Royal Commission on the Constitution (Kilbrandon Report 1973). Much of the report is devoted to this problem and paragraph 1236 reads as follows: "Government (should) be exposed to the force of democratic opinion and be required to explain the reasons for its decisions."

We the ordinary people should have the same right as MPs to ask questions of ministers. This could be done by using teletext as an interactive system in the following way.

Radio, television and the press would issue regular reminders that a feedback system existed, and when we wanted to publicly ask a question of a minister we would send it to either Ceefax or Oracle. When several questions had been received about a particular matter they would be condensed and sent to the minister concerned.

Three groups of teletext pages would be set aside for this feedback system. Group 1 would indicate the type of questions which were being received at any particular time; group 2 would display verbatim the questions which had been put to ministers and which were awaiting reply; and group 3 would display the questions which had been asked, with the ministers' replies alongside.

It is the latter which is the key to the system. It would permit a constant ebb and flow of opinion; it would provide a medium for the cross-fertilisation of ideas; it would be an outlet for tension and would reduce the feeling of helplessness in the face of big government; and it would go some way towards turning us from serfs to partners.

To enable *everyone* to take part we would have to install screens in public places such as Post Office windows.

I have developed this idea as a result of what I found when I lived in Tasmania in 1974. The Chief Librarian for Tasmania, Mr W. L. Brown, has installed in the foyer of the State Library a suggestion-box with a notice-board alongside. Suggestions from library members are received via the suggestion-box and are then typed out and displayed on the board with Mr Brown's reply alongside.

The same principle should incidentally be applied to every sphere of life, whether it be local government, the unions, churches, companies, the civil-service, public bodies, and organisations of all kinds; with the object of forcing the people at the top to explain their policies to customers, members and workers, and to show cause why a suggestion should not be adopted.

Because the system would permit the interaction of ideas between different levels it could perhaps be called INTRAK (meaning "interact.").

S. Frost
Dunsyre
Lanarkshire

FAILURE OF DISTRESS SIGNALS AT SEA

Since the time of the *Titanic* the band 410-515 kHz has been allocated to the maritime mobile service, and under the Convention for Safety of Life at Sea ships have been equipped with an automatic alarm receiver tuned to 500kHz, the international distress frequency. This is programmed to recognise a pre-arranged alarm signal emanating from another vessel and correspondingly equipped with a battery powered 500kHz transmitter with which to send it. A better system has yet to be found.

Such a transmitter is typically of 100 watts power, with pi-coupler feeding an antenna of much less than quarter wavelength, being whatever 'bit of wire' that can be conveniently hung up on a given superstructure. A typical commercial transmitter currently in wide use will match antennas from 250pF, 4 ohms to 750pF, 1.9 ohms. The antenna is invariably brought into the radio room via a ceramic feed-through insulator 10 or 12 inches long and 4 or 5 inches in diameter. The aerial may have up to 8 strain insulators, made necessary by frequent changes in the direction of the wire.

This arrangement works well enough at the wharf where it is tested and inspected, but the sea is rough, it throws up spray, the spray is salt, it coats the insulators, and crystals may be formed. The feed-through insulator then becomes a concentric capacitor, the outer plate formed by a salt water film which at the same time acts as a resistive load in parallel, and there may be sufficient shift of impedance and phase angle to take the aerial outside the tunable range of the pi-coupler. There is a loss of aerial/pi-coupler tuned circuit Q. It has actually been observed by several marine radio officers (of whom I am one) that under such conditions, with some installations, it has been impossible to 'dip' the transmitter tank on 500kHz and therefore impossible to get any current up the wire. Transmission can be instantly restored if one can wash the offending insulators, but that cannot readily be done in severe gale conditions at sea. Last year, according to Lloyds, £243 million of tonnage was lost, some of it just vanishing, reported 'overdue,' no radio call ever being heard.

I have carried out some simple experiments with a comparable feed through insulator and sea water, obtaining d.c. resistance of 1500 to 5000 ohms on coating it with water by a quick dip in the sea, but if a constant drizzle of sea water is aimed at the insulator, it is possible to go down to 400 or 500 ohms. In the case of the ship's insulator this resistive film will not be required to dissipate any power if none can be radiated. Some vessels are sometimes equipped with rather inefficient 'spray shields,' seldom entirely satisfactory, and in some cases where insulators go through a wall rain can wash salt from the superstructure onto the insulator despite any shield that may be fitted.

If any reader has had any experience of this phenomenon, or can direct me to any research which may have been done on it, I would be extremely interested to hear and I would also like to know if any firm is interested in the design of an improved spray shield. No thought has been given to this question for about 70 years!

John Wiseman
107 Antill Road
London E3

MILITARY ELECTRONICS

Congratulations on your editorial "The death delivery business" in the January issue. I never expected to see such sentiments expressed in a technical journal, at Christmas. Miracles continue to happen.

However, while being wholly with you in your distaste of the application of our professional work we must be aware of the alternatives. Could we, for instance, stand by and see defenceless people (our own families?) become the victims of force?

The real crime is that of insensitivity to one's "neighbour" and his needs. Jesus Christ had much to say about those who neglected the needs of others.

Presumably, those in the death business are not prepared to sacrifice their career prospects by seeking employment elsewhere, and few will blame them. In any case, the blame is not only theirs but all who contribute to the country's defence, both financially (by taxation) and by their political vote.

War is a terrible thing in whatever form, but so are greed and selfishness, and these also bound in all professions. Only when man is prepared to sacrifice his own needs and put those of others first will such things be defeated.

J. Skinner
Melsham
Wilts

F.M. TUNER DRIFT

Following your articles on the Nelson-Jones Mk II f.m. tuner (September and November 1978 issues), I feel some readers may be interested in a possible source of drift which I found in the Mk I (varicap tuned) version, and which may also apply to the Mk II and probably other designs as well.

The tuning voltage is applied to pairs of varicaps through 1MΩ resistors on the assumption that the leakage current of the varicaps will be very small. This is normally true – the ZC101 has a typical leakage current of 1nA at 20°C, but it has a maximum specified value of 2μA, which would drop 2V through 1MΩ! In my tuner, I was suffering from drift on warm-up (on a time switch in a cold house) equivalent to something like a 50mV drift in tuning voltage. This could be produced by a 50nA change in leakage current which, being a highly temperature sensitive parameter, seems quite possible. Though I have no means of measuring such a current, parallelling the 1MΩ resistors with 100kΩ does seem to have done the trick.

P. J. Le Riche
Harpenden
Herts

The author replies: Yes I agree, and I have done some quick calculations which show that a value of feed resistor down to 47kΩ rather than the present value of 1MΩ is quite acceptable. The limitation of value in this downward direction is set by the need to avoid unduly loading the oscillator tuned circuit at the h.f. end of the band.

Assuming that the capacitance total in the circuit is around 10pF at 108MHz, the impedance of the tuned circuit unloaded would be around 16kΩ. The varicaps in fact provide a tapping at 50% so that the impedance of such a tuned circuit at that point would be around 4 to 5kΩ in an unloaded state (Q=200-250). However, the tuned circuit is connected in an oscillator circuit and thus has a 'Q' greater than infinity in effect. Thus any loading is merely a l oad on the oscillator and will only serve to lower the oscillation level slightly unless it is so heavy as to stop the oscillator altogether. Thus a value of 47kΩ seems quite in order.

L. Nelson-Jones

"SOFTWARE DABBLERS"

As one of Professor H. Barker's "dabblers" I would like to add to the comments already made by M.A.I. Wilson in your February issue (letters). Yes, modern technology has made it possible for mechanical control engineers to use single chip microcomputers and low chip-count systems. It has made it possible for mechanical engineers to design better systems using microprocessors. In the recent past the operational amplifier has had a similar effect on analogue systems. Is it so bad that mechanical engineers and others should be able to step over the so-called boundaries? Control engineers using electrohydraulic systems have been crossing the boundaries every day. Test and development engineers think nothing of using electronic equipment for test purposes. Most modern engineers are quite familiar with computing, and software in the form of BASIC or FORTRAN.

I agree wholeheartedly with Mr Wilson in his call for unification of hardware and software. The design engineer, in whatever discipline he may work, who can understand the whole of his system and know when to call in specialists to help him is just what this country needs. What we don't want is a demarcation attitude of "who drills the holes" when the holes happen to go through metal and wood.

Extensive commercial exploitation will come from installation in all manner of equipment. To use equipment one does not need to be a specialist in its design but only to be aware of the characteristics which affect the remainder of the design.

In the teaching profession, to which Professor Barker belongs, the specialist often cannot bring himself down to the level of the people he is teaching. Articles written in *Wireless World*, when they are written by the people who have made the equipment, perhaps even classed as dabblers, often provide the reader with a better understanding of the topic than ever a specialist could.

The microprocessor revolution is upon us and Professor Barker might do well to remember what has happened to the elite in some of the revolutions of the past.

G. A. Jones
Kidderminster.

THE MILLIBEL

May I enter a private and personal plea for an hitherto unused "unit" the millibel or mB.

This little fellow is, of course, 0.01 of the familiar decibel and represents the smallest part of a dB with which one is likely to be concerned. In its favour it can be shown to save space and writing effort; and it also removes any ambiguity in the placing of a decimal point. I have used it myself, unofficially, in lab notebooks.

Still on the subject of decimal points I draw your attention to the current practice of giving values of resistance and capacitance without them. Thus 4.7μF is shown as 4μ7 and 2.2Ω as 2k2. It seems to me that this economical method might usefully be extended to other electrical units in the form of 1kW5 for 1.5kW or 11mA3 for 11.3mA. Where power or current is clearly meant the W or A can be omitted, as Ω or F are for resistance or capacitance.

As a by-product this stifles any controversy over whether one should write 4.7, 4·7 or 4,7.

Philip D. R. Marks
Bourne End
Bucks

RELATIVITY AND TIME SIGNALS

All of us would like to know more about the workings of the universe, hence our interest in relativity, whose object is to unravel those workings. Relativity readily gives rise to contradictions and its current protagonists seem to echo R. A. Houston in the 1930s, who wrote, "It is inadvisable to devote attention to its paradoxical aspects." Dr Essen (October 1978 and April 1979 issues) has testified to this "inadvisability."

A recent television documentary in the USA quoted experimental evidence for the slowing of light in the vicinity of the sun. The scientists on the programme hastened to save relativity by claiming that an observer on the sun would find the same light moving at its (full) velocity c. I wonder where this leaves the statement of Dr Griffiths (December 1978 letters) that "the velocity of light is the same for all observers." (I might point out that these words are not the same as nor, in my opinion, are necessarily equivalent to the words used by Einstein in his famous Principle 2.)

Whether any experiment has ever been performed to measure the speed at which light from a source S approaches an object moving at velocity *v* towards S I do not know. If not, I am impressed by Dr Griffiths' faith. In his original paper, Einstein, in deducing the Lorentz quotations from his postulates and his synchronisation procedure, used the commonsense relative velocity of $c + v$ for Dr Griffiths' example and, wonder of wonders, came up with a different formula for compounding two velocities. The logic is equivalent to, "If $A = B$, if follows that A is not equal to B."

R. J. Diamond
Department of Mathematics
California State University
Los Angeles, USA

FERRITE ROD AERIALS

Professor Sutcliffe's article on the effective length of ferrite rod aerials in your December issue is sub-titled "A topic that has received almost no treatment in the literature". This may be true of recent years but there is a rather full treatment in the reference given below*. The approach is more general but the design equations are entirely consistent with those of Prof. Sutcliffe.

However, an expression for effective aerial height which depends on guessing an effective dipole length is of limited value. The suggestion that manufacturers might include the effective dipole length in the literature is helpful only if there is a standardized winding configuration, but this is not so in practice. In the above reference the expression for effective height, h_e, is given as

$$h_e = \mu_{rod}\,\omega ANF_A/c$$

The rod permeability, μ_{rod}, is a function of the material permeability and the length/diameter ratio, so, together with the cross-sectional area A, it is specific to a given rod type and could be quoted as data. However, the factor F_A is only unity for a short coil in the centre of the rod. In practice the windings usually occupy an appreciable length of the rod and are not centrally placed. The above reference gives data for estimating F_A and has graphs giving μ_{rod} as a function of permeability and the length/diameter ratio.

Another consideration is that the designer is mainly interested in optimising the signal/noise ratio and this, it is shown, involves maximising $h_e{}^2Q/F_n$, where Q is the unloaded Q factor and F_n is the noise factor of the r.f. amplifier.

I am grateful to Prof. Sutcliffe for raising this subject and thus providing an opportunity for discussion.

E. C. Snelling
Haywards Heath
Sussex

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* Snelling, E. C. "Soft Ferrites", Butterworth, London 1969, (Chap. 10)

WANTED — FOR THE SCIENCE MUSEUM

Next March the Science Museum is mounting a retrospective exhibition on television, and although offers of exhibits are coming in from industry and collectors alike I should like to enlist your help in finding two items that are proving elusive: a notable type of pre-war receiver, and a valve needed for the restoration of another receiver.

The receiver I am trying to trace is the Scophony large-screen projection set of about 1937, which employed mechanical scanning and modulated the light from a mercury vapour lamp by means of a 'supersonic light control'. The video signal was modulated onto a carrier at the resonant frequency of a quartz transducer and propagated through a liquid as an ultrasonic wave! The velocity of the wave was offset by the scanning process to give a stationary image that comprised, at each instant, something approaching fifty picture elements; this technique, it was claimed, gave much brighter pictures than could be obtained with conventional light controls transmitting only one picture element at a time.

Scophony produced several domestic models, with screen widths ranging from 18 to 48 inches, as well as a theatre model giving a six-foot picture from a 3kW arc. The price of the 24-inch model was 220 guineas, so not many can have been sold, but it was undoubtedly an advanced piece of engineering and I should very much like to exhibit a specimen if one survives in anything like complete condition.

At the other end of the price range was the Pye 817, a five-inch model selling for 23 guineas; this was a 'vision only' set, the detected output of the sound receiver being fed out to the pick-up sockets of the owner's radio. One of these little sets is being restored to working order for the exhibition, but the restorer is stuck for one valve: a Hivac AC/TZ, which was a triode tetrode and served as line oscillator and output stages. Again, any offers of help will be gratefully received.

Keith Geddes
Deputy Keeper (Telecommunications)
The Science Museum
Exhibition Road
London SW7 2DD
(Telephone 01-589 3456, Ext. 638)

CITIZENS' BAND

Why are so many people against c.b.? It appears that somehow they are afraid it's going to degrade or lower the position of that almighty being, the licensed transmitting amateur. Surely this cannot be, as any citizens' band would not be connected with, or in, any amateur band. I am in full agreement with the people who argue about the interference caused by operation on a.m. in the 27MHz band. This is, as anyone with basic radio knowledge should know, useless for local or short-haul contacts, the all-round answer being the use of u.h.f. and f.m. An Australian friend of mine tells me that since the introduction of a u.h.f. c.b. band in his country they get better range; also the operating standards of stations seem to have improved.

I do not like the emphasis placed on the American system on 27MHz in most letters, and in recent programmes on the radio and television. All this talk of "Rubber Ducks", "Smokey Bears", "10-4" etc. has gone a long way to putting people against c.b. It may sound romantic to some, but in my opinion does nothing to help.

In reply to Mr Riley's letter in the January issue, in the controlled experiment it is apparent that the driver was compelled to answer the questions put to him while trying to negotiate a difficult course. Fair enough, but surely in an actual "on the road" situation any sane driver would firstly be moving very slowly, and if called on the radio could say "stand by, I'll call you back". Personally in bad traffic conditions I even turn off my car set to avoid distraction. As to the reference to inexperienced c.b. users vs. experienced communicators, I think driving experience comes first. Anyway, one only gains experience by being able to do a thing in the first place.

In conclusion, on the arguments that a citizens' band could be misused, you find in all walks of life there are always a few who try to spoil things for others; one can even hear this at times on the amateur bands. Also I think a good c.b. band could be a source of income for the government, i.e. licence fees, VAT on equipment, possible c.b. magazines, etc.—even, as some people have suggested, compulsory membership of a society, such as the RSGB, so there can be some check that you're not being a bad boy. Finally, if anyone does not like c.b., he need not buy any equipment, or even listen on the band, need he.

J. Berry
Bristol

DISPLACEMENT CURRENT

The pattern of magnetic field made when a very sharp edge of voltage propagates along any TEM wave structure is the same as that obtained if the wave front is replaced by a thin sheet of uniform conductor and the current of the wave is applied as a balanced d.c. on one side only of this sheet.

If this experiment is performed it will be found that there is no magnetic field whatever beyond the sheet and no longitudinal magnetic field at any point, despite the fact that lateral current is clearly flowing in the sheet. On page 67 of the March issue this result is described as being absurd, but it is nevertheless true.

Since the field pattern is just the same for the propagating edge as for the d.c. case it seems only reasonable to talk of a "displacement current" when a magnetic field is caused by change of the vector D rather than by real current. There is no question whatever of "displacement current" not causing magnetic field in some particular cases, and neither Maxwell nor Heaviside have overlooked a discrepancy in this matter.

K. C. Johnson
Cheadle
Cheshire

The authors reply:

In Mr Johnson's first paragraph, when he writes "uniform conductor" he must of course mean "uniform resistor."

When a TEM signal advances at the speed of light, there is a close mathematical correlation between the E field and the H field at every point.

When a TEM signal glides through a dielectric edged by a perfect conductor, there is a close mathematical correlation between the H field and the electrical current in the surface of the conductor.

D being a mathematical function of E and i also being a mathematical function of E, it is not surprising that the two mathematical derivations from the same source, E, correlate, even to the extent that there is a consistent relationship between

$$\frac{d(\epsilon E)}{dt}$$

and *i*. One could say that these two derivations from *E* correlate by definition. Since

$$\frac{d(\epsilon E)}{dt}$$

and *i* are obviously functions of *E*, it is mathematically impossible for the reverse mathematical process (cf. logs and anti-logs) to produce anything other than the original *E* field from which *i* and displacement current are derived.

The key question is, "Does any function which is correctly derived from a real physical entity also have physical reality?" For instance, to carry the point to absurdity, what physical reality can be attached to the "circularity," α, of a circle, defined in terms of the circumference as follows:

$$\alpha = \frac{C^2}{4\pi^{1/2}}$$

from which it can be deduced that the circle's area *A* is

$$A = \frac{\alpha}{\sqrt{\pi}}$$

We could have just as much futile fun with "circularity" as we do with "displacement current." They are both the results of valid mathematical manipulation. But do they exist physically, and are they useful?

Displacement current has shed no light and produced much fog. Is it anything more than a mathematical derivation from the Poynting Vector, which we call the Heaviside signal?

To put it another way; if we describe an $E \times H$ wave which has an edge, does it have an edge? Displacement current "shows" that we have the thing we defined.

I. Catt, M. F. Davidson, D. S. Walton

CURRENT IN COAXIAL CABLES

Your recent contributions on the subject of current flow in coaxial cables (March letters and "Did you know?" December issue) make heavy weather of the problem, but fail to come to terms with the nitty-gritty.

When a current-carrying conductor penetrates a hole in a perfectly conducting sheet, an equal and opposite current is induced in the boundary of the hole; the total current through the hole must be zero. This follows from the fact that there can be no penetration of magnetic flux into the material of the sheet.

A coaxial cable is merely an elongated hole. A current in the centre conductor induces an equal and opposite current on the inside of the sheath. If the sheath is not connected at one end, the current on its inner surface must continue back along the outer surface until it can again flow to the ground plane, and thence to the load. If follows that voltages induced along the outside of the cable by an external field will tend to produce current in the inner conductor, so that proper shielding is not obtained.

If energy is required to be fed through a sheet, the go and return conductors should ideally be fed through the same hole. Lack of attention to this can result in unwanted coupling between r.f. circuits, and to ground-loop effects causing hum in sensitive audio amplifiers.

This subject is excellently treated by E. E. Zepler, in "The technique of radio design" (Chapman and Hall, 1945) in a section on the principles of screening.

J. L. Crosthwait
Cheltenham, Glos.

NOVICE LICENCE FOR AMATEURS?

The recently formed European CW Association is examining the possibility of western European nations introducing a c.w.-only novice amateur radio licence. This licence would be a stepping-stone for beginners who wish to eventually qualify for a full amateur licence. Suggested licence conditions are:

1. A simple examination covering regulations and radio theory.
2. A 5 w.p.m. morse test (administered by any amateur who has held a full licence for at least 3 years).
3. Crystal control only, in defined segments of amateur bands (h.f. and v.h.f.).
4. Maximum power input 10 watts.
5. Holders of an RAE pass certificate need only pass the morse test.
6. A novice licence could only be held for 2 years in any 5 year period.

To try and establish the volume of support for such a proposal I would be obliged if you would publish this letter. Those in favour of the idea, whether licensed amateurs or not, should send their name and address to me on a post card, at the address below. In the case of local radio clubs correspondence could be saved by the secretary informing me of the number of his members who are in favour of the idea. Considerable support is essential if the proposal is to succeed, and even then negotiations may take many months.

The European CW Association currently consists of the Scandinavian CW Activity Group (Denmark, Finland, Norway and Sweden), the West German CW Activity Group, The TOPS CW Club (UK), and the G QRP Club (UK). It represents over 1500 licensed radio amateurs and a number of short wave listeners.

A. D. Taylor, G8PG
European CW Association
37 Pickerill Road
Greasby, Merseyside L49 3ND.

ANTENNA AIMING CALCULATIONS

As a yachtsman, I studied Mr A. M. Stephenson's article in the March issue with considerable interest. The article is too short.

We were shown how to calculate the angle subtended at the centre of the earth by two points on the surface. The author should have pointed out that if this angle were expressed in minutes (by multiplying by 60) we have the distance in nautical miles. It surely is of interest that it is 9291 miles from Kit Hill to Melbourne?

The use of the nautical mile, of 6080ft leads to the proposition that the grazing range from an antenna at a height of *h* ft, is $\sqrt{h}$ nautical miles. Two 100ft antennae have line of sight over water of 20 miles. The use of $\sqrt{h}$ rather than the more accurate 1.06 $\sqrt{h}$ gives a small margin of safety.

The author's calculations were checked using the well established haversine formula and exact agreement found. It would not have occurred to me to programme a calculator for a one-off calculation; what a pity that the article was restricted to programmable machines when any scientific calculator will do!

I must protest that there is no such thing as a negative angle. Latitude is either north or south of the equator and longitude is either east or west of the Greenwich meridian. Longitude has the dimensions of time and whoever heard of negative time? Has Mr Stephenson's calculator taken charge? Fig. 1 does not seem very helpful to me.

There may well be differences between paths to the antipodes; it is recommended that the great circles be plotted on a Mercator's projection of the earth when the differences between land masses and sea will be apparent.

A very useful and much needed article – perhaps Mr Stephenson should have written a book!

P. Wadham
Carshalton
Surrey

The author replies:

As a yachtsman, Mr Wadham has hit on one application which, to be honest, was not envisaged when the article was written. Actually, the article evolved from the realisation that (back in 1976), although good scientific calculators were becoming an economic proposition for private small users, the procedures then employed were very likely still bound by the restrictions of the old days when log tables and slide rules were about the best tools that most folk could lay their hands on. No doubt this is still so in many instances.

Another consideration is that of applicability. Calculators are developing rapidly, under market pressures that demand from the makers more and more features so that their products will continue to sell. Texas, Hewlett-Packard, CBM are only three of the names that have shown signs of being aware of the 'specialist' markets by bringing out calculators dedicated to navigational calculations. (Well, perhaps H-P have tended to rely more on the programmability of their established lines.) In 1976 one had to consider the difficulties associated with running a non-waterproof, electricity-consuming device out at sea before serving the needs of someone like Mr Wadham. Now one can buy dedicated devices. So perhaps, subconsciously, I omitted the seafarers on the grounds that they might prefer the traditional methods.

It is reassuring to learn that old and new approaches have yielded the same answers. I must confess total ignorance of the haversine formula*. The equations given in the article were all the result of some rather tedious slogging through spherical geometry relationships and pages of algebra, an exercise I would not be eager to repeat. So, although I suspect Mr Wadham of lodging his tongue firmly in his cheek when he protests my use of negative angles, may I excuse further effort on the grounds that (a) *my* calculator lacks compass-point keys and (b) it works? Falkland Islanders and other inhabitants of points south and west please copy.

Andrew M. Stephenson

*The name haversine comes from "half of the versine" of an angle, that is ½(1 − cosθ) where θ is the angle concerned.—Ed.

Teletext remote control — 3

Installation and commissioning

by R. T. Russell

This concluding part of the article covers the construction, installation and operation of the ultrasonic remote control for the *Wireless World* teletext decoder. The receiver and transmitter for the controller were described in the April and May issues.

WHETHER USING copper-strip board or a printed-circuit board there should be just about enough room in the original decoder cabinet (if used) for the remote control unit, although it will probably be necessary to reduce the spacing between the original boards as much as possible. If the character rounding board has been fitted, then the remote control board fits alongside, at the front of the cabinet. Only three connexions to the remote control board (IC_{48}, pin 12, IC_{80}, pin 9 and IC_{78}, pin 4) are inaccessible without dismantling the decoder, the majority of the remaining connexions going to digital board one or to the switches, although if board 4 (character rounding) and/or board 3 (new facilities) are fitted, access will be a little more difficult. It is suggested that the 'automatic clear' modification to board 2 be carried out and at the same time three flying leads attached at the above points for connexion to the remote control board. The decoder may now be partially reassembled and tested to ensure that it still works. The automatic clear can be tested by momentarily connecting the lead from (78.4) to 0 volts, whereupon the header should start "rolling" and, on arrival of the selected page, the display should clear just before being rewritten. Choose a page on which a genuine Clear Page bit is not expected.

At this stage the remote control board can be fitted. Many of the connexions go to points on digital board one and, if done with care, the wires can be soldered directly to the i.c. pins on the top of the board. The minimum of heat should be used, consistent with getting a good joint.

If it is desired to dispense entirely with the original push-button and thumbwheel switches the wires originally going to these should be transferred to the appropriate points on the remote control board. These are auto-newsflash select, time on, time select, clear, video switch (to tv), cut box, reveal and the thumbwheel wipers (commoned). If preferred, the switches may be retained and a multipole local/remote changeover switch fitted to select either the remote control or the thumbwheels and pushbuttons.

Power supply

The interface board requires a +5V supply at approximately 650mA plus a -12V supply at 15mA max. for the u.a.r.t. The power consumption could be reduced considerably by using low-power Schottky i.cs (74LS) instead of the standard types specified, although IC_{307} must be a 7473, not a 74LS73.

Testing

Because of the digital nature of the circuitry there is a good chance that it will work first time, assuming there are no wiring errors. For this reason it pays to take extra care with assembly and to make sure that no connexions are omitted or transposed. The boards should be examined closely for any unsoldered i.c. or component leads or solder-bridges between pins. When first switched on a check should be made that the power supply voltage is reaching all the i.cs and that it is in the correct range (4.75V to 5.25V for the receiver and decoder boards). The tv receiver must be fed from a mains isolating transformer whilst testing.

A normal, steady display (probably of random characters) should be obtained at switch-on, although the video-switch signal to the tv might have to be temporarily disconnected from the remote control board and connected to +5V. Any obvious display fault at this stage must be due to one or more of the connexions from the horizontal and vertical addressing to the remote control board having been connected to the wrong point or shorted. Such a fault can be located by disconnecting each of these in turn.

Once a normal display is obtained, the remote keypad can be tried to see if any of the control functions operate. If it is completely "dead" it is advisable to bypass the ultrasonic link by temporarily adopting the "wired" option shown in Fig. 3. It should be found that the serial input to the interface board is normally at logic 1, but goes to logic 0 for a short time when any key is pressed. If this does not happen the fault lies in the keypad unit. If an oscilloscope is available the signal can be examined to ensure that it corresponds with the format shown in Fig. 1.

If a signal is observed at the serial input, but still no commands are operative, a check should be made that (304.19) pulses to logic 1 each time a key is pressed. If not, then IC_{304} or its connexions are at fault. Once some degree of response has been obtained, testing should be fairly straightforward. The miscellaneous functions (reveal, clear, text, tv) should be checked first, followed by the entry and display of page number/time and finally a check that the selected page is correctly acquired and displayed by the decoder.

The spare command

As mentioned previously, a seventeenth, spare, command was included for general purpose use. When this command is sent (302,10) goes to logic 0 and remains there until another command is sent. An inverted version of this signal is available at (302,11). If a pulse rather than a steady signal is required then (302,11) may be gated with the pulse at (305,6) using either diodes or a NAND/AND gate. There are two points to note if the spare function is to be used. Firstly, if it is used to provide a sequential channel-change, it should be borne in mind that the decoder uses line syncs as a timing reference and if a channel is selected which has no signal present then the remote-control will "lock-out" and inhibit further changes. One solution to this would be to feed IC_{304}, pins 17, 18 and 40 from a separate 1600Hz oscillator rather than from the line divider. Secondly, by the nature of the coding system adopted for the ultrasonic link the "spare" command is the most likely one to be spuriously activated by reflections or other sources of ultrasound. If the occasional spurious operation is undesirable (as in the case of channel change) an improvement can be effected by additionally gating with the spare command a signal which is active only when the four least significant data bits (IC_{306}, pins 3, 6, 8 and 11) are all zero.

I would like to thank Humphrey Hinton for his encouragement and advice, and Messrs. Catronics Limited for their assistance with printed circuit work.

Parts list

Transmitter

Resistors 5% ¼W carbon film

R_1	47k
R_2	47k
R_3	5k6
R_4	180k
R_5	1M
R_6	3M9
R_7	10k
R_8-R_{15}	1M

Capacitors

C_1	22µF 16v tantalum bead
C_2	22µF 16v tantalum bead
C_3	100pF polystyrene
C_4	22pF polystyrene
C_5	100nF polyester
C_6	1nF ceramic disc

Integrated circuits

IC_1	4518
IC_2	4520
IC_3	4070
IC_4	4569
IC_5	4068
IC_6	4021
IC_7	4027

Other components

D_1-D_{20}	1N4148
Tr_1, Tr_3	2N3906
Tr_2	2N3904
X_1	crystal 4.433619 MHz
X_2	transducer Murata MA40L1S or RS 307-351
B_1	9 volt battery PP3-P

Receiver

Resistors 5% ¼W carbon film

R_1	10k
R_2	10k
R_3	1M
R_4	120k
R_5	1k2
R_6	33k
R_7	1M
R_8	4k7
R_9	1k5
R_{10}	100
R_{11}	3k9
R_{12}	100
R_{13}	330
R_{14}	10k
R_{15}	39k
R_{16}	22k
R_{17}	10k

Capacitors

C_1	56pF tubular ceramic
C_2	330pF polystyrene
C_3	330pF polystyrene
C_4	4n7 disc ceramic
C_5	47µF 6.3V tantalum bead
C_6	39pF polystyrene
C_7	120pF polystyrene
C_8	0.33µF polyester
C_9	100nF ceramic disc
C_{10}	47µF 10v electrolytic

Integrated circuits

IC_1	CA3130
IC_2	CA3130
IC_3	7400
IC_4	7492
IC_5	7492
IC_6	7492
IC_7	7474
IC_8	CA3130

Other components

Tr_1	BC109
Tr_2	BC109
L_1	2.5 mH r.f. choke
X_1	transducer Murata MA40L1R or RS 307-367
X_2	crystal 4.433619 MHz

Interface

Resistors 5% ¼W carbon film

R301-305 1k

Capacitors

C301-303	0.1µF ceramic disc
C304	47µF 10V electrolytic
C305, 6	0.1µF ceramic disc

Integrated Circuits

IC_{301}	7400
IC_{302}	74175
IC_{303}	7442
IC_{304}	AY-5-1013
IC_{305}	7400
IC_{306}	7408
IC_{307}	7473
IC_{308}	7404
IC_{309}	7402
IC_{310}	7473
IC_{311}	7402
IC_{312}	74170
IC_{313}	74170
IC_{314}	7401
IC_{315}	7400
IC_{316}	7483
IC_{317}	7486
IC_{318}	7408
IC_{319}	74126
IC_{320}	74126
IC_{321}	7485

References

1. Daniels J. F., "*Wireless World* Teletext Decoder" – *Wireless World*, November 1975 to June 1976. ☐

Literature Received

Catalogue of instruments for hire from Livingston in 1979 now available. Over 3000 items now offered. Livingston Hire Ltd, Shirley House, 27 Camden Road, London NW1 9NR .... WW 401

Data sheets are published by Cotron on PMC series of colour video monitors, intended primarily for the display of computer graphics. Cotron Electronics Ltd, Rockland Works, Eagle Street, Coventry CV1 4GJ .. .. WW 402

750 watts of mains-frequency a.c. are provided from 24V or 50V inputs by the ROAC sine-wave inverter from Roband, who publish a descriptive leaflet. Roband Electronics Ltd, Charlwood, Horley, Surrey RH6 0BY .... WW 403

Brochure on the specifications, design and application of film circuits is produced by ITT Film Circuit Division, Paignton, Devon ... . WW 404

Short catalogue illustrating Brandenburg's range of accomplishments in inverters, high-voltage supplies and a cardiac teaching aid is obtainable from Brandenburg Ltd, 939 London Road, Thornton Heath, Surrey CR4 6JE .... WW 405

Second part of "Tecknowledgey" — Ambit's catalogue — now available, containing full information on audio, radio (broadcast and amateur) kits and components. More informative than many we have seen. Price list not included. Ambit International, 2 Gresham Road, Brentwood, Essex. Sent free to applicants writing on company notepaper, 50p to anyone else.

Dual-in-line switches from Erg described in colour brochure obtainable from Erg Industrial Corporation Ltd, Luton Road, Dunstable, Beds LU5 4LJ .... WW 406

Dipping unit for applying varnish to printed-circuit boards is subject of data sheet from Robnorganic Systems Ltd, Highworth Road, South Marston, Swindon, Wilts SN3 4TE . ... WW 407

Travel for Telecom 79

Associated with the opening of WARC 79 this year (24 September to 30 November) is another important event in Geneva, the 3rd World Telecommunications Exhibition and Conference. Called Telecom 79, it is sponsored by the ITU and supported by the telecommunications administrations of the 154 ITU member countries and runs for the period 20-26 September. *Wireless World* will be taking part.

Our publishers, IPC Electrical-Electronic Press Ltd, have arranged special visits to Telecom 79 in association with Commercial Trade Travel Ltd. Accommodation is in Hotel Beau-Rivage, situated on the lake in Geneva, and air travel from London (Heathrow) by scheduled flights is arranged to offer three or six nights. Tour A (3 nights) is: depart 20 Sept; return 23 Sept. Tour B (3 nights) is: depart 23 Sept; return 26 Sept. Tour C (6 nights) is: depart 20 Sept; return 26 Sept. Price of tours A and B is £248.00 while tour C is £348.00 (all sharing a twin bedded room; single room supplement £15.00 per night). Accommodation-only can be provided. For a booking form write to *Wireless World*, Dorset House, Stamford Street, London SE1 9LU.

Functional logic symbols — acknowledgement

The article on functional logic symbols by G. M. Whittaker which appeared in our April issue was based on a paper read by the author to a symposium on technical documentation held by the Society of Radio and Electronic Technicians in November 1978. The Society has asked us to point out that the article also appeared in their journal *Electronic Technology* in January 1979. We apologize for the omission of this acknowledgement from the *Wireless World* article.

A scientific computer — 3

Construction, testing and operating

by J. H. Adams, M.Sc.

ALTHOUGH this is not a simple project, with careful soldering and the usual m.o.s. precautions, the construction should be quite straightforward. It is worthwhile building the power supplies first and testing them under load conditions of 3A for the +5V and 0.5A each for the —5V and +12V, until the regulators have reached their working temperatures. As a power supply failure can be particularly damaging, a generous heatsink, especially on the 2N3055, is recommended.

The next section to build should be the v.d.u. circuit, which will provide the video and sync signals required in the development of the display interface. To ease later work, the interface should be built as described in part 2. With the character generator and the 21L02s left out, and with the variable resistor set to a maximum, a correct display will consist of 32 rows of 64 oblongs. With the character generator and memories in place, these oblongs will become rows of random ASCII characters. When this is displayed, the variable resistor is reduced to move the display up the screen until it is as high as possible with correct linearity of all 32 lines. Reducing the resistor too much will either cramp or expand the top line and eventually wrap it back into what will then become visible fly-back. Table 2 gives test points and their waveforms for the v.d.u., and table 3 gives processor checks.

Once the circuit has been completed it should be thoroughly checked. A particularly devastating fault occurs if power lines appear on the wrong i.c. pins, especially the outputs of t.t.l. circuits. An ohm-meter, connected between each of the supplies in turn and the i.c. pins, will check for this kind of fault. Cautious constructors need only insert IC_{18} and IC_{26} out of the memory devices, the first r.o.m. and the r/w.m. covering 1C00 to 1FFF, for the initial test. Fig. 17 gives a suitable sequence for these tests.

The computer requires an ASCII coded input, comprising 7 bits of inverted data, together with a positive strobe pulse, active during the presence of the code at the computer input buffer. The Carter type 756 keyboard will give such signals when connected as shown in Fig. 18. For those constructing a purpose-built keyboard, DEL, ESC, CTRL and — are not required, and RS should carry the legend ↗S the legend ↓. The l.e.d. lights whenever the Z80 is in the halt state and indicates that the computer is waiting for keyboard data.

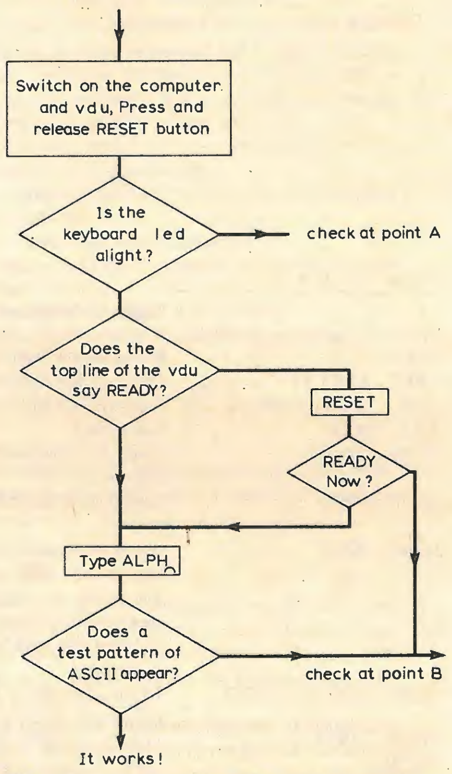

Fig. 17. *Test sequence for the computer.*

Fig. 18. *Connection for the Carter 756 keyboard.*

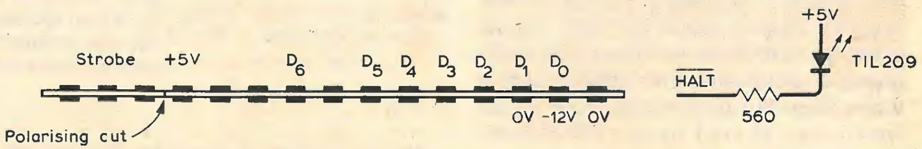

Table 2 v.d.u. test points and waveforms

Location	Waveform	Possible remedy
IC_{28c} out	8MHz clock, t.t.l.	IC_{28} or crystal
IC_{32a} out	4μs pulses every 64μs	check back through IC_{48}, IC_{30}, IC_{29}
IC_{35} pin 11	approx 50Hz, t.t.l.	check through IC_{35}, IC_{29}, IC_{34}, and then,
IC_{36} pins 1, 6	approx 100μs pulses every 20ms	check IC_{36}; pin 6 is normally low
IC_{37} pin 2	16μs pulses every 64μs	check IC_{31b}, IC_{48}
IC_{45} pin 1	1.333MHz with 8MHz bursts	check IC_{37}, IC_{33}
IC_{45} pin 7	48μs bursts of data every 64μs	check IC_{45}
Video	mixed video and blanking information	check IC_{33}
Sync.	mixed syncs	check IC_{32b} and the differentiating network

Using the computer

When the assembled computer has been tested, the r.o.ms and at least IC blocks 22 and 26 should be inserted. Two programs, one in the low-level and one in the high-level language, are programmed into some spare space at the end of the third r.o.m., and these will be used to demonstrate the computer's ways.

In the tables and explanations of commands and program lines, the symbol ⌢ means that a space has to be typed at that point, e.g.

TAPE ⌢ 1800 1880

means that you type TAPE space 1800 1880. As explained earlier, this is one of the bases of the systems operation.

Low level operation

When you have a high-level language, working in machine code may seem like talking in Morse code. However, low-level programs, if properly written, usually occupy less memory space, run faster and allow the computer to be used as a controller of processes, as well as a calculating machine. Table 4 lists the computer's machine code commands. At the address 0B16, there is an example of a code-breaking game where the computer makes up a four digit number using the digits 1 to 8, and then marks your attempts to guess the code by awarding black symbols for correct digits in the correct place and white symbols for any remaining digits in the code which are in the wrong place. With the computer in the READY state, type

```
RUN ‸ 0B16
```

and then your first guess at the code, say 1234. The computer will mark your guess and wait for your next attempt. Note that, as soon as you type something, in this case, the first letter of RUN, the READY disappears, and does not return until you break the code, indicating that the program has finished running. The READY state may be achieved at any time by pressing RESET, or by typing FS. To examine the code set during the program, return to the READY state and type

```
LIST ‸ 1FE4
```

The computer will then list from address 1FE4 to 21CF. The format used for listing gives the address of the first byte, which will appear on that line, and then the remainder up to the end of the row of 16, spaced in blocks of four for easy inspection. When a line is broken into, as in this case, the computer maintains the layout by indenting the top line by the correct amount. The first four bytes contain the computer's code, a 00 representing a digit 8.

The game may be played over and over again, using the command

```
RUN ‸ 0B16
```

but, as an illustration, suppose that the program is to be simplified. To alter the program, it must first be copied into the r/w.m. so type

```
MOV ‸ 0B16 0C00 1E16
```

which will move the program out into r/w.m. and, because some of the bytes in the program relate to the memory area that the program occupies, type

```
COR ‸ 1E16 1F00 0B 1E
```

The computer will reply

```
1E24 1E37 1E3D 1E5B 1E62
```

meaning that it found 0Bs at these addresses, and changed them to 1Es. Now list the program,

```
LIST ‸ 1E16
```

and note that the byte at 1EAC, i.e. the 13th byte on the row starting 1EA0, is a 77. Type

```
ALT ‸ 1EAC 33
```

at which the 77 will change to a 33. This will limit the number range in the code from 1 to 4, rather than 1 to 8 as in the original. The computer will not return to the READY state because often more than one modification is carried out at a time and, as in this case, the 0B at 1E5B, which was altered in the COR command, was not part of an address to be altered, but is the k in the word black, and so must be changed back with

```
1E5B 0B
```

Now, press FS to achieve the READY state and

```
RUN ‸ 1E16
```

to play the simpler form of game.

Using the machine code is essentially a matter of practice and experience, but more details will appear in part 4.

High level language

Table 5 lists the BURP statements, and

Table 3. Processor checks.

Location	Waveform	Possible remedy
Point A IC$_1$ pin 18	low	If it is low, test the l.e.d.
Point B IC$_1$ pin 6	8MHz	If not, check clock buffer circuit around IC$_{14b}$.
Address bus	Various	A$_0$ to A$_6$ should be cycling through refresh addresses, A$_7$ to A$_{15}$ should be low, except for A$_8$, which carries a 500kHz square wave. A line not conforming to this pattern is not necessarily at fault. Check for levels between 0.8 and 2.4V, as these imply a short to one of the other address lines.
$\overline{RD}$	750ns pulses every 2µs	These are active low, and so the pulses described are to a low state. Repeat the test for shorts.
$\overline{WR}$	High	
$\overline{MREQ}$	750 then 500ns pulses every 2µs	
$\overline{IORQ}$	High	
Data bus	Various	During the $\overline{RD}$ pulse, the computer accesses the memory, although, as it is the HALT state, (when working correctly) the Z80 ignores the accessed byte. The accessed address is 0357, which puts the byte E6$_H$ or 11100110 on lines D$_7$ to D$_0$ respectively during the pulse. If these lines are tested, short circuits must not be confused with tri-state periods, when the lines may float into the intermediate voltage range.

Table 4. Machine code commands.

ALPH ‸	Produces an alphanumeric test pattern on the v.d.u.
* ALT ‸ XXXX YY	Changes the contents of location XXXX to YY
COR ‸ XXXX YYYY AA BB	Scans XXXX to YYYY-1 inclusive and alters any AA to BB.
FILL ‸ XXXX	See note 3.
FIND ‸ XX YY	Finds the consecutive bytes XX YY and lists the addresses at which they occur.
LIST ‸ XXXX	Lists the contents of the memory from address XXXX up to a full v.d.u. screen.
LOAD ‸ XXXX	Loads hexadecimal data at XXXX, using the same display format as in list. To load ASCII directly, type a [and to return type a] after which, the computer gives the next byte's address and continues to load hexadecimal data. To leave LOAD, type @ which gives a full listing of what has just been loaded, or press RESET or the FS key to regain command.
MOV ‸ XXXX YYYY ZZZZ	Moves the block XXXX to YYYY-1 inclusive to the area of memory beginning with the address ZZZZ.
PRINT ‸ XXXX	Lists from XXXX on the second output device
PROM ‸	Used in conjunction with the e.p.r.o.m. programmer, this programs the block of data at 1C00 to 1CFF inclusive into the sector of the 2708 selected on the programmer.
READ ‸ XXXX	Reads from tape into memory, starting at location XXXX. READ must be terminated by pressing any key, once the tape has been read in.
RUN ‸ XXXX	Runs from address XXXX.
TAPE ‸ XXXX YYYY	Records, on tape, a short leader of stop bits, followed by the data at locations XXXX to YYYY-1 inclusive and a short trailer of stop bits.

*Having accepted the alteration, the computer lists out from the previous LIST command starting address. Normally, a LIST of the area in which the alteration is to take place will have been carried out immediately prior to using ALT, and so the altered byte will change to its correct contents on the v.d.u. screen as well as in the memory. After an alteration, the computer does not return to the command state, but waits for any further alterations, typed in as

```
XXXX YY
```

and so on. To return to the command state, type FS or press RESET.

Notes

1. Take care when using MOV. MOV 1D00 1E00 1CFF will work, and move the block 1D00 to 1DFF inclusive, forward one byte in memory, but MOV ‸ 1D00 1E00 1D01 will copy 1D00 into 1D01, then 1D01 into 1D02 etc., leaving you with a block of identical characters and your original data lost. While this can sometimes be useful for filling out a block with a particular byte, to do this properly requires a MOV of the block to a separate, vacant, area and then a MOV to 1D01.

2. The PROM ‸ command takes about 40s to program the e.p.r.o.m. sector completely, and during this time the computer is fully occupied.

3. If less than 256 bytes are to be programmed into an e.p.r.o.m. sector, and the other must be left blank for later additions to the e.p.r.o.ms contents, or, if you wish to add this later bit to an already partly filled e.p.r.o.m., FFs must be present at the bytes which are not to be programmed. This can be achieved by using the extra command FIL ‸ XXXX, which will fill from XXXX to the next YY00 with

FFs, either before loading into the p.r.o.m. area, or, after loading, to mask off the other unused bytes up to 1CFF. This command also makes programs easier to study on the v.d.u. as it can be used to mask off the rubbish following a program.

4. When loading ASCII, do not try to include a] in the string of characters as it will terminate your ASCII mode of loading. Also, do not type in any further [as these will be used in a future adaption to graphics, whose firmware is already in the 2708. Ordinary parentheses, (and) are quite acceptable to the computer.

Table 5. Burp statements.

INPUT ⌢ A ⌢ B ⌢ etc.	Inputs and assigns one or more variables.
LET ⌢ X=A ⌢ SIN ⌢ SQ ⌢ etc.	Assigns the value computed in the expression following the = sign to X.
IF ⌢ X=Y ⌢ THEN ⌢ 50 ⌢	If the condition (which may be <, = or >) is met, then go to line 50. Otherwise, continue.
FOR ⌢ X=1 ⌢ STEP ⌢ B ⌢ UNTIL ⌢ C ⌢	X takes the value 1, the lines up to the line NEXT X are then executed. X is then increased by B and the lines executed again, and this continues until X is greater or equal to C, at which point the computer carries on through the line NEXT X to the next one.
NEXT ⌢ X ⌢	
GOSUB ⌢ 200 ⌢	Goes to line 200 and executes from there until the line RETURN is found, and then returns
RETURN ⌢	to the line following GOSUB. GOSUBs may appear within GOSUB blocks.
HALT ⌢	Halts execution until any key is pressed.
TOP ⌢	Clears, and resets the PRINT position to, the top line of the display area.
ERASE ⌢	As TOP, but it clears the whole display area.
END ⌢	Stops execution and returns to the command state.
GO ⌢ 25 ⌢ or GOTO ⌢ 25 ⌢	Executes from line 25.
WRITE ⌢	As PRINT for the second output device.
PRINT ⌢	
In prints, the following may appear	
An ⌢	A, printed with n figures after the decimal point and then spaces for the blanked characters, 13 in all. For less than an 8 digit mantissa, the last figure is rounded if necessary.
A ⌢	A, printed with the same number of figures after the decimal point as the previously printed variable or, if it is the first one to be printed, to four figures. This four can be altered in r.o.m. location 0818 by programming 01 to 07 in place of the 04.
An, ⌢	As An ⌢ but with the blanked figures completely suppressed and, if the number is in scientific notation, with the exponent and exponent sign against the mantissa.
A, ⌢	As A ⌢ but with the suppression described above.

Summarising, without the comma, printed figures always occupy 13 screen locations and thus columns of results will be tabulated no matter what the magnitude of the number. With the comma, alphanumeric data (see below) and variables may be printed in the same line without large gaps appearing.

"PRINTED TEXT" ⌢	Prints the actual characters within the quotes, implying that quotes must not appear in the string of characters.

It is not possible to have a second (or subsequent) FOR . . . NEXT block within a FOR . . . NEXT block, because the single on-chip memory in the MM57109 is used as a loop counter in conjunction with the NEXT line. These loops, if required, can be set up using for example, in place of the FOR line given,

```
20⌢ LET ⌢ X = 1 ⌢              replaces the FOR
21⌢                        }
22⌢                        }   lines within FOR and NEXT
23⌢                        }
24⌢ LET X=X⌢ B⌢ + ⌢
25⌢ IF⌢ X<C⌢ THEN⌢  21⌢         replaces the NEXT
```

Table 6 gives the mathematical expressions for LET statements. With the computer in the READY state, type

MOV ⌢ 0BB5 0C00 0C00

and then change to the high level language by pressing RS on the keyboard. The word READY will then be replaced by BURP. The RS key types in RUN ⌢ 0800, and initiates the high level system. The low level MOV command moves the sample program in r.o.m. out into the r/w.m., where it can be examined by typing

LIST ⌢ 5 ⌢

which gives

```
005 FOR A=1 STEP 1 UNTIL 25—
006 LET L=A LOG—
007 PRINT A0 L8 —
008 NEXT A—
009 END—
OC4A
```

The dash shows where a line ends and virtually every term, including the last on each line, is followed by a space. The address 0C4A gives the upper limit of the program storage currently in use, and from 0C00 up to 1DC0 is available. Now type

RUN ⌢ 5 ⌢

The computer should print the common logarithms of the numbers 1 to 25. When it has finished, the computer is ready for a command, indicated whenever BURP is the only word on the top line. Type

DEL ⌢ 6 ⌢

and the program will list out with line number 6 deleted. Note that the end address is now 0C3B, i.e. when lines are deleted, the computer reworks the remaining lines back towards the start of the memory space. This makes best use of the memory and stops the build up of rubbish within the memory which would slow down the program execution. Next,

ADD ⌢

6 ⌢ LET ⌢ L=A ⌢ ROOT ⌢ :

After typing the colon the word ADD will disappear, i.e. you are back in command. The colon is necessary at the end of an ADD or a LOAD because it inserts the hex byte C0 at the end of the program block. This code tells the computer where to stop and go back from, when it is scanning through the memory. Now,

RUN ⌢ 5 ⌢

which will list out the square roots of the numbers 1 to 25. Then,

DEL ⌢ 6 ⌢

ADD ⌢

6 ⌢ LET ⌢ L=A ⌢ EX ⌢ :

RUN ⌢ 5 ⌢

This program lists the natural anti-logs, e^x, of the numbers 1 to 25, and will show how the display switches over to scientific notation, the last result being 7.2004907×10^{10}. Although mathematically correct, these are rather crude presentations of the results. Type

ADD ⌢

4 ⌢PRINT ⌢"⌢ X ⌢⌢⌢⌢⌢⌢⌢⌢⌢⌢⌢⌢⌢⌢⌢ EXP X":

RUN ⌢ 4 ⌢

which adds a heading above each of the columns, or,

```
DEL ‸ 7 ‸
ADD ‸
7 ‸PRINT ‸"THE NATURAL ‸ANTI-
LOG ‸OF" AO, ‸" ‸IS"L4 ‸:
RUN ‸ 5 ‸
```

which gives a different display format, see Table 7. Note that the comma after A0 suppressed the characters after the decimal point, rather than leaving a large gap. L4 means L, printed to 4 decimal figures, although without the compaction of the scientific results that a comma would bring. Try

```
DEL ‸ 7 ‸
ADD ‸
7 ‸ PRINT ‸ "THE NATURAL. ANTI-
LOG ‸OF" A0 ‸" ‸IS"L4, ‸:
RUN ‸ 5 ‸
```

to see the difference. If you make a mistake in these exercises, just terminate the line with a RETURN and type it in again. It is important, as already explained, that the LOAD and ADD commands are only left with a colon, do not be tempted to do so with an RS. If you have corrected a line in this way, when back in the command state, delete that line, and the computer will erase the first line it comes to with that number and then re-list with the second version in the correct place. Naturally, if you have mis-typed a line twice or more, this deleting procedure must be repeated until the correct line appears in place. The running of a program may be halted at any time by pressing any key on the keyboard, but as this returns the computer to the low-level, READY state, follow it with an RS for BURP.

Table 6. Mathematical expressions for LET statements.

Expression	Effect
+ — * /	Y+X→X, Y—X→X, Y×X→X. Y/X→X. In these four operations, the stack collapses thus; Z→Y, T→Z, 0→T.
YX	Y to the power of X→X. Stack collapses as above.
REC	1/X→X, i.e., reciprocal of X. In this, and the following, Y, Z and T remain unchanged.
ROOT	$\sqrt{X}$→X
SQ	X^2→X
TENX	10^x→X i.e., common anti-logarithm.
EX	e^x→X i.e., natural anti-logarithm.
LN	1n(X)→X i.e., natural logarithm of X.
LOG	log(X)→X i.e., common logarithm of X.
SIN	sine (X)→X All trig. functions operate in degrees.
COS	cosine (X)→X
TAN	tangent (X)→X
SIN-	$\sin^{-1}$(X)→X
COS-	$\cos^{-1}$(X)→X
TAN-	$\tan^{-1}$(X)→X
DTR	Converts X in degrees to radians
RTD	Converts X in radians to degrees
NEG	—X→X i.e., change sign.
PI	3.1415927→X
ENT	X→Y, Y→Z, Z→T. T is lost, X remains in X.
ROLL	Y→X, Z→Y, T→Z, X→T. Nothing is lost.
XEY	X exchanges with Y.

In use, all of these expressions are followed by a space, e.g. for;

$$X=\frac{1}{2\pi\sqrt{LC}}$$

```
LET ‸ X=L ‸ C ‸ * ‸ ROOT ‸ 2 ‸ * ‸ PI ‸ * ‸ REC ‸
```

Errors will occur in calculations under certain conditions;
LN or LOG, when X is less than or equal to zero.
TAN when X is an odd multiple of 90° (90°, 270°, 450° etc.)
SIN, COS or TAN when IXI is greater or equal to 9000°
SIN- or COS- when IXI is greater than 1 or less than 10^{-50}
ROOT when X is negative
/ or REC when X = 0
or for any result less than 10^{-99} or greater than 9.9999999×10^{99}

Table 7. Print out giving natural anti-logs of numbers 1 to 25. The display switches to scientific notation at number 19.

```
THE NATURAL ANTI-LOG OF 1. IS 2.7183
THE NATURAL ANTI-LOG OF 2. IS 7.3891
THE NATURAL ANTI-LOG OF 3. IS 20.0855
THE NATURAL ANTI-LOG OF 4. IS 54.5982
THE NATURAL ANTI-LOG OF 5. IS 148.4132
THE NATURAL ANTI-LOG OF 6. IS 403.4288
THE NATURAL ANTI-LOG OF 7. IS 1096.6332
THE NATURAL ANTI-LOG OF 8. IS 2980.9580
THE NATURAL ANTI-LOG OF 9. IS 8103.0839
THE NATURAL ANTI-LOG OF 10. IS 22026.466
THE NATURAL ANTI-LOG OF 11. IS 59874.143
THE NATURAL ANTI-LOG OF 12. IS 162754.79
THE NATURAL ANTI-LOG OF 13. IS 442413.40
THE NATURAL ANTI-LOG OF 14. IS 1202604.3
THE NATURAL ANTI-LOG OF 15. IS 3269017.4
THE NATURAL ANTI-LOG OF 16. IS 8886110.7
THE NATURAL ANTI-LOG OF 17. IS 24154953.
THE NATURAL ANTI-LOG OF 18. IS 65659970.
THE NATURAL ANTI-LOG OF 19. IS 1.7848     08
THE NATURAL ANTI-LOG OF 20. IS 4.8517     08
THE NATURAL ANTI-LOG OF 21. IS 1.3188     09
THE NATURAL ANTI-LOG OF 22. IS 3.5849     09
THE NATURAL ANTI-LOG OF 23. IS 9.7448     09
THE NATURAL ANTI-LOG OF 24. IS 2.6489     10
THE NATURAL ANTI-LOG OF 25. IS 7.2005     10
```

Loading programs

Programs are loaded by typing

```
LOAD ‸
```

and then the lines of the program, each of which must start with the number of that line. These lines do not have to be entered in the correct order, nor do all three digits of the number need to be typed in as they appear in the list. For internal reasons of the computer, it is not possible to have lines 0, 192, or 237. It is recommended that, for speed of execution, the lines used are kept fairly close together numerically, as this saves the computer scanning for lines which do not exist. In program development, it helps to initially use every third line number so that there is plenty of room for later additions. Remember that LOAD starts loading at the beginning of the program storage area and will thus erase any previously stored programs. If you want to add to the present lines, use ADD.

Entering data

When the computer comes across the program line INPUT, it goes to the next clear line on the v.d.u. and waits for you to enter the number of variables specified in the program line. Numbers entered must be followed by a space, except in the case of scientifically expressed numbers, which, because of the fixed length of the exponent, are recognised as terminated when the second exponent digit has been typed in. The l.e.d. associated with the keyboard is useful because it indicates whether the computer is, or is not, waiting for you to do something.

Finally, remember the spaces required during loading, and those after the three factors you type in during program execution.

To be continued

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RF circuit checks: test local oscillators, BFOs, test IF and detector performance.

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Technical specifications

Frequency range: 20 Hz to 200 MHz
Display resolution: up to 8 digits
Lowest frequency resolution: 0.1 Hz
Gate time: decade adjustable from 0.01 secs to 10 secs
Sampling rate: varies with gate time up to 5 per second
Display format: 8 LEDs, direct reading in kHz.
Attenuator: –20 db
Input impedance: 1M in parallel with 50 pF
Timebase accuracy: 0.3 ppm/°C, 10 ppm/ year
Dimensions: 6.2 in x 3 in x 1.25 in
Weight: 6 oz
Power requirement: 9V DC or AC adaptor
Sockets: standard 4 mm for resilient plugs
Standard accessories: test leads and prods, carrying wallet, owner's instruction manual
Optional equipment: AC adaptor for 240 V 50 Hz power; deluxe padded carrying case; connector kit comprising BNC, co-ax, DIN and phono adaptors, plus telescopic aerial for off-air transmitter measurements

WW — 018 FOR FURTHER DETAILS

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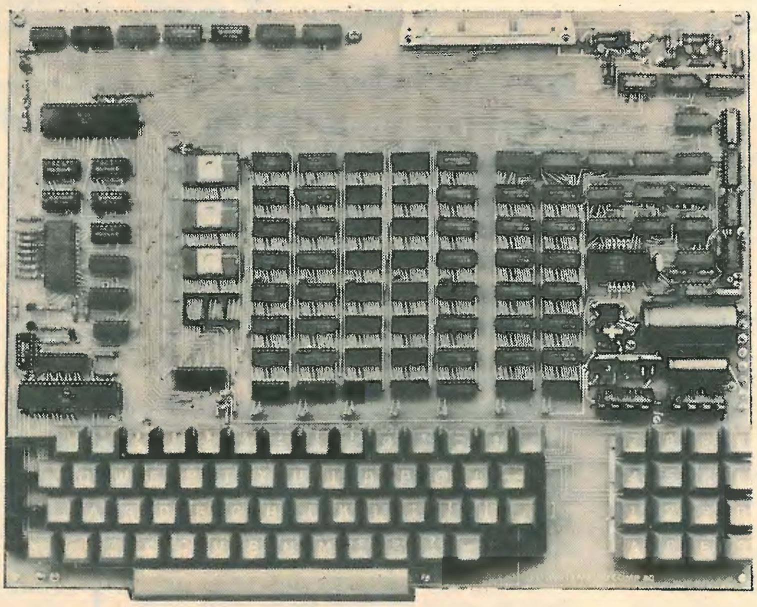

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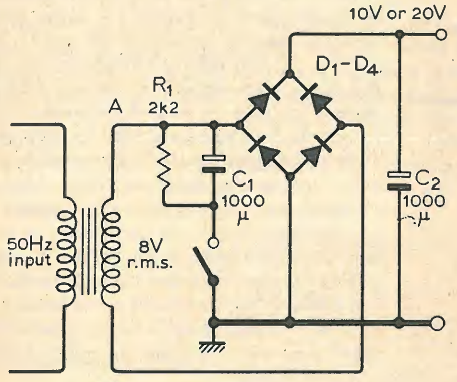
CIRCUIT IDEAS

Single switch doubles bridge voltage

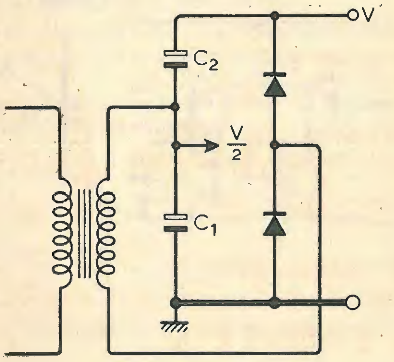
In Fig. (a), with the switch open, D_1 to D_4 act as a full wave rectifier feeding C_2. When the switch is closed, C_1 becomes charged via D_4 when A is positive with respect to B, and then feeds C_2 via D_3 when B is positive with respect to A. Capacitor C_1 therefore becomes charged to the peak voltage of the a.c. input, and C_2 becomes charged to twice the peak voltage. Diodes D_1 and D_2 are both reverse-biased and do not conduct. Resistor R_1 discharges C_1 when the switch is opened.

If the switch facility is not required, the circuit in Fig. (b) is preferable because the ripple frequency of V is 100Hz, rather than the 50Hz of usual doubler circuits, and is hence easier to smooth.

D. D. Williams
London



(a)



(b)

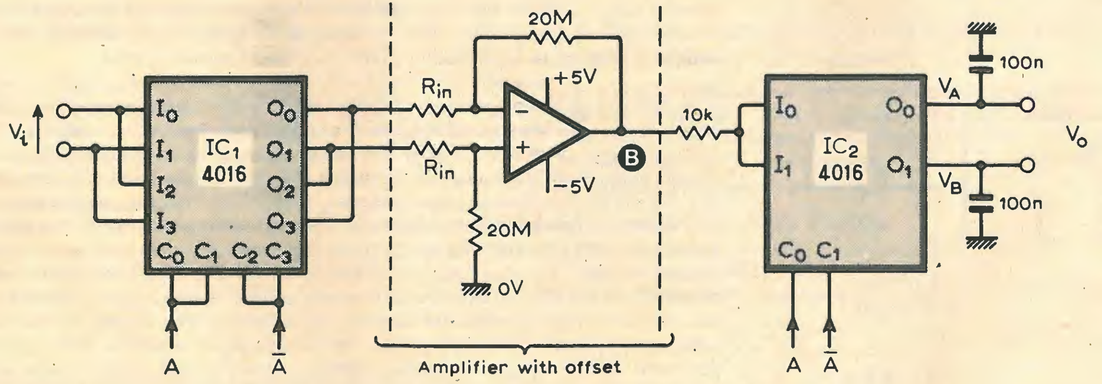
Chopper stabilised amplifier for d.c. voltmeter

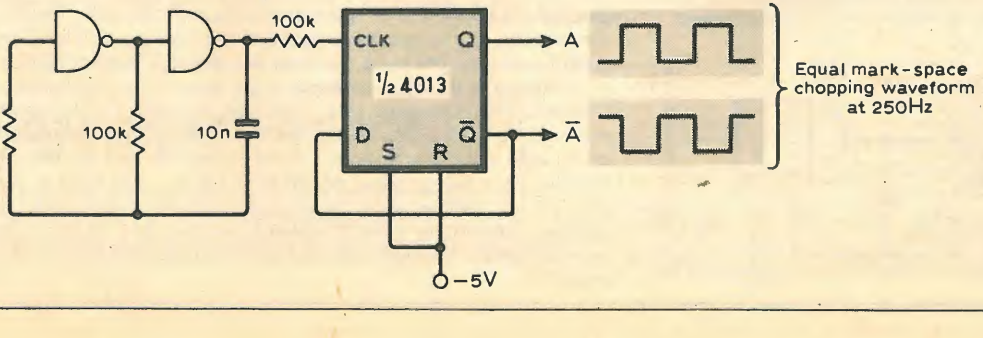
This circuit was used to reduce the offset of an op-amp in a battery powered d.c. voltmeter.

The differential input voltage is alternately inverted by the c.m.o.s. switches in IC_1, and the amplified voltage at B is demultiplexed by a second set of switches. Voltages V_A and V_B have the same offset component but opposite magnitude components, therefore the differential output $V_A - V_B$ contains virtually no offset. Use of an equal mark-to-space ratio chopping waveform and well matched analogue switches ensures good performance.

The prototype used an op-amp with a measured input offset of about 1mV, and this was reduced to less than 0.5µV with the circuit shown. This level is negligible on a 1mV f.s.d. scale, and only ½% f.s.d. on a 100µV scale. The error can be reduced still further by trimming the op-amp.

G. C. Hammond
Nuneaton
Warwks

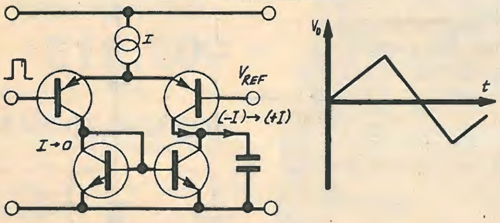




Triangular wave generators: current switching

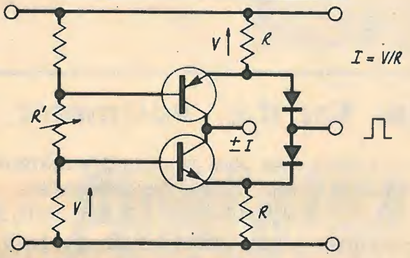
by **Peter Williams,** Ph.D.
Paisley College of Technology

LONG TAILED PAIR / CURRENT MIRROR



It could be imagined that an operational amplifier is the only proper way to construct a triangular-wave generator. For some time it was the easiest way to construct one of high linearity and has the additional merits of low output impedance and is capable of voltage control. The restriction on frequency response implied by the limited small-signal bandwidth of the operational amplifier is severe enough; the large output swing often required from a generator brings the second and even more severe constraint of slew-rate limiting. At 0.5 V/μs for standard op.amps and then for 20V pk-pk triangular waves a cycle must occupy 80μs, i.e. corresponding to 12kHz maximum even if distortion and tolerance effects are ignored. Thus at higher frequencies direct switching of currents into a capacitor is the preferred method. This is the basic method employed in integrated circuits as apparently diverse as phase-locked loops and sine-square-triangle generators. A simple illustration of the principle is shown using a long-tailed pair and a circuit mirror. A square wave drives the long-tailed pair transferring the constant current from one collector to the other. The current mirror is thus driven from +I or O and draws an approximately equal current. The net current in the capacitor changes from —I to +I when the input base of the long-tailed pair is driven more positive then V_{REF}. (N.B. V_{REF} must itself be more positive than the most positive output potential desired).

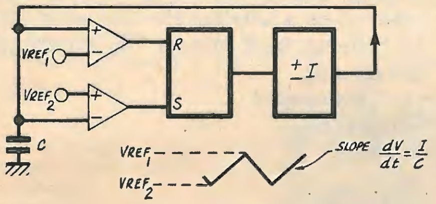
CURRENT SWITCHING : COMMON BASE STAGES



The previous circuit is related to the common-base form of ramp generator. It requires a separate current source and suffers from the limited accuracy of current transfer of the basic current mirror. A related circuit easily implemented with discrete components is shown with complementary current sources connected to a common point. By feeding a square wave to the two emitters via diodes these currents are by-passed into the square-wave generator.

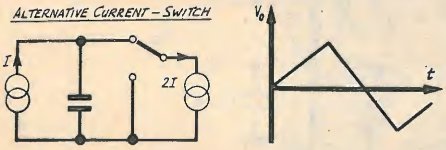
Provided they have been set equal in magnitude initially then the available charging current is possible by varying R' (which could be replaced by a voltage, light or temperature-controlled resistance for external control). In these and the following variants the capacitor voltage needs to be buffered if the triangular wave output is to be fed to a resistive load. In some cases such as the phase-locked loop referred to, the waveform is only incidental to the voltage-control facility and the square-wave output of the complete generator is the more useful. In these cases the capacitor remains unloaded and separate buffering is not needed.

FLIP-FLOP BASED SQUARE-TRIANGLE CIRCUIT



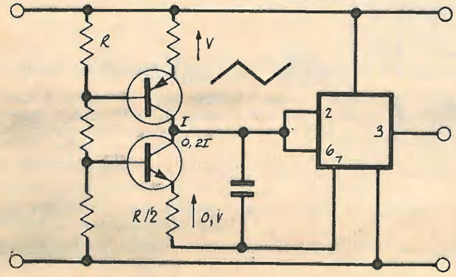
It is convenient to anticipate a particular form of level-sensing switch based on a set-reset flip-flop. Preceded by a pair of comparators referenced to two different voltages, it is used to drive any switchable current generator such as those described above. The loop is closed and the capacitor charges linearly until one of the reference levels is reached. This reverses the flip-flop and hence the polarity of the current. The capacitor charges in the opposite direction until the other threshold is reached and the flip-flop and current return to their original states initiating the next cycle. This illustrates the way in which the elements of the system are interconnected; each subsection can be replaced to produce a variety of practical versions. One example that is discussed further below is to replace the comparator/flip-flop combination by a Schmitt trigger such as the op. amp. form. Alternatively there is a standard i.c. designed for astable/monostable operation that contains all the comparators, flip-flop, biasing and output networks, that can be used directly with a switchable current source.

ALTERNATIVE CURRENT-SWITCH



A useful modification of the current reversing circuit is also convenient for operation with the same i.c. (generic type number 555). A permanent current of I is fed to a capacitor while a second current of reverse polarity and twice the magnitude is alternately connected to and disconnected from the capacitor. Provided the ratio of the current magnitudes is precisely 2:1, the net current flow switches between +I and —I. This simplification is related to those employed with operational amplifiers and is used in commercial waveform-generator integrated circuits. Provided the currents can be controlled from a common voltage (or current) usually via current mirrors, the linear control of frequency follows, since the peak-peak amplitude is restrained by the sensing circuit to lie between precise reference levels. For example if doubling the control voltage doubles the currents, then because the slopes are doubled the voltage excursions are covered in half the time, i.e. the frequency is double. Although an ideal current generator cannot be open-circuited (infinite voltage would result!) many practical circuits merely have a very high slope-resistance over a limited voltage range and the current can be interrupted by a single-pole on-off switch.

CURRENT-SWITCHING TRIANGLE GENERATOR



This is illustrated in a circuit that uses a 555 i.c. The precise operation of the circuit is described below. Pin 7 is an open-collector transistor that is switched into and out of conductance as the input taken to the comparator inputs (pins 2 and 6) reaches the upper and lower thresholds. The p-n-p transistor delivers a permanent current of I while the n-p-n current of 2I flowing in the opposite sense in the capacitor is repeatedly interrupted as the transistor internal to the i.c. is switched off. The high impedance of the comparator inputs minimizes the slope-error provided the charging current is large enough. Substitution of an op. amp. Schmitt would only serve if the input current is equally low. As with inverting and non-inverting amplifiers it is found that only one form fits this requirement. A voltage follower buffer can always be inserted between the capacitor and the level-sensing circuit provided it can handle the slew-rate requirements. This also meets the need for a buffered triangle-wave output but reintroduces the bandwith and slew-rate constraints if the voltage follower uses an operation amplifier.

Triangular wave generators — 2

THEORY

●Let the input be a square wave of amplitude V centred on V_{REF} and let the long-tailed pair collector currents be I_1, I_2 for the positive input. By symmetry, the currents will be reversed for the negative input excursion. If the base-emitter voltages are V_1, V_2 and the transistors are identical, and have high h_{FE} then the output current is

$$I_0=I_1-I_2$$
$$I=I_1+I_2$$
$$I_1=I_s\exp\left(\frac{qV_1}{kt}\right)$$
$$I_2=I_s\exp\left(\frac{qV_2}{kt}\right)$$

For I_0 to approach I, then $I_1>>I_2$ and $I_0\approx I_1$. Let x be the fraction by which I_0 falls short of I

$$x=\frac{I-I_0}{I}=\frac{2I_2}{I_1I_2}\approx\frac{2I_2}{I_1}$$

From the equations for I, and I_2 and noting that $V_1-V_2=V/2$

$$x=2/\exp\frac{q(V_1-V_2)}{kT}$$

$$\exp=\frac{qV}{2kT}=\frac{2}{x}$$

$$V=\frac{2kT}{q}\log_e\left[\frac{2}{x}\right]$$

e.g. for I_0 to be 99% of I, $x=0.01$
$V\approx(52\log_e 200)\text{mV}\approx275\text{mV}$.

Hence a square-wave of 275mV peak-peak symmetrically about V_{REF} is enough to guarantee an output current that switches to ± I with an accuracy of getter than 1%, assuming high current gains. If h_{FE} falls below say 100 then the current gain will dominate the fall of I_o below I.

●The circuit requires large V_{EB} breakdown voltages if the potential divider and hence the charging currents are not to be disturbed.
Square wave amplitude V_s-2V and could be conveniently taken from c.m.o.s. buffer if of high enough current rating.

●Time to complete positive ramp is

$$\frac{1}{\frac{dV}{dt}}(V_{REF1}-V_{REF2})$$

For equal and opposite currents the cycle period is double this value.
Hence

$$f=\frac{dV}{dt}\,\frac{1}{2(V_{REF1}-V_{REF2})}$$
$$=\frac{1}{2C(V_{REF1}-V_{REF2})}$$

●Let the larger current be subject to a fractional error. The net current flows are then I and $I-2I(1+x)$ i.e. I and $-I(1+2x)$.

Thus the two ramps differ in the time taken to complete them by a fraction 2x. The fractional change in the period is ~x. Hence a 1% change in the larger current shifts the frequency by 1% while changing the ratio of the times by 2%.

EXAMPLES

1. The long-tailed pair has a tail current of 30μA and via a current mirror feeds a 30pF capacitor. Show that the slew-rate is 1V/μs and that the small-signal unity-gain frequency is 3MHz.
The slew rate corresponds to the pair being overdriven so that the capacitor charging current switches between + 30μA and —30μA.

$$\text{Slew rate}=\frac{dV_c}{dt}=\frac{I}{C}=\frac{30.10^{-6}}{30.10^{-12}}=1\text{V}\mu\text{s}$$

$$\text{For each transistor } g_m=\frac{dI_c}{dV_{BE}}=\frac{I_c}{kT/q}$$

If the input differential voltage is V then the signal currents in the collectors are $\pm g_mV/2$. The current mirror action results in a net current to the capacitor of $g_mV/2-(-g_mV/2)=g_mV$.

$$\text{Voltage across capacitor}=\frac{g_mV}{sC}$$

$$\therefore \text{ unity gain frequency } f_T=\frac{\omega_T}{2\pi}=\frac{1}{2\pi}\cdot\frac{g_m}{C}$$
$$=\frac{15.10^{-6}}{26.10^{-3}\,.\,30.10^{-12}}=\frac{10^9}{52.2\pi}=3\text{MHz}$$

c.f. a standard 741 type op. amp with an input quiescent current of 20μA and a configuration that reduces the g_m by a factor of 2 i.e. reducing the unity gain frequency by a factor of 2 x 30/20. The resulting value is $f_T\approx$ 1MHz.

2. The same long-tailed pair is driven from a 200mV peak-peak square-wave. What is the ratio of the peak differential current to the total quiescent current and the corresponding slew-rate?

$$I_0=I_1-I_2$$
$$I=I_1+I_2$$
$$\frac{I_0}{I}=\frac{I_1-I_2}{I_1+I_2}=\frac{I_1/I_2-I}{I_1/I_2+1}=\frac{\exp\left(\frac{q(V_1-V_2)}{kt}\right)-1}{\exp\left(\frac{q(V_1-V_2)}{kt}\right)+1}$$

$$\therefore\frac{I_0}{I}=\tanh\frac{q(V_1-V_2)}{2kT}=\tanh 1.92$$

∴ Slew rate ≈0.96/μs as charging current switches between ±0.96×30μA into a 30pF capacitor.

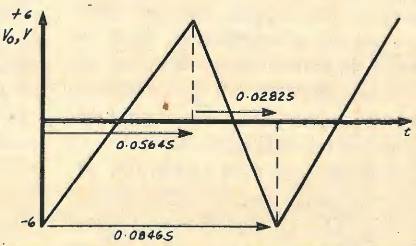
3. A 0.47μF capacitor is fed from a fixed current source of +100μA with a second source of —300μA switched into and out of circuit. The triangular wave is sensed by comparators referenced to ± 6V, their outputs operating a set-reset flip-flop that operates the switching circuit. What is the resulting frequency of oscillation and the waveform?

Positive charging current +100μA
Negative charging current (+100—300)=—200μA
Positive ramp +12V

$$\therefore\text{time for positive ramp, } t_1=\frac{0.47\times10^{-6}}{100\times10^{-6}}.12=0.0564\text{s}$$

$$\text{time for negative ramp, } t_2=\frac{0.47\times10^{-6}}{200\times10^{-6}}\;12=0.0282\text{s}$$

Period $T=t_1+t_2=0.0846$s
$\therefore f=1/T\approx11.8$Hz.



Acoustic breakthrough in record players — 2

Listening tests to decide acceptability of the distortion

by James Moir and William R. Stevens James Moir & Associates

In the May issue the authors presented a test procedure and a set of measurements showing the sensitivity of record players to acoustic breakthrough from associated loudspeakers. Here they discuss the audible effects and their significance in practical conditions.

FINALLY we can try and decide on whether these acoustically induced noise effects are of any significance in practice. The objective tests confirm that 'distortion voltages' are induced into the pickup circuit by the signals from the loudspeaker but this could have been predicted without any experiments. The real question is whether these distortions are audibly significant under practical conditions.

We attempted to decide this by careful listening tests though this is not any easy decision to reach for it is on a par with trying to decide on just what harmonic distortion is acceptable in a reproducer system. The audibility of any distortion depends so much on the type of music being played that it is rarely possible to make any precise statement about the percentage distortion that is detectable and exactly the same comments apply to the problem of deciding on the amount of acoustically induced breakthrough distortion that is subjectively detectable or acceptable.

The charts show that the majority of the breakthrough noise occurs at frequencies below about 300Hz. Music or other programme material that contains little or no energy in this low frequency end of the spectrum will be less likely to excite the pickup than will music that has a lot of the energy in the band below 300Hz. The colouration that is introduced at a breakthrough level below that which will maintain continuous oscillation is a function of the type of music and indeed it has many characteristics of music. Not only may it not be audible but it may be thought by many listeners to enhance the quality of the music and to that extent it may be a 'distortion' that is desirable. Thus our findings should be considered as only indicating the order of the result rather than as a precise specification of what is detectable.

A fairly complex arrangement of equipment was used for the preliminary listening test. The record player under test, its amplifier, and a loudspeaker were set up in one room with a second loudspeaker and amplifier system reproducing the programme in another room acoustically isolated from the room in which the turntable system was operating.

Thus the amount of breakthrough signal could be altered by increasing the gain of the amplifier driving the loudspeaker located near the record player without its producing any significant increase in the loudness of the signal reproduced by the second loudspeaker system in the adjacent listening room. Speech and various types of music were then reproduced and the amount of acoustically induced breakthrough slowly increased until the effect was just detectable to the listener.

Level of acceptability

As might be expected, the breakthrough was not really a serious problem when reproducing most kinds of music. The breakthrough signal could be increased until it was only 3-6dB below the programme level before its effects were audibly detectable but the exact amount that was detectable was a function of the type of music being played. When reproducing speech the results were very different. Colouration could be detected when the breakthrough voltage was 10-15dB below the basic speech signal. If a safety margin of 5dB is allowed then we can specify that if a record player is to be acceptable the distortion voltage acoustically induced into the pickup should be more than 20dB below the signal output voltage from the pickup when replaying a 1kHz recording with a lateral velocity of 5cm/second.

The limited listening tests we made rather suggest that the acceptability of this breakthrough distortion is inversely proportional to frequency, at least in the frequency band below about 600Hz. Breakthrough in the 500-800Hz band is much more obvious and annoying than the same amount of the distortion in the 50-100Hz band. Any final objective ranking requires the establishment of a weighting curve relating 'acceptability' or 'annoyance' to frequency.

The breakthrough voltage from the record player is determined by the design of the turntable and tone arm assembly and the level of the acoustic signal at the record surface. Thus if we specify that the acoustically induced breakthrough voltage must be at least 20dB below the signal voltage we can specify the maximum sound level that is permissible for any particular turntable design before the breakthrough exceeds this limit. High values for the permissible sound level indicates a well designed turntable.

Our investigation was directed towards ranking the performance of several turntables from one manufacturer and not to a ranking of many of the current commercial products so we cannot quote specific permissible levels for a wide range of turntables. Some turntables in the £50 to £80 price bracket reached the —20dB limit when the sound level at the turntable reached 86dB, whereas with others in the same price class a sound level of 95dB was permissible. Some of the professional turntables in the £200-and-up class could withstand sound levels in excess of 95dB before the —20dB breakthrough level was reached. The Technics 1800 turntable we use in the laboratory reproducer system could tolerate a sound level of 98dB before the —20dB point was reached.

In an ordinary domestic environment a sound level of 90dB in the vicinity of the turntable would imply a sound level about 10-12dB higher at a point 10 feet away where the loudspeaker might be standing. Thus if we assume that the listeners are seated near the turntable and are also about 10 feet from the loudspeakers then the specified acceptable breakthrough level is also the maximum listening level that is permissible before acoustically induced breakthrough needs to be taken into account.

A simple test

Few listeners will have access to the technical equipment necessary to measure the performance of their own record player but there is a very simple test of acceptability that can be carried out without any equipment. Play a record of a concert orchestral work and adjust the amplifier gain to that giving the maximum sound level you tolerate in ordinary usage. Stop the turntable, put the pickup in an inside groove and, using the same amplifier gain setting, gently tap the top of the deck. If the system bursts into sustained oscillation you certainly need to take some corrective measures. If you hear a recognisable reverberant tone that is sustained for perhaps one or two seconds after the impact you can expect that the acoustic breakthrough will introduce some colouration into speech and perhaps music.

If the gentle impact does not result in a sustained tone, but only produces a 'tap' noise for a fraction of a second then no remedial action is necessary. Our somewhat limited experience suggests that if the loudspeakers are more than six feet from the turntable only the worst of the current record players will exhibit any significant acoustically induced effects. Corrective measures, if necessary, are generally fairly simple.

All the breakthrough effects can be minimised by reducing the sound level at the turntable surface, the simplest procedure being to separate the loudspeaker and turntable by the maximum amount. This is an effective method of increasing the attenuation of the feedback path. Mounting the loudspeaker on the same table, or the same shelf, provides a direct route for the transmission of mechanical vibration from the speaker enclosure to the turntable and has obviously to be avoided. If a shelf or table must be used to support the equipment, it should be of the minimum possible area. Standing the unit or loudspeaker on a piece of soft foam at least four inches thick effects a significant reduction in the induced noise, but this is not a very practical suggestion. However, it allows a quick and simple method of checking whether acoustically induced vibration is being transmitted from the table or shelf to the player. □

Single-sideband for land mobile radio demonstrated

To create more channels for land mobile radio, single-sideband operation at v.h.f. is the "most promising" technique from both the technical and economic points of view, according to Graham West, marketing director of Pye Telecommunications Ltd. This claim was made at a demonstration in London of a pilot carrier s.s.b. system developed by Pye in conjunction with Philips Research Laboratories and Mullard Application Laboratories. The system allows a channel spacing of 5kHz, a figure which Mr West said the Home Office had encouraged them to aim at, rather than 6.25kHz (a halving of the existing 12.5kHz channel spacing) because "it fits in better with international requirements."

Witnesses of the demonstration toured round the Swiss Cottage area of North London in a motor coach listening to switched comparisons of speech on the pilot carrier s.s.b. with the same speech on conventional f.m. in a 12.5kHz channel bandwidth. The two transmitters were in a nearby hotel, and both carrier frequencies were 85.875MHz. In the s.s.b. transmitter the peak envelope power was set equal to the carrier power of the f.m. transmitter. In general the listeners preferred the speech quality and intelligibility of the f.m. at the higher signal levels of around 10μV at the receiver, but between about 0.3μV and 3μV they preferred the s.s.b. because the effects of fading were less pronounced and intelligibility was better. Overall, Philips claim that the s.s.b. is "generally preferred".

The big problem in using s.s.b. for v.h.f. land mobile radio is the rapid fading caused by multi-path propagation as the vehicle moves through a built up area producing numerous reflections. An a.g.c. system is called for but this cannot operate from the signal envelope in suppressed carrier s.s.b. because the pauses in speech cause interruptions of the a.g.c. signal — which of course must be continuous to be effective. Pye/Philips tackle this problem by transmitting a pilot carrier at —10dB relative to peak envelope power, extracting this in the receiver by a crystal filter with a bandwidth of only 300Hz and using this signal in a fast acting a.g.c. system with a time constant of 20ms to control the gain of the r.f. amplifier. The pilot carrier is also used for demodulation. This system controls fading up to a frequency of 50Hz and is claimed to be adequate for use up to 175MHz.

Whereas suppressed carrier s.s.b. demands a frequency stability of ±20Hz, Pye/Philips say that their pilot carrier system has a tolerance of ±150Hz on receiver tuning, even without a.f.c. Further, they point out that the use of the pilot carrier for demodulation in the receiver also removes the a.f. offset well known in s.s.b. operation when the receiver is mistuned (causing "Mickey Mouse" voice quality) because the carrier and sideband track in frequency. The required local oscillator stability in transmitter and receiver can be achieved economically by the use of i.c. frequency synthesizers (see December 1978 issue, p. 78).

Apart from the features mentioned above and the well known efficiency of the s.s.b. transmission mode, the developers state that their system is compatible with double-sideband a.m. systems, has an a.f. band of 300Hz to 3kHz, making it suitable to link with the public telephone network, and is compatible with 5-tone sequential signalling, sub-audio signalling and with data modems that use a normal telephone line.

Of course the system is at the moment only experimental, the result of a research project. And it is only one — perhaps the most obvious – of the several ways in which bandwidth saving is being investigated in the mobile radio world – others being various forms of digital speech processing using techniques such as linear predictive coding (see January issue, p.89, "Inexpensive speech synthesis"). Nevertheless, the developers see it as a practical way of getting more channels — and hence more users and sales of mobile radio equipment – and it appears that they have the encouragement of the UK Home Office which is "eagerly awaiting the outcome of the trials" according to Graham West.

Literature Received

Full range of over 300 power supply units from Coutant is illustrated and described in short catalogue, available from Coutant Electronics Ltd, 3 Trafford Road, Reading RG1 8JR .... WW 409

Leaflet describing a range of broadcasting triodes, tetrodes and klystrons is entitled "Mullard Broadcasting Tubes" and is obtainable from Department C1H, Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD .... WW 410

Catalogue of hand tools for electrical and electronic work is produced by A. B. Engineering Co., Apem Works, St. Albans Road, Watford, Herts WD2 4AN .... WW 411

Catalogue of mercury-wetted-contact relays by Elliott describes, in addition to the various types of relay, protection circuitry, P.O. specifications and mechanical and electrical characteristics. Associated Automation Ltd, 70 Dudden Hill Lane, London NW10 1DJ .... WW 412

Wire strippers, both manual and automatic, wire cutters and p.c. board cleaning brushes by Eraser International are described in a brochure obtainable from 2/3 Hampton Court Parade, East Molesey, Surrey KT8 9HB .... WW 413

Specification sheet describing the PA-3 Automatic Measuring Set for p.c.m. telephone channels is obtainable from Wandel and Goltermann, Postbox 45, D-7412 Eningen, u.A., West Germany ... WW 414

Catalogue from Radiatron describes a Japanese "comprehensive insulation displacement connector facility" — flat connectors — together with accessories and tools. Radiatron Components Ltd, 76 Crown Road, Twickenham, Middx ...... WW 415

Transducers for measurement of level, pressure, acceleration, liquid density and vibration briefly described in Bell and Howell's short catalogue, which can be obtained from Lennox Road, Basingstoke, Hants RG22 4AW .... WW 416

Leaflet giving details of courses in safety training, from first aid up to a Diploma in Safety Management, is published by the British Safety Council, 62-64 Chancellor's Road, London W6 9RS .... WW 417

British Standard BS3549, Part 1, "Methods of measuring and expressing the performance of television receivers," is now available at a cost of £12 from BSI Sales Department, 101 Pentonville Road, London N1 9ND.

Soldering irons, both thermally-limiting and "free-running," types, together with a stand and a selection of bits, are described in a leaflet from Tele-Production Tools Ltd, Stiron House, Electric Avenue, Westcliff-on-Sea, Essex SS0 9NW .... WW 418

PARIS COMPONENTS SHOW

The 1979 Paris Components Show, held under the patronage of Groupement des Industries Electroniques, opened its doors to the public from 2 to 7 April. More than 1,500 companies from 31 countries exhibited (about 200 more than at the 1978 show) occupying an area of some 36,000 square metres of the exhibition site at Porte de Versailles.

Nearly 91,000 trade visitors received permanent entrance cards and computer analysis of those officially registered showed that the area of greatest interest (predictably) was in components. This conclusion was based upon responses indicating that 71.9% of French and 76.8% of non-French visitors put components at the top of the importance list.

According to an opinion census taken at the show, the second most important area was that of measuring instruments with 41% of the French and 27% of other nationalities declaring a specific interest — the difference may or may not be significant.

Breakdown by professional groups showed that 28% of all visitors were involved in communications; 19.1% were concerned with radio and tv, 13.8% with business described in the official hand-outs as "hi-fi electro-acoustic", the remainder being active in space aeronautics (surely "astronautics"?), automobile, watchmaking, photographic, cinema, medical electronics, toys, data processing and automation.

This year's show appears to have presented no outstanding innovations or technical surprises. In previous years it has been the occasion for introducing new integrated circuits and new technical processes such as fibre optics but development now seems to have settled down to the progressive improvement of established devices and measuring instruments.

By far the largest number of exhibitors were those actually specialising in components, forming about 75% of the total — an understandable wedge considering that no matter what the level of sophistication reached in test instruments, capacitors, resistors and connectors in one form or another are likely to be needed as essential building elements for many years to come.

The remainder of the exhibitors could be split into three approximate groups: materials and products, equipment and methods, and measuring instruments. A central force in the exhibition was difficult to establish, but the widespread development of l.s.i. and related devices was noted. The way in which each offering was presented to the public varied enormously, some sticking to a conventional display of static objects, while others opted for prominently visual means using opto-electronic devices and sound-to-light outputs of various machines.

Plessey fell into both groups to some extent with their working demonstration of model control receivers. The action illustrated remote control of a battle tank, functions such as forward, right, left, stop, reverse, etc. being activated from a nine-point key pad. The circuits involved are the ML928 and ML929 16 code receivers linked to the standard Plessey SL490 pulse transmitter which transmits b.c.d. commands by means of a pulse-position modulated signal. Multi-participation games are made possible by this dual remote control technique, avoiding the usual problems of lock-out.

Motorola was proudly demonstrating two 16K e.p.r.o.m.s, the TMS2716 and the TMS 27A16 which are 2048 × 8 bit devices featuring access times of 450ns and 300ns respectively. Stored data can be erased by exposure to u.v. radiation for 30 minutes, although storage is normally non-volatile, data being retained when power is removed. Coincidentally, the news was spread, although not actually confirmed during the exhibition, that Motorola and Fairchild have made a deal with General Motors to supply about five million 6802 microprocessors and memory parts in relation to new US government regulations concerning exhaust emission control. There is little doubt that, with rumours that Ford are equally interested, the atmosphere at the show was indicative of an opening market for e.p.r.o.m. manufacturers.

Microprocessors in measurement and automatic testing were evident and frequently demonstrated although the language barrier seemed often to prevent a continuous exchange between interested parties and the man on the stand. This also applied to the display cards and especially to stand literature — thick lumps all in French or German don't encourage persistence in the English-speaking visitor, which may be deplorable in terms of the relations of the British with their European cousins (many of whom speak very good English), but it's not very professional.

Those who opted for the more obvious demonstrations did so with imagination, many stands literally humming and flashing with both serious and trivial demonstrations of machines under the control of one chip or another — waving Lissajous figures converted to back projection and synthesised audio "jingles" among the more lurid phenomena.

Anyone searching for a particular national identity in exhibits or instruments would have been disappointed. Bruel and Kjaer (France) were quite naturally concerned with the finest detail of accuracy represented by their new range of frequency response checking and logging equipment, but there was no marked increase in hand waving (technical gestures) on their stand! CML (Consumer Microcircuits Ltd.) a British company, demonstrated creditable reserve in outlining the salient points of a new range of 20 i.cs designed for tone selective calling systems in mobile radio equipment. The '03 series of l.s.i. circuits results from three years of research into digital filtering techniques, and through them the company claims the capability to operate two-way exchange of data over high noise radio and telephone links.

Unquestionably this international exhibition, covering the whole spread of electronic devices and equipment helps to boost the world electronics trade, and especially the French components industry. Informed opinion suggests a general rise in demand for components in France of 15% or more in the coming year, and a 16% increase in sales of semiconductors alone. Added to this is the fact that both the French electronics giants, Thomson-CSF and RTC are to be funded by the French government in bipolar development, while Motorola enters the scene again in the form of a link-up with EFCIS (a Thomson-CSF subsidiary) in m.o.s. production. No single aspect of the world electronics industry necessarily depends upon such giant exhibitions for growth, but it must surely be the French industry's biggest market place.

The next Paris Components Show will he held at Porte de Versailles from Thursday, March 27 until Wednesday, April 2 inclusive, but closed on Sunday, March 30.

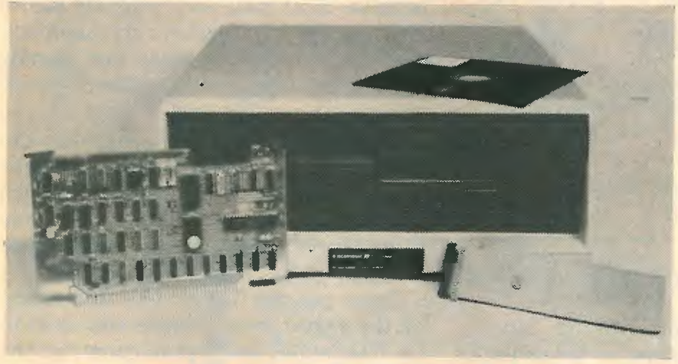
Photomultiplier power supply

Specialists in high voltage power supplies and static inverters, Brandenburg Ltd. introduced their new range of photomultiplier power supplies at the show. The "Double C" series features boosted output current ratings, re-styling of case outline and an improvement in stability at 1 part in 10 against a ±7.5% mains change. There are three basic models in the new series: the 378R with an output voltage range of 600V to 1.2kV, the 483R giving 10V to 2.1V and the 486R providing the range 410V to 2.5kV. Maximum output current is 20mA, 10mA and 8mA respectively. All models are equipped with push-button output selection and a helical potentiometer sets fine calibration adjustment, and each unit is fully protected against overload, short-circuit of output terminals in addition to accidental over-voltage setting. Units can be rack-mounted (standard 19in) or equipped for bench-top use with the aid of fold-away feet. Brandenburg Ltd., 939 London Rd., Thornton Heath, Surrey CR4 7JE.

New products seen at the Show

Double-sided floppy disk system

Offering storage for more than a million bytes and over two million with the addition of an optional dual-drive expansion unit, Motorola Microsystems Exordisk III essentially provides a removable store for Motorola's Exorciser, Exorterm and Micromodule products. The unit consists of two double-sided, single density drives in a compact tabletop cabinet, with a controller board and interconnecting cable assembly from the controller to the disk drive unit. Circuitry is included for protection of master disk programs, and the drive enclosures contain power supplies for all voltage requirements. The main features include 512k bytes per diskette, in 154 tracks with 26 sectors per track and 128 bytes per sector. Motorola Inc., Semiconductor Products Division, P.O. Box 8, 16 Chemin de la Voie-Creuse, 1211 Geneva, Switzerland.



Sound power processor

Measurement of unusual relationships between sound power and room acoustics is a specialist's domain, and the 7507 Sound Power Processor, introduced at the Paris Show by Bruel and Kjaer, can provide this facility. The unit is programmed with a mathematical relationship comparing the sound pressure from an audio source within a room to a quantity known as the "room correction term". Given any two of these quantities the third can readily be calculated. The correction term can be determined either quantitatively from the reverberation time, room volume, total surface area, wavelength of the sound being checked and the barometric pressure, or experimentally by using a source of known power output. Comparisons are achieved by reference to octave or third octave bands, and the unit contains 21 third octave filters in the range 100Hz to 10kHz (centre frequencies) which can be combined to give 7 octave filters from 125Hz to 8kHz (centre frequencies). An l.e.d. display provides information on the room correction term as well as the centre frequency to which it is related, with each range being selected by flick switch. Input is via a multiplexer or microphone preamplifier with the microphone mounted on a swinging boom. Digital output is via an IEC standard interface permitting connection to any other IEC compatible peripheral such as the alphanumeric printer type 2312. Bruel and Kjaer (France), 38, Rue Champoreux, 91540 Mennecey, France.

Low noise f.e.t.

The CM860 is a very low noise n-channel junction f.e.t. which the manufacturer, Teledyne Crystalonics, claims represents an advance on the standard 2N6550. The device is TO-72 packaged and uses a fourth lead which grounds the case, isolating it from the gate. Reduction of stray capacitance is the intention behind this move in order to give the designer greater freedom, and the CM860 is claimed to possess all the other advantages of the 2N6550 including the low input noise figure, being 1.4nV/$\sqrt{\text{Hz}}$ at 1kHz. Another common feature is a minimum g_m of 25000 μmho, assuring a voltage gain of at least 25 with a 1kΩ drain load. Teledyne Crystalonics, 1300 Terra Bella Avenue, Mountain View, California 94043 USA.

Magnetic ticket head

Growth of automatic systems using magnetic character-sensing methods such as toll gates, banknote dispensers and railway barriers has resulted in a Thomson-CSF subsidiary company introducing an improved Ferrinox R head for the purpose. The CMC7 magnetic character reader is intended specifically for banknotes, and it is claimed that the new head offers the advantages of uniform electromagnetic performance and general magnetic characteristics which remain unaffected by the amount of wear of the head's active face. A very uniform air gap geometry and improvements in the structure of the facing material are features responsible for the improvements. LCC-CICE, Galliení 2, 36 Avenue Gallieni, 93170, Bagnolet, France.

Twin-channel, twin-trigger oscilloscope

Two-channel oscilloscopes with triggering on only one of the channels are commonplace according to Philips Test and Measuring Instruments. Their PM 3207 automated twin-channel scope offers full twin channel triggering facilities, eliminating the need to switch cables if triggering from another source is required. The instrument offers 5mV per cm sensitivity (15MHz bandwidth) and it is claimed that even with weak signals on acceptable sensitivity of 50 or 500mV per division will be realised. This applies both to X and Y functions, once again obviating the need to change cables during an experiment. Auto-triggering is included so as to ensure that the trace never leaves the screen — a feature which will be of use to busy test engineers or novices unaccustomed to oscilloscopes. N.V. Philips Gloeilampenfabrieken, Eindhoven, The Netherlands.

SIDEBANDS by Mixer

Economics

When the pound was worth twenty bob and when each sheikh only had one Rolls-Royce for each wife; before integrated circuits coloured the world dark grey and before inflation turned Impressionists into hedges, it was possible for this journal to respond with careless abandon to requests to publish a design for an oscilloscope. Or a signal generator, or any reasonably advanced piece of measuring gear. Nowadays, all we can do is mutter gloomily about its not being economically viable – meaning it would cost too much. The process was even under way when we designed an oscilloscope about fifteen years ago. We chose a tube and published the design, only to find that the makers promptly put the tube price up by about 100%, so we chose another and the same thing happened.

We still receive letters asking us to publish another oscilloscope design, but on looking at the one-off prices of tubes, printed-circuit boards and all the other odds and ends, we still have to say that such a project would cost only a little less than a commercial instrument. There is the satisfaction of building one's equipment, of course, but the price of ego-bolstering is going up all the time.

It's possible that a home-built instrument with a very advanced specification would cost considerably less than a commercial design of the same type, the labour cost of design having been eliminated – or rather absorbed by our publishers. But an oscilloscope costing, say, £500 still represents a pretty heavy sum of money for an amateur to lay out, even though the instrument performs as a £1,000 professional unit.

I can see no solution to this problem, unless there are one or two affluent souls out there who would consider spending several hundred pounds on what is, for many readers, a hobby. People spend that kind of money on computers, after all.

Three-piece microprocessor

It may be considered backward of me, but I had not yet given much thought to the problem of which microprocessor I ought to select to control my next new suit. I am accustomed (if once every ten years can be considered habit-forming) to demanding of my tailor that he build me a suit as nearly as possible like the last one, since that had been relatively reliable, and the question of controlling the thing has, frankly, not been uppermost in my thinking.

But I see now that a 12-bit microprocessor is going to be used in the space shuttle programme "to provide full monitoring of space suit and astronaut conditions". Furthermore, this particular piece of gent's business wear will have a rocket unit and navigation system sewn into the lapels, as it were. It makes the decision on whether to have two or three buttons on one's sleeves look a bit sick, and I do believe that having on one's chest a display of one's conditions would not go down at all well with the well-dressed man in the average street. "Two stone overweight and dying for a pint" is not the sort of information most people would like bandied about by street urchins.

But the real point about this space suit, if I may abandon the facetiousness for a moment, is its function of replacing the umbilical space-walking cord normally used to keep the astronaut alive and to prevent him nipping off on his own as a kind of minor heavenly body. I mean, it's all right giving the poor chap a box of electronics and sending him off through the air lock with a light-hearted slap on the back and a "Don't be long – I'll have the kettle on", but how would you like to place your chances of remaining in the same galaxy as the rest of us in the care of a bit of electronic gizmology? Couldn't he at least be given a bit of elastic?

Bull's eye, my eye!

To mix a metaphor, purple isn't everyone's cup of tea, and as far as I'm concerned this is especially true when a manufacturer leads off into reams of violet verbiage largely unrelated to the item or equipment he is attempting to sell. A few weeks ago I spotted a very interesting ad for a direct-drive turntable unit which, among other extraordinary claims, maintained that the "platter represents impeccable concentricity."

My point is this – the outer rim and any inner circular points or the centre bearing itself either have a common centre or they don't. Degrees of concentricity are, I'm afraid, as with degrees of "uniqueness", neither accurate nor semantically acceptable expressions. While it is true that there are organizations working in the interest of the consumer on a direct price or value basis, and the Trade Descriptions Act spreading its umbrella somewhat impotently over the whole scene, there seems to be no way in which the horrified reader can legislate against such meaningless drivel, short of libellous lampoon or outright derision.

The advertising standards people often point out that they are vigilant, but like the calculated irrelevancy which gets voiced in court as evidence and is then officially stricken "from the record", the essential damage forges ahead unchecked, mainly due to the fact that any opposing action is always considerably in arrears.

A united front is definitely needed here, otherwise we may even find a plus or minus figure creeping into the already bewildering welter of audio and hi-fi specifications. Furthermore, if we look at the term "represents" in the main claim to concentricity, it is highly unlikely that *WW* will consider mounting a competition to find the platter most deserving of the title "representative of impeccable concentricity."

Steady, chaps!

Although I've attempted to take a rise out of the Government's love affair with microprocessors and 64K memories, it would be foolish of me to deny that £70 million is better than a thump in the eye with a piece of wet cod. But the money must be used imaginatively.

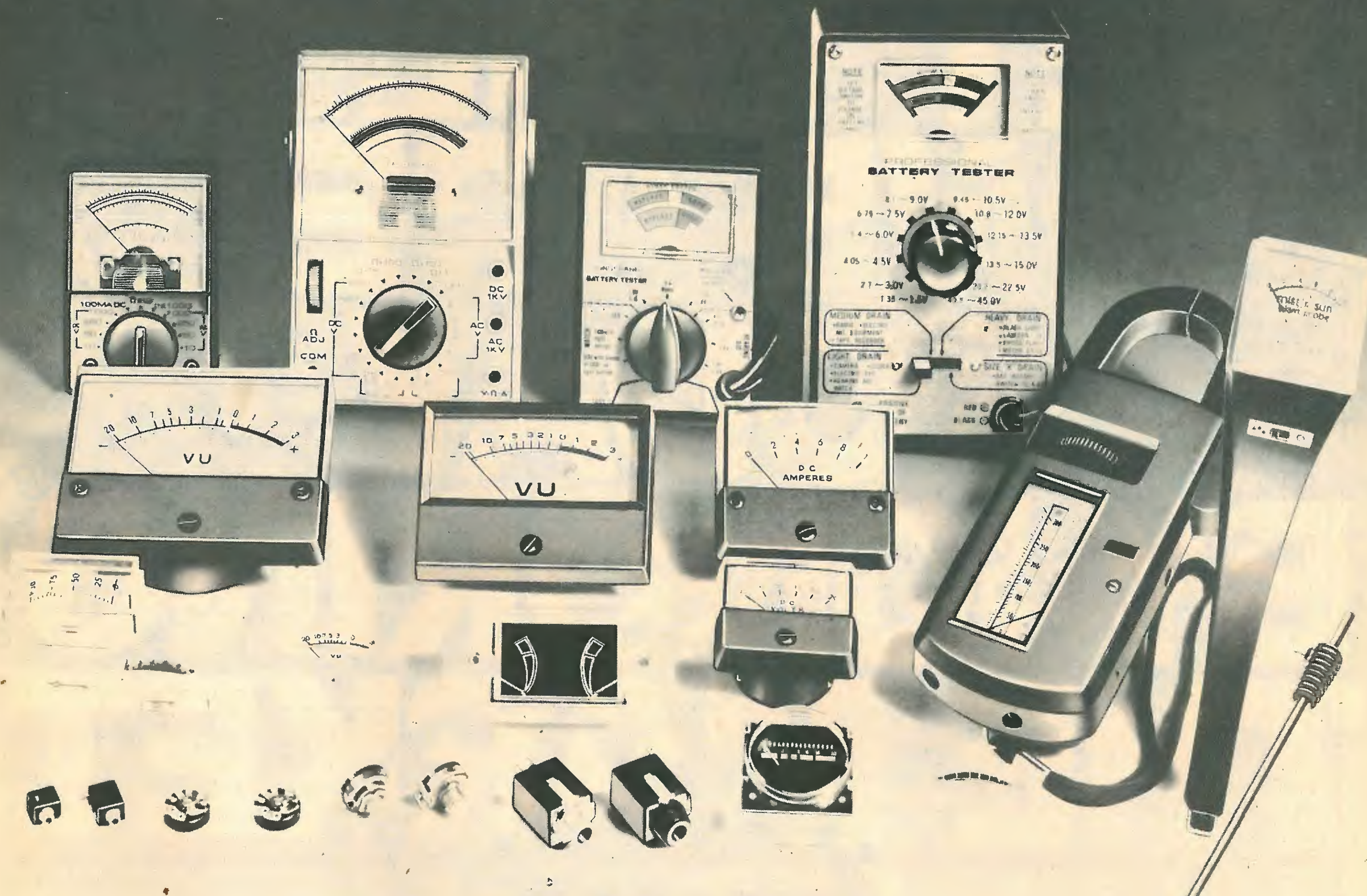
The only really effective way of putting this money to work is to decide, before any of it is spent, what results – specific, not general ones – you want to achieve. That may very probably sound fatuous, but governments are positively brilliant at frittering away our money, as everyone must surely realise, by now. The decisions on which part of the market to aim at must come from engineers and marketeers, not politicians – our recent history is littered with development programmes which have been forcibly shot down for political reasons.

Once having taken the decisions, *all* the money must then be allocated to the companies selected to carry out the development and production. There is no room for oddball notions here. If it is open for any hare-brained inventor to send in an application for five thousand quid to market a microprocessor-controlled ludo game or electronic cat-door, sure as little apples some government clerk will think it's a super idea and shell out.

To forestall aggrieved proponents of free enterprise telling me that the Spitfire would never have been designed under the above scheme, that is taken care of by allowing practical people to make the decisions, rather than waiting for ludicrously impractical government specifications.

The money being made available is little enough when compared with the amounts invested by American and Japanese companies – if it is squandered we might as well all go home and take up woodwork.

ELECTRONIC COMPONENTS
AND VARIOUS TESTERS



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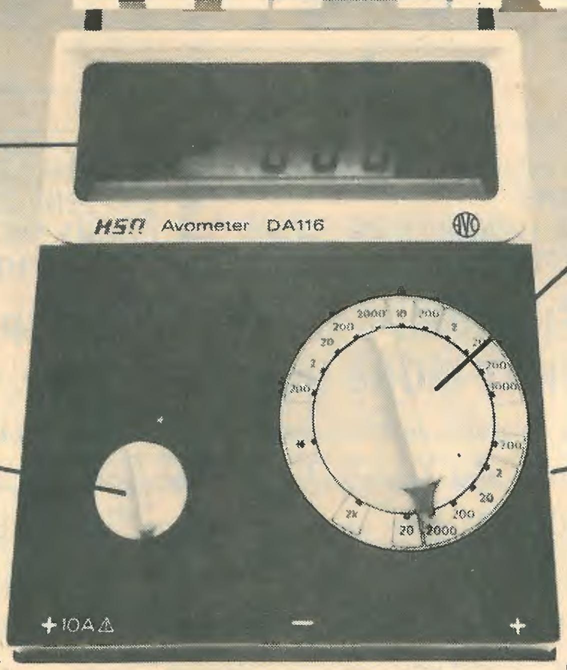

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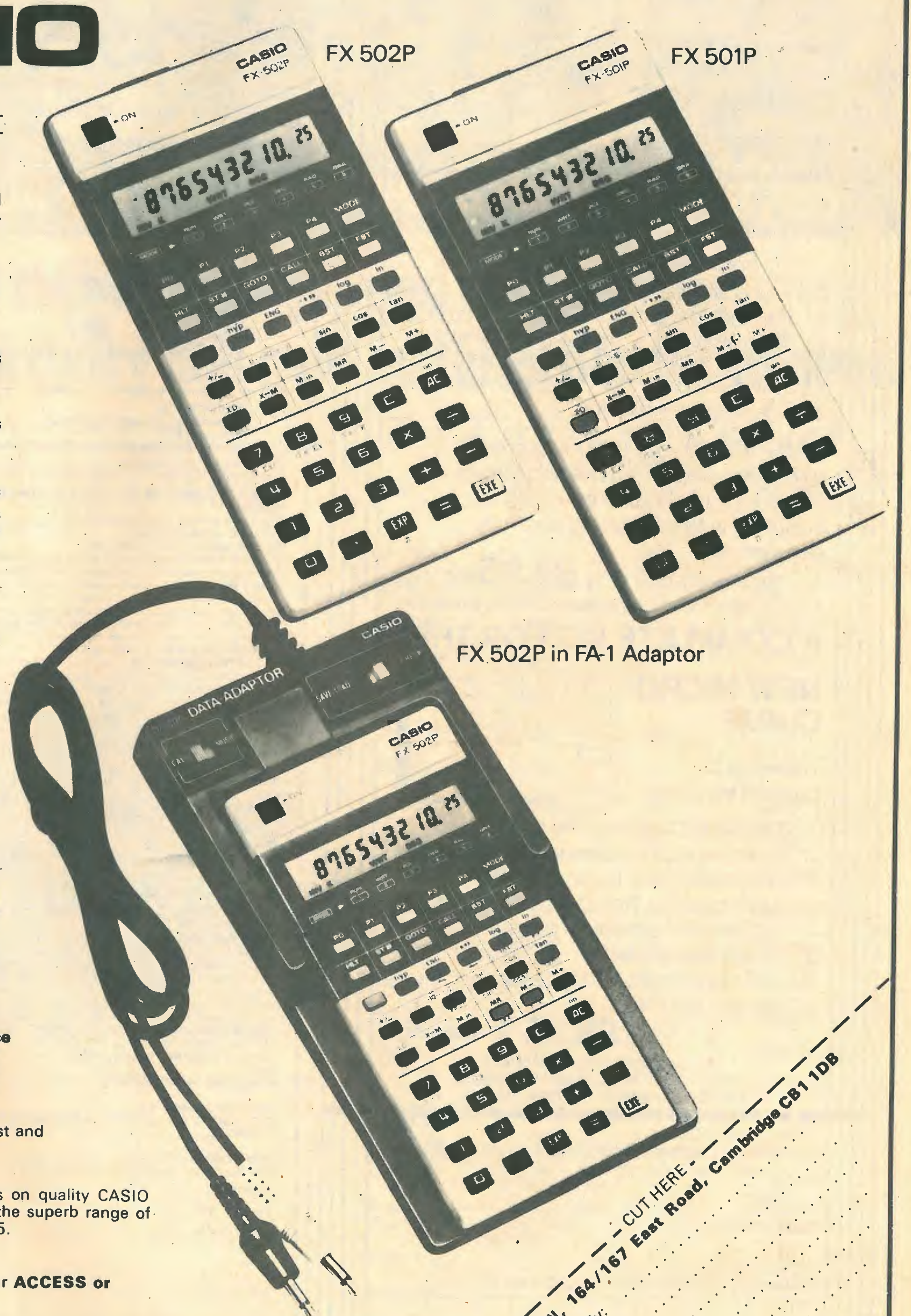

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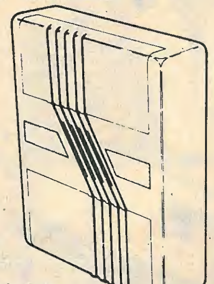

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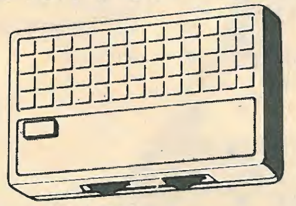

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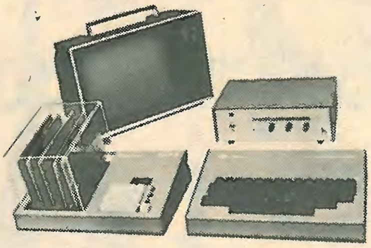

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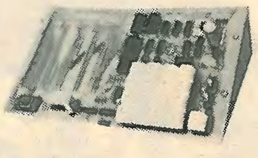

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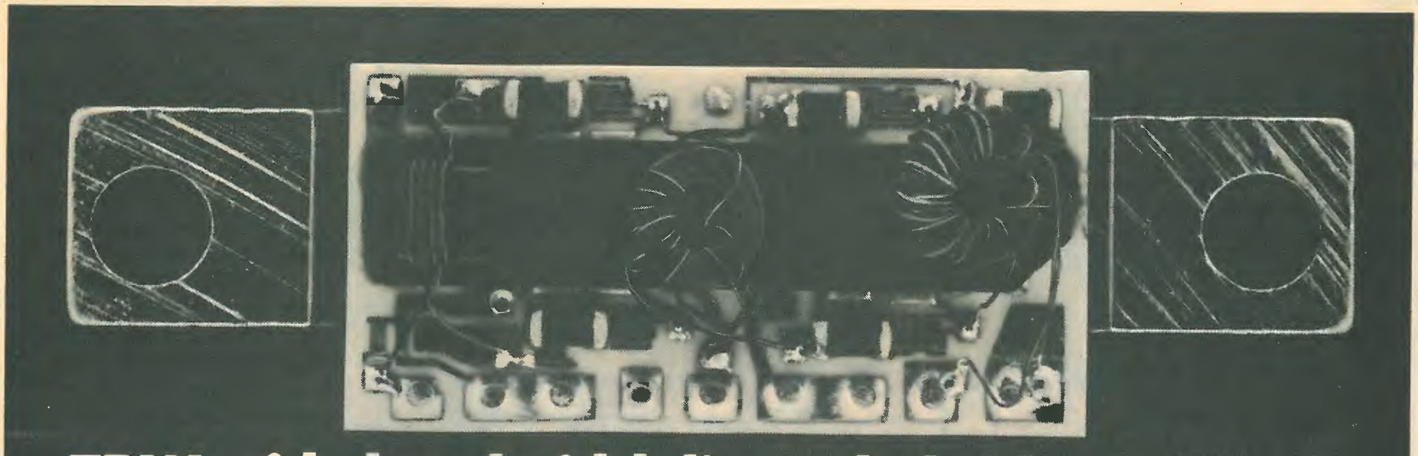

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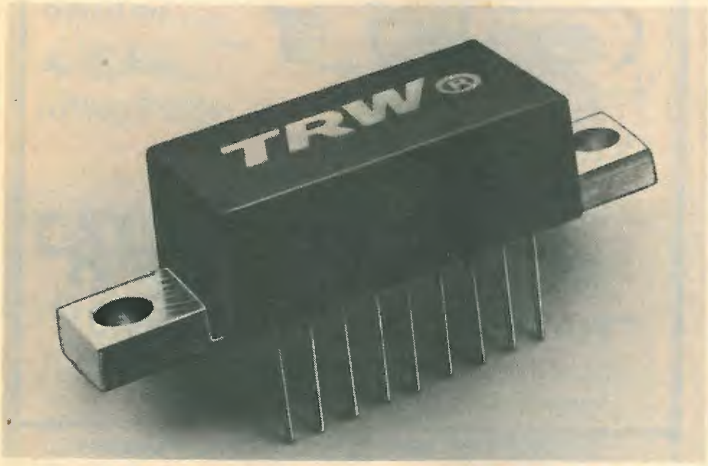

Just check opposite the module that suits your particular requirements, then contact MCP for the complete data.

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CA 2810	10-350	33	800 mW
CA 2818	1-200	18	800 mW
CA 2820	1-520	30	400 mW
CA 2830	5-200	34	1 W
CA 2832	1-200	35	2 W
CA 2833	5-200	34	1 W
CA 2840	30-300	22	1 W
CA 2842	30-300	22	1 W
CA 2850	40-100	17	250 mW
CA 2851	40-100	17	250 mW
CA 2870	20-400	34	400 mW
CA 2875	40-100	17	310 mW
CA 2876	40-100	22	100 mW
CA 2880	40-100	22	100 mW

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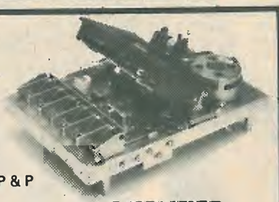

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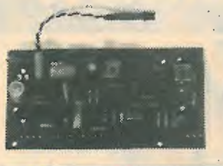

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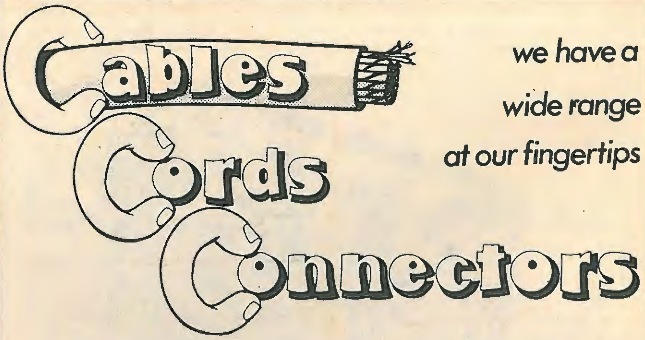

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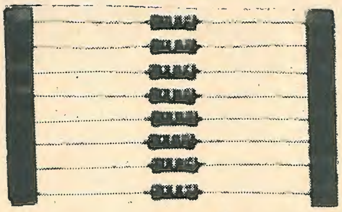

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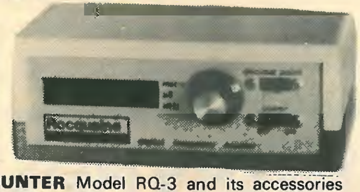

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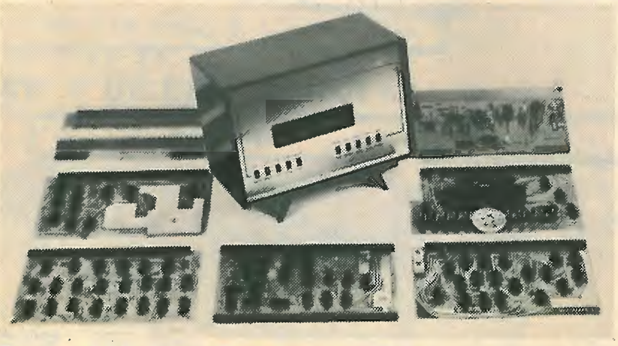
Radiocode Clocks

As supplied to the National Physical Laboratory



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Wireless World Dolby™ noise reducer

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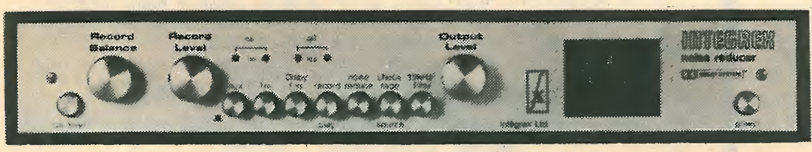

Typical performance

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.

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.

Complete Kit **PRICE: £43.90** + VAT

Also available ready built and tested . . . . **Price £59.40** + VAT

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Selected FETs **65p** each + VAT, **110p** + VAT for two, **£2.10** + VAT for four.

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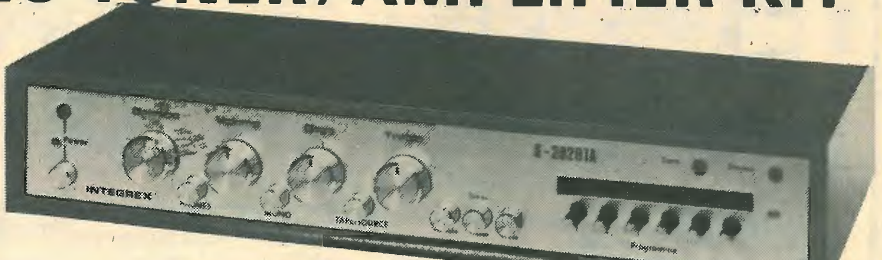
S-2020TA STEREO TUNER/AMPLIFIER KIT

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: £59.95** + VAT

Nelson-Jones Mk. 2 Stereo FM Tuner Kit. Price: **£69.95** + VAT.

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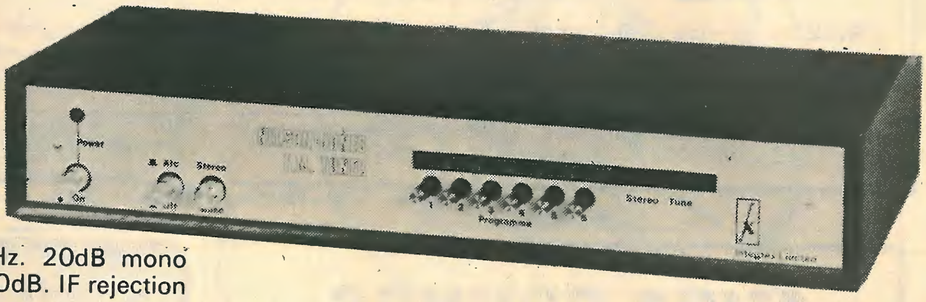

Brief Spec. Tuning range 88—104MHz. 20dB mono quieting @ 0.75µV. Image rejection — 70dB. IF rejection — 85dB. THD typically 0.4%.

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.

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THD typically 0.3%

Tuning range 88—104MHz

LED sig. strength and stereo indicator

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PRICE: Stereo £33.95 + VAT

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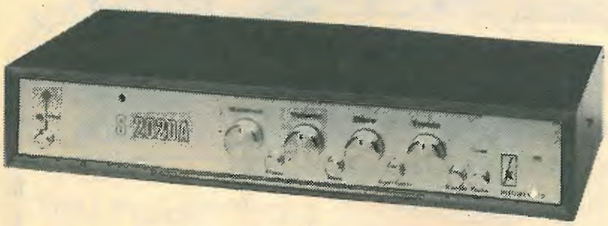

Typ Spec. 24+24W r.m.s. into 8-ohm load at less than 0.1% THD. Mag. PU input S/N 60dB. Radio input S/N 72dB. Headphone output. Tape In/Out facility (for noise reduction unit, etc.). Toroidal mains transformer.

PRICE: £35.95 + VAT

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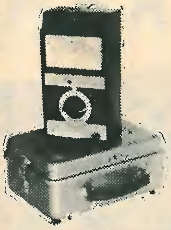

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Sensitivity D.C.	20,000 o.p.v.	20,000 o.p.v.
Sensitivity A.C.	2,000 o.p.v.	2,000 o.p.v.
D.C. Current	60μA-1.5A	50μA-2.5A
A.C. Current	0.6mA-1.5A	0.5mA-2.5A
D.C. Volts	75m V-600V	75mV-1000V
A.C. Volts	15V-600V	1V-1000V
Resistance	1K-1M	300Ω-500kΩ
Capacity	0.5μF	0.5μF
Accuracy	1.5% D.C. 2.5% A.C.	2.5% D.C. 4% A.C.
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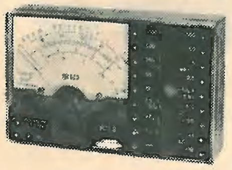

Sensitivity:	20,000Ω/V
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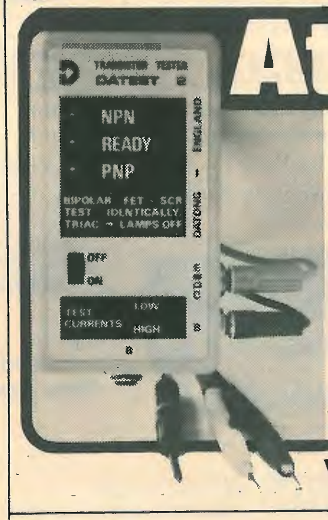

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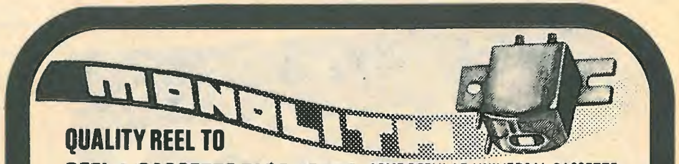

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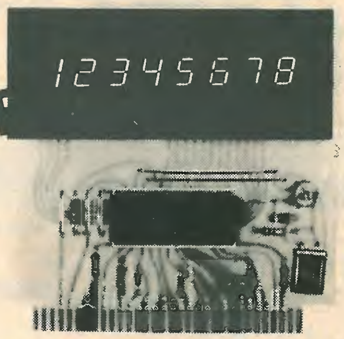

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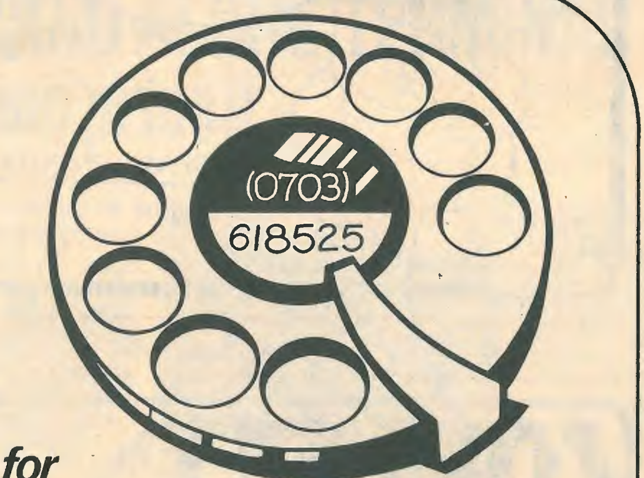

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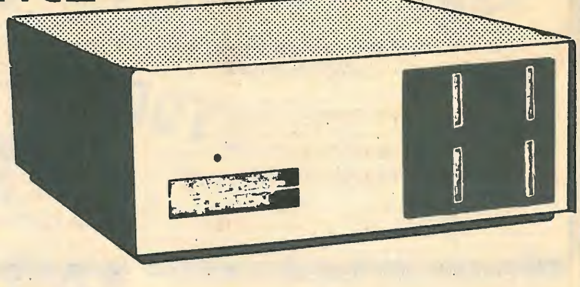

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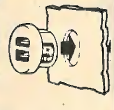

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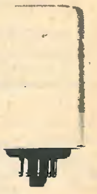

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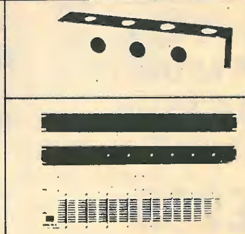

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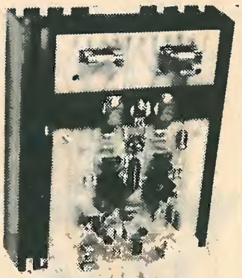
All modules are made in the United Kingdom.



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(ASTONKILN LTD.)
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STEELE ROAD
PARK ROYAL
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Tel: 01-961 1274/5

JPS

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Studelek Elektronika
Tiensestraat 260
3000 Leuven, Belgium
Tel. (016) 234554
Contact: Mr. Leo Swinnen

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64 London Road
Leicester
Tel. 0533 538465
Mr. Phil Croxford

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Bristol BS7 8TZ
Tel. 0272 41666
Mr. Peter Hannay

ENGLAND, South
R.E.W. AUDIO VISUAL
126 Charing Cross Road
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WC2
Tel. 01-836 2372
Mr. John Cowan

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57 Nelson Street
Aberdeen
Scotland
Tel. 0224 572905
Mr. Keith Main

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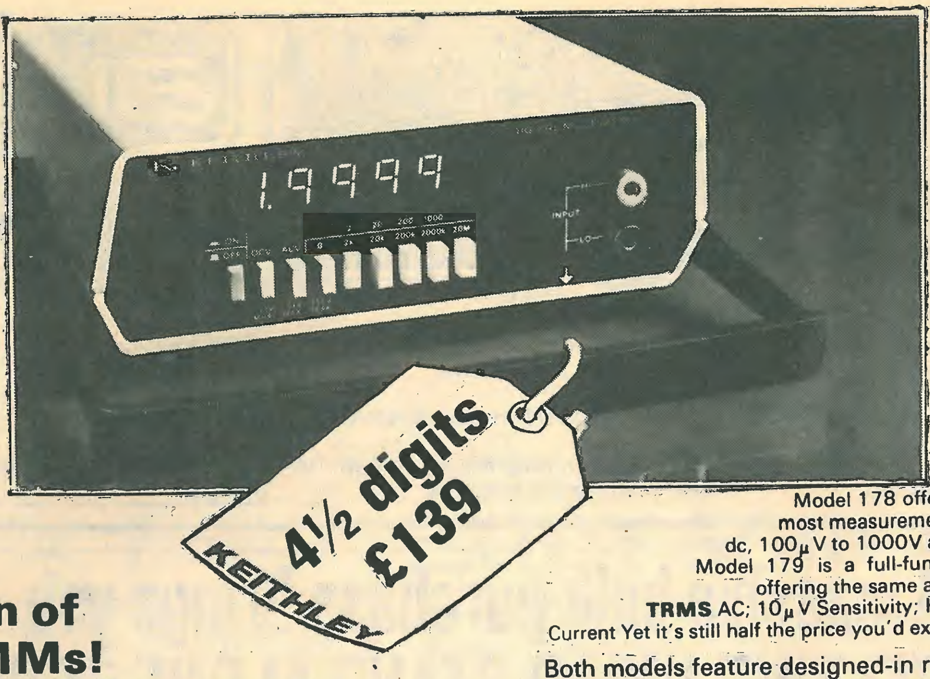
MUSIQUE & SON
1 Residence Bel-Event
35260, Cancale, France
Tel. (99) 89 67 77
Mr. Yves Jamois

WW—045 FOR FURTHER DETAILS



Model 178

Now . . . the next generation of bench DMMs!

Two New Keithley Models offer uncompromising performance and outstanding value!

- Accuracy 3½'s can't match 0.04% + 1 digit on dc volts and ohms
- Large, bright, 20,000-count LED display that's quick and easy to read.
- Convenient bench size that won't get "lost" yet doesn't crowd.
- Exceptional reliability.

Model 178 offers functions and ranges for most measurement needs 100μV to 1200V, dc, 100μV to 1000V ac, 0·1Ω to 20MΩ.

Model 179 is a full-function, multi-feature model offering the same advantages as the 178. Plus **TRMS** AC; 10μV Sensitivity; Hi and Lo Ohms; AC and DC Current Yet it's still half the price you'd expect. Only £199.

Both models feature designed-in reliability

Rugged circuits use a minimum of parts — high quality, off-the-shelf parts — carefully assembled and tested by Keithley.

Outstanding overload protection and rugged mechanical design keep both units going even after severe abuse. One-year accuracy specifications minimise recalibration costs.

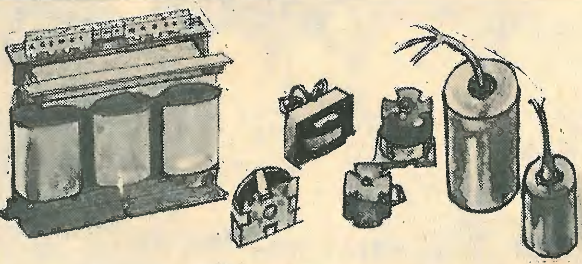
A battery option, user installable, gets you off "line" for critical measurements or for field use.

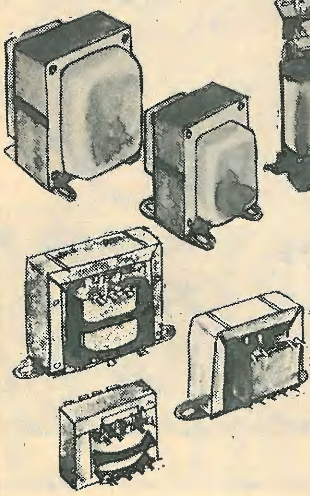
For complete specifications on the 178 and 179, call Keithley Instruments, 1 Boulton Road, Reading. Phone 0734 861287

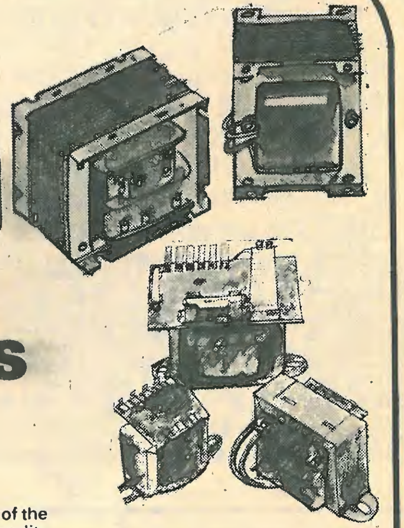
KEITHLEY

The measurement engineers.

WW — 032 FOR FURTHER DETAILS







there are Transformers and . . .

We have been established for over twenty years and are proud of the reputation earned for the design and manufacture of high quality transformers, and other wound components.

Our design team is available to give their personal attention to customers' technical requirements.

Development and pre-production samples can be supplied by our prompt prototype service.

Drake Transformers

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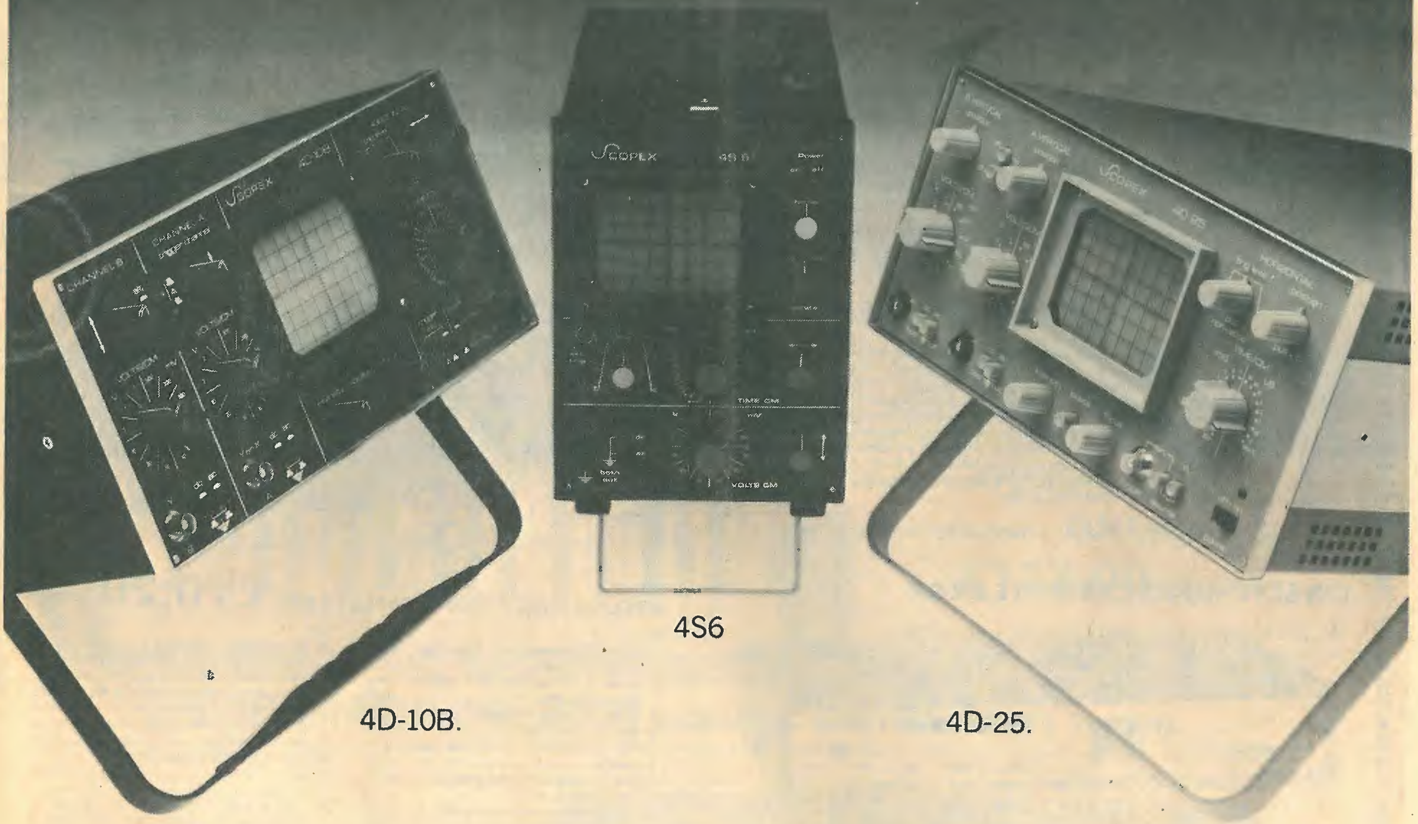
Kennel Lane, Billericay, Essex CM11 2SP
Telephone: Billericay (02774) 51155
Telex: 99426 (prefix message DRAKE)

WW—048 FOR FURTHER DETAILS

Why Scopex?



There's a range of answers.

There's something every one of our scopes has in common. Great accuracy, tremendous reliability and keener pricing, plus free delivery on UK mainland.

Take the new 4D-10B. The fully stabilised power supply gives 3% accuracy. There's a full XY facility using CMOS IC'S for extra reliability, Z modulation for brightening or dimming the trace, 10MHz scan at full bandwidth over the full screen area, trace locate and TV field trigger. At £188.00* it's astonishing value.

Or the 4D-25. A dual trace model with DC-25MHz bandwidth and 10mV/cm sensitivity. Signal delay allows you to trigger from and see the leading edge of any signal. Trigger level and slope are selected on one dual function control. 3% accuracy and still only £315.00*.

Plus the 4S6 single beam 6MHz bandwidth model with easy to use controls. 10mV sensitivity and timebase range of 1 us to 100ms/cm. Lightweight, compact and a very good price. £138.00*.

Return the coupon for full details of the range that gives you a lot more scope.

*UK list price excluding VAT.

SCOPEX

Scopex Sales,
Pixmore Avenue, Letchworth, Herts SG6 1JJ.
Tel: (04626) 72771.

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Company____________________

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____________________ WW 6/79

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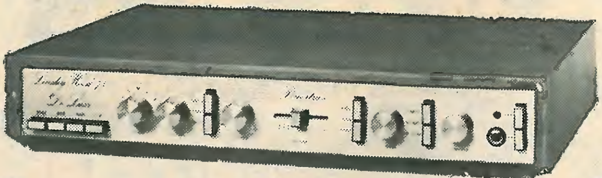
WW — 019 FOR FURTHER DETAILS

ELECTRONIC KITS OF DISTINCTION FROM POWERTRAN

DE LUXE EASY TO BUILD LINSLEY-HOOD 75W AMPLIFIER



Pack	Price
1. Fibreglass printed circuit board for power amp	£1.15
2. Set of resistors, capacitors, pre-sets for power amp	£2.80
3. Set of semiconductors for power amp	£6.20
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	£4.50
7. Set of low noise, high gain semiconductors for pre-amp	£2.00
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	£12.95
11. Fibreglass printed-circuit board for power supply	£0.85
12. Set of resistors, capacitors, secondary fuses, semiconductors for power supply	£4.90
13. Set of miscellaneous parts including DIN skts., mains input skt., fuse holder, interconnecting cable, control knobs	£6.70
14. Set of metalwork parts including silk screen printed fascia panel and all brackets, fixing parts, etc.	£8.20
15. Handbook	£0.75
16. High Quality Teak Veneer 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 £93.25

PACK PRICES FOR STANDARD KIT

AVAILABLE AS SEPARATE PACKS
PRICES IN OUR FREE CATALOGUE

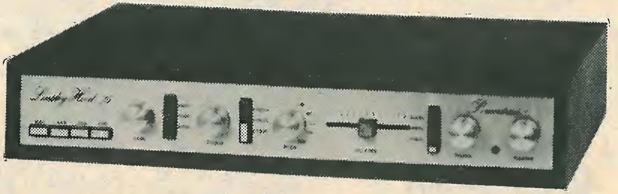
SPECIAL PRICE FOR COMPLETE KIT £99.30 + VAT

The standard model of our kit for Mr. Linsley-Hood's 75 watt design has for a long time offered exceptional performance at a very modest cost with high quality high power ready-built units of comparable quality generally being over three times the price.

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.

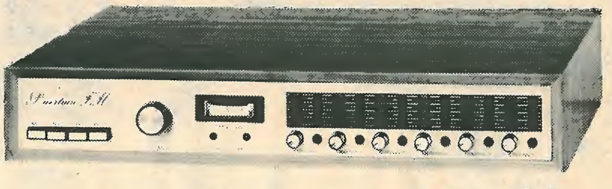
Our new De Luxe model uses 14 boards which interconnect with gold plated contacts and are designed to have the potentiometers and switches mounted upon them. This system almost eliminates internal wiring, making installation, after their assembly, delightfully straightforward, and as each board can be 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 the latest circuit improvements, generously sized heat sinks for heavy duty use, even in tropical climates, and metal oxide resistors throughout for long-term stability and reliability.

STANDARD LINSLEY-HOOD 75W AMPLIFIER



SPECIAL PRICE FOR COMPLETE KIT £79.80 + VAT

WIRELESS WORLD FM TUNER

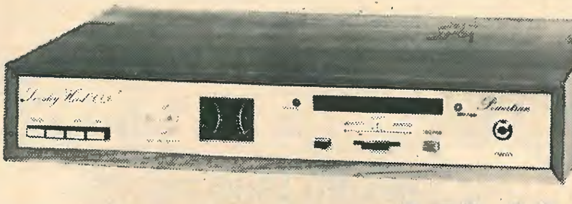


SPECIAL PRICE FOR COMPLETE KIT £70.20 + VAT

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.

AVAILABLE AS SEPARATE PACKS — PRICES IN OUR FREE CATALOGUE

LINSLEY-HOOD CASSETTE DECK



SPECIAL PRICE FOR COMPLETE KIT £79.60 + VAT

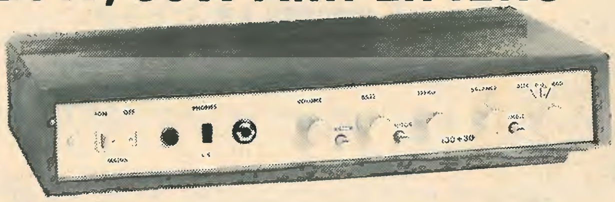
Pack	Price
1. Stereo PCB (accommodates 2 rep. amps, 2 meter, amps, bias/erase osc. relay)	£3.35
2. Stereo set of capacitors, M.D. resistors, potentiometers for above	£8.95
3. Stereo set of semiconductors for above	£7.50
4. Miniature relay with socket	£2.90
5. PCB, all components for solenoid, speed control circuits	£3.40
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 P.C.B. for power supply (Powertran design)	£2.80
11. Set of miscellaneous parts, including sockets, fuse holder, fuses, interconnecting wire, etc	£3.80
12. Set of metalwork including silk screened fascia panel, internal screen, fixing parts, etc	£7.10
13. Construction notes	£0.50
14. High Quality Teak Veneer 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 £87.75

Matsushita WY 436 AZ head (optional extra) . £4.50
(free with compete kit)

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. Pushbutton 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 AT NO EXTRA COST! A higher performance head (Matsushita WY 436 AZ head as recommended in the follow-up article) is offered as an optional extra but this will be automatically supplied FREE OF CHARGE with all orders for complete kits!

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 rumble 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.

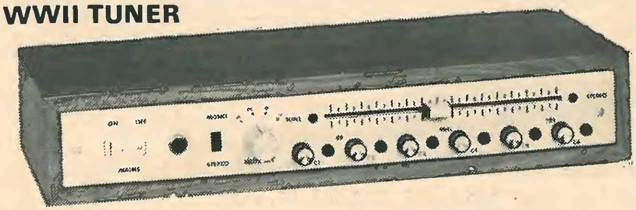
SPECIAL PRICES FOR COMPLETE KITS

T20+20 KIT PRICE £33.10 + VAT

T30+30 KIT PRICE £38.40 + VAT

AVAILABLE AS SEPARATE PACKS — PRICES IN OUR FREE CATALOGUE

WWII TUNER

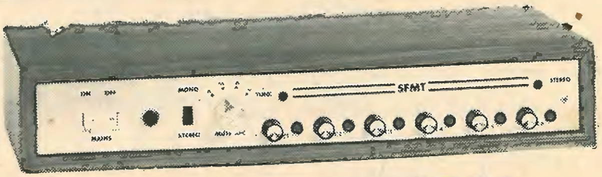


SPECIAL PRICE FOR COMPLETE KIT £47.70 + VAT

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.

POWERTRAN SFMT TUNER



PRICE FOR COMPLETE KIT £35.90 + VAT

AVAILABLE AS COMPLETE KIT ONLY

This is a simple, low cost design which can 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. 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.

ASCENSION ISLAND YUGOSLAVIA UNITED STATES OF AMERICA JORDAN GREECE INDIA GUYANA PORTUGAL FALKLAND ISLANDS UNITED ARAB EMIRATES JAMAICA HOLLAND KENYA

EIRE GRENADA SAUDI ARABIA NEW ZEALAND NORWAY SINGAPORE ICELAND SWEDEN MALAYA INDONESIA BRAZIL SWITZERLAND ZAMBIA GIBRALTAR CHILE SPAIN

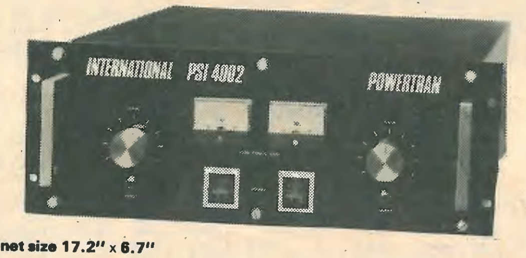
200 + 200 watt AMPLIFIER

As featured in Electronics Today International

400W rms continuous —— 800W peak!
0.03% THD at FULL power!
PLUS all the following features too!

- ★ Each channel totally independent with its own stabilised power supply driven by custom designed TOROIDAL transformers!
- ★ Inherent reliability — monster heat sinks for cool running at the hottest venues — electronic open and short circuit protection!
- ★ Ultra low feedback (an incredible low 14dB overall!), super high slewing rate (20V/µs), 200W rms continuous to 4 ohm from EACH channel, input sensitivity 0.775V (0dB).
- ★ Professional quality components, sturdy 19" rack mounting chassis complete with sleeve and feet for free standing work too.
- ★ Easy to build — plenty of working space with ready access to all components, minimal wiring, extensive instruction suitable for both experienced constructors and newcomers to electronics.
- ★ Value for money — quality and performance comparable with ready-built amplifiers costing over £600!

PSI 4002 STUDIO MODEL



Cabinet size 17.2" x 6.7"

COMPLETE KIT ONLY £196.90 + VAT

READ THE REVIEW
IN SOUND INTERNATIONAL DEC 78!

TRANSCENDENT 2000 SINGLE BOARD SYNTHESIZER

As featured in Electronics Today International

The kit includes fully finished metalwork, fully assembled solid teak cabinet, filter sweep pedal, professional quality components (all resistors either 2% metal oxide or ½% metal film!) and it really is complete — right down to the last nut and bolt and last piece of wire! There is even a 13A plug in the kit — you need buy absolutely no more parts before plugging in and making great music! Virtually all the components are on the one professional quality fibre glass PCB printed with component locations. All the controls mount directly on the main board, all connections to the board are made with connector plugs and construction is so simple it can be built easily in a few evenings by almost anyone capable of neat soldering! When finished you will possess a synthesizer comparable in performance and quality with ready built units selling for between £500 and £700!

COMPLETE KIT
ONLY
£172.00 + VAT!

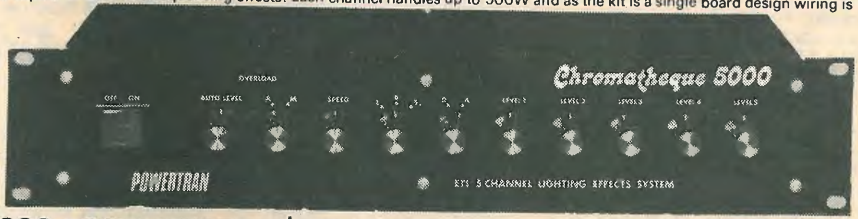
Comprehensive handbook supplied with all complete kits! This fully describes construction and tells you how to set up your synthesizer with nothing more than a multi-meter and a pair of ears!

CHROMATHEQUE 5000 5-CHANNEL LIGHTING EFFECTS SYSTEM

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

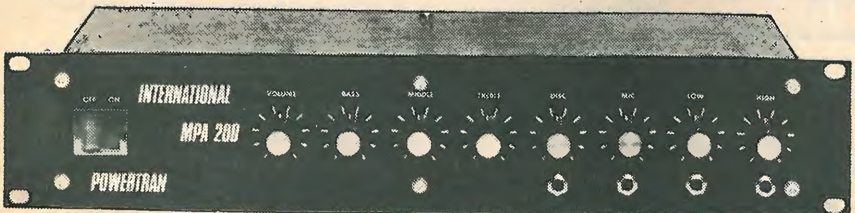
Kit includes fully finished metalwork, fibreglass PCB, controls, wire, etc. — Complete right down to the last nut and bolt!

COMPLETE KIT ONLY
£49.50 + VAT



MPA200 100W MIXER/AMPLIFIER

Featured as a constructional article in Electronics Today International the MPA 200 is an exceptionally low-priced but professionally finished general purpose, rugged, high-power amplifier which has an adaptable range of inputs such as disc, microphone, guitar, etc. There are 3 wide range tone controls and a master volume control. Mechanically the design is simplicity in the extreme with minimal wiring making construction very straightforward. Kit includes fully finished metalwork, fibreglass PCB's, controls, wire, etc. — Complete right down to the last nut and bolt!



COMPLETE KIT ONLY
£49.90 + VAT

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

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. There is no minimum order charge. Prices same as for U.K. customers but no Value Added Tax charged. Postage charged at actual cost plus 50p documentaton 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.

Value Added Tax not included in prices
UK Carriage FREE

PRICE STABILITY. Order with confidence! Irrespective of any price changes we will honour all prices in this advertisement until July 31, 1979, if this month's advertisement is mentioned with your order. Errors and VAT rate changes excluded.

U.K. ORDERS: Subject to 12½%* surcharge for VAT (i.e. add ⅛ to the price). No charge is made for carriage. *Or current rate if charged.
SECURICOR DELIVERY: For this optional service (U.K. mainland only) add £2.50 (VAT inclusive) per kit.
SALES COUNTER: If you prefer to collect your kit from the factory, call at Sales Counter (at rear of factory). Open 9 a.m.-4.30 p.m. Monday-Thursday.

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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PORTWAY INDUSTRIAL ESTATE
ANDOVER HANTS SP10 3NN

ANDOVER
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VALVES

Minimum Order £1.00

VALVES VAT PLEASE ADD 12½%

	£
A1065	1.40
AR8	0.70
ARP3	0.70
ATP4	0.60
B12H	3.35
CY31	0.60
DAF96	0.70
DET22	21.95
DF96	0.70
DK96	1.05
DH76	0.90
DL92	0.60
DY86/87	0.65
DY802	0.65
E55L	8.45
E88 CC/01	1.50
E180CC	1.50
E180E	6.75
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EA76	2.25
EABC80	0.60
EB91	0.45
EBC33	1.15
EBF80	0.60
EBF83	0.60
EBF89	0.60
EC52	0.45
ECC81	0.65
ECC82	0.60
ECC83	0.65
ECC84	0.50
ECC85	0.60
ECC86	1.40
ECC88	0.70
ECC189	0.90
ECF80	0.60
ECF82	0.55
ECF801	0.90
ECH34	1.15
ECH35	1.70
ECH42	0.95
ECH81	0.55
ECH84	1.15
ECL80	0.70
ECL82	0.65
ECLB3	1.40
ECL85	0.75
ECL86	0.65
EF37A	1.70
EF39	3.30
EF40	0.80
EF41	0.85
EF80	0.45
EF83	1.70
EF85	2.25
EF86	0.85
EF91	0.70
EF92	1.00
EF95	2.95
EF183	1.40
EF184	1.60
EF804	2.00
EFL200	0.75
EH90	0.60
EL32	0.90
EL34	2.60
EL37	3.00
EL38	4.50
EL41	0.90
EL81	1.20
EL82	0.70
EL84	0.90
EL86	1.05
EL90	1.45
EL91	1.80
EL95	0.80
EL504	0.90
EL802	1.70
EL822	5.05
EM31	0.85
EM80	0.70
EM81	0.70
EM84	0.45
EM87	1.15
EY51	0.55
EY81	0.55
EY86/87	0.65
EY8B	0.65
EZ80	0.55
EZ81	0.70
GY501	1.05
GZ32	0.75
GZ33	3.95
GZ34	2.25
GZ37	2.80
KT66	5.65
KT88	6.45
MH4	1.15
ML6	1.15
OA2	0.65
OB2	0.70
PABC80	0.60
PC85	0.60
PC86	0.95
PC88	0.85
PC900	1.40
PCC84	0.75
PCC89	0.65
PCC189	0.75
PCF80	0.90
PCF82	0.45
PCF84	0.75
PCF86	0.75
PCF200	1.05
PCF201	1.05
PCF801	1.05
PCF802	0.75
PCF805	2.05
PCF806	0.95
PCF808	2.05
PCH200	0.90
PCL81	0.70
PCL82	0.75
PCL84	0.80
PCLB6	0.80
PCL805/85	0.85
PD500	3.65
PFL200	2.80
PL36	0.90
PL81	0.85
PL82	0.60
PL83	0.60
PLB4	0.75
PL504	1.60
PL508	1.50
PL509	3.65
PL802	3.15
PLL80	3.40
PY33	0.70
PY80	0.70
PY81/800	0.65
PY82	0.55
PY83	0.60
PY88	0.75
PY500	1.50
PY859	6.45
PY801	0.70
QQV03-10	2.80
QQV03-12	2.80
WQV06-40A	15.75
QV03-12	2.80
SC1/400	4.50
SC1/600	4.50
SP61	0.95
TT21	11.80
U25	1.15
U26	0.95
U27	1.15
U191	0.85
U281	0.60
U301	0.60
U801	0.90
UABC80	0.70
UAF42	0.85
UBF80	0.65
UBF89	0.60
UBL1	1.15
UBL21	0.85
UCC84	0.70
UCC85	0.75
UCF80	0.90
UCH81	0.70
UCL82	0.85
UF41	0.90
UF80	0.55
UF85	0.60
UL41	0.85
UL84	0.85
UM80	0.70
UM84	0.45
UY82	0.65
UY85	0.60
VR105/30	2.05
VR150/30	1.40
Z66	1.05
X61M	1.70
Z800U	3.40
ZB01U	3.90
Z900T	1.70
1A3	0.70
1L4	0.40
1R5	0.65
1S4	0.45
1S5	0.45
1T4	0.45
1U4	0.70
1X2B	1.25
2D21	0.65
2K25	12.40
2X2	0.90
3A4	0.70
3D6	0.50
3D21	22.50
3E29	6.20
3S4	0.80
3V4	0.95
5B/254M	8.45
5B/255M	8.45
5B/258M	8.45
5R4GY	1.25
5U4G	1.05
5V4G	0.75
5Y3GT	0.75
5Z3	1.15
5Z4G	0.80
5Z4GT	0.85
6AB7	0.70
6AC7	0.70
6AH6	0.80
6AK5	0.65
6AK8	0.45
6AL5	0.45
6AL5W	0.75
6AM5	1.80
6AM6	0.75
6AN8	0.95
6AQ5	1.45
6AQ5W	0.95
6AS6	0.90
6AT6	0.85
6AU6	0.45
6AV6	0.60
6AX4GT	0.90
6AX5GT	1.15
6B7	0.85
6BA6	0.45
6BE6	0.60
6BG6G	1.15
6BJ6	1.25
6BQ7A	0.70
6BR7	2.60
6BW6	3.10
6BW7	1.15
6C4	0.45
6C6	0.65
6CH6	5.05
6CL6	1.70
6CY5	1.00
6D6	0.85
6EA8	0.90
6F6GB	0.85
6F8G	0.75
6F12	0.90
6F14	0.70
6F15	1.15
6F17	1.00
6F24	4.75
6F33	1.10
6H6	1.95
6J4WA	0.85
6J5	0.65
6J5GT	0.60
6J6	0.50
6J7	0.85
6J7G	0.60
6K7	0.80
6K7G	0.45
6K8GT	0.65
6L6M	2.15
6L6GT	1.05
6L7G	0.75
6L18	0.70
6LD 20	0.70
6Q7G	0.90
6SA7	0.65
6SG7	0.85
6SJ7	0.80
6SJ7GT	0.60
6SK7	0.70
6SL7GT	0.85
6SN7GT	0.85
6SQ7	0.85
6V6GT	0.90
6X4	0.70
6X5GT	0.65
6Y6G	1.10
6Z4	0.75
6-30L2	1.95
7B7	0.90
7V4	0.90
9D2	0.70
9D6	0.85
10C2	0.70
10F18	0.70
10P13	0.70
11E2	12.40
12A6	0.70
12AT6	0.55
12AT7	0.65
12AU7	0.60
12AV6	0.80
12AX7	0.60
12BA6	0.60
12BE6	0.70
12BM7	0.70
12C8	0.65
12E1	4.80
12J5GT	0.45
12K7GT	0.70
12K8GT	0.80
12Q7GT	0.60
12SC7	0.65
12SH7	0.80
12SJ7	0.65
12SQ7	0.65
12Y4	0.45
13D6	0.70
14S7	1.15
19AQ5	0.85
19G3	11.25
19G6	6.75
19H5	19.15
20D1	0.70
20F2	0.70
20L1	1.15
20P1	0.45
20P3	0.60
20P4	1.25
20P5	1.15
25L6GT	0.90
25Z4G	0.70
30C15	1.15
30C17	1.25
30C18	see PCF805
30F5	1.15
30F12	1.35
30FL12	1.35
30FL14	2.05
30L15	1.15
30L17	1.15
30P12	1.15
30PL1	1.15
30PL13	1.25
30PL14	1.25
35L6GT	1.15
35W4	0.80
35Z4GT	0.80
50C5	1.35
50CD6G	1.15
75	0.90
75C1	0.90
76	0.85
78	0.85
80	2.50
85A2	2.40
723A/B	6.75
803	20.25
805	1.15
807	11.80
B13	12.40
829B	5.05
832A	3.15
B66A	6.75
931A	0.60
954	0.55
955	0.60
956	1.00
957	1.15
1625	0.80
1629	1.15
2051	2.80
5763	7.35
5842	3.40
5933	0.95
6057	0.95
6060	0.95
6064	1.35
6065	1.15
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60B0	8.45
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6146B	6.20
6360	2.00
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TF 2400/1 Frequency Converter up to 510MHz.
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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 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.

WHITE NOISE TEST SET. The instrument consists of two units: a Marconi Noise Generator Type TF 2091 and Noise Receiver Type TF 2092. Measures noise and intermodulation on wide band multichannel telephone systems. Suitable for 12 channel to 2,700 channel system.

MARCONI TF 867 SIGNAL GENERATOR
Range 15KHz to 30MHz. Output 0.4µ V to 4V to 13 or 75 ohms. Impedance with termination (supplied). Built in crystal check facility with handbook. CT 478; CT479; QT480 Signal Generators frequency from 1.3kMS up to 11kHz output up to 1mV CW and imp. mod.
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FOR EXPORT ONLY

Mullard C11, High power installation, 1000W. Technical details and prices available on request.

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N24/G—10"x8"x6" 400 watts	£71.40
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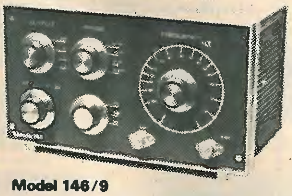

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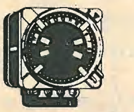

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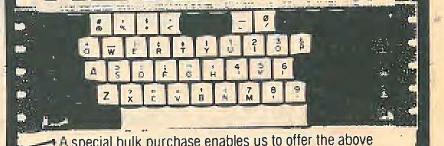

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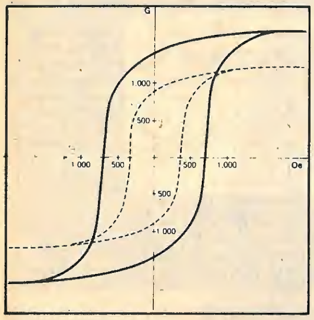
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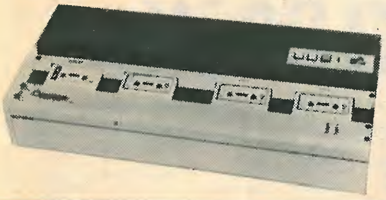

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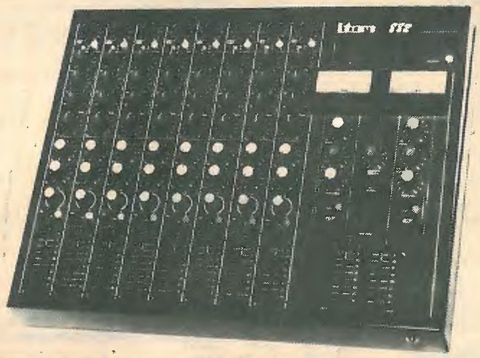

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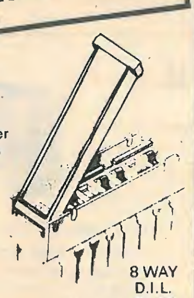

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fixed contacts gold plated £2.65

	Price
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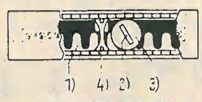

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2N1638	.70	2N2218A	.38	3N201	1.35	AD162	1.00
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2N1974	.98	2N2222	.25	AC151	.43	AF117	.70
2N1990	.45	2N2222A	.25	AC152	.54	AF118	.70
2N1991	1.10	3N81	3.50	AC153	.59	BC113	.22
2N2060	7.00	3N83	2.25	AC153K	.59	BC114	.22
2N2102	.50	3N128	1.35	AC176K	.70	BC115	.22
2N2147	1.55	3N139	1.60	AC176	.54	BC116	.21
2N2160	1.55	3N140	1.10	ACK187	.59	BC116A	.22
2N2192	.58	3N141	.95	AC187K	.65	BC117	.22
2N2193	.50	3N142	.70	AC188	.54	BC118	.22
2N2193A	.52	3N143	.88	AC188K	.65	BC119	.33
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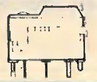

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AC128	£0.16	BC148	£0.07*	BC559	£0.14*	BU105	£1.40	ZTX500	£0.13*	2N4058	£0.12*
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AC142	£0.20	BC169	£0.09*	BD131/132MP	£0.60	MJE3055	£0.60	2N2148	£0.70	2N4286	£0.18*
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AC188	£0.18	BC182L	£0.09*	BD176	£0.60	OC24	£1.35	2N2904A	£0.21	2N5136	£0.10*
AC188K	£0.28	BC183	£0.09*	BD177	£0.68	OC25	£1.00	2N2905	£0.18	2N5138	£0.10*
AD140	£0.80	BC183L	£0.09*	BD17B	£0.68	OC26	£1.00	2N2905A	£0.20	2N5194	£0.56
AD142	£0.85	BC184	£0.09*	BD179	£0.75	OC28	£0.80	2N2906	£0,16	2N5245	£0.40
AD143	£0.75	BC207	£0.11*	BD201/202MP	£1.70	OC29	£0.95	2N2906A	£0.19	2N5294	£0.34
AD149	£0.60	BC208	£0.11*	BD203	£0.80	OC35	£0.90	2N2907	£0.20	2N5296	£0.36
AD161	£0.35	BC209	£0.12*	BD204	£0.80	OC36	£0.90	2N2907A	£0.22	2N5257	£0.32
AD162	£0.35	BC212	£0.09*	BD203/204	£1.70	OC70	£0.24	2N2926G	£20.09*	2N5458	£0.32
AD162/162MP	£0.70	BC212L	£0.09*	BDY20	£0.80	OC71	£0.15	2N2926Y	£0.08*	2N5459	£0.35
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AF117	£0.25	BC214L	£0.09*	BF459	£0.38	TIP29B	£0.42	2N3052	£0.16	2N6122	£0.70
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AF127	£0.32	BC301	£0.28	BFR79	£0.28*	TIP31A	£0.40	2N3416	£0.29*	40326	£0.40
AF139	£0.35	BC302	£0.29	BFR80	£0.28*	TIP31B	£0.42	2N3417	£0.29*	40327	£0.45
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BC107C	£0.10	BC478	£0.20	BIP29	£0.38	TIP3055	£0.50	2N3708A	£0.07*		
BC108A	£0.10	BC479	£0.20	BIP20	£0.38	TIS43	£0.22	2N3709	£0.07*		
BC108B	£0.08	BC547	£0.10*			TIS90	£0.18*	2N3710	£0.07*		
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7411	£0.17	7440	£0.12	7476	£0.25	74107	£0.24	74161	£0.62	74195	£0.60
7412	£0.15	7441	£0.50	7480	£0.44	74110	£0.36	74162	£0.62	74196	£1.05
7413	£0.24	7442	£0.40	7481	£0.65	74111	£0.58	74163	£0.62	74197	£1.05
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CA3054	£1.10*	LM3900	£0.58*	NE567	£1.70*	72748	£0.35*				
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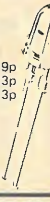

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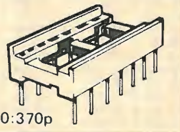

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TF1400 Pulse generator
TF675F Pulse generator
TF1370 Wide-range RC oscillator. **£125**
TF2162. MF Attenuator
TF1058 UHF/SHF signal generator
TF995A/4. AM/FM signal generator
TF1066 AM/FM signal generator
MARCONI TF144H/4 Signal Generator

ADVANCE CONSTANT VOLTAGE TRANSFORMERS

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

PYE RESISTANCE BOXES

5 decade resistance boxes measuring from 11.111 ohm to 0.001 ohm **£20**

NICKEL CADMIUM BATTERIES

Size 'D' (HP2) 4 A.H. **£2** (pp. 20p)
Size 'F' 6.00 A.H. **£2.75** (pp. 25p)

POWER SUPPLIES

FARNELL Switching power supplies 5VDC. 1KW
ADVANCE RMA20. 0-7V @ 20 Amps. . **£39**
Both brand new, boxed, with book.
APT 1045918. 12.5V-14.5V.DC @ 5A **£25**
APT10459/13. 24V (var) 5A **£25**
(All items + £1 carr.)

BECKMAN TURNS COUNTER DIALS

Miniature type (22mm diam.). Counting up to 15 turn "Helipots". Brand new with mounting instructions. Only **£2.50 each.**

Wandel & Gotterman Equipment

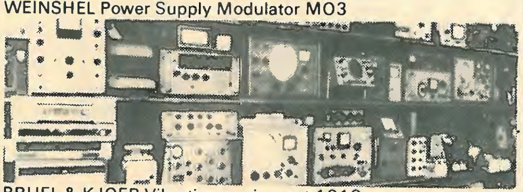
Level Meter 0.2-1600KHz
Level Oscillator 0.2-1600KHz
Level Transmitter 0.3-1350KHz
Carrier Frequency Level Meter

P. F. RALFE ELECTRONICS

10 CHAPEL STREET, LONDON, NW1
TEL: 01-723 8753

TEST EQUIPMENT

ADVANCE Q-Meter type T1 . . . . **£85**
GAUMONT-KALEE Flutter Meter
HEWLETT-PACKARD 302A Wave-Analyser
RACAL type 801R. 100MHz digital frequency meter
TELETYPE ASR33 now in stock
SOLARTRON 1420.2 digital voltmeter. 6 ranges to 1KV
BOONTON 80 Signal generator. 2-400MHz **£105**
BOONTON 230A Power Amplifier **£325**
BPL Capacitance decade (5) CD133. 100pF-1uF **£45**
GERTSCH Frequency meter and deviation meter 20-1000MHz
HEWLETT-PACKARD 65A Sweep oscillator **£350**
RADIOMETER AFM1/ Dev/Mod Meter. 3.5-320MHz **£185**
AIRMEC 314A Electronic Voltmeter. 300mV FSD-300V. AC/DC.
DERRITRON. Digital Wheatstone Bridge **£110**
MUIRHEAD K-134-A Battery op. wave analyser
WEINSHEL Power Supply Modulator MO3



BRUEL & KJOER Vibration equipment 1018
BRUEL & KJOER Frequency analyser 2105
BRUEL & KJOER Microphone amplifier 2603 **£195.**
BRUEL & KJOER Type 3301 Automatic frequency response recorder 200Hz. **£750.**
MUIRHEAD-PAMETRADA D489EM Wave Analyser
TEKTRONIX 555 scope with plug-ins types CA (2 off), 21, 22
TEKTRONIX 515A Oscilloscope
TEKTRONIX 545 main frames. **£210.** Choice of plug-in units extra
TEKTRONIX 585A oscilloscope with '82' P.I. DC-80MHz
TEKTRONIX type 561A DC-10MHz **£350**
TELEQUIPMENT DM53A Storage oscilloscope
TEKTRONIX 556. 50MHz oscilloscope

NOTICE. All the pre-owned equipment shown has been carefully tested in our workshop and reconditioned where necessary. It is sold in first-class operational condition and most items carry our three months' guarantee. Calibration and certificates can be arranged at cost. Overseas enquiries welcome. Prices quoted are subject to an additional 8% VAT.

ROHDE & SCHWARZ EQUIPMENT

HUZ Field Strength Meter. 47-225MHz.
AMF TV. Demodulator 55-90MHz.
Selective UHF v/meter, bands 4&5 USVF.
Selectomat. RF Voltmeter. USWV. BN 15221 . . . . **£450**
Standard attenuator. .0-100dB, 0-300MHz. DPR.
UHF Sig. gen. type SDR 0.3-1 GHz **£750**
UHF Signal generator type SCH. **£175**
UHF Test receiver type USVD **£325**
POLYSKOP SWOB 1.

KROHN-HITE 10-Watt Amplifier DC-1MHz
GR Impedance Bridge type 1650A **£175**

SPECTRAL DYNAMICS SD104/5 SWEEP GENERATOR

Sine/Square/Triangle outputs. Linear & Log Sweeps. Sweep rate 0.001Hz/sec to 1KHz/sec. Metered frequency indication **£250**

'CENTAUR' INSTRUMENT COOLING FANS

Made by Rotron Holland. These are very high quality, quiet running fans, specially designed for the cooling of all types of electronic equipment. Measures 4.5 x 4.5 x 1.5in. 115V AC. 11 Watts. The list price of these is over £10 each. Also 230V. AC available. 15V. **£4.50** (postage 25p). 230V **£5**

Finger guards for above — 50p each. Also small type Papst fans as above measuring 8 x 8 x 3.8 cms. 26 cu. ft/min. 110V only **£4.00** (PP 25p). RS price for all these fans are now around £12.50 each!!!

LAMBDA 5V DC POWER SUPPLIES

Stabilised/regulated modular type power supply units giving 5 Volts 4 Amps. These units are brand new complete with instruction book. 110V mains input (50 Hz) so ONLY **£10.00** each (+ £1 p&p).

MUIRHEAD DECADE OSCILLATORS Type 890A.

1Hz-110KHz in four decade ranges. Scope monitored output for high accuracy of frequency. Excellent generator.

TELETEXT DECODERS

including CATRONICS

ULTRASONIC REMOTE CONTROL

FOR THE

W.W. DECODER

Kits and PCBs are now available for the Ultrasonic Remote Control unit as described in this issue of W.W. Kit includes plated-through hole "Board 5", RX and TX PCBs, all components and installation instructions.

Price only £67.85 + VAT + Post = £75.00 total
Character Rounding "Board 4" Kit £25.75 total
New Facilities "Board 3" Kit for £37.45 total

Catronics 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 £1.95 + large 18½p SAE (included free in complete kit).

Prices are for the Version with TEXAS X887 INCLUDING VAT.

Set of 5 PCBs	**£26.80** +	30p P&P
Components Kit inc. PCBs .	**£139.25** +	£1.50 P&P
Cabinet	**£21.00** +	£1.00 P&P

Also **PLATED THROUGH** hole PCB at additional cost of £27.00

FULL FAULT-FINDING AND REPAIR SERVICE AVAILABLE

COMPONENTS ALSO AVAILABLE SEPARATELY — SAE for price list

READY BUILT AND TESTED DECODERS — £241.87 + £5 carriage

DE LUXE VERSION WITH NEW FACILITIES — £292.50 + £5 carriage

FULL SPEC. PROFESSIONAL TELETEXT DECODER

We are now agents for V.G. Electronics Ltd., and can offer their model VGE 1022 (as supplied to broadcasting authorities, etc.) at the

SPECIALLY REDUCED PRICE of £248 + VAT = £279

CHARACTER GENERATOR AND MEMORY I.C.S.

74S262N (X887) £12.95; 2102. 2602, £1.11
+ 8% VAT + 30p P&P

CATRONICS LTD. (Dept. 926)

Catronics

Communications House
20 WALLINGTON SQUARE
WALLINGTON, SURREY
Telephone: 01-669 6700

WW — 926 FOR FURTHER DETAILS

PRECISION DIAL GAUGES John Bull No. 6 series 1. 01mm. £6 P.P. 50p

COAXIAL CRYSTAL DETECTORS. (Marconi-Saunders), 200 MHZ-12 GHZ. £7.50

FIBREGLASS COPPER-CLAD BOARD
9x4½x1/16in. 40p P&P 10p
9x6x1/16in. 50p P&P 15p
9x4½x1/16in. (double sided) 50p P&P 10p
9x6x1/16in. (double sided) 65p P&P 10p
15x15x1/16in. (double sided) £2.50 P&P 50p

OFF-CUT PACKS. 150 sq. ins. £1 P.P. 25p.

LOW PROFILE RELAYS (ZETTLER) P.C.
Mounting. 6v or 12v. D.C.
1 P. c/o 50p. P&P 10p.
2 P. c/o. 75p. P&P 10p.
4 P. c/o. £1. P&P 10p.

TRANSISTORISED BRIDGE MEGGERS (500v.)
Ex P.O. Good condition. £20. P&P £2.

PLUG-IN (CRADLE) RELAYS 6/12/24/48V.W.
2 P. c/o. 65p. P&P 10p
4 P c/o. 85p. P&P 10p.
BASES 10p each

P.A.R. BI-STABLE RELAYS. 24v d.c. 4 c/o £1 P.P. 15p.

U.H.F. COAXIAL CABLE (white) Double screened.
Lab. quality 100m. drum £10 p.p. £1.50.

MULTICORE CABLES
10 CORE CABLE 10 x 7/76 (10 colours) P.V.C.
O.D. 7m.m. 10m—£2: 50m—£8.50: 100m—£16. P&P 2p per metre
10 PAIR RIBBON CABLE
10 x 7/76 twisted pairs, p.v.c.
Forming 18 m.m. wide loom. Polarised.
10m. — £3; 50m — £13.50; 100m — £25.
16 PAIR RIBBON CABLE 16x2 core P.V.C.
Double sheathed forming 2in wide strip
10m—£3; 50m—£13.50; 100m—£25. P&P 2p per metre.
18 CORE SCREENED OVERALL, black p.v.c. outer.
18 x 7/76 colour coded o.d. 7 m.m.
10m — £4; 50m — £30; 100m — £50. P&P 2p/metre.

E.H.T. MODULES (resin encapsulated, in metal box)
i/p 240x.50hz. o/p 13.7 kv. @ 7 watts (150x95x72m.m.) £10 P.P. £1.

P.C. EDGE CONNECTORS
32 way (.1 pitch) finished end 49p P&P 10p
56 way (.1 pitch) cuttable 65p P&P 15p
64 way (.1 pitch) cuttable 75p P&P 15p
Mounting pillars for 56/64 way 15p per pair.

H.D. THYRISTORS on deep finned heat sink.
65 amp @ 200 p.i.v. £3. P&P 50p.

'DRYFIT' RE-CHARGEABLE BATTERIES (Lead/Acid)
Ex. Equip. Good condition, tested.
6v @ 2.6 A.H. £2.50 P&P 50p
6v @ 6 A.H. £3.50 P&P 75p
6v @ 7.5 A.H. £5.00 P&P 75p

STEP-DOWN TRANSFORMERS. Double wound.
Input 200/240v. Output 115v @ 20 amps.
Fused output. £22.50. P&P £2.50.

J. B. PATTRICK

191/193 London Road
Romford, Essex RM7 9DJ
Romford 44473

TRANSFORMERS

SAME-DAY DESPATCH

Please add VAT after P&P

VAT 8%

MAINS ISOLATOR

PRI 120 or 240V Sec 120 or 240V
Centre Tapped and Screened

Ref.	VA (Watts)	£	P&P
07★	20	**4.40**	.79
149	60	**6.70**	.96
150	100	**7.62**	1.14
151	200	**11.16**	1.14
152	250	**13.28**	1.50
153	350	**16.43**	1.84
154	500	**20.47**	2.15
155	750	**29.06**	OA
156	1000	**37.20**	OA
157	1500	**51.38**	OA
158	2000	**81.81**	OA
159	3000	**86.66**	OA

★115 or 240 sec only. State volts required. Pri 0.220-240V.

12 or 24-VOLT

Separate 12V windings Pri 220-240V

Ref	Amps 12v	Amps 24v	£	P&P
111	0.5	0.25	**2.20**	.45
213	1.0	0.5	**2.64**	.78
71	2	1	**3.51**	.78
18	4	2	**4.03**	.96
85	5	2.5	**5.00**	.79
70	6	3	**6.35**	.96
108	8	4	**7.42**	1.14
72	10	5	**8.12**	1.14
116	12	6	**8.99**	1.32
17	16	8	**10.72**	1.32
115	20	10	**13.98**	2.08
187	30	15	**17.93**	2.08
226	60	30	**36.14**	OA

50 VOLT RANGE

Pri 220-240V. Sec. 0-20-25-33-40-50V. Voltages available 5, 7, 8, 10, 13, 15, 17, 20, 25, 30, 33, 40 or 20V-0-20V and 25V-0-25V Screened

Ref.	Amps	£	P&P
102	0.5	**3.41**	.78
103	1.0	**4.57**	.96
104	2.0	**7.16**	1.14
105	3.0	**8.56**	1.32
106	4.0	**15.06**	1.50
107	6.0	**14.62**	1.64
118	8.0	**20.26**	2.08
119	10.0	**24.98**	OA
109	12.0	**28.90**	OA

30 VOLT RANGE

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

Ref.	Amps	£	P&P
112	0.5	**2.64**	.78
79	1.0	**3.57**	.96
3	2.0	**5.77**	.96
20	3.0	**6.20**	1.14
21	4.0	**7.99**	1.14
51	5.0	**9.87**	1.32
117	6.0	**11.17**	1.45
88	8.0	**14.95**	1.64
89	10.0	**17.25**	1.84
90	12.0	**19.17**	1.95
91	15.0	**21.96**	2.08
92	20.0	**29.45**	OA

60 VOLT RANGE

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

Ref.	Amps	£	P&P
124	0.5	**3.88**	.96
126	1.0	**5.91**	.96
127	2.0	**7.60**	1.14
125	3.0	**11.00**	1.32
123	4.0	**12.52**	1.84
40	5.0	**15.84**	1.64
120	6.0	**18.06**	1.84
121	8.0	**25.56**	OA
122	10.0	**29.55**	OA
189	12.0	**34.06**	OA

SCREENED MINIATURES Primary 240V

Ref.	mA	Volts	£	P&P
238	200	3-0-3	**2.57**	.55
212	1A, 1A	0-6, 0-6	**2.85**	.78
13	100	9-0-9	**2.14**	.38
235	330, 330	0-9, 0-9	**1.99**	.38
207	500, 500	0-8-9, 0-8-9	**2.77**	.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	**2.57**	.38
214	300, 300	0-20, 2-20	**2.80**	.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	**6.04**	.96

HIGH VOLTAGE

MAINS ISOLATING
Pri 200/220 or 400/440
Sec 100/120 or 200/240

VA	Ref.	£	P&P
60	243	**6.70**	1.32
350	247	**16.43**	1.84
1000	250	**41.76**	OA

AUTO TRANSFORMERS

Ref.	VA (Watts)	TAPS	£	P&P
113	15	0-115-210-240V	**2.48**	.71
64	75	0-115-210-240V	**4.01**	.96
4	150	0-115-200-220-240V	**5.35**	.96
69	250	" "	**7.04**	1.14
67	500	" "	**10.99**	1.64
84	1000	" "	**18.76**	2.08
93	1500	" "	**23.28**	OA
95	2000	" "	**34.82**	OA
73	3000	" "	**59.21**	OA
80s	4000	0-10-115-200-220-240	**76.86**	OA
57s	5000	" "	**89.50**	OA

Step Up or Step Down

BRIDGE RECTIFIERS

100v	25A+	**£2.10**
200v	2A	**45p**
400v	2A	**55p**
200v	4A	**65p**
400v	4A	**80p**
400v	6A	**£1.40**
500v	12★	**£2.35**

+P&P 15p. VAT 12½% ★VAT 8%

CASED AUTO TRANSFORMERS

240V cable input. USA 115V. Flat pin outlets.

		P&P	Ref.
20VA	**£5.95**	.90	56W
75VA	**£7.73**	1.14	64W
150VA	**£10.01**	1.14	4W
200VA	**£10.92**	1.45	65W
250VA	**£11.59**	1.45	69W
500VA	**£19.17**	1.64	67W
1000VA	**£27.88**	2.30	84W
1500VA	**£26.02**	OA	93W
2000VA	**£49.97**	OA	95W

TEST METERS

AVO8 Mk. 5	**£88.10**
AVO71	**£36.00**
AVO73	**£48.70**
AVOMM5 MINOR	**£32.95**
WEE MEGGER	**£74.25**
TT169 (tests transistors in circuit)	**£39.53**
EM272 316Ωv	**£57.80**
DA116 Digital	**£108.90**
Megger BM7 (Battery)	**£51.76**

Avo Cases and Accessories

U4315 budget meter (42 ranges) 20kΩ V/DC 1000V AC/DC (9 ranges) 2.5A AC/DC 500K resistance, in robust steel case with leads, full instructions.
P&P £1.15 VAT 8% **£15.85**

MINI-MULTIMETER

DC1000V, AC-1000V
AC/DC-1000Ω/V
DC-100mA. Res — 150K
Bargain at **£7.20**
VAT 8% P&P 62p

PANEL METERS

43mm x 43mm		82mm x 78mm	
0-50μA	**£6.20**	0-50μA	**£6.70**
0-500μA	**£5.95**	0-500μA	**£6.70**
0-1mA	**£5.95**	0-1mA	**£6.70**
0-30V	**£5.95**	0-30V	**£6.70**

VU Indicator Edge 90mm 250μa	**£3.36**
VU Indicator Edge 54mm x 14mm μa FSD	**£2.60**
VU Panel Ind. 48 x 45mm, 250μa FSD ...	**£2.60**

Carriage 65p VAT 8%

Purbeck Oscilloscope Transformer 250-0-250 at 80mA 12.9-0-12.9 at 300mA, 6.3 at 600mA **£6.95.** P&P 90p.

MINIATURE TRANSFORMER

O-Centre Tapped-15V

Ref.	Amp	Price	P&P
171	500MA	**2.09**	.45
172	1A	**2.96**	.78
173	2A	**3.59**	.78
174	3A	**3.75**	.86
175	4A	**5.73**	.96

NEW RANGE TRANSFORMERS

Pri 0-120; 0-100-120; (120v or 220-240v) Sec. 0-36-48 twice to give 72v or 92v.

2A **12,14** PP **£1.40** 4A **18.17** PP **£1.90**
3A **14.70** PP **£1.5C** 5A **26.64** PP **£2.20**

ELECTROSIL TR4 5% **£1.99/100**

ABS PLASTIC BOXES

Inset brass nuts, slots to take PC cards (boards) flush fitting lid.

PB1 80mm x 62 x 40	**.65p**
PB2 100mm x 75 x 40	**.73p**
PB3 120mm x 100 x 45	**.87p**
PB4 215mm x 130 x 85	**£2.54**

P&P 29p. VAT 8%

PLUG-IN — SAVE BATTERIES

MVA30. 6, 7.5, 9v at 300mA plugs direct into 13A socket (fused). 4-way multi plug **£4.00**
12½% VAT 55p P&P

ALUMINIUM BOXES—with ½lip lid and screws

	L	W	H	Price
B1	5¼	2¼	1½	**62p**
B2	4	4	1½	**62p**
B3	4	2¼	1½	**62p**

P&P29p. VAT 8% other sizes available

ANTEX SOLDERING IRONS

15W **£3.95.** 25W **£3.95**
Stand for above **£1.52.** P&P 46p. VAT 12½%.

Transformer Ref. 63 Pri 0-240V Sec 0-240 500VA **£11.50** £2.15 P&P

Send 15p for catalogue Prices correct at 30/1/79

Barrie Electronics Ltd.

3,THE MINORIES, LONDON EC3N 1BJ
TELEPHONE: 01-488 3316/8
NEAREST TUBE STATIONS: ALDGATE & LIVERPOOL ST.

Electronic Brokers

49/53 Pancras Road London NW1 2QB Tel: 01-837 7781. Telex 298694

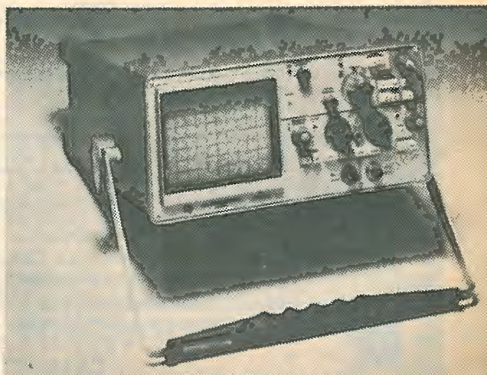
Our background

Electronic Brokers is Europe's largest specialist in quality, second user test equipment, mini-computers and associated peripherals. Established 11 years ago, we have pioneered the second user concept in Britain, and many overseas territories.

One reason for our success is the company's policy of continually updating the type of equipment we sell. So from selling to private users, the business has rapidly developed, and today, our customer list includes leading international companies, research establishments, universities, colleges and government institutions throughout the world.

SEND FOR NEW 86 PAGE CATALOGUE

Containing latest information on our stocks of test equipment, mini computers, computer peripherals, stroboscopes and tachometers. Airmail to overseas addresses £2.



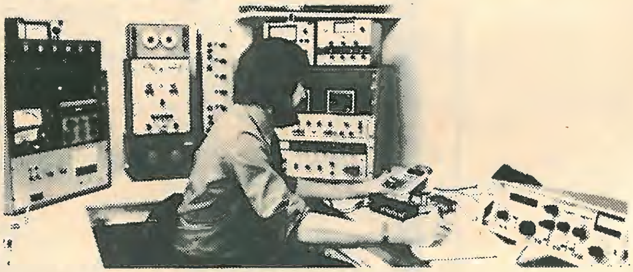
TEKTRONIX

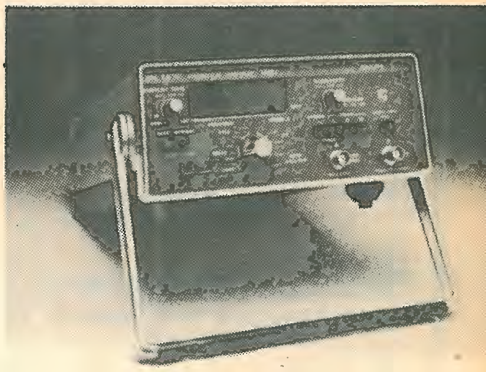
DUAL TRACE PORTABLE OSCILLOSCOPE 432
DC-25MHz 1mV-10V/div
Self-setting mains i/p
A superb unit for the service engineer

£495.00

Back up

To support our growth we have a skilled team. This includes trained sales staff, whose role is not only to sell, but provide a helpful information service to our many customers. Backing this team is our own service laboratory where technicians monitor each item of equipment we sell. Our maxim is *service*, and those who have dealt with us will know that we endeavour to always live up to our reputation. Equipment can be configured to customer's exact requirement, and a number of options can be made available — almost like custom-tailoring.





PHILIPS

1GHz TIMER COUNTER PM6615
10mV sensitivity
9 digit display
Superb condition.

£795.00

Current new price £921.00

Refurbishing

Our own service laboratory checks each item that arrives at our Pancras Road headquarters. Electronic test equipment is then thoroughly cleaned and a schedule prepared for any work which needs to be carried out to meet customer's requirements. Whether it is new test equipment or used, all items pass through the service laboratory where they are given final tests to ensure they meet manufacturers' specifications, before delivery to the customer.

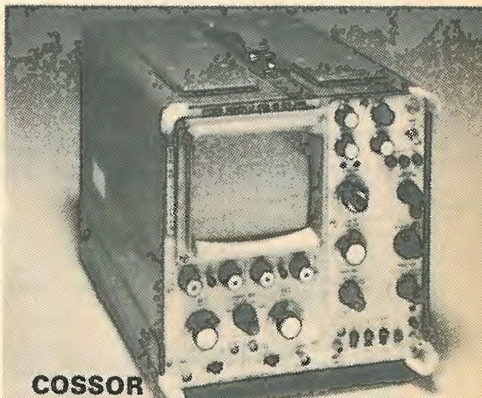
Unless otherwise stated all equipment offered in the Electronic Brokers 4 page advertisement is refurbished and in the case of Test Equipment also calibrated. Test equipment is guaranteed for 12 months; computer peripherals for 3 months.

Hours of Business: 9 a.m. - 5 p.m., Mon.-Fri. Closed lunch 1-2 p.m.

Add 8% VAT to ALL PRICES

Carriage and Packing charge extra on all items unless otherwise stated.

A copy of our trading conditions is available on request.



COSSOR

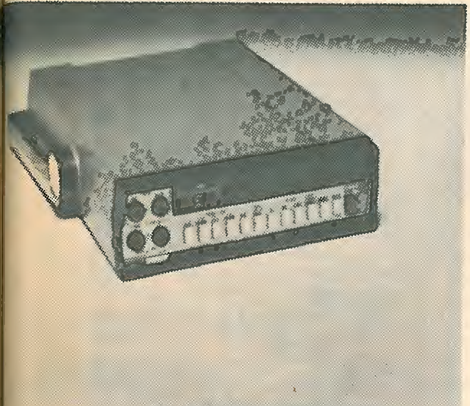
DUAL TRACE
OSCILLOSCOPE
CDU150
DC-35MHz 5mV-20V sensitivity
Delayed Sweep. Quantities available. Superb value.

£450.0

WW — 111 FOR FURTHER DETAILS

No.1 in Second User Test Equipment

Add 8% VAT to all prices



FLUKE

GIT D.M.M. 8600A-01
C Volts and current.
nce
resolution
DC Volts
mains operation.

£335.00

Current new price £451.00

GENERAL RADIO

PORTABLE SOUND
LEVEL METER 1981
70-120dB. A weighting Digital and analogue readout. Peak hold facility.

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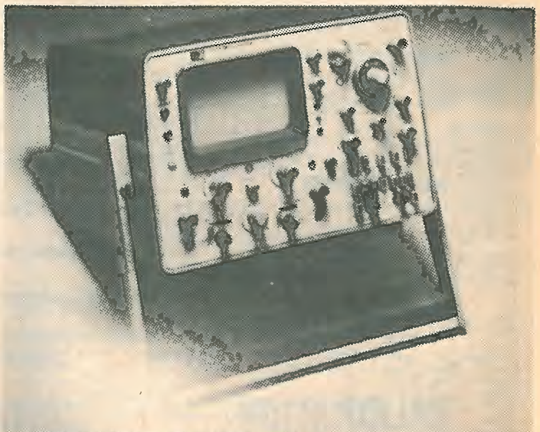

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DC-75MHz. 10mV-10V sensitivity.
Delayed Sweep. Very
High Quality.

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Function Generator PM5167
Freq. Range ImH to 10MHz
Sine, Triangle, Square
+pulse, −pulse and Ramp

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WESTON

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3½ digit. Scale length 1999
AC-DC Volts 100mV-1kV.
100µV resolution.
AC-DC current 100µA-1mA.
100nA resolution

Resistance 100Ω-10mΩ.
100mΩ resolutions.

UNUSED CONDITION— QUANTITIES AVAILABLE.

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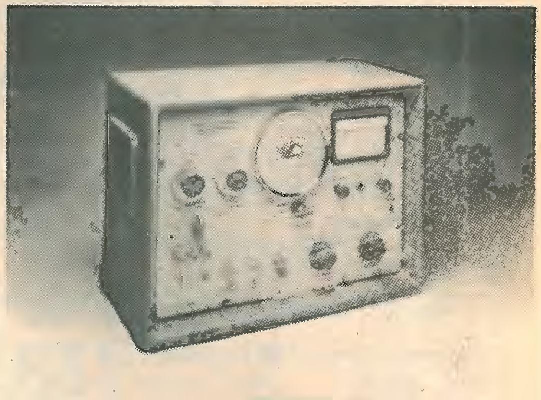

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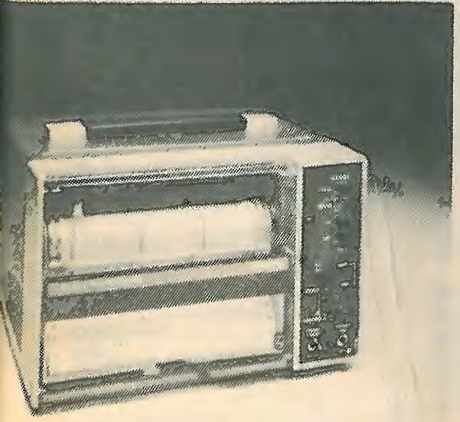
AM FM SIGNAL GENERATOR TF995B/2
200kHz-220MHz.
0— ± 75kHz
0.1µV —200mV
into 75 or 52Ω

from £675.00



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E CHANNEL
T RECORDER PM8110
vity 10mV-10V
vidth 12cm
ndition. Excellent value.

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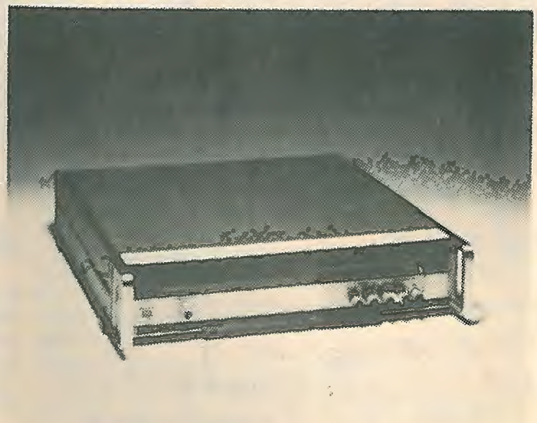

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AC-DC volts
and resistance
Self check facility.

only £550.00

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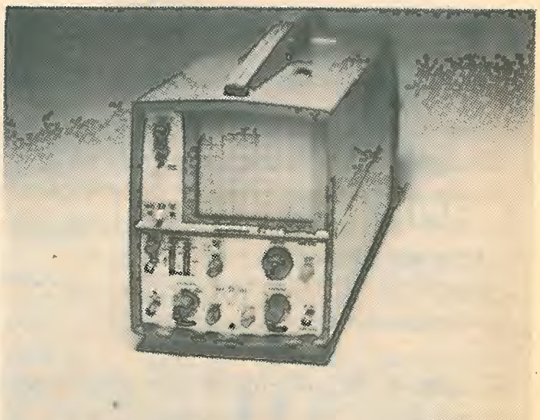

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DUAL TRACE PORTABLE OSCILLOSCOPE T932
DC-35MHz 2mV-10V
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Superb condition

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DC Voltage Source & AC/DC Diff. Voltmeter 741B	£975
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AM/FM Signal Generator PM5324	£450
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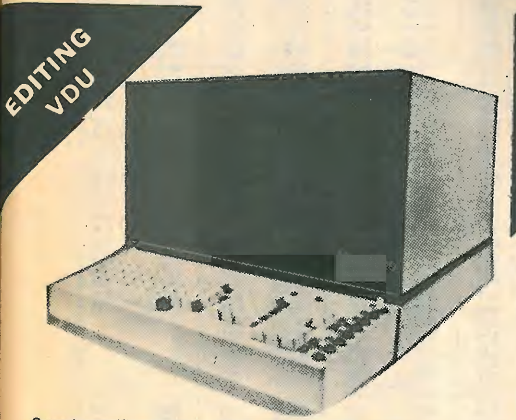

Superb specification includes full edit capability, direct cursor addressing, standard V.24 (RS232) interface. 90 days warranty.

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SCOPE DATA PRINTERS

240 cps. 80 column receive-only matrix printer. Full upper and lower case ASCII character set. Standard RS232 interface. Electro-sensitive printing ensuring quiet operation. BRAND NEW SURPLUS.

NEW LOW PRICE **£495**

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80-column KSR terminal with selectable transmission speeds of 10, 15 & 30 cps. Upper case ASCII character set. Current loop interface. Integral pedestal

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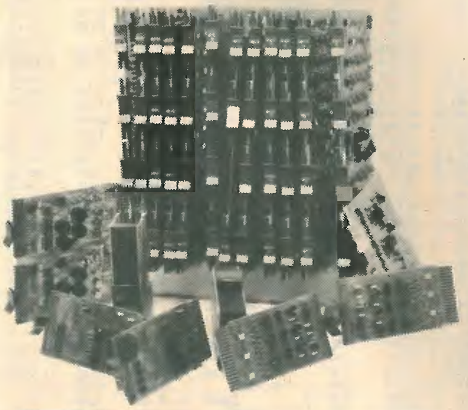

DEC

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400 Minifloppy — 110KB pacity, 35 tracks, transfer rate 25bits/sec. AV access time 0msec Power requirements 5VDC+12VDC

ICE **£195.00**

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Illustrated is the KB771, latest addition to our range of top-quality ASCII keyboards. See next column for full details of prices and range of accessories

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ASR33 and KSR33 TELETYPES
Input/Output terminals with 64 ASCII character set. 110 baud operation. Paper tape punch and reader (ASR33 only). Choice of interface (20mA or RS232)
PRICE: KSR33 £425. ASR33 £650. Pedestal £30

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PRICE: £750

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CALCOMP 565 DIGITAL DRUM PLOTTER Y-Axis 11", X-Axis 120'. Maximum speed 900 increments (6.3") per second. Input: Positive or negative polarity pulses, amplitude greater than 10V, rise time less than 10 microsec., minimum pulse with 4 microsec. Source impedance less than 500 ohms.
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AAY30	0.29
AAY32	0.45
AAZ13	0.19
AAZ15	0.37
AAZ17	0.29
AC107	0.65
AC125	0.22
AC126	0.22
AC127	0.22
AC128	0.22
AC141	0.27
AC141K	0.38
AC142	0.22
AC142K	0.32
AC176	0.22
AC187	0.22
AC188	0.22
ACY17	0.92
ACY18	0.86
ACY19	0.81
ACY20	0.76
ACY21	0.81
ACY39	1.62
AD149	0.76
AD161	0.49
AD162	0.49
AF106	0.49
AF114	0.81
AF115	0.81
AF116	0.81
AF117	0.81
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AF239	0.49
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ASY27	0.43

ASZ15	1.35
ASZ16	1.35
ASZ17	1.35
ASZ20	1.62
ASZ21	2.16
AU113	1.84
AUY10	1.84
AV110	1.84
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BA148	0.15
BA154	0.10
BA155	0.11
BA156	0.10
BAW62	0.06
BAX13	0.07
BAX16	0.10
BC107	0.13
BC108	0.13
BC109	0.14
BC113	0.13
BC114	0.14
BC115	0.15
BC116	0.17
BC117	0.19
BC118	0.11
BC125	0.18
BC126	0.23
BC135	0.16
BC136	0.17
BC137	0.17
BC147	0.10
BC148	0.09
BC149	0.10
BC157	0.10
BC158	0.09
BC159	0.11
BC167	0.14
BC170	0.12
BC171	0.11

BC172	0.11
BC173	0.13
BC177	0.16
BC178	0.15
BC179	0.17
BC182	0.12
BC183	0.11
BC184	0.12
BC212	0.14
BC213	0.14
BC214	0.17
BC237	0.10
BC238	0.14
BC301	0.27
BC303	0.26
BC307	0.11
BC308	0.11
BC327	0.23
BC328	0.21
BC337	0.21
BC338	0.19
BCY30	1.08
BCY31	1.08
BCY32	1.08
BCY33	0.97
BCY34	0.97
BCY39	3.24
BCY40	1.08
BCY42	0.27
BCY43	0.27
BCY58	0.17
BCY70	0.16
BCY71	0.18
BCY72	0.14
BCZ11	1.62
BD115	0.49
BD121	1.30
BD123	1.30
BD124	1.40

BD131	0.38
BD132	0.41
BD135	0.37
BD136	0.37
BD137	0.38
BD138	0.43
BD139	0.46
BD140	0.48
BD144	2.16
BD181	1.19
BD182	1.27
BD237	0.43
BD238	0.59
BDX10	0.98
BDX32	2.16
BDY20	1.35
BDY60	1.62
BF115	0.27
BF152	0.19
BF153	0.22
BF154	0.18
BF159	0.25
BF160	0.17
BF167	0.22
BF173	0.22
BF177	0.26
BF178	0.26
BF179	0.27
BF180	0.32
BF181	0.32
BF182	0.32
BF183	0.27
BF184	0.27
BF185	0.27
BF194	0.10
BF195	0.10
BF196	0.11
BF197	0.14
BF200	0.29
BF224	0.23
BF244	0.30

BF257	0.26
BF258	0.28
BF259	0.35
BF336	0.32
BF337	0.32
BF338	0.33
BFS21	4.28
BFS28	2.41
BFS61	0.23
BFS98	0.23
BFW10	0.70
BFW11	0.70
BFX84	0.24
BFX85	0.25
BFX87	0.23
BFX88	0.23
BFY50	0.28
BFY51	0.28
BFY52	0.28
BFY64	0.28
BFY90	1.35
BSX19	0.23
BSX20	0.22
BSX21	0.22
BT106	1.35
BTY79/400R	3.45
BU205	1.97
BU206	2.53
BU208	2.25
BY100	0.49
BY126	0.15
BY127	0.16
BZX61 Series	0.19
BZY88 Series	0.14
CRS1/05	0.49
CRS1/40	0.65
CRS3/40	0.81

CRS3/60	0.97
GEX66	1.62
GEX541	1.89
GJ3M	0.81
GM0378A	1.89
KS100A	0.51
MJE340	0.86
MJE370	1.26
MJE371	0.66
MJE520	0.56
MJE521	0.59
MJE2955	1.35
MJE3055	0.81
MPF102	0.34
MPF103	0.34
MPF104	0.34
MPF105	0.34
MPSA06	0.26
MPSA56	0.29
MPSU01	0.41
MPSU06	0.52
MPSU56	0.55
NE555	0.49
NKT401	2.16
NKT403	1.87
NKT404	1.87
OA5	1.03
OA7	0.59
OA10	0.65
OA47	0.15
OA70	0.32
OA79	0.32
OA81	0.32
OA85	0.32
OA90	0.09
OA91	0.09
OA95	0.09
OA200	0.10
OA202	0.10
OA211	1.08
OAZ200	1.08

OAZ201	1.08
OAZ206	1.08
OAZ207	1.08
OC16	2.16
OC20	2.70
OC22	2.70
OC23	2.97
OC24	3.24
OC25	0.97
OC26	0.97
OC28	2.16
OC29	2.16
OC35	1.62
OC36	1.62
OC41	0.86
OC42	0.81
OC43	2.43
OC44	0.65
OC45	0.59
OC71	0.59
OC72	0.59
OC73	1.08
OC74	0.70
OC75	0.70
OC76	0.59
OC77	1.30
OC81	0.70
OC81Z	1.30
OC82	0.70
OC83	0.70
OC84	0.70
OC122	1.62
OC123	1.89
OC139	2.43
OC140	2.97
OC141	3.51
OC170	1.08
OC171	1.08
OC200	1.62
OC201	1.89
OC202	1.89

OC203	1.89
OC204	2.70
OC205	2.70
OC206	2.70
OC207	1.89
OCP71	1.35
ORP12	0.81
R2008B	1.97
R2009	2.43
R2010B	1.97
T1C44	0.32
T1C226D	1.30
TIL209	0.22
T1P29A	0.46
T1P30A	0.50
T1P31A	0.49
T1P32A	0.52
T1P33A	0.75
T1P34A	0.79
T1P41A	0.68
T1P42A	0.76
T1P2955	0.72
T1P3055	0.60
T1S43	0.51
ZS140	0.28
ZS170	0.24
ZS178	0.61
ZS271	0.26
ZS278	0.64
ZTX107	0.12
ZTX108	0.11
ZTX109	0.14
ZTX300	0.14
ZTX301	0.15
ZTX302	0.17
ZTX303	0.19
ZTX304	0.21
ZTX311	0.14
ZTX314	0.23
ZTX500	0.15
ZTX501	0.16

ZTX502	0.18
ZTX503	0.19
ZTX504	0.23
ZTX531	0.23
ZTX550	0.18
1N914	0.06
1N916	0.08
1N4001	0.07
1N4002	0.07
1N4003	0.08
1N4004	0.08
1N4005	0.09
1N4006	0.09
1N4007	0.10
1N4009	0.07
1N4148	0.07
1N5400	0.14
1N5401	0.14
1S44	0.05
1S920	0.08
1S921	0.08
2G301	1.08
2G302	1.08
2G306	1.19
2N404	1.08
2N696	0.27
2N697	0.27
2N698	0.32
2N705	1.30
2N706	0.16
2N708	0.22
2N930	0.22
2N1131	0.28
2N1132	0.28
2N1302	0.38
2N1303	0.38
2N1304	0.49
2N1305	0.49
2N1306	0.54
2N1307	0.54
2N1308	0.59

2N1309	0.59
2N1613	0.27
2N1671	1.62
2N1893	0.27
2N2147	1.89
2N2148	1.78
2N2218	0.27
2N2219	0.26
2N2220	0.19
2N2221	0.19
2N2222	0.19
2N2223	2.97
2N2368	0.18
2N2369A	0.23
2N2484	0.22
2N2646	0.59
2N2904	0.27
2N2905	0.27
2N2906	0.23
2N2907	0.23
2N2924	0.24
2N2925	0.25
2N2926	0.16
2N3053	0.27
2N3054	0.54
2N3055	0.76
2N3440	0.65
2N3441	0.86
2N3442	1.19
2N3525	0.86
2N3614	1.62
2N3702	0.12
2N3703	0.15
2N3704	0.15
2N3705	0.15
2N3706	0.15
2N3707	0.15
2N3708	0.11
2N3709	0.15
2N3710	0.11
2N3711	0.11

2N3771	1.87
2N3772	2.16
2N3773	3.24
2N3819	0.41
2N3820	0.51
2N3823	0.62
2N3866	0.81
2N3904	0.15
2N3905	0.15
2N3906	0.15
2N4058	0.16
2N4059	0.11
2N4060	0.14
2N4061	0.14
2N4062	0.15
2N4124	0.18
2N4126	0.18
2N4286	0.23
2N4288	0.25
2N4289	0.27
2N5457	0.39
2N5458	0.39
2N5459	0.39
2S017	7.02
2S019	7.02
2S026	12.96
2S103	1.62
2S302	0.81
2S303	0.81
2S322	0.86
2S324	1.35
2S701	1.62
2S703	1.62
2S721	3.24
2S745A	0.38
2S746A	0.38

VALVES

A1834	9.72
A2087	12.75
A2134	7.29
A2293	8.10
A2426	12.09
A2521	10.92
A2900	8.19
A3343	24.00
AZ31	1.24
AZ41	1.29
BK448	29.11
BK484	106.92
BS90	29.43
BS810	29.43
BT5	38.88
BT17	70.25
BT19	23.98
BT29	214.22
BT69	219.13
BT75	90.34
BT95	84.29
CBL31	1.69
CL33	2.25
CY31	1.13
C1K	11.25
C3A	11.25
C3JA	21.82
DA41	20.20
DA42	11.56
DA100	49.68
DAF91	0.45
DAF96	1.13
DET22	22.68
DET24	49.68
DF91	0.45
DF96	1.13
DK91	1.18
DK92	1.41
DK96	1.24
DL92	1.24
DL94	1.35
DL96	1.24
DLS10	8.91
DLS15	11.62
DLS16	11.62
DLS19	11.62
DM70	1.35
DM71	1.35
DM160	3.54
DY86/7	0.72
DY802	0.95
E55L	23.64
E80CC	6.22
E80CF	10.69
E80F	6.82
E80L	6.44
E81CC	6.22
E81L	9.19
E82CC	6.61
E83CC	6.73
E86C	11.18
E88C	6.00
E88CC	3.63
E90CC	6.34
E90F	6.39
E91H	5.02
E92CC	5.83
E99F	6.86

E130L	18.20
E180CC	6.34
E180F	7.00
E182CC	6.85
E186F	8.68
E188CC	5.70
E280F	23.14
E283CC	8.48
E288CC	16.20
EA52	18.25
EA76	1.90
EABC80	1.35
EAF42	1.41
EAF801	1.97
EB41	2.25
EB91	0.95
EBC33	1.97
EBC41	1.41
EBC81	1.24
EBC90	0.96
EBF80	0.57
EBF83	1.41
EBF89	0.96
EBL31	2.81
EC90	1.26
EC91	7.04
EC92	1.41
EC157	259.69
ECC33	303.26
ECC35	3.94
ECC40	1.41
ECC81	0.99
ECC82	0.81
ECC83	0.99
ECC84	1.34
ECC85	1.35
ECC86	2.29
ECC88	2.03
ECC89	1.77
ECC91	7.45
ECC189	1.87
ECC807	1.97
ECC808	2.53
ECF80	1.22
ECF82	1.35
ECF86	1.69
ECH35	2.25
ECH42	1.29
ECH81	1.35
ECH83	1.41
ECH84	1.44
ECL80	1.13
ECL81	1.69
ECL82	1.13
ECL83	1.69
ECL84	1.58
ECL85	1.26
ECL86	1.35
EF37A	3.94
EF39	3.09
EF40	1.29
EF41	1.35
EF42	2.25
EF50	1.69
EF54	5.63
EF55	2.81
EF80	0.90
EF83	1.97
EF85	0.90

EF86	1.71
EF89	1.80
EF91	2.03
EF92	5.63
EF93	1.13
EF94	1.22
EF95	4.91
EF98	1.41
EF183	0.90
EF184	0.95
EF804S	7.02
EF805S	7.56
EH90	1.56
EK90	1.22
EL32	1.69
EL33	3.94
EL34TAN	2.52
EL34HUL	2.48
EL36	1.80
EL41	1.41
EL42	1.97
EL81	1.24
EL83	1.41
EL84	1.13
EL86	2.43
EL90	1.08
EL91	6.92
EL95	1.49
EL156	17.55
EL360	5.98
EL500/504	2.13
EL509	3.56
EL821	9.30
EL822	7.29
EM80	1.24
EM81	1.13
EM84	1.13
EM85	1.41
EM87	1.69
EN32	17.16
EN91	2.76
EN92	6.99
EY51	1.97
EY81	1.86
EY83	1.97
EY84	7.79
EY86	0.95
EY88	1.97
EY500A	2.18
EY802	92
EZ35	96
EZ40	1.41
EZ41	1.41
EZ80	0.95
EZ81	0.95
EZ90	1.35
FW4-500	2.81
FW4-800	2.81
G1.371K	21.82
G551K	11.88
G180.2M	17.30
G240.2D	12.07
G400.1K	18.11
GN4	8.10
GN4A	8.10
GS16	9.72
GT1C	9.97
GU18	25.16
GU50	13.45

GU51	12.80
GXU1	13.47
GXU2	26.71
GXU3	28.64
GXU4	30.78
GXU50	12.80
GXU51	12.80
GY501	2.89
GZ32	1.41
GZ33	4.50
GZ34	2.14
GZ37	4.50
KT61	3.94
KT66	6.19
KT88	7.59
KTW61	1.97
KTW62	1.97
KTW63	1.97
M8079	10.37
M8080	6.88
M8081	8.91
M8082	6.03
M8083	6.77
M8091	9.71
M8096	4.05
M8097	3.84
M8098	3.67
M8099	5.62
M8100	7.35
M8136	7.57
M8137	7.81
M8140	4.86
M8141	5.24
M8142	4.13
M8144	4.05
M8149	5.51
M8161	7.04
M8162	6.77
M8163	4.86
M8190	4.97
M8195	4.00
M8196	7.02
M8204	6.18
M8212	10.53
M8223	2.48
M8224	3.02
M8225	2.81
M8248	8.59
MU14	1.13
MX119	26.73
MX123	54.00
MX145	42.12
MX151	14.71
MX152	97.20
MX161	101.52
MX163	17.01
MX164	18.78
MX166	118.80
MX168	35.64
N78	10.13
OA2	2.16
OA3	5.57
OA4	3.78
OB2	1.35
OB3	2.07
OC2	2.86
OC3	2.07
OD3	2.07
OZ4	1.80

PC86	1.58
PC88	1.58
PC95	1.47
PC97	1.35
PC900	1.35
PCC84	1.13
PCC85	1.35
PCC88	1.35
PCC89	1.53
PCC189	1.58
PCC805	1.49
PCC806	2.03
PCE82	2.03
PCF80	1.13
PCF82	1.13
PCF86	1.80
PCF87	1.80
PCF200	2.77
PCF201	2.40
PCF801	1.80
PCF802	1.78
PCF805	1.80
PCF806	1.80
PCF808	1.80
PCL82	1.13
PCL83	1.78
PCL84	1.13
PCL85	1.22
PCL86	1.22
PCL805/85	1.22
PD500	4.05
PE06-40N	29.48
PFL200	2.03
PL36	1.35
PL81	1.35
PL81A	1.35
PL82	1.35
PL83	2.50
PL84	1.22
PL504/5	1.58
PL508	2.03
PL509	3.38
PL519	3.65
PL801	1.24
PL802	3.33
PY33	1.24
PY81	0.95
PY82	0.90
PY83	0.79
PY88	0.95
PY5000A	2.03
PY800	0.95
PY801	0.95
QQU02-6	11.23
QQU03-10	5.11
QQV03-20A	18.90
QQV06-40A	18.90
QQV07-50	48.09
QQZ03-20A	29.76
QQZ06-40A	51.74
QU37	13.50
QV03-12	3.24
QV04-7	2.70
QV08-100	101.27
QY3-65	48.06

QY3-125	12.96
QY4-250	61.92
QY4-400	71.06
QY5-500	149.69
QY5-3000A	265.36
QZ06-20	26.03
R10	5.40
R17	1.86
R18	4.59
R19	1.35
R20	1.62
RG3-250	28.86
RG3-250A	30.35
RG3-1250	26.41
RG4-1250	40.50
RG4-3000	67.50
RR3-250	43.31
RR3-1250	76.68
S11E12	28.62
S130	2.16
S130P	2.70
STV280-40	10.80
STV280-80	22.68
SU41	2.70
SU42	9.72
TD03-10	23.22
TD03-10E	23.22
TD03-10F	25.92
TT15	23.76
TT21	13.29
TT22	13.29
TT100	55.89
TY2-125	61.35
TY3-400	67.25
TY4-500	89.60
TY5-500	138.24
TY6-800	155.62
TY6-5000A	247.04
TY6-5000B	222.48
TY6-5000W	222.05
TY7-6000A	269.46
TY7-6000W	218.32
TZ40	16.20
U18-20	2.81
U19	9.70
U25	1.31
U26	1.62
U37	9.72
UABC80	1.41
UAF42	1.41
UB41	1.41
UBC41	1.69
UBF89	1.35
UCC84	1.24
UCC85	1.35
UCF80	1.29
UCH42	1.35
UCH81	2.61
UCL82	1.17
UCL83	1.62
UF41	1.13
UF42	1.41
UF80	1.62

UF85	1.62
UF89	1.62
UL41	1.82
UL84	1.35
UM80	1.13
UY41	1.41
UY85	1.17
VLS631	14.31
XG1-2500	28.84
XG2-6400	81.97
XG5-500	34.70
XGQ2-6400	84.89
XR1-1600A	24.30
XR1-3200	68.15
XR1-3200A	68.15
XR1-6400	71.06
XR1-6400A	71.06
YD1120	222.48
YD1240	226.80
Z759	10.37
Z803V	8.53
ZM1000	5.66
ZM1001	5.81
ZM1020	10.17
ZM1021	9.55
ZM1022	9.96
ZM1023	8.27
ZM1040	14.86
ZM1041	12.50
ZM1042	14.27
ZM1051	93.96
1B3GT	2.44
1B24	10.80
1B35A	27.00
1B63	54.00
1R5	1.18
1S5	0.45
1T4	0.45
2AS15	10.80
2C39A	20.52
2C43	19.44
2D21	2.76
2E26	7.34
2J42	84.24
2J55	189.00
2J70A	253.80
2J70B	270.00
2K25	37.80
3-400Z	48.60
3-500Z	48.60
3A5	1.46
3B24	8.64
3B28	4.86
3B29	10.80
3B240M	16.20
3B241M	16.20
3C23	13.05
3C45	21.38
3CX100A5	21.60
3E29	27.86
3S4	1.24
465A	27.38
4-125A	39.43
4-250A	39.43
4-400A	48.98

4B32	27.39
4C35	43.20
4CX250B	28.79
4CX350A	33.86
4X150D	27.00
5B254M	18.09
5B255M	18.09
5C22	43.20
5J180E	490.20
5R7GY	2.25
5U4G	4.25
5U4GB	2.54
5V4G	1.71
5Y3GT	0.96
5Z3	1.69
5Z4G	1.71
5Z4G7	1.69
6-30L2	1.76
6AB4	1.41
6AB7	1.69
6AC7	1.58
6AF4A	1.80
6AG7	2.25
6AH6	5.40
6AK5	3.89
6AK6	2.75
6AL5	0.99
6AM4	2.59
6AM5	4.29
6AM6	2.03
6AN5	5.90
6AN8A	4.66
6AQ5	1.08
6AR5	1.80
6A56	6.28
6A57G	7.29
6AT6	0.96
6AV5G7	4.70
6AV6	1.22
6AV5GA	4.25
6AV6	0.96
6AX5GT	3.49
6B7	1.09
6B8	1.97
6BA6	1.13
6BA7	5.76
6BA8A	4.22
6BC4	4.17
6BE6	1.22
6BH6	1.71
6BJ6	1.22
6BK4	4.74
6BL6	91.80
6BL7GT	4.34
6BM6	91.80
6BN6	1.86
6BQ7A	4.05
6BR7	4.50
6BR8	1.97
6BS7	4.56
6BW6	4.50
6BW7	1.71
6BX7GT	5.58
6BZ6	2.57
6C4	0.99
6CB6A	2.70
6CD6GA	5.51
6CG7	2.50
6CH6	7.31

6CL6	4.03
6CW4	8.15
6D2	0.99
6DK6	2.53
6DQ6B	4.39
6EA8	3.24
6EB8	2.39
6EW6	1.69
6F6	1.99
6F23	1.80
6F28	1.31
6F33	17.28
6H1	13.50
6H2N	1.18
6H3N	1.18
6H6	1.69
6J4	5.96
6J6	3.51
6J7	8.84
6K4N	1.41
6K6GT	1.46
6K7	1.69
6K8	1.97
6KD6	6.93
6L6G	2.81
6L6GA	1.69
6L6GT	0.96
6L6GC	2.19
6L7	2.25
6N2P	1.18
6N3P	1.18
6N7	1.69
6P25	4.05
6Q7	2.48
6R7	2.03
6SA7	1.63
6SC7	1.69
6SF7	1.80
6SH7	1.09
6SJ7	1.80
6SK7	1.46
6SK7GT	3.02
6SN7GT	1.80
6SQ7	1.47
6SR7	1.69
6SS7	2.03
6U5G	2.25
6U8	0.90
6U8A	3.17
6V6GT	1.80
6X4	1.35
6X5GT	96
7B7	1.91
7C5	1.97
7C6	1.41
7H7	2.25
7R7	1.69
7S7	2.53
7Y4	1.80
7Z4	2.08
11E3	57.12
12AT6	1.35
12AT7	0.99
12AU6	2.77
12AU7	0.81
12AV6	2.25
12AV7	3.89
12AX7	0.99
12AY7	5.13

12B4A	3.42
12BA6	2.36
12BE6	2.50
12BH7	1.26
12BY7	2.95
12E1	7.67
12E14	32.40
13E1	58.42
19H4	27.00
19H5	37.50
24B9	38.88
30C15	1.80
30C17	1.80
30C18	1.80
30F5	1.89
30FL1/2	1.26
30FL12	2.03
30FL14	1.80
30L1	1.13
30L15	2.03
30L17	2.03
30P4	1.04
30P19	1.35
30PL1	1.49
30PL13	2.03
30PL14	1.89
30PL15	2.03
35W4	0.68
50C5	0.79
75B1	2.12
75C1	1.91
85A1	8.10
85A2	2.00
90AG	8.60
90AV	8.60
90C1	1.94
90CG	14.77
90CV	14.36
92AG	8.60
92AV	8.60
95A1	5.24
150B2	2.32
150B3	4.21
150C2	1.62
150CH	1.89
211	6.48
723AB	37.80
803	10.80
805	21.60
807	3.89
811A	9.18
812A	9.02
813	34.56
833A	81.00
866A	6.21
872A	14.85
922	4.71
931A	13.22
1624	2.43
1625	1.93
2050	7.52
4212E	159.56
4212H	194.40
5544	58.32
5545	63.72
5551A	75.33
5552A	101.84
5553A	243.32
5642	5.69

5654	3.80
5651	1.94
5670	4.97
5675	13.18
5687	6.65
5696	4.26
5718	6.91
5725	5.90
5726	3.80
5727	5.18
5749	5.38
5751	5.03
5763	3.89
5814A	4.51
5840	4.75
5842	14.64
5876A	12.27
5879	4.23
5886	11.34
5963	3.24
5965	3.82
6005	6.14
6021	4.82
6057	3.78
6058	9.76
6059	4.32
6061	4.58
6062	4.05
6063	3.94
6064	6.10
6072	6.14
6080	7.40
6097A×B×C	43.20
6146A	5.53
6146A	6.03
6159	8.62
6189	8.27
6201	5.57
6442	16.20
6883B	6.39
6973	3.96
7025	2.57
7551	6.08
7586	12.80
7587	22.05
7609	34.34
7868	4.43
7895	14.51
8005	32.40
8068	6.19
6122	45.36
8136	2.75
8417	6.01
19042	6.50
18045	9.54

BASES

B7G unskirted	0.16
B7G skirted	0.32
B9A unskirted	0.16
B9A skirted	0.37
Int Octal	0.22
Loctal	0.59
Nuvistor base	0.59
8 pin DIL	0.16
14 pin DIL	0.16
16 pin DIL	0.18
Valve screening cans all sizes	0.32

CRTs

2AP1	9.18
2BP1	9.72
3BP1	8.64
3DP1	5.40
3EG1	7.56
3FP7	6.48
3GP1	6.48
3JP1	8.64
3JP2	8.64
3JP7	10.80
3KP1	16.20
3RP1	37.80

5ADP1	37.80
5BP1	10.89
5CP1	5.40
5CP1A	43.20
5FP15A	16.20
5UP7	15.12
DG7-5	27.00
DG7-32	38.80
DH3-91	33.48
DH7-11	73.44
VCR97	5.40

VCR138	10.50
VCR138A	13.50
VCR139A	8.64
VCR517A	10.80
VCR517B	6.48
VCR517C	6.48
Tube Bases	0.81

INTEGRATED CIRCUITS

7400	0.17
7401	0.17
7402	0.17
7403	0.17
7404	0.18
7405	0.17
7406	0.43
7407	0.43
7408	0.22
7409	0.22
7410	0.17
7412	0.28
7413	0.35
7416	0.35
7417	0.35
7420	0.18
7422	0.22

7423	0.35
7425	0.32
7427	0.32
7428	0.46
7430	0.18
7432	0.32
7433	0.39
7437	0.35
7438	0.35
7440	0.19
7441	0.92
7442	0.78
7447AN	0.97
7450	0.19
7451	0.19
7453	0.19
7454	0.19

7460	0.19
7470	0.38
7472	0.36
7473	0.39
7474	0.43
7475	0.58
7476	0.43
7480	0.59
7482	0.81
7483	0.97
7484	1.08
7486	0.38
7490	0.56
7491	0.86
7492	0.65
7493	0.65
7494	0.86

7495	0.78
7496	0.86
7497	3.24
74100	1.62
74107	0.49
74109	0.76
74110	0.54
74111	0.76
74116	1.89
74118	1.08
74119	1.62
74120	0.90
74121	0.43
74122	0.65
74123	1.08
74125	0.59
74126	0.59
74128	0.65

74132	0.76
74136	0.59
74141	0.86
74142	2.48
74143	2.70
74144	2.70
74145	0.97
74147	2.16
74148	1.89
74150	1.73
74151	0.92
74154	1.89
74155	0.92
74156	0.92
74157	0.81
74159	2.27
74170	2.48
74172	4.75

74173	1.51
74174	1.62
74175	0.97
74176	1.19
74178	1.35
74179	1.35
74180	1.25
74190	1.62
74191	1.62
74192	1.46
74193	1.46
74194	1.35
74195	1.08
74196	1.30
74197	1.19
74198	2.43
74199	2.43
76013N	1.97

TAA570	2.59
TAA630S	3.94
TAA700	4.22
TBA480Q	2.07
TBA520Q	2.59
TBA530	2.23
TBA540Q	2.59
TBA550Q	3.62
TBA560CQ	3.62
TBA673	2.46
TBA700	1.71
TBA720Q	2.59
TBA750Q	2.33
TBA800	1.30
TBA920	3.13
TBA920Q	3.36
TBA990Q	3.36
TCA270Q	3.36
TCA760A	1.55

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	ins L	W	H	Retail price +8% VAT
AB7	(5¼	2½	1½)	0.70
AB8	(4	4	1½)	0.70
AB9	(4	2¼	1½)	0.70
AB10	(4	5¼	1½)	0.70
AB11	(4	2½	2)	0.85
AB12	(3	2	1)	0.70
AB13	(6	4	2)	1.00
AB14	(7	5	2½)	1.20
AB15	(8	6	3)	1.55
AB16	(10	7	3)	1.75
AB17	(10	4½	3)	1.45
AB18	(12	5	3)	1.75
AB19	(12	8	3)	2.40

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RB1	(6	4½	2½)	1.45
RB2	(8	5	3)	1.70
RB3	(9	5	3½)	1.00
RB4	(11	6	4)	2.30
RB5	(11	7½	4½)	2.70

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0.1" Pitch Copper Clad		0.15" Pitch Copper Clad	
2.5"×5"	**0.59**	2.5"×5"	**0.53**
2.5"×3.75"	**0.50**	2.5"×3.75"	**0.44**
2.5"×17"	**1.77**	3.75"×17"	**1.98**
3.75"×5"	**0.66**	3.75"×5"	**0.74**
3.75"×3.75"	**0.59**	0.15" Pitch Plain Board	
3.75"×17"	**2.28**	5"×3.75"	**0.47**
4.7"×17.9"	**2.99**	2.5"×5"	**0.30**
2.5"×1" (Sold in 5s)	**0.70**	New V-Q DIP Board	**1.11**
0.1" Pitch Plain Board			
3.75"×17.9"	**1.49**		
3.75"×2.5"	**0.36**		
3.75"×5"	**0.56**		

SPECIAL OFFER
741 8 pin DIL **15p**

Cassette Erase Tape Heads ¼" **£1.00 each*.**
Cassette Monotape Heads ¼" **£2.00 each*.** Brand new.
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2200μF 100V computer grade electrolytic Mullard **£1.00*** + VAT. 12½%.

7400	0.12	7451	0.20	74141	0.75
7401	0.12	7453	0.20	74150	1.00
7402	0.12	7454	0.20	74151	0.70
7403	0.12	7460	0.20	74153	0.70
7404	0.12	7470	0.35	74154	1.00
7405	0.18	7472	0.30	74155	0.70
7406	0.32	7473	0.30	74156	0.85
7407	0.32	7474	0.30	74157	0.70
7408	0.20	7475	0.45	74160	0.95
7409	0.20	7476	0.35	74161	0.50
7412	0.20	7480	0.60	74162	1.00
7413	0.30	7481	1.00	74163	1.00
7414	0.70	7482	0.90	74164	1.00
7415	0.30	7483	0.80	74165	1.00
7417	0.30	7484	1.10	74166	1.00
7419	0.50	7485	0.90	74167	2.50
7420	0.18	7486	0.30	74170	2.00
7421	0.20	7489	1.60	74174	0.95
7422	0.35	7490	0.35	74175	0.80
7423	0.32	7491	0.50	74176	0.80
7425	0.30	7492	0.45	74177	0.80
7426	0.30	7493	0.40	74180	0.80
7427	0.30	7494	0.90	74181	1.85
7428	0.40	7495	0.65	74182	0.95
7430	0.18	7496	0.65	74184	1.50
7432	0.26	7497	1.90	74185	1.50
7433	0.50	74100	1.40	74188	2.50
7437	0.30	74104	0.70	74190	1.00
7438	0.30	74105	1.70	74191	1.00
7440	0.18	74107	0.30	74192	1.00
7441	0.70	74109	0.55	74193	1.00
7442	0.50	74110	0.55	74194	1.00
7443	1.30	74118	0.95	74195	0.95
7445	1.00	74119	1.30	74196	0.95
7446	1.00	74121	0.28	74197	0.80
7447	0.75	74122	0.55	74198	1.60
7448	0.75	74123	0.55	74100	1.60
7449	1.00	74125	0.50		
7450	0.20	74132	0.70		

4000UB	0.17	4027B	0.44	4075B	0.20
4001UB/B	0.17	4028B	0.77	4076B	1.17
4002UB/B	0.17	4029B	1.03	4077B	0.39
4006B	1.04	4032B	0.89	4078B	0.20
4007UB	0.18	4034B	1.71	4081B	0.20
4008B	0.87	4040B	0.97	4082B	0.20
4011UB/B	0.18	4043B	0.88	4093B	0.80
4012UB/B	0.20	4044B	0.84	40160B	1.19
4013B	0.43	4049UB	0.50	40161B	1.19
4014B	0.83	4050B	0.43	40162B	1.19
4015B	0.83	4051B	0.82	40163B	1.19
4016B	0.48	4052B	0.82	40174B	0.85
4017B	0.79	4053B	0.82	40175B	0.86
4018B	0.83	4066B	0.55	40194B	1.19
4020B	1.11	4068B	0.20	4510B	1.01
4021B	0.90	4069UB	0.20	4511B	1.25
4022B	0.82	4070B	0.46	4512B	0.91
4023UB/B	0.18	4071B	0.20	4516B	1.01
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6-0-6 500mA (63×35×48)	**£1.40***
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★SPECIAL OFFER★ 100k LIN Mono Slider Potentiometer by Noble (Metal body), 63mm length, **price 30p each***. All boxed as original. **Discount on quantity.**
Potentiometers W. Wound 1Ω-100v by A, B or Colvern Ltd, 1½ watt **40p,** 3 watt **60p,.** 5 watt **80p.**
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Cabinets with power supplies. Fans, mains filter units, 240V 50HZ. Nova 820 mainframe 240V 50HZ, Nova 820 expansion chassis 240V 50HZ. CPU1 (8206) power mon and restart.
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2.5m byte disc storage system (Diablo) Series 30 (4047A) moving head. Disc power supply (240V 50HZ) with adaptor and logic board (4047). Computer Control Panel. **OFFERS AROUND £5000**

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7400	13p
74S00	48p
7401	14p
7402	14p
7403	14p
7404	17p
74S04	90p
7405	18p
7406	32p
7407	32p
7408	19p
7409	19p
7410	15p
7411	24p
7412	20p
7413	30p
7414	60p
74C14	90p
7416	27p
7417	27p
7420	17p
7421	40p
7422	22p
7423	34p
7425	30p
7426	40p
7427	34p
7428	38p
7430	17p
7432	30p
7433	40p
7437	35p
7438	35p
7440	17p
7441	70p
7442A	80p
7443	112p
7444	112p
7445	100p
7446A	93p
7447A	60p
7448	80p
7450	17p
7451	17p
7453	17p
7454	17p
7460	17p
7470	36p
7472	30p
7473	34p
7474	30p
7475	38p
7476	35p
7480	50p
7481	100p
7482	84p
7483A	90p
7484	100p
7485	110p
7486	34p
7489	210p
7490A	33p
7491	80p
7492A	46p
7493A	33p
7494	84p
7495A	70p
7496	65p
7497	180p
74100	130p
74104	65p
74105	65p
74107	34p
74109	55p
74110	55p
74111	70p
74116	200p
74118	130p
74119	210p
74120	110p
74121	28p
74122	45p
74123	55p
74125	55p
74126	60p
74128	75p
74132	75p
74136	75p
74141	70p
74142	200p
74145	90p
74147	190p
74148	150p
74150	100p
74151A	70p
74153	70p
74154	100p
74155	90p
74156	90p
74157	70p
74159	190p
74160	100p
74161	100p
74162	100p
74163	100p
74164	120p
74165	130p
74166	140p
74167	200p
74170	240p
74172	720p
74173	120p
74174	93p
74175	85p
74176	90p
74177	90p
74178	150p
74180	93p
74181	200p
74182	90p
74184A	150p
74185	150p
74186	500p
74190	100p
74191	100p
74192	100p
74193	100p
74194	100p
74195	95p
74196	95p
74197	80p
74198	150p
74199	150p
74200	£10
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74279	140p
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74365	150p
74366	160p
74367	120p
74368	150p
74390	200p
74393	200p
74490	225p

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74LS00	14p
74LS02	14p
74LS04	16p
74LS05	25p
74LS08	25p
74LS10	20p
74LS11	40p
74LS13	45p
74LS14	72p
74LS20	20p
74LS21	40p
74LS22	28p
74LS27	38p
74LS30	20p
74LS32	27p
74LS42	70p
74LS47	90p
74LS55	30p
74LS73	50p
74LS74	40p
74LS75	45p
74LS76	45p
74LS83	110p
74LS85	100p
74LS86	40p
74LS90	60p
74LS92	70p
74LS93	60p
74LS96	110p
74LS107	45p
74LS112	100p
74LS123	70p
74LS124	180p
74LS125	50p
74LS126	60p
74LS132	95p
74LS136	55p
74LS138	60p
74LS139	60p
74LS151	100p
74LS154	200p
74LS155	90p
74LS156	90p
74LS153	60p
74LS157	60p
74LS158	120p
74LS160	130p
74LS161	100p
74LS162	140p
74LS163	110p
74LS164	120p
74LS165	180p
74LS166	180p
74LS173	110p
74LS174	90p
74LS175	110p
74LS181	320p
74LS190	100p
74LS191	100p
74LS192	140p
74LS193	140p
74LS195	140p
74LS196	120p
74LS221	140p
74LS240	175p
74LS241	175p
74LS242	170p
74LS243	170p
74LS244	195p
74LS245	195p
74LS251	140p
74LS253	140p
74LS257	120p
74LS258	160p
74LS259	160p
74LS266	100p
74LS273	130p
74LS279	90p
74LS298	249p
74LS324	200p
74LS365	160p
74LS367	160p
74LS368	160p
74LS373	180p
74LS374	195p
74LS378	200p
74LS390	160p
74LS393	160p
74LS445	140p
74LS668	100p
74LS669	100p

4000 SERIES

4000	15p
4001	17p
4002	17p
4006	95p
4007	18p
4008	80p
4009	40p
4010	50p
4011	17p
4012	18p
4013	50p
4014	84p
4015	84p
4016	45p
4017	80p
4018	89p
4019	45p
4020	100p
4021	110p
4022	100p
4023	22p
4024	50p
4025	20p
4026	130p
4027	50p
4028	84p
4029	100p
4030	55p
4031	200p
4033	180p
4034	200p
4035	110p
4040	100p
4041	80p
4042	80p
4043	90p
4044	90p
4046	110p
4047	100p
4048	55p
4049	32p
4050	48p
4051	80p
4052	80p
4053	80p
4054	150p
4055	125p
4056	135p
4059	800p
4060	115p
4063	120p
4066	55p
4067	450p
4068	22p
4069	20p
4070	30p
4071	22p
4072	22p
4073	22p
4075	22p
4076	107p
4081	22p
4082	22p
4093	80p
4094	250p
4098	107p
4411	1100p
4502	120p
4503	70p
4507	55p
4510	99p
4511	150p
4514	250p
4516	110p
4518	100p
4520	100p
4528	100p
4543	180p
4553	450p
4560	250p
4583	90p
4584	90p
40014	90p
40085	200p
40097	90p
14411	1100p
14412	1100p
14433	1100p
14500	700p
14599	290p

INTERFACE ICs

MC1488	100p
MC1489	100p
75107	160p
75182	230p
75322	300p
75324	375p
75325	375p
75451	72p
75491/2	96p
8T26	250p
8T28	300p
8T95	160p
8T97	160p
81LS95	120p
81LS96	140p
81LS97	120p
81LS98	140p
9601	110p
9602	220p
9603	160p

93 SERIES

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

LINEAR I.C.s

*AY1-0212	600p
*AY1-1313	668p
*AY1-1320	320p
*AY1-5050	211p
AY5-1224A	240p
*AY5-1315	600p
*AY5-1317	636p
*CA3019	80p
*CA3046	70p
*CA3048	225p
CA3080E	72p
*CA3089E	225p
*CA3090AQ	375p
CA3130S	100p
CA3140E	70p
CA3160E	100p
*CA3189E	400p
FX209	750p
ICL7106	850p
ICL8038	340p
LM301A	30p
LM311	120p
LM318	200p
LM319	225p
LM324	70p
LM339	75p
LM348	95p
*LM377	175p
*LM380	75p
*LM381AN	160p
*LM389N	140p
LM709	36p
LM710	50p
LM725	350p
LM733	100p
LM741	20p
LM747	70p
LM748	35p
LM3900	70p
LM3911	130p
LM4136	120p
*MC1310P	150p
MC1458	55p
MC1495L	350p
*MC1496	100p
*MC3340P	120p
*MC3360P	120p
MK50398	750p
MK57160	620p
NE531	110p
*NE540L	200p
NE543K	225p
NE555	25p
NE556	70p
NE561B	425p
NE562B	425p
NE565	130p
NE566	155p
NE567	175p
NE571	425p
RC4151	400p
*SAD1024	1500p
SFF96364	1150p
*SN76003N	175p
*SN76013N	140p
*SN76013ND	120p
*SN76023N	140p
*SN76023ND	120p
*SN76033N	175p
SN76477	250p
*SP8515	750p
*TAA621	275p
*TBA641B11	225p
*TBA651	200p
*TBA800	90p
*TBA810	100p
*TBA820	90p
*TCA940	175p
*TDA1004	300p
*TDA1008	320p
*TDA1022	800p
TDA1034B	250p
*TDA2020	320p
TL072	95p
TL074	150p
TL084	130p
TL170	50p
XR2206	400p
XR2207	400p
XR2211	600p
*XR2216	675p
XR2240	400p
*ZN414	90p
ZN424E	135p
ZN425E	400p
ZN1034E	200p
95H90	800p
IIC90	1400p

VEROBOARD

	0.1	0.15
	(copper clad)	
2½×3½	41p	33p
2½×5	40p	45p
3¼×3¾	49p	45p
3¼×5	56p	60p
2½×17	152p	121p
3¾×17	195p	163p
4¾×17	300p	—
Pkt of 35 pins		30p
Spot face cutter		85p
Pin insertion tool		99p

VERO WIRING PENS.

Plus spool	325p
Spare spool (wire)	60p
Combes	7p each

VOLTAGE REGULATORS

Fixed Plastic TO-220

1A	+ve		—ve	
5V	7805	75p	7905	90p
12V	7812	75p	7912	90p
15V	7815	75p	7915	90p
18V	7818	90p	7918	100p
24V	7824	90p	7924	100p
100mA	TO-92		79L05	80p
5V	78L05	35p	79L12	80p
12V	78L12	35p	79L15	80p
15V	78L15	35p		

OTHER REGULATORS

LM309K	135p	TBA625B	120p
LM317T	200p	78HGKC	725p
LM323K	625p	78HO5KC	675p
LM723	37p	78MGT2C	135p

OPTO-ELECTRONICS

2N5777	45p	ORP60	90p
OCP71	130p	ORP61	90p
ORP12	90p	TIL78	70p

LEDS

0.125"		0.2"	
TIL32	75p	TIL220 Red	16p
TIL209 Red	13p	TIL222 Gr	18p
TIL211 Gr	20p	TIL228 Red	22p
TIL212 Ye	25p	MV5491 TS	120p
TIL216 Red	18p	Clips	3p

DISPLAYS

3015F	200p	FND507	120p
DL704	140p	MAN3640	175p
DL707 Red	140p	NSB5881	570p
707 Gr	140p	TIL311	600p
DL747 Red	225p	TIL312/3	110p
747 Gr	225p	TIL321/2	130p
FND357	120p	TIL330	140p
FND500	120p	7750/60	200p
		NSB5881CC 4 DIGIT DISP	570p

DRIVERS

9638	200p
9370	200p

TRANSISTORS

AC126	25p
AC127/8	20p
AC176	25p
AC187/8	25p
AF116/7	30p
AD149	70p
AD161/2	45p
BC107/8	11p
BC109	11p
*BC117	20p
*BC147/8	9p
*BC149	10p
*BC157/8	10p
*BC159	11p
*BC169C	12p
*BC172	12p
BC177/8	17p
BC179	18p
*BC182/3	10p
*BC184	11p
BC187	30p
*BC212/3	11p
*BC214	12p
BC461	36p
BC477/8	30p
*BC516/7	50p
*BC547B	16p
*BC548C	9p
*BC549C	18p
*BC557B	16p
*BC559C	18p
BCY70	18p
BCY71/2	22p
BD131/2	50p
BD135/6	54p
BD139	56p
BD140	60p
BD189	60p
BD242	70p
BDY56	200p
BF200	32p
*BF244B	35p
*BF256B	70p
BF257/8	32p
BF259	36p
*BFR39	30p
*BFR40	30p
*BFR41	30p
*BFR79	30p
*BFR80	30p
*BFR81	30p
BFX29	30p
BFX30	34p
BFX84/5	30p
BFX86/7	30p
BFX88	30p
BFW10	90p
BFY50	22p
BFY51/2	22p
BFY56	33p
BFY90	90p
BLY83	700p
BRY39	45p
BSX19/20	20p
BU104	225p
*BU105	190p
*BU108	250p
BU109	225p
*BU205	200p
*BU208	200p
*BU406	145p
MJ481	175p
MJ491	200p
MJ2501	225p
MJ2955	100p
MJ3001	225p
*MJE340	65p
MJE2955	100p
MJE3055	70p
*MPF102	45p
*MPF103/4	40p
*MPF105/6	40p
MPSA06	30p
*MPSA12	50p
*MPSA56	32p
*MPSU06	63p
*MPSU65	78p
OC28	130p
OC35	130p
*R2008B	200p
*R2010B	200p
*TIP29A	40p
*TIP29C	55p
*TIP30A	48p
*TIP30C	80p
*TIP31A	58p
TIP31C	62p
TIP32A	68p
TIP32C	82p
TIP33A	90p
TIP33C	114p
TIP34A	115p
TIP34C	160p
TIP35A	225p
TIP35C	290p
TIP36A	270p
TIP36C	340p
TIP41A	65p
TIP41C	78p
TIP42A	70p
TIP42C	82p
TIP2955	78p
TIP4055	70p
*TIS43	34p
*TIS93	30p
*ZTX108	12p
*ZTX300	13p
*ZTX500	15p
*ZTX502	18p
*ZTX504	30p
2N457A	250p
2N696	35p
2N697	25p
2N698	45p
2N706A	20p
2N708A	20p
2N918	45p
2N940	18p
2N1131/2	20p
2N1613	25p
2N1711	25p
2N2102	60p
2N2160	350p
2N2219A	22p
2N2222A	22p
2N2369A	16p
2N2484	30p
2N2646	50p
2N2904/5	25p
2N2906A	24p
2N2907A	30p
*2N2926	9p
2N3053	22p
2N3054	65p
2N3055	48p
2N3442	140p
2N3553	240p
*2N3565	30p
*2N3643/4	48p
*2N3702/3	12p
*2N3704/5	12p
*2N3706/7	14p
*2N3708/9	12p
*2N3773	300p
*2N3819	25p
*2N3820	50p
2N3823	70p
2N3866	90p
*2N3903/4	18p
*2N3905/6	20p
*2N4037	65p
2N4058/9	12p
*2N4060	12p
*2N4061/2	18p
*2N4123/4	22p
*2N4125/6	22p
*2N4289	20p
*2N4401/3	27p
2N4427	90p
*2N4871	60p
*2N5087	27p
*2N5089	27p
*2N5172	27p
2N5179	90p
2N5191	83p
2N5194	90p
*2N5245	40p
*2N5296	55p
*2N5401	50p
*2N5457/8	40p
*2N5459	40p
*2N5460	60p
2N5485	44p
*2N6027	48p
2N6247	190p
2N6254	130p
2N6290	85p
2N6292	65p
3N128	120p
3N140	100p
3N141	110p
3N201	110p
3N204	100p
40290	250p
40360	40p
40361/2	45p
40364	120p
40408	70p
40409	85p
40410	85p
40411	300p
40594	97p
40595	105p
40673	75p
40841	90p
40871/2	90p

DIODES

*BY127	12p
*OA47	9p
*OA81	15p
*OA85	15p
*OA90	9p
*OA91	9p
*OA95	9p
*OA200	9p
*OA202	10p
*1N914	4p
*1N916	7p
*1N4148	4p
1N4001/2	5p
1N4003/4	6p
1N4005	6p
1N4006/7	7p
1N5401/3	14p
1N5404/7	19p
*1S920	9p

*ZENERS

2.7V-33V

400mW	9p
1W	15p

TRIACS PLASTIC

3A 400V	60p
3A 500V	65p
6A 400V	70p
6A 500V	88p
8A 400V	75p
8A 500V	95p
12A 400V	85p
12A 500V	105p
16A 400V	110p
16A 500V	130p
T2800D	130p

HEAT SINKS

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

THYRISTORS

1A 50V	40p
1A 400V	65p
1A 600V	70p
3A 400V	90p
8A 600V	140p
12A 400V	160p
16A 100V	160p
16A 400V	180p
16A 600V	220p
BT106	110p
C106D	45p
*MCR101	36p
2N3525	120p
2N4444	140p
*2N5060	34p
*2N5064	40p

BRIDGE RECTIFIERS

*1A	50V	21p
*1A	100V	22p
*1A	400V	30p
*1A	600V	35p
*2A	50V	30p
*2A	100V	35p
*2A	400V	45p
*3A	200V	60p
*3A	600V	72p
*4A	100V	95p
*4A	400V	100p
6A	50V	90p
6A	100V	100p
6A	400V	120p
10A	400V	200p
25A	400V	400p

LOUD-SPEAKERS

Size		
2½"	64R	70p
2½"	8R	70p
2"	8R	75p
1½"	8R	75p

MEMORIES

2102-2L	120p
2102L-4	120p
2107B	500p
2111-2	225p
2112-2	300p
2114	700p
4116	£11
5101	510p
6810	350p

ROM/PROMs

71301	700p
74S188	225p
74S287	350p
74S387	350p
93427	400p
93436	650p
93446	650p
93448	1000p

CPUs

*1600	£12
6502	1200p
6800	900p
6802	1250p
8080A	550p
Z80	1150p

EPROMS

1702A	500p
2708	900p
2716	£29

SUPPORT DEVICES

3245	400p
4002	
6820	600p
6850	700p
8205	320p
8212	225p
8216	225p
8224	400p
8228	525p
8251	700p
8253	1200p
8255	550p
B257	1100p
8259	1400p
Z80P10	650p
Z80CTC	650p
MC14411	1100p
MC14412	1100p

UART

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

CHARACTER GENERATORS

3257ADC	990p
MCM6576	£10
RO-3-2513 U.C.	600p
RO-3-2513 L.C.	600p
SN74S262AN	1350p

KEYBOARD ENCODER

AY-5-2376	£10

TRANSFORMERS

(prim 220/240V)

6-0-6	100mA	88p
9-0-9	75mA	82p
12-0-12	100mA	95p
0-120	12500mA	280p
0-25V (5VA)		250p
9-0-9 1A		270p*
12V 2A		350p*
0-12-15		
20-24-30 1A		340p*
15-0-15 1A		265p*

(Please add 50p p&p charge to all marked * above our normal p&p charge).

*RESISTORS High

*Stab 5% E12 Carbon Film

*¼W 10R-1M one value	7p/5pcs
*½W 10R-10M one value	5p/3pcs
*Miniature Presets Hor/Vert 100R-1M	12p
*Carbon Track Pots 5K-1M Log or Lin	
Single	30p
Single with Switch	60p
Dual	72p

LOW PROFILE DIL SOCKETS BY TEXAS

8 pin	11p	18 pin	25p	24 pin	33p
14 pin	12p	20 pin	28p	28 pin	42p
16 pin	13p	22 pin	30p	40 pin	51p

WIRE WRAP SOCKETS BY TEXUS

8 pin	30p	18 pin	70p	24 pin	90p
14 pin	40p	20 pin	75p	28 pin	110p
16 pin	55p	22 pin	80p	40 pin	140p

SUBMINIATURE SWITCHES

Toggle	
SPST	60p
SPDT	65p
DPDT	70p
DPDT (centre off)	85p
Push to make	15p
break	25p
*SLIDE DPDT	18p
*ROCKER SPST	28p

*WAFER

1P/12W	45p
3P/4W	45p
4P/3W	45p
2P/6W	45p

*CRYSTALS

100KHz	300p
1MHz	370p
3.2768MHz	350p
10.7MHz	350p
18MHz	300p
26.690M/27.145M	425p

ANTEX SOLDERING IRONS

C 15W	360p
CX 17W	360p
CCN 15W	380p

SPARE BITS

C/CCN/CX	46p
X25	50p

SPARE ELEMENTS

C/CX/X25	180p
CCN	200p
IRON STAND	150p

VEROBOARDS

DIP Breadboard 4.15 × 6.15 (Suitable for 20 × 14 pin pin or 16 × 16 pin DIL ICs)	270p
DIP Breadboard as above with tracks for 31 way connector	340p

CONNECTOR PLUGS

31 way Plug	100p
31 way Socket	105p
S-100 Busboard	£12

EDGEBOARD CONNECTORS 0.156" PITCH

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

COUNTERS

74C925	475p	ZN1040E	700p
ICM7217A	850p		

DATA BOOKS

TTLs, CMOs, Linears, Memories, etc, by Mfrs stocked.
Please send S.A.E. for details.

16 Key Keypads (Reed Switches)	400p
Breadboards	
EXP300 6" × 2.1" (Suitable for up to 6 × 14 or 5 × 16 Pin DIL ICs 470 points)	575p
EXP600 6" × 2.4" (Suitable for 24/28/40 Pin DIL ICs)	630p

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LOW-COST DIGITAL FREQUENCY METER (200MHz with 1KHz Resolution). As described in January/February '79 Wireless World. All components (except PCB) available MC10116P **60p,** MC10231P **350p.**
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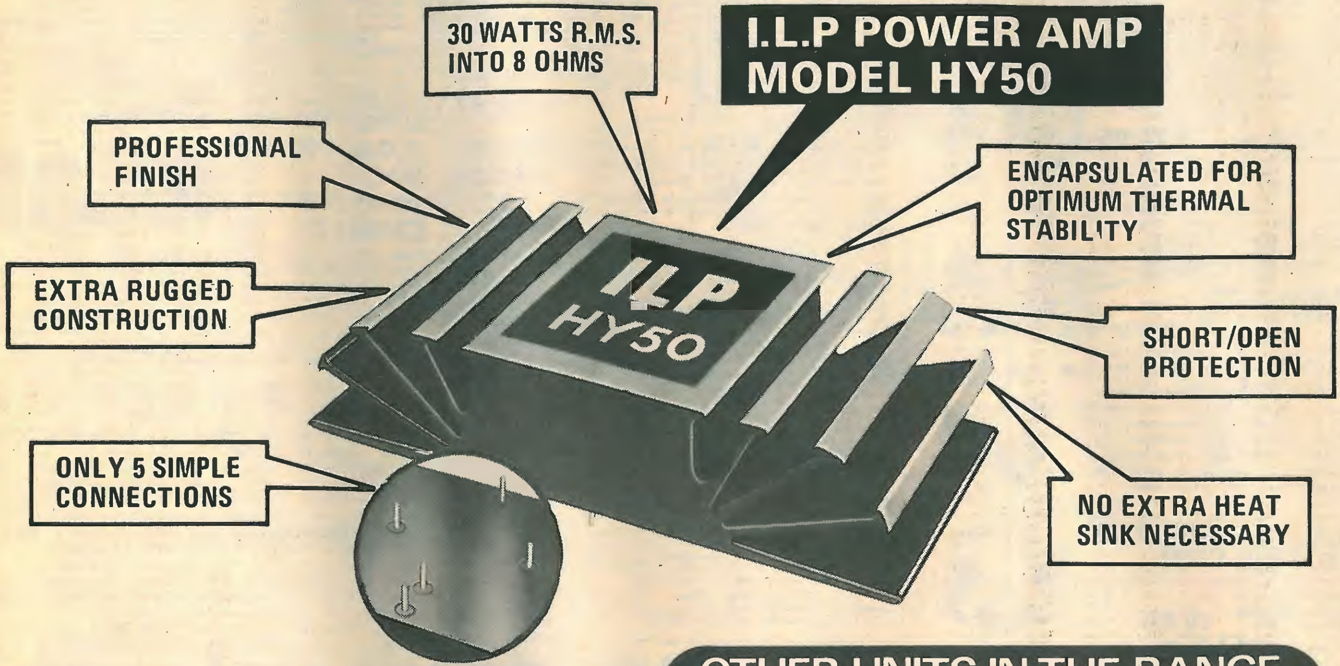

Of all the purpose-built power amplifier modules by I.L.P., the HY50 is understandably the most popular with those wanting to build or up-grade a hi-fi system, run a small high quality P.A. system, amplify a musical instrument (say for practise or small range use) or use it for lab work. Its useful 30 watts RMS output into 8 ohms, its rugged construction and freedom from heatsink worries make HY50 the ideal all-purpose quality power amp — and it is unconditionally guaranteed for five years! Tens of thousands are in regular use throughout the world.

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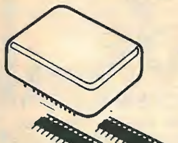

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Compatible with all I.L.P. power amps and P.S.U.s. In a single pack, needs external pots and switches. Multi-function equalization, 5 inputs. High overload margin. Active tone controls, 500mV out. Distortion at 1 KHz-0.01%. Two connects easily for stereo.

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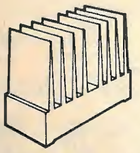

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Distortion typically 0.05% at 1 KHz.

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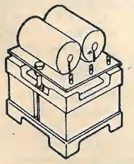

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(Split line outputs to suit I.L.P. power units and HY5).

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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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3-speed stereo cartridge.
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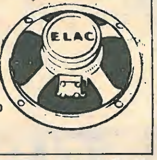
Single pole two-way. Surface mounting with fixing screws. Will replace existing wall switch to give light for return home, garage, automatic anti-burglar lights, etc. Variable knob. Turn on or off at full or intermediate settings. Brand new.

ELAC HI-FI SPEAKER 8in. TWIN CONE



Large ceramic magnet. 50-16,000 c/s.
Bass resonance 40 c/s.
8 ohm impedance.
10 watts. RMS. **£5.95** Post 35p
20 watt woofer **£7.95** Post 45p
Bass unit only

LOW VOLTAGE POWER PACK for MODELS

Ready made. Famous make. Will supply 10 volts D.C. at 400mA. With terminals and mains lead. **£2.50** Post 50p

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

FRINGE LOW LOSS **15p** yd.
PLUGS **10p.** SOCKETS **10p.**
LINE SOCKETS **25p**
OUTLET BOXES **80p**
300 ohm FEEDER **5p** yd.

EMI 13½ x 8in. LOUDSPEAKERS

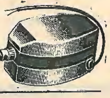
With tweeter and crossover. 10 watt. 3 or 8 ohm.
£8.95 Post 45p

Bass woofer only 8 ohm. 15 watt.
£10.50 Post 65p

Bass woofer only 15 ohm. 20 watt.
£11.50 Post 75p

Suitable Bookshelf Cabinet
Teak finish. For EMI 13 x 8 speakers.
Size 16 x 11 x 8 inches approximately.
£8.50 Post £1.00

THE "INSTANT" BULK TAPE ERASER



Suitable for cassettes, and all sizes of tape reels. A.C. mains 200/250V. Leaflet S.A.E.
Will also demagnetise small tools
Head Demagnetiser only £4.75. **£5.50** Post 50p

RELAYS. 12V DC **95p.** 6V DC **85p.** 240V AC **95p.**
BLANK ALUMINIUM CHASSIS. 6 x 4—**95p;** 8 x 6—**£1.40;** 10 x 7—**£1.55;** 12 x 8—**£1.70;** 14 x 9—**£1.90;** 16 x 6—**£1.85;** 16 x 10—**£2.20.** **ANGLE ALI.** 6 x ¾ x ¾in—**15p.**
ALUMINIUM PANELS. 6 x 4—**24p;** 8 x 6—**38p;** 14 x 3—**40p;** 10 x 7—**54p;** 12 x 8—**70p;** 12 x 5—**44p;** 16 x 6—**70p;** 14 x 9—**94p;** 12 x 12—**£1;** 16 x 10—**£1.16.**
PLASTIC AND ALI BOXES IN STOCK. MANY SIZES
VARICAP FM TUNER HEAD with circuit & connections. Some technical knowledge required **£4.95.**
TAG STRIP 28-way **12p.**
TAPE OSCILLATOR COIL. Valve type, **35p.**
BRIDGE RECTIFIER 200V PIV ½ amp **50p.** 8 amp **£2.50.**
TOGGLE SWITCHES SP **30p.** DPST **40p.** DPDT **50p.**
MANY OTHER TOGGLES IN STOCK. Please enquire.
PICK-UP CARTRIDGES ACOS, GP91 **£2.00.** GP94 **£2.50.**
SONOTONE 9TAHC Diamond **£3.75**
WIRE-WOUND RESISTORS 5 watt, 10 watt, 15 watt **15p.**
CASSETTE MOTOR. 6 volt **£1.00.**

RCS SOUND TO LIGHT KIT Mk. 2 £17

Kit of parts to build a 3 channel sound to light unit 1,000 watts per channel. Suitable for home use. Post 35p
Easy to build. Full instructions supplied. Cabinet **£4** extra.
Will operate from 200MV to 100 watt signal.

R.C.S. LOW VOLTAGE STABILISED POWER PACK KITS

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.

£2.95 Post 45p

R.C.S. POWER PACK KIT

12 VOLT, 750mA. Complete with printed circuit board and assembly instructions.
12 VOLT 300mA KIT, **£3.15.**

£3.35 Post 30p

RCS "MINOR" 10 watt AMPLIFIER KIT

This kit is suitable for record players, guitars, tape playback, electronic instruments or small PA systems. Two versions available: Mono, **£12.50;** Stereo, **£20.** Post 45p. Specification 10W per channel; input 100mV; size 9½ x 3 x 2in. approx. SAE details. Full instructions supplied. AC mains powered. Input can be modified to suit guitar.

R.C.S. DRILL SPEED CONTROLLER/LIGHT DIMMER KIT.
Easy to build kit. Printed circuit
Will control up to 480 watts AC mains
£3.25 Post 35p

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

MAINS TRANSFORMERS	ALL POST 75p.
250-0-250V 70mA, 6.5V, 2A	**£3.45**
250-0-250V 80mA, 6.3V 3.5A, 6.3V 1A	**£4.60**
350-0-350V 80mA, 6.3V 3.5A, 6.3V 1A	**£5.80**
300-0-300V 120mA, 2×6.3V 2A C.T.; 5V 2A	**£8.50**
220V 45mA, 6.3V 2A	**£1.75**
HEATER TRANSFORMER. 6.3V ½ amp **£1.50** 3 amp	**£1.75**
GENERAL PURPOSE LOW VOLTAGE. Tapped outputs	
2 amp. 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 25 and 30V	**£5.30**
1 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	**£5.30**
2 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	**£8.50**
3 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	**£11.00**
5 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	**£14.50**

12V, 100mA	**£1.00**	20V, 40V, 60V, 1 amp	**£3.50**
12V, 750mA	**£1.30**	12V, 3 amp	**£2.95**
10-0-10V 2amp	**£2.45**	10V, 30V, 40V, 2 amp	**£2.75**
30V, 5 amp and 17V-0-17V, 2 amp	**£3.45**	40V, 2 amp	**£2.95**
0, 5, 8, 10, 16V, ½ amp	**£1.95**	20V, 1 amp	**£2.20**
9V, 3 amp	**£2.75**	20V-0-20V, 1 amp	**£2.95**
25-0-25V 2 amp	**£3.50**	30V-0-30V, 2 amp	**£7.00**
30V, 2 amp	**£3.00**	2 of 18V, 6 amp, each	**£9.00**
30V, 1½ amp	**£2.75**	12-0-12V, 2 amp	**£2.95**
		9V, ¼ amp	**£1.30**

AUTO TRANSFORMERS, 115V to 230V or 230V to 115V 150W **£7.00**
250W ... **£8.00** 400W ... **£9.00** 500W ... **£10**
FULL WAVE BRIDGE CHARGER RECTIFIERS.
6 or 12V outputs, 2 amp.....**75p.** 4 amp.....**£1.25**
CHARGER TRANSFORMERS: 1½ amp.....**£3.50.** 4 amp.....**£6.50.**
12V, 1½ amp Half Wave Selenium Rectifier **25p**

COMPACT SPEAKERS

Teak 4 or 8 ohm White 4 ohm only 13 × 10 × 6in. approx. 50 to 14,000 cps. 10 watts.

£16 pair Post £1.30

EXTENSION SPEAKERS £3.95 ea.

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.
Full Range Quality
Frequency Response
Impedance: 8 ohms
Power Peak: 5 watts

LOW VOLTAGE ELECTROLYTICS
1, 2, 4, 5, 8, 16, 25, 30, 50, 100, 200mF 15V **10p.**
500mF 12V **15p;** 25V **20p;** 50V **30p;**
1000mF 12V **17p;** 25V **35p;** 50V **47p;** 100V **70p.**
2000mF 6V **25p;** 25V **42p;** 420mF/500V **£1.30.**
2500mF 50V **62p;** 3000mF 25V **47p;** 50V **65p.**
3900mF 100V **£1.60.** 4700mF 63V **£1.20.** 2700mF/76V **£1.**
5000mF 6V **25p;** 12V **42p;** 35V **85p.** 5600mF/76V **£1.75**

HIGH VOLTAGE ELECTROLYTICS

8/350V	**22p**	8+8/450V	**50p**	50+50/300V	**50p**
16/350V	**30p**	8+16/450V	**50p**	32+32/450V	**75p**
32/500V	**75p**	16+16/450V	**50p**	100+100/275V	**65p**
50/350V	**50p**	32+32/350V	**50p**	150+200/275V	**70p**

MANY OTHER ELECTROLYTICS IN STOCK

SHORT WAVE 100pf air spaced gangable tuner, **95p.**
TRIMMERS 10pF, 30pF, 50pF, **5p.** 100pF, 150pF, **15p.**
CERAMIC, 1pF to 0.01mF, **5p.** Silver Mica 2 to 5000pF, **5p.**
PAPER 350V-0.1 **7p;** 0.5 **13p;** 1mF 150V **20p;** 2mF 150V **20p;** 500V-0.001 to 0.05 **12p;** 0.1 **15p;** 0.25 **25p;** 0.47 **35p.**
MICRO SWITCH SINGLE POLE CHANGEOVER 20p.
SUB-MIN MICRO SWITCH, 25p. Single pole change over.
TWIN GANG, 385 + 385pF **50p;** 500pF slow motion **75p.**
365 + 365 + 25 + 25pF, Slow motion drive **65p.**
120pF **TWIN GANG, 50p;** 365pF **TWIN GANG, 50p.**
NEON PANEL INDICATORS 250V. Amber or red **30p.**
ILLUMINATED ROCKER SWITCH. Single pole. Red **65p.**
RESISTORS. 10Ω to 10M. ¼W, ½W, 1W, 20% **2p;** 2W, **10p.**
HIGH STABILITY. ½W 2% 10 ohms to 1 meg., **12p.**
Ditto 5%. Preferred values 10 ohms to 10 meg., **5p.**

ELECTRO MAGNETIC PENDULUM MECHANISM 95p

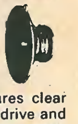
Post 30p.

1.5V DC operation over 300 hours continuous on SP2 battery, fully adjustable swing and speed. Ideal displays, teaching electro magnetism or metronome, strobe, etc.

BAKER SUPERB £22

12in 25 watt

Post £1.60



High Fidelity — Twin Cone

Quality loudspeaker, low cone resonance ensures clear reproduction of the deepest bass. Special copper drive and concentric tweeter cone. Full range reproduction with remarkable efficiency in the upper register.

Bass resonance 25 cps Useful response 20-17,000 cps Flux Density 16.500 gauss 8 or 16 ohms models.

"SALE" BAKER "BIG-SOUND" SPEAKERS. Post £1

'Group 25'	'Group 35'	'Group 50/15'
12 inch 30 watt **£12** 4 or 8 or 16 ohm	12 inch 40 watt **£14** 4 or 8 or 16 ohm	15 inch 75 watt **£33** 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 Post £1.60

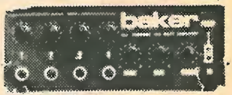
TEAK VENEERED HI-FI SPEAKER CABINETS
For 13x8in. or 8in. speaker **£8.50** Post £1
For 6½in. speaker and tweeter **£5.95** Post 75p
Many other cabinets in stock. Phone your requirements.
SPEAKER COVERING MATERIALS. Samples Large S.A.E.
LOUDSPEAKER CABINET WADDING 18in wide **20p** ft.

R.C.S. 100 watt VALVE AMPLIFIER CHASSIS

Four inputs. Four way mixing, master volume, treble and bass controls. Suits all speakers. This professional quality amplifier chassis is suitable for all groups, disco, PA, where high quality power is required. 5 speaker outputs. AC mains operated. Slave output socket. Produced by demand for a quality valve amplifier.
100V line output to order £10 extra. Send for leaflet.
Suitable carrying cab **£21** Price **£99** carr. £6.00

Horn tweeters 2-16kc/s. 10W 8 ohm or 16 ohm **£3.60.**
Audax Tweeters 3-18kc/s. 50W 8 ohms **£8.50**
CROSSOVERS. TWO-WAY 3000 c/s 3 or 8 or 15 ohm **£1.90.** 3-way 950 cps/3000 cps, **£2.20.**
LOUDSPEAKERS PM 3 OHM 7x4in. **£1.50;** 6½in., **£1.95;** 8x5in., **£1.90;** 8in., **£2.50.**
SPECIAL OFFER: 80 ohm. 2¼in., 2¾in., 35 ohm, 3in., 25 ohm, 2½in., 3in., 5x3in., 7x4in., 8 ohm, 2½in., 3in., 3½in., 5in., 15 ohm, 3½in. dia, 6x4in., 7x4in., 5x3in., 3 ohm., 2½in., 2⅝in., 3½in., 5in. dia. **£1.50 each.**
PHILIPS LOUDSPEAKER, 8in., 4 ohms, 4 watts, **£1.95**
RICHARD ALLAN TWIN CONE LOUDSPEAKERS
8in. diameter 4W **£2.50.** 10in. diameter 5W **£2.95;** 12in. diameter 6W **£3.50.** 3/8/15 ohms, please state.
MOTOROLA PIEZO ELECTRIC HORN TWEETER. £7.95
Handles up to 100 watts. No crossover required.
BLACK PLASTIC CONSTRUCTION BOX with brushed aluminium facia. Sturdy job. Size 6¼ x 4¾ x 2in. **£1.50**

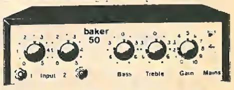
BAKER 150 WATT PROFESSIONAL MIXER AMPLIFIER



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.
100 volt line model **£99** **£79** £1.50 carr.

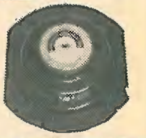
BAKER 50 WATT AMPLIFIER

£59 Post £1



Superior quality ideal for Halls/PA systems, Disco's and Groups. Two inputs with Mixer Volume Controls. Master Bass, Treble and Gain Controls. 50 watts RMS. Three loudspeaker outlets 4, 8, 16 ohm. AC 240V (120V available). Blue wording on black cabinet.

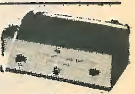
GOODMANS COMPACT 12-INCH BASS WOOFER



Standard 12in. diameter fixing with cut sides 12" x 10". 14.000 Gauss magnet. 20 watts R.M.S. 4 ohm imp. Bass resonance = 30 c.p.s. Frequency response 30-8000 c.p.s.
£9.95 each Post £1

ALUMINIUM HEAT SINKS. FINNED TYPE.
Sizes 5" × 4" × 1" **95p.** 6½" × 2" × 2¼" **65p.**
JACK PLUGS. Plastic 25p; Metal 30p.
JACK PLUGS Stereo Plastic 30p; Metal 35p.
JACK SOCKETS. Open 20p; Closed 25p.
JACK SOCKETS Stereo Open 25p; Closed 30p.
FREE SOCKETS — Cable end 30p.
2.5mm and 3.5mm JACK SOCKETS 15p.
2.5mm and 3.5mm JACK PLUGS 15p.
DIN TYPE CONNECTORS
Sockets 3-pin, 5-pin 10p. Free Sockets 3-pin, 5-pin 25p.
Plugs 3-pin 20p; 5-pin 25p.
PHONO PLUGS and SOCKETS ea. 10p.
Free Socket for cable end ea. 15p.
Screened Phono Plugs ea. 15p.
TV CONVERGENCE POTS 15p each
Values = 5, 7, 10, 20, 50, 100, 200, 250, 470, 2000 ohms.

MONO PRE-AMPLIFIER. Mains operated solid state pre-amplifier unit designed to complement amplifiers without low level phono and tape input stages. This free-standing cabinet incorporates circuitry for automatic R.I.A.A. equalisation on magnetic phono input and N.A.B. equalisation for tape heads.



£4.50 Post 50p

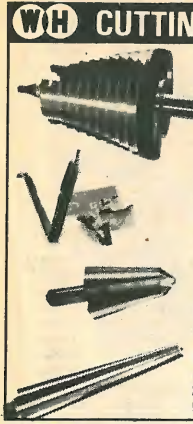
RADIO COMPONENT SPECIALISTS

Radio Books and Components Lists 20p. (Minimum posting charge 30p.) Cash prices include VAT. Access or Barclaycard.

337 WHITEHORSE ROAD, CROYDON
Open 9-6. Closed all day Wed. Open Sat. 9-5.
Telephone 01-684 1665.

West Hyde have more than 600 different instrument cases in stock + accessories

WH CUTTING TOOLS



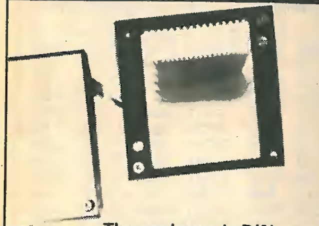
Bradrad drills and deburrs, thin or thick plastic or £19.75
17.80
6–36mm or
¼"–1½"

Adel nibbling tool cuts virtually any shaped hole.
£9.95

Conecut powered reamer.
6-20mm £5.15
16-30mm £8.95
25-40mm £14.95
37-52mm £19.75

Reamers for plastic or metal.
3-12mm £8.25
9-25mm £11.75

WH CONTIL-DIN



The ready-made DIN case you have been waiting for

Heavy aluminium extrusions lock rigidly together providing, heat dissipation, screening and strength, with provision for 16 P.C. boards and quick component mounting. **To order:** *See catalogue.*

DIN 212	£6.06	DIN 215	£7.56	DIN 914	£10.15
DIN 213	£6.57	DIN 912	£8.49	DIN 915	£10.96
DIN 214	£7.07	DIN 913	£9.33		

WH MOD-2

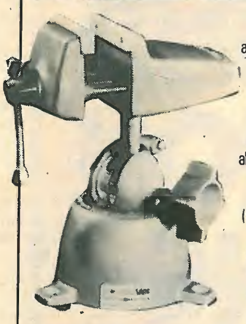
A very popular case of universal use
Modular design. Stores flat. Chassis fixes between front and back panels of PVC/aluminium. Covers of PVC/steel. Cheap enough for production, ideal for development work.

MD2A	9.25	MD2I	15.32	MD2Q	13.14
MD2B	10.32	MD2J	13.25	MD2R	15.12
MD2C	11.46	MD2K	16.25	MD2S	12.75
MD2D	9.98	MD2L	18.90	MD2T	14.72
MD2E	11.36	MD2M	10.30	MD2U	17.95
MD2F	12.92	MD2N	11.75	MD2V	15.45
MD2G	10.95	MD2O	13.35	MD2W	18.98
MD2H	12.60	MD2P	11.22	MD2X	22.30

Send for catalogue

Prices are correct at time of going to press. Prices are one off inc. P&P, but not VAT. Discounts for quantities.

WH PANAVICE



The Panavice has a 180° tilt action and turns a full circle locking in any position. Has a unique system of interchangeable components in world wide use. (See catalogue)

300	£10.53
311	£8.78
303	£8.58
304	£8.58
—vacuum base	
366	£8.78
380	£15.51
305	£10.41

Jaws from £2.02 to £2.30

300 Standard base 10.53
311 Bench clamp 8.78

WH BRIGHTCASE

Adds sophistication to any equipment
In anodised aluminium with top and bottom panels grained black P.V.C.

	L	B	H	
BC2/121	432	268	89	£28.95
BC2/222	219	268	89	£20.99
BC3/121	432	268	133	£31.95
BC3/222	219	268	133	£23.70

WH SAMOS

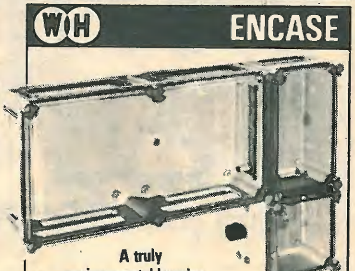
Miniature PVC/steel cases with hundreds of uses

Equipment can be assembled in the lower half, which is flanged for rigidity, completed, tested, then the top cover is sprung into place.

Moulded, plug in feet included.

	L	B	H			L	B	H	
S1	50	100	50	£1.45	S5	100	125	75	£2.24
S2	100	100	50	£1.65	S6	150	125	75	£2.63
S3	150	100	50	£1.91	S7	200	175	75	£2.92
S4	50	125	75	£1.96					

WH ENCASE



A truly environmental housing

Encase solves your waterproof and dustproof problems and because of its chemical resistance is ideal in the process industries. The polycarbonate is virtually unbreakable. Covers—clear PC. Case—glass-filled PC. Gaskets (screws inc), gland plates (hinges available).

ENC A	190	190	130	10.11
ENC B	280	190	130	12.63
ENC C	380	190	130	16.41
ENC D	280	280	130	17.10
ENC E	380	280	130	21.38
ENC F	560	280	130	30.70
ENC G	560	350	130	42.61

NOTE NEW ADDRESS

All West Hyde cases are available with substantial discounts for quantities. Most cases have discounts at 5, 10 and 25 off with discounts up to 25% at 100 off. Prices include P&P but not VAT, and are less 10% if collected on first two price breaks on cases only. Send for catalogue. Prices correct at press date.

WEST HYDE DEVELOPMENTS LIMITED, Unit 9, Park Street Industrial Estate, AYLESBURY, BUCKS. HP20 1ET. Phone: Aylesbury (0296) 20441. Telex: 83570

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TRANSAM

TRANSAM COMPONENTS LTD., 12 CHAPEL STREET, LONDON, N.W.1. TEL: 402 8137

The exciting new TRITON Personal Computer

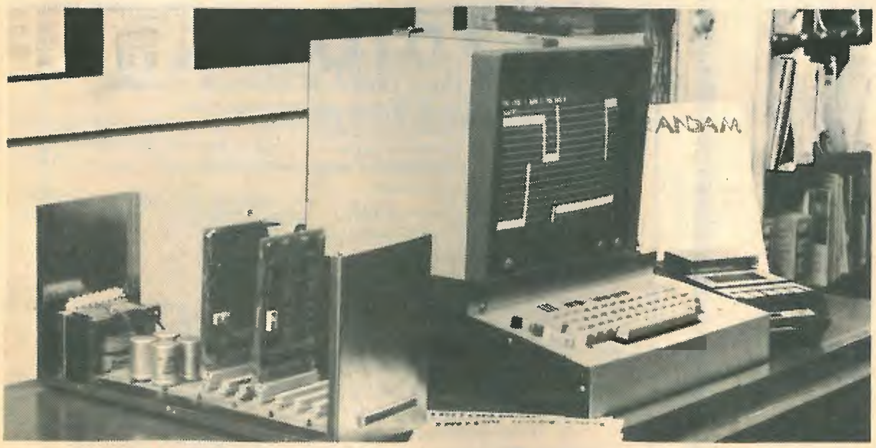
Basic In Rom: a powerful 2k Tiny basic resident on board, makes Triton unique, easy to use and versatile.

Graphics: 64 Graphic characters as well as full alpha numerics.

Single Board: Holds up to 8k of memory, 4K RAM and 4k ROM, supplied with 3k ROM and 2k RAM.

Memory Mapping: 2 mode VDU, I/O or memory mapped for animated graphics.

Cassette Interface: crystal controlled Modern tape I/O with auto start/stop + "named" file search.



U.H.F. TV Interface: On board uhf modulator, plugs into TV aerial socket.

COMES COMPLETE with keyboard, case, full power supply, quality through hole plated P.C.B. Full (118 page) instruction manual. A powerful 1k Monitor and 2k Tiny basic in Eprom all I.C. Sockets. All components can be bought separately, so you can start construction on a low budget. Full details of prices and discounts are shown in our new 1979 catalogue.

EXPANSION BOARDS
MOTHERBOARD — 8 slot
A new 8 slot Triton Motherboard is now available based on Eurobus. It allows easy expansion and has its own meaty power supply.

8k STATIC RAM
Eurocard size (160 x 100mm) 8k Static Ram fully buffered, on board regulation and decoding uses 4k (1k x 4) static rams. Just plugs into Motherboard for memory expansion.

8k EPROM BOARD
Designed to take 8 x 2708 Eproms on the Triton bus. Don't forget our Programming Service.

TRITON KIT	**£286**
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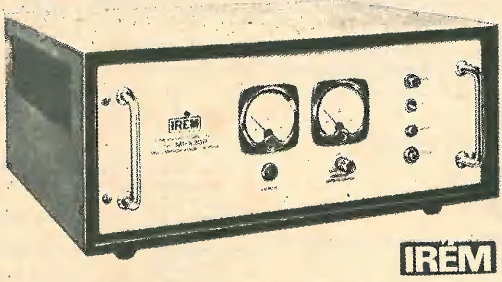
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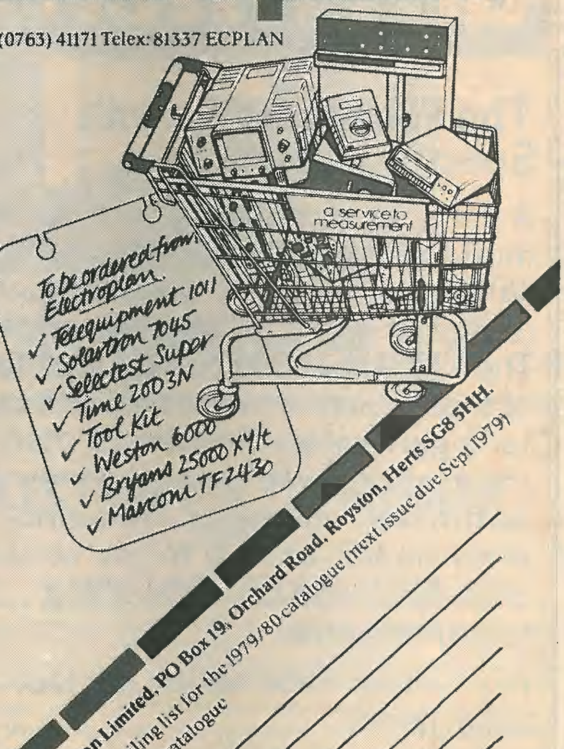

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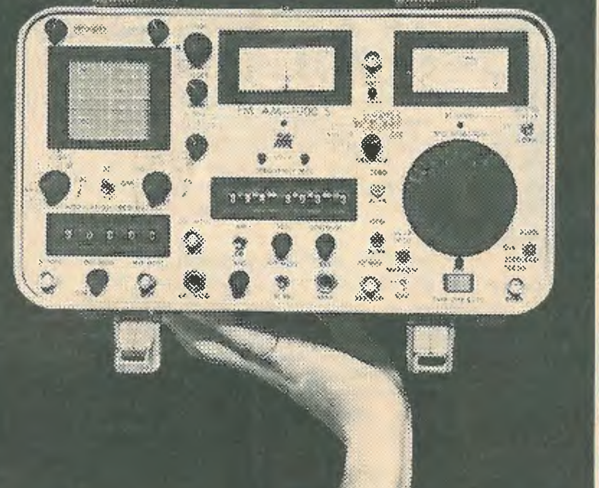

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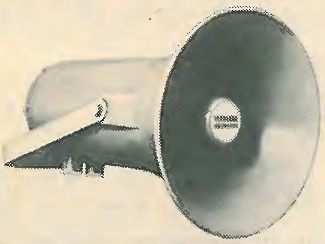

- * Ex. loudspeakers 12w and 25w
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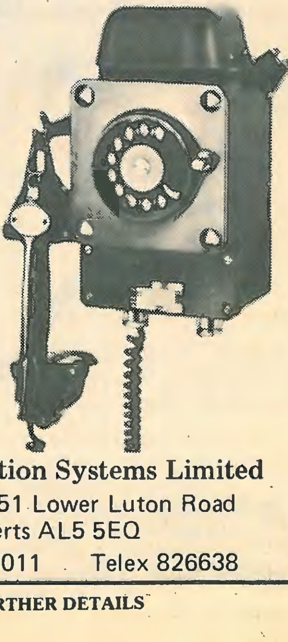


- * complete systems for the offshore – chemical – petroleum – railway – motorway environments

NEUMANN

Neumann Communication Systems Limited
Lea Industrial Estate, 151 Lower Luton Road
Harpenden, Herts AL5 5EQ
Telephone: (058 27) 67011 Telex 826638

WW — 082 FOR FURTHER DETAILS

Appointments

Advertisements accepted up to 12 noon Friday, June 1 for July issue, subject to space being available.

DISPLAYED APPOINTMENTS VACANT: £8.50 per single col. centimetre (min. 3cm).
LINE advertisements (run on): £1.20 per line, minimum three lines.
BOX NUMBERS: 60p extra. (Replies should be addressed to the Box Number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London SE1 9LU.)
PHONE: Barry Leary on 01-261 8508
Classified Advertisement Rates are currently zero rated for the purpose of V.A.T.

WE HAVE AN OPEN DOOR FOR AN OPEN MIND

Test Engineers

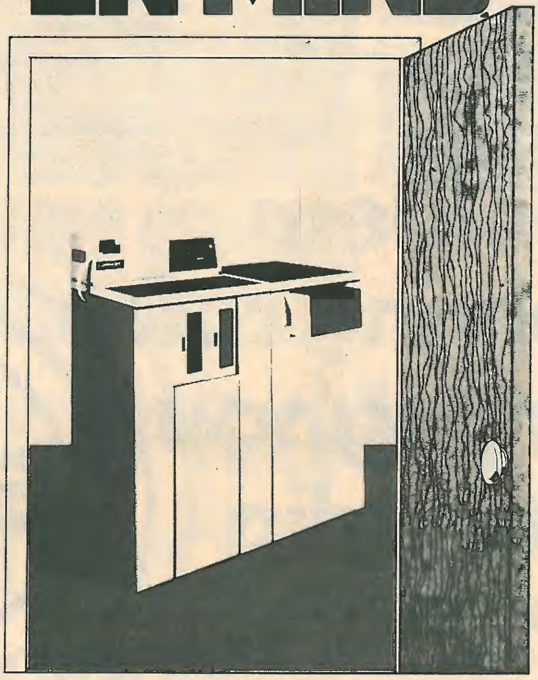
Open minds and creative thinking have made Linotype-Paul the market leader in the field of sophisticated phototypesetting equipment for the world's graphics industries.

We are leaders not by accident but by design and in order to maintain our position and our record growth pattern we now have excellent openings for electronics engineers at all levels.

If you have an electronic engineering background coupled with at least 2 years practical experience and/or a formal qualification we'd like to meet you.

Anyone with experience in the following, would also be welcome. Prototype Wirers, A.T.E. Engineers, Electronic and Mechanical Inspectors, Skilled Fitters, P.C.B. Draughtsmen/women, Programmers, Electronic and Mechanical Development Engineers.

Ring Cheltenham 41441,
reversing charges, or write to
Patrick Cooper, Personnel Officer,
Linotype-Paul Ltd., Chelham House,
Bath Road, Cheltenham.



Linotype-Paul 1974

JVC

Hi Fi and TV Technicians

Owing to continued expansion, JVC require more service engineers at their head office.

Applicants should have City and Guilds Certificates I, II and III and sound experience in repairing the most up-to-date hi-fi and TV apparatus.

Substantial remuneration, pleasant working conditions, subsidised canteen plus additional benefits.

Please apply to: **Staff Manager (Technical), JVC (UK) Ltd., Eldonwall Trading Estate, 6-8 Priestley Way, Staples Corner, London NW2 7AF. Or telephone (01) 450 2621.**

(9279)

UNIVERSITY OF WARWICK

ELECTRONICS TECHNICIAN

Grade 7

Required in the Department of Chemistry and Molecular Sciences to take charge of a well equipped electronics workshop. The duties include responsibility for maintenance of both electrical and electronic equipment in the Department, design and construction of specialised electronic equipment and modification to existing equipment and the supervision of a Grade 4 Technician employed primarily on repair and maintenance work. The Department is equipped with a wide range of scientific instrumentation including mass spectrometers, magnetic resonance instruments, spectrophotometers and chromatographic equipment, and the successful candidate, male or female, will probably hold an HNC or equivalent in the field of electronics and have wide experience in the design and maintenance of complex electronic equipment. The University is situated in pleasant rural surroundings within easy commuting distance of Coventry, Kenilworth and Leamington Spa. Salary on the Technician Grade 7 scale £4,638-£5,211 p.a., starting point depending on experience and qualifications. Application should be made by letter giving full details and the names and addresses of two referees to the Personnel Office, University of Warwick, Coventry CV4 7AL quoting Ref. No. 39/2D/79; as soon as possible.

At ERA we have developed considerable expertise in all areas of the radio spectrum, from dc transients to gigahertz transmission. Opportunities now exist for suitably qualified men and women to contribute their ideas in the following areas:

EMC Compatibility

A variety of interesting projects span problems ranging from electromagnetic interference to microwave frequencies in such diverse applications as civil and military aircraft, military vehicles and weapons systems, marine communications, the offshore oil and gas industry, industrial telemetry and control, and domestic appliances.
Applicants should have a degree or equivalent qualifications and some experience in either communications or radio frequency measuring techniques.

Antenna & Microwave Technology

Activities in these fields include a wide range of research, development and evaluation projects on high performance antenna systems for spacecraft, satellite, aircraft and terrestrial use; and the research and design of new types of millimetre-wave components. Two exceptional antenna and/or microwave engineers are required to complement a team with a growing international reputation. Degree level qualifications would normally be required although, for one of these posts, consideration will be given to an applicant with outstanding practical capabilities. Direct experience is desirable but not essential and a well motivated candidate without experience but with a good electromagnetics or numerical methods background would be given serious consideration.

At ERA you'll find an environment where your ideas can flourish. We're a highly creative organisation run on extremely sound commercial principles and a long way from the traditional image of a research association.

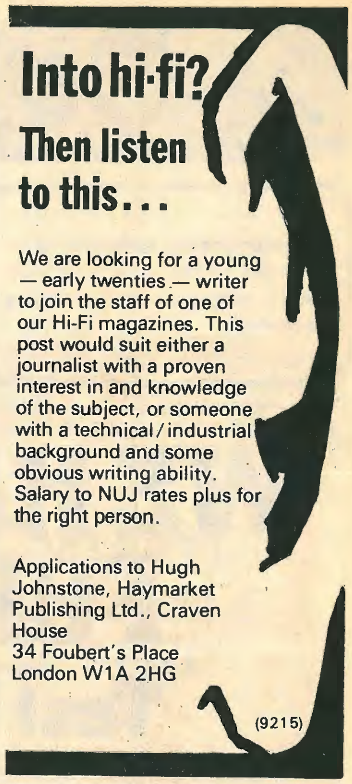
We're offering competitive salaries, genuine paths for career development and a wide range of attractive fringe benefits, including assistance with relocation where necessary.

For further details please contact
R. P. Thompson, Personnel Manager,
Electrical Research Association Limited,
Cleeve Road, Leatherhead, Surrey.
Telephone: Leatherhead 73933.

(9209)

Problem solving roles throughout the radio spectrum

ERA



Into hi-fi?

Then listen to this...

We are looking for a young — early twenties — writer to join the staff of one of our Hi-Fi magazines. This post would suit either a journalist with a proven interest in and knowledge of the subject, or someone with a technical/industrial background and some obvious writing ability. Salary to NUJ rates plus for the right person.

Applications to Hugh Johnstone, Haymarket Publishing Ltd., Craven House
34 Foubert's Place
London W1A 2HG

(9215)

DORSET COUNTY COUNCIL COUNTY EDUCATION DEPARTMENT POOLE ENGINEERING INDUSTRIAL TRAINING CENTRE

WORKSHOP INSTRUCTOR/ESS

(Fitter Electrical/Electronic) (Post ED/PTC/97)

Previous Bench Fitting and Electrical/Electronics production experience essential.
Workshop Instructor/ess instruct first year "off the job" apprentice craftspersons/technicians, and short course trainees; and cover the supporting duties coupled with posts of this nature.
Salary within Scale £3,831-£4,632 (BAR) — £4,773 plus planned overtime.
Application forms returnable by May 31st, 1979, and further details from Manager, Poole Engineering Industrial Training Centre, 42 Danecourt Road, Parkstone, Poole BH14 OLS. (Please quote Post Number ED/PTC/97. (9263)

Athrofa Gogledd-dd Cymru
The North E Wales Institute of higher education

KELSTERTON COLLEGE, CONNAH'S QUAY, DEESIDE, CLWYD

MICROPROCESSOR TECHNICIAN

Salary Scale T3 (£3,732 to £4,146)

A technician is required, with digital experience, to work in the College's new purpose-built Microprocessor Centre.

This will involve the construction and design of special purpose teaching instruments, interfaced to microprocessors. An interest in software or experience in microprocessor hardware would be an advantage.

The College is 8 miles from Chester, has easy access to Liverpool and Manchester and has beautiful mountain and coastal scenery close by.

Apply by letter as soon as possible (no forms) giving age, qualifications, experience and details of two persons from whom references can be obtained to: **The Institute Registrar, North E. Wales Institute of Higher Education, Kelsterton College, Connah's Quay, Deeside, Clwyd.** (9210)

Oxfordshire AREA HEALTH AUTHORITY (TEACHING)

CHURCHILL HOSPITAL MEDICAL PHYSICS TECHNICIAN

GRADE 3 — £3744-£4788

For mechanical section of Department of Radiotherapy and Oncology Workshop. Appointee will join a team maintaining cancer therapy machines and designing and manufacturing prototype equipment. Machines include Linear Accelerator and Telecobalt machines as well as deep and superficial X-ray machines. Recognised apprenticeship as toolmaker essential plus eight years' relevant experience. Qualifications: HNC or equivalent in mechanical engineering.

Please apply to Mrs. J. Durbin, Personnel Officer, Churchill Hospital, Oxford. Telephone 64841 ext. 228.

(9237)

System Designers

Controllers
SOFTWARE
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Customised Systems

COMMUNICATIONS
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Networks
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SYSTEMS
Consoles

There's real variety at Letchworth

£5000 to £9500

The Letchworth Development Centre in Hertfordshire is responsible for producing customised computer systems. We are free either to adapt standard ICL Systems or to produce new systems to meet the needs of individual customers.

As a Design Engineer you will be able to see a project through from start to finish in a matter of months. Teams are small, often a single engineer with complete responsibility, and seldom more than three. You will be involved directly with the customer and his real requirement. Responsibility does not end until customer satisfaction has been achieved. Most projects are unique and we deal with both ICL and other manufacturers' hardware and software.

Expansion

The Centre will expand dramatically during 1979 and will treble the business over the next five years. There are now immediate vacancies for Design Engineers at all levels, both in hardware and software, especially those able to take over Project Management.

Involvement

The attraction is complete involvement with a customer project including even the business and financial aspects. World-wide travel opportunities are excellent. During the last year we have installed customised systems in 26 overseas countries.

We are involved at the leading edge of systems requirements and technology, including aerospace, packet switching networks and financial terminals. New technologies which are being applied are microprocessors, voice response, the new ICL Content Addressable File Store, Distributed Array Processing, Prestel displays and so on.

ICL is Europe's leading computer Company and offers unequalled opportunities in the widest possible variety of career routes.

You will probably have a suitable degree or equivalent in electronics or computer science with a minimum of about five years experience in computer applications. However if you are a practical designer with proven experience though without formal qualifications, we are still keen to hear from you. The men and women we appoint will be given help with relocation where appropriate. They will also be eligible for our 1979 Productivity Bonus Scheme.

Please write to John Wells, Senior Personnel Officer, Letchworth Development Centre, ICL, Icknield Way, Letchworth, Herts SG6 1EL; quoting reference WW1196. Or telephone him on Letchworth (04626) 2191 extn 231.

ICL International Computers

think computers – think ICL

(9208)

Air traffic Engineers

The Civil Aviation Authority has vacancies for men and women as Air Traffic Engineers Grade 2 in its Telecommunications Division offering a variety of work on a wide range of electronic systems and specialised equipments.

Air Traffic Engineers Grade 2 are involved in the installation and maintenance of radio, radar, air navigational and landing aids, and data processing systems and are employed at some Civil Airports, Air Traffic Control Centres and Radar Stations and other locations throughout the UK. At present we have vacancies at Heathrow, Gatwick, Belfast and Sumburgh Airports and other locations in Scotland as well as the London Air Traffic Control Centre (West Drayton).

Qualifications and Experience

You should be at least 20 years of age and have had skilled working experience in radio, radar or data processing and preferably obtained either the ONC (ENG) with an electronics bias or C & G Telecommunications Technician T3 Certificates or other similar technical qualifications.

Salary

Salaries are on an incremental scale £3890 – £5763 (Under review) with starting point dependent on qualifications and experience.

Posts in the London area attract an additional allowance (Inner London £558 – Outer London £293). Grade 1 posts (maximum salary £6957 under review) are normally filled by promotion from Grade 2.

For full details and an application form complete and send the coupon to :– CAA Tels Staff Management (ATE2) Room K206, CAA House, 45/59 Kingsway, London WC2B 6TE.

Name

Address

(WW/6)

CAA

Civil Aviation Authority

(9269)

LEAD YOUR OWN DESIGN TEAM IN 3 YEARS

There are Electronic Engineers in their 20s capable of Project Management in the not so distant future.

POTENTIAL

Is what my client is seeking. It's a young persons world. Electronics is a young persons rainbow.
My client can lead you to the end of it.
If you think its about time you will recognise for what you are worth —

PHONE ME TODAY
TIM DAVIES

(9277)

0992 50541

The Personnel People

COLLEGE OF AIR TRAINING
HAMBLE — SOUTHAMPTON

Applications are invited for:—

SIMULATOR ENGINEER

required for fault diagnosis, repair, maintenance and development of Flight Simulators. Successful applicant must have served a recognised Electrical / Electronic Engineering Apprenticeship and have studied to at least ONC level. Previous experience of Flight Simulators, analogue computers, Servo mechanisms and the repair and calibration of Electrical / Electronic Instruments is essential. To be based at Hurn.

Apply in writing with evidence of recent experience to the Chief Engineer.

(9242)

ITN

requires a

SENIOR ENGINEER VTR/ CASSETTE MAINTENANCE

Salary £6,864 per annum plus productivity bonus

Independent Television News Ltd. has a vacancy for a Senior Engineer to maintain video cassette recorders. A trial period with electronic news gathering equipment has just started at ITN and the successful candidate will be working in an expanding area of the company's operations, with responsibility for maintaining both E & G and the normal ITN house cassette equipment. This position will be part of a total facilities maintenance team working to the highest professional broadcast standards, with prime responsibility for cassette recorder maintenance.

Candidates should have considerable experience of the maintenance and operation of Sony U-Matic equipment. Similar experience of VCR, VHF and BETAMAX equipment would be an advantage.

Please telephone the Personnel Officer on 01-637 3144 for an application form, quoting reference no. 83317.

(9252)

JVC

Spare Parts Manager

Owing to rapid and continued expansion, JVC — acknowledged leaders in Hi-Fi and Video — urgently require a Spare Parts Manager.

The funtion of the Spare Parts Department is to purchase, stock and distribute all the parts required for the servicing of our total Video and Audio range.

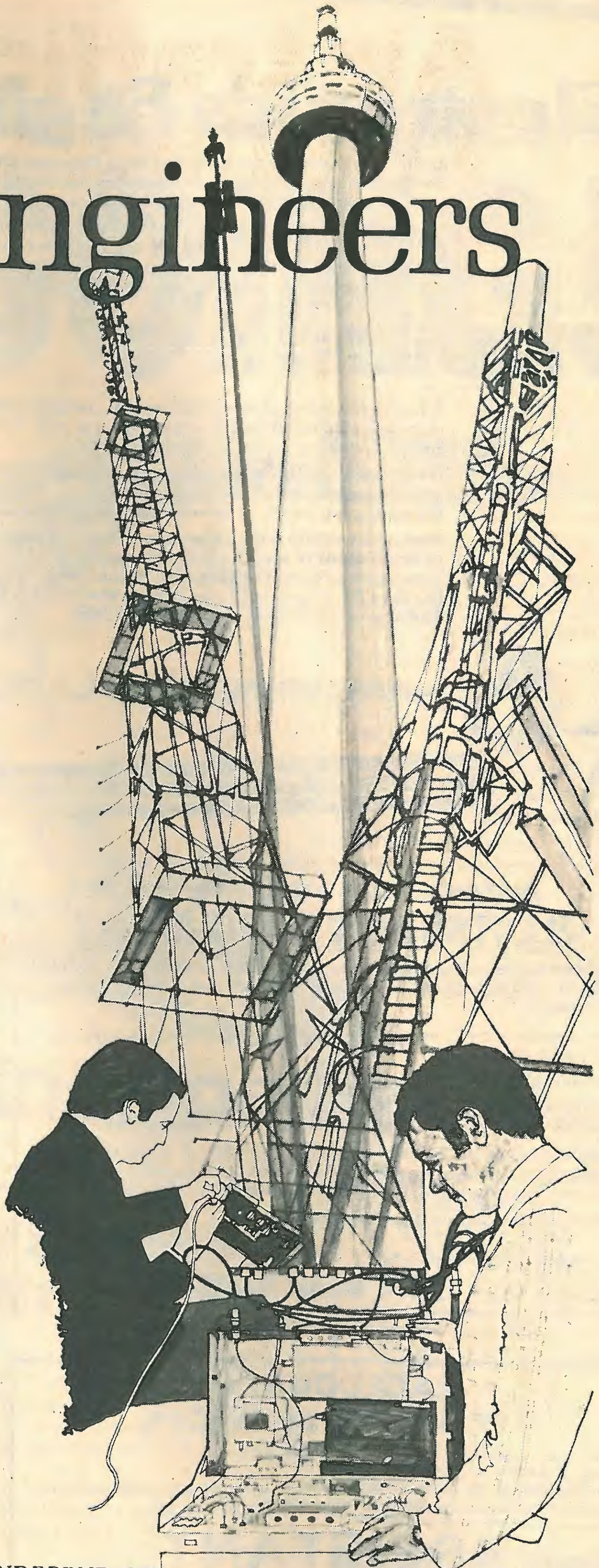
Applicants, male or female, must have sound experience of spares control and staff management together with the ability to maintain and further the relationship with our dealer network which is vital to the continued expansion of our business.

Substantial remuneration, pleasant working conditions, subsidised canteen plus additional benefits.

Please apply to: **Staff Manager (Technical) JVC (UK) Ltd., Eldonwall Trading Estate, 6-8 Priestley Way, Staples Corner, London NW2 7AF, or Telephone (01)-450 2621.**

(9280)

Aerial Engineers



Our Station Design and Construction Department is committed to a demanding programme of work for many years ahead. It has to plan, build and equip new Television and Local Radio stations to extend existing networks and now has responsibility for engineering the transmission facilities for the fourth Television Channel.

There are now opportunities for two Aerial Engineers (male or female, either qualified to degree level with relevant experience, or newly qualified graduates with an interest in Broadcast engineering). The work is interesting and technologically challenging and involves the design and specification, acceptance and commissioning of Aerial Systems, high and low power filters, channel combining and separating equipment for UHF, VHF and FM services.

You will be based at our Engineering Headquarters at Crawley Court but you will not be office-bound as your work will take you to sites throughout the U.K. You will need to be fully fit and able to climb and be in possession of a current driving licence.

Starting salary will be on a range which rises to £6,066 per annum (an initial appointment at a lower level will be made for those with more limited experience). We encourage promotion from within and Senior Engineers are currently on a range which rises to £7,172 per annum. In addition, we offer excellent working conditions, with a subsidised restaurant on the premises, free life assurance and personal accident scheme, generous pension scheme, and long service awards extending the above salary scales. (All salaries are due to be reviewed in July).

Re-location expenses will be paid where appropriate. Generous allowances apply whilst away from base.

IBA

INDEPENDENT
BROADCASTING
AUTHORITY

Please write or telephone for more information and an application form quoting Ref. No. WW/AE.

The Personnel Officer, IBA Crawley Court,
Winchester, Hampshire SO21 2QA.
Telephone Winchester 822270.

(9275)

Electronics Engineers

Electronics Engineers are needed at Rank Research Laboratories for advanced developments in the application of modern electronic systems mainly to the fields of optics, metrology and industrial processes.

This work will attract engineers with ability in digital and analogue design and keenness to exploit the power of electronics in creating new systems in the fields mentioned. Some of this work will involve the application of microprocessors and will give opportunities to develop hardware and software.

Physicist

A Physicist is required for special projects, initially to develop new manufacturing techniques for optical components. A knowledge of chemistry and/or metallurgy would be an advantage.

Good salaries will be offered to suitable candidates and it is Rank Organisation policy to assist professional career development. The company operates a first-class contributory pension fund and non-contributory life assurance scheme.

Men and women with a few years' R and D experience and a degree or equivalent in electronic engineering or physics are invited to 'phone or write to the Director, Rank Research Laboratories,
PO Box 33, Phoenix Works, Great West Road, Brentford,
Middlesex TW8 9AG. Tel: 01-568 9766.

RANK RESEARCH LABORATORIES

(9222)

BRIGHTON POLYTECHNIC

Learning Resources

VTR ENGINEER

£4245-£5073

Unique opportunity to work in the forefront of helical VTR development; using one-inch highband, broadcast threequarter-inch and all consumer formats, requiring a qualified engineer to work to broadcast standards interested in working with all VTR formats. Further details from the Personnel Officer, Brighton Polytechnic, Moulescoomb, Brighton BN2. Tel: Brighton (0273) 693651. Closing date: 10th June, 1979.

(9272)

UNIVERSITY OF DURHAM
DEPARTMENT OF PHYSICS

An ELECTRONICS/CONTROL ENGINEER is required to design the control and data acquisition electronics for a new astronomical experiment involving a number of large, very high bandwidth optical detectors on fully steerable mounts. The experiments will be carried out overseas, most probably in the U.S.A., and a small number of short visits to the site will be necessary. Experience with either high-speed analogue electronics or microprocessor control is desirable. The appointment will be for 2 years as an Senior Experimental Officer. Initial salary in the range £3,883-£4,382 per annum (under review) plus superannuation. Applications (3 copies) naming three referees should be sent by 31 May 1979 to the Registrar and Secretary, Science Laboratories, South Road, Durham DH1 3LE, from whom further particulars may be obtained. (9241)

DISTRICT WORKS DEPARTMENT

ELECTRONICS TECHNICIAN

Applications are invited for the above named post at Kettering General Hospital for the maintenance of electronic and electro-medical equipment.

The appointment will be made according to qualifications, age and experience.

Electronics Technician Grade IV — Salary scale £3069-£4134.

Qualifications: ONC or Full City and Guilds Technological Certificate plus three years' experience since obtaining these qualifications.

Application form and further information from Mr. J. C. Hall, Acting District Works Officer, District Works Department, General Hospital, Rothwell Road, Kettering, Northants NN16 8UZ.

Closing date for applications: 30th May, 1979.

Kettering **HEALTH DISTRICT**
NORTHAMPTONSHIRE AREA HEALTH AUTHORITY

(9236)

RACECOURSE TECHNICAL SERVICES LIMITED

Our Engineers go places. We provide quality colour television with our own cameras on UK racecourses and currently have a vacancy for an

ASSISTANT TV ENGINEER

If you are a young, fit, well-educated TV Engineer interested in gaining experience in OB operations, maintenance and installations as a member of a congenial team please contact:

Angela Gercke
RACECOURSE TECHNICAL SERVICES LIMITED
88 Bushey Road, Raynes Park, London SW20 0JH
Tel: 01-947 3333

(9225)

Radio Officers

If your trade or training involves radio operating and you are no more than 35 years of age, you qualify to be considered for a Radio Officer post with the Composite Signals Organisation.

A number of vacancies will be available in 1980 for suitably qualified candidates to be appointed as Trainee Radio Officers. Candidates must have had at least 2 years' radio operating experience or hold a PMG or MPT certificate.

On successful completion of 40 weeks' specialist training, appointees move to the Radio Officer Grade.

Trainee Radio Officers start on £2,605 at 19 up to £3,034 at 25 or over. After completion of specialist training Radio Officers start on £3,571 at 19 rising to £4,675 if you are 25 or over: then by 5 annual increments to £6,340 inclusive of shift and weekend allowances. Salaries at present under review.

GCHQ

For further details apply to:

The Recruitment Officer
Government Communications Headquarters
Priors Road, Oakley
Cheltenham, Glos. GL52 5AJ
Telephone: Cheltenham 21491 Ext. 2269

(9105)

to all Computer Electronics Service Engineers...

GET GOING!

Move to Linotype-Paul and we'll really put some wheels under you — not just in terms of fast moving career prospects, but we'll also throw in a company car.

"OK, so does everyone else." you say. "What's so special about your company?"

For a start, we're international leaders in the design and manufacture of a product range that's taking the world by storm — computerised phototypesetting equipment and its associated peripherals. And that's where you come in.

We're looking for experienced electronic service engineers, not necessarily in phototypesetting because that's fairly new, but in computer technology, digital electronics, VDUs or other peripheral devices.

The job involves field service work, operating out of our Kingsbury base, so you should be prepared to move so as to be within one hour's drive away. Suitable qualifications would be HND/HNC/ONC or equivalent.

The work is stimulating, interesting and very varied. We'll give you full product training and continuing updates as we introduce new models. On top of that, there's a salary negotiable around £5000, generous expenses, and assistance with relocation. And of course, the job's open to both men and women.

What more can we say? Get going, and phone or write as soon as you can to David Hilton, Personnel Manager, Linotype-Paul Limited, Kingsbury Road, London NW9 8UT. Tel: 01-205 0123.

Linotype-Paul 1974

(9244)

MARINE ELECTRONICS

We need an engineer familiar with Radar, MF/HF synthesised SSB/VHF Autopilots, etc. to service and install anywhere, but must be based in London.

If you are able to be your own boss apply giving details of experience, salary required.

We are also prepared to offer an engineering partnership arrangement, if you are the right man.

TELESONIC MARINE LTD.
243 Euston Road
London N.W.1.

(8959)

Engineers

- DESIGN / DEV
- TEST
- FIELD SERVICE

High Salaries – Most Areas
Phone 01 • 731 4353

Apex Personnel

(8995)

M.P.U. SYSTEMS DESIGN ENGINEER

Have you recently qualified, HNC/Degree?
Are you well versed in M.P.U. systems design and practice?
Could you design a complete system (software and hardware) from initial specifications through to production?
Would you like to have a career for yourself based near Frankfurt in West Germany?
In return we can offer very varied and interesting work allied to the leisure industry, a salary of £10,000-£11,000 p.a. plus profit sharing and other fringe benefits.
Interested?

Then please apply in writing giving concise personal details to:

Mr. P. Drury, Director
BARRY NOBLE
(COIN MACHINES) LIMITED
Sun Valley House
Ashley Street, Nottingham NG3 1JG

(9226)

ASSISTANT ELECTRONICS ENGINEER

To assist the Electronics Engineer in maintaining equipment for tolls registration, UHF radio telephones, P.A. systems, telemetry, PAX telephone system, gas monitoring, smoke detection and measurement, fire alarm system.

Salary £3912 to £4326 inclusive.

Applications to:

The General Manager, Dartford Tunnel Joint Committee, Tunnel Offices, South Orbital Way, Dartford, Kent.

(9246)

CA CAPITAL APPOINTMENTS LTD.

FREE JOBS LIST

for
FIELD SERVICE ENGINEERS
BASIC SALARIES TO •
£7,000 + CAR

(8781)

30 Windmill Street, London, W1
01-637 5551

Medical equipment for Hospitals

A VITAL ROLE FOR ELECTRICAL/ ELECTRONIC ENGINEERS

These opportunities are in the Scientific and Technical Branch which provides the scientific, engineering and other professional services essential to the provision of medical apparatus, instrumentation and supplies to hospitals.

The successful candidates will join a team working on the specification, laboratory testing, inspection and quality control of a wide range of medical electrical and electronic equipment used in the National Health Service. Some UK travel required.

Candidates must have a degree or an equivalent qualification in electronics or electrical engineering and at least 2 years' experience in the design of electronic equipment covering analogue and digital circuits. Experience of medical electrical equipment advantageous.

Starting salary between £4,850 and £6,260 depending on qualifications and experience. **Salaries under review.** Non-contributory pension scheme. Promotion prospects.

For further details and an application form (to be returned by 8 June, 1979) 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(40)85/4.**

DHSS

(9214)

RADIO COMMUNICATION ENGINEERS REQUIRED

Remuneration in the range of £4,400 and £4,900

Applicants are invited for the above positions at our North-West London and Harrow depots. We are London's largest independent radio-telephone company and would be interested in hearing from you if you have knowledge of mobile VHF equipment.

Contact Mike Rawlings or Bill Clarke on 01-328 5344.

London Communications
(Equipment) Ltd
30 Boundary Road, London, NW8 01 328 5344

(9243)

APPOINTMENTS IN ELECTRONICS

£5 – £10,000

Take your pick of the permanent posts in:

MISSILES — MEDICAL
COMPUTERS
RADAR — COMMS
MICROPROCESSOR
HARDWARE — SOFTWARE

For free expert advice and immediate action on salary and career improvement, 'phone or write to, Mike Gernat BSc.

Technomark
Engineering and Technical Recruitment
11 Westbourne Grove
London W2. 01-229 9239

(9257)

ATTENTION! ALL CALIBRATION & TEST ENGINEERS...

We are looking for experienced Calibration and Test Engineers who wish to progress with us in a more interesting and varied working environment.

The work involves the maintaining, servicing and overhauling of top quality audio equipment for the Film and TV industry. Full Product training will be given, and when fully conversant with our products, you would be dealing directly with our clients both on the telephone and in person. On some occasions you would also be required to visit other locations in the U.K. Initially, you would be based at our Service Department in London, N.W.1 (near Marylebone Station) but, we are planning to move to modern premises in the High Wycombe area in the near future. We are offering very attractive salaries plus non-contributory pension scheme and four weeks' annual holiday.

If this sounds interesting — please write giving full career history to Mr. J. Rudling at

HAYDEN LABORATORIES LTD

HAYDEN

6 Bendall Mews
Bell Street
London, N.W.1

(9212)

Radio Communications

Electronics Engineers and Software Designers

Mid-Sussex – S.W. London **Salaries up to £7,000**

To join our expanding R&D Laboratories covering a wide range of R.F. spectrum, from L.F. to V.H.F. Equipments include transmitters and receivers for marine and land based use, radio navaids and radio monitoring remote computer controlled systems.

Electronics Engineers should have experience in transmitter or receiver design, analogue or digital circuit design, microprocessor applications. Software Designers should be experienced Programmers with an interest in control, signal processing or navigational software.

Attractive salaries are complemented by excellent prospects and generous benefits.

Contact: **The Personnel Manager, Redifon Telecommunications Limited, Broomhill Road, Wandsworth, London S.W.18. Phone: 01-874 7281** (reverse charges).

(9033)

SAMUELSON FILM SERVICE LIMITED

CRICKLEWOOD, LONDON, N.W.2

We require for our expanding service dept.

A JUNIOR SERVICE ENGINEER

Ideally any applicant should have the 1st year City & Guilds or have had equivalent experience in either Audio or TV servicing.

Telephone during office hours to:
Gary Davis (01) 452 8090

(9228)

RADIO TECHNICIANS

At the Government Communications Headquarters we carry out research and development in radio communications and their security, including related computer applications. Practically every type of system is under investigation, including long-range radio, satellite, microwave and telephony.

Your job as a Radio Technician will concern you in developing, constructing, installing, commissioning, testing, and maintaining our equipment. In performing these tasks you will become familiar with a wide range of processing equipment in the audio to microwave range, involving modern logic techniques, microprocessors, and computer systems. Such work will take you to the frontiers of technology on a broad front and widen your area of expertise — positive career assets whatever the future brings.

Training is comprehensive: special courses, both in-house and with manufacturers, will develop particular aspects of your knowledge and you will be encouraged to take advantage of appropriate day release facilities.

You could travel — we are based in Cheltenham but we have other centres in the UK, most of which, like Cheltenham are situated in environmentally attractive locations. All our centres require resident Radio Technicians and can call for others to make working visits. There will also be some opportunities for short trips abroad, or for longer periods of service overseas.

You should be at least 19 years of age, hold or expect to obtain shortly the City and Guilds Telecommunications Technician Certificate Part I (Intermediate), or its equivalent, and have a sound knowledge of the principles of telecommunications and radio, together with experience of maintenance and the use of test equipment. If you are or have been in HM Forces your Service trade may allow us to dispense with the need for formal qualifications.

WORK IN COMMUNICATIONS R&D AND ADD TO YOUR SKILLS

You start on £2,927 at 19, up to £3,700 if you are 25 or over, rising to £4,252, and promotion will put you on the road to posts carrying substantially more. There are also opportunities for overtime and on-call work paying good rates. Salaries at present under review.

Get full details from our Recruitment Officer, Robby Robinson, on Cheltenham (0242) 21491, Ext. 2269, or write to him at GCHQ, Oakley, Priors Road, Cheltenham, Glos. GL52 5AJ. If you seem suitable we'll invite you to interview in Cheltenham — at our expense, of course.

(9106)

Electronic Development Engineer

Cambridge

We now have an opportunity for a qualified and experienced Electronic Design Engineer to join our Development Team. The successful applicant will carry out those design operations necessary in the development of new electrochemical products. These will be mainly analogue electronic circuit design requirements in the initial stages of the development procedure but will extend to cover all aspects of the development operation.

Applicants should have at least two years' experience in a relevant industrial environment.

Along with a competitive salary we offer many appreciable fringe benefits including 4 weeks' holiday, subsidised canteen and group pension scheme.

Please write or telephone for an application form to:

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(9276)

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We offer:

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★ Can demonstrate a high standard of proficiency.

Then write, giving full details of your age, qualifications and experience, to R. Grey, Granada TV Rental, 20 Allhallows, Bedford.

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(9270)

Electronic Engineers – What you want, where you want!

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All applications are treated in strict confidence and there is no danger of your present employer (or other companies you specify) being made aware of your application.

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TJB

Please send me a TJB Appointments Registration form:

Name ....

Address ....

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(9238)

AUTOMATIC TEST EQUIPMENT ENGINEERS

(Digital and Microwave) – Sussex

M.E.L., a division of the International Philips Electronic and Associated Industries Group, is an established world leader in the development and production of sophisticated Electronic Systems. Due to expanding activity in digital/microwave circuit techniques, we have vacancies within our Automatic Test Department for:-

A.T.E. Programmers and Test Engineers –

to work in a team using GenRad Automatic Digital Test Equipment providing a service to all departments. This activity supports the design, development and production of digital circuits used in a wide variety of applications. Applicants should be qualified to H.N.C. or degree level with preferably test programming, testing or design experience of digital circuits.

Senior Development Engineer –

with previous experience in the design and application of microwave networks who also possess a familiarity with programming techniques. The successful applicant will be responsible for the evaluation of circuits and components using methods of automatic test and analysis on Hewlett Packard microwave test equipment.

These important A.T.E. positions offer high job interest and the equipment is the basis of one of the most advanced microwave/digital test facilities in the United Kingdom.

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(9233)

M E L

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Small established mass metering manufacturer seeks

ELECTRONICS TECHNICIAN

Test experience desirable but manufacturing experience essential.

1. Subsidised house mortgage available
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Enquiries:
Klerkscale (Pty) Ltd., P.O. Box 944, Klerksdorp 2570 South Africa (9231)

LEEDS CITY COUNCIL
DEPARTMENT OF EDUCATION
Leeds Polytechnic — Educational Technology Unit

SENIOR TECHNICIAN
(Electronics). Ref. 188/10

T3/4 £3,732-£4,632 plus technicians' qualification allowance.

Required to service and maintain high grade electronics equipment used in the various Schools of the Polytechnic in their teaching work to a wide range of courses. Knowledge of micro-electronics technology would be a distinct advantage.

Application forms, quoting reference number, from the Administrative Services Officer, Leeds Polytechnic, Calverley Street, Leeds LS1 3HE.

Closing date: 14 days after appearance of advert.

(9230)

PAPUA NEW GUINEA
UNIVERSITY OF TECHNOLOGY

LECTURER

DEPARTMENT OF ELECTRICAL ENGINEERING

The Department is looking for an electrical engineer with some teaching experience and further experience in one or more of the following areas: electrical power, electrical machines, computing, industrial electronics, radio communication. One post is available immediately and a three-year contract would be offered in the first instance. Appointment at Senior Lecturer level may be possible for a suitably qualified candidate. As part of its forward planning the Department wishes to collect details of prospective staff members interested in short-term employment. Qualifications and experience for the temporary posts are as outlined above for the permanent post, but consideration would also be given to a young engineer just completing a postgraduate qualification. Temporary positions (six months to a year), caused by study leave absences, will be available during 1979 and 1980. Teaching in Papua New GHuinea is particularly interesting and challenging, and an ability to communicate effectively with Papua New Guinea students is essential. The Department is currently giving considerable thought to the further development of its teaching program and is particularly interested in extending the application of computing to problem solving and learning. The Department is active in applied research and rural development and is involved in a program of installation of micro-hydroelectric schemes in remote villages in the mountains of Papua New Guinea. Research related to this program includes the development of a solid state hydro-electric controller and low cost high voltage transmission lines for mountainous terrain. In conjunction with other Departments in the University and Government, the social and economic impact of these schemes is being studied. Other research work in the Department includes the development of a low cost emergency radio network, an investigation into the use of solar panels for power and communications applications, and microprocessor control of telephone switching. The Department works closely with provincial and national Government, who are supporting some of these projects. Student field trips are an important part of teaching and research activities which will require successful candidates to undertake a certain amount of field work away from the campus. Salary: Senior Lecturer K15,150; Lecturer 2 K13,300; Lecturer 1 K11,450. (1 PNG Kina=$A1.2541; UK £0.6590 as at 11/4/79.) Other benefits include a gratuity equal to 24% of total salary payable either on completion of the contract period or by five instalments during a three-year contract, salary indexation, appointment and repatriation fares for the staff member and his family, settling-in and settling-out allowance on appointment and repatriation, six weeks' paid leave per year, leave fares for the staff member and his family once in a three-year contract, assistance towards school fees, education fares for children being educated outside Papua New Guinea, free housing. Salary continuation and medical benefit schemes are available.

Applications must include copies of qualification attainments, curriculum vitae, and give names and addresses of three referees from whom confidential enquiries can be made. They should be addressed to: The Registrar, Papua New Guinea University of Technology, P.O. Box 793, Lae, Morobe Province, Papua New Guinea, to arrive not later than **30th June, 1979.** An additional copy should be sent to the Association of Commonwealth Universities (Appts.), 36 Gordon Square, London WC1H 0PF, from whom conditions of appointment can be obtained. (9268)

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Electronic Development work (analogue, digital and microprocessors). Liaison with customers may mean some travelling abroad. Graduate or HNC standard required.

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to lead small development team. Complete control of project from feasibility study to production. Further 'on job' training can be provided. Degree plus 5 years' experience.

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(9247)

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- **HIGH SPEED DIGITAL OR ANALOG SIGNAL PROCESSING**
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J S & A

(9211)

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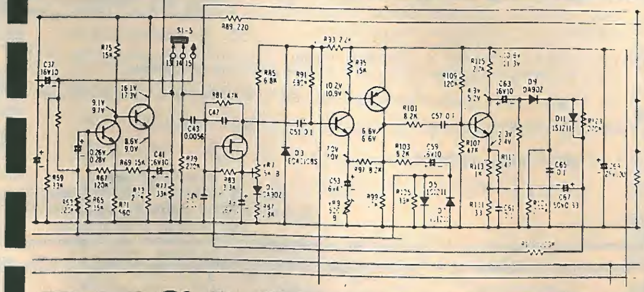

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Salary within the range £4,833 - £5,712 plus £330 Metropolitan Weighting, plus current self-financing productivity payment and the benefits normally associated with a large progressive organisaiton.

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EASTERN GAS

(9220)

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ATLANTIC REGION RESEARCH CENTRE

ALCAN

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Alcan Laboratories Limited require an Instrument Technician at their Research Centre in Banbury, Oxfordshire. The work will be concerned mainly with the development of electronic measurement and control equipment which will be used in the Laboratory and in Alcan factories.

The Research Centre, which is one of Europe's leading metallurgical laboratories, carries out Research and Development work for associated Group companies in the U.K., Europe, Africa and South America; it is part of the Canadian-based Alcan Aluminum Limited Group, which is one of the world's major aluminium producers.

Candidates will be required to work largely on their own initiative; they should have an HNC in Electronic Engineering followed by two/three years' experience in the development of prototype electronic equipment.

The Company offers excellent working conditions, progressive salary scales, flexible working hours and a contributory pension scheme.

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Application forms can be obtained from:

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(9217)

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(9218)

A leading manufacturer of artificial limbs and aids for the disabled require the following personnel to work in its research and development department.

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Salary negotiable

Applicants should have experience in low-noise amplifier design such as in audio frequency systems and some experience of servo and electro-mechanical systems. Familiarity with digital techniques would also be an advantage. HNC, HND or degree preferred.

ELECTRONICS TECHNICIAN

Salary negotiable

Applicants should have experience with development of prototype electronic circuit breadboards. The range of work is varied, and the ability to work from initial design diagrams, in close liaison with the product development engineer and with the minimum of supervision, is essential.

The successful candidate will ultimately be expected to take over the task of laying out printed circuit boards for the development department and hence initial experience in this field would be an advantage.

ONC or C & G preferred, although consideration will be given to applicants working towards a qualification and wishing to continue their studies.

For either position apply in writing, stating age, qualifications, experience and present salary, or telephone for further details.

Mr. D. Hawkins, Hugh Steeper Ltd., 237/239 Roehampton Lane, London, SW15 4LB. Tel: 01-788 8165.

(9250)

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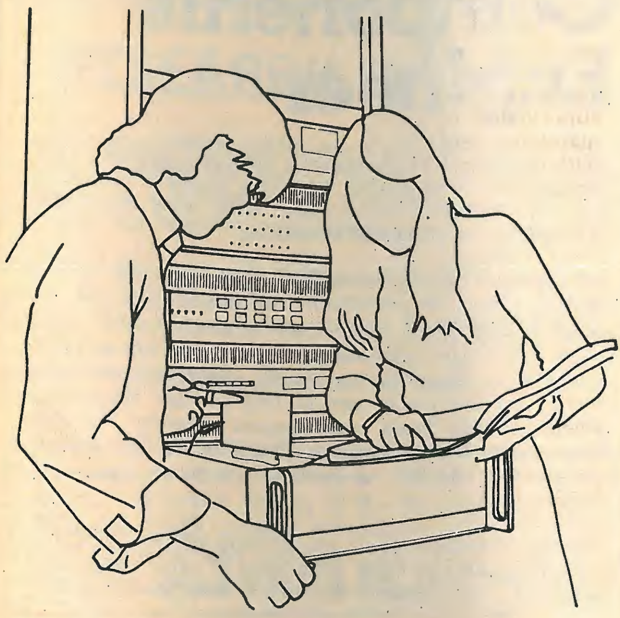

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Present salary £2,500-3,500 ☐ £3,500-4,500 ☐ £4,500-5,500 ☐ over £5,500 ☐

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(9200)

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We are looking for skilled men and women with experience of fault diagnosis, alignment and testing of electronic equipment, preferably communications equipment. Formal qualifications are desirable, but less important than sound practical ability. Armed Forces experience would be particularly acceptable.

We can offer you job security and long term career opportunities, both within the company and the Pye and Philips Group as a whole. Our salaries are competitive and we offer up to 4 weeks 3 days annual holiday. Attractive additional benefits include contributory pension scheme, good canteen facilities and assistance with relocation expenses where appropriate
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If you are interested please contact:
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Tel: Haverhill 4422
for vacancies at Haverhill.

or

Ann Maxwell, Personnel Department,
Pye Telecommunications Limited,
St. Andrew's Road, Cambridge
CB4 1DW..
Tel: Cambridge (0223) 61222

for vacancies at Cambridge.

(9271)

Pye Telecommunications Ltd
St Andrews Road Cambridge England CB4 1DP
Tel: Cambridge (0223) 61222 Telex: 81166 PYETELECOM CAMBGE

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We have a vacancy for a technician to join our expanding instrument department to carry out repairs and preventative maintenance on our varied laboratory instruments (G.C. H.P.L.C. spectrophotometers, mass spectrometer). In addition the technician would liaise with laboratory staff in the design and construction of custom built items of equipment.

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Erl Wood Manor, Windlesham, Surrey.
Telephone: Bagshot 73631

Lilly

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Ultra Electronic Communications Limited, members of the international Dowty Group, are world leaders in the design and manufacture of sophisticated ASW sonar buoys and other advanced radio location devices.

We are now looking for an electronics engineer with a sound understanding of circuit principles to assist with the selection of electronic components for use in a wide variety of projects. Main responsibilities will be to obtain components and devices for use in both new development and production equipment, and to find suitable alternatives where specified types have become obsolete. This will require an ability to identify and match critical component parameters and to understand complex equipment requirements.

Applicants, male or female, should be qualified to HNC and have had sound practical experience of either component selection or of electronics design and development work.

We are offering an attractive salary, excellent conditions of employment and first-class benefits, including assistance with relocation where applicable.

Please write or telephone **Mr. Gavin Rendall, Personnel Manager, Ultra Electronic Communications Ltd., 419 Bridport Road, Greenford, Middlesex. Tel: 01-578 0081.**

(9262)

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Ready, Steady, GROW!

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Electronics Test Technician

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(9253)

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(9261)

University of Liverpool
Department of Building Engineering

TECHNICIAN

required to assist with work of Acoustics Group concerned with problems of computer interfacing and development of signal processing equipment. Candidates should possess ONC (Electronics) or appropriate equivalent qualification and practical experience. The post is tenable for a maximum of three years. Salary within a range up to £4056 p.a. according to qualifications and experience. Application forms may be obtained from The Registrar, The University, P.O. Box 147, Liverpool L69 3BX. Quote Ref. RV/576/WW.

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Applications to: The General Manager, Dartford Tunnel Joint Committee, Tunnel Offices, South Orbital Way, Dartford, Kent.

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GRADE 5

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UNIVERSITY OF LONDON

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DEPARTMENT OF COMPUTING AND CONTROL

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(9221)

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c. £6,000 + BONUS + FREE MEALS

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We rent a wide range of sophisticated electronic test equipment, including Microprocessor based instruments to companies of international repute.

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R.F. Test Equipment including Spectrum Analysers.

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The test equipment we stock is the finest available in the world and our engineers always have available the correct instruments to repair and calibrate these equipments.

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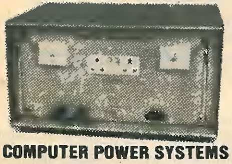

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