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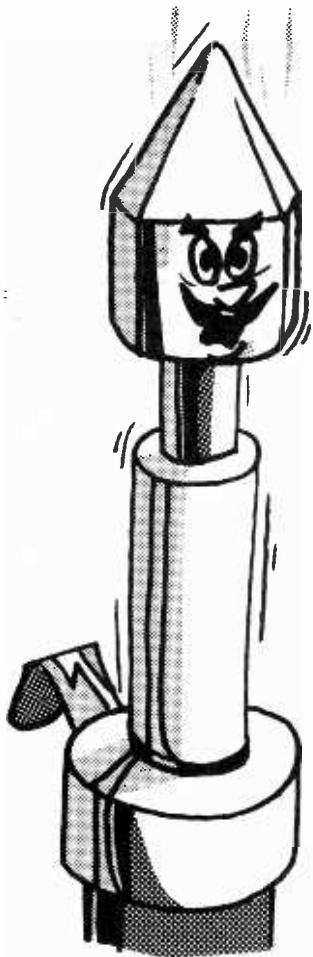
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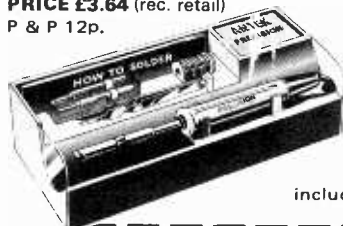
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Suitable for production work and as a general purpose iron.

MODEL SK.1 KIT
Contains 15 watt miniature iron fitted with 3/16" bit, 2 spare bits 5/32" and 3/32", heat sink, solder, stand and "How to Solder" booklet.
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I enclose cheque/P.O./Cash WW5
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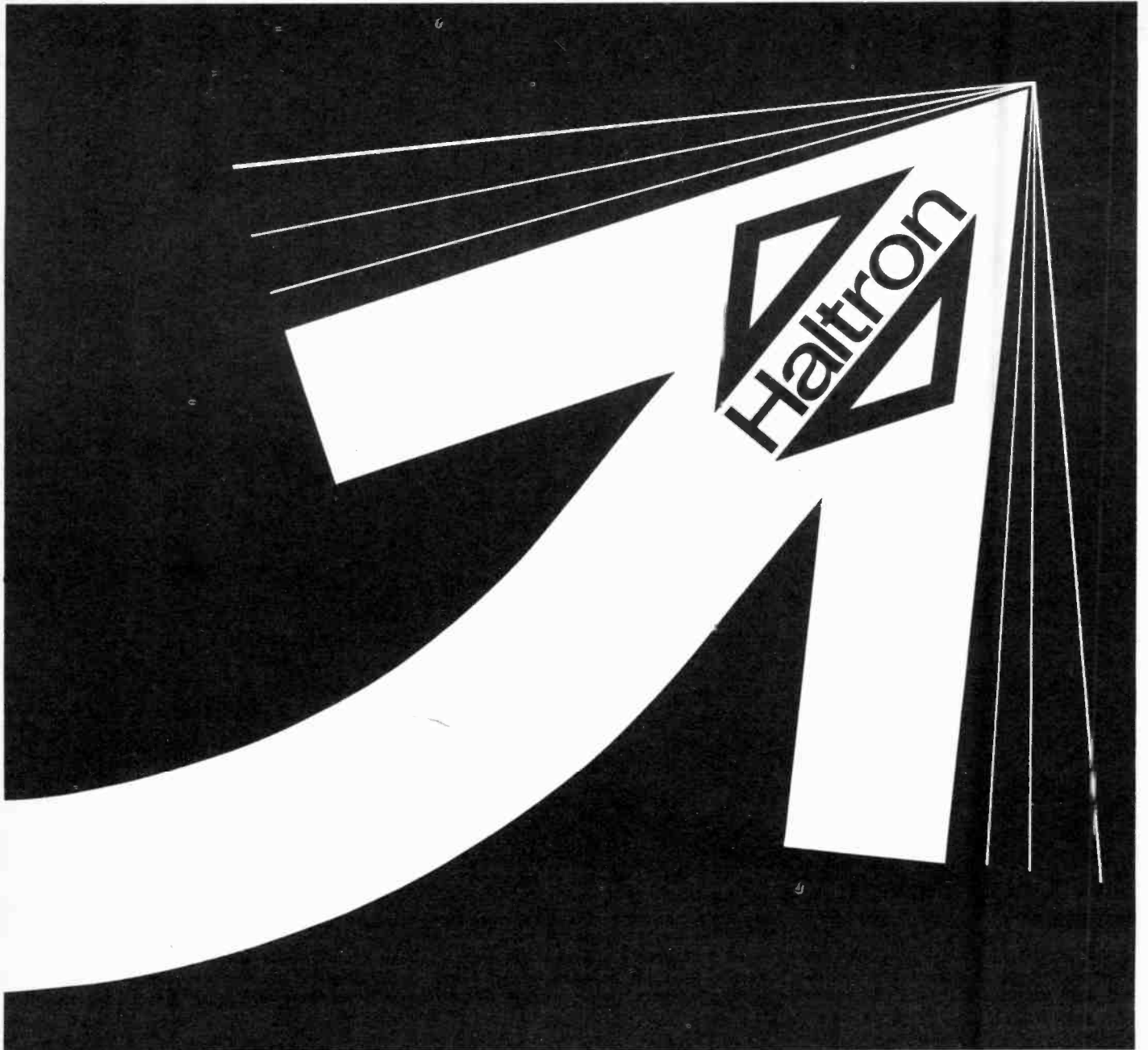
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Please send the ANTEX colour catalogue.



WW—006 FOR FURTHER DETAILS

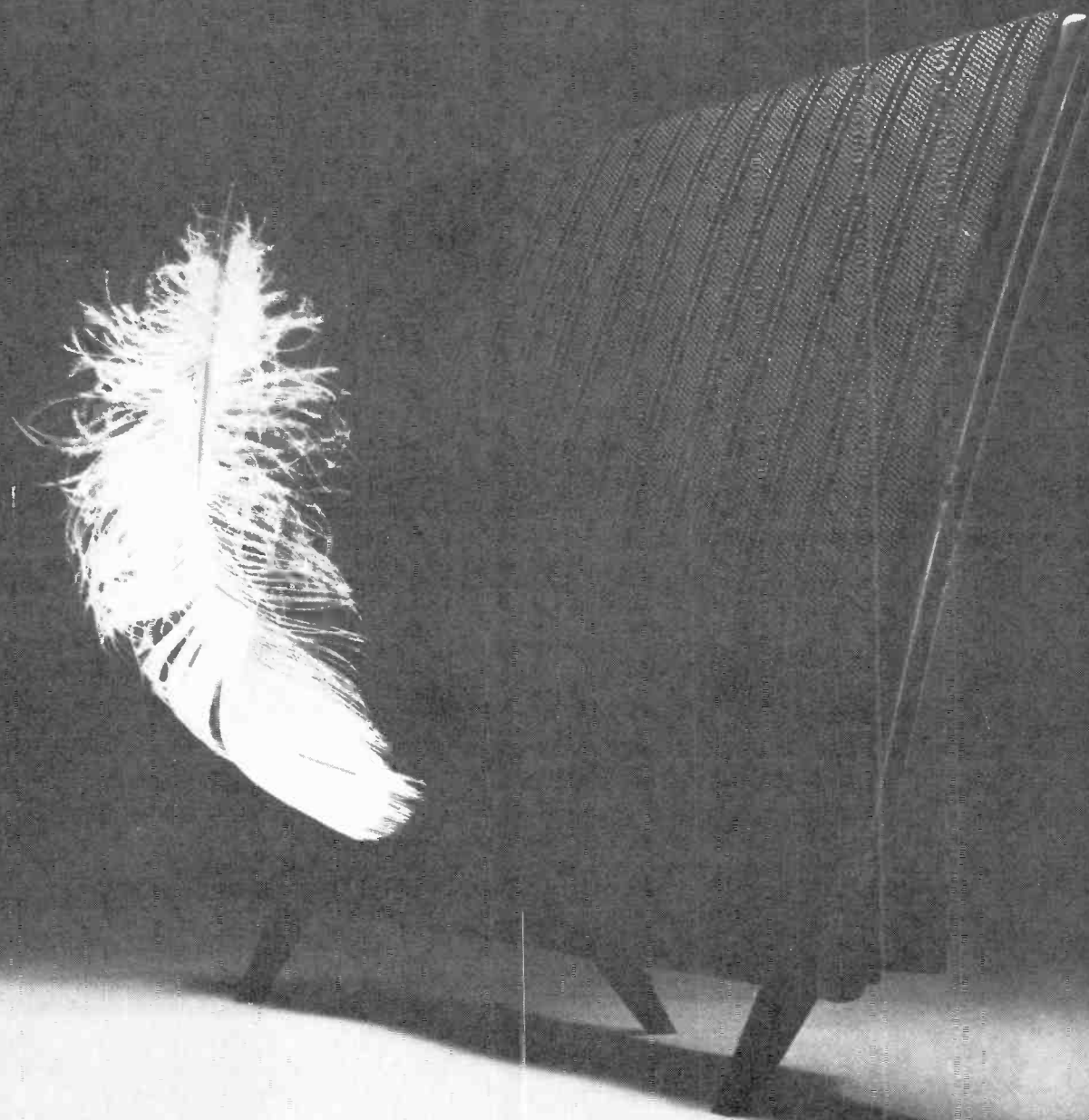


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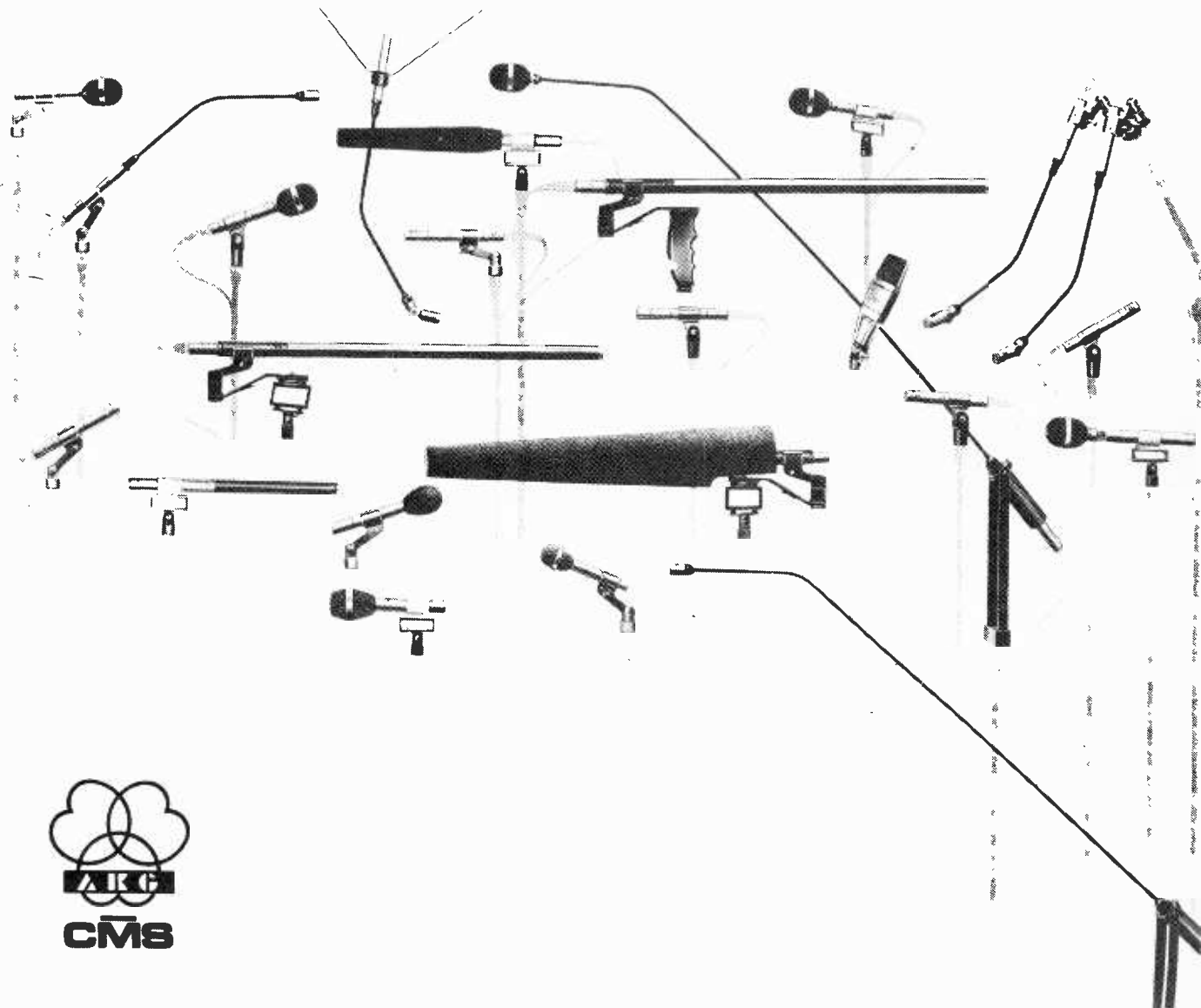


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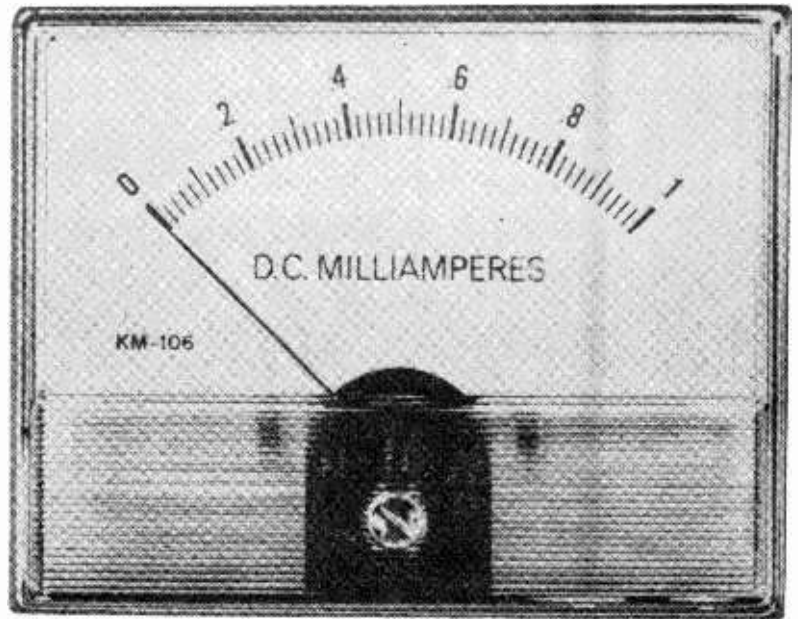
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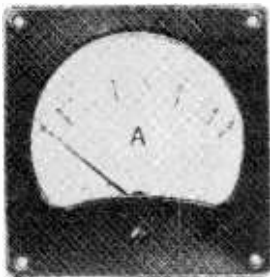
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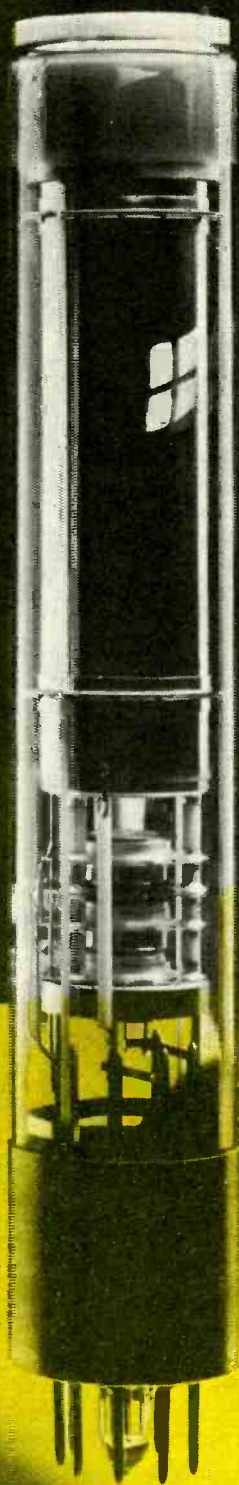
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Mullard's background in electron optics is based on a thorough understanding of vacuum and glass technologies. At Mitcham, part of Europe's biggest Electron optics capability—complete with its own fibre optic drawing plant, we make night vision and low light level TV devices. Years of experience in the design and manufacture of image intensifiers and other electron optical devices has resulted in a capability well geared to today's and tomorrow's requirements. Whether your need is for high volume standard devices, or custom-built specials, Mullard have the experience and the resources to meet it.

For full details about Plumbicon and other camera tubes, contact:

**Mullard Limited, Mullard House,
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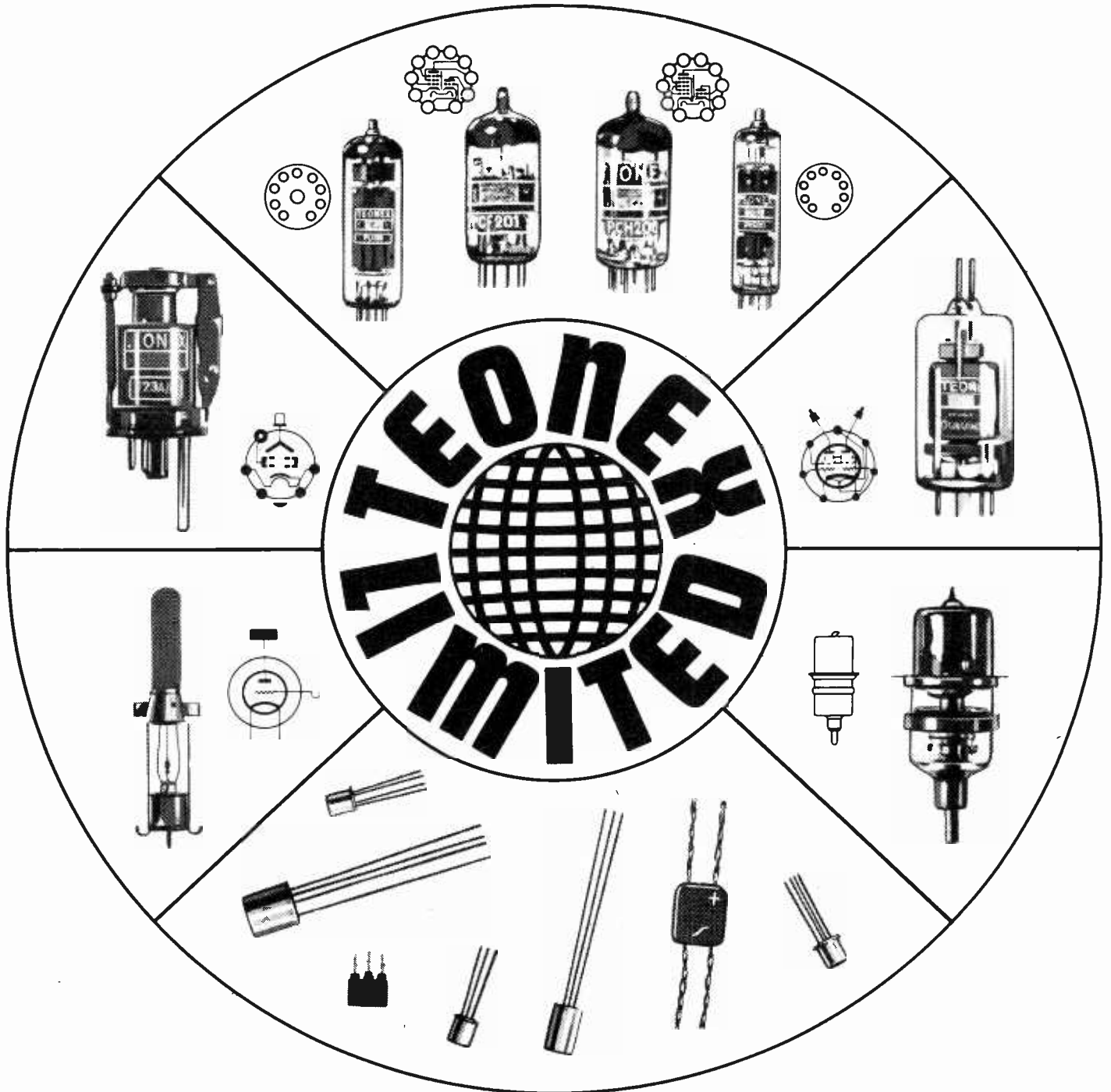
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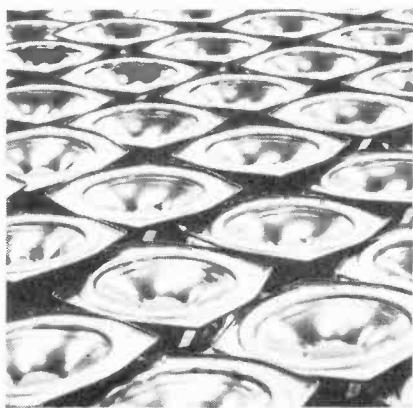
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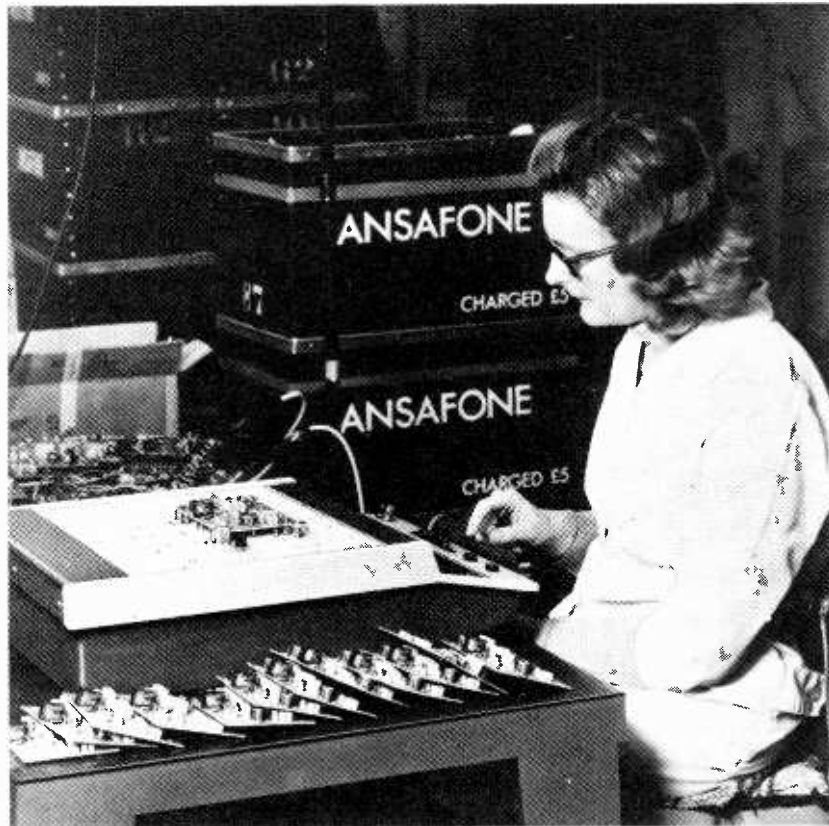
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KEF

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Testmatic answers testing problems



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saying "I-told-you-so" if the saving turns out to be even more dramatic than that.

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The Wayne Kerr Testmatic TM30 tests circuit boards, cableforms, and sub-assemblies. Capable of 30 separate DC measurements, which it does in seconds. For complete information, post this coupon—or call Bognor Regis (02433) 25811.

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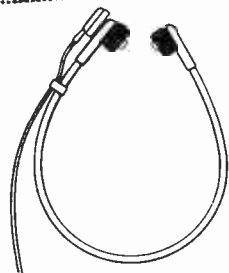
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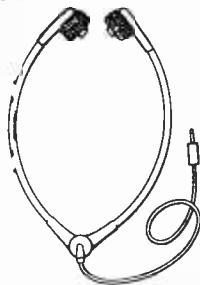
WW—May

Years of research...

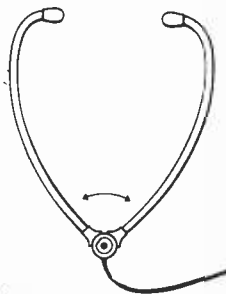
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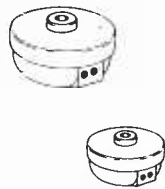
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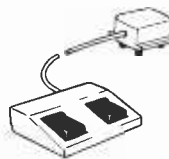
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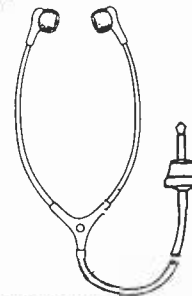
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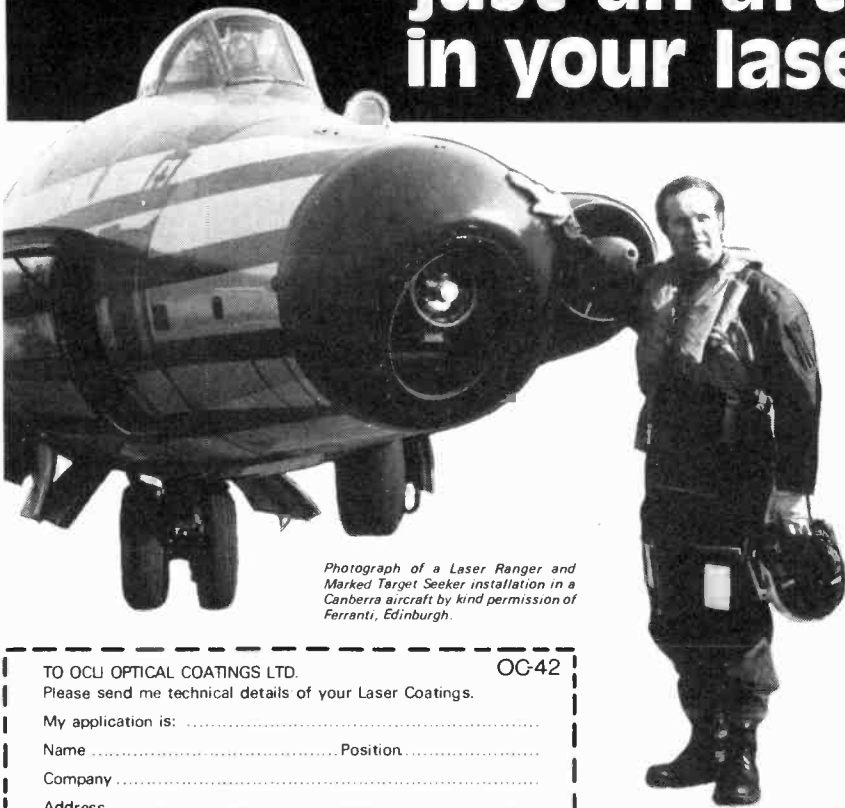


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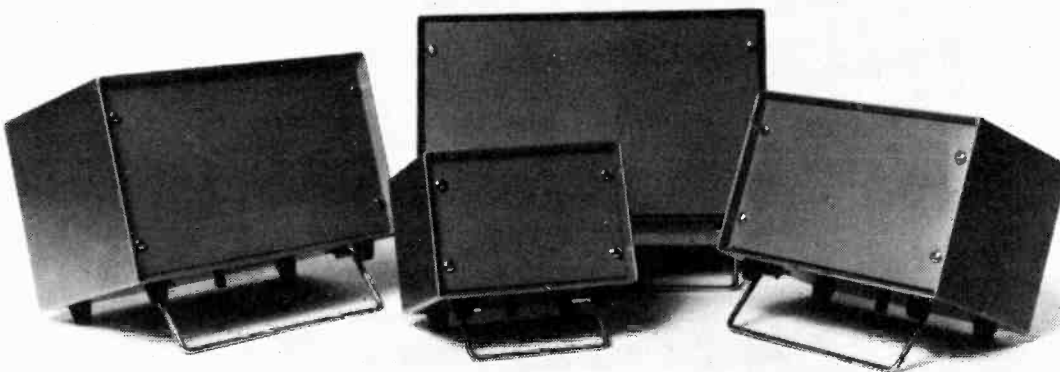
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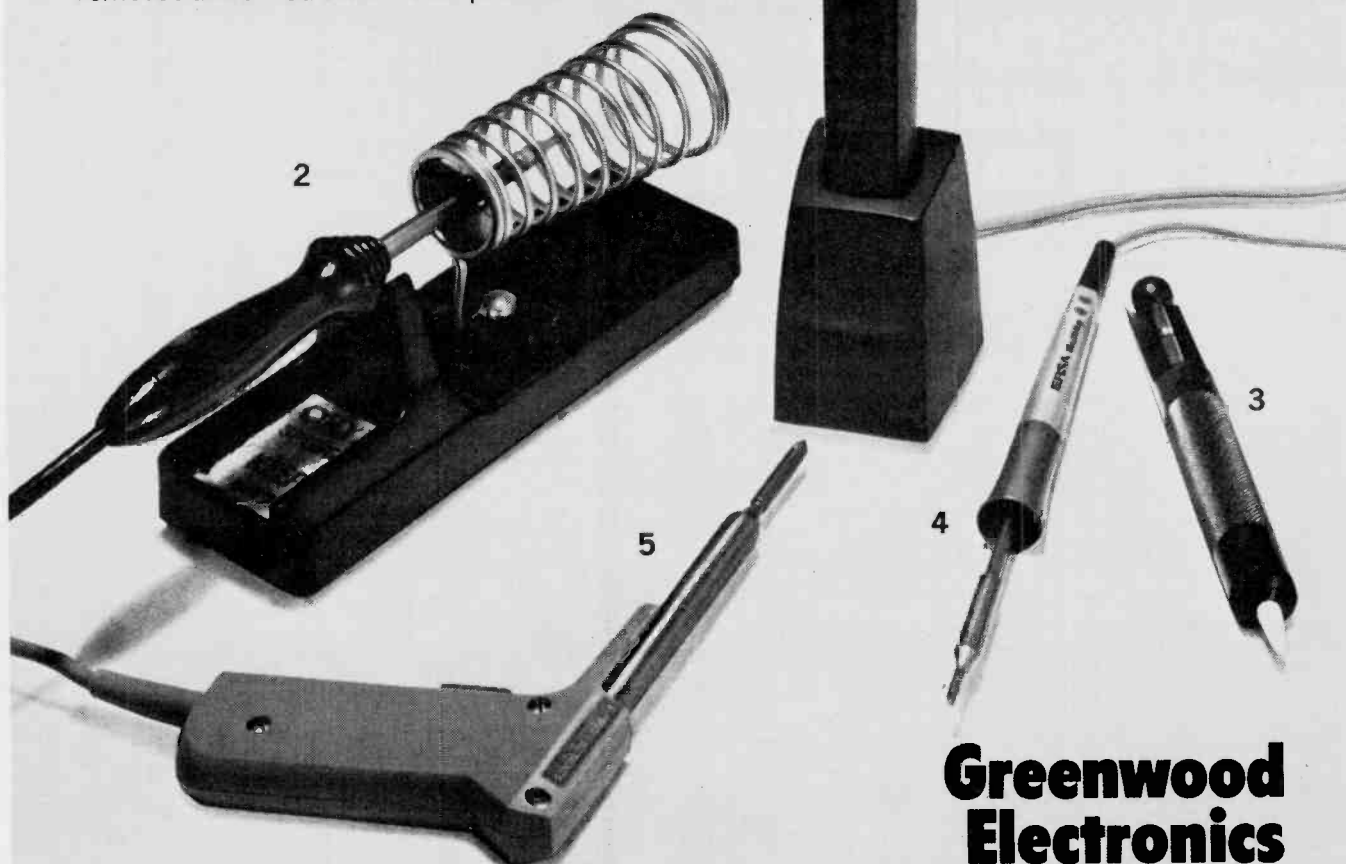
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The illustrations show a selection of modules from the standard range and include the new EM/ 100/100A servo drive system. All items are available individually or can be supplied engineered to custom-built systems.

1. EM 100/100A SERVO AMPLIFIER. A new addition to the range. A complete servo drive system including power supply which is eminently suitable for driving printed circuit motors and other servo motors up to 1/6 h.p. EM 100 - output $\pm 24V$, 4 amps continuous, 45 amps peak. EM 100A - output $\pm 24V$, 7 amps continuous, 75 amps peak.
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3. LOW INERTIA DC SERVO MOTOR. Output 5W
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5. TYPICAL PRECISION GEARS 120 to 32 DP



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Telephone : Steyning (0903) 814321

LTD/S25

WW—023 FOR FURTHER DETAILS

How can you justify buying a new public address system at a time like this?

Nobody's going to forget the 3-day week overnight. It'll take time to catch up on lost production.

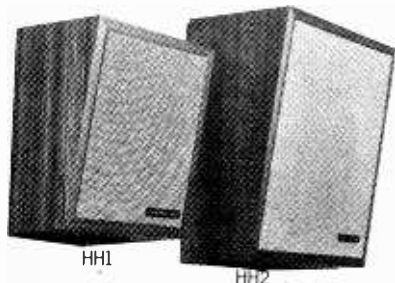
But for the smart, efficient company it's a time to get ahead of competition. A chance to catch up first.

More than ever you'll need to keep everyone on their toes, ready for last minute instructions, always available for an unexpected meeting.



TPA 20 PAGING AMP.

One of the best ways we know of doing this is a good public address system. Like the equipment you see here from the Eagle range.



HH1 HH2
WALL MOUNTING SPEAKERS.

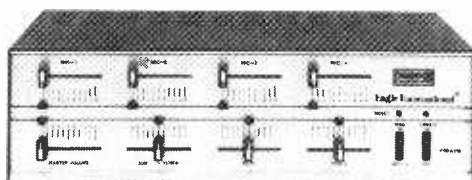
Imagine how much time you'd save with every member of staff at your receptionist's fingertips.

At the touch of a switch she could reach anyone you wanted—whether they were out in the loading bay, in one of the offices, on the factory floor. Anywhere.



DD7 DD5
PAGING MICROPHONES.

Whatever size your office, factory or workshop, we have the perfect PA system to suit you.



PRO. A120-120 WATTS AMP.

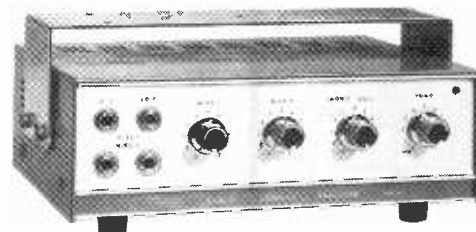
There's even a specialised contractor in your own area who's used to dealing with us. He'll come and fit your system with no fuss, and very little waiting. For him it's a simple wiring job.



HDB 8/12
OUTDOOR SPEAKER.

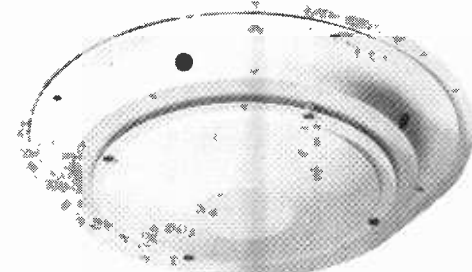
And because he's local you'll get a speedy after-sales service. As well as our two year guarantee.

If it only saves you a few minutes a day over the next critical months, your profits will be looking up again sooner than you expected.



TPA 40 MAINS/MOBILE AMP.

And who knows, maybe sooner than anyone else's.



FF22 CEILING SPEAKER.

Eagle International

Eagle International, Precision Centre, Heather Park Drive, Wembley HA0 1SU. Telephone 01-903 0144.

Please send me more information on Eagle PA and details of how it can help towards more efficient running of my firm.

Name _____

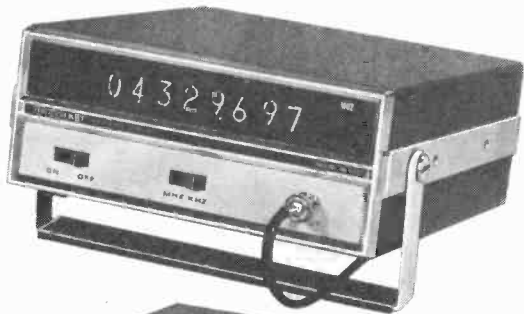
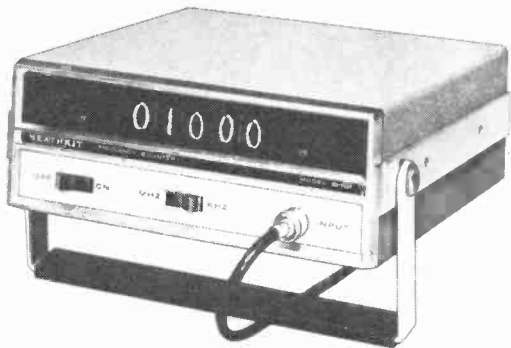
Company _____

Address _____

Telephone No. _____ WW1

Mr. W. Morrow, Eagle International, Precision Centre, Heather Park Drive, Wembley, Middlesex HA0 1SU. Tel. No. 01-903 0144.

If you need specific details urgently, please don't hesitate to contact Mr. Morrow personally.



Heathkit for Frequency Counters

CHOOSE KITS OR FACTORY ASSEMBLED AND CALIBRATED MODELS.

IB-1101 100 MHz counter with 5-digit resolution—8 digit capability; 50–100 mV sensitivity; wide range input.
Price – Assembled IB-1101 £108.50 + VAT.

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IB-1103 180 MHz counter with phase-locked frequency multiplier; 8½ digit display plus overrange; 50–100 mV sensitivity; time-base stability better than ± 1 ppm.

Send for comprehensive catalogue containing complete instrument range.

Free Catalogue

Please send me the FREE Heathkit Catalogue & details of Monthly budget plans.

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ADDRESS _____



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Schlumberger

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Gloucester GL2-6EE

WW—025 FOR FURTHER DETAILS



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IF YOU'RE STILL NOT CONVINCED THAT AMTRON ELECTRONIC KITS ARE A GREAT SALES PROMOTION—THINK ABOUT OUR 'SALE OR RETURN' OFFER

*And that there are over 200 different kits for your customers to choose from appealing to hobbyists, students, teachers, technicians, etc. etc.

*And that Rec. Ret. Prices vary from £1.56 to £96.00—a very wide market.

*And that we look after all after-sales services and similar worries for you.

*And that we pass on all the numerous enquiries that we get everyday straight to our dealers.

*And that we support you with constant national advertising.

*And that we supply you with all the necessary brochures, catalogues and price lists, etc., that you need, along with very attractive point-of-sale material and useful sales-aids.

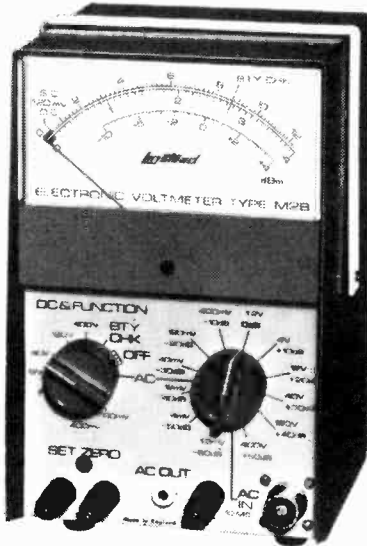
*In fact, if you don't already stock AMTRON Kits you're missing out. So what are you waiting for? Contact us today for further information.



THE BIG NAME IN ELECTRONIC KITS

AMTRON U.K., 4 & 7 CASTLE STREET, HASTINGS, SUSSEX TN34 3DY. Telephone HASTINGS 437875

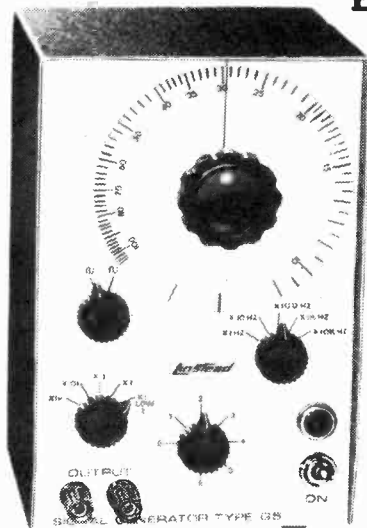
Linstead Laboratory Instruments



M2B

WIDE RANGE MILLIVOLTMETER
High impedance millivoltmeter with 20 scales total measurement range 60 micro-amp a.c. to 400 volts d.c. 10-megohm input with overload protection and frequency range of 500 kHz.

£38.80



G5

WIDE BAND SIGNAL GENERATOR
Sine-square wave wide band high power signal generator. 10 Hz-1 MHz. 0-6 volts r.m.s. 2 watts into 5 ohms incorporating short circuit protection.

NUFFIELD SPECIFICATION 181

£32.80

Linstead
the best for less

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London N15 5JB. Telephone: 01-802 5144**

Ireland, Lennox Laboratory Supplies Ltd., 3/4 South Leinster Street,
PO Box 212A, Dublin 2.

Denmark, Scanfysik, 13-15 Hjørringgade, DK 2100, Copenhagen.

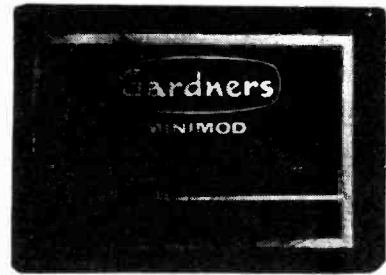
Sweden, EMI Svenska A/B, Tritonvagen 17, Fack, 171 19 Solna 1.

Norway, EMI Norsk A/S, Postboks 42 Korsvoll, Oslo 8.

Malaysia, Laboratory Equipment Sdn. Bhd., P.O. Box 60, Batu Pahat.

Benelux, A.S.E. Ltd., Nationalestreet 38, B-2000 Antwerp.

WW-026 FOR FURTHER DETAILS



Minimod

Made in Britain by Gardners...

First of a new range of all-British miniature encapsulated power supplies, the Minimod series is designed and manufactured by Gardners to provide reliable, regulated power supplies in a neat pack designed to plug into your P.C. board. Minimod simplifies development or production of equipment by providing power where

you need it. Minimod provides a choice of a standard 5 volt output (available up to 1 Amp) for digital circuits or 12-0-12 or 15-0-15 volts for linear circuits, using a 230 volt input. Each unit is fully stabilised with fold back current limiting, and in the case of 5 volt units, over voltage crowbar is provided . . .

Ask Gardners to tell you more about Minimod. Standard or special models can be supplied.

Gardners

Specialists in Electronic Transformers and Power Supplies.

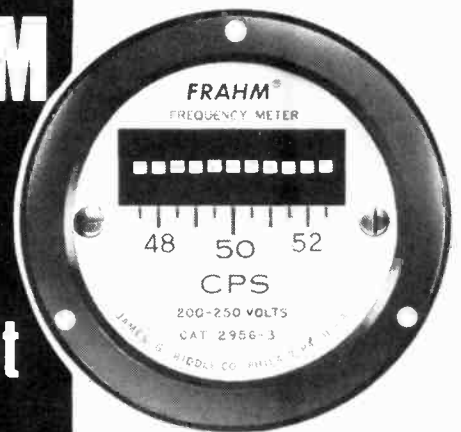
GARDNERS

TRANSFORMERS LIMITED

Gardners Transformers Limited, Christchurch, Hampshire BH23 3PN
Telephone 02-015 2284 Telex 41276 Gardners XCH

WW-027 FOR FURTHER DETAILS

FRAHM



resonant reed FREQUENCY METERS

used as standards in many industries

- Accurate to $\pm 0.3\%$ or $\pm 0.1\%$ as specified
- Not sensitive to voltage or temperature changes, within wide limits
- Unaffected by waveform errors, load, power factor or phase shift
- Operational on A.C., pulsating or interrupted D.C., and super-imposed circuits
- Need only low input power
- Compact and self-contained
- Rugged and dependable

FRAHM Resonant Reed Frequency Meters are available in plastic and hermetically sealed cases to British and U.S. Government approved specification. Ranges 10-1700 Hz. Literature on these meters and Frahm Resonant Reed Tachometers available on request. Manufacture and Distribution of Electrical Measuring Instruments and Electronic Equipment. The largest stocks in the U.K. for off-the-shelf delivery.

ANDERS ELECTRONICS LIMITED

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Anders means meters

WW-028 FOR FURTHER DETAILS

The new Rank WOW & FLUTTER Meter Type 1742



Fully transistorised
for high reliability

Versatile

Meets in every respect all current specifications for measurement of Wow, Flutter and Drift on Optical and Magnetic sound recording/reproduction equipment using film, tape or disc

High accuracy

with crystal controlled oscillator

Simple to use

accepts wide range of input signals with no manual tuning or adjustment

Two models available:

- Type 1742 'A' BS 4847: 1972 DIN 45507
CCIR 409-2 Specifications
- Type 1742 'B' BS 1988: 1953 Rank Kalee
Specifications

For further information please address your enquiry to

Mrs B. Nodwell
Rank Film Equipment, PO Box 70
Great West Road, Brentford
Middlesex TW8 9HR

Tel: 01-568 9222 · Telex 24408 · Cables Rankaudio Brentford



WW-033 FOR FURTHER DETAILS

**1" and 1/2" Video Tape
from
Dixons Technical.
At very
non-technical prices.**

Our 1/2" Tape range.	Recommended Price (Exc. VAT)	Dixons Price
SCOTCH 1/2" 2400 ft	£10.40	£8.50
SCOTCH 1/2" 3000 ft	£16.82	£13.50
BASF 1/2" 2400 ft	£10.75	£8.50
SHIBADEN 1/2" 2400 ft	£10.80	£9.10
DIXTEC CCTV 1/2" 2400 ft		£5.50

**Now 1" tape at less
than half price!**

	Average recommended price (Exc. VAT)	Dixons price
1075 ft on 8" x 1" NAB Metal Spool	£15.00	£7.00
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2150 ft on 8" x 1" NAB Metal Spool	£20.75	£9.50
3000 ft on 9 3/4" x 1" NAB Metal Spool	£26.50	£9.50

All Dixtec Video Tapes are of the highest quality; we supply 1/2" in air-tight containers, also 1" on metal spools. Current stocks are high, but so is demand. We recommend you place your order quickly.

Please send me reels of Tape.

Size Length Dixons Price

TOTAL PRICE:

I enclose a cheque made payable to Dixons Technical Limited.

NAME

ADDRESS



WW/VT/5

WW-034 FOR FURTHER DETAILS

NEW VAT INCLUSIVE PRICES

OVERSEAS CUSTOMERS DEDUCT ONE ELEVENTH.

AUDIO I.C.'S

Audio I.C. Leaflet No. 12 (Circuit data etc) FREE with I.C.'s 10p separately.

- MC1303L £1.89
Dual Pre-amp
- MC1339P £1.29
Low noise Dual Pre-amp Single
- MFC4000 A or B 49p
250mW
- TAA300 £1.79
1 Watt into 8n. 9v rail
- LM380 £1.40
2 Watt
- SL414* £1.76
3 Watt NEW pin for pin replacement for SL403D
- TBA800 £1.59
5 Watt into 356
- BHA0002 £3.95
15 Watt
- NE540L £1.32
35 Watt driver TO99 Can
- MC1310 £3.05
Inductorless, phase-locked loop multiplex stereo decoder, supplied with FREE leaflet No 11 (available separately 10p)
- MC1312 £6.49
The I.C. CBS SQ Quadraphonic decoder Available, only with all components inc. veroboard & detailed leaflet. Price is all inclusive.

*see SL414 above. Also available, heatsink for SL414 or SL415 15p. Suitable stereo P/C Board 69p. SL415 (5 Watt Amp) £2.29
ZN414 with free leaflet no 10 £1.32

74 Series TTL

INTERNATIONALLY KNOWN BRANDS
1st. GRADE DEVICES AT NEW ROCK BOTTOM PRICES

SN7400	20p	SN7473	41p
SN7401	20p	SN7474	41p
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SN7404	20p	SN7476	44p
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SN7413	31p	SN7493	82p
SN7420	20p	SN74100	£2.37
SN7430	20p	SN74121	45p
SN7441	81p	SN74141	£1.10
SN7442	81p	SN74192	£2.15
SN7447	£1.45		

Cheapest Opto yet GaAsp LED's

Remember **Vat Inclusive Prices**

RED
LED 2. 0-125" 26p
LED 3. 0-175" 17p

GREEN
LED 4. 0-125" 69p
LED 5. 0-175" 75p

PRICE BARRIER SLASHED

LED READOUTS LITRONIX DL707 SERIES

1" high characters 14pin Di! Ref LED 1

also available + 1 Ref LED 1A

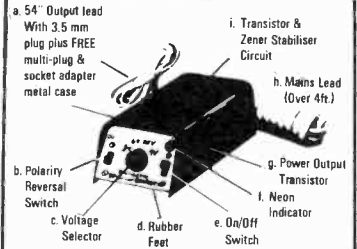
£1.99 + 20p VAT = £2.19

Linears

8pin DIP	TO99	14pin Dtl
709 34p	40p	35p
710 35p	40p	39p
711 —	45p	39p
723 —	96p	95p
741 42p	45p	43p
747 —	—	32p
748 42p	45p	43p
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CA3075 £1.65	MVR12V (L036) £1.65	
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LM201H £1.15	NE 560 B £4.92	
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NEW stabilised POWER PACK/CONVERTER

Switched 3, 6, 7½ or 9 Volts
Up to 400ma Output



Our Price £4.99 + p & p 20p
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Other Eliminators (unstablised)* £1.65
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Dual in line

8pin 13½p	28pin 30½p	14pin 15½p
14pin 15½p	36pin 39½p	16pin 17½p
16pin 17½p	40pin 44p	24pin 26½p

Z16 Z46

NEW

- MM5316 - alarm clock £16.50
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CHROMASONIC electronics

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DIGITAL CLOCK



MM5314

12 or 24 hour. 4 or 6 digit
50 or 60Hz operation
leading zero supression
single voltage supply
similar to DIGITRONIC in
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Only £ 7.99

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Transistor Range
Series 1T to 5T inclusive
Blue; Yellow; Red & White
All 49p each

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R.F. Choke Range 0.1uH to 19mH
For full details ask for leaflet No. 5 p & p 5p.

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COPPERCLAD	PLAIN	EXTRA P & P
2½ x 3½" 0.1" 24p	0.15" 18p	12p
2½ x 5" 26p	23p	13p
3½ x 3½" 26p	23p	—
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17 x 5" —	90p	10p
Dip Breaboard 4.15" x 6.15"		£1.15
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Terminal Pins (PK550)—State Size		55p

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TYPE C804	TYPE 0	TYPE 00
5pf 71p	365pt 83p	365pt & 365pt 99p
10pf 71p		
15pf 71p		
20pf 77p		
25pf 71p		
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60pf 83p		
75pf 83p		
100pf 85p		
		208 + 176pf with screen & trimmers 99p
		Dilecon 100pf 69p
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3 1/2 decade DVM

Price includes data booklet (10p separately)

A State-of-the-Art Digital Voltmeter I.C. or only £7.79



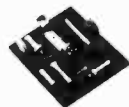
Mullard LP1186

Varactor diode tuned F.M. Tuning heart £4.75 as described in P.E. May 1973. LP1185 matching 1.F strip £5.50.



THE TEXAS

20 + 20 Watt Integrated stereo amplifier Kit superb state-of-the-art design by engineers of Texas Instruments £31.35 + p & p 49p



SGS EA1000

3 Watt amplifier module Price including handbox and FREE HEATSINK (Quantity Discounts) Our Price £2.49



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F.M. tuner chassis, fully transistorised, 9 Volt positive earth operation Our Price £8.20



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Goldring Manufacturing
Company (Great Britain) Ltd.

EPPING
Essex
10. 6. 1973

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Yours faithfully
D. M. Day

One of our customers puts the achievement of the G800 on record!

This letter is typical of many received by Goldring. If you would like some further evidence, start by writing for a full descriptive leaflet on Goldring Cartridges to: Goldring Limited, 10 Bayford Street, Hackney, London E8 3SE.

Goldring ©

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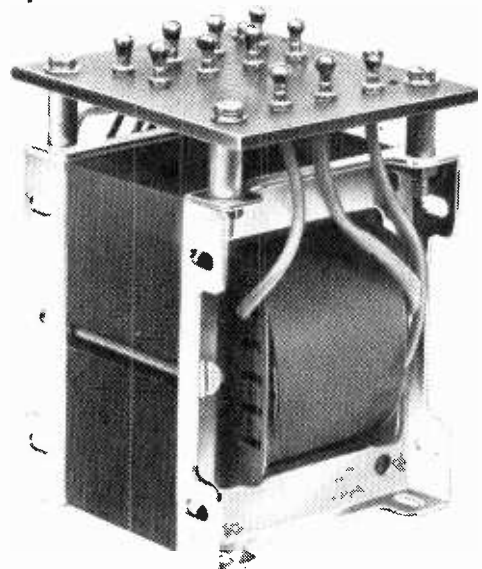
transformers

mains, audio, microphone, ferrite core and other wound components

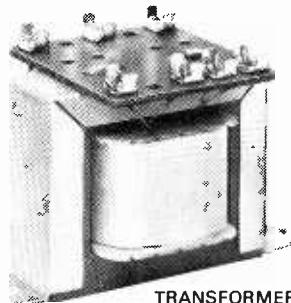
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TRANSFORMER WITH TWO HOLE CLAMP AND SOLDER TAG CONNECTIONS

Drake Transformers Limited

Telephone:
Billericay 51155

Kennel Lane,
Billericay, Essex.

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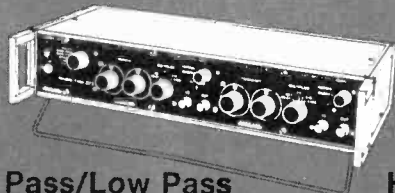
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MODULAR FILTERING

ONE MAIN FRAME - MANY OPTIONS



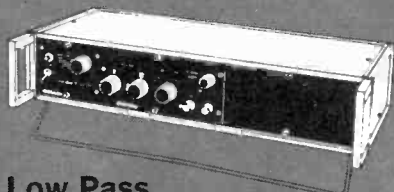
High Pass



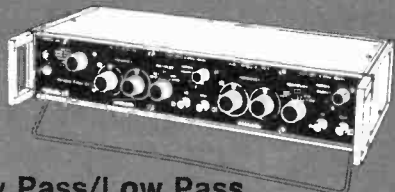
High Pass/Low Pass



High Pass/High Pass



Low Pass



Low Pass/Low Pass

and that's
only the start!

Barr & Stroud's new EF3 Electronic Filter System means no more compromises when you buy variable filters. Now you can get the filter you need today, and additional plug-in units tomorrow. Today — the basic main frame and your choice of two modules to operate in low-pass, high-pass, band-pass, band-stop, band-separate, band-combine or cascade modes. Tomorrow — other interchangeable modules to meet your newest requirements. The first two modules,

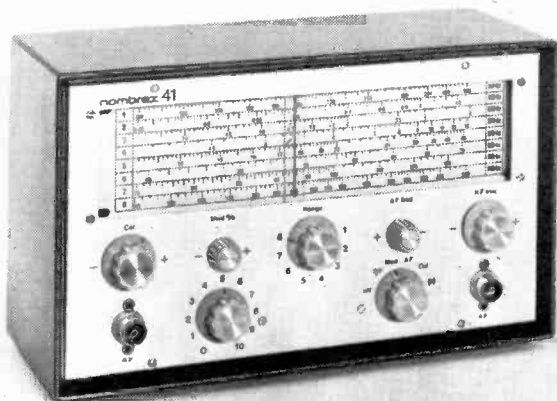
already available, provide filtering with variable cut-offs between 0.01Hz and 10.0kHz, stop-band attenuation of 48dB/oct. (96dB/oct. in cascade), and pass-band response from dc to 500kHz. Get full details of EF3, the big breakthrough in electronic filtering from

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1 Pall Mall East, London SW1Y 5AU
Tel: 01-930 1541
Telex: 261877



WW—038 FOR FURTHER DETAILS

nombrex



MODEL 41
R.F. SIGNAL GENERATOR
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PLUS 10% FOR V.A.T.

- ★ 150 KHz — 220 MHz on fundamentals.
- ★ 8 clear scales — Total length 130mm.
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- ★ Powered by 9V Battery.

Trade and Export enquiries welcome.

Send for full technical leaflets.

Post and Packing 50p. extra.

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WW—039 FOR FURTHER DETAILS

JUST ONE OF A RANGE



TYPE 301

32 MHz, 50mV Sensitivity, STABILITY 3 parts in 10⁶ **£75**
DELIVERY . . . EX-STOCK TO 10 DAYS

THE HIGHEST PERFORMANCE DIGITAL FREQUENCY COUNTERS
AT THE PRICE IN THE WORLD EVERYBODY BUYS THEM

OTHERS IN THE RANGE:—

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PRICES EXCLUSIVE OF VAT

ELECTRONIC START STOP version PLUS £12

MEMORY version PLUS £25

DIRECTLY COUPLED INPUT AND SPECIALS AS REQUIRED

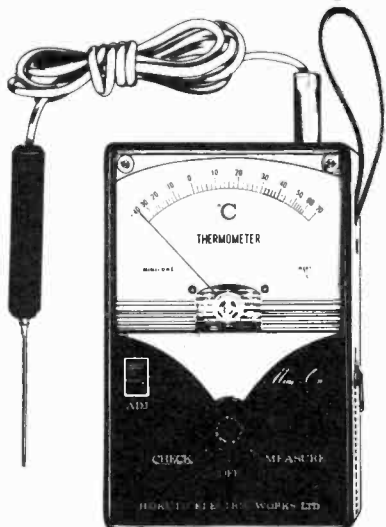
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ELECTRONIC INDUSTRIAL THERMOMETER



THE MODERN WAY TO MEASURE TEMPERATURE

A Thermometer designed to operate as an Electronic Test Meter. Will measure temperature of Air, Metals, Liquids, Machinery, etc., etc. Just plug-in the Probe, and read the temperature on the large open scale meter. Supplied in zippered vinyl case with transparent front and carrying loop. Probe, and internal 1½ volt standard size battery. Model "Mini-On 1" measures from - 40°C to + 70°C, price £17.50 Model "Mini-On Hi" measures from + 100°C to + 500°C, price £20.00 (V.A.T. EXTRA)

Write for further details to

HARRIS ELECTRONICS (LONDON),
138 GRAY'S INN ROAD, LONDON WC1X 8AX
(*Phone 01-837 7937)

WW-047 FOR FURTHER DETAILS

Gardners line up

Line Matching Transformers from Standard to Super Fidelity

It's easy to choose the right Line Matching Transformer from the five Gardners ranges

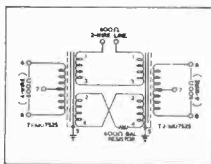
The Super Fidelity Series, with a frequency response of 10Hz to 80kHz - 0.5dB, gives the widest possible bandwidth for high accuracy instrumentation and recording applications.

Then there's the Wide and Extra Wide-band ranges. Outstanding performers with a frequency range 30Hz - 20kHz or more - for the 0.5dB points. Used a lot by broadcasting and recording companies throughout the world.



The Miniature and Standard ranges provide excellent bandwidth for most purposes. 30Hz - 22kHz for the 1.0dB points

Except for the very smallest in the range, all Gardners Line Matching Transformers are fully magnetically shielded, giving very high hum rejection ratios.



So accurate is the balancing of the windings on some of these transformers that, when used as pairs in a hybrid circuit (as illustrated) we can guarantee a rejection of better than -55dB over the frequency range 50Hz to 10kHz and normal rejection of up to 75dB may be expected



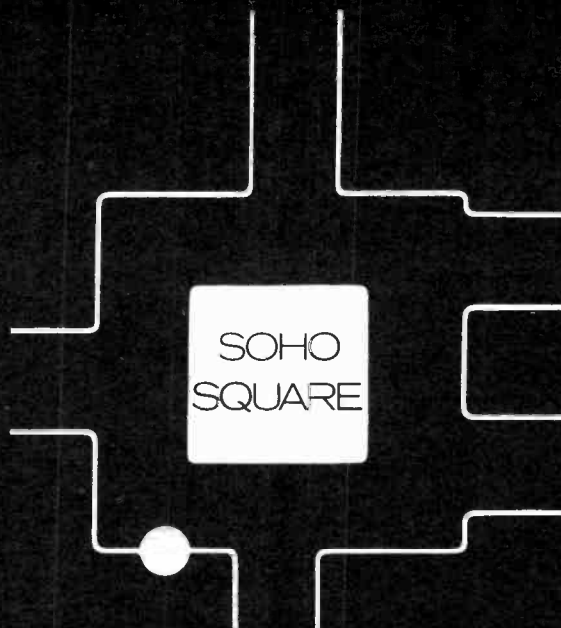
Specialists in Electronic Transformers and Modular Power Supplies

GARDNERS

TRANSFORMERS LIMITED

Gardners Transformers Limited, Christchurch, Hampshire, BH23 3PN
Tel: Christchurch 2284 (STD 0201 5 2284) Telex 41276 GARDNERS XCH

WW-048 FOR FURTHER DETAILS



CCTV in Soho

As a result of continued expansion, Dixons Technical require CCTV engineers to work in their new showrooms and workshops.

Applicants should be fully experienced in the installation and maintenance of PalColour cameras, videotape recorders and all makes of CCTV equipment.

Salaries around £3500 can be expected along with a pension scheme and all other benefits associated with a large company.

Dixons Technical Ltd

Write or telephone

Mike Biddle, Managing Director, Dixons Technical Ltd.
3 Soho Square London W1 01-437 8811

Importers of ITC Palca Fora equipment.
Agents for National Panasonic, Akai, Philips, Shibaden.

WW-049 FOR FURTHER DETAILS

Celestion Loudspeaker Engineering advances the state of the art to a new plateau.

Ditton 66 Studio Monitor



1.) Celestion's new super tweeter. 2.) New design 'pressure' mid-range unit. 3.) Ultra Linear 12" Bass drive unit. 4.) A.B.R. ensures controlled bass down to 16Hz. 5.) Precision crossover for perfect system integration.

A new Loudspeaker of advanced design suitable for studio use and for home installations of the highest quality.

UNITS: HF 2000 (dome 'pressure' type) MF 500 (Mid-range Dome 'pressure' type) Ultra linear 12" bass driver and 12" AER. The crossover has resulted from considerable research and crossover points are at 500 Hz and 5000 Hz 80 Watts Maximum, 4-8 ohm. This monitor loudspeaker system has an exceptionally wide and flat frequency response. Very low order harmonic and inter-modulation distortion. Precise response to transients. Beautifully maintained polar response ensures absence of unwanted directional effects and provides a highly satisfactory stereo image throughout the listening area. Matched pairs.

SIZE 40 x 15 x 11 1/2 Natural Teak or Walnut Cabinet

Celestion



Loudspeakers for the Perfectionist

ROLA CELESTION LTD.
DITTON WORKS, FOXHALL ROAD, IPSWICH, SUFFOLK IP3 8JP

WW—050 FOR FURTHER DETAILS

S single SOURCE makes sense

IF you buy electronic or electrical components, industrial or consumer fastenings . . .

As the largest stockists of Cinch, Dot & FT products we shall be happy to deliver small or assorted quantities of anything you need. Let us have your next enquiry.

Make United-Carr Supplies your SINGLE SOURCE for

CINCH

DOT

FT

United-Carr Supplies Ltd., 112 Station Road,
Ilkeston, Derbyshire, DE7 5LF.

Tel: Ilkeston 78711 STD 06072 78711. Telex: 377117

WW—051 FOR FURTHER DETAILS

DO YOU WANT

a 1MHz
pen recorder ?

to use your
oscilloscope
for storage
with digital
readout ?

to capture
one-shot
waveforms ?

Then see the
datalab
range of transient
recorders on stand 623—
IEA, or details from:



DL901



DL905

Data Laboratories Limited, 28 Wates Way, MITCHAM CR4 4HR, Surrey Tel: 01-648 4643/4 Telex: 947680

WW—052 FOR FURTHER DETAILS

chart recorder



TYPE CR100

Designed and built to professional standards this British product introduces a new price/performance concept in pen-recording. Modular design and optional facilities permit an advanced system to be built up at a modest cost.

Facilities include access to a transmitting potentiometer with or without "High-Low" alarm facilities; remote control of speed selection; extension of basic speed ranges by externally generated digital pulses; ability to 'slave' one recorder to another for chart speed correlation; event marker; range of existing and projected plug-in pre-amplifiers.

Slewing rate: 400 mm/sec
Sensitivity: 50 μ V/cm - 500 nV/cm [with pre-amplifier]
Speeds: 1, 2, 5, 10, 20 sec/cm, 1, 2, 5, 10 min/cm
Paper size: 270 mm wide [DIN 16230]
Paper drive: Digitally controlled stepper motor
Pen type: Ballpoint, fibre tip, capillary
Pen drive: Infinite resolution d.c. potentiometric servo

Compact, robust design

Basic Recorder **£154**
Pre-amplifier from **£36**
(prices subject to V.A.T.)

STAND No. 630
ground floor
I.E.A. OLYMPIA

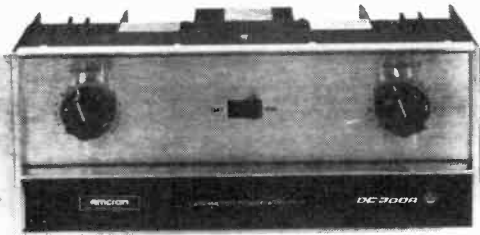


J.J. Lloyd Instruments Limited

Brook Avenue, Warsash, Southampton SO3 6HP. Tel Locks Heath 4221
Telex No. 477042 JAY JAY - SOTON

WW—053 FOR FURTHER DETAILS

HIGH POWER DC-COUPLED AMPLIFIER



- ★ UP TO 500 WATTS RMS FROM ONE CHANNEL
- ★ DC-COUPLED THROUGHOUT
- ★ OPERATES INTO LOADS AS LOW AS 1 OHM
- ★ FULLY PROTECTED AGAINST SHORT CCT, MISMATCH, ETC.
- ★ 3 YEAR WARRANTY ON PARTS AND LABOUR

The DC300A Power Amplifier is the successor to the world famous DC300 which is so widely used in Industrial, and Research applications in this country. It is DC-coupled throughout so providing a power bandwidth from DC to over 20,000Hz. The ability of the DC300A to operate without fuss into totally reactive loads while delivering its full power, and maintaining its faithful reproduction of Pulse or complex waveforms has established the DC300A as the world's leading power amplifier. Each of the two channels will operate into loads as low as 1 ohm, and the amplifier can be rapidly connected as a single ended amplifier providing over 650 watts RMS into a 4 ohms load, and still providing a bandwidth down to DC. Below is a brief specification of the DC300A, but if you require a data sheet, or a demonstration of this fine equipment please let us know.

Power Bandwidth	DC-20kHz @ 150 watts + 1db. - 0db.	Slewing Rate	8 volts per microsecond
Power at clip point (1 chan)	500 watts rms into 2.5 ohms	Load impedance	1 ohm to infinity
Phase Response	+0. - 15° DC to 20kHz. 1 watt 8Ω	Input sensitivity	1.75 V for 150 watts into 8Ω
Harmonic Distortion	Below 0.05% DC to 20kHz	Input Impedance	10K ohms to 100K ohms
Intermod. Distortion	Below 0.05% 0.01 watt to 150 watts	Protection	Short, mismatch & open cct. protection
Damping Factor	Greater than 200 DC to 1kHz at 8Ω	Power supply	120-256V, 50-400Hz
Hum & Noise (20-20kHz)	At least 110db below 150 watts	Dimensions	19" Rackmount, 7" High, 9 3/4" Deep
Other models in the range: D60 — 60 watts per channel		D150 — 150 watts per channel	

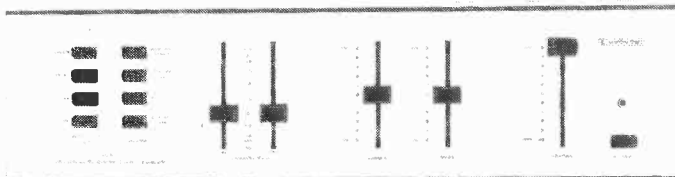


MACINNES LABORATORIES LTD

MACINNES HOUSE, CARLTON PARK INDUSTRIAL ESTATE,
SAXMUNDHAM, SUFFOLK IP17 2NL
TEL: (0728) 2262 2615

WW—054 FOR FURTHER DETAILS

A NEW STANDARD FOR SOUND REPRODUCTION HD250 High Definition Stereo Control Amplifier



Designed for disc and tuner input and two tape machines, with complete recording and reproducing facilities.

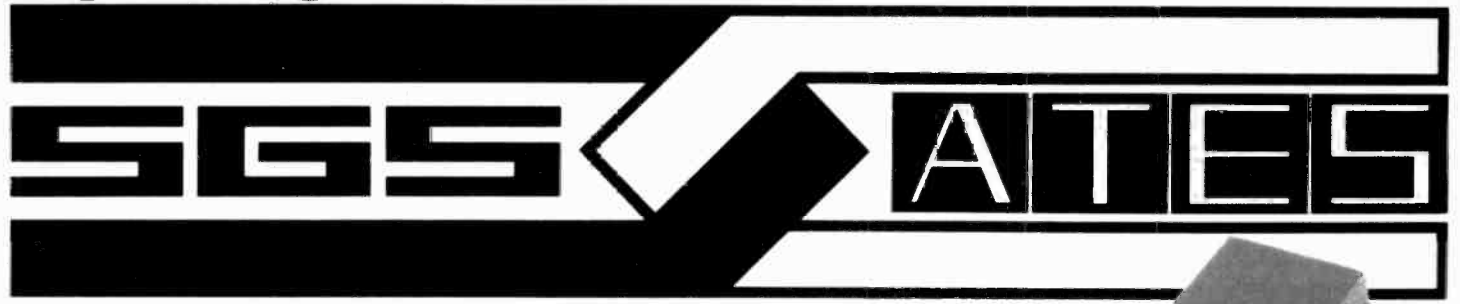
The HD250 amplifier establishes a new standard in amplifiers for sound reproduction in the home. Improvements have been made in respect of performance, engineering design and quality of construction. We believe that no other amplifier in the world can match the specification of the HD250. Look at extracts from the specification below.

Power output.		Overload margin.	
Rated:	50 watts average continuous power per channel, into any impedance from 4 to 8 ohms, both channels driven.	Disc input	40 dB min.
Maximum:	90 watts average power per channel into 5 ohms load.	Hum and noise output.	
Distortion.		Disc:	—83dBV Measured flat with noise bandwidth of 23kHz. —88dBV Measured with 'A' weighted characteristic
Pre-amplifier:	Zero. (Cannot be identified or measured as it is below inherent circuit noise.)	Line:	—85dBV Measured flat. —88dBV 'A' weighted.
Power amplifier:		Size:	17 inches X 4 3/4 inches X 11 inches deep overall.
at rated output:	Less than 0.02% (typically 0.01% at 1kHz).	Weight:	21 lb.
at 25w output:	Typically 0.006%.		

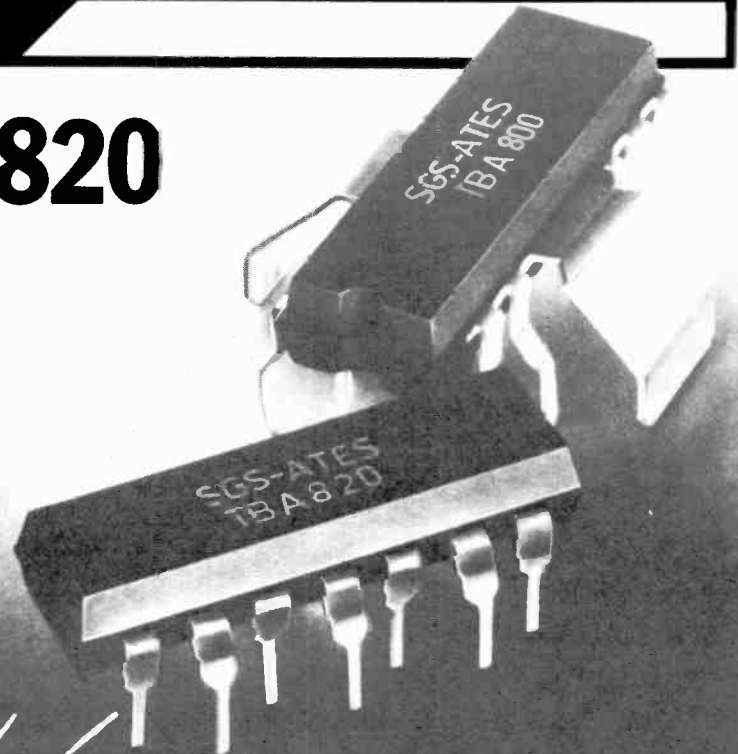
Write or phone for leaflet which describes the design philosophy and conception of the HD250 together with a complete specification.

RADFORD AUDIO LIMITED, BRISTOL, BS3 2HZ Telephone: 0272 662301

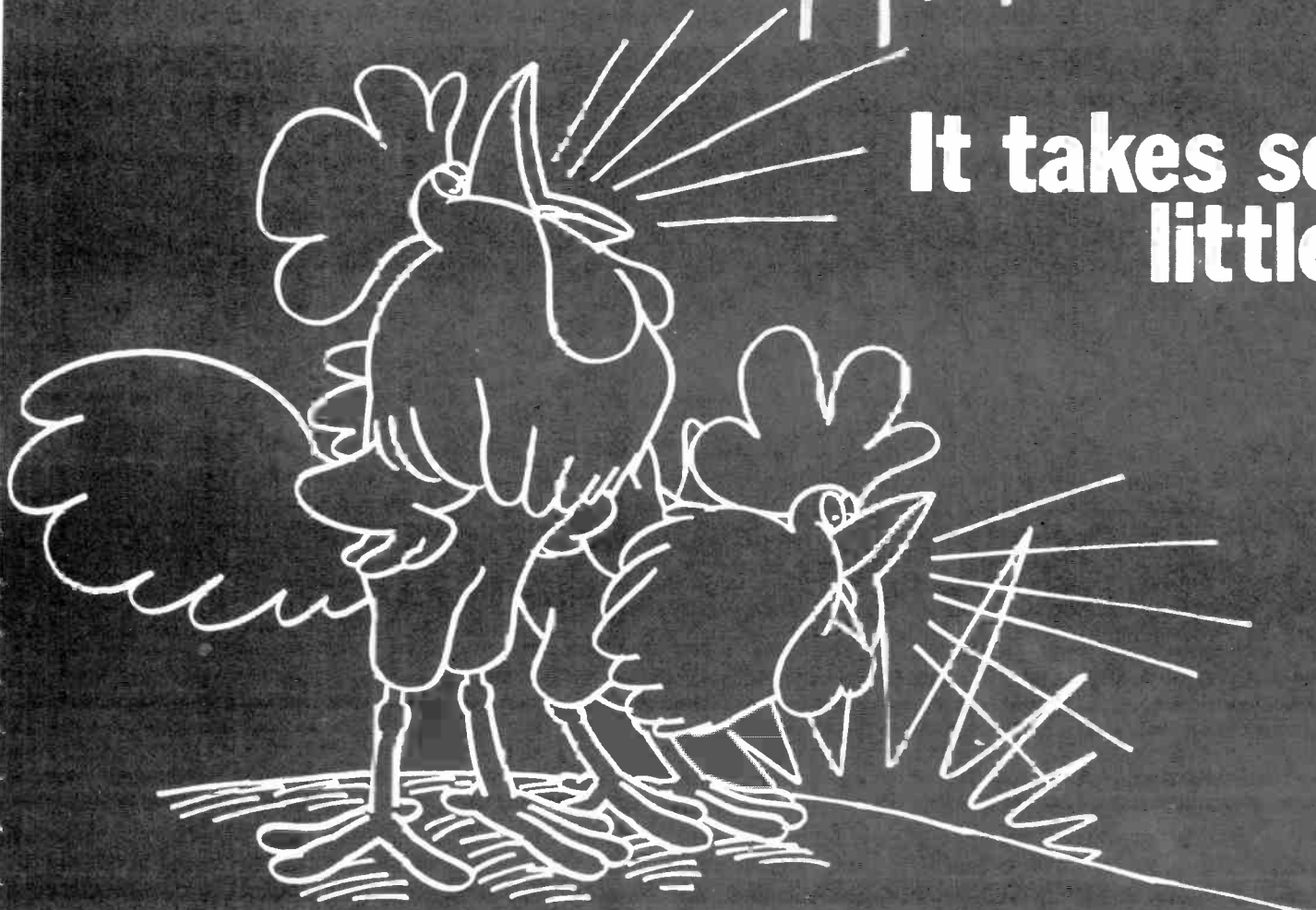
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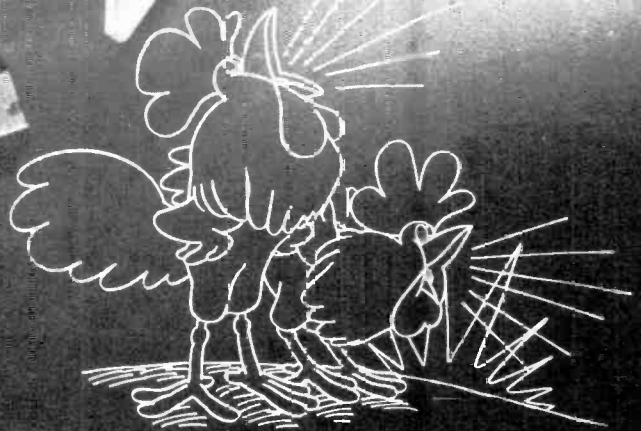
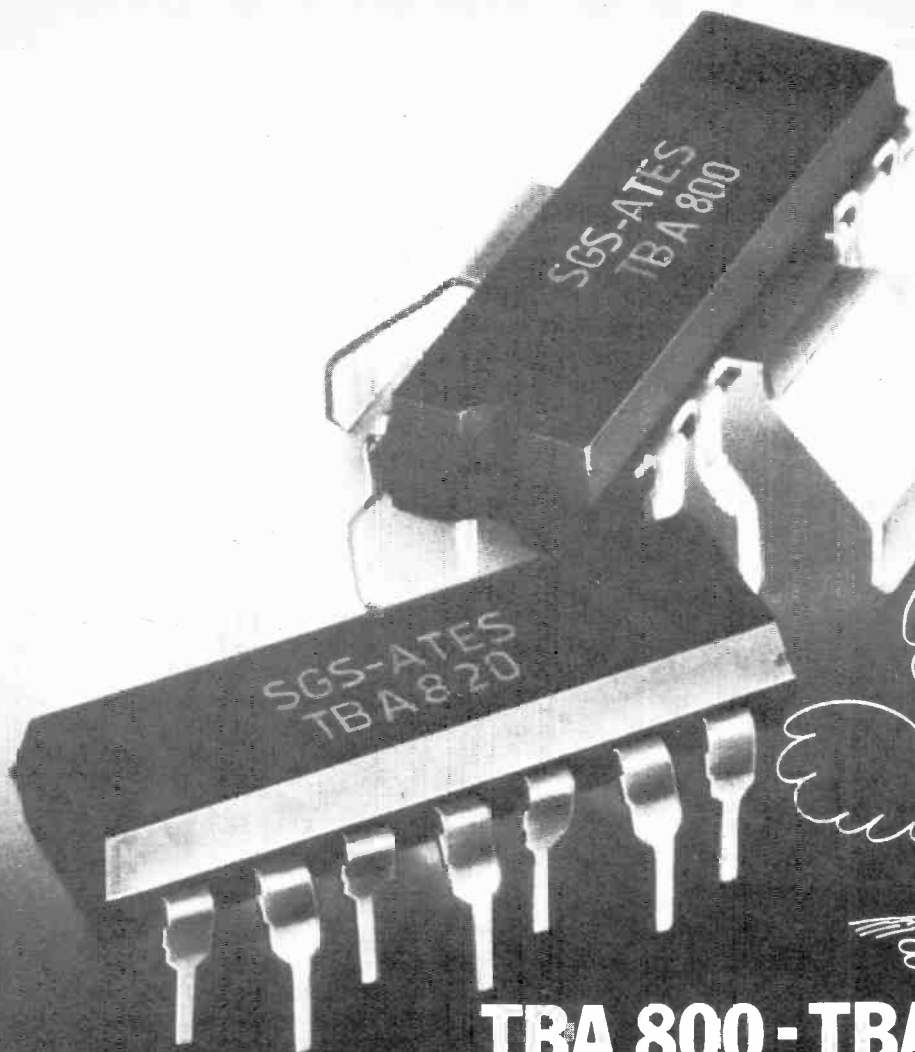
TBA 800 - TBA 820



**It takes so
little**



to make them crow at full power



TBA 800 - TBA 820 Cost saving audio power amplifiers

TBA 800 and TBA 820 are much-copied high performance audio circuits, developed and patented by SGS-ATES. They are important new low-cost designs for low frequency stages in radio, record player and TV equipment, and allow the component count to be reduced by more than 50% compared with discrete component audio circuits. Considerable savings can be made in total component cost, storage cost and assembly time with increased performance and reliability. Both devices are available in volume, ex-stock.

TBA 800: 5W at 24V/16Ω

The performance, versatility and easy application of TBA 800 have made it the natural choice for the audio stage in the most advanced colour TV sets manufactured in Europe today. Providing a guaranteed 4.4W (min) output power at 24V/16Ω, it works with a supply voltage up to 30V and

features high efficiency (70% at 4W output) and very low harmonic distortion without cross-over problems. The addition of a complementary transistor output stage will allow power output of 15W.

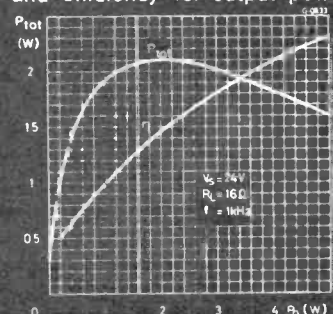
Its high current handling capability (output peak current 2A) makes it suitable for non-audio applications such as vertical deflection in large screen B&W TV sets, or for driving very high power systems. The TBA 800 is mounted in a 12-lead quad in-line package, originally introduced by SGS-ATES, and now an industry standard. The external cooling tabs of this package enable 2.5W to be dissipated without external heat sink while up to 5W can be dissipated using only a small part of the printed circuit copper area as heat sink.

TBA 820: 2W at 12V/8Ω

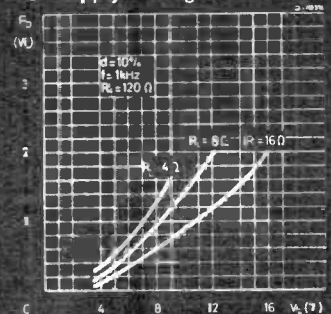
At only £ 0.70 100-999, the TBA 820 is a low cost, high performance audio amplifier. It is specifically designed for portable, battery-operated radios, TV receivers, cassette tape recorders and record players.

Working with supply voltages ranging from 3V to 16V, its low current drain, freedom from motor-boating and absence of cross-over distortion make it the perfect choice for a large variety of applications, including: intercom systems, staff location systems, two-way radios, telephone monitoring amplifiers, ultrasonic door openers, inductive transmitters and receivers. The TBA 820 comes in a 14-lead dual in-line (or quad in-line) plastic package.

TBA 800: dissipation and efficiency vs. output power



TBA 820: out put power vs. supply voltage



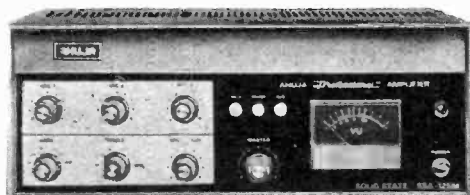
(United Kingdom) Ltd.

AHUJA

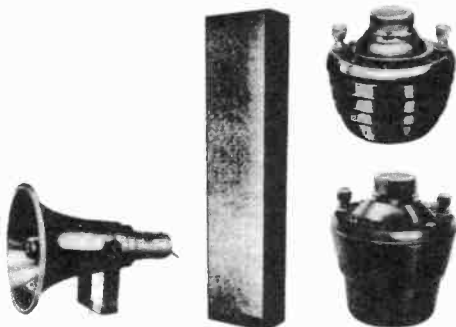
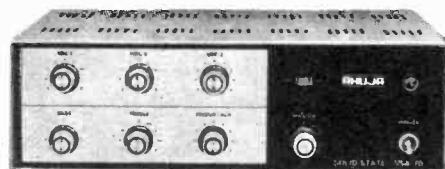
Public Address & Sound Communication Systems



AMPLIFIERS
MICROPHONES
DRIVER UNITS
UNIT-HORN
COMBINATIONS
MEGAPHONES

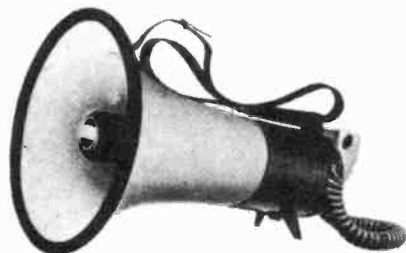


All AHUJA products manufactured with scientific precision for sound communication are the last word in performance reliability and finish. And all this at money-saving prices.



Solid State and Vacuum Tube P A amplifiers with power output from 10 Watts to 120 Watts.

With world-wide reputation AHUJA is the leading choice in over 35 countries including Western Europe.



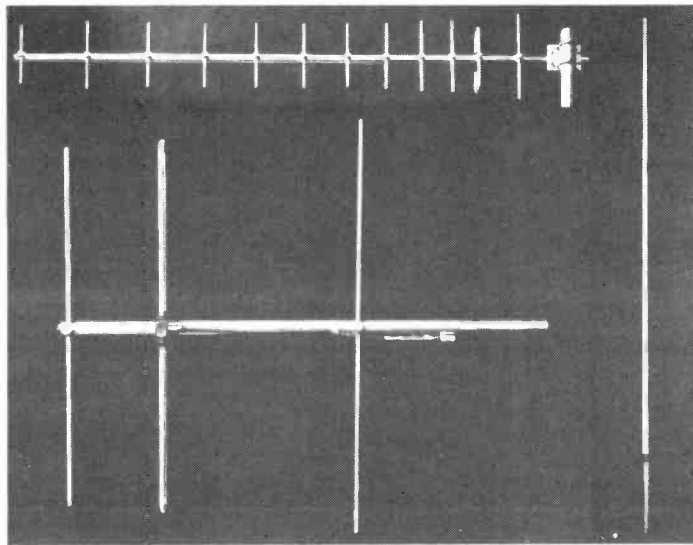
AHUJA

Manufacturers :
AHUJA RADIOS
215, OKHLA INDUSTRIAL ESTATE
NEW DELHI-110020, (INDIA)
Issued by : Engineering Export Promotion Council, Calcutta (India)

WW-058 FOR FURTHER DETAILS

WW-057 FOR FURTHER DETAILS

ARE YOU LOOKING FOR COMMUNICATION ANTENNAS?



HY-Q ANTENNAS LIMITED, a newly formed company with technical staff having 10 years experience in the development of radio telephone ship to shore, satellite tracking, telemetry and broadcasting antenna, together with a well equipped laboratory are now offering Professional Communication Antennas.

At this time we are able to offer VHF and UHF Yagis, Centre Fed Dipoles covering low and high bands and are rapidly developing further new ranges. Stocks are being maintained and in instances where your orders cannot be supplied from stock, we guarantee delivery within 7 days. We would greatly welcome your enquiries and details of specifications and prices may be obtained by telephoning in the absence of our printed catalogue.

HY-Q ANTENNAS LIMITED

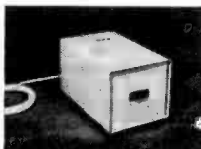
Pondwood Close, Moulton Park Industrial Estate, Northampton.

Tel: Northampton 48129 Cable Address: Hikeant, Northampton, England.

WW-059 FOR FURTHER DETAILS

NEW FROM A.S.P.!

CASED AUTO TRANSFORMERS



240 Volt Mains to 115 Volts, smart steel cased units coated in tough resin, fitted with power lead, fuse and 115 Volt American type socket up to 500VA, above 500VA cable entry.

VA (Watts)	PRICE	Post
200 ..	£5.58	38p
500 ..	£9.50	67p
1000 ..	£15.92	82p
2000 ..	£29.70	£1.50

20VA version uncoated, no fuse:—
£2.52 30p

AUTO TRANSFORMERS (Open)

VA (Watts)	Ref. No.	Price	Post
Tapped at 115, 220, 240 Volts			
20	113	1.32	0.22
75	64	2.83	0.30
Tapped at 115, 200, 220, 240 Volts			
150	4	3.29	0.30
200	65	3.96	0.40
300	66	4.64	0.52
500	67	8.03	0.67
1000	84	13.50	0.82
2000	95	25.30	1.00
3000	73	33.00	1.20

POWER UNIT Type P6200

Supplying 6 or 9 Volt DC at 200 mA
In moulded case forming a 2 pin 5 A mains plug.
2 metre output lead with 4-way multiplug giving 2.1 and 2.5 mm sockets and 3.5 mm plugs.
Price £2.25, Post 10p.



POWER UNIT Type P1076

Output switched 3, 4.5, 6, 7.5, 9 and 12 Volts at 500 mA D.C. Operates from 240 V mains, suitable for Radios, Tape Recorders, Record Players etc. Size 7.5x5.0x14.0 cm. Price £3.95, Post 25p.



TRANSFORMERS

SAFETY ISOLATING

Prim. 120/240V, Sec. 120/240V. Centre Tap with screen

VA (WATTS)	REF. No.	Cased PRICE	Open PRICE	Post
60	149	—	3.74	0.38
100	150	—	4.16	0.52
200	151	9.48	7.48	0.52
250	152	12.05	9.57	0.65
350	153	14.00	11.44	0.80
500	154	15.90	13.20	1.00
1000	156	30.70	27.46	1.20
2000	158	60.95	55.44	O.A.
3000	159	79.63	72.49	O.A.

CASED VERSION in plastic coated steel case with Powerlead. Please state 115V or 240V output British or American outlet sockets up to 500VA. Over 500VA Cable Entry.

MINIATURE & EQUIPMENT

Primary 240V with Screen

VOLTS	MILLIAMPS	TYPE	PRICE	Post	
3-0-3	200	238	1.23	0.10	
0-6	500	234	1.30	0.10	
0-6	1000	212	1.68	0.22	
9-0-9	100	13	1.23	0.10	
0-9	330	235	1.43	0.10	
0-8-9	500	207	2.28	0.22	
0-8-9	1000	208	3.03	0.30	
15-0-15	40	240	1.23	0.10	
0-15	200	236	1.30	0.10	
20-0-20	30	241	1.23	0.10	
0-20	150	237	1.30	0.10	
0-15-20	500	205	2.97	0.38	
0-20	300	214	1.76	0.22	
0-20	3500	No Screen	1116	3.00	0.40
20-12-0	700	221	1.55	0.30	
12-20	(D.C.)	—	—	—	
0-15-20	1000	206	3.80	0.38	
0-15-27	500	203	3.08	0.38	
0-15-27	1000	204	3.24	0.38	

12 and 24 VOLTS PRIMARY 200-240 Volts.

12V AMPS	24V AMPS	TYPE	PRICE	Post
0.3	0.15	242	1.34	0.22
0.5	0.25	111	1.34	0.22
1	0.5	213	1.59	0.22
2	1	71	2.00	0.22
4	2	18	2.75	0.38
6	3	20	3.58	0.42
8	4	108	3.96	0.52
10	5	72	4.67	0.52
12	6	116	5.67	0.52
16	8	17	8.04	0.52
20	10	115	10.23	0.69
30	15	187	13.75	0.97
40	20	232	18.20	1.00
60	30	226	22.52	1.10

30 VOLTS

PRIMARY 200/240V. SECONDARY 12, 15, 20, 24, 30V.

AMPS	Ref. No.	Price	Post
0.5	112	1.58	0.22
1	79	2.20	0.38
2	3	3.19	0.38
3	20	3.98	0.42
4	21	4.88	0.52
5	51	5.80	0.52
6	117	9.93	0.52
8	88	9.00	0.67
10	89	10.00	0.67

50 VOLTS

PRIMARY 200/240V. SECONDARY 24, 30, 48, 60V.

AMPS	Ref. No.	Price	Post
0.5	124	2.10	0.38
1	125	2.97	0.38
2	127	5.77	0.42
3	125	7.15	0.52
4	123	8.35	0.67
5	40	11.55	0.67
6	120	13.57	0.82
8	121	18.00	1.00
10	122	19.40	1.00
12	189	21.62	1.10

60 VOLTS

PRIMARY 200/240V. SECONDARY 18, 25, 33, 48, 50V.

AMPS	Ref. No.	Price	Post
0.5	102	2.11	0.30
1	103	3.08	0.38
2	104	4.29	0.42
3	105	5.77	0.52
4	106	7.40	0.52
6	107	11.00	0.67
8	118	14.19	0.97
10	119	17.00	0.97

BRIDGE RECTIFIERS



ONE AMP	Price	TWO AMP	Price
50 P.I.V.	0.25	50 P.I.V.	0.35
100 P.I.V.	0.25	100 P.I.V.	0.40
200 P.I.V.	0.28	200 P.I.V.	0.45
600 P.I.V.	0.30	400 P.I.V.	0.50

FOUR AMP	SIX AMP
100 P.I.V.	50 P.I.V.
200 P.I.V.	100 P.I.V.
400 P.I.V.	200 P.I.V.
600 P.I.V.	400 P.I.V.

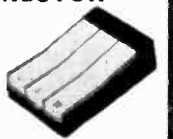
ELECTRONIC MAINS TIMER

A reliable unit ideal for timing Bathroom/Toilet Ventilators, Stairway / Cloakroom Lighting etc. Gives up to 30 mins. delay before switching off. Delay: 1-30 mins, adjustable. Max Load: 400 VA or 1000 Watts resistive. Ivory Case: 3 1/2in. x 3 1/2in. x 2in. Fittings Instructions included. Trade Price: £5.80. Post 20p.



MAINS KEYNECTOR

The safe, quick, connector for electrical appliances, 13 Amp rating, fused will connect a number of appliances quickly and safely to the mains, ideal for testing, demonstrating, window displays, etc., Warning Light, interlocked to prevent connecting when live. Trade Price: £2.95. Post 25p.



PLEASE ADD 10% FOR V.A.T.

A-S-P

BYRE HOUSE, SIMMONDS RD. WINCHEAP, CANTERBURY KENT CT1 3RW
Tel: Canterbury (0227) 52436

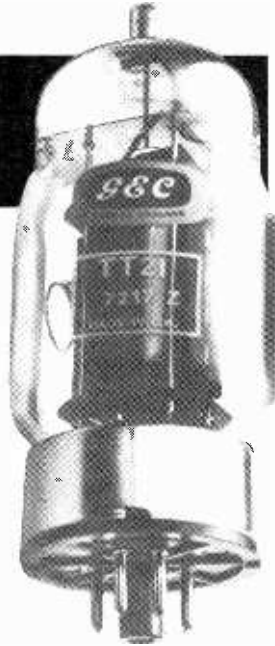
WW-060 FOR FURTHER DETAILS

Problem

Where to obtain a low-cost device to use as a linear output stage for mobile and marine radio under SSB conditions.


Solution

M-OV long-life beam tetrodes. A single TT21/22 gives 100W PEP at 1200V H.T. and one TT100 delivers 180W PEP at 850V H.T.



EEV and M-OV know how.

LAP 80

THE M-O VALVE CO LTD, Hammersmith, London, England W6 7PE.
Tel: 01-603 3431. Telex: 234356. Grams: Thermionic London. **S&C** 
WW—061 FOR FURTHER DETAILS

DC/AC SINEWAVE TRANSVERTORS (transistorised Invertors/Convertors)



TYPE D12/400S

Many world famous car manufacturers such as FORD, BRITISH LEYLAND, including ROVER-TRIUMPH, VAUXHALL, develop their cars under exact laboratory conditions. The AC electric power to drive the precision instruments and computers is provided by Valradio Transvertors.

Type	Input Volts	Output	Price & 10% VAT
C12/30S	12	115/230v 50Hz 30W Sine Wave	£35.70
R12/250/24R	12	24 7A DC	£75.55
R24/250/50R	24	50 3A Regulated	£97.25
D12/400S	12	115/230 400W 50Hz Sine Wave	£197.00
D24/500S	24	115/230 500W 50Hz Sine Wave	£197.00

All prices +10% VAT. All 50Hz $\pm \frac{1}{4}$ Hz. Also available 60Hz $\pm \frac{1}{4}$ Hz at same price.

For operating frequency and wave form sensitive equipment such as sound tape recorders, video tape recorders, professional film cameras, sensitive instruments, etc.

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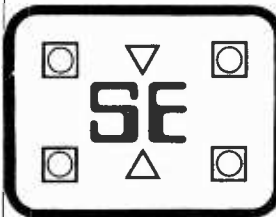
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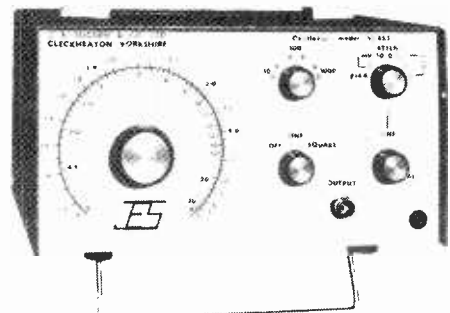


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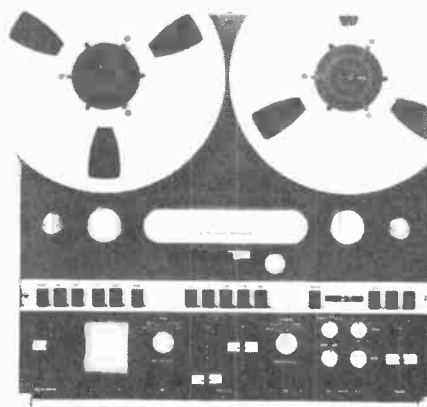


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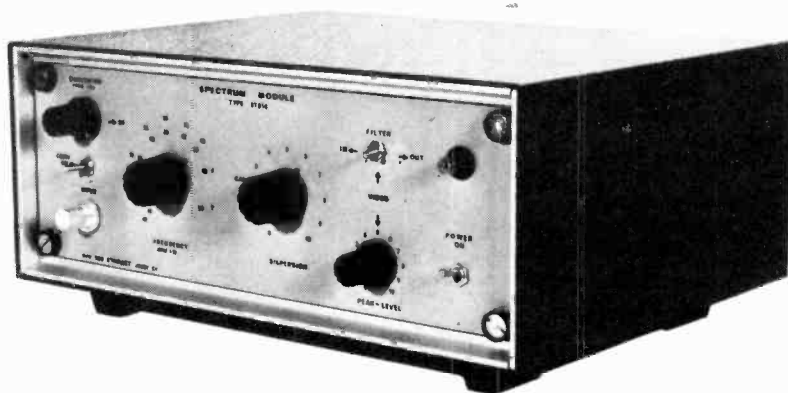
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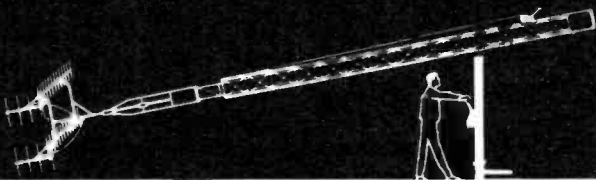
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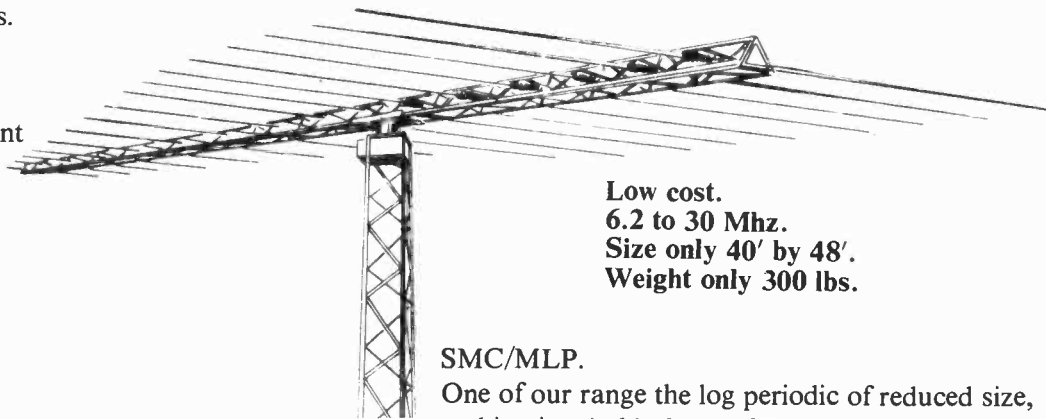
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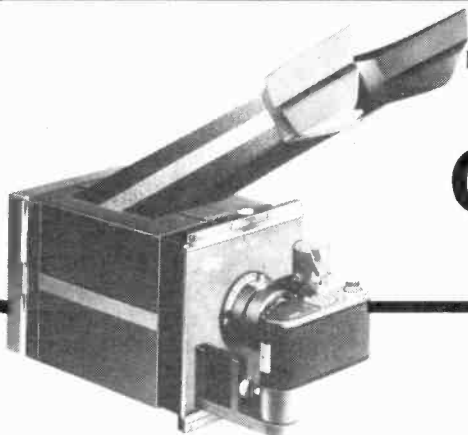
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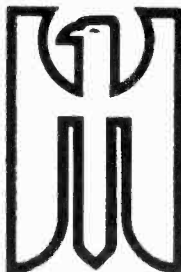
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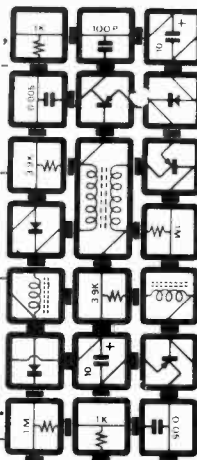
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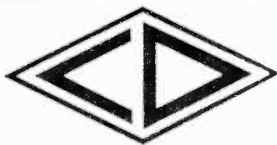
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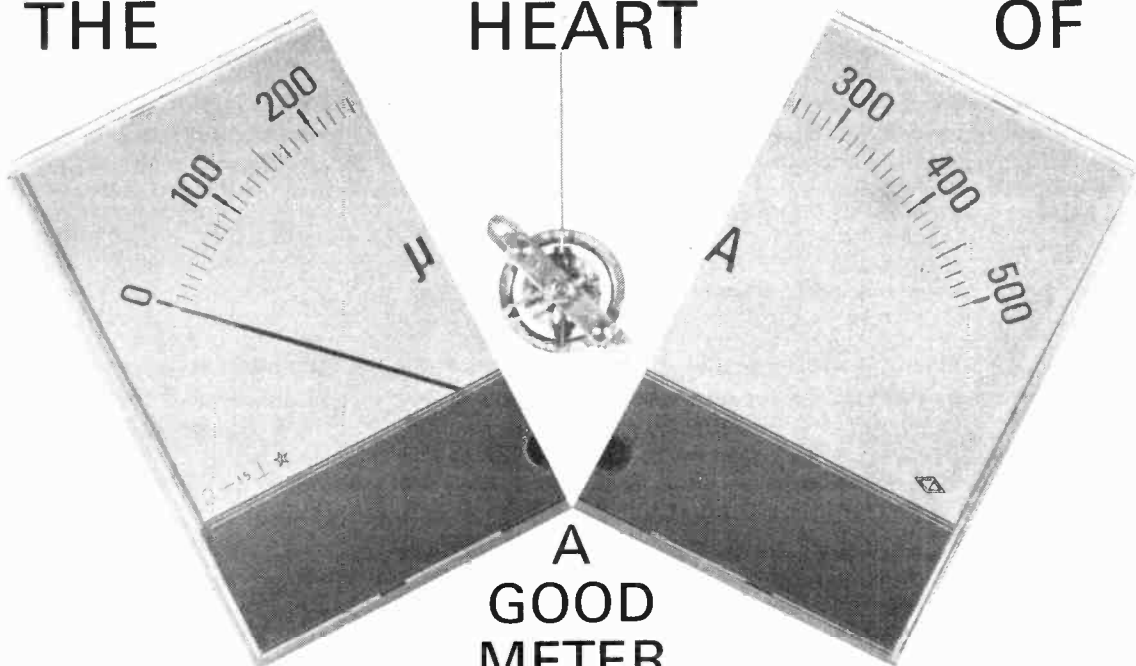


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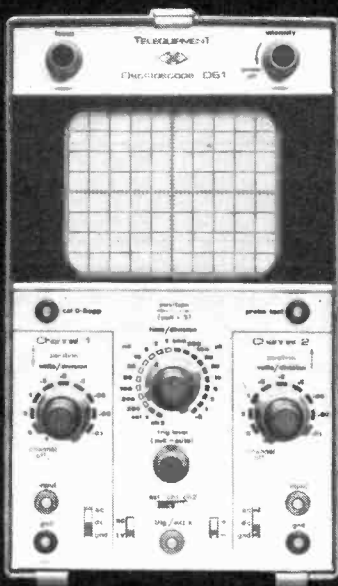
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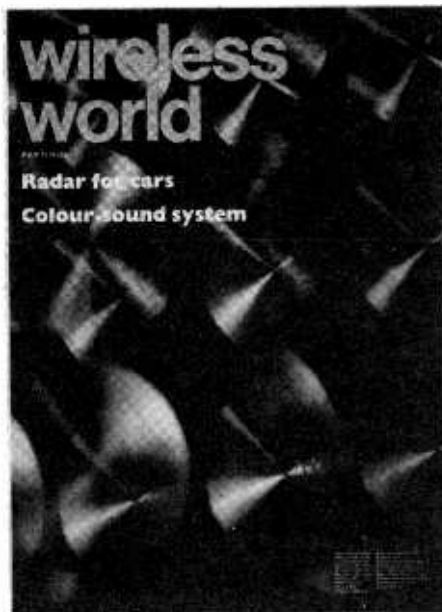
Electronics, Television, Radio, Audio

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SIXTY-FOURTH YEAR OF PUBLICATION

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This month's cover picture is an abstract design symbolizing the colour-sound system described by J. R. Penketh in this issue.

(Photographer Paul Brierley)

IN OUR NEXT ISSUE

(published June 19)

FM tuning indicator. A novel design using only one indicator lamp.

Professional sound recording. A review of techniques, equipment and development.

Horn loudspeaker design. Series concluded, with two systems for construction.

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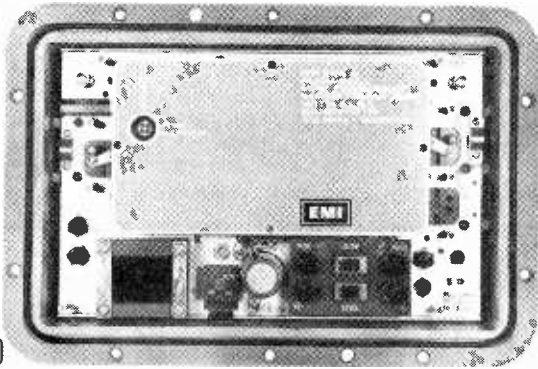
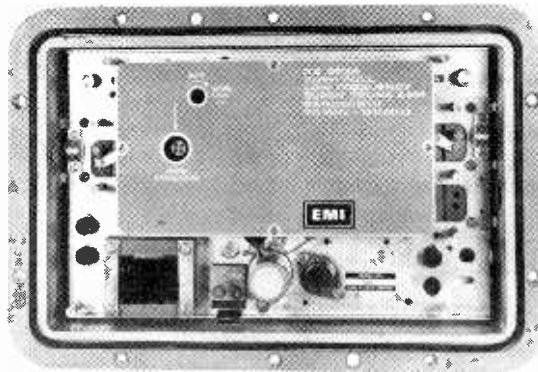
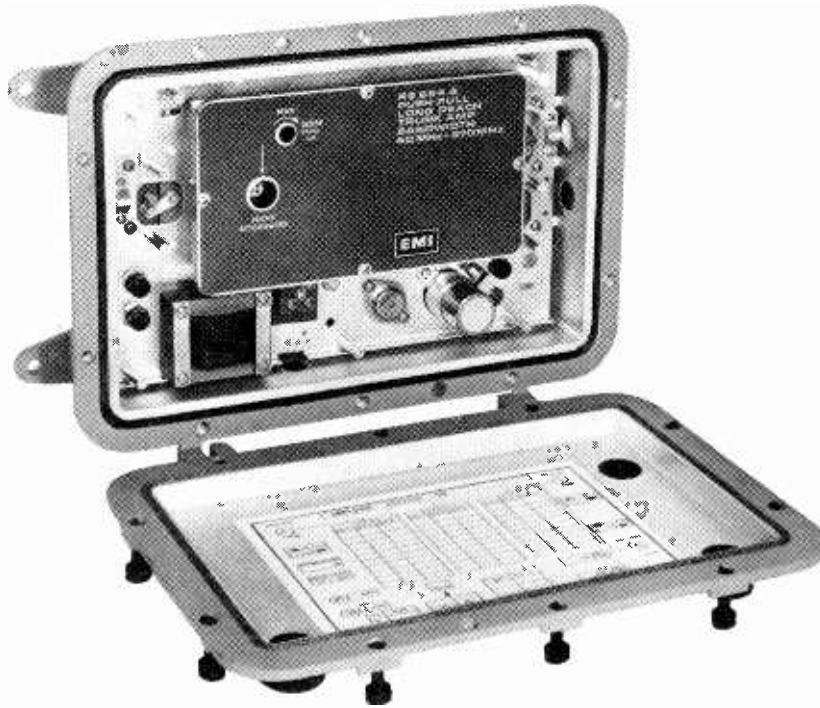
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versions of both amplifiers are also available. Another new device is the EMI outlet plate (complying with the recommendations of IEC 169-2) for Colorline or other cable television systems.

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WW—089 FOR FURTHER DETAILS

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Pocket numeracy

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The pocket electronic calculator is another case of a technology that has found its market. The availability of c.m.o.s. integrated circuits with their low power consumption and low supply voltage has made possible an instrument of about the same size as a cigarette-case at a price within the reach of private individuals. In one sense the product was forced on the general public, because it was one of those things by which the American semiconductor manufacturers created a new market for their devices after the cutback in spending on the Vietnam war and the space programme. On the other hand, the public seems to have been very willing to buy the product. What we don't yet know is the motivation behind the buying. Does the pocket calculator fill a real need that has existed for 2,000 years or more? Or is it being bought mainly as a new toy, or as a status symbol for impressing one's friends or colleagues, to be discarded when the novelty has worn off? Whatever the answer, the manufacturers are not worried as long as the buying continues.

One of the problems that this new tool brings with it is its effect on our mental powers. If it results in mental arithmetic being largely abandoned will our ability to manipulate numbers atrophy, putting us even more at the mercy of the machine? For example, a school-child equipped with a pocket calculator does not need to learn multiplication tables. This could mean a relief from time-consuming drudgery or it could mean a loss of an elementary and therefore important faculty in the handling and understanding of numbers. When we do mental arithmetic, perhaps with the aid of pencil and paper, we are constantly aware of our fallibility—as an animal is constantly on the alert for dangers that threaten it—and we therefore check and re-check what we have done. When we use a calculator, an error—perhaps caused by incorrect key operation or an electrical fault—could go undetected. But to set against this dependence on the machine the advantages it may bring for mental development seem greater. One school science master we know considers that because a pupil with a calculator can handle numerical data at a vastly greater rate than normal his intuitive feel for numbers will be tremendously enhanced. The same way well apply to other users. If this is so, the pocket calculator could be an important step on the road to universal numeracy—the lack of which has been so often deplored by people concerned with science and engineering education.

In the end probably a compromise will be found between usage of the brain and usage of the machine for arithmetic. It should be possible to achieve a balance between the alleviation of mental drudgery and the cultivation of a good understanding of numbers and ability to manipulate them. As with many other products of advanced technology placed suddenly in our hands, we must learn to use this new instrument wisely.

Colour-sound system design

Providing coloured illumination as functions of sound frequency and intensity

by J. R. Penketh, B.Sc., M.I.E.E.

Highbury Technical College, Portsmouth

The compact system to be described for construction provides coloured illumination of a reflecting or opalescent surface, the brightness and colour being functions of the frequency and amplitude of an audio input. The circuitry is based on the 741 op-amp and its dual version the 747. Triacs control the mean lamp power which is a maximum of approximately 2kW for each of three channels.

The sound intensity and light intensity correlation of a colour-sound system is based on the premise that related simultaneous sensory activity of ear and eye will produce a reaction to which most people will be sympathetic. The relationship between pitch and colour (that is between the frequencies of sound and light) is not at all critical, probably because of the very different responses of the brain to these phenomena—few people, except possibly physicists, consciously relate colour to frequency.

Other systems are possible. For example, a sound intensity/colour correlation may be sought, coupled with a pitch/light intensity correlation. Whilst the author is not aware of any published work in this field, it is likely that aesthetic appreciation of such a system would require a considerable training programme. This would necessarily severely restrict the enjoyment of an untrained majority of observers.

A gate pulsing arrangement is used for each controlling triac which relates the firing angle to the instantaneous peak output voltage from the appropriate filter. In this way the conduction angle is closely proportional to the sound intensity, resulting in a good correlation between brightness and sound intensity. Tungsten filament lamps form the light sources. Fluorescent tubes could be used as an alternative.

Design philosophy

A block diagram of the colour-sound system and the waveforms at the various points in the system are shown in Figs. 1 and 2.

The incoming mains voltage (V_1) is squared (V_2) and integrated to provide a linear time varying voltage (V_3) in each half cycle. This is compared with the peak rectified filter output voltage (V_4) to advance or retard the triac firing angle α in sympathy with the amplitude of the audio input to the filter. Voltage V_4 is arranged to increase towards zero from

+10V for control during the positive mains half cycle and from -10V during the negative mains half cycle. The output from the level detector (V_5) is arranged to rest at zero volts when

$$(-12 + V_4) < V_3 < (12 - V_4) \quad (1)$$

to be +10V when

$$V_3 > (12 - V_4) \quad (2)$$

and to be -10V when

$$V_3 < (-12 + V_4) \quad (3)$$

The positive and negative edges occurring at the times set by the above relationships (2) and (3) initiate narrow pulses (V_6) which fire the triac appropriately.

Three channels are used to cover the frequency ranges below.

Bass:	30Hz–125Hz
Mid:	125Hz–500Hz
Treble:	500Hz–2000Hz

These frequency ranges cover adequately the range of fundamental frequencies in music. The rest of the audio spectrum above 2000Hz carries principally harmonic information for aural identification

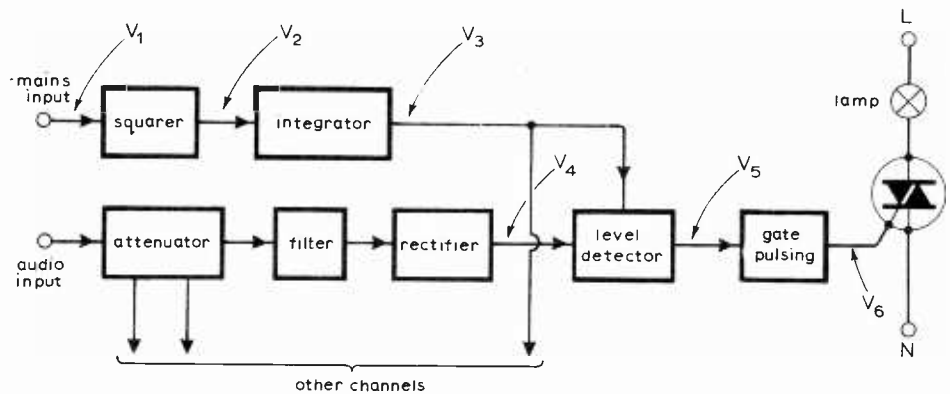


Fig. 1. Block diagram of one channel of the colour-sound system. See Fig. 2 for the waveforms marked at V_1 , V_2 , etc.

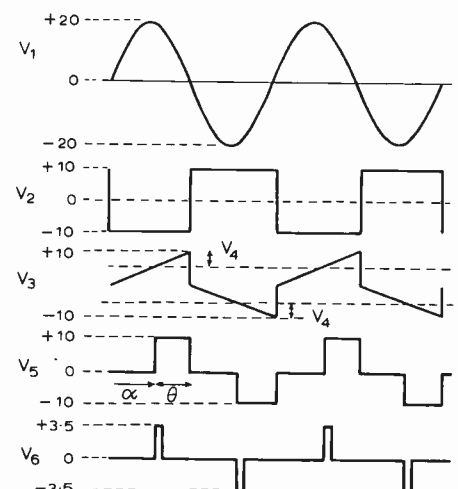


Fig. 2. Waveforms at the points indicated (V) in Fig. 1. See text for full explanation.

of particular instruments. The lower limit of the bass range is judged to be a reasonable compromise between adequate bass instrument coverage and the exclusion of mechanically originated signals such as turntable rumble. Harmonics from the bass and middle range tones of instruments cannot be excluded from the filter if they lie within the pass band. Subjective tests with various types of music indicate, however, that no serious problems arise from these harmonics.

Circuit description

The circuit diagram is shown in Fig. 3.

The filters are low pass/high pass combinations based on the voltage controlled source (v.c.v.s.) circuit. The requirement for this application is to have no pronounced peaks in the response curves of either the low or the high pass sections (see Appendix).

The filter output rectifier is of conventional design and provides two symmetrical outputs. Under no-signal conditions the outputs settle to potentials $\pm V_B$ close to $\pm 10V$, determined by R_{15} , R_{16} and R_{17} . Voltage V_3 sets a minimum conduction angle for the triac and so provides a minimum brightness facility. This is desirable to ensure that lamps respond visibly to small input signals. Trimming is provided by R_{26} which controls the slope of the integrator output. Alternatively R_{17} may be made a preset resistor, but integrator slope control has the advantage of taking up the tolerance in the feedback capacitor. Resistors R_{13} and R_{14} are included to limit the maximum output current from the amplifier to a safe value. Time constants C_7R_{15} and C_8R_{16} are chosen as a compromise between reasonable smoothing of the lowest audio

frequency and rapid decay so that musical transients are tolerably handled.

An amplifier with a non-linear feedback loop comprising zener diodes D_{11} and D_{12} squares the transformed mains waveform. The zero-resetting integrator time constant $C_{12}(R_{26} + R_{27})$ is calculated from

$$V_3 = (1/C_{12}R_T) \int_0^t V_2 dt$$

where V_3 is the integrator output, V_2 the input square wave, and $R_T = (R_{26} + R_{27})$. With $\pm 12V$ supplies, a 741 amplifier has a useful output voltage range of $\pm 11V$. Hence, $V_3 = 11V$ at $t = 10ms$. Therefore

$$11 = V_2/C_{12}R_T \times 10 \times 10^{-3}$$

$$C_{12}R_T = 0.91 \times 10^{-3} \times V_2$$

But $V_2 = 10V$ so $C_{12}R_T = 9.1ms$, and C_{12} is made $0.1\mu F$ and R_T $91k\Omega$.

Resistor R_T is conveniently formed by a series combination of $68k\Omega$ and a preset $50k\Omega$. Transistor Tr_1 or Tr_2 is pulsed momentarily at the end of the mains half cycle to discharge C_{12} rapidly through R_{30} . Which transistor is pulsed depends on the direction of the square wave edge and it is arranged that the transistor with the appropriate collector polarity at this time turns on. The emitters are at earth potential because of the virtual earth property of the amplifier.

Resistor R_{30} limits the capacitor discharge current to a safe value for Tr_1 and Tr_2 but still provides a very short discharge time constant.

Diodes D_{13} and D_{14} prevent spurious reverse bias effects of Tr_1 and Tr_2 affecting the integration.

Transistors Tr_1 and Tr_2 must conduct for long enough to fully discharge C_{12} but for a short time compared with the

mains half cycle duration of 10ms.

Assuming $R_{SAT} = 0$ for Tr_1 and Tr_2 , C_{12} will discharge in approximately $5C_{12}R_{30}$ secs. Inserting values yields a discharge time of

$$t = 5 \times 0.1 \times 330 \times 10^{-6} = 165 \mu s.$$

Allowing $200\mu s$ for safety, C_{11} can be estimated from a knowledge of the base-emitter resistance R_b of Tr_1 and Tr_2 . The calculation will be approximate because of the non-linear nature of R_b and the natural spread of this parameter between transistors. Resistors $R_{28,29}$ limit the peak base current.

Assuming $R_b = 3k\Omega$ and a base turn-on voltage of $0.7V$, then the turn-off potential is $(4/3) \times 0.7 = 1V$. Therefore

$$1 = V_2 \exp(-t/C_{11}R) \text{ where}$$

$R = R_b + R_{28}$ and the applied square-wave amplitude, V_2 , is $10V$. Then,

$$C_{11} = t/R \log_e 10 = 22nF.$$

A standard $22nF$ capacitor suffices for C_{11} . Care must be taken not to make C_{11} too large since it prolongs transistor conduction and impairs the integration waveform.

The two outputs from the rectifier are compared with the integrator output using the differential input facility of the 741 amplifier.

For amplifier 3, diode D_3 holds the output (V_3) at $+10V$ unless the integrator output (V_3) voltage is greater than the appropriate (positive) filter rectifier output (V_4).

When $V_3 > V_4$, V_5 falls to a value $V_4 - V_2$ where V_2 is the zener voltage of D_6 .

A similar result but inverted is obtained

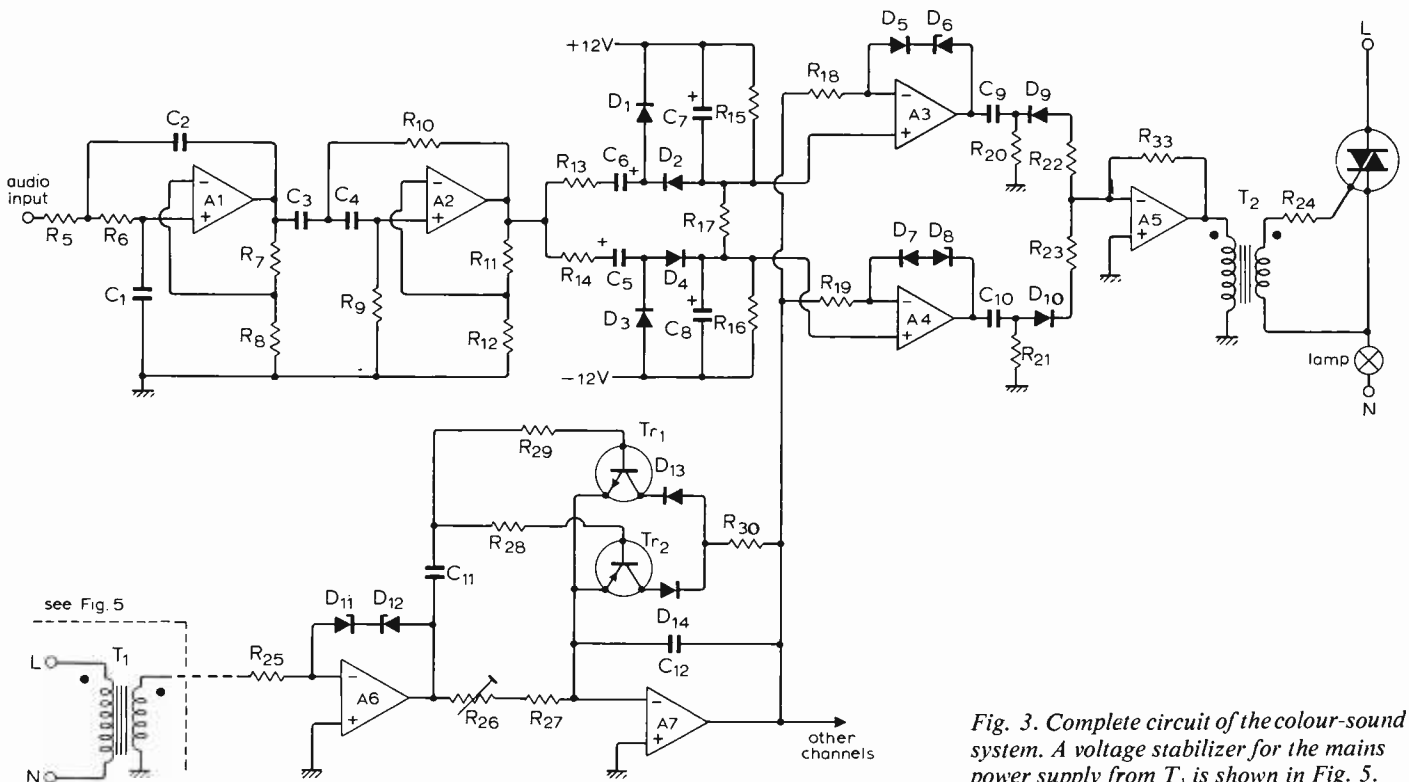


Fig. 3. Complete circuit of the colour-sound system. A voltage stabilizer for the mains power supply from T_1 is shown in Fig. 5.

from amplifier 4 when the negative rectifier output falls below V_{z4} in the negative half cycle.

Resistors R_{18} and R_{19} provide the zener current and should not be large. A value of $1k\Omega$ is satisfactory.

The networks C_9, R_{20}, D_9 and C_{10}, R_{21}, D_{10} provide short negative and positive pulses respectively generated from the leading edges of the level detector outputs. These are summed and squared by amplifier 5 which provides gating pulses to the triac.

Transformer coupling to the triac (T_2 in Fig. 3 and T_{2-4} in Fig. 8) is used to provide isolation of the control circuitry from the mains.

It is useful to have a separate manual gain control for each channel. Since the audio input comes from a low-impedance (i.e., loudspeaker terminals) a simple network such as that in Fig. 4 gives excellent results.

The current demand per channel is approximately 20mA. A regulated power supply based on zener diode stabilization of the base of a transistor is shown in Fig. 5.

It is desirable when using linear i.c.s to decouple the supply rails close to the amplifier. Capacitors C_x of value $0.1\mu F$ are used for this as shown and are placed close to the filter amplifier in each channel, and close to the integrator.

Triac circuitry and layout

Triacs are constructed usually with the A_2 anode in contact with the heat sink. To simplify the mounting of the three triacs a single heat sink is used and all anodes are thus in contact. The lamps are placed in the A_1 anode leads and the gating transformer secondaries connected between gate and A_1 anode. The electrical arrangement appears in Fig. 6.

The main system (filter channels, resetting integrator and power supply) are conveniently laid out on a single 0.1in pitch stripboard. The prototype main system used single 741 amplifiers and was laid out as in Fig. 7. The input attenuator, triacs, mains transformer, input and output sockets are mounted separately to suit the installation. The prototype used the layout in Fig. 8.

Lamps and displays

The triacs specified are capable of handling up to 8A r.m.s. which corresponds to approximately 2kW per channel. Filament lamps of this order of power tend to have long thermal time constants and do not follow a sound intensity pattern as well as do lamps of lower power. Very satisfactory results are obtained with filament lamps up to 150W. Three of these are considered adequate for a domestic installation (i.e., one per channel). For larger installations in dance halls, discos and exhibitions, banks of 150W lamps are recommended.

The author has found it more satisfactory to use a reflecting surface than a transmitting opalescent medium for display since attention tends to be drawn

Components

Resistors—R

1	100 lin 1W	11, 12	10k
2, 3, 4	1k lin ½W	13, 14	470
5	12k low range	15, 16	22k
	3.3k mid range	17	150k
	820 high range	18, 19	1k
6	12k low range	20, 21	2.2k
	3.3k mid range	22, 23	10k
	820 high range	24	47 ½W
7, 8	10k	25	6.8k
9	56k low range	26	50k lin preset
	12k mid range	27	68k
	3.3k high range	28, 29	1k
	56k low range	30	330
10	12k mid range	31, 32	560
	3.3k high range	33	100k

All resistors ½W 5% unless stated otherwise.

Capacitors—C

1, 2, 3, 4	0.1µ ± 20%	12	0.1µ ± 20%
5, 6, 7, 8	10µ/25V	13, 14	1000µ/25V
9, 10	0.1µ ± 20%	x	0.1µ ± 10%
11	22n ± 20%		

Diodes—D

1-5	0A200	11, 12	BZY88-C9V1
6	BZY88-C9V1	13, 14	0A200
7	0A200	15, 16	0A210
8	BZY88-C9V1	17, 18	BZY95-C12
9, 10	0A200		

Transistors—Tr

1	BC108	3	AC176
2	2S303	4	AC128

Triacs

All MAC11

Op amps

All 741 8-pin d.i.l.

Sockets—SK

1, 2, 3 2-pin 250V 5A 4 jack

Transformers—T

1 Radiospares 12V miniature primary 300mH and <5Ω turns ratio 3:1.
Insulation to withstand 1000V flash test between prim. and sec.

Suppression

R_s 47 ½W
 C_s 0.05µ/400V
 L_s 0.2mH non-saturating up to full load current

Heatsinks, switch, stripboard

Triac sinks—aluminium 150mm × 40mm × 16 s.w.g.
 Tr_3-Tr_4 sinks—aluminium 80mm × 40mm × 16 s.w.g.
Switch—250V, 5A
Stripboard—0.1in pitch 34-way

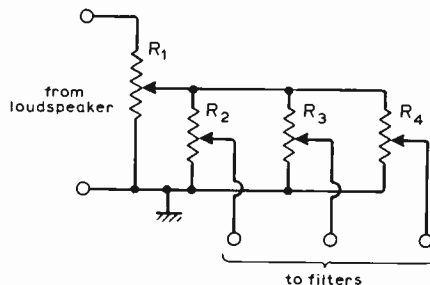


Fig. 4. Input attenuator which can provide separate manual gain control for each channel.

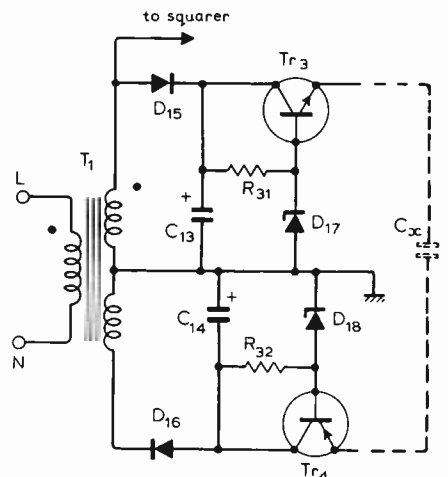
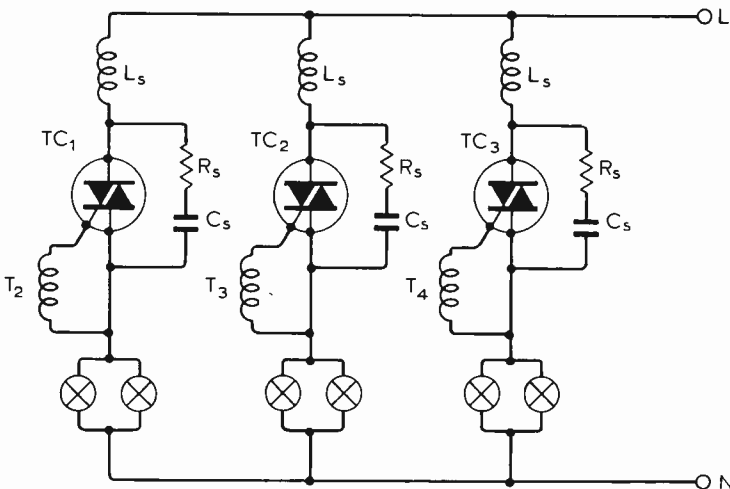
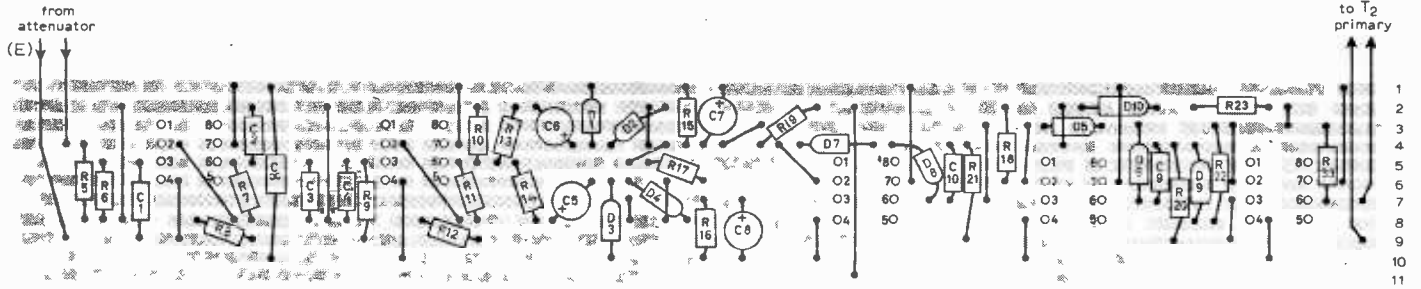


Fig. 5. Regulated power supply based on the zener diode stabilization at the base of a transistor.

Fig. 6. Lamp and triac circuitry. Mounting the three triacs is simplified by using a single heat sink.

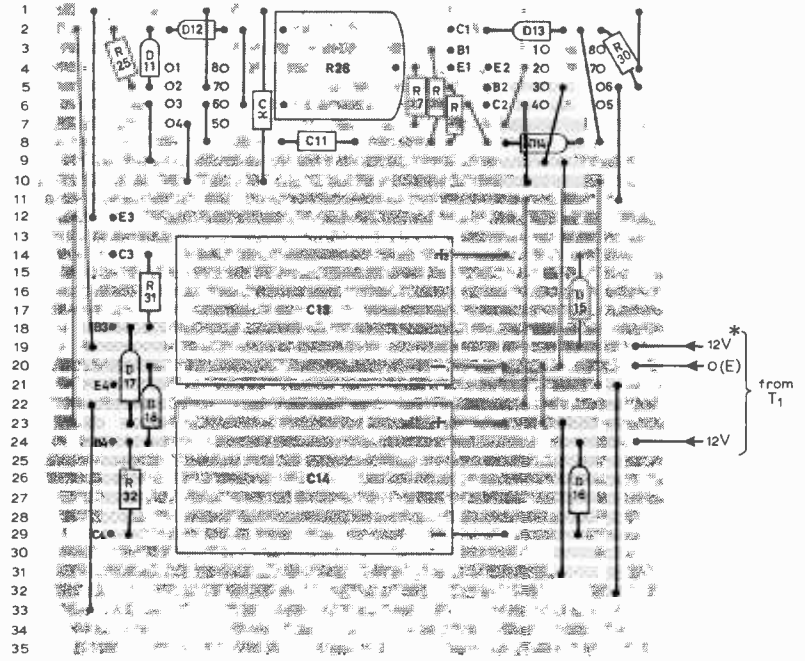




AMPLIFIER PIN CONNECTIONS

null (not used)	O1	O5	null (not used)
inverting input	O2	O6	output
non-inverting input	O3	O7	positive supply
negative supply	O4	O8	no connection

Fig. 7. Layout of one filter channel (top), resetting integrator and power supply from the component side. Strips 1-11 (top) are continuous to 35 (not shown) to facilitate the remaining two channels. These strips (1-35) are continuous with the lower diagram. * 12V from T₁ secondary in phase with line (mains) input.



to the brightest parts of a transmitting system, namely the lamp filaments. A simple but effective display for domestic purposes consists of three lamps mounted separately in ventilated boxes with gelatine colour filters on the fronts and aluminium foil reflectors behind the bulbs. Set about a yard apart and tilted upwards to illuminate a white or cream wall some pleasing results are obtained.

The rapid switching of triacs every half cycle gives rise to a wide spectrum of harmonics in the mains current waveform. These must be properly filtered to prevent interference with television reception. Present practice with lamp dimming circuits is to employ an r.f. choke/capacitor arrangement as shown in Fig. 6.

Appendix
Filter design

The v.c.v.s. (Fig. 9) is chosen for this application because of its very high input impedance and low output impedance, and its tolerance of variations in component values.

Moreover, the parameter H_o (see below) in the filter transfer function is a free parameter equal to the v.c.v.s. gain constant K . This makes mid-band gain simple

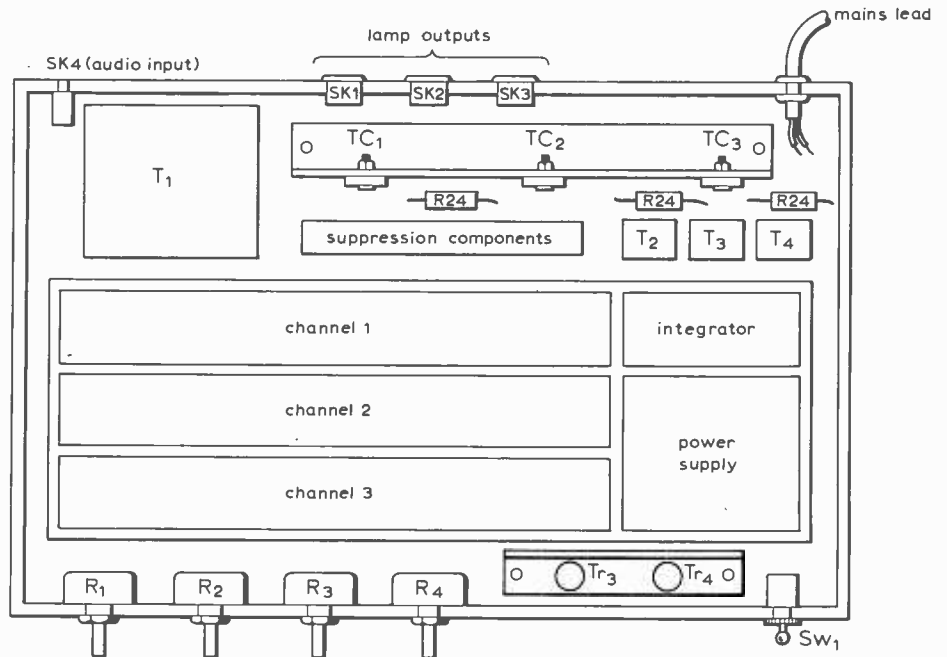


Fig. 8. Layout in the prototype.

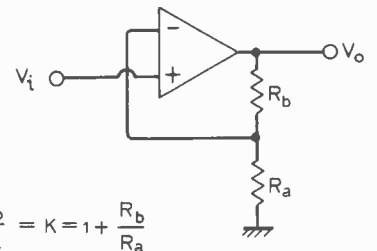


Fig. 9. Configuration of the voltage-controlled voltage source circuit.

$$\frac{V_o}{V_i} = K = 1 + \frac{R_b}{R_a}$$

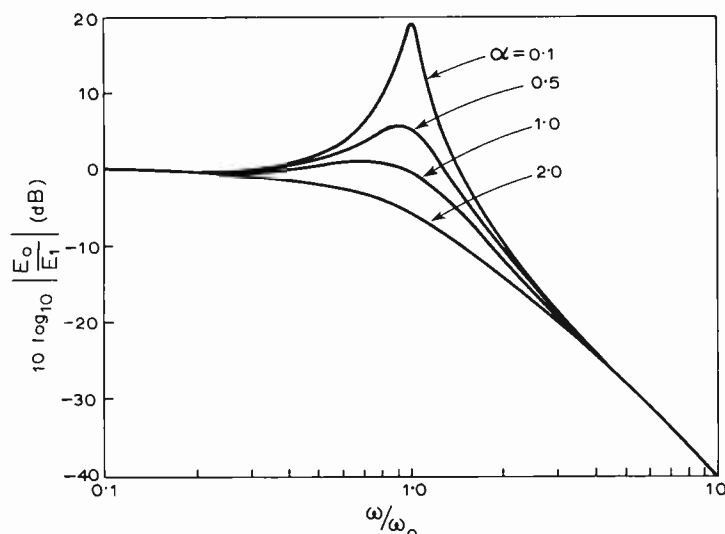


Fig. 10. Response curves for various values of $\alpha = 1/Q$. The equivalent high pass case is given by ω_o/ω .

to control for the cascaded sections. The design equations are:

$$V_o/V_i = K = 1 + R_b/R_a$$

$$H_o = K$$

Low pass section:

$$R_6 = \frac{\alpha}{2\omega_o C} \left(1 + \sqrt{1 + 4(H_o - 2)} \right)$$

$$R_5 = 1/\omega_o^2 R_6 C^2$$

High pass section:

$$R_9 = \frac{\alpha}{4\omega_o C} \left(1 + \sqrt{1 + 8(K - 1)} \right)$$

$$R_{10} = 1/\omega_o^2 R_9 C^2 \text{ where } \alpha = 1/Q$$

and ω_o is the undamped natural frequency of the two-pole filter.

The curves of Fig. 10 show the generalized responses for various values of K . From this it is clear that $\alpha = 1$ provides the type of response suitable for the present application.

The input voltage will be that appearing across the terminals of a loudspeaker. Adopting a nominal 2V r.m.s. for full brightness the overall mid-band gain of the filter should be, by assigning the same value K to each section and assuming a peak output of 11V from amplifier 2,

$$K^2 = 11/2\sqrt{2} = 3.89.$$

This leads to a nominal K value per section of 2. Inserting these results in the above formulae gives:

$$\text{low pass: } R_2 = 1/\omega_o C \text{ and } R_1 = R_2$$

$$\text{high pass: } R_1 = 1/\omega_o C \text{ and } R_2 = R_1.$$

The procedure is now to choose C for convenience and calculate R_1 and R_2 . Resistors R_b and R_a are chosen for a K value of 2 and for minimal output loading of the amplifiers.

The design of these sections has been such as to ensure overlap of responses between the three bands. Some frequencies, therefore, will excite responses from two adjacent lamps. Additive or subtrac-

tive combinations of colours can be so produced to the requirements of a particular installation. Should wider band separation or different bandwidths be required for a particular application it is a simple matter to apply the above formulae. Only four resistors per channel need be altered to tailor responses to suit these requirements provided the $0.1\mu\text{F}$ filter capacitor value is unchanged.

AES Convention—Copenhagen

Copenhagen's Scandinavia Hotel was the site of the 1974 European Section Convention of the American Audio Engineering Society held from March 23rd to 30th. The choice of Copenhagen this year was particularly apt as the work of Valdemar Poulsen "the father of magnetic recording", P. O. Pedersen, Holger Lauridsen and other Danish engineers, has given Denmark a surprisingly large contribution to the history of audio technology development.

Seventy-nine papers in 12 sub-groups were presented to members (compared with fewer than 50 at the 1973 Convention in Rotterdam). The papers covered subjects ranging from "Acoustics and Psychoacoustics" through "Design Considerations For a Multi-Track Sound Recording Vehicle" to "Digital Techniques in Audio".

While space does not permit detailed comment on the material read, it was interesting to note that some papers dealing with quite basic subjects had universal interest. James Moir described a method of sound power measurement which avoids the complication of calculating power from the output of a hemispherical multimicrophone array at many frequencies or the equally difficult alternative of using a single microphone in a very large reverberant room of special design. Moir's method involves introducing an amount of noise from a calibrated amplifier/loudspeaker combination until the sound pressure level of both the signal under test and the calibrated source is 3dB

higher than the pressure level created by the signal under test alone. The method offers independence from room acoustics and can be used when checking loudspeaker efficiency and sound power output of permanently sited industrial machinery.

Hugh Ford presented a paper of great topical interest—especially in the United States—on the Admissibility of Magnetic Tapes as Evidence in Law. Mr Ford's extensively researched paper concluded that while it is possible to detect alteration to recordings in some cases, present techniques are not able to detect interference with the material in every case.

Automation in multi-track studio recording and quadraphony have both excited a great deal of attention at past AES conventions. Both fields were treated cursorily in Copenhagen although both Sansui and Nippon Columbia operated demonstration suites equipped with their respective systems.

Forty-six companies exhibited commercial audio equipment. The exhibits representing the greatest commercial value were those relating to multi-track sound recording. European tape-machinery of this category was exhibited by Lyrec, Studer and Telefunken and American 3M, Ampex and MCI multi-track machines were also shown. Twenty-four track, two-inch tape recording seems well established now in spite of its departure from the four-track/half-inch, eight-track/one-inch, sixteen-track/two-inch progression.

Electronic tape-noise reduction equipment by Dolby and DBX Inc., was shown. The DBX system claims to improve the signal to noise ratio of a transmission medium by some 39dB—more than enough to defeat the 16dB noise build-up encountered when mixing down 24-track master tapes. Discs encoded with the DBX noise reduction system demonstrating this figure of noise reduction, were played in the JBL loudspeaker booth.

BASF, again, showed the "Unisetete", their extremely well engineered 6.3mm professional tape cassette. The Unisetete has no internal tape guides as it is intended that these be built into the transports with which the cassette is used. Although the intended area of application is audio, the cassette is sure to find use in data recording when suitable transports are available.

Frequency allocations wallchart

A wallchart showing frequency allocations for the UK and Europe is the subject of a special offer to be made by coupon in the June issue. Designed by *Wireless World* and printed in colour, the chart covers the electromagnetic spectrum from 3kHz to 300GHz. It is scaled on eight logarithmic bands containing 15 main categories of transmissions identified by colours. All the important spot frequencies are marked, as well as "special interest" frequencies. The special-offer price, available only to readers of *Wireless World*, is 30p including VAT, postage and packing. Normal price is 80p including VAT, postage and packing. See the June issue for details of how to order the wallchart.

News of the Month

TV information service

A unified system for a broadcast television information service of the CEEFAX or ORACLE type (see May and July 1973 issues) has been agreed by a working party representing the BBC, the IBA, BREMA and the MPT.

A bit rate of about 7 Mbits/sec will allow each 40-character row of the display to be accommodated on a single television line. Information will be transmitted on lines 17 (330) and 18 (331) of the television waveform. Thus every television field will convey two rows of the display. The alphanumeric characters will be represented by a seven-bit ASCII code with an additional parity bit for error protection. Each of up to 99 pages will have 40 characters per row and 24 rows per page. Complete pages will be transmitted in sequence so it will take some 15 seconds to transmit a complete "magazine" of say 60 pages. Each page will have a page heading followed by 23 rows of text. The page heading will also show the time to the nearest second.

Among refinements of the system are arrangements for news flashes and subtitles to be displayed along with the normal programme. The system is very flexible and allows for differing amounts of complexity to be incorporated in the receiver. The simplest receiver might use only capital letters, the most complex would use capital and lower case letters and make use of all the other refinements that are possible.

There will be full-scale tests of the new standard in the autumn or winter of this year, as soon as a supply of prototype receivers has been produced by the industry.

Automated satellite station

By means of a new telemetry and command control station for communications satellites one engineer can monitor the flight behaviour of up to three satellites at one time. The station, designed by Hughes Aircraft in the USA, has a display panel that presents the satellites' spin-speed, temperatures, antenna-pointing accuracy, spin-axis inclination, information from transponders and the quantity of jet-thruster fuel remaining aboard each spacecraft. While

the information is being monitored by an engineer it is simultaneously recorded into a computer.

The most critical time for use of the equipment is when the satellite separates from the rocket booster after launching. From then on the spacecraft's behaviour must be known precisely and continuously in order to determine when to fire the on-board apogee motor to shift the satellite from its elliptical transfer orbit into the final circular orbit 22,300 miles above the equator.

Colour recording by laser

Images in colour and other multi-spectral data can be recorded on black-and-white film by a laser system developed by RCA. The system can be used to display and interpret information generated by sensors used in aircraft and spacecraft, and can also be used with other colour scanners in facsimile systems. Recording is accomplished by combining three modulated video signals to drive a single light modulator. The modulated laser beam is expanded and focused via scanning mirrors into a small spot on the film. At present a laboratory model records the information on long lengths of five-inch-wide film.

A simple, portable display device enabling the recorded images to be viewed in full colour has also been developed. This viewer is small enough to fit in a typewriter case and weighs 11 lb. It contains three lamps, each with a filter so that three primary colours are provided. Colour balance is achieved by thumbwheels which adjust the brightness of the lamps.

Portable colour camera

A portable version of their Mark VIII colour television camera has been produced by Marconi Communication Systems. In its hand-held form the camera fits on to a harness which rests on the operator's shoulder. A light-weight tripod is also available, while an alternative mounting unit permits the use of studio tripods and heads. A range of lenses is provided, and



The new Marconi portable colour television camera.

lens changes are made by a quick-release coupler.

The camera head contains the optical assembly, three one-inch light-weight scanning yokes and four printed circuit boards carrying the scanning circuits, tube supplies and amplifiers. The design retains the Mark VIII features of automatic alignment and automatic colour balance, which are particularly important for portable cameras because they are sometimes subjected to rough treatment. Brightness and contrast controls are provided for the cameraman and there is a built-in "crispensing" circuit for enhancing the sharpness of the picture. The viewfinder is a removable unit, using a high-definition one-inch c.r.t. with an optical magnifier to obtain the required image size.

Up to 150ft of 13mm cable may be used between the camera and its auxiliary pack, which is designed primarily to be mounted on a trolley but may be carried on a harness by the cameraman or his assistant.

Call China by satellite

Britain's telephone service with the People's Republic of China, which had been available for only three hours a day, has now become full time with a change to satellite working. The move follows the opening in China of a satellite earth station using the INTELSAT-IV communications satellite positioned 22,300 miles above the Indian Ocean. Telephone calls from Britain to China are now transmitted from the Post Office satellite earth station at Goonhilly Downs, Cornwall, and received by China's new earth station near Peking.

The satellite link replaces a high-frequency radio route (08.00–11.00 hours GMT) and gives an immediate improvement in service. Clarity of speech is much greater, while continuity of communications—always difficult to maintain on h.f. radio, which can be affected by weather conditions—is greatly improved. The satellite link consists of one telephone circuit but can be readily increased to three if there is sufficient demand.

The cost of telephone calls to China remains unchanged, with a minimum charge of £3.75 for the first three minutes and £1.25 for each additional minute (plus VAT at standard rate of 10 per cent).

Queen's Awards for 1974

Technical innovations in the electronics industry which have this year received the Queen's Award to Industry encompassed the fields of solid state TV, sound and vision transmission and production of high-performance silicon integrated circuits.

A two-dimensional self-scanned photosensor array which forms the heart of a miniature solid-state TV system is the award-winning development from Integrated Photomatrix. The prototype camera contains a $\frac{1}{4}$ in sq. light-sensing array. At

present, this technology has applications from screening of medical slides to dimension monitoring in inspection systems but will result eventually in a complete miniaturized solid-state TV camera.

The now well-known "sound in syncs" system developed by the BBC for the transmission of sound and vision signals over a single vision link has also received an award. The system was brought into use progressively throughout the country in 1972 and is already in regular use for the international exchange of television programmes over much of the Eurovision network.

An award for a new production process which permits the production of integrated circuits of greater complexity and with improved performance was made to Plessey for their Bipolar Process III, first reported in *Wireless World*, News of the Month, March 1973.

Congratulations to all award-winning companies for their outstanding contributions to Britain's industrial development.

Display terminals for news pages

Composition of display advertisements and full newspaper pages can be built up on a new video display system and then stored for use in automated typesetting and printing processes. The system is known as CAM (for Composition and Make Up). In use, an operator calls up copy and graphics from a computer store which are displayed on a video display. The displayed material is then positioned by means of the equipment's keyboard, a cursor, and a table of digital/graphic information. When the most effective composition is obtained, the presentation is stored for later use.

Raytheon Company's equipment division, Massachusetts, is to develop the CAM terminal for the automated full-page composition system being developed by the Newspaper System Development

Group. The first CAM system, consisting of three operative terminals, should be delivered for testing in early 1975.

Electrical measurements seminar

A residential specialist seminar on "Electrical Measurements in Europe" will be held at the Université Libre de Bruxelles, Belgium, from September 2-5, 1974. It is being organized jointly by the Institution of Electrical Engineers and the Société Royale Belge des Electriciens in association with the British Calibration Service.

The seminar will provide a forum for a supranational review of electrical measurements in Europe and is intended to promote harmonization in this field of technology by surveying the scene, identifying industrial needs, highlighting problems and postulating solutions to such needs and problems. The five half-day sessions will be devoted to specification and certification, national standards and problems of traceability, national calibration facilities, the market for electrical instruments, and prospects of European co-operation.

Attendance will be by invitation, and those wishing to be considered are asked to write to the Divisional Secretary LS(S), IEE, Savoy Place, London WC2R 0BL, England.

Picture telephone system

An experimental picture telephone system is being tried out in Holland between establishments of the Dutch PTT and the Philips company. It interconnects offices and laboratories at Waalre (20 subscribers), Eindhoven (10 subscribers), Hilversum (11 subscribers), The Hague (4 subscribers) and Leidschendam (9 subscribers). The PTT provides the transmission paths via radio relays and cables, while Philips Telecommunicatie Industrie supplies the equipment. For the local sections of the

network, transmission is over the conductors of existing telephone cables.

In order to reduce the bandwidth from the 5MHz television standard to about 1MHz, the number of lines used in picture scanning has been reduced from 625 to 325. The number of picture elements per line has been reduced proportionally. This has resulted in a bandwidth of 1.3MHz.

During frame flyback a digital code word is transmitted which accurately defines the end of the past frame period and the start of a new one. During part of the line flyback a series of short pulses ensures that an oscillator in the receiver remains in synchronism with a similar oscillator in the transmitter. The remaining part of the line flyback time is used on a "sound in sync" basis to transmit a delta-modulated sound signal. The visual information is transmitted in the conventional way by an analogue signal. Transmission of the combined picture, sound and sync signals takes place on one pair of conductors for each direction. Thus a four-wire connection is available for the sound signal, which means that crosstalk will not occur in the transmission path.

The camera has an automatic lighting control system, which adapts the camera to any changes in lighting conditions. The picture tube has a screen size of about 19cm x 14cm.

Data Act

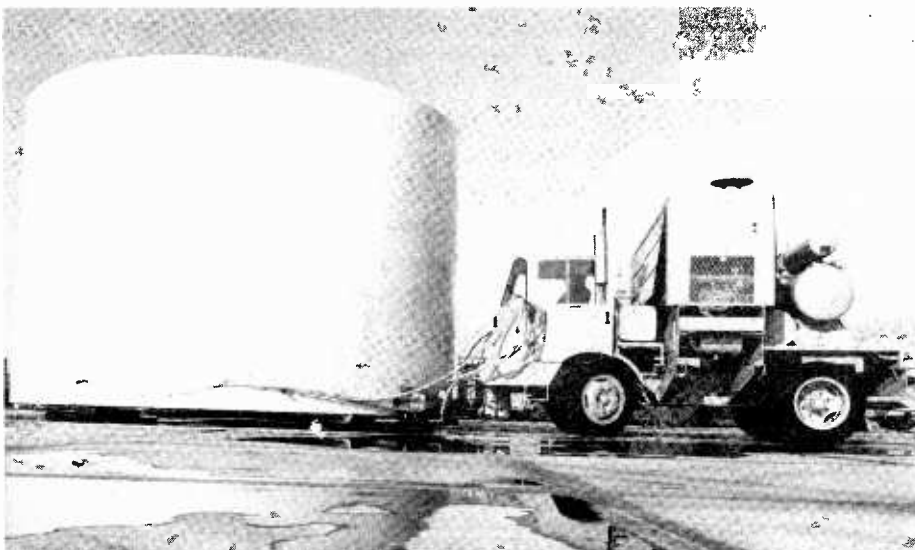
The Swedish Data Act, a comprehensive piece of legislation directed against misuse of computerized files, has aroused widespread interest abroad. This has prompted the Federation of Swedish Industries to publish in English a 22-page booklet on the Act.

The Swedish Data Act is divided into five parts. The first is concerned with the definition of terms. The second prescribes basic regulations on the issue of permits to create a personal information file. The third lays down the obligations and duties of those holding such files. The fourth specifies how the files should be supervised. The fifth deals with penalties, award of damages, etc.

Two important provisions of the Act—part of which came into force on July 1, 1973, the rest becoming operative a year later—are that permits to create a personal information file must be issued by a special body, the Data Inspection Board, and that organizations holding files must inform those recorded in them of their contents.

Pro-Electron goes passive

The Pro-Electron system of codification of active devices in operation in Europe is to be extended to include all passive components. The eventual object is to achieve a standard codification for both active and non-active components for all consumer, professional and government interests in the latter half of this decade. This was decided when the Pro-Electron association held its eighth general meeting in Brussels.



Floating a 70ton load on air. Application of the hovercraft principle allows the British Post Office to move cable loads with ease. The system is to be used at the new cables depot being built at Southampton.

Clutter-free radar for cars

by J. Shefer, R. J. Klensch, G. Kaplan and H. C. Johnson

RCA Laboratories, New Jersey

A radar system using second harmonic reflection that monitors the distance and closing rate of the car in front as well as the ground speed of the driver's car but remains immune to "blinding" and "clutter" from surrounding objects.

During 1970, in the USA, there were 12.3 million collisions involving two or more vehicles. Of this number, 3.8 million, or close to one-third, were rear-end collisions.¹ An experimental car radar has been demonstrated which is designed to avoid rear-end collisions. A completely passive reflector, mounted on the back of vehicles, returns the second harmonic of the frequency transmitted from the trailing vehicle. The radar is immune to clutter since its receiver is tuned to the second harmonic frequency only. It is also immune to blinding by cars travelling in the opposite direction, as well as to other interference problems inherent in a "dense" environment.

System considerations

RCA Laboratories have developed a radar system that will aid the driver in maintaining a safe distance from the car in front by constantly monitoring the distance and the closing rate, as well as his own ground speed. The driver would be warned by sound or light signals whenever the combination of these parameters indicates that the separation between his car and the car in front becomes unsafe. As a further step in the system's development, the brakes would act at the same time be activated automatically. Throttle control can eventually be added for completely automated headway control.

A viable radar for cars on highways must first be immune to clutter, which includes reflections from the roadway, trees, highway signs, overpasses, bridges, and similar highway fixtures. The seriousness of clutter can be assessed when it is recognized that the radar cross-section of an overhead sign can be 30dB larger than the radar cross-section of the back of a small car. Other car radar systems try to cope with this problem by excluding any returns from objects that are stationary with respect to the ground. That kind of processing does eliminate clutter from stationary objects. Unfortunately, it also eliminates the return from a car standing in one's own lane. This is a serious deficiency, especially since a majority of all rear-end collisions occur at a time when the car in front has completely

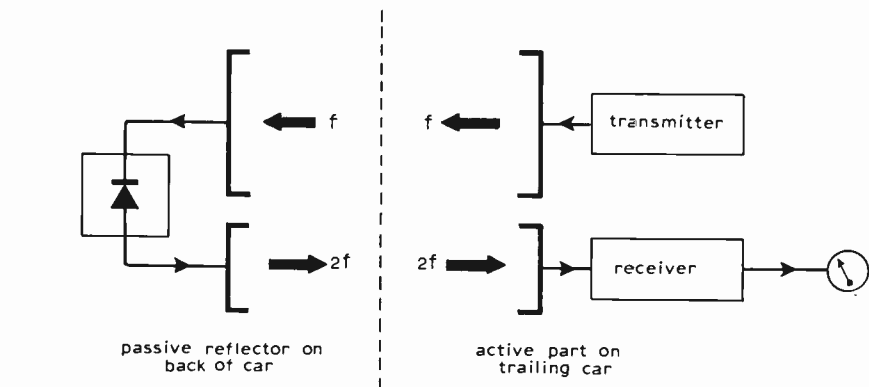


Fig. 1. Harmonic radar configuration.

stopped. When we add to the picture a large number of other cars carrying the same kind of radar and travelling in both directions of a highway, a whole new family of mutual interference problems arise. These can be characterized as blinding, masking, and cross-talk types of interference, which can cause false alarms or mask true alarms in conventional radar systems. In the harmonic radar system, however, they have been completely eliminated. Minimizing the incidence of false alarms is of prime importance if automobile radar systems are ever to become a reality. When false alarms occur more often than at a very low threshold rate, users are likely to lose faith in the system and either override it or shut it off completely.

The harmonic radar concept

The radar receiver shown in Fig. 1 is tuned to the second harmonic of the transmitted frequency and the car in front is equipped with a special reflector that efficiently returns the second harmonic only. (In extensive testing so far we have not found any natural objects that will produce a detectable second harmonic frequency.) Thus clutter is eliminated because the sources, such as signs and overpasses do not produce radar echoes at the second harmonic. Blinding is eliminated because all radar receivers respond only to signals

at the second harmonic of the transmitted frequency.

Blinding interference

Car A in Fig. 2 is travelling behind car E, with its conventional radar measuring distance to car E. Car D, going in the opposite direction, will deliver an enormously large signal to car A's receiver, compared with the reflection from car E. Quantitatively, the blinding signal can be 50dB or 60dB higher than the echo being looked for. This blinding transmission will therefore be seen from a long distance ahead and may cause a false alarm, as well as saturate the receiver of car A. The sidelobes from cars B and C may have the same effect. In the harmonic radar system, however, the receiver of car A will reject all signals other than the second harmonic of its transmitted frequency.

Cross-talk interference

Indicated in Fig. 3 is another kind of interference, inherent in conventional radar, which may be called cross-talk interference. Car C in Fig. 3(a) may receive a false alarm even though it is in no danger of running into car B. With a harmonic radar, as in Fig. 3(b), the return signal is shaped into a well-defined beam, covering the width of one lane only.

In the situation on a curve, as in Fig. 4(a),

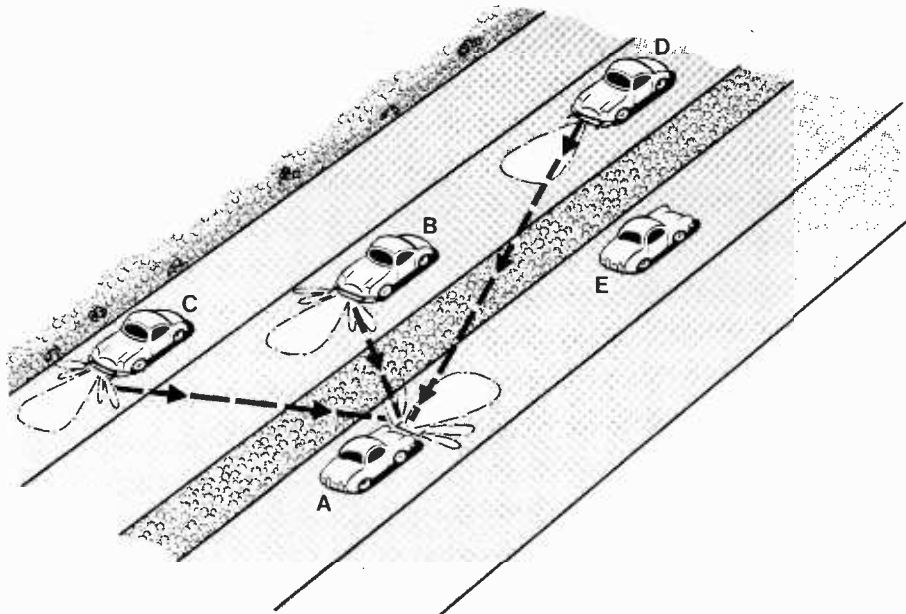


Fig. 2. Blinding by oncoming vehicles.

quite evidently we do not need a third car to produce a false alarm. The skin of car B will respond to the transmission from a fundamental radar and may cause a false alarm at car A. Fig. 4(b) shows that with a well-defined narrow beam reflected from car B, if any reflection occurs at all, the possibility of a false alarm is drastically reduced.

Masking interference

Illustrated in Fig. 5 is yet another problem inherent in a conventional radar which uses the car's body as the reflector. Radar cross-sections of rears of cars can vary tremendously: the back of a lorry may have a radar cross-section several hundred times larger than a small car. The effect is then the masking of the desired return from a close vehicle by a larger vehicle much farther down the road. With the harmonic radar, all radar cross-sections of reflectors are the same, unless designed otherwise. If all reflectors are mounted at a standard height, only the nearest reflector can be "seen" while all others will be blocked.

The radar system described in this paper is unique in its ability to eliminate false targets and clutter, in its immunity to blinding by radars of similarly equipped vehicles, and in its potential of providing automatic braking for specifically "tagged" objects, such as known off-highway collision hazards or wrong-way entrances to one-way streets and highway access ramps.

When in general use, it also has the potential for safely providing higher traffic packing densities without running the risks of massive "pile-ups".

Although it is a co-operative system, in that all vehicles must carry the harmonic reflector, the reflector is completely passive, quite inexpensive in mass production, and can easily be fitted on existing vehicles. The co-operation required is not more burdensome than the requirement for red tail-light assemblies; and the purpose is the same—to aid in preventing collisions.

The radar uses solid-state components throughout, and is easily adaptable to integration and printed circuit techniques. It uses a frequency spectrum region that is still not crowded and, with a power density over the antenna aperture of 0.15mW/cm^2 , it does not constitute a radiation hazard even in the immediate vicinity of the radar.

General description of harmonic radar system

The harmonic radar system is shown in the block diagram of Fig. 6. A varactor-tuned transferred-electron oscillator (t.e.o.) generates c.w. power at X-band. A triangular waveform is used to frequency modulate the t.e.o. with a total frequency excursion of ΔF at a rate of f_m as shown in Fig. 7. The frequency-swept power is radiated from antenna A_1 mounted on the front of the trailing car (see Fig. 6). This power impinges on a similar antenna A_2 which is a part of the harmonic reflector mounted on the back of the front car. The passive doubler generates the second harmonic frequency of the power incident on

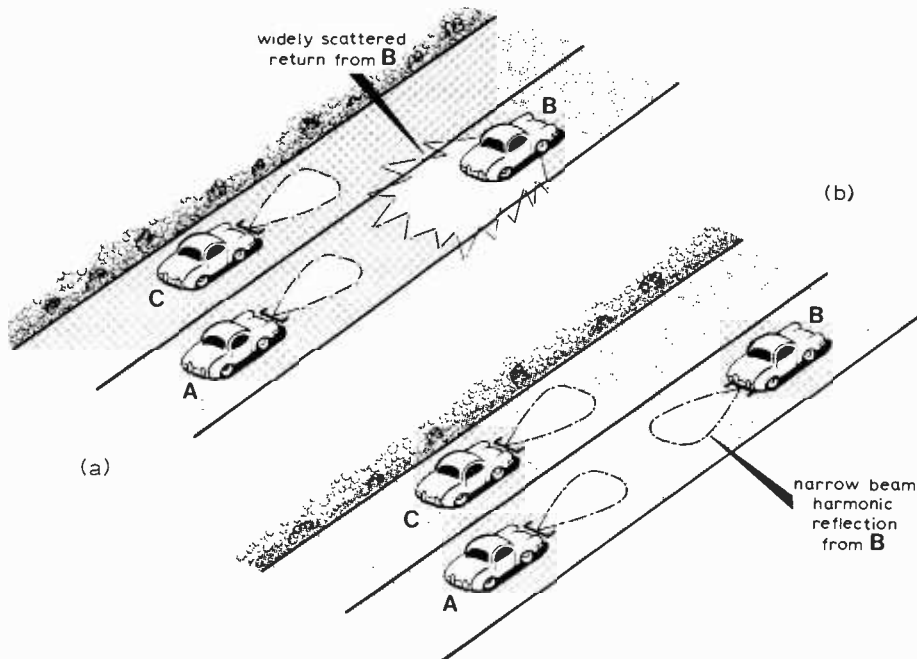


Fig. 3. Conventional versus harmonic radar: "cross talk" from adjacent lanes.

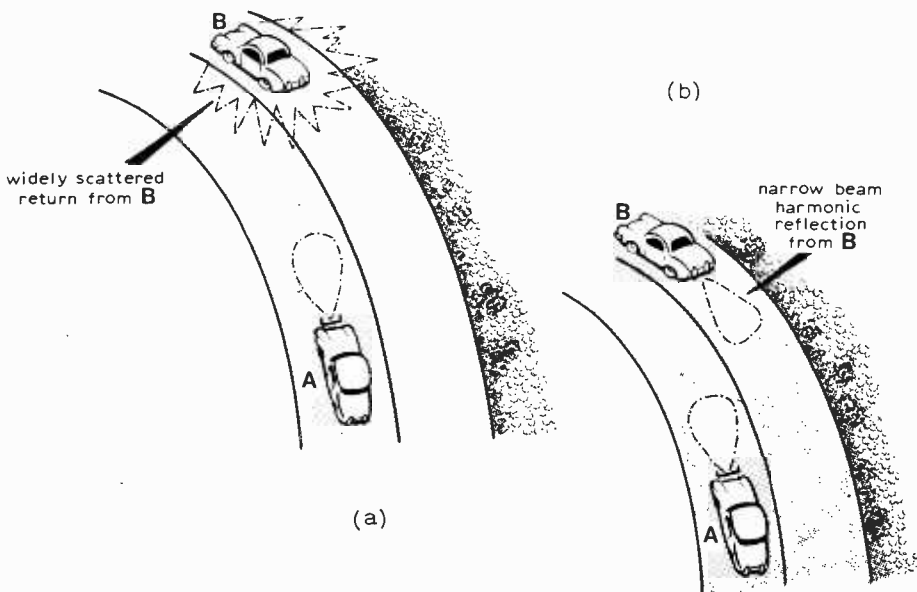


Fig. 4. Conventional versus harmonic radar: road curves.

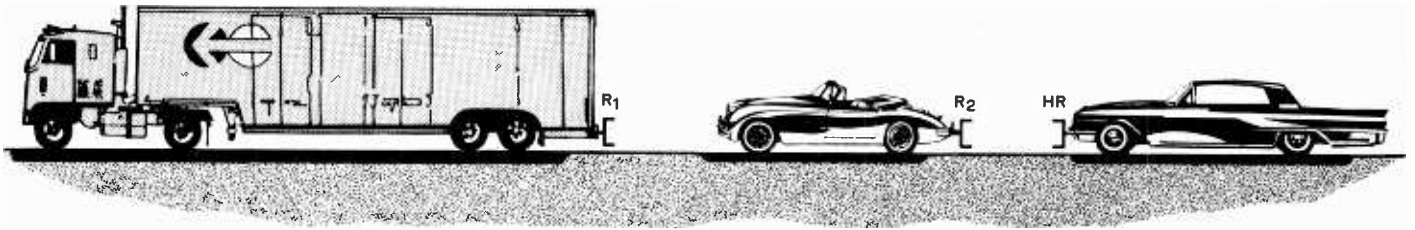


Fig. 5. Conventional versus harmonic radar: masking.

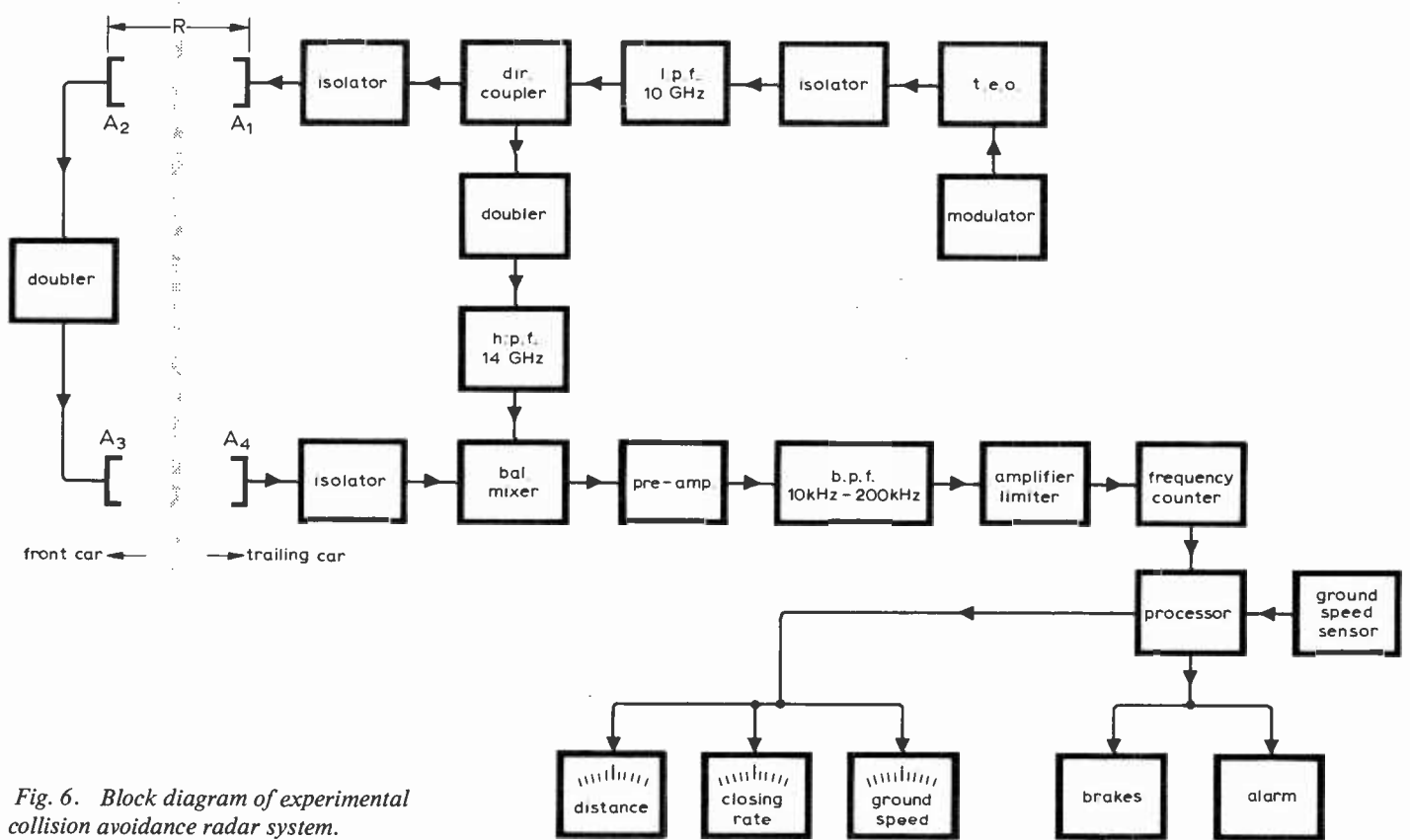


Fig. 6. Block diagram of experimental collision avoidance radar system.

antenna A_2 and radiates it back to the trailing car via antenna A_3 . This frequency is in Ku-band. The receiving antenna A_4 delivers the received power, which is at the second harmonic frequency, to the mixer, where it is mixed with a sample of the doubled frequency of the transmitter power.

The returned signal is shifted in frequency from the second harmonic of the transmitted frequency due to the round trip time delay $\tau = 2R/c$ (R is the distance between cars and c is the velocity of light). The frequency shift (or difference frequency, f_R) is given by

$$f_R = \frac{df}{dt} \cdot \tau = \frac{8\Delta F f_m R}{c}$$

A measurement of the frequency shift yields the range since the time delay is proportional to the distance between cars.

Two techniques for measuring this frequency shift have been investigated for the automotive radar. The first, for which the bulk of the experimental effort has been carried out, will be described first.

The output of the mixer is amplified, filtered and then fed into a counting

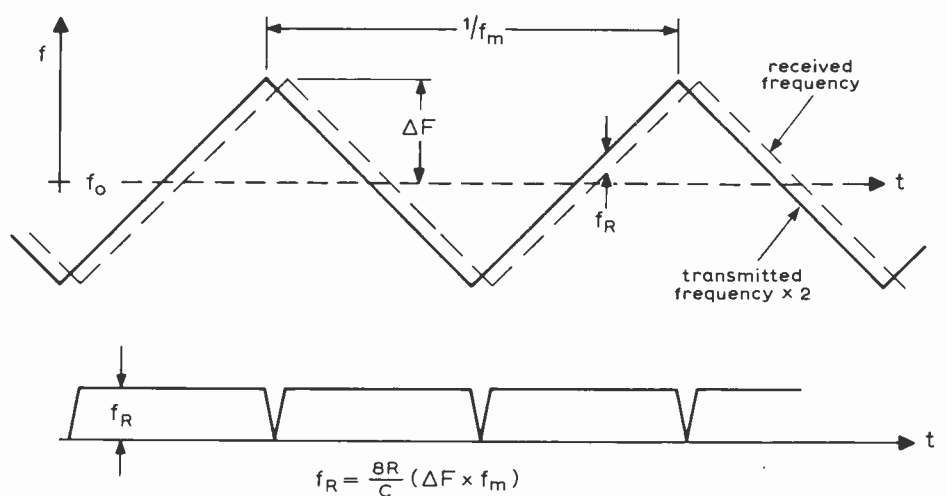


Fig. 7. Modulation scheme of harmonic radar.

circuit. This counting circuit develops a voltage which is proportional to the rate of zero crossings of the input signal and therefore the range. In addition, the radar processing circuitry derives a voltage which is proportional to the first derivative of the range, i.e., the closing rate. To make a

proper decision for a "safe distance", a third piece of information—the ground speed of the vehicle—is used. The ground speed is derived from an independent microwave Doppler speed sensor. The radar processor combines the three measurements of range, closing rate and

ground speed in a predetermined fashion, depending on the criteria chosen for "safe distance", which are, of course, dependent on weather and road conditions. When a dangerous driving situation is detected, an audible warning is sounded and a light is flashed. In our experimental unit, with the system switched to the automatic braking mode, the brakes are also applied for dangerous driving situations. The range, closing rate and ground speed are displayed on three panel meters mounted on the dashboard. In an operational system, it is not expected that these measured quantities would be displayed.

Quantization effects

As shown in Fig. 7, the difference frequency f_R is given by

$$f_R = 8\Delta F f_m R / c \quad (1)$$

where R is the distance between vehicles, ΔF is the total frequency excursion at X-band, and f_m is the modulation frequency. The choice of parameters ΔF and f_m is closely related to the presence of a step error (or quantization error) in distance

measurements with frequency modulated radar. The conventional signal processing technique² which measures the return frequency by counting the number of zero crossings that occur within a fixed time interval leads to a result which is quantized in frequency and therefore in range. The quantization arises because the difference frequency waveform is periodic in f_m . Therefore the average measured frequency (as measured by using the entire waveform and counting zero crossings in a fixed time interval) must be a multiple of f_m . The quantization step in range ΔR is therefore (from equation (1)) equal to

$$\Delta R = c / 8\Delta F$$

To minimize this basic "granularity" in distance readings, ΔF should be chosen as large as possible. In practice, bandwidth limitations in the doubler and mixing circuits, as well as regulations requiring the efficient use of frequency spectrum do not allow ΔF to exceed a few tens of MHz. In the experimental system, a good compromise was found to be ΔF equal to 25MHz, resulting in a range quantization of 1.5 metres. This quantization error can

be tolerated in a distance measurement for collision avoidance where the relative motion of the two vehicles tends to have an error-smoothing effect.

A different processing technique has also been investigated. This technique processes the difference frequency waveform in a digital manner allowing accurate range measurements to be made without the quantization limitation just described. This technique can allow the radar to operate with a smaller frequency deviation ΔF which in turn simplifies the bandwidth requirements at the t.e.o., mixer, doubler, etc., as well as conserving r.f. spectrum.

To understand how this signal processor overcomes the quantization limitation refer to Fig. 8, which depicts a typical difference frequency waveform. The number of zero crossings in a given time interval is quantized, with the quantization effects arising because of the phase reversals occurring every $1/2f_m$ seconds. However, if we restrict our attention to portions of the difference frequency waveform that are removed from the phase reversals, then we see that the time between zero crossings of this restricted portion of the waveform is not quantized.

If an accurate measurement of this time period (p_0) were made, then a non-quantized frequency ($1/2p_0$) could be found by generating the reciprocal of the measured period. This non-quantized frequency could then be converted to range via the relationship shown in eq. (1). Further details of the non-quantized signal processing technique are presented in the video circuits and signal processing sections of this paper.

Modulation parameters

The frequency excursion at X-band is 25MHz while the modulation frequency is 3kHz. This was chosen as a compromise because if f_m is made very high, the video bandwidth needed to accommodate the expected variation in range becomes very large while if f_m is made very low, there are various components of noise (in excess of thermal noise) which behave as $1/f$ noise, limiting system performance. For the parameters chosen, the frequency versus range slope is 2kHz/m resulting in a 10kHz-200kHz range for the difference frequency as the distance varies from 5 to 100 metres.

Doppler shifts

As seen in Fig. 9, relative movement between vehicles will have the effect of shifting the difference frequency by an amount equal to the Doppler frequency. It will be a positive shift during one half of the modulation cycle and an equal but negative shift during the other half. The average difference frequency (averaged over many cycles of f_m) will be the same as for a stationary car at the same average distance. The range reading is therefore independent of the Doppler shifts. An up-down counter switched in synchronism with f_m could be used to detect the closing rate. In the present system, however, the closing rate is derived by differentiation of R .

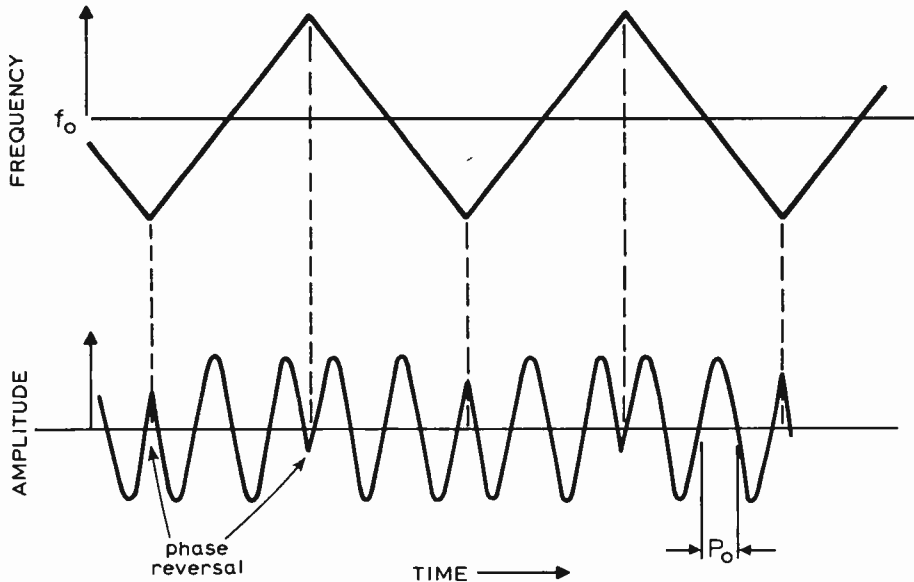


Fig. 8. Typical difference frequency waveform.

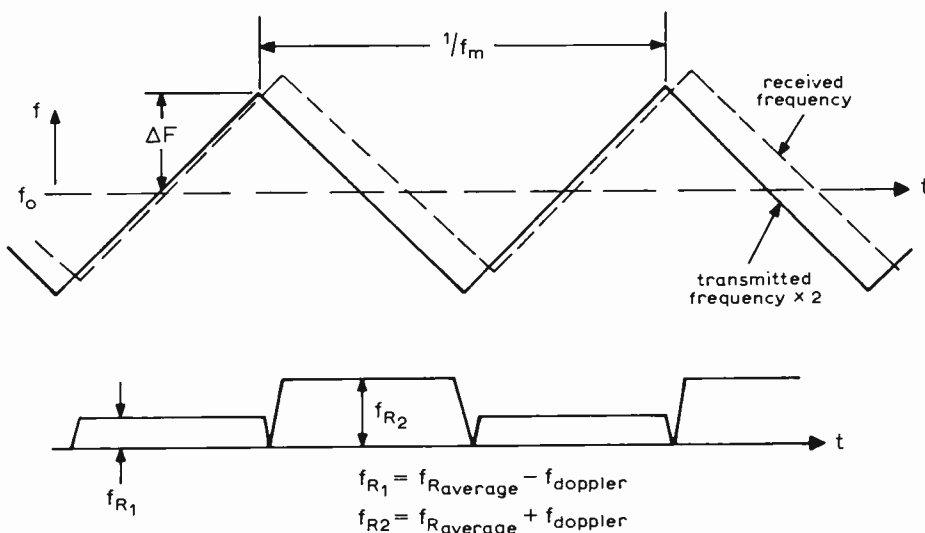


Fig. 9. Doppler shifts with moving vehicles.

Frequency doubler

The success of the harmonic radar concept was critically dependent on developing an efficient, passive harmonic reflector, i.e., finding a solid-state device which in a suitable circuit will generate the second harmonic with the required efficiency. For the car radar application it was felt strongly that the reflector must be completely passive, with no wiring to the car's electrical system to insure reliable operation and inexpensive installation.

The above needs have been met by the device shown in Photo 1. A silicon Schottky barrier diode is mounted in a microstrip circuit. A 0.8thou'-diameter diode chip is seen connected across a gap, located for best impedance match in a $\lambda/2$ (fundamental resonator). Input at X-band is coupled at a voltage maximum point of the fundamental frequency, output is coupled at a voltage maximum point of the second harmonic, with a $\lambda/4$ open section coupled to the output line to reflect the fundamental frequency back into the circuit. Fig. 10 shows the conversion efficiency of the doubler circuit. As one would expect, at the lower levels the power output at the second harmonic varies as the square of the power input at the fundamental, following a law of

$$P_{out} = KP_{in}^2$$

with K equal to $2500 W^{-1}$. The bandwidth of the doubler is approximately 75MHz, centred within the Ku-band in the experimental unit.

A similar doubler circuit is used to provide a sample of double frequency transmitter power to the local oscillator port of the mixer, but this circuit is operating at high power levels. A 50mW input at X-band yields a conversion efficiency of 10% over a 200MHz band.

Antennas

The choice of antennas and the r.f. frequency are closely related. For reasonable traffic-lane discrimination, a maximum horizontal beamwidth of 5° requires a horizontal aperture width of ten wavelengths. To achieve this aperture in a 12in physical size (approximately licence plate size) necessarily places us somewhere in X-band. A $10\lambda \times 10\lambda$ aperture with 50% efficiency has a gain of 28dB, which makes transmitter power requirements quite reasonable. Also, solid-state power sources at X-band frequencies are readily available, and spectrum space at X-band is still under-utilized.

Printed antenna design was found quite suitable for our system. The X-band antenna has an aperture of $13 \times 7\frac{1}{2}$ in, a gain of 26dB at 9GHz, and a 10% bandwidth. It consists of 128 fan-shaped dipoles printed on both sides of a 1/32-in thick polyethylene sheet, phased into a 50 Ω input through a succession of quarter-wave balanced transmission lines. An 18GHz antenna has been produced by scaling up in frequency from the X-band design, with similar electrical characteristics.

By using a polarization of the Ku-band antenna at 90° to the polarization of the

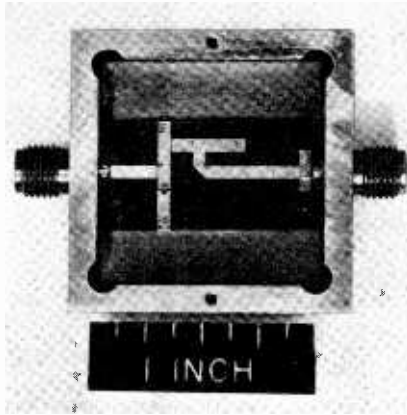


Photo 1. Frequency doubler microstrip circuit.

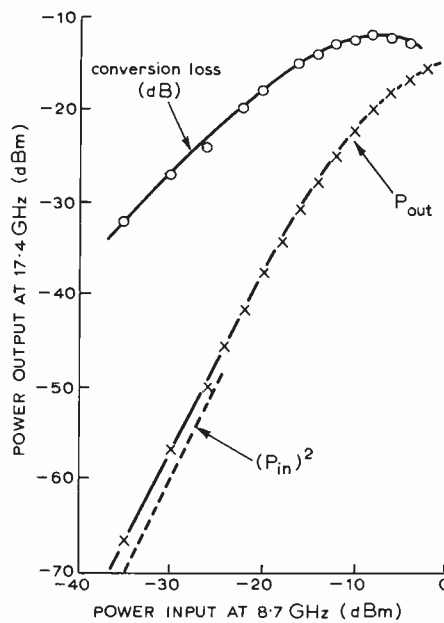


Fig. 10. Harmonic generation efficiency of frequency doubler.

X-band antenna, we get additional rejection of spurious second harmonic power generated at the source and received either directly from an oncoming vehicle or reflected from "nontagged" objects. This is in addition to second-harmonic filtering at the low-pass filter and isolators in the transmitter circuit. Total rejection of spurious second harmonic amounts to 150dB, reducing it to well below receiver noise level.

Doppler speed sensor

A low-power microwave Doppler speed sensor was developed for use on cars and lorries to provide true ground speed for both anti-skid braking and speedometer applications. In an anti-skid system, the true ground speed and wheel speed are compared to accurately determine wheel slip during braking.

The speed sensor, which is shown in photo 2 and diagrammatically in Fig.11, is a completely self-contained radar including transmitter, receiver, antenna, d.c. and signal processing circuits. A smaller version of the printed antenna in the collision avoidance radar is used for transmitting to and receiving signals from the road surface. The radar is mounted on the vehicle so that the beam lies in a vertical plane, with the vehicle's velocity vector at an acute angle θ (typically 45°) to the road surface. Part of the transmitted signal is diffusely reflected from the road surface back to the antenna. If the vehicle is moving with a velocity v , the reflected signal is shifted by the Doppler effect and the difference between transmitted and reflected frequencies is given by $F_D = 2v \cos\theta/\tau$ where τ is the wavelength of the transmitted signal. This difference frequency is extracted from the mixer and is converted to a series of fixed width pulses having a repetition rate proportional to speed. The pulses may be counted to indicate total distance or may be averaged for analogue speed information as is the case for the collision avoidance system. These radar speedometers have an operating

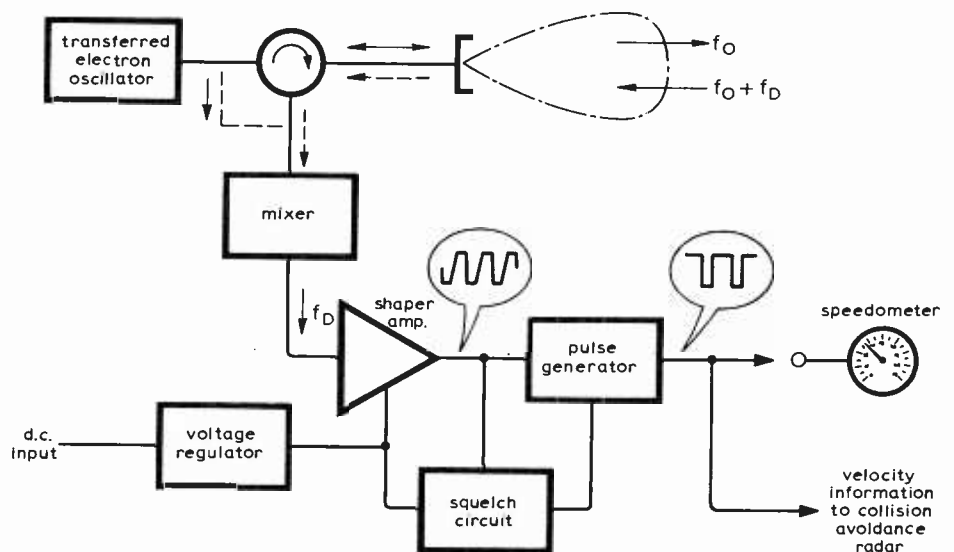


Fig. 11. Block diagram of Doppler radar module.

temperature range of -60 to $+75^{\circ}\text{C}$ and, once calibrated, have demonstrated inaccuracies of about 1% or less on dry road surfaces for speeds of 20–70 m.p.h.

Signal propagation

Assuming free-space propagation conditions, effective antenna apertures of A_f and A_{2f} for the X-band and Ku-band antennas, respectively, a target at distance R will present to the receiver a signal power of

$$P_r = (4K)P_0^2 A_f^2 A_{2f}^2 / \lambda^6 R^6 \quad (2)$$

where P_0 is the transmitter power at the fundamental wavelength λ and K is the doubler coefficient when operating in its square law region where P_{out} equals $K(P_{\text{in}})^2$.

The signal strength at the receiver is modified by ground reflections. Power will reach the antennas via a ground reflection in addition to the direct path. For the car, radar angles of incidence are between 5° and 0.5° . At such small angles, the reflection coefficients for horizontal and vertical polarization are similar (about 0.7 to 0.8 in magnitude and a phase shift of close to π radians). As a result of the ground reflected component, the range equation (2) has to be modified. Assuming an ideal case (not far from reality) where the reflection coefficient is equal to -1 ,

$$P_r' = P_r [64 \sin^2(2\pi h_1 h_2 / \lambda R) \times \sin^2(4\pi h_1 h_2 / \lambda R)] \quad (3)$$

where h_1, h_2 are heights above ground of the active radar and passive reflector antennas, respectively, and λ is the fundamental wavelength. As R changes, we expect a series of reinforcements and partial cancellations of signal strength. A partial cancellation will occur wherever $R = 4h_1 h_2 / n\lambda$, where $n = 1, 2, 3 \dots$ and for the values $h_1 = h_2 = 0.52\text{m}$ of the experimental radar. A signal minimum is expected at $R_{n=1}$ equals 32m and $R_{n=2}$ equal to 16m, with more below R_{min} .

For distances where $R > 10h_1 h_2 / \lambda$, the trigonometric functions in eq. (3) can be replaced by the arguments, resulting in a received signal of

$$P_r'' \propto P_0^2 A_f^2 A_{2f}^2 (h_1 h_2)^6 / (\lambda R)^{12}$$

indicating a drop-off with distance as steep as R^{-12} .

It is obviously more advantageous, relative to conventional radar systems, to increase the source power, and, for a given total aperture, to allocate the larger area to the fundamental antenna. In our radar, this aperture ratio is 4:1, giving the same gain to the two antennas. The very steep decrease of signal strength with distance has an advantage in that interference effects caused by out-of-range targets will be greatly reduced.

Measured signal strength as a function of distance is shown in Fig. 12 for the experimental radar over dry asphalt.

Source of noise

There are several sources of noise in the present radar system which limit the range. These sources include thermal noise, essentially "white" across the system-bandwidth

$$B = f_{R_{\text{max}}} - f_{R_{\text{min}}}$$

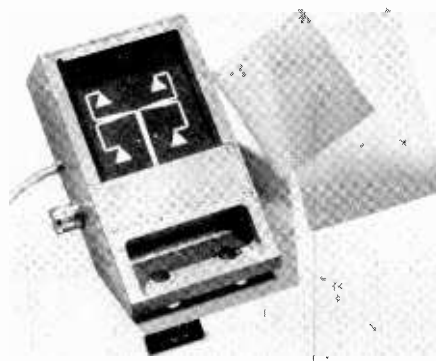


Photo 2. Doppler ground speed radar.

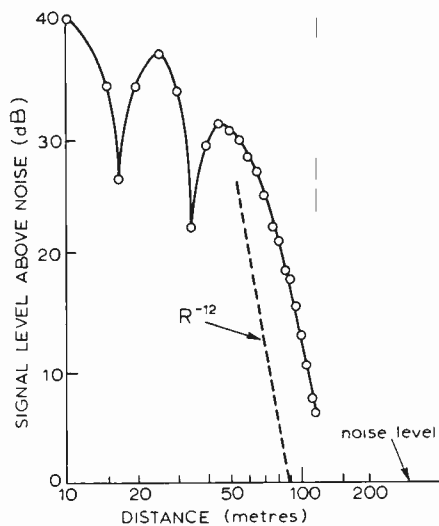


Fig. 12. Signal strength versus distance. (Antenna is 21in above road surface.)

Local oscillator noise, generated by beat products of the t.e.o. noise spectrum in a bandwidth B away from the carrier^{3,4}. This noise source varies with the "corner" at $f = 100\text{kHz}$. It is possible to reduce the effects of noise source by using a balanced mixer. For the radar parameters, with a mixer balance reduction of 20dB, the local oscillator noise becomes less than thermal. Amplitude modulation at the local oscillator, caused by the dependence of t.e.o. output power on frequency as frequency is varied over a range ΔF . This noise source has frequency components at f_m and its harmonics. Use of a balanced mixer and a t.e.o. power variation of less than 0.1dB over ΔF ensure that this noise source is of minor importance. Mixer sensitivity and balance are strongly dependent on frequency. This is partly caused by the fact that the isolation between the r.f. ports is rather poor ($\sim 6\text{dB}$), causing multiple reflections of the local oscillator power and its harmonics at the imperfectly matched isolator, antenna, and high-pass filter (see Fig. 6). When swept over a range of frequencies ΔF , a noise signal at f_m is generated at the i.f. output port, the harmonics of which enter the video band, $f_{R_{\text{min}}}$ to $f_{R_{\text{max}}}$, of the system. The magnitude of this noise signal varies with the mixer diodes in use and the

choice of centre frequency. With careful matching of components and adjustment of cable lengths it can be reduced, but in practice it is the dominant noise source, exceeding the first two contributions by 10–20dB. Therefore, the current design is not operating at its theoretical Johnson noise limit regarding signal-to-noise ratios, and consequently its maximum range of 100m is below a theoretical noise limited system.

Improvement in the future can be achieved by using a balanced mixer design which has better isolation and is less prone to generating spurious signals at f_m and its harmonics. One could also attempt matched filtering in the video amplifier chain to improve matching between the amplitude and range characteristic of the radar system. Should increased range become necessary a more sophisticated and complex design may be used, incorporating a tracking, narrow-band filter.

In the present design, a signal of P_{min} equal to -80dBm is required at the receiver input for a 10dB overall s/n ratio.

(To be continued)

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2. Luck, D. G. C., "Frequency Modulation Radar", McGraw-Hill (1949).
3. Narayan, S. Y., and Sterzer, F., "Transferred Electron Amplifiers and Oscillators," *IEEE Trans. on Microwave Theory and Techniques* (November 1970).
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Sixty Years Ago

In these days of "light current" electronics, and the professional, highly qualified radio engineer, it is worth remembering that it was not always thus. This extract from *Wireless World*, May 1914, may give some inkling of the sort of thing your average engineer came up against.

'Wireless Engineer' sends us the following two recipes for a cheap mixture for covering boilers in order to prevent loss of heat:

(1) Take 1 bushel of fireclay, 1 bushel of ordinary clay, 1 bushel of cow-dung, $\frac{1}{2}$ bushel of ashes (not the finest dust), $\frac{1}{2}$ gal. of coal-tar, and a little plasterers' hair as a binder; mix well together . . ."

And now we grumble when integrated circuits are in short supply!

Circuit Ideas

Ten-digit code-operated switch or combination lock

The circuit is that of a switch which is only operated by the insertion of a ten-digit code. On pushing either the "1" or "0" button, a positive-going clock pulse is applied to the clock input of the shift registers which then clocks into the first bit whatever is present at the serial input. With the serial input connected as shown, it is clear that pushing the "1" or "0" button will clock into the shift registers a "1" and "0" respectively. One requirement of the shift registers is that the information be present at the serial input before the clocking pulse occurs. This is clearly achieved in this design. The pair of cross-coupled NAND gates associated with each switch is to prevent the undesired effects of contact bounce.

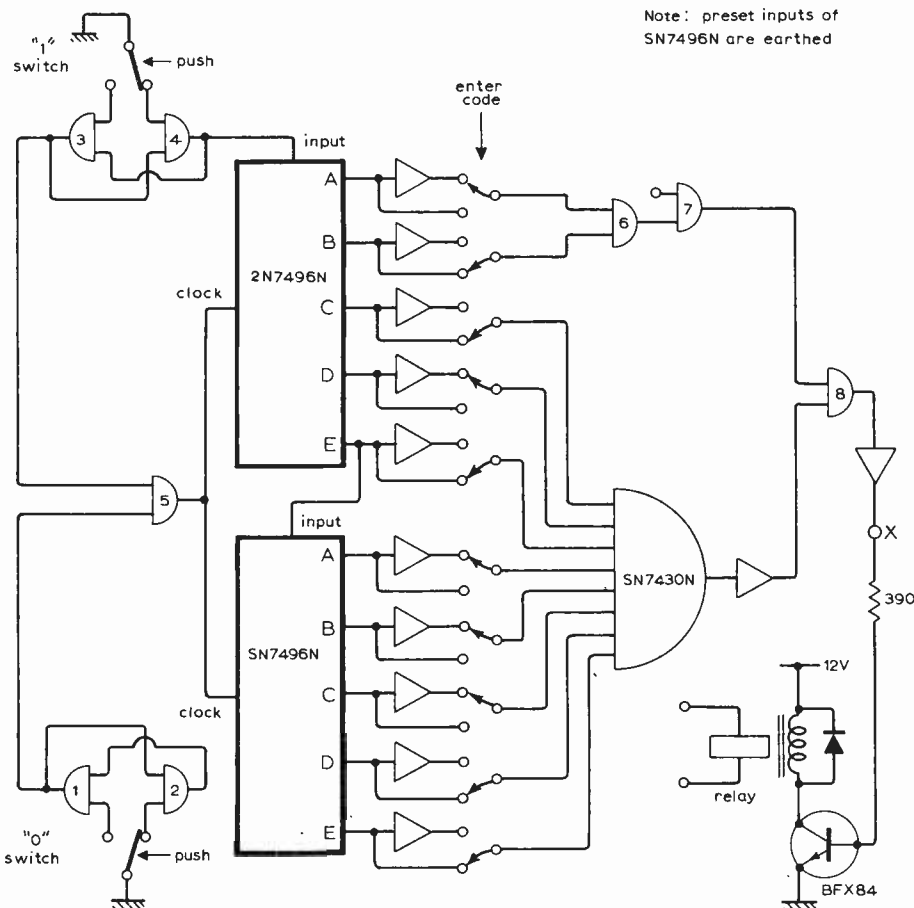
Each output of the shift registers is applied either directly or through an inverter to a NAND gate which, when all inputs are high, will cause the point X to go high. Thus the insertion of an inverter between a shift register output and the NAND gate will make it necessary for that particular output to be "0" before X goes high. As two five-bit shift registers are used, then clearly a ten-digit code will be required to operate the switch. Though the shift registers have a "clear" input, it was found that its use was unnecessary as any states present at switch-on are virtually no help in obtaining the code.

The theoretical probability of obtaining the correct code is one in 2^{10} or 1 in 1024, assuming that one knows that ten digits are required. The average code breaker will not know this, and so the odds against him will be much larger.

Seven Texas monolithic positive-logic chips are used in the present design. The NAND gates 1, 2, 3, 4, are part of a SN7400N package. Likewise are gates 5, 6, 7, 8. The 12 inverters are formed by using two SN7404N packages, each of which contains six inverters. The eight-input NAND gate is a SN7430N, and each of the two shift registers is a SN7496N.

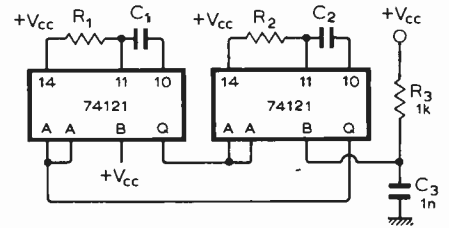
If one chooses a code with only four zeros, then only one SN7404N will be required. The system operates with a 5-V supply rail and consumes 100mA, excluding relay current.

K. E. Potter,
University of Sheffield.



Stable t.t.l. oscillator

This circuit satisfied my requirements for a self-starting t.t.l. oscillator which was more than the usual Schmitt trigger circuit. Components R_3, C_3 provide a starting pulse at switch on.



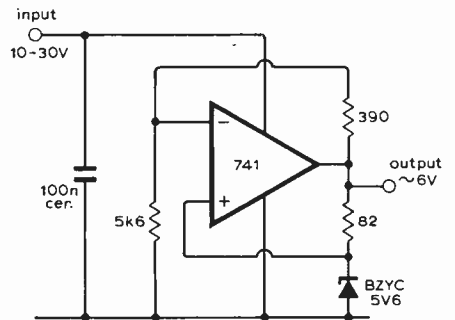
Period of oscillation is approximately $\log_e 2(C_1R_1 + C_2R_2) + \text{sum of propagation delays (about 45ns each)}$.

Stability is approximately 0.07% change in frequency for a supply change from 4.75 to 5.25V, and approximately 0.015%/degC for a 1MHz oscillator. For reliable operation $R_1C_1 \approx R_2C_2$.

M. Walne,
Brighouse,
Yorks.

High performance reference

Using only six components this reference circuit has exceptionally good characteristics. Current through the zener diode is held constant because it is derived from the stabilized output. With the equipment at my disposal I have been unable to measure most of the parameters of the circuit and so can only quote limits to these values.



Regulation < 0.005% i.e. when the input rose from 10 to 30V the output changed by less than 1mV.

Output resistance approximately 0.1Ω. Short-circuit current approximately 20mA.

Ripple rejection < 80dB; with an input ripple of 10V pk-pk output ripple was less than 1mV pk-pk.

Temperature coefficient typically 0.003%/degC although this can be reduced to zero by adjustment of the resistors.

Circuit can be rearranged to give either positive or negative outputs, and other values of output voltage.

M. Walne,
Brighouse,
Yorks.

Novel stereo f.m. tuner

2—Stereo decoder, assembly and setting up

by J. A. Skingley and N. C. Thompson

Plessey Company Ltd, Swindon

Using a ready-made front-end, integrated circuits and only one inductor, this tuner design is simple to operate, construct and set up. Part 1 gave novel circuitry for inter-station muting, a.f.c. restricted to less than station spacing, a single-lamp tuning indicator, and temperature compensated varicap tuning allowing stations to be preset. This second article gives a stereo decoder circuit that uses active filters to eliminate "birdies" and subcarrier harmonics, assembly instructions, setting up procedure and a linear-scale frequency meter circuit.

Fig. 7 shows the internal circuit of the SBA 750. Pins 3 and 4 receive the input from the i.f. which is passed along the chain of five limiting amplifiers to pins 6 and 7. From here the signal is passed internally direct to the quadrature detector, and also externally via the quadrature coil and pins 8 and 9. The demodulated signal is then available at pins 10 and 11, and it is from here that the drive for the a.f.c. and tuning indicator is taken. This audio signal is taken internally to an amplifier giving a single-ended output on pin 12.

The stereo signal is taken from this pin and fed to the stereo decode board. It is also coupled via C_{11} to pin 1, and after further amplification is available de-emphasized as a mono signal on pin 15. De-emphasis is accomplished by C_{13} on pin 16. Both stereo

and high-level mono outputs are therefore available.

The amplifier output to pin 12 can be attenuated by varying the current fed into pin 13. In this design pin 13 is open circuited to fully mute the amplifier while preserving the a.f.c. drive from pins 10 and 11. This ensures that the receiver captures a station from the muted condition.

Improved stereo decoder

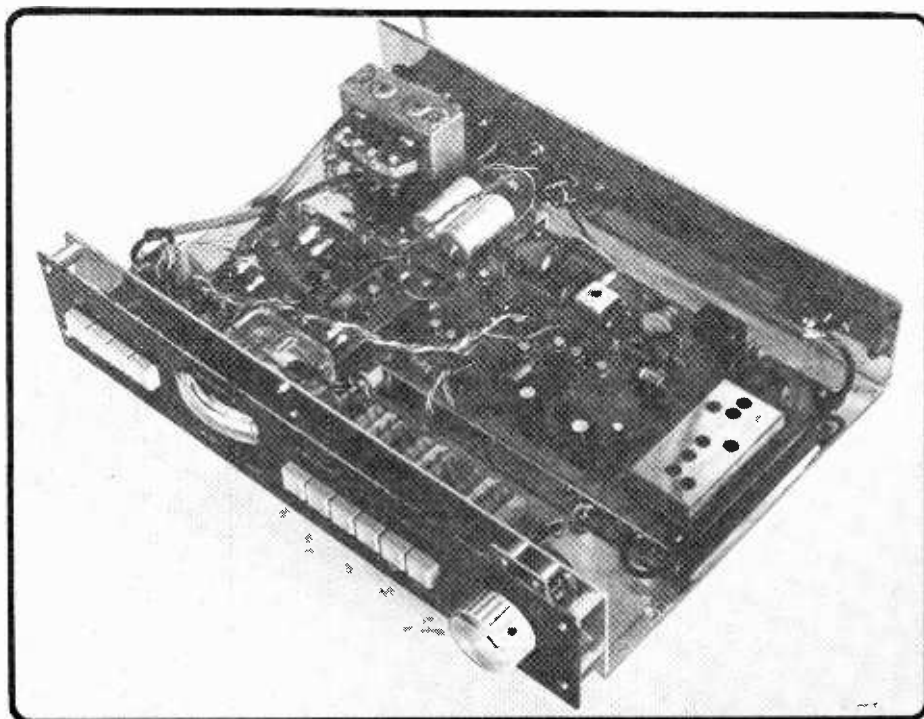
The stereo decoder is shown in Fig. 8. When this decoder integrated circuit was first used "birdy"-type interference was experienced under certain conditions. The causes of this have been reported elsewhere, but it is worthy of further explanation judging by the lack of effort to remove it in expensive receivers.

The nature of a frequency modulated signal is such that a bandwidth many times that of the deviation is needed for accurate transmission and reception, around 300kHz often being used. The spacing of broadcast programmes is however only 100kHz and this inevitably results in frequencies from one station arriving at the detector of a tuner receiving an adjacent station. The products from the detection are however normally supersonic and therefore inaudible.

This is fine until we introduce stereo reception which involves demodulation of the stereo channel at 38kHz usually using square-wave switching. This process also demodulates signals around the odd harmonics of 38kHz, i.e. 114, 190, 266kHz etc. The first two of these will produce audible signals from the adjacent channels at 100 and 200kHz away from the wanted station, giving interference centred on 14 and 10kHz respectively. These sound like high-pitched twittering sounds commonly called birdies.

Knowing the cause, the effect can be greatly reduced, if not completely eliminated. The wanted stereo information extends up to 53kHz, so by filtering the signal above this frequency before the stereo decoder, the unwanted adjacent channel signals can be attenuated. This also brings about an improvement in signal-to-noise ratio during stereo reception, as noise above 53kHz is also reduced. Such noise can be demodulated down to the audio band by the harmonics of the 38kHz switching frequency in a similar fashion to the adjacent channel signals if it is not removed.

The filtering required is carried out by Tr_1 in Fig. 8, which also shows the complete stereo decoder. (This circuit has been built on a separate board, and for this reason the components have been numbered independently). Transistor Tr_1 forms an active filter of the Sallen and Key type and provides a second-order response. There is an addi-



tional pole supplied by C_{10} between pins 10 and 11 of the SBA750 and this, together with the two poles of the active filter, combine to give a three-pole optimally flat response up to 53kHz, followed by a sharp roll off of 18dB per octave. This transistor is directly coupled and biased from pin 12 of the SBA750, and its output fed to the input of the decoder integrated circuit.

This decoder is of the phase-locked loop type, and in appreciating the advantages of this form of decoder, it is worth looking briefly at the conventional type. These decoders work by generating the necessary 38kHz switching frequency either by converting up the 19kHz pilot tone, or by phase locking a local oscillator to this pilot tone. The 38kHz signal may then be used to switch the multiplex signal into its two separate paths. Obviously, this switching must not only be at the correct frequency but it must also be in synchronism with the original coding. In other words the phase of the coding and decoding signals must be identical. If a tuned circuit is used as in the conventional decoder to separate the 19kHz from the audio, then a high-Q tuned circuit must be used to avoid phase jitter from the residual audio. A high-Q tuned circuit however has a high phase shift for a small amount of mis-tuning. For this reason a low Q would be required. Hence there is a compromise.

The phase-locked decoder operates by generating a 38kHz signal (in this case a 76kHz signal divided by two). This is divided by two to give 19kHz which is compared in phase with the pilot tone. The difference between the two is used to provide

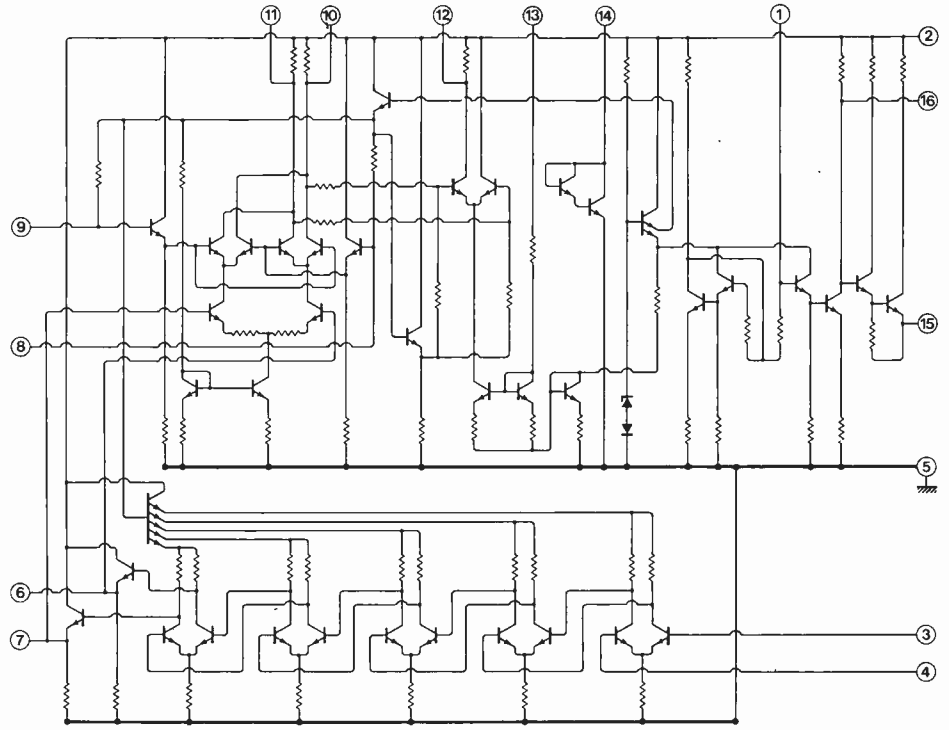


Fig. 7. Internal circuit of SBA750A i.c. includes circuitry i.f. amplifier (below) balanced quadrature detector and a.f. preamplifier (used on mono only). Signal to unmute output is applied from Fig. 4 to pin 13. Drive for a.f.c. and indicator circuit is taken from pins 10 and 11 via circuit of Fig. 5 and drive for mute circuit is taken from pin 6.

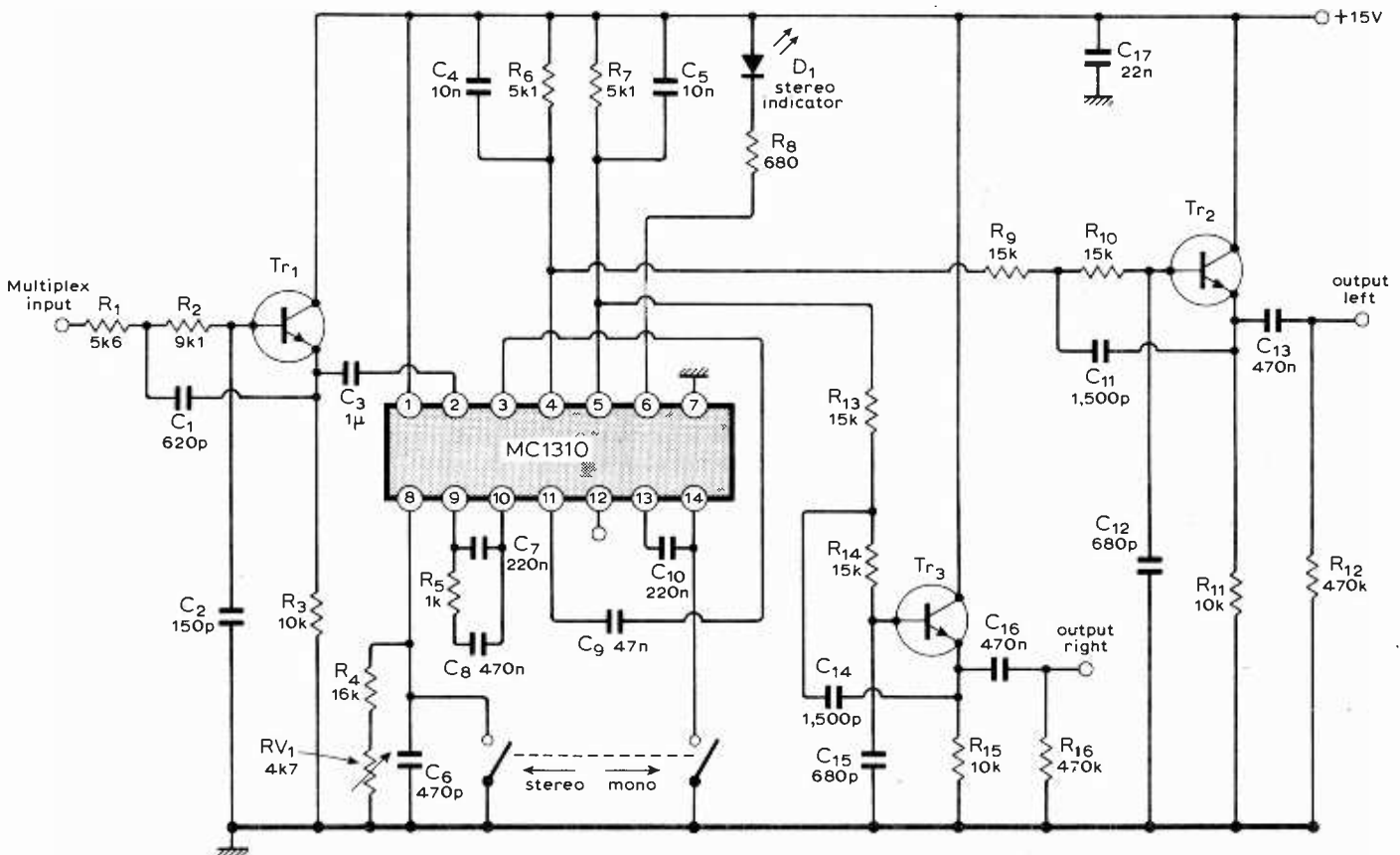


Fig. 8. Decoder circuit includes an active filter to roll-off response at 18dB per octave above 53kHz to prevent "birdies" that result from interference between odd harmonics of 38kHz and adjacent carriers. Two further active filters remove the 38-kHz harmonics from the outputs.

feedback, and hence phase lock the local oscillator to the pilot tone. The time constant of the feedback path may be made long so as to reduce the phase jitter to a negligible amount. This is equivalent to producing a high-Q tuned circuit, but one which cannot drift in phase provided the loop gain of the feedback path is high. This system also has the advantage that no coils are required. The complexity required dictates the use of integrated circuits on economic grounds, which has the added advantage that fewer corners need be cut in the design stage, so that the full potential of the system may be realized.

Two more active filters have been added, one per channel, formed by Tr_2 and Tr_3 (Fig. 8) and these are directly biased from the integrated circuit. Their function is to remove unwanted signals from the outputs, such as the 38kHz sub-carrier and its harmonics, which could otherwise cause trouble when tape recording.

The MC1310 has a direct output for a stereo indicator lamp and the facility for disabling the decoding process if desired. In the tuner described this is implemented by a second pole to the switch which also stops the oscillator to prevent any possible interference. The stereo decoding may need to be stopped if the signal is weak and a poor signal-to-noise ratio is obtained. Reverting to mono reception will provide an improvement. You may prefer to use the mono output provided from the receiver board, but this will need attenuation to give a compatible level when switching to mono. The tuner will, of course, automatically give a mono output in the absence of a pilot signal.

Construction

Layout and general presentation of the tuner is largely a matter of personal choice, and in this connection the mechanics de-

scribed represent only our solution, offered as a suggestion. The layout of the printed boards are critical, and it is strongly advised that the board design offered here is used. The system employs a generous amount of gain at high frequencies and even small deviations from the layout given could prove troublesome. This layout, given in Figs 9 and 10, follows good engineering practice and ensures stable performance.

When assembling a board of this com-

plexity it is a good idea to insert a few components at a time, solder these and clip their leads before inserting a few more. Start with the passive components and finally the transistors, integrated circuits, filter and front end. There are four wire links and these are made using discarded resistor ends. The single coil is 15 turns of 33 s.w.g. cotton cord wire, close-wound on a Neosid type A screened assembly using an F16 screw core. Before soldering the wire ends of this, insert the capacitor C_9 (100pF) into the same pins

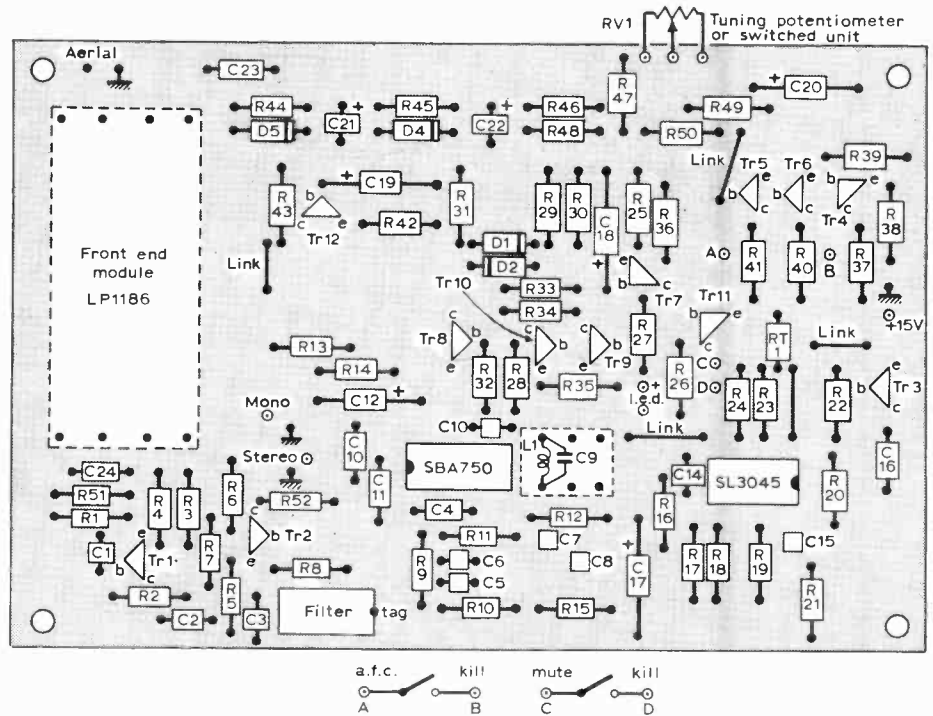


Fig. 9. Component layout for Fig. 6 is critical and p.c. board shown in Fig. 10 should be used. Points A and B connect to the a.f.c. switch and points C and D to the mute switch.

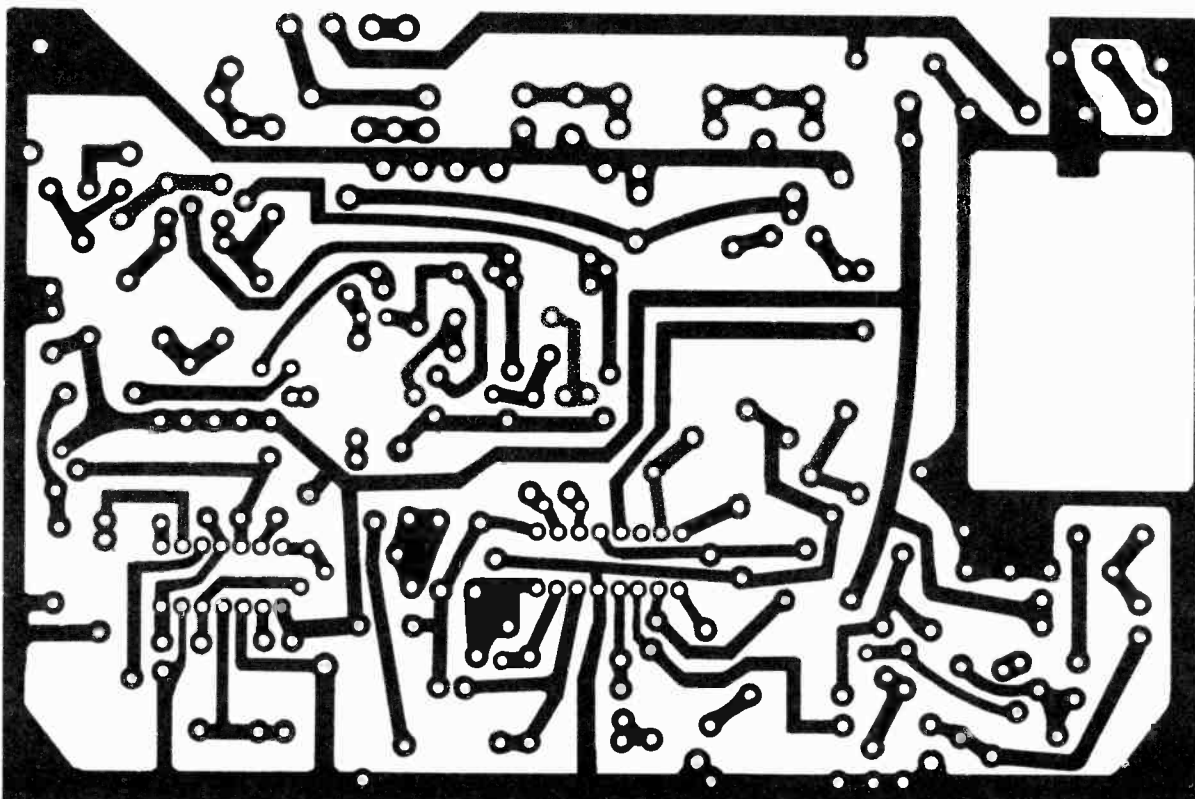


Fig. 10. Copper side of printed board, actual size. Component side shown above.

as the coil. This capacitor is slim and is easily accommodated within the can.

The emitters of the transistors are adjacent to the tag on the can. Transistors Tr_1 and Tr_2 are an exception to this. Insert so that the flat face of the plastic package is on the opposite side to the base of the triangle. If the centre (case) lead is bent forward towards the flat all these leads will fall into place.

Finally, solder twisted-pair wires at points A and B for the a.f.c. switch and C and D for the mute switch, together with pairs for the tuning indicator lamp (observe polarity), audio outputs and 15-volt power supplies. Mount the two boards on $\frac{1}{2}$ in brass pillars at the four corners, preferably on a metal chassis to ensure good earthing and screening.

The chassis system (Fig. 12) was constructed from 16 s.w.g. aluminium sheet, a piece 11in square being required. After drilling the chassis is bent into a U-shape where shown, and the front panel fitted on $\frac{1}{2}$ in brass pillars. This can be made of aluminium, sprayed and marked with Letraset. Alternatively, perspex may be used, marked in mirror image and sprayed on the reverse side. There are many ways open to home constructors these days, and the production of a professional finish is largely a matter of ingenuity and personal taste.

The front panel is made $\frac{1}{4}$ in deeper than the front edge of the chassis to allow the use of rubber feet on the chassis, yet leaving a smaller clearance beneath the front panel. A false front panel has the advantage of hiding most of the screws and allowing the push buttons and meter to protrude the correct distance. It also allows space for a hidden pilot lamp to illuminate the meter. A cover made of polished wood or sprayed metal may easily be made to fit over this chassis, consisting of inverted U-shape forming the sides and top. This should be about 8 or $8\frac{1}{2}$ in from front to back, depending on the front and back overhang desired, and the sides the same drop as the front panel.

The only difficulty is in mounting the ten-turn potentiometer which has a short spindle and must be brought forward $\frac{1}{4}$ in from the chassis. This is achieved by cutting a clearance hole in the chassis 1-in square and mounting the potentiometer on a strip 1×2 in held on $\frac{1}{4}$ in pillars, or long screws and double nuts. The spindle will then protrude from the front panel by the correct distance.

The prototype used six push buttons for pre-selected stations mounted on a printed board with the pre-set potentiometers between them. This resulted in a compact switch unit, but the method necessitated a minor trimming of the width of the potentiometer by rubbing their faces with emery paper until a sliding fit was obtained. This board also held a drive circuit for the meter used to display the frequency. This is shown in Fig. 13, and the p.c.b. in Fig. 14. This unit may be mounted on 0.1in pitch Letrokit board and hand wired if preferred, using the p.c.b. layout as a guide.

The meter drive circuit is basically an emitter follower driven from the tuning voltage, but the addition of a Plessey SL301 matched pair as shown results in a tempera-

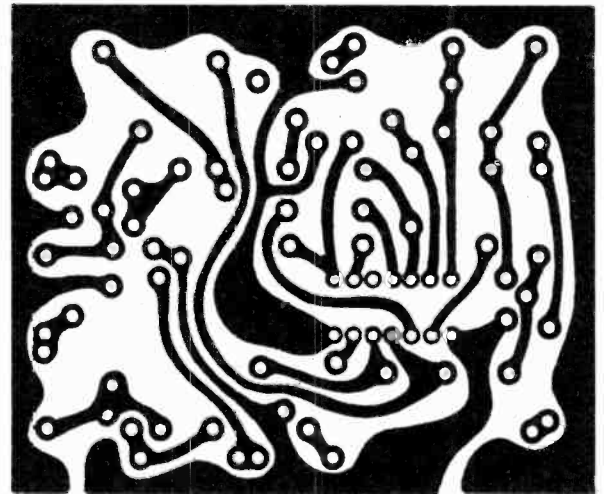
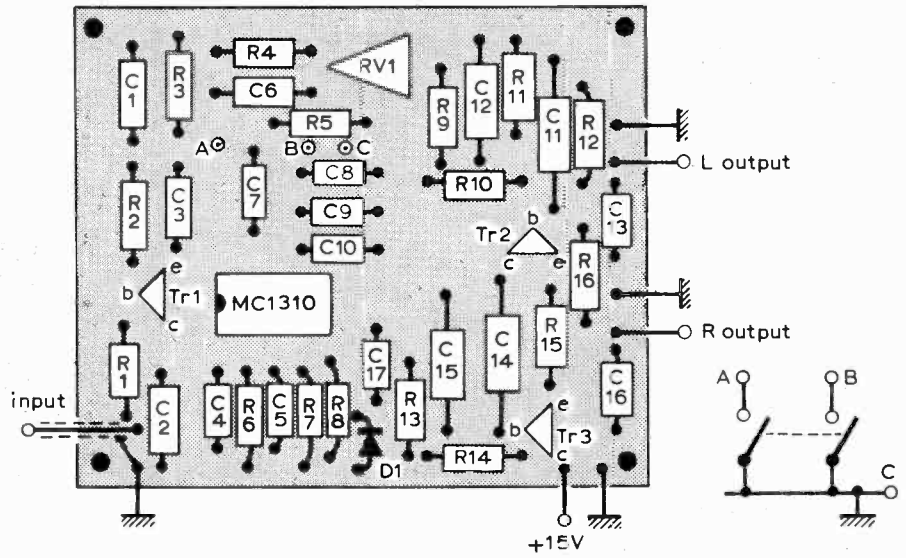
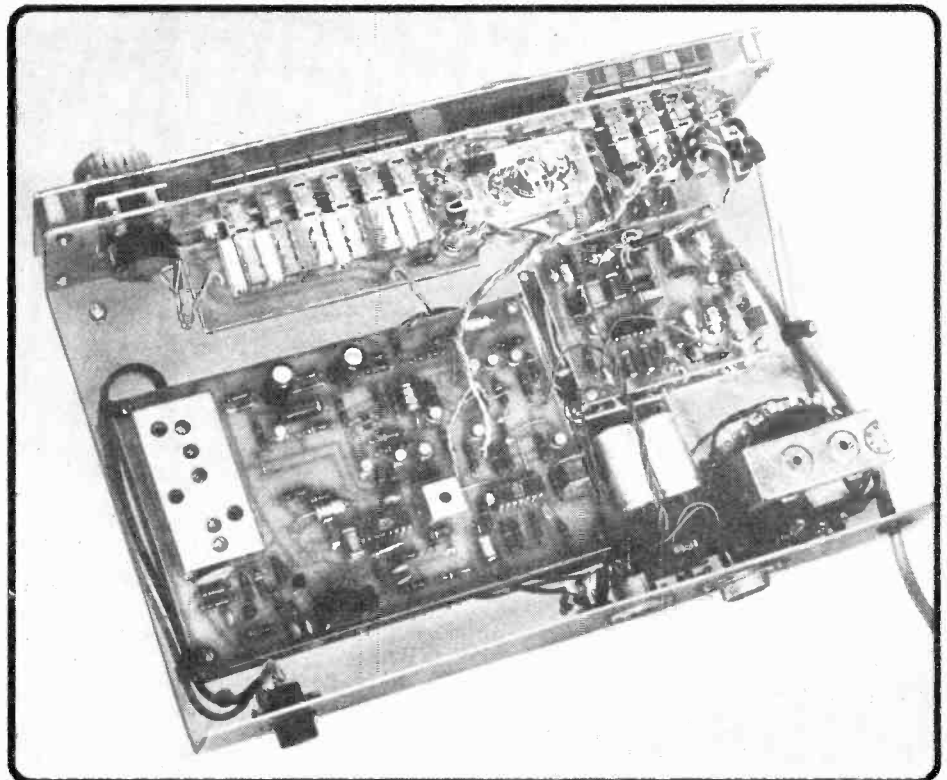
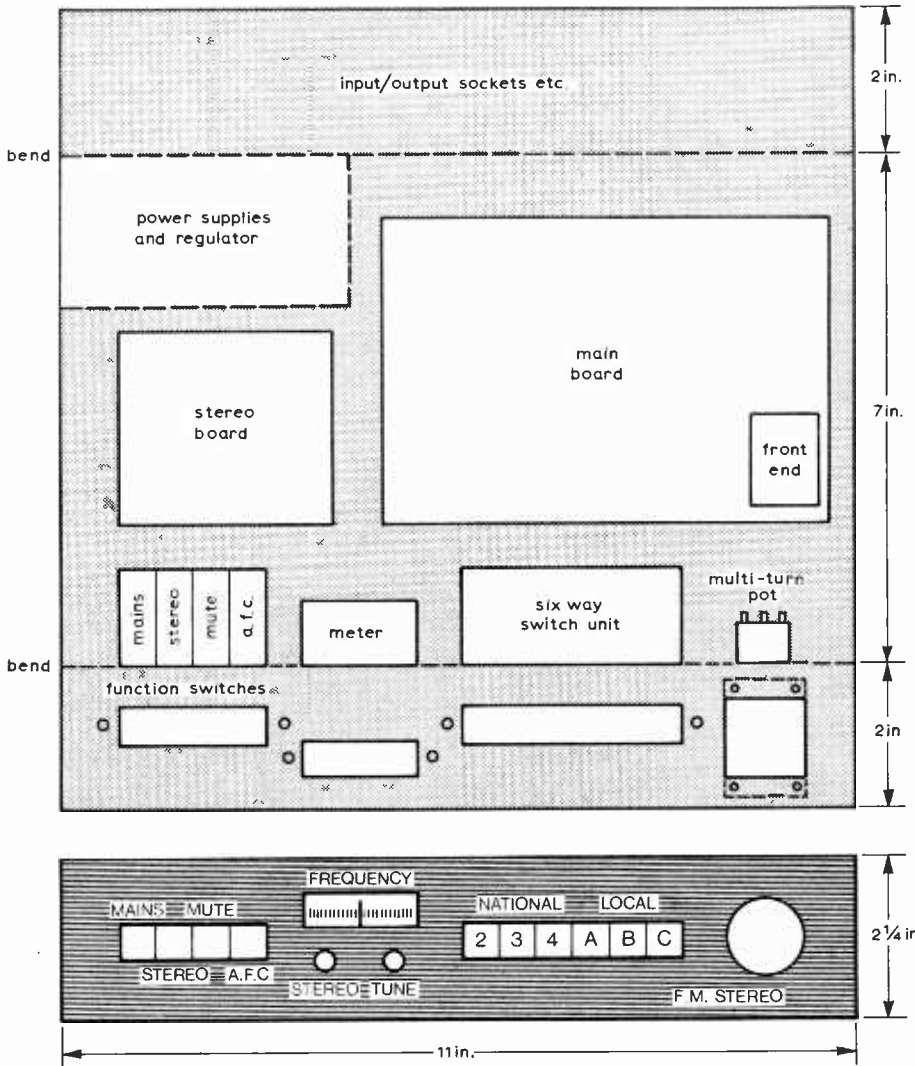
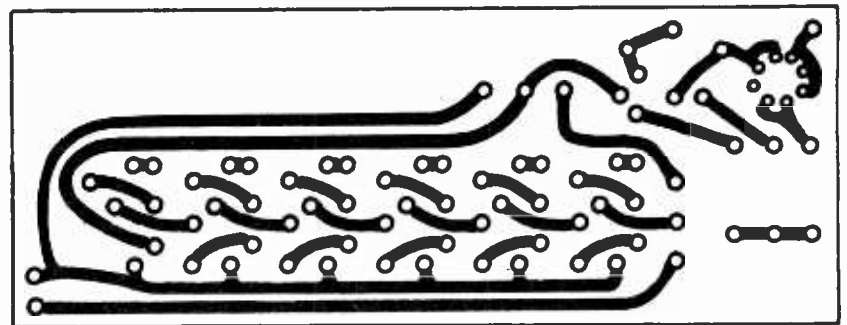
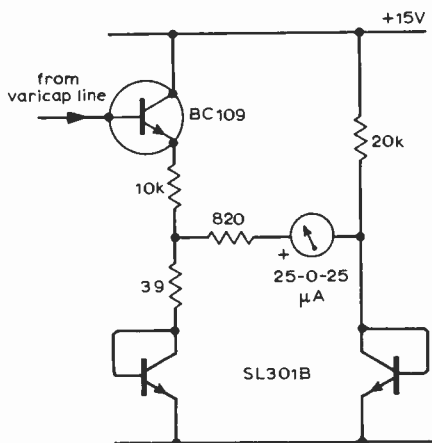


Fig. 11. Stereo decoder layout. Points A, B and C connect to mono/stereo switch shown actual size.

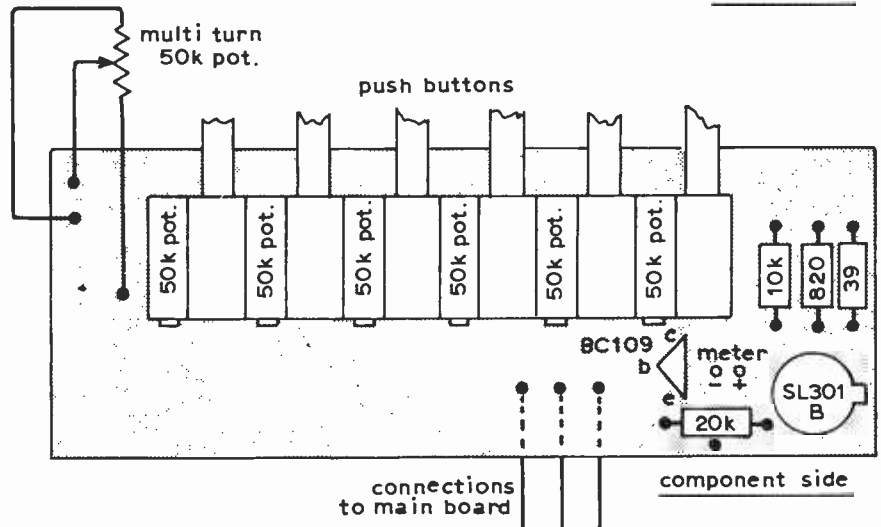




Chassis for complete receiver can be made from an 11 in square 16-s.w.g. sheet of aluminium, bent into a U-shape (Fig. 12, above). Separate front panel and cover improve appearance. Drive circuit for frequency meter gives linear frequency scale, varicap non-linearity being matched by matched-pair integrated circuit (Fig. 13, below). Layout on right shows pre-set potentiometers and frequency meter components (Fig. 14).



copper side



connections to main board

component side

ture-stable law-bending circuit producing a linear frequency scale from the non-linear law of the front-end varicaps. The meter is an RS Components miniature edge meter MR42A, 25-0-25 μ A. By removing the two screws the case may be removed and the scale lifted from its mounts. A wipe with acetone or nail varnish remover removes the lettering which may then be replaced with a suitable frequency scale using Letra-set—or free-hand if you have a steady one! Take care to avoid damage to the pointer, and the case should be replaced to exclude dust while the scale is being redrawn. Final calibration is done by mechanical adjustment of the zero adjuster while receiving a known station.

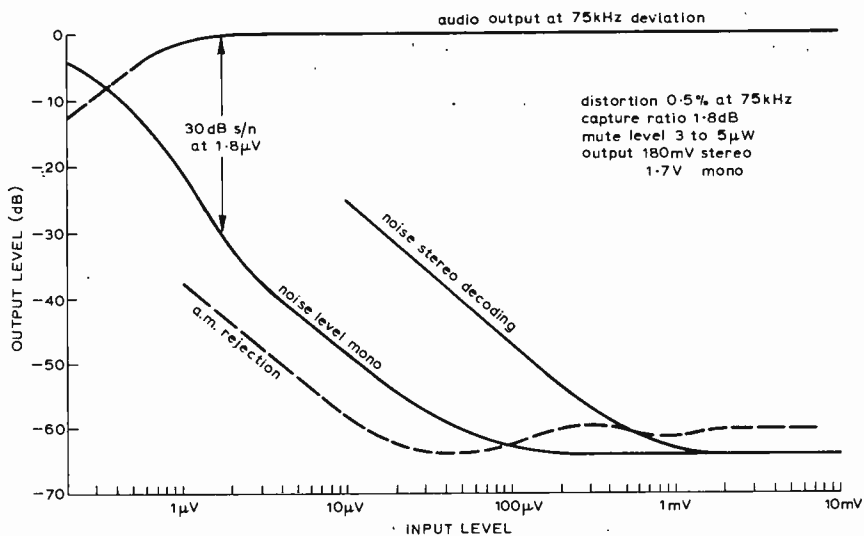
It is important that the power supply should be free of ripple and temperature stable, and this is achieved by a regulator integrated circuit RS Components MVR15V. This, together with bridge rectifier REC70, 1000 μ F capacitor, and transformer (634) from the same supplier complete a stable power supply for little effort.

Top-grade components were used to ensure reliability and consistency of performance. It is strongly recommended that the components specified are used. There are parts of the circuit which require 2% resistors, for example, to ensure correct biasing and balance of the tuning point and a.f.c. circuitry.

Setting up and testing

When the boards have been wired and mounted make the appropriate interconnections. Connect i.e.ds and switches and check everything before switching on. Put switches in the a.f.c.-off and mute disabled

Tuner performance



**Components
(stereo decoder)**

Transistors BC109
IC MC1310
Diode 5082-4403 (l.e.d.)

Resistors

R_1	5.6k Ω
R_2	9.1k Ω
R_3, R_{11}, R_{15}	10k Ω
R_4	16k Ω
R_5	1k Ω
R_6, R_7	5.1k Ω
R_8	680 Ω
$R_9, R_{10}, R_{13}, R_{14}$	15k Ω
R_{12}, R_{16}	470k Ω
R_{V1}	4.7k Ω

Capacitors

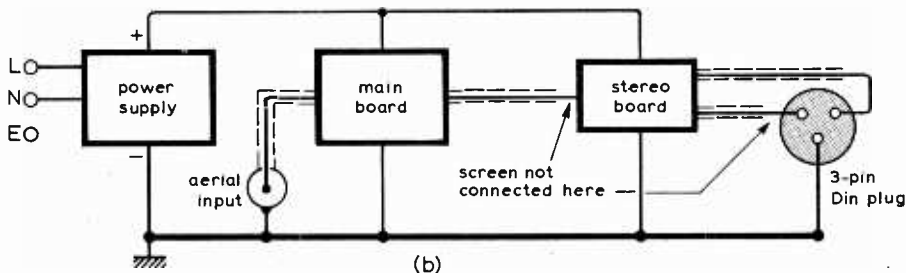
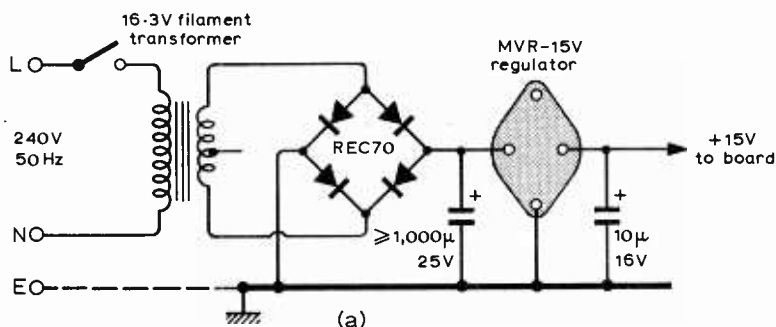
C_1	620pF (polystyrene)
C_2	150pF (polystyrene)
C_3	1 μ F (polycarbonate)
C_4, C_5	10nF (polycarbonate)
C_6	470pF (polystyrene)
C_7, C_{10}	0.22 μ F (polycarbonate)
C_8, C_{13}, C_{15}	0.47 μ F (polycarbonate)
C_9	47nF (polycarbonate)
C_{11}, C_{14}	1.5nF (polystyrene)
C_{12}, C_{15}	680pF (polystyrene)
C_{17}	22nF (polycarbonate)

release and pre-press the stereo switch and adjust the potentiometer until the l.e.d. lights in the shortest possible time after the switch is pressed. This is the correct setting.

Finally, a word about aerials. This tuner will receive stations on a few feet of wire, but if the full potential and maximum signal-to-noise ratio is to be obtained, a good aerial is essential. Any system can only be as good as its signal source, be it a pick-up cartridge, tape head or radio aerial, and this can easily be the weakest link in the chain.

Tuner kit. A kit of parts will be available for this tuner from Icon Design at 33 Restrop View, Purton, Wilts SN5 9DG. See advertisement on page 40 for details.

Modification. A resistor (R_{53}) of 2k Ω should be added in place of the wire link shown just below R_{43} in Fig.9. Because Motorola have altered the specification for the MC1310, a 150- Ω resistor should be added in the supply line to the decoder board, returning the l.e.d. current directly to the +15V rail. Increase C_{17} to 20 μ F to decouple this.



Components for suitable power circuit, above, were listed in part 1.

positions, and leave the aerial unconnected. Do not adjust the front-end module which is pre-aligned and should not be touched. Under these conditions there will be a band of noise defined by the i.f. filter passing through the limiting amplifier to the detector. If the core of the single coil is adjusted until the tuning lamp responds and be trimmed for maximum brilliance, the detector will be correctly adjusted to the centre of the i.f. pass band.

Now connect an audio amplifier and speaker. A loud smooth hiss should be heard. If the mute switch is operated this hiss should be silenced and the tuning lamp extinguished. Connect the aerial—a short length of wire may receive several stations—and, with all push-buttons out, adjust the ten-turn potentiometer to find stations. Observe a.f.c. action by mis-tuning a station until the tuning indicator is just extinguished and the output muted. Switching in the a.f.c. should recover the station.

A good aerial will now reveal anything around a dozen stations. The three least noisy should prove to be the national stations, and the frequencies of these are given in the local Radio Times. Trim the meter using the internal adjuster and obtain pre-set stations by pressing the appropriate button and adjusting the adjacent pre-set potentiometer. If this adjustment procedure cannot be achieved switch off and check all components and interconnections. Particularly check for incorrect polarity l.e.d.s and capacitors, misplaced n-p-n an p-n-p transistors, capacitors omitted in coil assembly or wrong number of turns.

If the alignment of the main board is achieved set the stereo decoder. This involves adjusting the oscillator using the single pre-set potentiometer. First find a transmission known to be stereo; check with the *Radio Times*. Ensure that decoding is not disabled by the switch provided and adjust until the stereo indicator lights. Now

An introduction to digital counters

—to accompany series 14 of Circards

by J. Carruthers, J. H. Evans, J. Kinsler & P. Williams

Paisley College of Technology

A digital counter comprises an interconnection of bistable or two-state memory circuits or, colloquially, flip-flops. The counter embraces those circuits which accumulate pulses according to a specific code as they appear at the input, frequency dividers, sequence generators and pulse waveform generators. The application requirement will generally determine how the collection of flip-flops is identified, but in this article the generic name of counter will be used.

The basic flip-flop has one or two control inputs, and two outputs termed Q and \bar{Q} (not $-Q$), where \bar{Q} represents the opposite state of Q . The logic state of these outputs may be termed set or reset, high or low, 1 or 0, and the change of state may occur on 0 to 1 or 1 to 0 transitions at the input, depending on the type used. The varieties of flip-flops used in counters are normally described by the control inputs and are termed D-type, T-type, RS and JK. The triggering input, called the clock-pulse input, ensures that a change of state will only take place on the occurrence of a pulse at the clock-input. Other facilities that may be available are preset and clear inputs which allow a flip-flop to be set ($Q = 1$) or reset ($Q = 0$), independently of the control inputs. Typical symbols for these flip-flops are shown in Fig. 1. Other variations include operation by positive or negative logic,

triggering on positive or negative pulse edges or a combination of these as in master-slave flip-flops.

A basic RS flip-flop using NAND gates is shown in Fig. 2. To represent the dependence of the Q output on the control inputs when a clock pulse occurs, a truth-table is used to demonstrate the state of Q at the n th clock pulse (Q_n), and after the next clock pulse (Q_{n+1})—Fig. 3. For example, if S and R are both at logic zero when a clock pulse occurs, the output Q will not change state, but remain as it was before the clock pulse. However, if $S = 1$, $R = 0$, then Q becomes logic 1, i.e. if it was previously logic 0 a change of state occurs, and if it was logic 1, it remains so.

The indeterminate state of Q for the condition that $R = S = 1$ exists because of a race condition between gates and is one disadvantage of this flip-flop—such a condition must be avoided. The JK flip-flop, however, does not have this disadvantage—all output conditions are predictable, as shown in Fig. 4. The last combination of $J = K = 1$ permits a useful toggle action in which the output changes state on the occurrence of every clock pulse.

Counters are generally classified as asynchronous or synchronous. The basic asynchronous circuit is implemented with cascaded toggle flip-flops, where the output of a previous flip-flop is the clock-

input for the next in sequence. Alternatively, the drive inputs may come from Boolean combinations of other outputs. In either case, a disadvantage is that each flip-flop changes state at a different time in a sequence. For each flip-flop a propagation delay exists between the occurrence of a trigger pulse and the next state of the output, and this delay “ripples-through” the counter. This restricts the maximum operational speed of the counter, since the maximum ripple-through delay must be less than the time between input pulses.

In integrated circuit technology, these counters have the advantage that each flip-flop operates at half the frequency of the preceding one. This allows a trade-off in high-speed (high-power dissipation) circuits to be used in the first stage, with lower speed (low-power) configurations being used in later stages. The maximum count (including zero) of a counter containing n flip-flops is 2^n , feedforward or feedback techniques allowing counts less than this to be achieved. The number of distinguishable states through which the counter cycles is known as the modulus of the counter, and this may be fixed when implemented with individual flip-flops, but some m.s.i. packages are available that permit variation of the modulus by a simple connection or change or simple gating. If the outputs of ripple-counters are to be

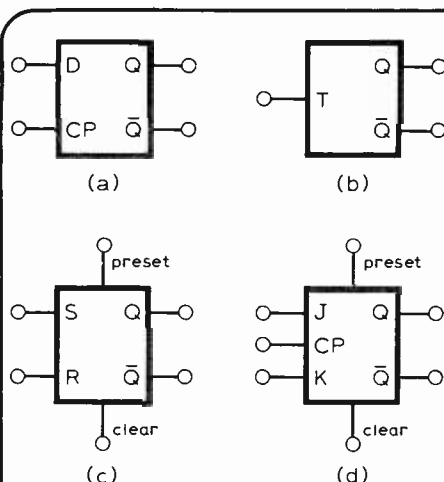


Fig. 1. Four basic types of flip-flop.

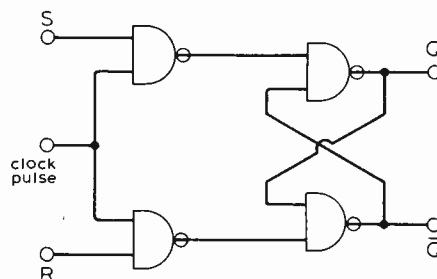


Fig. 2. Nand-gate RS flip-flop.

S	R	Q_{n+1}
0	0	Q_n
1	0	1
0	1	0
1	1	undefined

Fig. 3. Truth table for Fig. 2.

J	K	Q_{n+1}
0	0	Q_n
1	0	1
0	1	0
1	1	\bar{Q}_n

Fig. 4. Truth table for JK flip-flop.

decoded, care must be taken to ensure that the decoder network is enabled only when it is certain that all intermediate state changes have occurred.

The disadvantage of the asynchronous counter is avoided by the synchronous or parallel counter, in which all flip-flops change state in synchronism with a common clock-pulse. The speed of operation is limited by one flip-flop delay and that of any gating necessary, and these will depend on the type of hardware being used, e.g. c.m.o.s., t.t.l., e.c.l. Recent Schottky synchronous counter packages have internal circuitry which eliminates all external gating, and counting speeds up to 70MHz are claimed, and e.c.l. packages are available for speeds up to 110MHz.

Any sequence may be generated using individual JK flip-flops and associated gating. The design is more complicated than the asynchronous types, but one technique simplifies the design problem using Karnaugh maps.¹

The map is a two-dimensional representation of all possible combinations of a number of variables, where each square is one unique combination and adjacent squares are identical except for one variable. The rows and columns are arranged in accordance with the Gray code representation of decimal numbers, in which only one bit changes as we progress through adjacent numbers (Fig. 5). A Karnaugh map for four variables, A, B, C and D, is shown in Fig. 6, where a 1 in a square means the existence of logical "ANDed" variables, identified by the row and column common to that square.

The 1 squares are connected by the logical OR function, and the Boolean expression represented by Fig. 6 is $F = \bar{A}.B.\bar{C}.D + A.B.\bar{C}.D + \bar{A}.B.C.D + A.B.C.D$. A 0 in a square indicates that this particular combination does not exist. The advantage of the map is that minimization of the Boolean expression is simplified by being able to group adjacent squares in pairs, fours, etc. Two squares can be combined to eliminate one variable, and these two squares can be combined with another two adjacent squares to eliminate one more variable. The four squares may be looped as shown, because of their adjacency, thus A and C become redundant as both states of each are included in these squares reducing the function to $F = B.D$. This can be confirmed by a Boolean minimization. Note that adjacency of squares exists at the extreme ends of horizontal rows, and at the extreme ends of vertical columns.

A design of a modulo-6 Johnson counter is considered as an example of the technique. The maximum modulus of an m -stage Johnson counter is $2m$, hence a minimum of three flip-flops is required. It is assumed that the outputs are taken from the Q output of the flip-flops designated A, B and C, and the map is used to minimize the gating necessary to obtain the prescribed sequence Fig. 8. As all possible combinations of the variables are not used, the "can't happen" or redundant states are denoted by a

combination of one and zero (0) in the state table (Fig. 9) because the states are not specified and may be made 1 or 0 at will. In this case they will be considered as 1s. The state table shows the desired outputs at A, B and C on the occurrence of the numbered clock pulse, where 0 and 6 are equivalent, i.e. the 6th pulse resets the counter to zero. It will be assumed that the counter commences from the zero state.

The design technique requires the preparation of a Karnaugh map for the J and K input of each flip-flop to determine the control levels required at each input for every step of the sequence, by deriving a minimal Boolean expression for each map, though as these are derived independently

the circuit may not necessarily be minimal. This then determines the internal gating required.

An excitation table for the JK flip-flop is derived from the JK truth-table shown earlier. This table (Fig. 7) shows the necessary J and K inputs to either hold the flip-flop in a 1 condition or a 0 condition, or to cause a 1 to 0 or 0 to 1 transition, all on the occurrence of an input clock-pulse. The X indicates that it does not matter what that particular J or K state is, provided the other control input is in the correct state.

For example, if it is assumed that $Q = 1$, and a transition to logic 0 is required on the occurrence of a clock-pulse, then from the truth-table either

DECIMAL	GRAY-CODE			
	A	B	C	D
0	0	0	0	0
1	0	0	0	1
2	0	0	1	1
3	0	0	1	0
4	0	1	1	0
5	0	1	1	1
6	0	1	0	1
7	0	1	0	0
...

Fig. 5. Gray code for decimal numbers.

	A	0	0	1	1
	B	0	1	1	0
C	D				
0	0				
0	1		1	1	
1	1		1	1	
1	0				

Fig. 6. Karnaugh map for four variables.

	A	0	0	1	1
	B	0	1	1	0
C	0	1	0	X	X
1	0	0	X	0	

$J_A = \bar{C}$

	A	0	0	1	1
	B	0	1	1	0
C	0	X	0	0	0
1	0	X	1	0	

$K_A = C$

	A	0	0	1	1
	B	0	1	1	0
C	0	0	0	X	1
1	0	X	X	0	

$J_B = A$

	A	0	0	1	1
	B	0	1	1	0
C	0	X	0	0	X
1	X	1	0	0	

$K_B = \bar{A}$

	A	0	0	1	1
	B	0	1	1	0
C	0	0	0	1	0
1	X	X	X	0	

$J_C = B$

	A	0	0	1	1
	B	0	1	1	0
C	0	X	0	X	X
1	1	0	0	0	

$K_C = \bar{B}$

Q_n	Q_{n+1}	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

Fig. 7. Excitation table for JK flip-flop.

C	E	A	input pulse no.1
0	0	0	0
0	0	1	1
0	1	1	2
1	1	1	3
1	1	0	4
1	0	0	5
0	0	0	6

Fig. 8. Johnson counter sequence.

	A	0	0	1	1
	B	0	1	1	0
C	0	0	0	2	1
1	5	4	3	0	

Fig. 9. State table for Fig. 8.

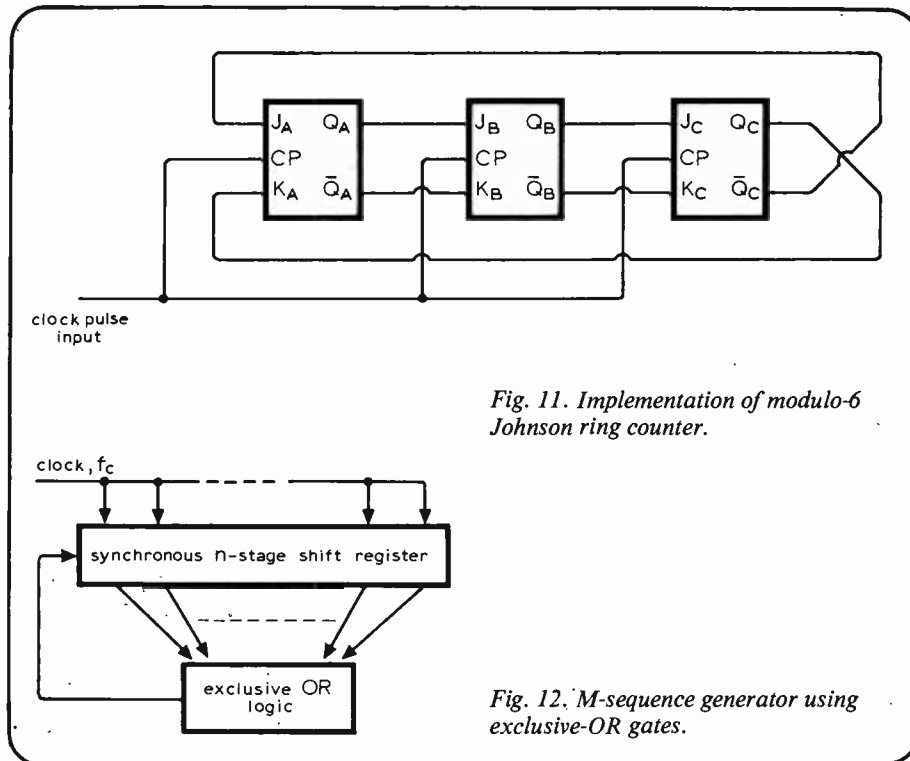


Fig. 11. Implementation of modulo-6 Johnson ring counter.

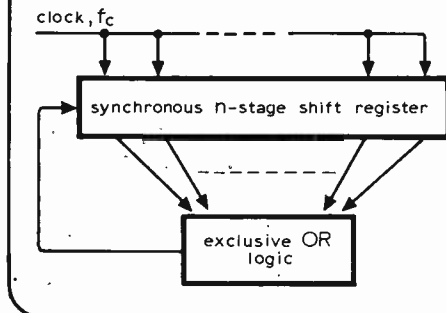


Fig. 12. M-sequence generator using exclusive-OR gates.

$J = 0, K = 1$, or $J = 1, K = 1$ will cause this change, i.e. provided $K = 1$, J may be either 0 or 1. As each input pulse occurs, the flip-flops should change in accordance with the truth-table of Fig. 8. The steps involved in filling the JK maps are as follows.

The can't-happen conditions of the state-table are transferred to equivalent squares on the separate J and K maps. Consider the J_A and K_A maps. On the occurrence of the first pulse, Q_A should hold at logic 1, hence an X is put in the J_A map square representing pulse no. 1, and a 0 in the K_A map square. This is repeated for pulse no. 2. At pulse no. 3 a 1 to 0 transition is required, hence an X is put in J_A map square for pulse no. 3, and a 1 in K_A map. A 0 is maintained for pulse no. 4, hence a 0 in J_A and X in the K_A square for pulse no. 4 is necessary. This is continued until all squares for each map are filled.

As an example of the minimization, notice that symbols 0 or X may be 1, hence a loop of four adjacent squares is available in the J_A map, i.e. the minimal solution for J_A is given by \bar{C} . Similar loops of four are obtained for each of the other maps, the circuit being implemented in Fig. 11. No external gates are required in this circuit, because the complemented outputs are already available from each flip-flop.

Common arrangements using this technique are b.c.d. counters, decade counters, up-down counters, though some are also available in m.s.i. packages.

The implementation of Fig. 11 has been described as a modulo-6 Johnson ring counter. However, examination of Fig. 8 shows that each output Q_A, Q_B and Q_C has one pulse for every six of the input so that the device could be regarded as a divide-by-six frequency divider. Most frequency dividers, on the other hand, allow one to divide by an arbitrary

number so it cannot be regarded as a very good frequency divider.

The device of Fig. 11 can also be regarded as a sequence generator, in that, given an input pulse sequence, one obtains a different output pulse sequence—admittedly not a very interesting one.

There is an infinite number of sequence generators that one could build but of particular interest are those which produce so-called maximal length binary sequences (M-sequences). Used in many areas, such as data communication system identification and correlation methods, M-sequences are generated by synchronous shift registers with feedback from various stages being used to determine the next state to be fed in. Feedback complexity is not proportional to the register length and very long sequences can be generated by very simple feedback arrangements. Feedback is performed by modulo-2 addition, i.e. via exclusive-OR gates (Fig. 12).

The properties of these sequences depend on the clock rate, f_c , and on the number of stages in the shift register, n , but all of the sequences possess to some degree properties close to those of band-limited white noise. (Hence the name pseudo-random binary sequences or p.r.b.s.) The signal bandwidth is given approximately by $f_c/3$ and the greater the value of n the more closely do the properties resemble those of random noise. The sequences are not in fact random because they are binary in nature and because they are cyclic, the cycle length being $2^n - 1$ clock periods. The binary nature of the signals is easily removed by passing them through simple first- or second-order filters so that the signal becomes continuous and has a probability density function which is close to Gaussian. The cyclic nature of the signal is in fact one of the advantages of M-sequence and is one of the non-random features one would wish to retain. This is

because experiments can be repeated for checking purposes over a cycle length without the statistical difficulties of genuine random noise. From this point of view it is therefore desirable to limit n .

Design is greatly facilitated by tables which indicate what feedback paths are necessary to produce an M-sequence of given length.² The problem comes down to one of choice of f_c and of n for the particular application in mind.

References

1. Dean, K. J., "Design of bidirectional coherent counters". *Proc. IEE*, vol. 113, 1966, pp. 1751-54.
2. Davies, W. D. T., "Generation and properties of M-sequences", *Control*, June, July and August 1966.

Titles or cards in series 14 are:

- Basic binary counters
- One out of n ring counter
- Johnson counters
- Reversible counters
- Reversible Johnson counter
- Divide by n counters
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- High-speed counters
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- Decade counters
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- Glossary: flip-flops and b.c.d. codes

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- 8 astable circuits
- 8 optoelectronics: devices and uses
- 10 micropower circuits
- 11 basic logic gates
- 12 wideband amplifiers
- 13 alarm circuits
- 14 digital counters

Next issue will cover pulse modulators. Introductory articles in *Wireless World* indicate availability of Circards, which are normally ready for despatch on the 14th of the month. The Circard concept was outlined in the October 1972 issue, pages 469/70.

Horn loudspeaker design—2

Continuing the development of design theories and techniques

by J. Dinsdale, M.A., M.Sc.

Cranfield Unit for Precision Engineering

The previous sections have outlined the physical principles underlying the operation of horns, and have shown how, provided certain basic rules are followed, sound reproduction of startling clarity and realism is possible from horns. However, it will also be clear by now that, unless one is prepared to accept extremely large and costly structures, it is all too easy to lose many of the potential qualities of horns through attempts to reduce the size to more acceptable proportions. This section now considers the procedures to be adopted in designing a domestic horn enclosure.

It has already been stated that the horn behaves as a transformer, converting acoustic energy at high pressure and low velocity at the throat to energy at low pressure and high velocity at the mouth. As with the analogous electrical transformer in which electrical voltage and current correspond to acoustical pressure and velocity, the basic requirements of the acoustical horn are that: (a) the primary (throat) should be correctly matched to the signal source (loudspeaker motor); (b) the secondary (mouth) should be correctly matched to the load (listening room); (c) the horn should be designed to handle the specified power level and frequency range. There are four principal parameters of the horn, namely mouth area, throat area, flare contour, and axial length. Any three of these will determine the fourth, and hence the characteristics of the horn itself. Once non-circular cross-section and non-linear axes are adopted, the problem becomes far more complex, and mathematical and physical concepts are no longer sufficient to design a horn. Nevertheless, the basic characteristics even of folded horns are determined to a large extent by known acoustic principles, and the most effective method of design is to work from these principles, ensuring that any deviation from theory is made on scientific grounds where possible.

Flare profile

Previous sections discussed the most commonly considered flare profiles, and it was concluded that a contour which allowed an exponential increase of the area of the wavefront as it travelled from throat to mouth provided the best compromise between the extremely gradual expansion of the hyperbola (giving optimum loading of the motor, but excessive throat distortion) and the

rapid expansion of parabolic and conical horns (giving minimum throat distortion but poor loading of the motor). However, the exact shape of the wavefront within a horn of curved profile is uncertain, and therefore assumptions have to be made, ranging from Wilson's modified exponential (lying a little inside the true exponential) to Voigt's tractrix, (which commences in a virtually identical manner to the true exponential, but departs substantially outside it in the region of the mouth). Which contour one adopts must be largely a matter of personal preference based preferably on careful listening experience.

Mouth geometry

The mouth of the horn couples the horn itself to the listening room. One of the commonly raised disadvantages of horns is that they require a very large mouth area if bass notes are to be properly reproduced. To some extent this is true; one cannot get a double bass out of a piccolo. However, there are a number of ways in which the mouth area may be reduced to manageable proportions without significantly sacrificing bass response.

As a sound wavefront travels up the steadily increasing bore of the horn, it should not meet any major discontinuity. However, it is clear that, unless the length and mouth diameter of the horn are infinite, there must be some discontinuity as the wavefront emerges and is no longer constrained by the walls of the horn. Although the cut-off frequency of the exponential horn is determined by the flare constant, the linearity with frequency of the acoustical resistance and reactance are determined by the mouth area, which, for a given throat area and flare constant will also determine the overall length of the horn. Strictly speaking, for no

discontinuity, the mouth should have infinite area. However, Olson³ has shown that provided the perimeter of the mouth of an exponential horn is greater than four times the cut-off wavelength,

$$\text{i.e. } p_m > 4\lambda_c$$

there will be no significant deviation of mouth resistance from that of the infinite horn.

A more important result is that for only 6dB variation in acoustic resistance, the mouth perimeter may be made equal to the cut-off wavelength, i.e. mouth area = $\lambda_c^2/4\pi$ where λ_c is the cut-off wavelength. As the mouth area is reduced below this value, the non-linearity of the acoustical resistance and reactance will increase.

Now these figures refer to the situation where the horn is suspended in free space, i.e. it radiates into an angle of 4π solid radians. In practice, this situation never occurs: even if the horn were placed on the ground at the centre of an infinite field, the mouth would only radiate into half a solid angle, or 2π solid radians; against the centre of a wall the mouth would be loaded by π solid radians, and in a corner formed by two walls and the floor the mouth will be loaded by only $\pi/2$ solid radians. The significance of this is that, whereas the minimum mouth area for a circular horn has been shown to be $\lambda_c^2/4\pi$ when loaded by 4π solid radians, *this value may be divided by a factor of two each time the solid angle is halved.* Thus the mouth area may be reduced to a size more in keeping with domestic conditions, e.g. a horn with a cut-off frequency of 56Hz (wavelength 20ft) would require a mouth area of 32 sq ft in space, but only 8 sq ft against a wall and 4 sq ft in a corner position, to give variations in loading of less than 6dB.

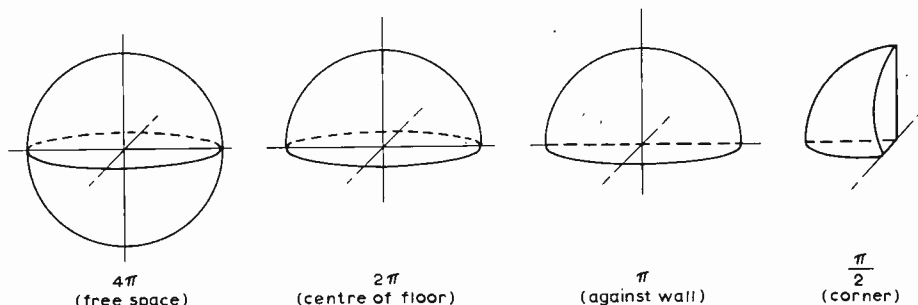


Fig. 8. Solid angles presented to a horn in different positions.

This situation which is illustrated in Fig. 8 may be compared with the mouth of a single horn placed at the intersection of eight rooms: four on the ground floor and four on the first floor. The bass response of the original horn will not be impaired, even though a listener in each room will see only one eighth of the total mouth area. One seldom gets anything for nothing in this world, and those who adopt corner speaker positioning in order to obtain a purer extended bass response from as small an enclosure as possible, may have to live with the eigen-tones such a position produces.

A plan view of a corner horn shows that the room itself provides a natural extension of the horn mouth. Many listeners have observed that corner horns can provide bass notes from fore-shortened horns, well below the limit dictated by the mouth area²⁵. It is tempting to reduce the mouth area still further below the 3dB limit established earlier and rely instead on the corner placement itself to supply the additional mouth area and horn length. In the author's experience, this technique cannot be justified because although the bass response is undoubtedly there, careful listening reveals an uneven response over the first two octaves above the cut-off frequency which will often detract from the realism offered by the horn. It is therefore recommended that in cases where overall enclosure size is a limitation, a correctly-designed horn with a cut-off frequency of (say) 80Hz will give a more satisfying and linear response than a fore-shortened horn whose expansion constant has been set to 40Hz but whose length has been limited to give a mouth area corresponding to 80Hz.

Most domestic horns will be of rectangular cross-section for ease and cheapness of manufacture. The foregoing comments regarding horns of circular section apply also to rectangular sections, although it is clear that the wavefront must behave in a most complex way at the corners, thereby reducing slightly the effective cross-sectional area. Provided that the ratio between the major and minor axes at the mouth does not exceed 4:3, rectangular horns may be employed to good effect.

Tabular design data is given for horns of both round and square section, with mouth areas computed for both corner positioning ($\pi/2$ solid radians) and wall positioning (π solid radians).

Throat geometry

The throat of the horn couples the wavefronts from the loudspeaker, which should ideally be plane at this point, to the horn itself. It has previously been shown that the horn is an acoustic transformer, converting acoustic radiation of high pressure/low velocity at the throat to low pressure/high velocity at the mouth. It is clearly of advantage to have a high pressure (and hence a low velocity) at the throat, because the low velocity will result in smaller movement of the loudspeaker cone, thus reducing the distortion produced by non-linearities in the magnetic field and the suspension. One way of increasing the pressure, and also of ensuring a higher degree of "plane-ness" of the wavefronts is to employ a throat area

substantially smaller than that of the loudspeaker itself. Tests carried out on a number of loudspeakers have shown that the "equivalent piston area" is approximately 70% of the speech cone area, i.e. the loudspeaker diaphragm in the shape of a truncated cone gives the same acoustic output as a plane piston with 70% of its area.

There are a number of practical reasons why modern loudspeakers are not manufactured as plane pistons; one of the unfortunate results of employing conical diaphragms is that the resulting wavefronts are in general not planar. However it has been found empirically that a throat area of between one quarter and one half the "equivalent piston area" of the loudspeaker provides satisfactory coupling between the loudspeaker and the horn, and also gives an approximation to plane wavefronts at wavelengths well in excess of the throat dimensions. It must be emphasized that for higher frequencies, where the wavelengths are of the same order as the physical dimensions of the loudspeaker diaphragm, the throat area should be made the same as that of the loudspeaker, and the horn should be of circular section, at least at the throat, so as to minimize standing waves across the horn itself.

The phenomenon of air overload distortion is caused by the non-linear relationship between pressure and volume of the air in the throat of the horn as it undergoes adiabatic compression and expansion. Beranek⁴ has derived the relationship for 2nd harmonic distortion at the throat of an infinite exponential horn as:

$$\% \text{ 2nd harmonic distortion} = 1.73(f/f_c)I_t \times 10^{-2}$$

where f = driving frequency f_c = cut-off frequency I_t = intensity (watts/sq in) at the throat.

This expression is also closely correct for finite horns because most of the distortion occurs near the throat. This expression has been plotted in Fig. 9 from which the throat area for given power and distortion may be obtained.

It is important to appreciate that the acoustic power radiated by musical instruments is extremely small²⁶, and that the higher the frequency the lower is the acoustic power to give the same subjective effect at the human ear. With the exception of full orchestra and pipe organ, which in the author's view it is futile to attempt to reproduce in domestic surroundings at anything

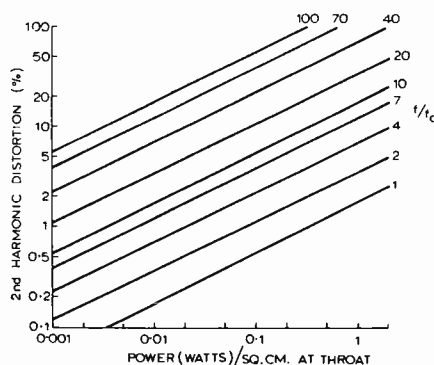


Fig. 9. Distortion caused by air overload at the throat.

approaching normal volume level, the acoustic power levels are extremely small, and an aim-point of (say) 3 watts and 1% distortion at the cut-off frequency, reducing to 0.05 watts and 0.5% distortion at four times the cut-off frequency, is likely to prove entirely satisfactory for domestic listening²⁷.

The above proposals for power and distortion give a throat area of around 10 sq cm, from Fig. 9, which compares not unfavourably with the effective piston area of 43 sq cm for a 3½in loudspeaker, one quarter of which is a little over 10 sq cm. Of course, if the throat area is increased, as would be the case with larger loudspeakers, the available power for a given level of distortion will also increase.

Having established the throat and mouth areas and the flare profile, the length of the horn and hence its area at any point may be obtained mathematically or graphically.

The horn as a filter

The foregoing sections have indicated how the horn can act as a bandpass filter—the lower pass frequency of which is determined by the expansion coefficient and the upper by the volume of the cavity between the loudspeaker and the throat of the horn. It is important that the response should be as linear and free from distortion as possible over this passband, and as far as the lower frequencies are concerned, careful choice of mouth area, in conjunction with a knowledge of the solid angle into which the horn will radiate and the flare constant, can ensure that non-linearities in the frequency response are kept to a satisfactorily low level.

However, with regard to higher frequencies, non-linearities of increasing amplitude become apparent at frequencies exceeding about four times the cut-off frequency, due to internal cross-reflections and standing waves set up within the horn itself. These non-linearities will be more serious if the material of which the horn is constructed can resonate, and they are also accentuated if the horn is folded, when wavefronts at the higher frequencies will be distorted at bends. In fact, there is also a practical limit beyond which folding becomes undesirable: folding should not occur beyond the point at which the lowest wavelength (highest frequency) to be transmitted exceeds 0.6 of the diameter of the horn. More will be said of this limitation during the discussion on folding, but it clearly points to a practical limit on the highest frequency a horn may accurately transmit.

Yet a further limitation becomes apparent from the graph of throat distortion versus frequency (Fig. 9). As the frequency increases, the percentage distortion for a given power density at the throat will also increase, and although it is generally true that in the majority of complex musical sounds the energy level reduces with increasing frequency there will still be a frequency above which throat distortion becomes unacceptable.

A commonly used and quite adequate rule of thumb is that a horn should not handle frequencies higher than four octaves above its cut-off frequency, although purists may prefer to limit at only three octaves in order to ensure lower distortion levels.

The complete multi-horn system

The maximum frequency range to be handled by a wide-range high-quality loudspeaker is about 9 octaves, i.e. 40Hz to 20kHz. This is clearly too wide a range to be handled by a single horn, for the reasons already noted, but it can conveniently be divided into three ranges, i.e. 40Hz to 320Hz, 320Hz to 2.5kHz and 2.5kHz to 20kHz. In practice, a 10% overlap should be allowed to ensure that there are no troughs in the response at the crossover points, and a case could be made for a four-horn system to cover a wider range.

It is worth considering a more modest instrument. If the cut-off frequency is limited from 80Hz to 18kHz and a two-horn system is considered with each horn handling a little under four octaves, the frequency ranges become 80Hz to 1.2kHz and 1.2kHz to 18kHz. Again, about 10% frequency overlap should be allowed.

The great attraction of a two-horn system is that only a single loudspeaker is required: the bass horn will be loaded from the rear of the loudspeaker; while the middle and treble horns will be loaded from the front of the loudspeaker, to eliminate interference and diffraction effects caused by the frame and magnet assembly at lower wavelengths. It has already been emphasized that the throat of the horn should match exactly the loudspeaker dimensions at these higher frequencies, and this arrangement is particularly attractive if a twin-cone speaker is employed. Treble wavefronts may be prevented from going down the bass horn by the cavity. To show the ease and utility of this approach, this article will include the design of a "mini-horn" utilising both sides of a single loudspeaker in a cabinet of reasonable size and cost for small domestic living rooms.

Purists may claim that the curtailed frequency range of 80Hz to 18kHz is inadequate. It is however the author's experience that the flat relatively distortionless response between these limits, together with

the sense of presence afforded by the horn's transformer action, make the mini-horn sound more attractive than many commercial loudspeaker systems of similar size but two or three times its price.

Once one adopts a multi-horn approach, there will be a number of frequencies which fall within the compass of two horns, i.e. 320Hz and 2.5kHz in the case of the three-horn system, and 1.2kHz for the two-horn system. It is essential that the radiation from the relevant pair of horns should be reasonably in phase at the crossover frequency, to avoid the presence of troughs in the frequency response, because the bass horn will be folded to bring its mouth adjacent to the other horns (it is not normally necessary or desirable to fold the middle and treble horns). This requirement places a restriction on the length of the horn, which has until now been regarded as a parameter to be determined solely by the throat and mouth diameters and the flare constant, and it is now apparent that the length of the lower horn of each pair should be either an odd or even number of half wavelengths of the crossover frequency, depending on whether the radiation wavefronts at the throats of the two horns are respectively in or out of phase.

Thus, if separate loudspeakers are used and the voice coils are connected in phase, the combined length of the horns from the loudspeakers to the plane of the mouths should be an even number of half wavelengths. Conversely, if a single loudspeaker is used to feed two horns, the radiation from the front and rear of the cone will be out of phase and the combined length of the two horns should be an odd number of half wavelengths. In practice, the lower horn will be considerably longer than the upper, and will effectively determine the design.

Folding, cabinets and room placing

Hitherto, discussion has been confined to ideal horns, of circular cross-section and straight axis, constructed of very stiff ma-

terial. Although typical dimensions for practical horns have not been calculated formally, it will be clear from many of the tables and diagrams that the dimensions of bass horns are almost certainly too large for comfortable accommodation in an average living room. Two further points must therefore be added to the design procedure, adoption of rectangular sections and folding the horn into a compact size.

Rayleigh showed that bends in tubes of constant cross-section will have no effect on transmitted sounds if the wavelength is large compared with the diameter, but that any cross vibrations set up will have a fundamental wavelength of 1.7 times the tube diameter. Wilson¹¹ has summarized the three principal rules of folding horns as follows: the wavefronts must not be twisted across the horn; the horn diameter (or width if rectangular) must be less than 0.6 times the lowest wavelength to be transmitted by that horn; the wavefront should be accelerated round bends to preserve its form.

As soon as one departs from the straight horn of circular cross-section, the scientific design principles described cease to be so relevant and become of more approximate value, although the three basic rules quoted above, together with the choice of a suitably stiff material for construction, provide very acceptable results.

A folding technique which twists the wavefront across the horn is difficult to achieve in practice, and may be eliminated by folding always in one plane. The requirement to "accelerate the wavefront around bends to preserve its form" is difficult to achieve when more than one fold is involved, since it requires a rectangular cross-section before the bend to become trapezoidal around the bend itself¹¹, and then revert to a different rectangular section after the bend. If one considers a multi-fold horn, concertina-fashion within an overall rectangular enclosure, this is not really a practical proposition, and is unnecessary because

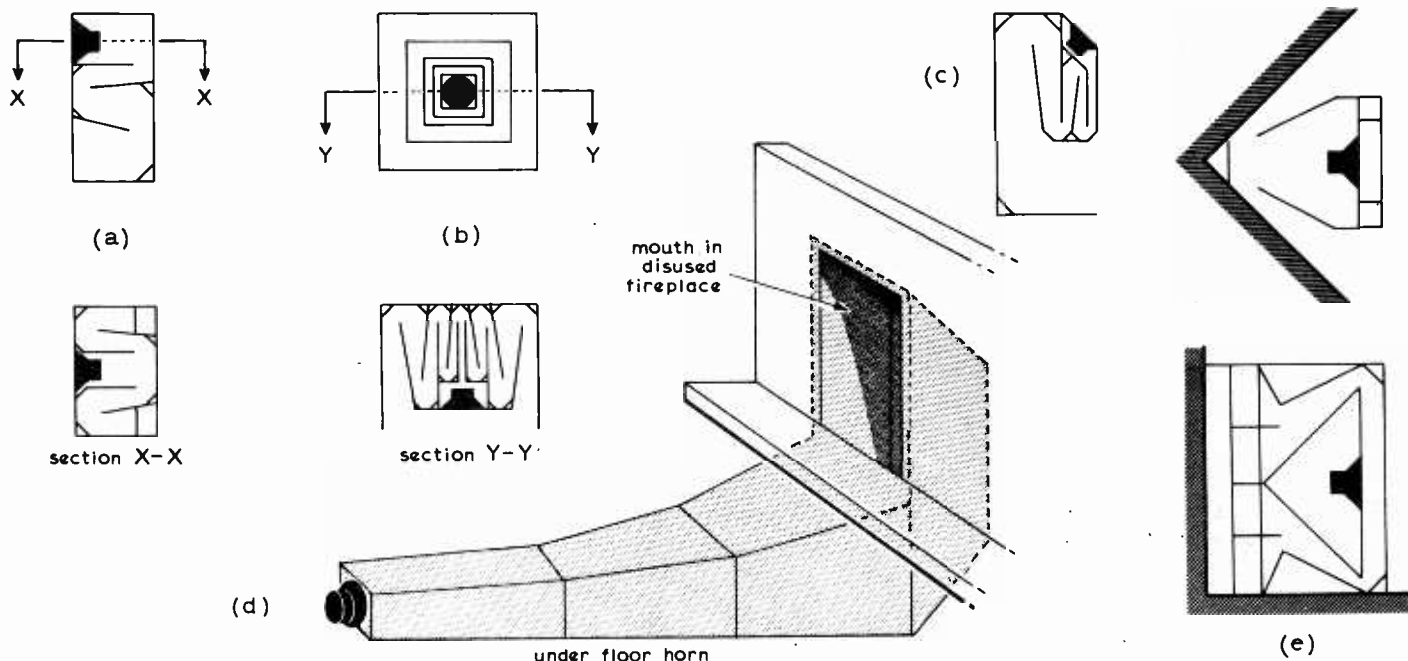


Fig. 10. Methods of folding horns (a) Olson, (b) Olson and Massa, (c) Lowther, (d) Newcombe, (e) Klipsch.

subsequent bends correct the waveform. But for single bends it can be adopted, and the mini-horn design described later could utilize this feature.

Examination of the Patent Office records for folded horn designs registered during the 1920s and 30s provides a fascinating monument to the ingenuity of acoustical designers, and Fig. 10 illustrates a number of the more well-known methods of folding. The restriction of horn width at a bend to 0.6 times the highest wavelength to be transmitted suggests initially that folding can only be attempted over the first few feet of the length of a horn; after that point the width will have reached the limiting value. However, this limitation may be overcome by bifurcating the horn (splitting into two equal channels) at each point when the width limits. Thus the mouth of a horn may comprise four equal mouths (brought together for convenience and to ensure audio realism) and the four "quarter-horns" may be folded far closer to the mouth than would otherwise be possible. Rayleigh has shown⁷ in Art. 264 that bifurcating a conduit will have no effect on the transmission of sound provided the lengths of the two portions are equal and the sum of their areas at corresponding points is equal to that of the original conduit.

In many cases, the front side of a loudspeaker, whose reverse side is horn loaded, will be physically close to the mouth of the horn itself, and it is commonly feared that there will be cancellation at certain frequencies caused by interference between the two radiations in anti-phase. However, the direct radiation from the unloaded front of the cone is only a few percent of that through the horn, and so the amount of cancellation is negligible.

Frequency handling

Although it has been shown that each horn acts as an acoustic bandpass filter, the lower cut-off frequency being determined by the expansion coefficient and the upper cut-off frequency by the throat cavity, there are important reasons why the full audio signal should not be applied directly to all horns regardless of their frequency handling capability. At the low frequency end of the spectrum, examination of Fig. 3 (Part 1) shows that the horn provides the loudspeaker with no resistive acoustic loading below its cut-off frequency. Thus any applied signals below this frequency will cause excessive movement of the loudspeaker diaphragm, which will be constrained only by the mechanical and electro-magnetic factors. This excessive movement can cause unpleasantly high intermodulation distortion, and can also lead to further non-linear distortion when the loudspeaker moves outside its linear range. At the upper frequency end, signals of excessive power can also give rise to distortion products due to deficiencies in the cavity/throat relationship. It is therefore beneficial to restrict the bandwidth of the electrical signal reaching each loudspeaker to match the acoustic bandwidth of its corresponding horn.

Although most commercial multi-unit loudspeaker systems use passive LC cross-over networks between power amplifier and

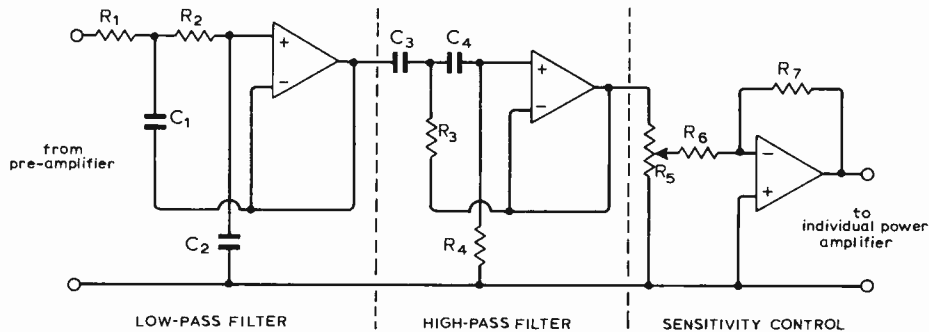


Fig. 11. Circuit for an active filter network. See appendix for component details.

loudspeaker to route signals of the appropriate bandwidth to each loudspeaker, careful comparative listening tests show that these units undoubtedly introduce a "dullness" or loss of "brilliance" into the audio output. Many explanations have been offered for this situation; in the author's opinion, the most likely reason being the loss of "direct drive" from the output of the amplifier, allied with a significant reduction in the degree of electro-magnetic damping afforded by the low output impedance of the amplifier.

Recent correspondence in *Wireless World*²⁸ and elsewhere has extolled the virtues of splitting the frequency range at low signal level, and employing a separate power amplifier directly coupled to each loudspeaker. The author has devised such a circuit, which consists of three (or four) parallel frequency-selective channels comprising Sallen & Key active filters giving preset low and high-pass characteristics in series in each channel, together with some gain adjustment to allow for the inevitable differences in sensitivity of each loudspeaker/horn combination. The active filters provide 2nd order Butterworth characteristics, a response which appears to give the least displeasing effects at the cross-over frequencies. (There will inevitably be phase-shifts associated with any filter circuit, and the effects of these on transients can produce a marked difference in their character.) This circuit is in Fig. 11 and the Appendix.

Thus, some form of electrical cross-over is generally necessary in addition to the acoustic cross-over provided by the horn itself. An exception is of course the case where a single loudspeaker drives two horns: one loading the front and one loading the rear of the diaphragm. In this situation, some compromise will be necessary in the acceptable distortion level and bandwidth of the loudspeaker system.

Directional horns

This article has extolled the ability of the horn to propagate wavefronts that are nearly plane at its mouth. However, there are situations where it is desirable to propagate wavefronts with different characteristics in the vertical and horizontal planes, particularly when middle and treble horns are used in stereophonic systems; it is often desirable to spread the wavefronts in the vertical plane while preserving more of a "point-source" in the horizontal plane. There are a number of different techniques

for achieving this, based on diffraction and refraction effects at the horn mouth with the comparatively short wavelengths (a few inches or less) with which these high frequency horns are concerned.

The design and manufacture of multicellular horns, distributed-source horns, diffraction horns and reciprocal-flare horns is beyond the scope of this article, and with the exception of the first two mentioned is probably outside the capability of most amateur constructors. Those interested should refer to the papers by Smith²⁹, Winslow³⁰ and to the relevant chapters by Olson³ and Cohen⁵.

Klipsch^{16,17} has described the design of his high frequency horn, in which the length/breadth ratio of the (rectangular) mouth assumes a value in excess of 4:1 c.f. the ratio of near unity advocated for bass horns). The optimum dimensions, length/breadth ratio, and apportionment of flare to the long and short axes depend on a number of complex factors, however, an aspect ratio between 2:1 and 4:1 with the flare apportioned in similar ratio has been found to give good practical results, and these parameters have been adopted for the "no-compromise horn" to be described. Although the high frequency horn of the "mini-horn" system is specified as circular (in view of its handling the relatively large wavelengths at 1kHz) an alternative rectangular mouth with aspect ratio of 2.5:1 has also been described.

Detailed design procedure

The previous sections have dealt in some detail with the basic theory of the horn, and the essential design procedures have been outlined for a series of horns which can cover the complete audio range. The final sections will consider the detail design of two horns: a "mini-horn" and a "no-compromise horn".

Because all horns are designed to slightly different requirements, and inevitably many readers will wish to "bend" the specification to a greater or lesser extent in order to satisfy their own needs, the designs are presented here by means of tables so that they represent a comprehensive design code for a wide range of horns.

Bass horn design

The bass horn should be examined initially, commencing with the mouth. Tables 1, 2 and 3 indicate the relationship between

continued over page

Table 1

Freq. (Hz)	Wave-length (ft)	Diameter (ft)	Area (sq. ft)
30	37.5	11.94	111.98
40	28.13	8.95	62.92
50	22.5	7.16	40.27
60	18.75	5.97	28.0
70	16.07	5.12	20.59
80	14.06	4.48	15.77
90	12.5	3.98	12.44
100	11.25	3.58	10.07
110	10.23	3.25	8.30
120	9.38	2.98	6.98

Table 1. Minimum mouth dimensions for bass horn (free loading).

Table 5

Freq. (Hz)	Cut-off freq. (Hz)	Flare coeff. (ft ⁻¹)	Area increase (% ft ⁻¹)	Doubling dist. (ft)
30	25	.278	32	2.49
40	33	.366	44	1.89
50	42	.466	59	1.49
60	50	.555	74	1.25
70	58	.644	90	1.08
80	66	.733	108	.945
90	75	.833	130	.832
100	84	.932	154	.744
110	92	1.02	178	.679
120	100	1.11	205	.624

Table 5. Exponential constants for bass horn.

Table 7

Nom. dia. (in)	Area (sq. in)	Effective area (sq. in)	Throat area (sq. in)	Throat area (sq. ft)
3½	9.62	6.74	2.02	.014
5	19.64	13.75	4.12	.029
6½	33.19	23.23	6.97	.048
8	50.27	35.19	10.56	.073
10	78.55	54.99	16.50	.114

Table 7. Throat dimensions.

Table 2

Freq. (Hz)	Area (sq. ft)	Dia. (ft)	Sq. side (ft)	Rect. sides (ft)
30	28	5.97	5.29	4.69 5.97
40	15.73	4.47	3.96	3.52 4.47
50	10.07	3.58	3.17	2.81 3.58
60	7.0	2.98	2.64	2.34 2.98
70	5.15	2.56	2.27	2.01 2.56
80	3.94	2.24	1.98	1.76 2.24
90	3.11	1.99	1.76	1.56 1.99
100	2.52	1.79	1.58	1.41 1.79
110	2.07	1.62	1.44	1.27 1.62
120	1.74	1.49	1.32	1.17 1.49

Table 2. Minimum mouth dimensions for bass horn (wall position).

Table 6

Freq. (Hz)	Cut-off freq. (Hz)	Flare coeff. (in ⁻¹)	Area increase (% in ⁻¹)	Doubling dist. (in)
200	166	.155	17	4.48
250	208	.193	21	3.59
300	250	.233	26	2.97
350	292	.271	31	2.56
400	330	.307	36	2.26
450	375	.349	42	1.98
500	420	.391	48	1.77
550	458	.426	53	1.63
600	500	.465	59	1.49
700	580	.539	71	1.29
800	660	.614	85	1.13
900	750	.698	101	.993
1000	840	.781	118	.887
1100	920	.855	135	.810
1200	1000	.930	153	.745
1300	1083	1.01	175	.686
1400	1166	1.08	196	.642
1500	1250	1.163	218	.596
2000	1660	1.54	368	.450
2500	2080	1.93	590	.359

Table 6. Exponential constants for mid/top horn.

Table 10

Freq. (Hz)	3½	5	6½	8
200	30.9	26.3	22.9	20.3
250	22.5	18.8	16.1	14.0
300	17.1	14.0	11.8	10.0
350	13.6	10.9	8.98	7.46
400	11.1	8.78	7.07	5.73
450	9.09	7.05	5.55	
500	7.58	5.77	4.42	
550	6.51	4.84		
600	5.56			
700	4.24			
800	3.31			
900	2.58			

Table 10. Length of mid/top horn (in), free loading. Since the mouth perimeter equals 1.5 times the highest working wavelength, the tractrix cannot be used. Tractrix contours can however be incorporated if the mouth perimeter is reduced to one wavelength.

Table 3

Freq. (Hz)	Area (sq. ft)	Dia. (ft)	Sq. side (ft)	Rect. sides (ft)
30	14.0	4.22	3.75	3.32 4.22
40	7.87	3.16	2.81	2.49 3.16
50	5.03	2.53	2.24	1.99 2.53
60	3.5	2.11	1.87	1.66 2.11
70	2.57	1.80	1.60	1.42 1.80
80	1.97	1.58	1.40	1.24 1.58
90	1.55	1.41	1.25	1.10 1.41
100	1.26	1.27	1.12	0.995 1.27
110	1.04	1.15	1.02	0.904 1.15
120	0.87	1.05	0.93	0.829 1.05

Table 3. Minimum mouth dimensions for bass horn (corner position).

Table 8

Freq. (Hz)	3½		5		6½		8		10	
	Ex	Tr	Ex	Tr	Ex	Tr	Ex	Tr	Ex	Tr
30	27.3	25.1	24.7	22.5	22.9	20.7	21.4	19.2	19.8	17.6
40	19.2	17.6	17.2	15.6	15.8	14.2	14.7	13.1	13.5	11.9
50	14.1	12.8	12.6	11.3	11.5	10.2	10.6	9.3	9.62	8.30
60	11.2	10.1	9.88	8.78	8.98	7.88	8.22	7.12	7.42	6.32
70	9.17	8.23	8.05	7.11	7.25	6.31	6.60	5.66	5.92	4.98
80	7.69	6.83	6.70	5.84	6.01	5.15	5.44	4.58	4.83	3.97
90	6.48	5.75	5.61	4.88	5.00	4.27	4.50	3.77	3.97	3.24
100	5.57	4.91	4.79	4.13	4.25	3.59	3.80	3.14	3.32	2.66
110	4.90	4.30	4.18	3.58	3.69	3.09	3.28	2.68	2.84	2.24
120	4.34	3.79	3.68	3.13	3.23	2.68	2.85	2.30	2.46	1.91

Table 8. Length of bass horn (ft) for different flare constants, wall position. Ex-exponential, Tr-tractrix. N.B. The tractrix lengths are approximate.

Table 4

Freq. (Hz)	Wave-length (in)	Dia. (in)	Area (sq. in)	Sq. side (in)	Rect. sides (in)
200	67.5	32.2	815.4	28.6	25.3 32.2
250	54.0	25.8	522.9	22.3	20.3 25.8
300	45.0	21.5	365.1	19.1	16.9 21.5
350	38.57	18.4	265.9	16.3	14.5 18.4
400	33.75	16.1	203.6	14.3	12.6 16.1
450	30	14.3	160.6	12.7	11.3 14.3
500	27.0	12.9	130.7	11.4	10.1 12.9
550	24.55	11.7	107.5	10.4	9.2 11.7
600	22.5	10.7	89.9	9.5	8.4 10.7
700	19.28	9.2	66.5	8.2	7.2 9.2
800	16.88	8.1	51.5	7.2	6.3 8.1
900	15	7.2	40.7	6.4	5.6 7.2
1000	13.5	6.4	32.2	5.7	5.1 6.4
1100	12.27	5.9	27.3	5.2	4.6 5.9
1200	11.25	5.4	22.9	4.8	4.2 5.4
1300	10.38	4.9	18.8	4.3	3.9 4.9
1400	9.64	4.6	16.6	4.1	3.6 4.6
1500	9	4.3	14.5	3.8	3.4 4.3
2000	6.75	3.2	8.0	2.8	2.5 3.2
2500	5.40	2.6	5.3	2.3	2.0 2.6

Table 4. Minimum mouth dimensions for mid/top horn (free loading).

Table 9

Freq. (Hz)	3½		5		6½		8		10	
	Ex	Tr	Ex	Tr	Ex	Tr	Ex	Tr	Ex	Tr
30	24.8	22.6	22.2	20.0	20.4	18.2	18.9	16.7	17.3	15.1
40	17.3	15.7	15.3	13.7	13.9	12.3	12.8	11.2	11.6	10.0
50	12.6	11.3	11.1	9.8	9.98	8.66	9.08	7.76	8.12	6.80
60	9.95	8.85	8.64	7.54	7.73	6.63	6.97	5.87	6.17	5.07
70	8.10	7.16	6.96	6.02	6.18	5.24	5.53	4.59	4.83	3.89
80	6.75	5.89	5.75	4.89	5.07	4.21	4.50	3.64	3.89	3.03
90	5.65	4.92	4.78	4.05	4.17	3.44	3.67	2.94		
100	4.83	4.17	4.05	3.39	3.51	2.85				
110	4.22	3.62	3.51	2.91						
120	3.72	3.17								

Table 9. Length of brass horn (ft) for different flare constants, corner position. Ex-exponential, Tr-tractrix. N.B. The tractrix lengths are approximate.

minimum frequency and mouth dimensions for horns positioned in free air (4π solid radians) at a wall (π solid radians), and in a corner ($\pi/2$ solid radians). In table 1, the speed of sound has been taken as 1125 ft/sec, and the mouth perimeter as the wavelength. The mouth areas in tables 2 and 3 are equal to $\frac{1}{4}$ and $\frac{1}{8}$ respectively of the mouth area in free air, and the dimensions for the circular, square and rectangular mouths are derived from these areas. It is tempting to reduce the areas of the square and rectangular horns so as to give a perimeter equivalent to the wavelength (suitably scaled for wall or corner positioning) but this is not recommended. However, the shorter side of the rectangular horn has been derived in this way (i.e. a square horn with this side would have the appropriate perimeter).

After settling the mouth dimensions, the throat may be determined from the chosen loudspeaker unit. Table 7 gives suggested throat areas for five typical mean loudspeaker sizes. In some designs, the choice of loudspeaker will be influenced by considerations of overall size (the length of the horn is greatest for the smallest loudspeaker) and whether the loudspeaker is to perform as both bass and mid/top driver, using two separate horns on either side. Many loudspeakers will possess different dimensions, and in these cases table 7 will be of little value. The effective area (piston area) has been taken as 0.7 of the area derived from the mean (quoted) diameter, and the throat area as 0.3 of the effective area. Although there is obviously scope for experiment here, the quoted dimensions should give very acceptable results.

Having decided the throat and mouth areas, tables 8 and 9 give the overall lengths of horns with true exponential and tractrix contours for both wall and corner placing for horns with the five derived throat areas at each of the cut-off frequencies specified in table 1. The factor of 1.2 applied to the cut-off frequency in table 5 when calculating the flare coefficient is to ensure a fairly linear frequency relationship throughout the working range of the horn. The flare coefficient m is thus given by

$$m = (4\pi/c)(f/1.2)$$

where c is the speed of sound (1125ft/sec) and f is the lowest frequency to be reproduced.

The area increase is given by $(e^m - 1)\%$ and the doubling distance by $(\log_e 2)/m$ for each frequency. The length of the exponential horn is given by $(1/m) \log_e S_m/S_T$ for each specified set of areas, and the length of the tractrix horn will be $r_m(1 - \log_e 2)$ shorter than the true exponential, where S_m = mouth area, S_T = throat area, r_m = mouth radius.

N.B. The tractrix lengths given in tables 8 and 9 are approximations, being based on the fully developed tractrix referred to the flare cut-off frequency, whereas the mouth radius is referred to the lowest bass frequency to be reproduced.

Middle top horn design

Attention should now be directed to the middle and high frequency horns. The

mouth perimeter should not be less than the wavelength of the lowest working frequency, and in practice a perimeter of 1.5 times the lowest working frequency has been found to give good results. Table 4 is based on this factor of 1.5, and gives the recommended minimum mouth dimensions for free air loading. It is safest to assume free air loading to apply at these higher frequencies, because diffraction and reflection effects at short wavelengths prevent true wall or corner loading from being achieved, and it is for this same reason that the perimeter has been specified at 1.5 times the wavelength of the lowest working frequency. The dimensions of square and rectangular horns have been derived in the same way as those in tables 2 and 3. The throat dimensions of middle and high frequency horns should match the drive unit directly, and may be taken as the mean diameter and area of the chosen loudspeaker, shown in table 7. Tables 6 and 10 give the flare constants and lengths of exponential horns assuming the throat and mouth dimensions of tables 7 and 4 respectively.

Integration of multiple horns

It has been emphasized that the radiation from the mouths of each pair of horns at their common crossover frequency should be in-phase. Assuming that the mouths of all the horns will lie in the same plane, the total length of each pair of horns should be compared with the multiples of half wavelengths of the crossover frequency set out in table 11. If the drive signals at both throats are in-phase (separate loudspeakers), the total length should be an even number of half-wavelengths; if the drive signals are out-of-phase (single speaker horn-loaded at both front and rear) the total length should be an odd number of half wavelengths. If necessary, small changes may be made to the crossover frequency (with subsequent re-design of the higher frequency horn) to ensure optimum conditions at crossover.

The complete design

The bass horn will generally be folded. Originally it was intended to provide a table giving the maximum permitted length of horn before folding should cease because the horn diameter has become equal to 0.6 times the lowest wavelength to be transmitted. However, examination has shown that at frequencies up to five times the bass cut-off frequency (i.e. 4 octaves bandwidth) this restriction does not apply to the corner-positioned horn (due to the small mouth dimensions) and with the wall-positioned horn the limitation lies between 92% and 95% of the full exponential length. It may therefore be assumed that provided the wall-positioned horn is not folded within the final 10% of its length, the problem of cross reflections will not arise.

Finally, the cavities at the throats of the lower frequency horns should be designed in accordance with the formula already given, remembering to allow for the loss of cavity volume due to the frame, magnet and cone assembly of the loudspeaker itself.

The design procedure laid down in this part has been applied to two different designs of horn to follow, and further examples

of overall horn design are given in refs 34 to 37, and also in ref. 5.

Appendix

A variable bandpass active filter for feeding a 3 horn loudspeaker system (see Fig. 11):

Low-pass filter

Frequency (Hz)	R_1 (k Ω)	R_2 (k Ω)	C_1 (pF)	C_2 (pF)
200	59	59	20,000	10,000
1k	12	12	20,000	10,000
2k	59	59	2,000	1,000
10k	12	12	2,000	1,000
6k	59	59	680	330
30k	12	12	680	330

N.B. R_1 & R_2 to be realized as 12k in series with 47k log pots.

High-pass filter

Frequency (Hz)	R_3 (k Ω)	R_4 (k Ω)	C_3 (pF)	C_4 (pF)
25	28	57	160,000	160,000
100	7	14	160,000	160,000
250	28	57	16,000	16,000
1k	7	14	16,000	16,000
4k	28	57	1,000	1,000
16k	7	14	1,000	1,000

N.B. R_3 to be realized as 6.8k in series with 22k log pot. R_4 to be realized as 12k in series with 47k log pot.

All i.c.s to be Signetics N5741V, etc. R_5 10k log, R_6 22k, R_7 100k.

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* Papers presented at the 46th Convention of the Audio Engineering Society, New York, Sept. 1973.

PROJECT

Radio astronomy as a school activity

by J. C. Codling,* F.R.A.S.

As readers of this journal will know, there have, in recent years, been many important changes at all levels in the teaching of science in our schools. These have included not only important changes in the curriculum but also in the way science is presented to pupils of all levels of ability.

Very briefly, curriculum changes have brought science, and physics in particular, more into line with the world outside the classroom, while the emphasis has shifted from teaching to learning. Pure blackboard and lecture demonstration methods have largely given way to pupil-based activities either individually or in small groups using an impressive array of modern apparatus. Topics which were once the preserve of "A" level and above are now introduced much lower down in the school. So now, it is not uncommon to see basic courses in electronics introduced in the first and second years, i.e. with 11- to 13-year-old children, while higher up in the school their colleagues often reach a remarkable level of ability and are encouraged to design and build interesting projects based on their earlier mastery of fundamentals. Their physics

lessons are no longer complete in themselves because the children are actively encouraged to apply this knowledge to problems they will meet in the world of technology outside the classroom. Nowhere has this trend been more evident than in the field of electronics, which is now well established in physics syllabi from CSE level upwards. A recent series of articles in this journal by a distinguished colleague well illustrates the sort of advanced projects which are being successfully undertaken by schools up and down the country.¹

It is against this background of change that the work described below was started in a Suffolk school and continues now with students undergoing a three-year course of teacher training.

The boys concerned with this project were already following a course in practical electronics as part of their physics work in the school. As they progressed from the simple experiments of the first and second years they became used to handling test equipment such as oscilloscopes, signal generators and valve voltmeters. At different stages of the course they constructed projects of increasing difficulty from simple logic circuits using relays or transistors to

oscillators, model binary computers and amplifiers. Some of these have been described elsewhere.²

The school already had a flourishing astronomical group who made regular observations with a six-inch telescope and small home-constructed refractors. As part of their work they took photographs of the moon, of star trails and carried out a variety of astronomical measurements both at school and at home. It seemed an exciting idea to extend these to include a regular radio watch of the sun over the recent maximum period and try to relate the results to any optical activity observed on the disc. By choosing a frequency of 136MHz they could at the same time monitor the many American scientific satellites transmitting beacon and telemetry signals on this band. As we wished to record not only the more intense radio storms but also the continuous level of the quiet sun (of the order of $10^{-22} \text{W}(\text{Hzm}^{-1})^{-2}$ of aerial power) we decided in spite of the added circuit complexity and the extra amount of setting up involved, a phase-switching interferometer would best serve our purpose (Fig. 1).

In this arrangement the signals are

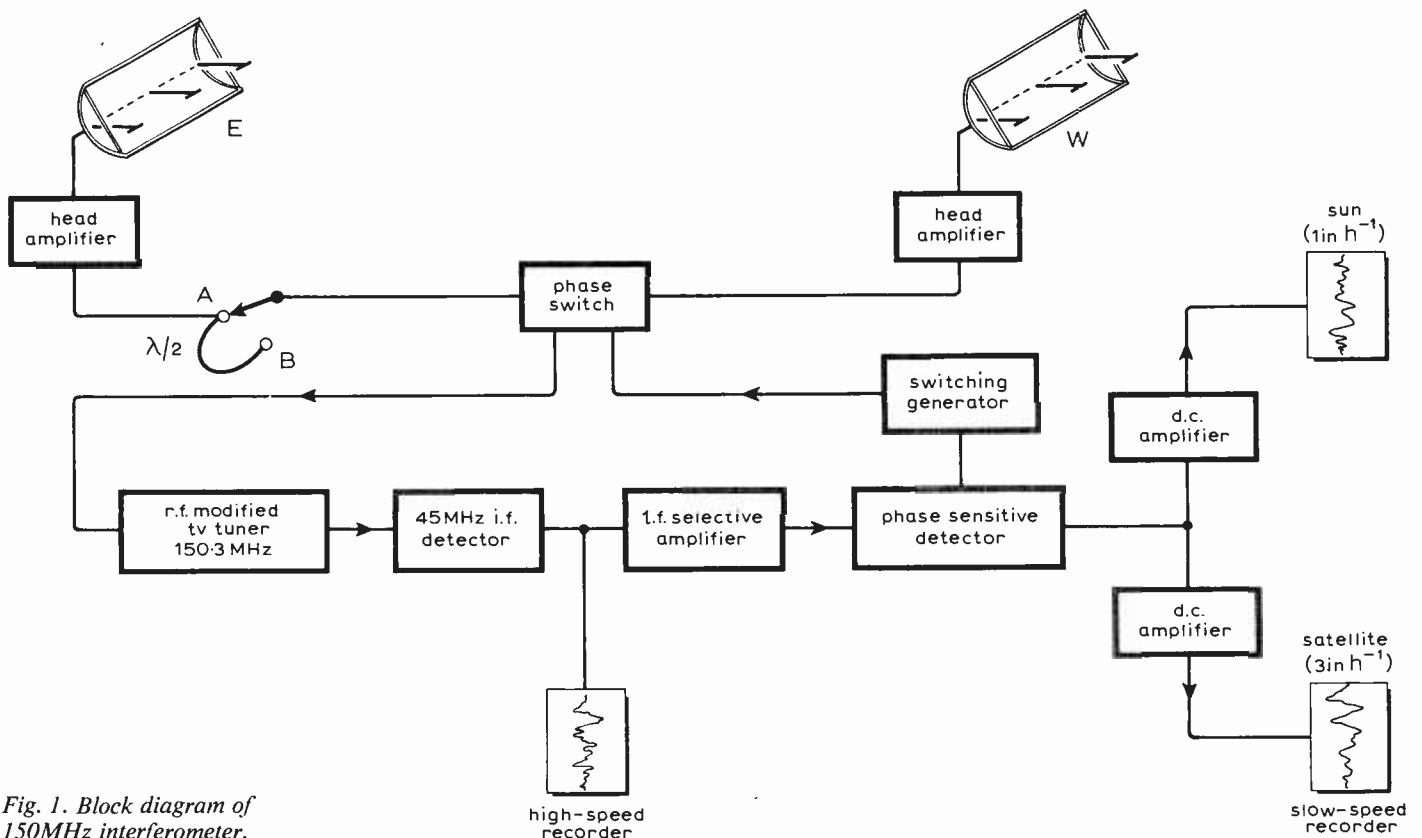


Fig. 1. Block diagram of 150MHz interferometer.

*Gipsy Hill College of Education

received by two aerials on an east-west baseline spaced an exact number of electrical wavelengths apart. The aerials can be altered in altitude to allow for the changing N-S swing of the sun during the year, but they are fixed in azimuth. The polar diagram of one aerial is shifted by half a lobe when an extra half wavelength of coaxial cable is switched into its feeder by a conventional multivibrator operating at a low frequency, in this instance, 600Hz. In position *A* of Fig. 2 the signals reach the aerials by equal paths, in position *B* all previous lobe maxima become minima and vice versa. If a signal source is on a fringe maximum at moment *A*, the aerial outputs will add and the detector output will be, say, positive. The next moment *B* they will cancel and the detector output will be zero. Noise is neglected in both cases.

$$\text{Output} = \frac{A}{(2S+N)} - \frac{B}{(O+N)} = 2S$$

When the source has moved half a fringe:

$$\text{Output} = \frac{A}{(O+N)} - \frac{B}{(2S+N)} = -2S$$

Here *S* is the signal from one aerial and *N* is the receiver noise. The fringe amplitude thus remains unchanged but reverses in sign as the phase of one aerial is reversed. By adding a $\lambda/2$ piece of coaxial cable to one of the aerial feeders the fringe pattern will be shifted so that peaks will occur where nulls used to be. By switching the loop in and out at a rapid rate the fringes scan back and forth between two adjacent regions of the sky. If one of these regions contains a local source like the sun, for one half cycle the receiver will see the source, whilst on the other half cycle it will not. So the interferometer will generate an alternating signal which is easily detected and amplified. A broad source like the Milky Way gives rise to little or no signal, since the receiver sees virtually the same intensity for both fringe positions. The lobe-switching interferometer is highly effective in picking out small sources from background interference and also reduces problems of receiver noise and stability.

The aerials

Ready-made Yagi aerials are expensive and not easily modified for other frequencies. Parabolas provide excellent reflectors giving full illumination and could be built by students at minimum cost. Accordingly the graph of $y = \frac{x^2}{72}$ was plotted and enlarged on the workshop floor so that the end formers could be bent to this shape. These were bolted to 12-ft-long galvanized pipes. The reflecting surface consisted of lengths of Post Office wire spaced at one-inch intervals—more than adequate for this frequency. The six folded dipoles, three for each aerial, were cut from aluminium strip supported at their earthy ends on angle iron. The dipoles were sited along the *latus rectum* of the reflector and fed by twin 300Ω feeders in parallel and one wavelength long (Fig. 3). In order to match the balanced aerials to the unbalanced input of the aerial ampli-

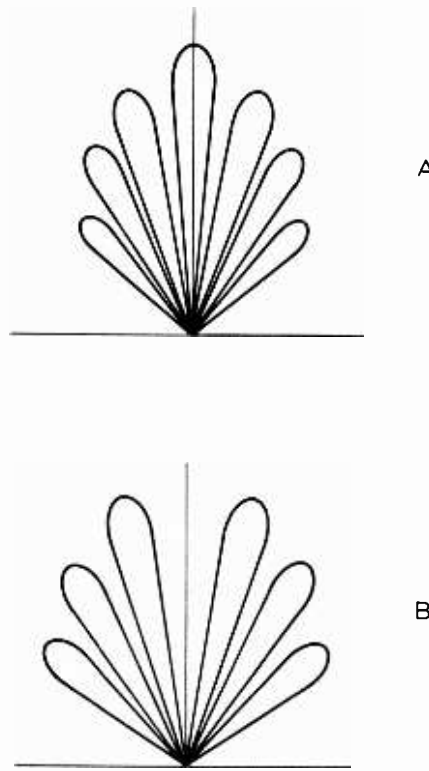


Fig. 2. Polar diagram of parabolic aerial shown with shifted lobes introduced by $\lambda/2$ addition of feeder cable.

fiers, a quarter wave balun was used and sealed in wax to protect it from the weather.

Receiver components

Power supplies All d.c. power supplies are stabilized against mains fluctuations. These include h.t. stabilization for the valve sections of the receiver and low-voltage supplies of 14V for the f.e.t. converter and aerial head amplifiers—the latter fed up the coaxial feeders. To make fault-finding easier all voltages and currents are monitored by meters on the power supply panel. Alternating current for the heaters is supplied from a constant-voltage transformer.

Phase switch and switching generator (Fig. 4). The half wave loop in the phase switch and other stubs were cut to resonance by driving them with an oscillator at the operating frequency and cutting off small pieces at a time until a simple reflectometer showed the best forward/backward standing wave ratio. The half wavelength loop in the phase switch is switched in and out of the feeder of the east aerial by using square wave to block off two OA47 diodes connected between the feeder and the loop. The frequency and amplitude of the square wave was checked with an oscilloscope and the mark to space ratio adjusted for unity.

R.f. and i.f. units (Fig. 1) The r.f. unit is a current AB Electronics f.e.t. television tuner realigned for the 150–153MHz band and with its i.f. output increased to 45MHz. The i.f. strip is an ex-radar unit Type 7925 with a centre frequency of 45MHz and a band width of 5MHz. This is a more recent

unit than the previous wartime i.f. strip which used EF50 valves, and after some modifications to the suppressor and bias circuits has proved reliable and free from faults over a long period of continuous use. After the diode detector the usual cathode follower feeds the valved low-frequency sections of the receiver.

Low-frequency sections From the cathode follower of the i.f. strip, the signal is passed to a selective amplifier tuned to the narrow pass band of the switching frequency. It was here that resistor and capacitor values had to be selected with some care using decade boxes whilst watching the output waveform on the oscilloscope. This output is applied to two EB91 diodes, each diode connected in series with its partner. The detector is synchronized to the frequency of the lobe switch by the other square wave output from the multivibrator. The output waveform at the anode cathode junction of one diode pair is shown on the oscilloscope in Fig. 5 and shows receiver noise contained within the square wave envelope.

The output of this phase-sensitive detector is fed via an integrating circuit of a 1MΩ resistor and suitable paper capacitors of values required to smooth out small impulsive interference, depending on the chart speed of the particular recording. It was found, for example, that with the slow excursion of the sun across the aerials at a chart speed of 1in/hr, a time constant of 1MΩ and 8μF was adequate.

When the telescope started recording solar noise, by far the most serious problem was interference from strong aircraft transmissions near the original operating frequency of 136MHz. Due to the exceptional sensitivity of the receiver and the wide bandwidth used, these signals frequently obliterated the trace due to the quiet sun. The problem was further aggravated because cross modulation by these signals was occurring through the original germanium transistors in the head amplifiers.

At this stage we decided to apply to the Royal Society Research in Schools Committee for a grant to purchase two high-gain f.e.t. head amplifiers. This proved to be a double blessing for not only did we obtain new head amplifiers but also the Royal Society appointed Professor Anthony Hewish, F.R.S., as our adviser. It is largely due to his interest and help that the project advanced beyond this stage. At his suggestion we also changed our operating frequency to 150–153MHz so that aircraft interference was greatly reduced. Although we lost contact with the scientific satellites on 136MHz we still occasionally record those operating near the amateur two-metre band.

Calibration The instrument is calibrated by allowing the Cassiopeia "A" radio source to drift across the aerials during the night and the maximum pen deflection (Fig. 6) is measured. The mean amplitude of the solar fringe pattern is measured at noon each day and, after conversion, for convenience to a logarithmic scale, is plotted on a monthly summary chart (Fig. 7) which also shows the level of the calibration source. Solar flares show as peaks on top of the interference fringes and are drawn on top

of these with a scale to represent duration in minutes or hours. A much faster pen recorder is connected to the output of the i.f. detector to record details of these short-lived bursts. A more complete picture is seen if any optical activity on the sun's disc is recorded on the same time scale.

Solar activity 1968-1973

We have tried to keep a continuous radio watch on the sun over this, the 21st recorded solar cycle. From mid-1965 onwards, there was a rapid rise of active areas to a peak during 1969-1970. One of the most interesting observations has been the number of intense storms in the period 1970-1972, the last major one recorded being of exceptional intensity occurring during August 1972, after a relatively quiet July. From worldwide reports this gave rise to brilliant aurorae, severe interruption of microwave radio reception and a noticeable increase in solar wind recorded by Pioneer 9 at the beginning of August. A glance at the *Wireless World* h.f. predictions for August 1972 will confirm the many results of this storm. At present it looks as if the predicted minimum of 1973-1974 will be extended to 1975 or even 1976. Certainly, there have been two or three peaks of activity over the whole four years or so of the maxima. The most intense storm for years originating in a 100,000-mile-diameter group of spots was first detected by OSO7 on July 28, 1972. The 28, 21 and 14MHz amateur bands were subject to almost complete blackout. This was certainly the highest energy solar storm ever recorded.

A glance at the two summary charts for March/April 1972 and January/February 1970 (Fig. 6) will show the high levels of two of these storms which have been a characteristic of this late and prolonged maximum period. For comparison these peaks, often of days duration, should be compared to the level of the calibration source and that of the quiet sun—all on the vertical log scale. During the prolonged storm of October 1970 a second interferometer on 610MHz was brought into use, and although this receiver was handicapped by low collecting power of single Yagi aerials, the recorder indicated sufficient amplitude to confirm the activity on the v.h.f. band.

Looking forward to the next active sunspot period we should hope by then to compare results continuously on both v.h.f. and u.h.f. bands, together with some detail of shorter bursts with a faster speed recorder.

Looking back over the years since the project started it is difficult to assess the success of the enterprise since no current examination could possibly do this justice. There are, however, several interesting facts which emerge which those of us interested in education in its broadest sense would do well to note.

1. Most of the boys involved in this project have now gone on at different levels according to their ability to make their careers in the electronics industry, and a fair number with the GPO Engineering Branch. All these boys, including those who completed university courses success-

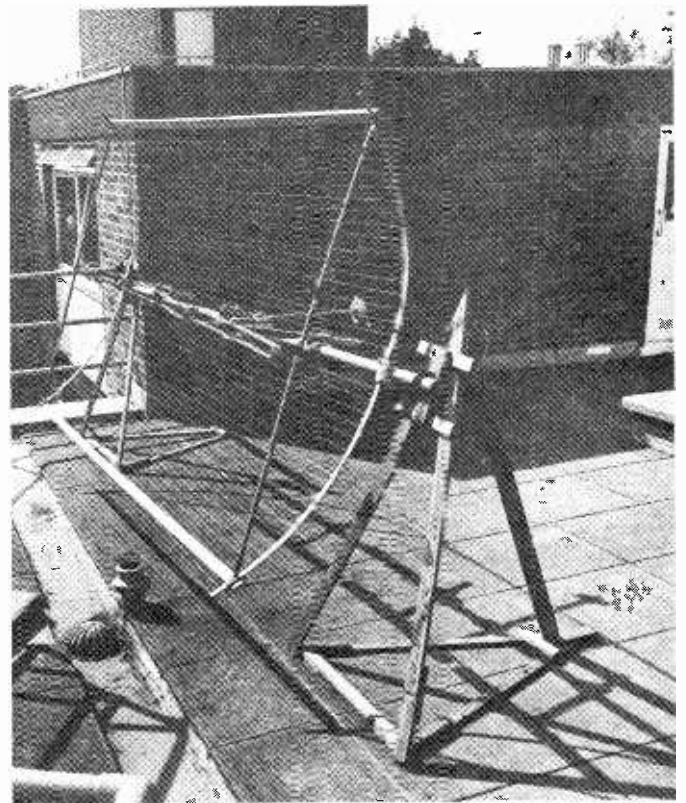


Fig. 3. East aerial showing the folded dipoles at the focus.

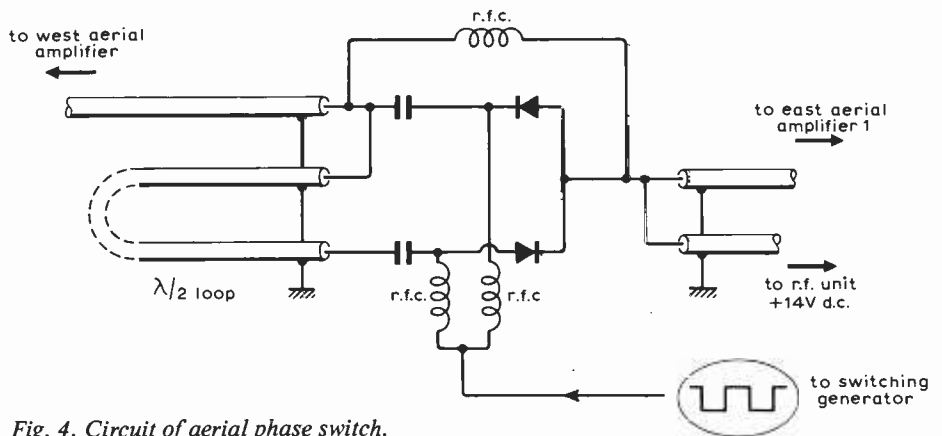


Fig. 4. Circuit of aerial phase switch.

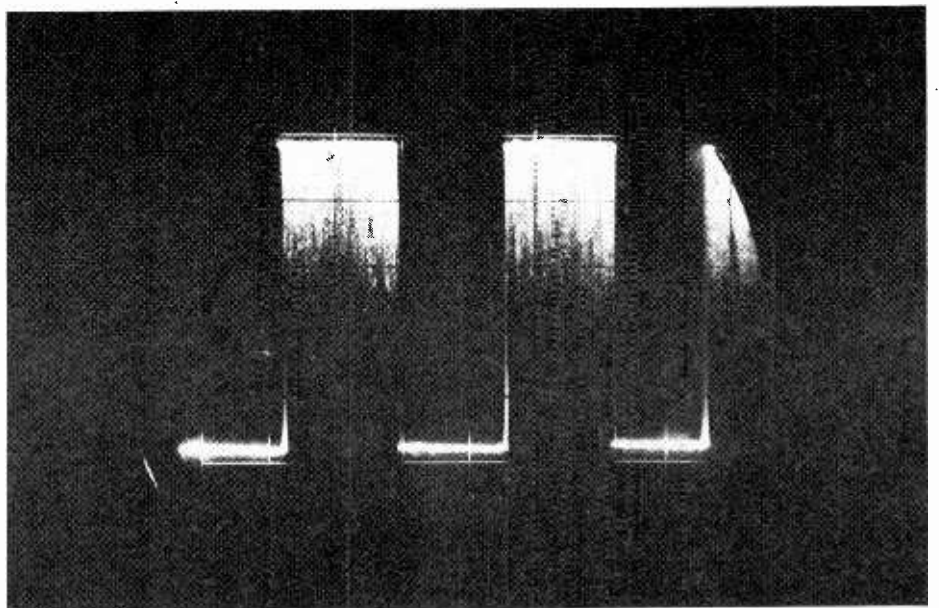


Fig. 5. Square wave enclosing received noise, at the anode-cathode junction of phase-sensitive detector.

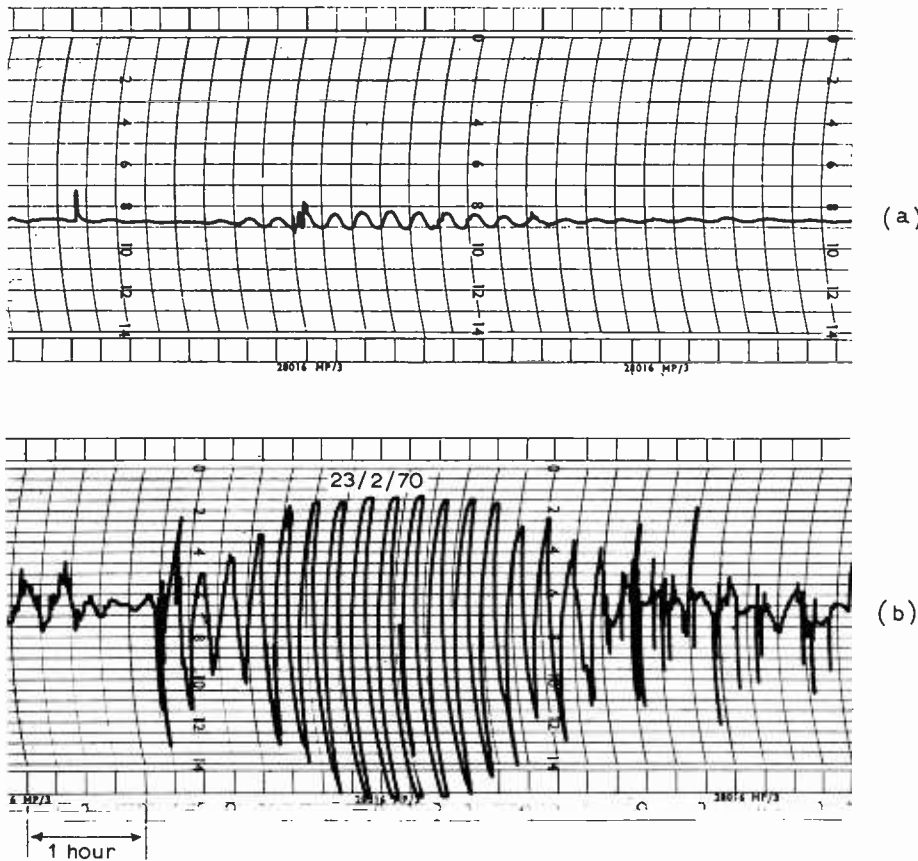


Fig. 6. (a) Pen recording at 1in/hr showing the noise from a quiet sun. (b) Recording at same chart speed showing a full-scale deflection obtained during a solar storm recorded in 1970.

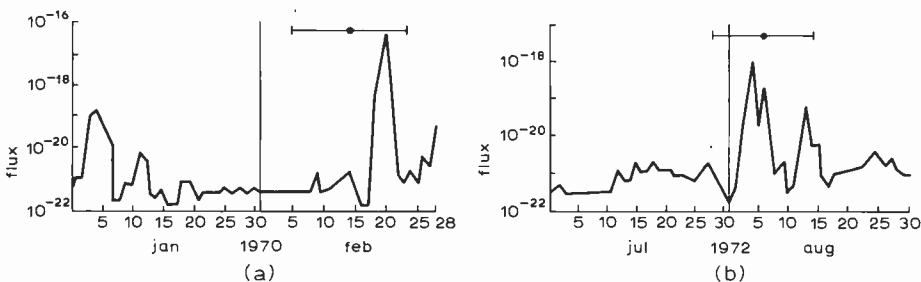


Fig. 7. (a) Summary chart for Jan./Feb. 1970. The horizontal line shows the passage of a major sunspot group. (b) Summary chart for Jan./Feb. 1970. The horizontal line shows a major storm from Aug. 1 to Aug. 10.

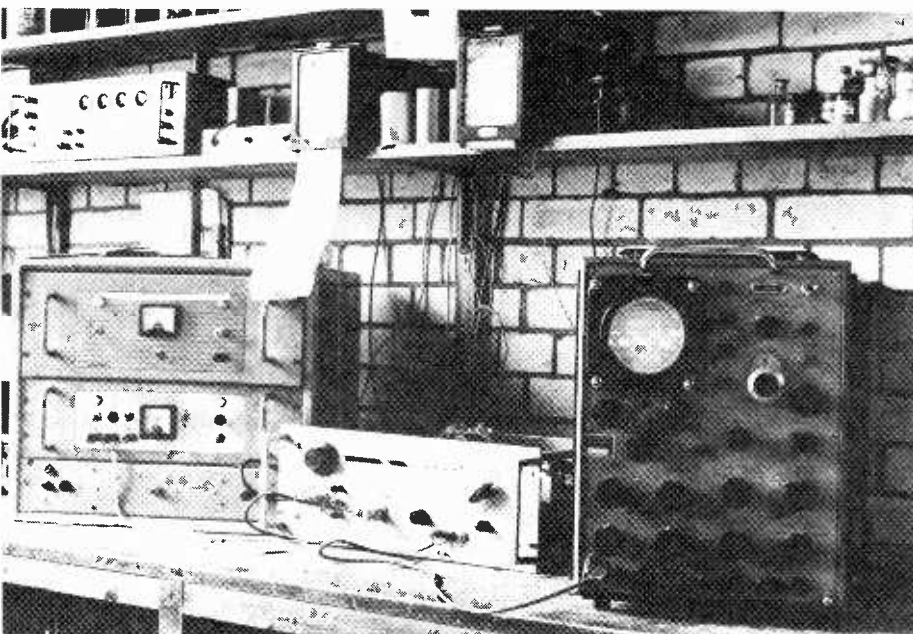


Fig. 8. Complete interferometer receiver and recording equipment.

fully, had failed the selection examination as 11-year-olds.

2. Reports of their success beyond "O" level, i.e. ONC, HNC and degree courses, have shown consistently that they not only did well in these examinations but in their practical work they showed a much broader grasp of the subject than the examinations themselves demanded.

3. Probably, most of all, they have learnt to apply branches of their school physics to the solution of problems, some of which presented considerable difficulties. They were certainly tremendously enthusiastic about the work and looked upon the many difficulties we encountered as problems which we could solve together, sometimes with help from interested people in the world of electronics outside the school. For these reasons, amongst others, I personally welcome the approach to science which the Schools Council Project Technology is now advocating at this level.

Finally, this enterprise could never have succeeded but for the generous help of the people and organizations listed below. Nowadays schools who wish to embark on such projects have a ready-made organization for liaison with the electronics industry. One of the conclusions of the Committee established by the Working Group on Scientific and Technological Manpower states, "There is almost universal goodwill in industry towards schools, there is a widespread desire among teachers for practical and improved contacts with industry at local level."³ Long before this report was written, we had to make our own contacts not only locally but nationwide and everywhere we found such a desire to help that we wondered why this great pool of goodwill had not been used before.

Acknowledgments

The author would like to acknowledge the following without whose help this project would not have succeeded.

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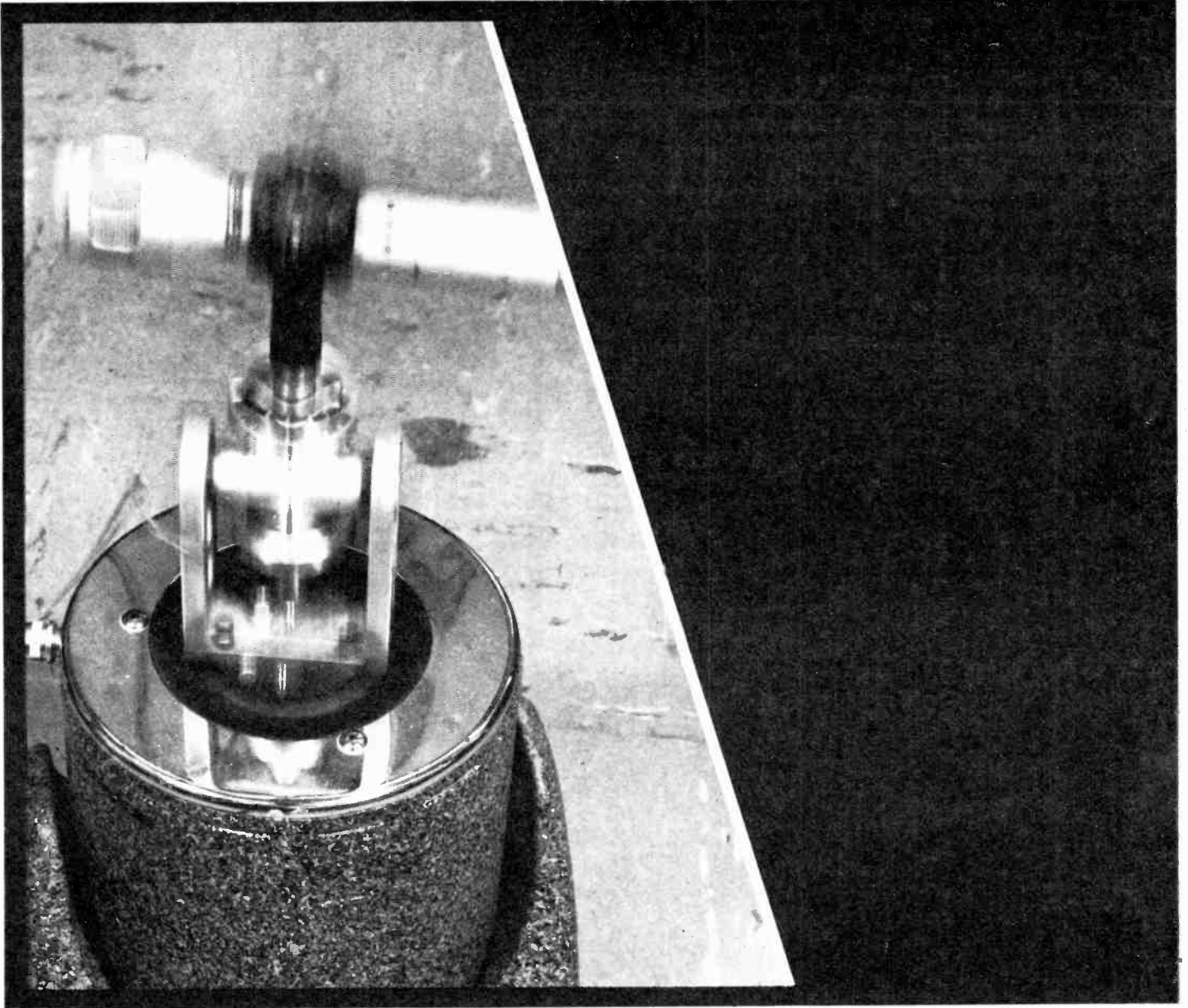
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The Directors, Solartron Ltd, Farnborough. The Director, Sensitised Coatings Ltd.

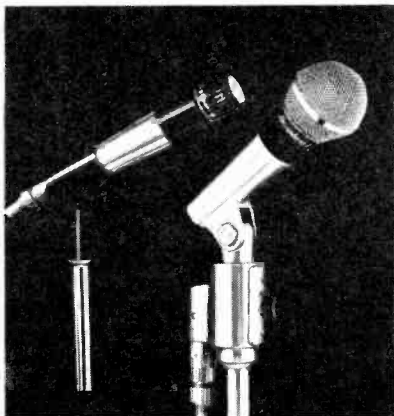
Photography by Mr Peter Smith of the Audio-Visual Aids Department, Gipsy Hill College of Education.

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10⁻⁹⁹ to 10⁺⁹⁹

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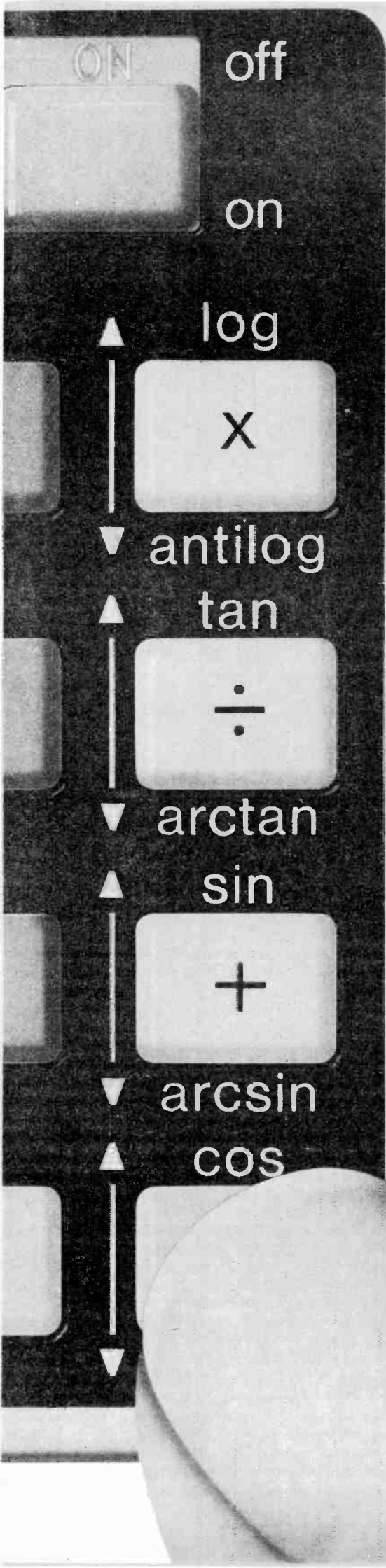
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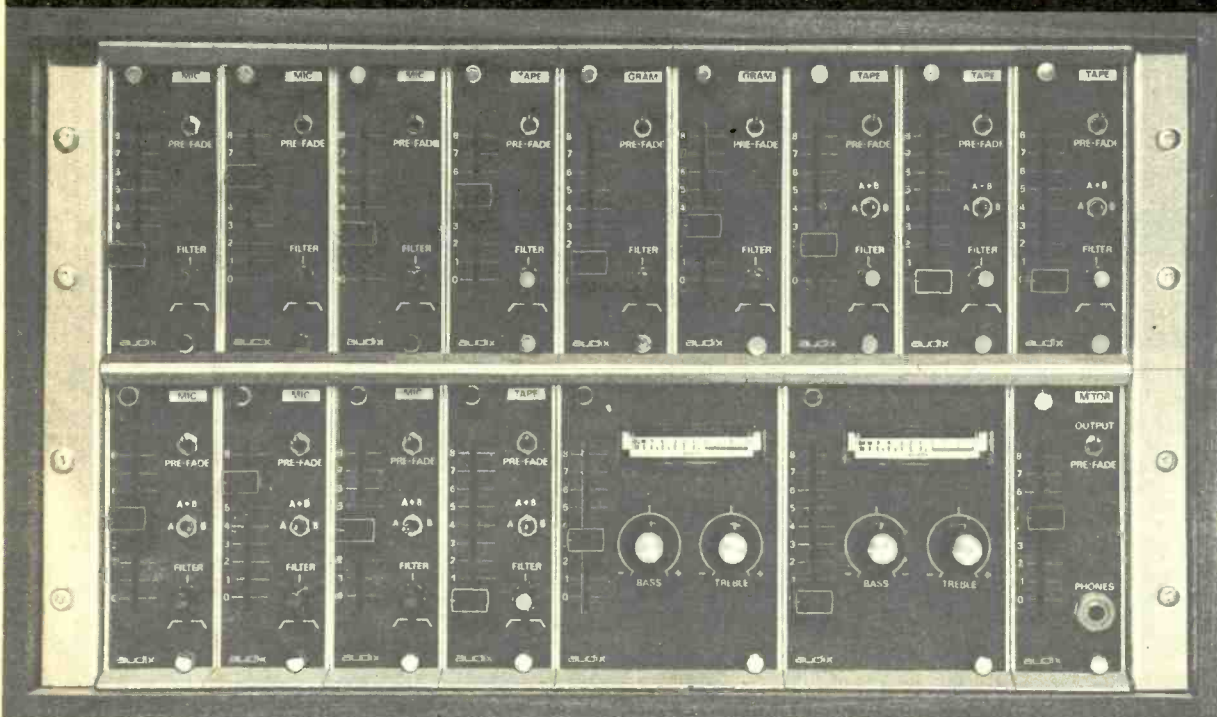
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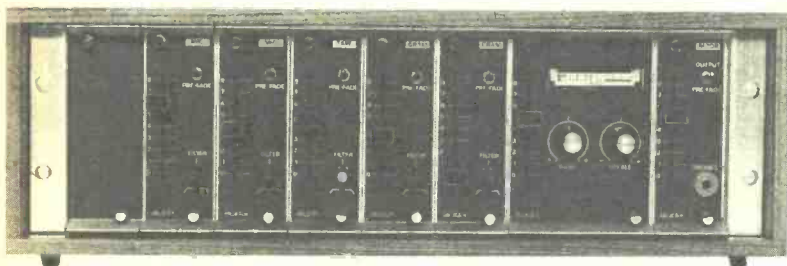
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Electronic piano design

Part 3—tuning the touch-sensitive design, an m.o.s. master oscillator and other optional circuits.

by G. Cowie, B.Sc.

This simple and inexpensive design retains the touch-sensitive feature of string pianos, unlike most electronic keyboard instruments. The first article (vol. 80 no. 1459) described design concepts together with circuit and component details and the second part (vol. 80 no. 1460) gave constructional procedure. This final article includes circuits for suppressing "thump", hiss due to leakage and an m.o.s. master oscillator to simplify tuning.

When you have completed the wiring of the piano the remaining work is to commission and tune it. In a project of this complexity it is inevitable that a number of faults and wiring errors will occur and the purpose of the commissioning stage is to weed these out and make various adjustment.

Start by applying power and making the following voltage checks

- supply busbars, 0V, +5V, -5V
- collector busbar, about 0.5V
- switch busbar (after R_{507}), 7 to 8V
- damper busbar, about -0.4V
- bias busbar, about +0.8V
- output busbar, +0.4V.

Turn both potentiometers on the amplifier board to mid-position, and check that the pre-amp and amplifier outputs are about 0V before proceeding further.

Connect headphones or an audio amplifier to one of the output sockets. A hiss and probably some whistles will be audible but ignore this for the moment. If nothing is heard, check the output amplifier and preamplifier. Check that a note is heard when each key is struck, and that the pitches are more or less in the right order, bearing in mind that the oscillators are not tuned.

The system is organized in such a way that with a little thought any fault evident can be localized to one or two connecting lines, or a few components either in a letter-group or in a key circuit. Absence of signal from a key circuit will most likely be caused by absence of input signal, resulting from a reversed diode, or a misconnection at a divider or oscillator. Whistles, traceable by their pitch, will be caused by leaky transistors or bias connection faults, or damper faults. Faint notes will be caused by collector open-circuits. Open or bent key-switches will show up as faults. The sort of defects to look for are missing wires, missing links near i.cs, bad soldered joints, assembly mistakes, solder bridges, parts touching where they should not touch, tracks not cut. It may possibly be necessary to add power supply decoupling capacitors on the various circuit boards.

If the power supply uses a 9-volt transformer, R_{507} must be increased to about 18 ohms to drop the raw direct voltage to the 8V required for the switch busbar.

Check that each note ceases when its key is released, then short-circuit the sustain pedal socket and check that the notes now are sustained after the keys are released.

When all the circuits have been made to work, several finer adjustments can be made. Disconnect the positive-signal input of the summing preamplifier from 0V and extend it from the edge-connector with about 30in of flex wire. Solder the wire to the end of resistor R_{401} and then attach R_{401} to the 0-V busbar on the key circuit boards, in a position that gives minimum pick-up of unwanted signals. Run the positive-signal lead alongside the output busbar as far as possible. It is important to arrange the 0-V lines carefully, to minimize stray signals. Connect a lead directly between the key circuits 0-V busbar and the preamplifier

ground. Hiss should be inaudible while the instrument is being played.

If there is still too much background hiss,* then reduce the value of R_{501} , until the hiss is reduced to a low level. If the resistance is reduced too much there will be an undesirable effect whereby the keys refuse to work at all when pressed down very slowly.

If the damper action is felt to be too abrupt then the potential of the damper bus can be raised by connecting a resistance of a few hundred ohms in series with R_{502} , and connecting the base of Tr_{502} to the junction of the resistors.

If the action of any of the keys is noticeably different from that of the majority, the cause should be looked for and put right, otherwise it will be a permanent irritation when playing the instrument.

It is important to alter the light spring-

*If a hiss present while the piano is not being played is annoying, it can be eliminated with a "squelch" circuit, given later.

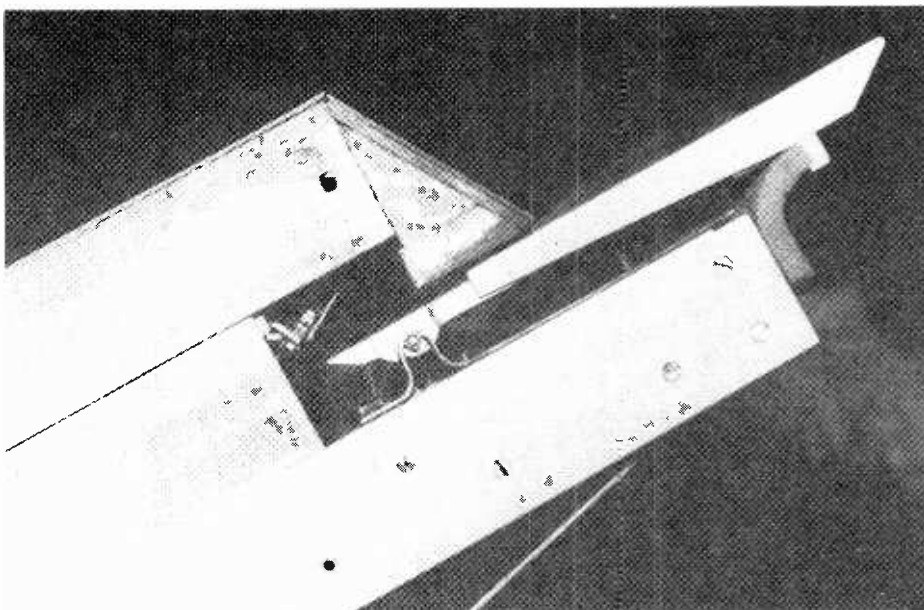


Fig. 21. To simulate the inertial load of the keying action, a piece of foam plastics material is inserted between the key undersides and the lower flange on the keyboard chassis.

loaded feel of the keys if the touch-sensitive action is to be satisfactory. The ideal arrangement would compromise 61 viscous dampers simulating inertial loads, but in the prototype a much simpler device was adopted which proved to give an acceptable result.

Cut a piece of flexible foam plastics material to dimensions of $2 \times \frac{3}{8} \times 33$ in. If a piece 33-in long cannot be found then use shorter lengths. Push this into place between the white key undersides and the lower flange on the key chassis (see Figs 10 & 21). In this position the black keys will rub against the foam and the white keys will deform it so that a drag is felt on the keys. Key action will not be satisfactory unless this is done.

Tuning

The easiest and most satisfactory way of tuning the oscillators is to remove the oscillator board from the instrument and take it to a laboratory which has a suitable digital timer/counter and d.c. power supplies. The oscillators should be connected to a ± 5 -V supply. They should be monitored at the op-amp output where a clean square wave is present. It is advisable to use an oscilloscope to look at the waveforms and see that all is well.

The oscillators can then be adjusted to the frequencies in Table 1 (part 1) by the tuning pots to an accuracy of ± 2 parts in 1000. If an adjustment is outside the span of the potentiometers it will be necessary to

add padding resistors. Label the oscillators after they are set so that they can be wired up without confusion.

If you do not have access to the above equipment, either through work or friends, the oscillators must be tuned *in situ*, by ear. The person doing the tuning must have a musical ear and be equipped with an "A" tuning fork. The piano case must be open so that the tuning pots are accessible. Tune the A group of notes against the fork. Notes F are next tuned against the A; the interval should be a major third. Next tune C by means of the major chord F-A-C, and adjust F again if necessary. Use C to tune E, the interval being a major third, then tune G in the major chord C-E-G. Use G to tune B (major third) then tune D using the major chord G-B-D. This completes the white notes.

Tune E_b using the chord F-A-C- E_b and B_b using the major chord E_b -G- B_b . Tune A_b using the chord B_b -D-F- A_b or the major third C- A_b . Tune $F^\#$ using the major third D-F $^\#$. Tune $C^\#$ using the major chord A-C $^\#$ -E. You will probably need to go over the process several times. Fortunately the electronic piano is much easier to tune than a string piano, which has over two hundred adjustment points.

If you use a m.o.s top-octave synthesizer i.e., only one tuning adjustment will be necessary, and will take only a few minutes (see later).

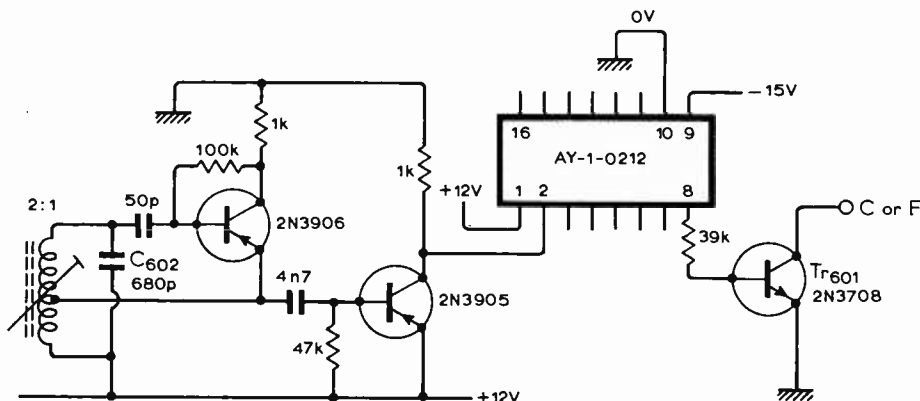


Fig. 22. This alternative tone generator, which can replace the twelve RC oscillators used in the original design, avoids conventional tuning procedures.

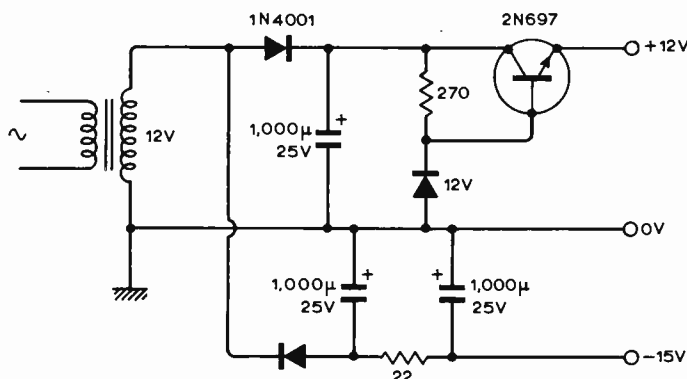


Fig. 23. Power unit to provide appropriate supplies for the m.o.s. tone generator also feeds the preamplifier and headphone amplifier. If the m.o.s. circuit is used, the -5V supply in Fig. 8 (part 1) can be omitted.

Circuit options

On the key circuit boards (Fig. 18), remove the links between track 24, to which resistors R_2 are grounded, and track 23. Link the tracks by a silicon signal diode on each board, connecting the cathodes to track 23. This modification is based on work done after the prototype was completed, and if carried out should slightly improve the keying action at the "soft" end of the dynamic range.

The prototype is a basic instrument in that no attempt is made to modify the inherent tone of its working waveform, except by a single low-pass filter. It is purely by coincidence and the laws of physics that it sounds as much like a harpsichord as anything. If this tone is not acceptable then additional wave-shaping can be added fairly easily. There is room on the keying boards to fit a low-pass filter between D_1 and R_5 . I fitted filters on the 16 lowest notes to take harshness out, with resistors of 10k Ω and capacitors of 20nF. More complex circuits could be built on a separate board, linked by a 61-way cableform.

A power amplifier could be fitted inside the case, but as this would need a separate power supply it does not seem worthwhile. Similarly, loudspeakers could be fitted in the case, but as fairly large speakers will be needed to reproduce the bass notes properly, and as the case is not designed as a loud-speaker enclosure, this is not recommended.

A tremolo circuit could easily be fitted after the preamplifier. It is not known whether vibrato can be applied to the oscillators successfully, and anyway this seems inappropriate.

The headphone amplifier could be replaced by an integrated circuit. The MFC 4000 is a cheap i.c. designed for the output stage of transistor portable radios.

A board containing twelve L-C oscillators could be made as a plug-in replacement, but as discussed in part 1, relaxation oscillators are preferred for several reasons.

Amplification

For low-power amplification, as for practising, almost any amplifier and speaker can be used provided that the speaker is of adequate size. A speaker of 8in diameter should give good results, bearing in mind that the bass notes have more fundamental than those of an acoustic piano. If high powers are wanted then it is essential to use heavy-duty speakers of the type used for electric guitars. The speakers should have a higher nominal rating than the amplifier otherwise the percussive piano waveform will probably damage them.

A standard volume control pedal may be bought and fitted between the piano and amplifier, and R_{403} preset to a suitable level.

M.O.S. master tone generator

The r.f. oscillator and AY-1-0212 master tone generator replace twelve oscillators (Fig. 22). The frequencies generated are within 0.1% of an equal-temperament scale, so the piano will work perfectly well without being tuned at all! It can easily be tuned against another instrument or a frequency counter if desired. It would be possible to

Parts for m.o.s. tone generator

AY-1-0212 i.c. from General Instrument Microcircuit Sales, 57 Mortimer Street, London W1N 7TD.
 470-kHz i.f. transformer, 2:1 turns ratio, with ferrite core
 2N3708— Tr_{601} (twelve)
 2N3706
 2N3905
 Capacitors—50pF, 680pF (C_{602}), 4.7nF
 Resistors—1k (two), 100k, 39k Ω (twelve)
 16-pin d.i.l. socket

Power unit (Fig. 23)

12-V, 50-mA transformer
 Capacitors—1000 μ F, 25V (three)
 Resistors—270, 22 Ω
 1N47001 diodes (two)
 BZY88-C12V zener diode
 2N697 or BFY52 transistor

AY-1-0212 connections

- | | |
|--------------------|-------------------|
| 1 $V_{SS} + 12V$ | 9 $V_{GG} - 15V$ |
| 2 in 500 or 334kHz | 10 $V_{DP} 0V$ |
| 3 C^* or F^* | 11 A^* or D^* |
| 4 E or A | 12 A or D |
| 5 G or C | 13 F^* or B |
| 6 G^* or C^* | 14 F or A^* |
| 7 B or E | 15 D^* or G^* |
| 8 C or F | 16 D or G |

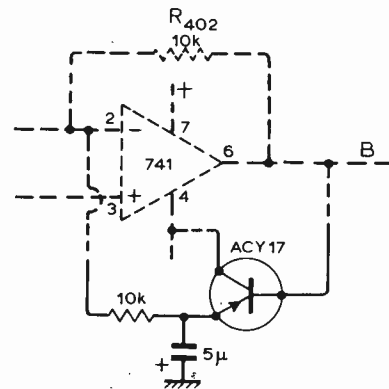


Fig. 24. Optional "anti-thump" circuit comprises three additional components to the circuit of Fig. 7.

arrange the circuit for rapid transposing; this is impracticable with twelve oscillator generators. It is still necessary to have twelve interface circuits to the t.t.l. dividers.

An extra power supply is necessary also. The circuit shown (Fig. 23) provides regulated +12V and smoothed unregulated -15V for the AY-1-0212. The -5V supply of the original piano design is omitted. The preamplifier and headphone amplifier should be powered from the +12V, -15V power supply.

A coil of the 470kHz, i.f. type, with a 2:1 turns ratio is needed. It may be necessary to change C_{602} to get the frequency into adjustment range of the ferrite screw core. The circuit will oscillate with any coil of about the right turns ratio.

The AY-1-0212 will stand a certain amount of abuse but should nevertheless be treated with care. It should be mounted in a 16-pin dual in-line socket. The one-off price is about £5.90. A Veroboard of 3x4in should give ample room for the oscillator, i.c. and the transistor/resistor array. It is advisable to bring the connections out at the edge of the board in scale order; the i.c. outputs are in a random order.

If high-frequency noise causes trouble on the lower octaves, additional power line filter capacitors should be fitted on the circuit board, or 1nF capacitors can be fitted at the Tr_{601} collectors or bases.

Squelch and anti-thump circuits

Some degree of "thump" will always be present where waveforms are not generated symmetrically about ground potential. Fig. 24 shows the anti-thump circuit now fitted in the prototype.

Hiss due to leakage though the reversed-biased diodes D_1 is very low, but can be completely eliminated by the "squelch" circuit of Fig. 25. Connect between points B-B in Fig. 7.

Correction. In the text on page 11 of part 1 (March issue) a line was omitted between lines 16 and 17. The missing line is "... that in the high state it acts as a current ..."

In Fig. 3 the annotations S_2 and S_3 should be transposed. In Fig. 18 of part 2 (key circuit board) diode D_2 should be reversed.

Parts kit. Elvins Electronics will supply a kit of parts for the piano design. Details from 12 Brett Road, London E8.

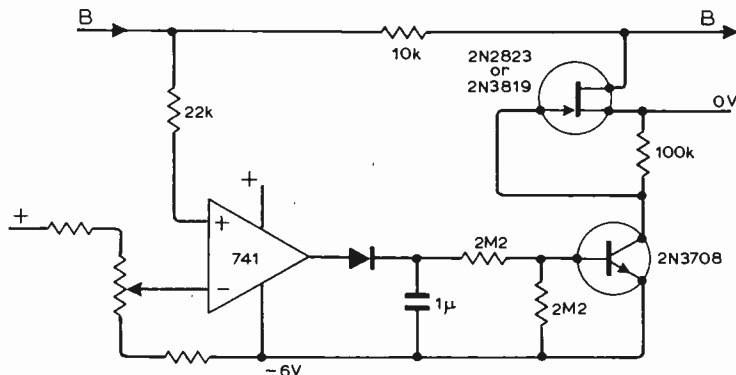
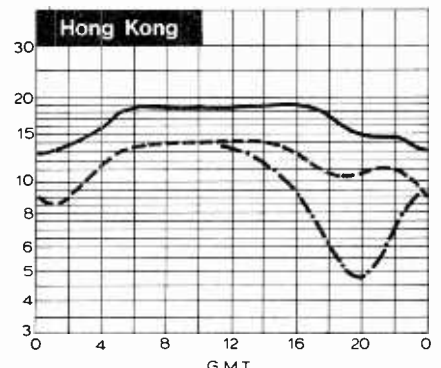
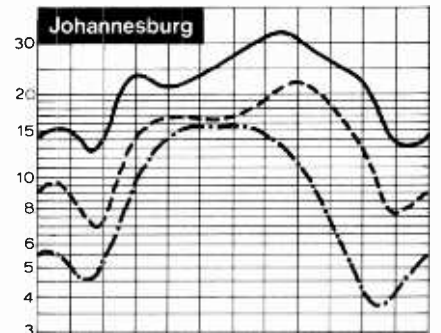
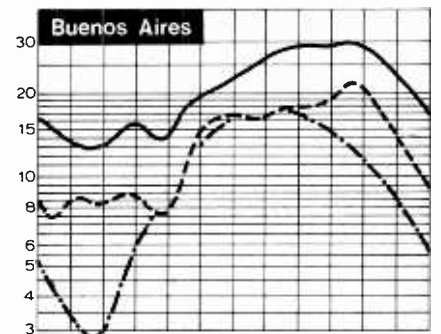
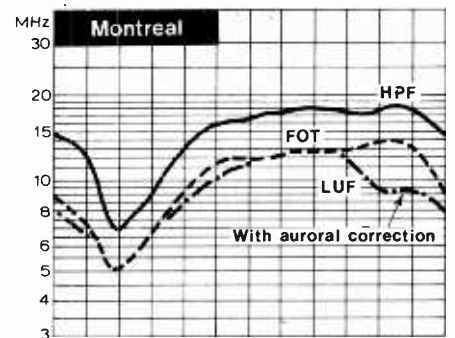


Fig. 25. Use this squelch circuit to eliminate "hiss" due to leakage currents that may be evident during standby. Suitable values for potential divider are 10k Ω and 5k Ω for the preset resistor.

H.F. Predictions for May

The charts are based on an ionospheric index of 8 giving FOT curves two or three MHz lower than those for May 1973 when the index was 40. Magnetic disturbances are likely on all days except between the 7th and 14th. This gloomy outlook should be brightened by sporadic-E propagation considerable modifying FOT curves on at least 20% of the days as follows: Hongkong peaking to 21MHz at 10GMT. Johannesburg rising to 22MHz at 09GMT and remaining so until 15GMT. Montreal maintaining 10MHz from 23 to 08GMT. Buenos Aires dip between 06 and 10GMT smoothed out.



World of Amateur Radio

10GHz to Guernsey

What is believed to be the first-ever amateur microwave contact between the Channel Islands and the mainland of England was effected at 1000GMT on Saturday, March 30. This was between Dr Dain Evans, G3RPE, operating portable at Prawle Point, south Devon, and Gordon Lean, G3WJG, operating as GC3WJG/P at Torteval, Guernsey, both on the 10GHz amateur band. The distance spanned was 111km from sites 100ft (Devon) and 250ft (Guernsey) above sea level. The transmitter used by G3RPE consisted of a 1W klystron and 3ft dish reflector; for GC3WJG a Gunn-diode oscillator provided 20mW of microwave power into a 4ft dish aerial. Further contacts were made at hourly intervals with the mainland signals received in Guernsey at least RS56, although there were times when signals from GC3WJG could not be heard in Devon; for the initial contact reports were RS59-plus at both ends.

The following day contacts on 10GHz were established between GC3WJG/P and A. R. Williams, G3KSU/P, at St Catherine's Point on the Isle of Wight from a site 750ft above sea level and where the equipment included a Gunn-diode oscillator providing 5mW output to a large horn aerial with a gain of 27dB. On Guernsey signals from this station varied from not readable up to RS56. The incoming signals at G3KSU/P were RS59 and at times the carrier/noise ratio varied from 18dB to as high as about 28dB. Path length is 161km. To assist the setting up of the microwave links, contact between the stations was made initially on 70MHz. It had been hoped to complete the triangle with contacts between Devon and the Isle of Wight but this was not possible in the time available.

On the other side of the world a new long-distance record for 2304MHz has been claimed by two Californian amateurs, W6FZJ and WA6HXW. With both stations operating from home locations and using "homebrew" equipment a 330-mile c.w. contact was made by means of tropo-scatter mode. Both stations used 6ft aerial dishes but W6FZJ had a power of only 5W compared with the 1kW input at WA6HXW.

Notes and news

The proposal to install a 144MHz f.m. repeater at the Crystal Palace (see March issue) has now been approved in principle by the Ministry and a licence has been applied for.

Contacts through the amateur satellite Oscar 6 are now being limited to the ascending orbits (afternoon and evenings) on Mondays, Thursdays and Saturdays in an effort to preserve battery life—hopefully until the launch of Oscar 7 later this year. Oscar 6 has already achieved an operational lifetime of 18 months, 50 per cent longer than the predicted lifetime of one year.

The International Amateur Radio Union has introduced new "five-band" and "six-band" categories of their "Worked All Continents" award with a view to promoting more uniform use of the h.f. bands for international communication. To qualify for these new versions of the popular WAC award contacts must have been made on or after January 1, 1974. While the original award is relatively easy to achieve using the 14 and 21MHz bands, a five-band or six-band award, for which two-way communication must be achieved with the six continental areas of the world on each band, represents no mean achievement.

The regular news and code-practice "broadcasts" from PAoAA in the Netherlands (see August, 1973, issue) on Friday evenings have been extended to "Top Band". PAoAA now transmits on 1827kHz, 3600kHz, 14.1MHz and 144.8MHz (changed from 145.14MHz) with news in English at 1915GMT, beginners' code practice at 1930GMT, advanced code practice at 2000GMT, r.t.t.y. news bulletin (45 baud) at 2030GMT and news in English again at 2115GMT. Proficiency tests at various Morse speeds are transmitted on the last Friday in each month at 2130GMT.

On the h.f. bands

Following a longish period of subdued "sunspot minimum" conditions on the h.f. bands, conditions perked up noticeably over the Easter holiday period with many Japanese and other Far Eastern signals on 21MHz and extremely strong North and South American signals in the evenings on 14MHz. Many amateurs are beginning to wonder if we shall soon reach the end of the present sunspot cycle; this would agree with forecasts made over a decade ago that mid-1974 might see the beginning of the next sunspot cycle. On the other hand, the curious and still unexplained high level of sunspot activity throughout the summer of 1972 could mean that the old cycle still has some time to run. But once past the low point, a new cycle usually sees a fairly rapid rise in sunspot levels and consequent rise in usable frequencies to the benefit of users of 14, 21 and 28MHz.

Some amateurs can indeed claim to have experienced a considerable number of sunspot cycles. A recent QSL card from Robert Galea, 9H1E (one-time ZB1E and VP3E), mentions that he was first on the air as long ago as January, 1914. A personal

reminder of passing years and sunspot cycles came when working VX1AW at St John's, Newfoundland, on Good Friday; it so happens that the very first long-distance contact ever made from G3VA was with VO1B, St John's, and that was 35 years ago on Good Friday 1939. I have to admit, however, to no longer using an 0-v-1 two-valve "straight" receiver and 10W transmitter as in 1939!

And 50 years ago (April/June, 1924) saw the biggest threat ever to British amateur operation (or "experimental" operation as it was then called) in the form of new licence conditions which stated that "Messages shall be transmitted only to stations in Great Britain or Northern Ireland which are actually co-operating in the licensee's experiments and shall relate solely to such experiments". It was this condition, which would have eliminated all casual and all international contacts, that caused *Wireless World* to offer to provide £500 to support the RSGB in a test case in the Courts. However, the authorities gradually gave way although they insisted that British amateurs should not use the general call "CQ" and this remained in force until 1946.

In brief

Callsigns in the sequence G4DAA are now being issued. . . . A meeting of the executive committee of the IARU Region 1 Division is to be held in The Hague from October 11 to 13. . . . Class-B type licences with a ZR prefix are being issued in South Africa for use on 144MHz and above to those who have passed all the conditions for the amateur licence except the Morse test. . . . Rosario Vollero, I8KRV, is the new president of the Italian amateur society ARI. . . . From the *Newsletter* of the Wirral Amateur Radio Society comes the following advice on successful low-power operation: "Stable transmitter, good operating technique, intelligent use of propagation, patience, perseverance, the courage to 'have a go' realizing that once you become an addict, you are 'hooked for life'." . . . The Hull and District Amateur Radio Society is holding a mobile rally on Sunday, May 26, at the East Riding College of Agriculture, Bishop Burton on the A1079 York to Beverley road with talk-in stations on 1980kHz and 145MHz a.m. and 144.3MHz s.s.b. with a full programme of events (last year over 1,000 people attended). . . . The fifth Elvaston Castle Mobile Radio Rally is on Sunday, June 9, organized by the Nunsfield House Community Association amateur radio group. Elvaston Castle, near Derby, is on the B5010 some five miles south-east of Derby, just off the A6 and within easy access of the M1 (junction 24). The rally aims at providing a "family day out" of interest to the general public as well as to the radio amateur himself. . . . A meeting of the International Amateur Radio Club in Geneva will immediately follow the XIIIth Plenary Assembly of the CCIR, July 27 to 28, at the ITU headquarters building with a technical panel on "CCIR studies and the radio amateur".

PAT HAWKER, G3VA

Communications 74

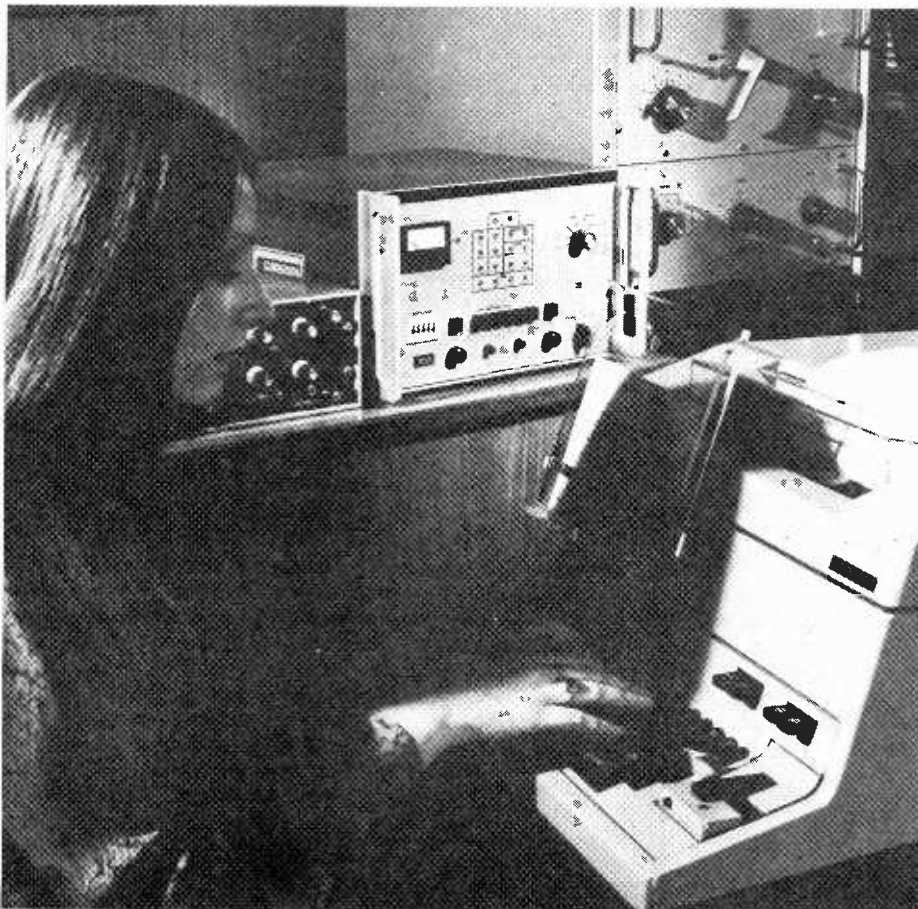
Radio & Data Communications

Exhibition and Conference
Brighton June 2-7

Encouraged by the success of Communications '72 held in 1972 the organizers are putting on a similar, but larger, conference and exhibition this year at the Metropole Convention Centre, Brighton, from June 4 to 7. Devoted to radio and data communications, it enjoys the full support of Government departments such as the DTI and the Ministry of Defence and of the industry's Electronic Engineering Association. The exhibition is a four-day event, embracing data, mobile radio, fixed radio and defence communications and has over 100 exhibitors. The conference call for papers attracted well over 100 papers from all parts of the world and 56 of these are to be read in a four-day, 14-session conference organized by *Electronics Weekly* and *Wireless World*. Six "inward missions" of senior users of radio and data communications equipment are being brought into the UK at a time to coincide with the event. These "missions" are sponsored by the EEA. For further information on the exhibition contact: ETV Cybernetics Ltd, BETA, 109 Kingsway, London WC2 6PU. For further information on the conference contact: Roger Woolnough, IPC Electrical-Electronic Press, Dorset House, Stamford Street, London SE1 9LU.

List of exhibitors

Airtech
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Antenna Specialists UK
Astro Communication Laboratory
Automation & Technical Services
Bantex
Barkway Electronics
J. Beam Engineering
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Marconi Spector automatic error correction unit

continued over page

continued from previous page

Racal Electronics
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 Trend Communications
 Varta (GB)
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 Watkins Johnson International
 Wragby Plastics
 Zellweger Uster



Racal transportable station including a solid-state 1kW transmitter (right), h.f. receiver and a radiotelephone terminal (centre)

The conference

June 4 is "data communications day" and has sessions on data communications, equipment design and mobile communications. A "highlight" paper is on the Post Office and its data customers—teleprocessing now and in the future.

June 5 is "mobile communications day" and has sessions on mobile communications, equipment design and maritime communications. A "highlight" paper is on computerized frequency assignment for the private land mobile services.

June 6 is "fixed communications day" and has sessions on fixed communications, equipment design and defence communications. A "highlight" paper is on tropospheric scatter.

June 7 is "defence communications day" and has sessions on defence communications (featuring the Clansman system), equipment design and instruments. A "highlight" paper is on electromagnetic compatibility—the army's outlook and the work of the army.

Letters to the Editor

Damping factor

More and more do we see damping factor incorrectly stated as the ratio of loudspeaker impedance to amplifiers internal (source) impedance. Figures quoted because of this assumption are often many hundred percent in error, errors arising largely because the source impedance of an amplifier is for very good reasons seldom resistive at low frequencies.

The method of measurement laid down by the British Standards Institution in BS 3860:1965 obviates these errors and should always be used if damping factor is to be quoted.

To the user, of course, damping factor is largely irrelevant because as soon as music is played via a moving coil loudspeaker the speech coil will warm up and change its resistance. The first four bars of Beethoven's fifth played at any reasonable level will change the loudspeaker damping by an amount greater than any variations between amplifier specifications.

The damping (in terms of circuit Q) of a moving-coil loudspeaker at resonance is approximated by

$$\frac{2\pi fM}{B^2 l^2} \left\{ \frac{(R_E + R_G)^2 + X_G^2}{R_E + R_G} \right\}$$

The relevant terms in the bracket are: R_E , d.c. resistance of speech coil (varying by 0.4% per degree centigrade); R_G , source resistance of amplifier; and X_G , source reactance of amplifier at loudspeaker resonant frequency.

P. J. Walker

The Acoustical Manufacturing Co. Ltd,
 Huntingdon

Printed circuits kit

I have been following your recent correspondence on printed circuits with considerable interest and I wish to offer the following information in response to M. R. Yeo's letter "One-off printed circuit boards" (March 1974 issue).

For some time we have been marketing a printed circuit kit which was designed to provide the enthusiast, laboratories, educational establishments, etc., with a method of making low-cost, one-offs or prototypes to a reasonable degree of precision. The use of self-adhesive, paper-surfaced resist allows the user to draw, or trace, the desired

pattern with any normal writing implement such as a pencil, ball-point, etc. A scalpel is used to cut and strip the unwanted resist. Chemicals are pre-packed for the convenience of the user who merely adds water, and the printed circuit board, for the etching process which can be observed as it proceeds.

J. H. Evans,
 Keltronix Ltd,
 15 Barra Street,
 Glasgow G20 0AX,

Howl suppression

I agree with K. J. Young (Letters, March 1974) that, where there are one or two dominant peaks in the overall frequency response of a public address system, tunable rejection filters can be helpful in reducing acoustic feedback problems. Such equalization is often achieved nowadays by the incorporation of an octave-band or third-octave-band graphic equalizer.

However, one is still left with the inevitable response irregularity of the room itself, where adjacent peaks and dips are typically only a few hertz apart (Fig. 2 in my original article, *W.W.* July 1973, p.317). The smoothing of such a response is an impossible task for conventional filters, but the frequency shifter is able to overcome the ill-effects of such irregularity and effect a significant improvement in available gain prior to feedback.

I should be the last to deny that frequency shifting on music is a highly controversial subject. When I first designed and used the howl suppressor, it was solely with speech applications in mind; I expected the technique to be unacceptable for music. It was therefore with some surprise that I found the frequency shift usable for musical performances. The 5Hz beat, which, as I mentioned in the article, is sometimes audible on long continuous notes, is the only unusual effect. There are just one or two instruments, such as organ and electric guitar, where the beating is obvious, being heard as a sort of "stereo vibrato" between the original sound and the frequency-shifted version.

I found the absence of a beat in the majority of musical applications rather mystifying at first, but the answer was found to lie in the delay between direct and amplified sound. Virtually all public address systems exhibit such a delay, which occurs because of the difference in sound path lengths; in a well-designed system the direct sound is arranged to arrive at the listener first, exploiting the "Haas effect" to produce the correct apparent sound direction. To investigate the effect of time delays on beats, I tried mixing a music signal and its frequency-shifted version and feeding the signal to headphones. Strong 5Hz beats were audible on all types of music. When, however, an adjustable time delay was interposed in the frequency-shifted channel, a time difference of 3 ms was found to be sufficient to destroy coherence between the two signals on most types of music, thus eliminating beats.

Exceptions were found in the cases of organ and electric guitar, where even delays as long as 100 milliseconds did not destroy coherence, owing to the steady pitch and level of the notes produced. The beats produced on these instruments become very much less obvious if the frequency shift is reduced to 2.5Hz by doubling the values of capacitors C_2 , C_3 , and C_{10} in the oscillator circuit to 200nF. This change usually involves a slight loss (typically 2dB) in the amount of feedback reduction available, but it is worth trying if beats are audible.

I should be very interested to hear reports, whether favourable or otherwise, from any readers who have used the frequency shifter in a music amplification system.

M. Hartley Jones,
University of Manchester,
Institute of Science and Technology,
Manchester.

Current flow controversy

The letters by Messrs D. V. Ellis and C. H. Banthorpe in your December 1973 issue each has a final paragraph of such graceful compliment that it largely defuses what I might otherwise have said about what went before. Fortunately I feel I can confidently leave readers to draw their own conclusions on most of the arguments put forward, so that replying to them all in detail would be superfluous.

For example, if, as Mr Ellis suggests, my ideas on cathode rays are freakish and absurd, how is it that since those ideas were introduced into *Foundations of Wireless (and Electronics)* 22 years ago about 100,000 copies have been bought, and (many of them being in public and college libraries) the number of readers must be considerably greater, yet not a single one of them has pointed out the difficulties arising from use of the conventional direction of current flow in connection with that subject or with any other in that or any other of my works, but on the contrary people continue in large numbers to vote with their purses right up to the present day?

One thing I have ascertained from Mr Ellis's second letter is that he advocates reversing the current-flow convention but *not* the polarity conventions. So he does have to teach that his current flows from negative to positive, i.e., from a deficit to a surplus, presumably on the principle that "to him that hath shall be given and from him that hath not shall be taken away even that which he hath"—another paradox, but not one applicable to electric circuits. And yet by some logic that escapes me he reconciles this with water flow! This, in addition to teaching that the rules in the textbooks mean the opposite of what they say, and the arrows in device symbols are there to show the direction the current does *not* flow! And yet in August he found unacceptable an imaginary situation in which a horse described as black had to be taken as white!

Mr Banthorpe seems not to know what "the positive direction of current" means. May I try to enlighten him? The actual direction of current (conventional or electronic) from A to B in a complicated circuit may not be known; in fact, that may be what is to be found. So let us agree to call current from A to B (say) positive. Then if our calculations result in a positive value of current in that branch it does indeed flow from A to B. A negative value means it flows from B to A.

May I reiterate that "the direction of current flow" cannot be established consistently on a basis of physical facts, since an electric current can be constituted by physical movements in either or both directions. So it is a convention; and whichever of the two possible ones is adopted students and others will have to accept that some current carriers will move "against" the current. (In spite of what Mr Ellis says, the existence of negative ions does not get rid of this awkward fact.) If we could start from scratch we in electronics would almost certainly vote for the direction of electron flow, but Mr Smethurst has wisely reminded us that we are not the only pebbles on the beach of science. The important thing is that everyone should use the same conventions.

For about a century and a half there has been an accepted convention among British railwaymen that trains going in the general direction of London are referred to as "up" trains and those going in the opposite direction are "down" trains. If signalmen in cabins where this convention is manifestly absurd, because the track thereabouts goes uphill in the "down" direction, decided to take the "sensible" view and report as "down" all trains they saw going downhill, confusion in British Rail would be as great as during a work-to-rule. Much less confusing, when nobody can be literally right all the time, to stick to the convention that has been in use for so long. So it is, surely, with current. "Cathode Ray"

Soldering-iron leakage

I was interested to read the letter from Mr Sproston of Home Radio in your March issue. As far as I know only one soldering-iron manufacturer makes an issue of leakage currents but, I suspect, misguidedly.

The point really is that to solder semiconductor devices safely it is necessary to ensure that no voltage appears on the bit of the iron. Provided that the iron is fitted with a three-core flex which in turn is properly connected to a three-pin plug, then the bit must always be at earth potential, and it would take a very large leakage current indeed to make it otherwise. If the earth connection is not used, then even the smallest leakage current will cause a possibly damaging potential to build up on the bit.

Incidentally, nearly all temperature-controlled irons also produce switching

transients which can damage the more delicate (and expensive) devices since they use mechanical or thyristor switching techniques. It was for this reason that we developed the special transistor switching circuit for our variable temperature ETC/1 system.

C. P. Adamson,
Light Soldering Developments Ltd,
Croydon,
Surrey.

Active filter crossover networks

Mr Read's article "Active filter crossover networks" (December) raised interesting ideas, which could prove very fruitful to audio experimenters. Indeed, I intend to experiment with such networks when student finances permit. However, I was astonished to read "Peak powers of 20W occurred in all the three bands". Could the author possibly enlarge as to how he measured these peak powers, and under what circumstances?

D. J. Bradshaw,
University College,
Oxford.

The author replies:

In answer to Mr Bradshaw's query regarding amplifier power requirements the following details of tests and observations made when setting up the 2 × 3-way arrangement described in my article may be helpful.

With the three KEF units (types B139 for l.f., B110 for m.f. and T27 for h.f.) installed in the transmission-line enclosure each speaker input signal was monitored by display on a storage oscilloscope during repeated runs of the same test programme comprising music from full orchestra, choir and solo female singer. The storage oscilloscope persistence control was set so that the decay time was of the same order as the test programme duration; the brightness control was at a suitably low setting to avoid "overloading" the phosphor during that period. In this way, the three filter outputs were (sequentially) displayed to indicate and record:

(1) Instantaneous peak power. Voltage amplitude was here considered proportional to *instantaneous* power; because of the change of load impedance with frequency. However, such an assumption was valid only for the intended purpose of comparative estimate.

(2) Integrated peak power. The differing trace brightness at various voltage levels showed the proportion of programme time spent at these levels and hence, taking the brightest level in each instance, the average peak power during the programme run. Again, this test is more concerned with intelligent observation than measurement—the human eye is a poor judge of brightness difference even by direct comparison and is still worse if it has to "remember" a previous

image. But, as the results show, the observed differences were sufficiently large to justify the conclusions reached.

The results were:

(a) The highest peak voltages (instantaneous powers) were those handled by the B139 (l.f. unit), being about 6dB more than for the B110 mid-range speaker.

(b) The integrated peak power was obviously much larger for the B110 unit—say 75% of the total compared to 20% for the B139.

(c) The T27 tweeter received the least amount of energy during the programme—in fact, the estimated figure for integrated peak power was only a few percent. But, and this is of prime importance, the input to this unit included short-duration peaks of nearly the same amplitude as the maximum recorded for the B110. Hence it was concluded that the *instantaneous* power requirement here was similar to that for the mid-range units.

Further tests were done using the same technique but for an input of typical “pop” music. As might be expected with the heavy bass component normal in this type of music, the results indicated a shift in power distribution between the m.f. and l.f. speakers such that their “integrated-power” percentage figures were more or less equal. In all other respects there was little difference as compared with the previous test.

I hope that above serves to show why the amplifiers feeding h.f. units required the full 20-watt capability and also why the output-stage heat sinks in both “l.f.” and “m.f.” amplifiers were chosen to be of the same size as the circuit boards themselves ($3\frac{1}{2}$ in \times $4\frac{1}{2}$ in) whereas those for the “h.f.” amplifiers were made smaller.

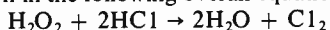
Finally, two other points should perhaps be mentioned. First, to obtain an overall level response (according to measurement in an anechoic chamber) the gain of amplifiers driving the l.f. units was made 5dB greater than for the other amplifiers. Secondly, considering the wide variation in speaker characteristic impedance, at some frequencies it is obviously the available supply voltage (and hence the maximum possible voltage swing) which sets the limit on amplifier output rather than its power handling capability.

D. C. Read

Fast printed circuit etching

I was appalled to read Mr Langvad's letter in the December 1973 issue of your magazine and fervently hope that my comments may prevent the occurrence of a very serious accident. Your correspondent recommends that printed circuits be etched with a mixture of hydrochloric acid and hydrogen peroxide. Although he issues a fairly gentle warning about the use of these chemicals, I would like to emphasize that the two are very vicious substances indeed, and hydrogen peroxide at the suggested concentration in particular is very, very

hazardous to handle. The use of these should only be permitted in a laboratory and not in any amateur's workshop. Your correspondent may also be unaware that the result of the reaction between hydrogen peroxide and hydrochloric acid, as shown in the following overall equation



is chlorine gas, which, as everyone knows, is a very toxic gas.

E. I. Szabó,
Ottawa,
Canada.

Radio and TV museum

As part of educational technology, I am attempting to build a small museum of radio and television equipment to show the change in components and design philosophy since the inception of radio.

I would be most appreciative of any suitable equipment, however small, or technical literature, for the period 1900 to 1930. I must make it plain that the above would be in the form of a gift, as I have no finance for this project.

C. Matthews,
School of Engineering Science,
University of Edinburgh,
King's Buildings,
Mayfield Road,
Edinburgh EH9 3JL.

Valve amplifiers

Recently a “Williamson” amplifier fell into my hands, displaying the fault of falling gain over a period of hours of operation. (The older hands may remember that the Williamson design was first published in 1947 and modified in 1949—I, personally, wasn't born then!) On examination I discovered two major faults: (1) a cracked wire in the negative feedback meant that there was no negative feedback; and (2) a short-circuited decoupling capacitor was preventing half the output stages from functioning.

Yet, despite the faults, the amplifier was producing quite acceptable results. It makes one wonder if we were a little hasty in abandoning valves so absolutely.

D. J. Bradshaw,
University College,
Oxford.

“Recording by ear”

I was rather amused to read of the efforts of the scientists at the Battelle Institute (December, News of the Month). During 1963 I constructed an intercom system for use between the rider and passenger of a motor-cycle combination. As those with two- or three-wheel experience will know, high noise levels are prevalent. However, communication was secured as follows. Mounted in the toe of the sidecar was a 7×4 elliptical loudspeaker driven by a 2-watt amplifier. The passenger spoke into a hand-held noise-cancelling microphone which was permanently live. This arrangement gave useful sidetone with no howl. The rider for his part listened through a miniature earphone let into the earflap of his crash

helmet. This, however, pressed snugly against the ear, and doubled as a microphone operated by a push-button on the handlebars. Bystanders might be seen giving anxious and startled looks as a loud male voice apparently issued from the female resident of the sidecar. A. Puffett,
Stevington,
Beds.

Calculator I.C.

I read with interest your article on the GIM C500 calculator chip in the March issue. I am in the process of designing and building a more ambitious calculator using this chip. Additional features are:

20 fixed functions (pi, reciprocals, %, metric conversion, etc.)

Automatic squaring and square root.

1 non-calculating store.

1-inch-high home-made display.

Left and right shift on decimal point.

The point of this letter is to air a criticism that all the above would have been far simpler if the manufacturers had provided a b.c.d. output instead of seven-segment. After all one can buy (quite cheaply) a chip to convert from b.c.d. to seven segment, but not the reverse.

Messrs GIM have expressed the wish that by releasing the C500 at a competitive price it would encourage its use in fields other than calculators, but the above remarks place limitations on interfacing with other logic. The m.o.s. inputs and outputs can be overcome with suitable circuitry.

A. M. Coppin,
Feltham,
Middlesex.

Return to c/s?

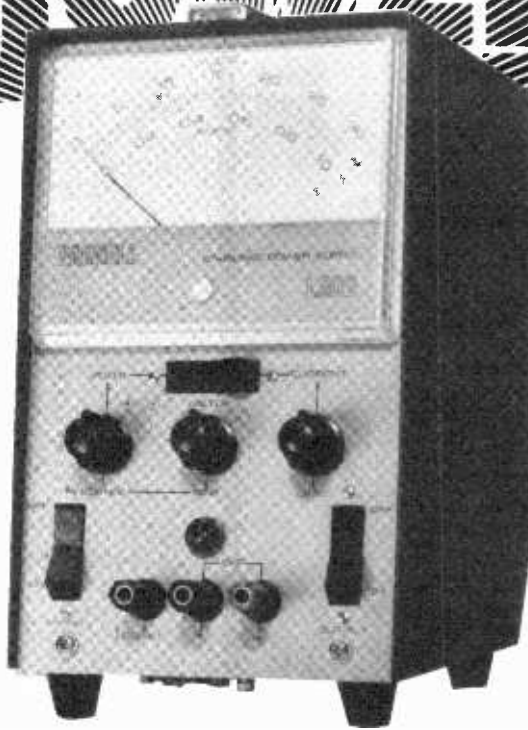
I am sure you will find your new feature Project very rewarding, especially as it will have the backing and experience of *Wireless World* behind it. Writing as a teacher of long experience, could I make one observation which I think would improve the physics masters' lot quite considerably?

Ever since the introduction of the term “hertz” instead of “cycles per second” there has been uncertainty as to its meaning. I noticed some hesitation and difficulty by lecturers on two occasions while giving the Christmas lectures, and on another occasion a member of the BBC television “Tomorrow's World” team deliberately used the old-fashioned “cycles per second” as it expressed what he wanted to say.

After all, Heinrich Hertz was investigating electromagnetic waves radiated through space, and if the term “hertz” were confined to this, then cycles per second could be applied to sound-wave frequencies. In fact, I would suggest that all wave frequencies below 20kHz, including the 50Hz mains, should revert to its more meaningful description.

G. A. Cozens,
Bartley,
Southampton.

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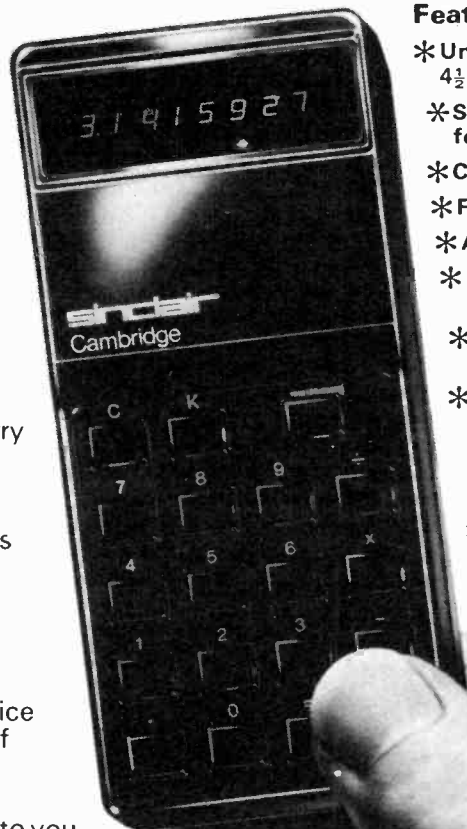
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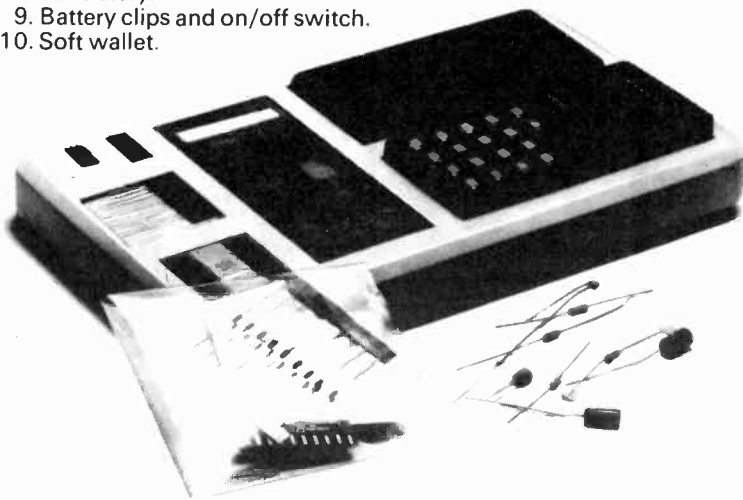
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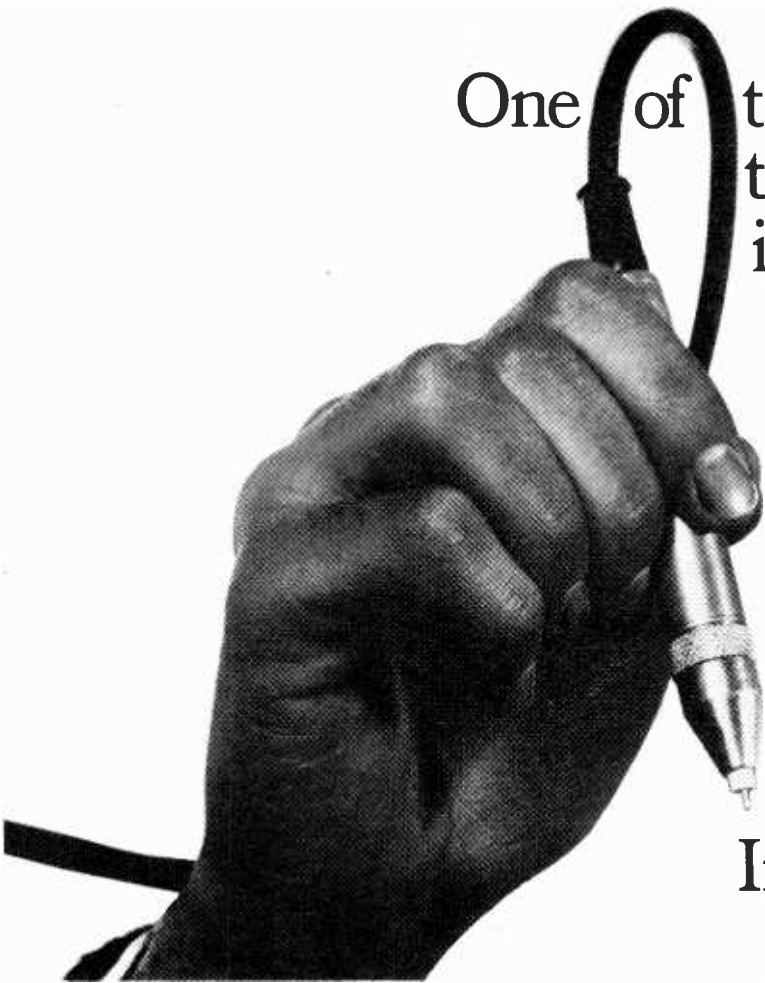
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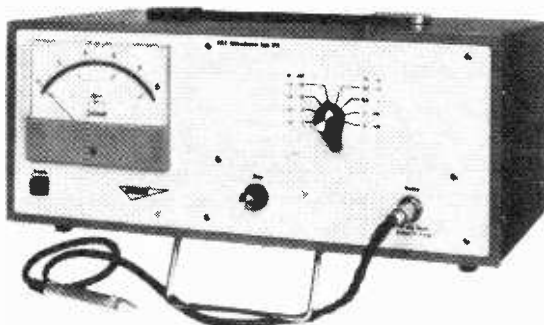
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Realm of microwaves

8—Lenses and radomes

by M. W. Hosking, M.Sc.

British Aircraft Corporation, Stevenage

From the last two articles it should be apparent that the most usual antenna function is to direct as much radiated energy as possible within a specified beamwidth. The efficiency with which this can be achieved depends on how closely the radiation from the antenna system approximates to a plane wavefront; that is, a constant phase across the aperture. An obvious and good example of this is the paraboloid reflector which converts the generally spherical wavefront of the primary feed to a plane-wavefront radiated beam. Such a situation implies equal electrical path lengths for all rays from the feed to the aperture plane and this can also be achieved by a microwave lens.

Microwave lens design can be approached along similar lines to those in optics but, because certain lens dimensions are comparable to the wavelength, diffraction effects cannot always be ignored. These lenses fall conveniently into three categories, although not every type of lens is discussed within each category.

Firstly, there is the uniform dielectric type of lens constructed from some solid material and behaving in much the same way as its optical counterpart. Secondly, there is the artificial dielectric lens wherein, as the name implies, an effective dielectric constant is produced by means other than the bulk property of a material. Thirdly, the non-uniform dielectric lens of which the dielectric constant is not, in fact, constant throughout the lens, but varies with distance in some prescribed manner.

Dielectric lens

Bringing back memories of school physics, the design of solid dielectric lenses can be based on the methods of geometrical optics. Analogous to the optical transparency is the dielectric loss tangent of the lens so for microwaves there is a much wider choice of materials. The lens does not have to be optically transparent and, being the same order of size in thickness as the wavelength, the overall transmission loss is low. However, when the mechanical, environmental and fabrication requirements are taken into account, the range of suitable materials is reduced; those most generally applicable being plastics such as the polyolefins, polystyrene and p.t.f.e.

Refractive index is one of the main design parameters, but microwave materials are

characterized by their dielectric constant. There is, however, a direct relationship between the two. Refractive index is defined as the ratio of the speed of light or electromagnetic propagation in free space to that in material; that is, $n = c/v$. These speeds can be expressed in terms of the relative and absolute permeability and permittivity as

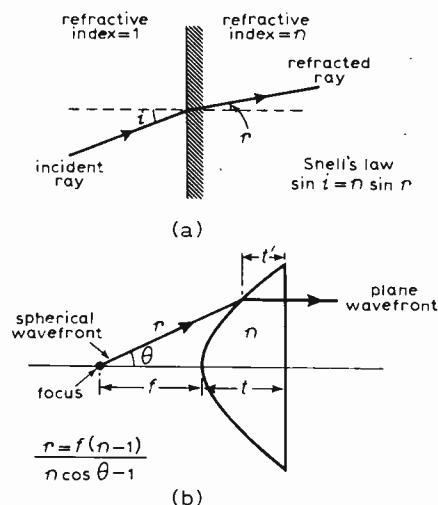


Fig. 1. Refraction of a plane wave at a dielectric interface (a). A point source, spherical wavefront can be converted to a plane wavefront by a suitably curved surface (b). In this case the contour can be hyperbolic or elliptical depending on whether n is greater or less than unity.

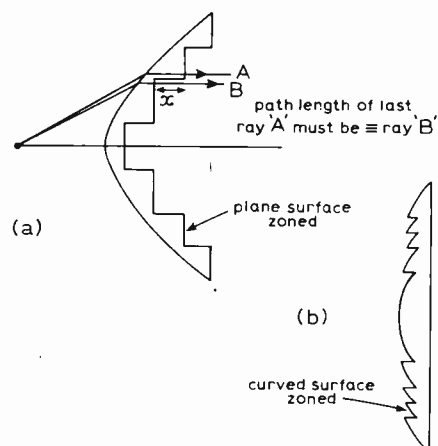


Fig. 2. Zoning the microwave lens saves weight, although at a sacrifice in bandwidth for the solid lens.

$c^2 = 1/\mu_0 \epsilon_0$ and $v^2 = 1/\mu_0 \mu_r \epsilon_0 \epsilon_r$. Manipulation of these relationships shows that $n = \sqrt{\epsilon_r}$ for the case when $\mu_r = 1$. A word of caution here in that n is not necessarily the same as the optical refractive index, because the dielectric constant may vary with frequency between the microwave and optical bands.

Another important characteristic of the uniform lens is that Snell's law is obeyed so that $\sin i = n \sin r$ using the notation of Fig. 1(a). This makes ray-path tracing easier and simplifies equations for the lens surfaces; which brings us to Fig. 1(b). The requirement of the lens shown is to convert the spherical wavefront from a source at the focus into a transmitted plane wavefront. For this to happen, all of the ray-paths into and out of the lens must be equal electrically and defining one surface of the lens as plane, the problem is to find the equation for the other one. From the geometry shown, this means that $r + nt'$ must equal $f + nt$, or $r - f = n(t - t')$. The term $(t - t')$ can be expressed as $(r \cos \theta) - f$ resulting in the surface equation

$$r = \frac{f(n-1)}{(n \cos \theta) - 1}$$

For values of refractive index greater than unity this is the equation of a hyperbola of eccentricity n . So a simple microwave lens might be made from, say, polystyrene having a microwave refractive index of 1.6 and would be plano-convex in shape with the convex surface being a hyperbola facing the incident radiation.

If such a lens were to have an appreciable diameter, then the thickness would be large and the weight would consequently be high: both undesirable features. It is, however, possible to remove material from the lens in a controlled fashion and to drastically reduce the weight; the process being termed zoning, Fig. 2 showing end result. By "controlled" is meant removing a section of the lens such that the last ray, so to speak, in the dielectric, A of Fig. 2(a), differs in path length from the adjacent ray B in the air-gap left by a whole number of 2π phase changes. In this way the phase relationship between all rays is maintained at the correct value and, electrically, the lens does not know that pieces have been removed. The price paid is a reduction in bandwidth due to the frequency-sensitive nature of the steps,

together with a reduction in aperture efficiency due to a diffraction at the edges of each step.

Although the dielectric lens antenna holds promise of greater ease of beam scanning by just moving the feed, it is up against severe competition from the reflector antenna and the phased array and is not nearly so widely used. Possibly its main application is as a phase corrector for microwave horns. The horn itself was reviewed in an earlier article and it can readily be appreciated that, due to the changing path length within the horn, there can be considerable phase change across the aperture causing inefficient radiation. By placing a lens in the aperture, the efficiency can be raised from something like 50 to about 80% together with a reduction in spill-over and back radiation.

Artificial dielectrics

It is possible to calculate, with varying degrees of success, the dielectric constant of a material from a knowledge of its molecular structure. In general, this means the determination of a quantity called polarizability, which is a measure of the ease with which an applied electric field can induce a directional charge in each atom. Normally, each molecule with its atoms and orbiting electrons has no preferential charge on it and is electrically neutral. But when brought under the influence of an electric field, some electron re-positioning occurs, producing a preferential alignment of charge in the same direction as the field—the dielectric becomes polarized.

Polarization also occurs in metallic conductors due to an applied electric field re-positioning surface charge and has led to a class of artificial dielectrics wherein metallic particles of various shapes are used to simulate the molecules and so form what is really a large-scale model of a molecular structure. Knowing the shape of the particles, their polarizability, and hence dielectric constant, can be fairly simply calculated (compared with an atomic structure) from an electrostatic approach.

Things are not that simple in practice, due largely to variations in particle size and shape and in uniformity of distribution. The particles can be of a variety of shapes: spheres, discs or flakes, filaments and strips being commonly used, with cross-sectional dimensions typically lying between 0.05 and 0.01 of a wavelength. Dielectric constant depends on the particle shape used and

whether the particles have a preferred orientation. Spheres, for example, place an upper limit of about 1.6 ($n = 1.27$) on the dielectric constant, but being symmetrical this does not vary with the direction of propagation through the material. A disc on the other hand allows any value (theoretically) to be obtained, provided that both the electric and magnetic fields are tangential to the disc's surface. This means that the dielectric constant becomes a function of direction, to say nothing of alignment problems in producing the material itself. Whichever shape is selected, the particles themselves must be supported in some way and distributed as evenly as possible. The most popular supporting medium is polystyrene or polyurethane foams as these are light, easy to produce and have a very low refractive index.

Having selected the particle shape and distribution to give a particular refractive index, together with the binding medium the lens design can proceed as for the solid dielectric. The main advantage of this type of artificial dielectric is its low density, resulting in significant weight saving and not only in lens design. The material can also be used for radomes (see later). Possibly the largest problem facing its use is that of obtaining a uniform and repeatable dispersion of the metallic particles within the supporting medium.

There is another, widely-used method of creating an artificial dielectric constant which makes use of the guiding properties of parallel metal plates. A stack of such plates is shown in Fig. 3(a) with an incident electric field parallel to the plate surface. Under these conditions, the plates will support a waveguide mode, the wavelength of which then becomes governed by the plate spacing. It may be recalled from an earlier part of this series that the guide wavelength can be expressed as $1/\lambda_g^2 = (1/\lambda_0^2) - (1/4a^2)$ where the quantity $2a$ represents a cut-off wavelength above which energy will not propagate in the guide. The refractive index, $n = c/v$, which is the same as $n = \lambda_0/\lambda_g$, as the frequency remains constant. Therefore, by using the above expression for waveguide wavelength, a refractive index for the parallel plate system can be written as $n = [1 - (\lambda_0/2a)^2]^{1/2}$. Some limitations are put on this expression as the spacing, a , must be greater than $\lambda_0/2$ to remain above cut-off and must be less than λ_0 to avoid risking the propagation of the next-order waveguide mode.

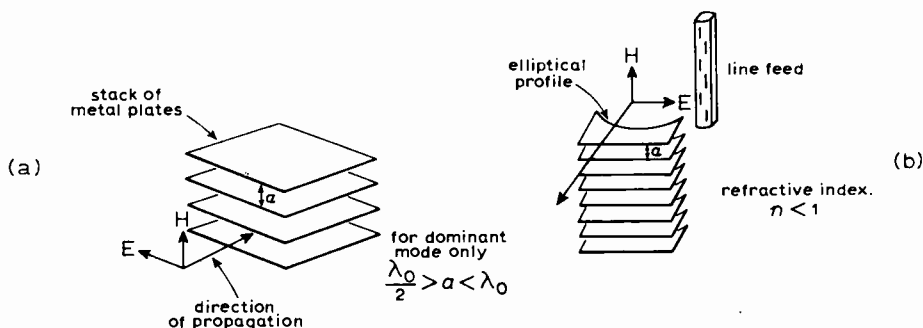


Fig. 3. Equivalent dielectric constant of less than unity can be produced by constraining the wave to pass through metal plates (a). By shaping the plate surface (b), a further type of microwave lens can be produced.

An interesting feature of this type of structure is that the refractive index is less than unity, implying that the velocity within the guide is greater than that of light. However, the overall velocity within any substance can be considered as the geometric mean of two velocities. One being that at which signal energy is carried, called group velocity and which cannot exceed c , and the other called phase velocity, which describes the movement of the phase front and which can be greater than c . For a non-dispersive medium the two are equal, but that is not the case here and v is the phase velocity.

We thus have another artificial dielectric with an equivalent refractive index and, in similar fashion to the solid dielectric case, wish to find the profile of one surface to produce a lens. The first equation can be used again, but with $n < 1$ is re-written $r = f(1-n)/(n \cos \theta) - 1$ which is now the equation of an ellipse. Thus, a metal plate lens might appear something like Fig. 3(b) in general profile.

Many other types of lens are possible and the methods of producing artificial refractive indices and lenticular effects are many and varied, although often having little practical application. Consequently, there is little to be gained in reviewing these further; rather the intention has been to introduce to the reader the concept of a microwave lens and to highlight differences in physical form between it and the more familiar optical counterpart. Anyone interested in delving further into the subject could obtain the basic groundwork.* There is one other lens from the category of non-uniform dielectrics which is well worth mentioning; partly because of its novelty and partly because it is the most widely used of all microwave lenses.

The Luneberg lens

This was first propounded in a treatise on optics but proved impractical to construct at those wavelengths. The idea is to produce a lens that will focus energy from a point on one side to a point on the other, with particular attention paid to the limiting case where one of these points is on the surface of the lens and the other point is at infinity. In other words, to derive another spherical to plane wave-front convertor. The lens itself is a sphere having the general ray geometry shown in Fig. 4(a) wherein radiation from a point-source feed on the surface follows elliptical ray paths through the lens and, if all of these ray paths can be made electrically equivalent, emerges as a plane wavefront. A fairly complicated mathematical analysis of this lens shows that to provide the necessary phase variations within the lens, the dielectric constant must vary with the distance from the centre of the lens, r , in the simple fashion given by: $\epsilon_r(r) = 2 - (r/r_0)^2$. In other words, the refractive index must vary continuously from unity at the lens surface ($r = r_0$) to $\sqrt{2}$ ($r = 0$) at the lens' centre.

When one gets down to constructing the Luneberg lens such a variation is not really practicable, so an equivalent approach

*From "Microwave Lenses" by J. Brown, Methuen 1953.

must be found. One which gives exceedingly good results and also permits a simple manufacturing process is to divide the lens into a series of hemispherical shells as in Fig. 5. Each shell has a definite dielectric constant, but different from its neighbour and so the variation of the last equation is achieved in step fashion instead of continuously. Provided the thickness of each shell is chosen so that the phase errors are not cumulative, the lens performs very well.

Because of its symmetry, the Luneberg lens is capable of scanning a beam in all directions and without distortion by just moving the feed. Its widest use, however, is as a radar reflector wherein the feed is replaced by a metal cap as shown in Fig. 4(b) onto which an incident plane wavefront is focused and then reflected back again in the same direction. Such reflectors are used in enhancing the radar return from small airborne targets, calibrating radar systems and acting as marker buoys.

Radomes

This topic is lumped together with that of the lens because, to my mind, the two have many similarities. Both are constructed from dielectric materials, either solid or artificial, both strive for maximum power transmission, and both involve the same basic design problem of an incident electromagnetic field at a dielectric air interface. Often a "tail-end Charlie" in system design and perhaps in receipt of less fundamental design attention than other components, the radome is nonetheless a vital part of radar and communication systems.

The radome is an unwanted extra in the majority of systems and it would always be an advantage, electrically, to do without it. This is seldom possible, as the prime function of the radome is to provide weather protection for the microwave and electronic equipment beneath it. Also, in the case of aircraft and missiles, the radome must form a part of the aerodynamic profile and therefore has to contend with the harsher set of environmental conditions which this imposes. Thus, the radome designer must be a fairly versatile character as he must produce

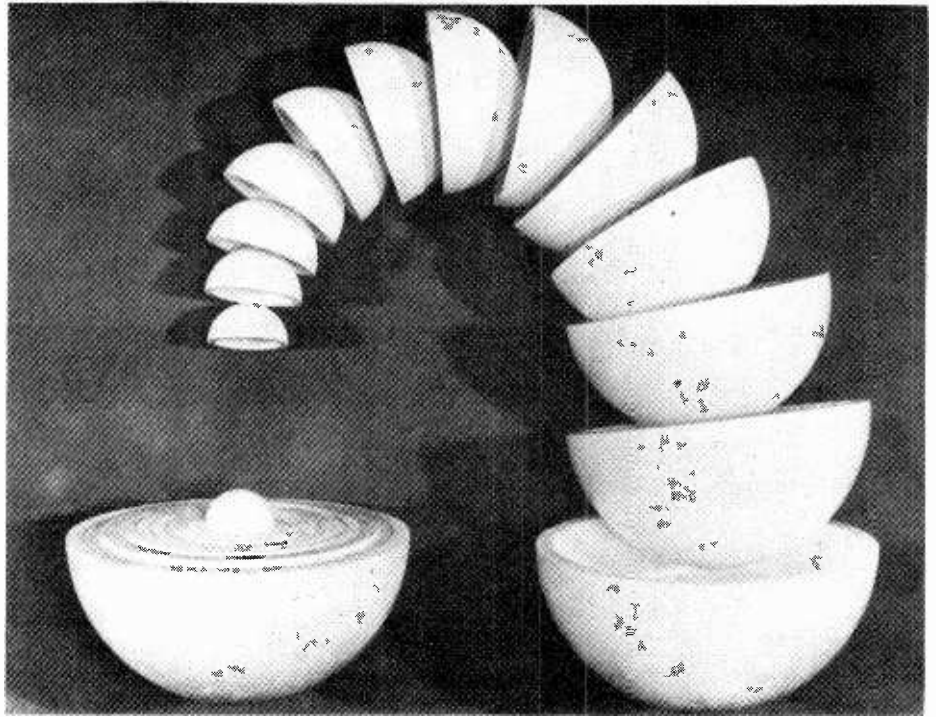


Fig. 5. Continuous radial variation of refractive index is not practically possible, so the lens is constructed of hemispherical shells, each with a slightly different refractive index.

an equipment cover that is electrically invisible, will withstand rain, snow, ice and extremes of temperature, is mechanically strong and is often aerodynamically profiled. Needless to say, these diverse requirements are not mutually compatible.

It is not reasonable to try and cover here the mechanical and environmental side, except to highlight major points, as this is really a materials technology problem. On the electrical design, however, radomes can be divided into fairly definite categories according to their method of construction and the design itself boils down to that of proper phasing of the reflections which occur at the various material boundaries.

Suppose a radome consists of a sheet of some plastics material of thickness d and dielectric constant ϵ_r . A wave travelling along in free space will see the dielectric as an abrupt change in the characteristic impedance of its environment. The net result will be a reflection of some power at the interface with an amplitude depending on ϵ_r and having a maximum possible value of $R = (\epsilon_r - 1)^2 / (\epsilon_r + 1)^2$.

In addition, the phase of this reflected wave will be opposite to that of the incoming radiation. Having traversed the sheet, the wave now meets another impedance change as it emerges back into free space and this gives rise to a second reflected wave, equal in amplitude to the first but without the phase change. In summation, there will thus be two reflected waves emerging from our plastic sheet, one from the front surface and one from the back and, depending on the phase relationship between them (remember that one wave has traversed the panel twice), they will form a resultant. Such a resultant wave, by interfering with the incident radiation, will cause a further loss in the transmission performance of the radome and it is here that the radome designer steps in.

Fig. 6(a) shows how, for normal inci-

dence, the power transmission of a dielectric sheet varies with its thickness, the features to note being the periodic nature of the curves and the existence of optimum values of d/λ_0 . These optimum values to give maximum power transmission occur when the two reflected waves from the radome combine in such a way that their resultant is zero. In other words, one must be π radians out of phase with the other. Bearing in mind that because of the nature of the impedance change (high to low) the reflection from the front surface is 180° out of phase with the incident wave, the condition for cancellation is that the second wave should travel

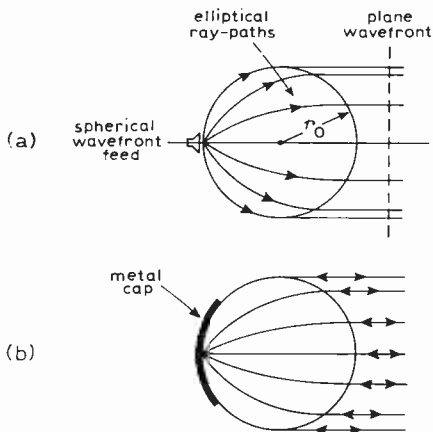


Fig. 4. Spherical Luneberg lens can convert a point source on its surface to a plane radiated wavefront by suitable radial grading of its refractive index (a). By placing a metal cap on the surface the lens can be converted into an efficient reflector (b).

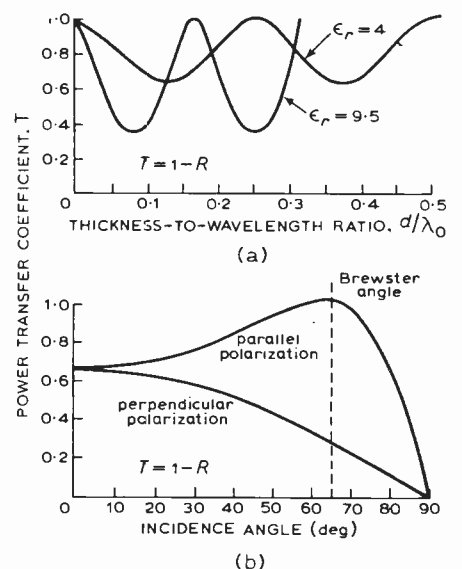


Fig. 6. Variation in power transmission through a dielectric sheet as a function of thickness for normal incidence (a). Transmission properties are different for perpendicular and parallel polarizations, that for perpendicular always being worst (b).

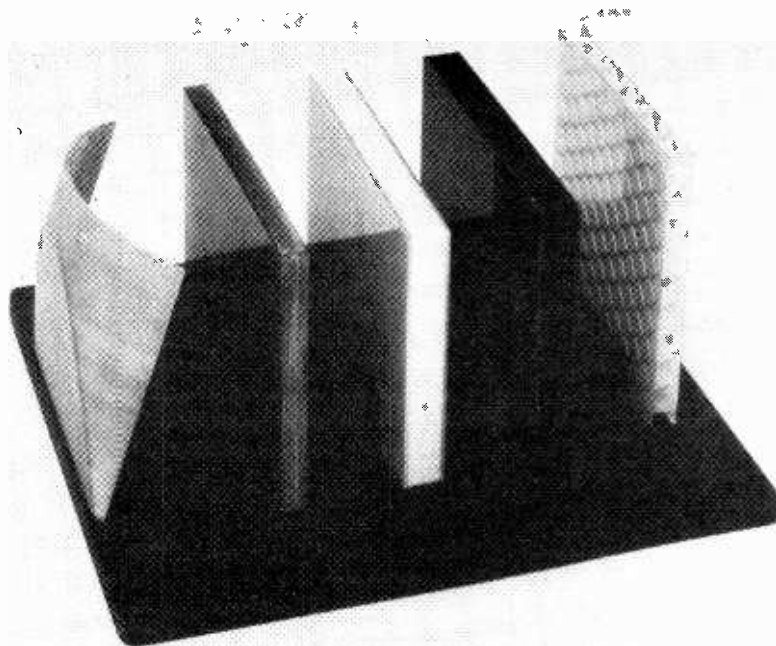


Fig. 7. Main types of radome construction are, from left to right: thin skin, half-wave and three A-sandwiches with different cores.

multiples of 2π radians before combining with the first. As 2π radians corresponds to one wavelength, the radome should therefore be a half-wavelength thick. This means the wavelength within dielectric; i.e. $\lambda_0/\sqrt{\epsilon_r}$.

This feature of a dielectric sheet gives one of the main radome classifications: the half-wave type which finds application at frequencies generally above X-band (above about 10GHz). While many dielectrics are convenient for manufacture, the most popular material by far is fibreglass/resin laminate. Its loss tangent may leave something to be desired at about 0.01, but this is made up for by ease of fabrication, good weathering properties and great strength. With a dielectric constant of four, a fibreglass, half-wave radome designed to operate at 15GHz would thus be a nominal 0.5 cm thick.

A second radome type, really a limiting case of the half-wave, is the thin-skin radome which, as its name implies, has a thickness small compared with the wavelength. Generally, this means less than $\lambda_0/20$ and Fig. 6(a) shows that, for a fibreglass laminate, 85% power transmission is still achieved at this upper limit. Glass-fibre is still a commonly used material for the thin-skin radome but, when circumstance permits, relatively cheap radomes in polyolefin or polystyrene types of plastic can be made using vacuum forming. Example of a thin-skin and a half-wave radome are shown in the two left-hand items of Fig. 7.

The three other samples shown in this figure are from a third main type of radome: the sandwich. In this case, they are of an A-sandwich which consists of two high-dielectric constant thin skins and a low-dielectric constant core. There is also a less-used B-sandwich in which the core is of higher dielectric constant than the skins and a C-sandwich which is really a double A-sandwich. The main reason for going to a structure such as the A-sandwich is that of weight saving, at the same time main-

taining good strength and rigidity. Electrically, the idea is to arrange the spacing of the two skins so that the reflection from the front skin cancels out the one from the rear. For this to happen, a 180° phase difference must exist, which means that the skins must be $\lambda/4$ (in the core material) apart. If the difference between this situation and the half-wave radome is not at first apparent, remember that the sandwich reflections arise at two high/low impedance interfaces whereas those of the half-wave come from a high/low and low/high transformation.

Construction-wise, the outer skins of the A-sandwich are usually of fibreglass and the core can be made from a number of low-density, low ϵ_r , materials. The left-hand and centre sandwiches of Fig. 7 have cores of polyurethane foam and the end one uses a honeycomb or resin-impregnated fibreglass. Typical dielectric constants range from 1.1 to 1.2.

So far, the transmission properties of radome materials have been maintained with radiation incident only normal to the surface, but in practice angles of incidence as high as 80° can be encountered. The design situation then becomes much more complicated because the transmission coefficient varies both with incidence angle and polarization of the E-field vector. Before looking at this in more detail, it is necessary to define what is meant by E-field polarization. If this page represents the radome surface, then it is possible to define a plane of incidence formed by the normal to the page and a line indicating the direction of the incident wave. There are then two polarizations: vertical when the E-vector is perpendicular to the plane and parallel polarization when the E-vector is parallel to the plane. The transmission properties are different for each type. This difference is marked and is shown in Fig. 6(b) for fibreglass sheet of $\epsilon_r = 4$. At normal incidence, the power transmission is limited by the reflection coefficient of the last equation

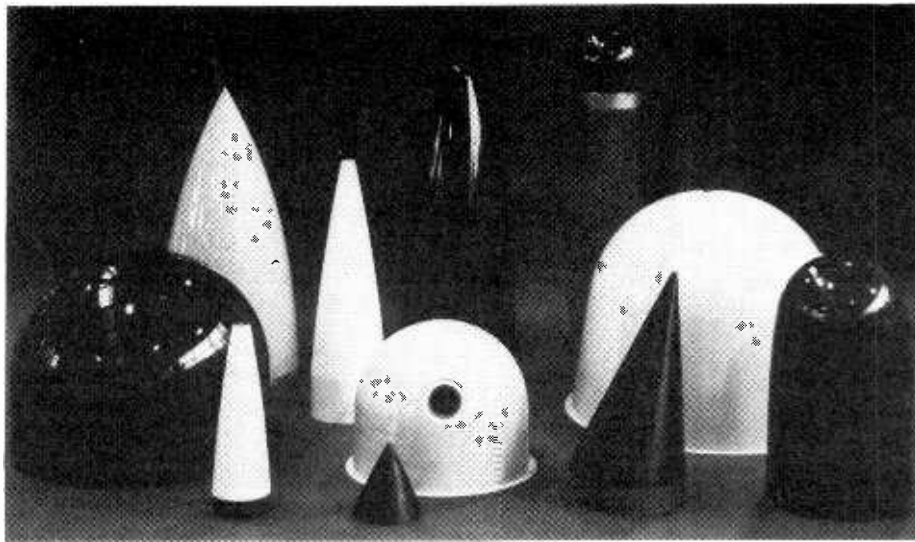
giving $T = 0.64$. As the incidence increases, the transmission coefficient for perpendicular polarization steadily decreases to zero for 90° incidence, while that for parallel polarization increases and eventually reaches 100% transmission.

The incidence angle at which this occurs is the Brewster angle and is equal to $\tan^{-1}\sqrt{\epsilon_r}$. Having passed this angle, the transmission falls off rapidly to zero at 90° . Over the whole range of incidence angles, the transmission of parallel polarization is always better than that for perpendicular which makes it much more difficult to design the more streamlined type of radome having a wide range of incidence angles. This is particularly so for the case of the sandwich radome as its transmission properties are more susceptible to changes in incidence angle than are those of the half-wave type. Fig. 8(a) shows a sample of aircraft and missile radomes of thin-skin; half-wave and sandwich construction where it can be seen that the designs range from the relatively straightforward, normal incidence, hemispherical radomes to types having a very high fineness. An advanced half-wave radome, both production-wise and design-wise, is the Concorde radome shown in Fig. 8(b). It is made from epoxy resin fibreglass, is 11ft high and has a slightly elliptical cross-section. Fig. 8(c) shows an example of a large A-sandwich radome 14ft diameter for a ship-borne radar.

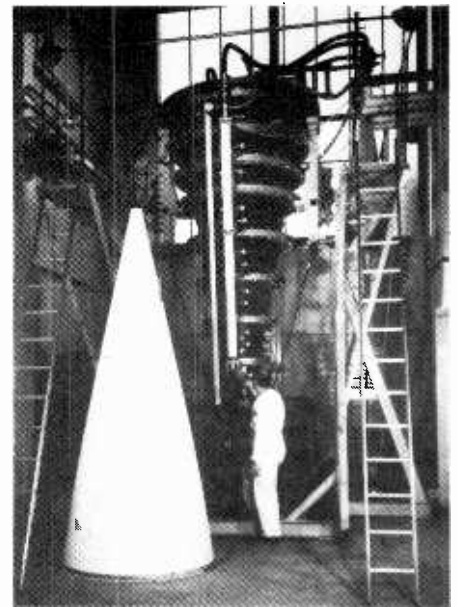
Because of the imperfect transmission properties and the way in which these vary with incidence and polarization, the placing of a radome over an antenna system gives rise to various types of performance degradation which it is the designer's job to minimize. One of these is the straightforward reduction of radiated power due to the mismatch reflections from the radome wall and the attenuation in passing through the lossy dielectric medium. Usually, these losses can be kept to around 0.5dB.

Another effect, generally called boresight error, causes the radiated beam to point in a slightly different direction from that of the antenna. The cause is diffraction effects at the radome and the amount of error is largely dependent upon the variation in phase across the radome surface. Depending on the method of construction, the boresight error is generally less than 20 minutes of arc, which may not sound much but can be most important to certain types of radar: missile homing systems, for example. Once again, due to phase variations, the radome can distort the antenna pattern, usually manifesting itself as a broadening of the beam and an increase in sidelobe level.

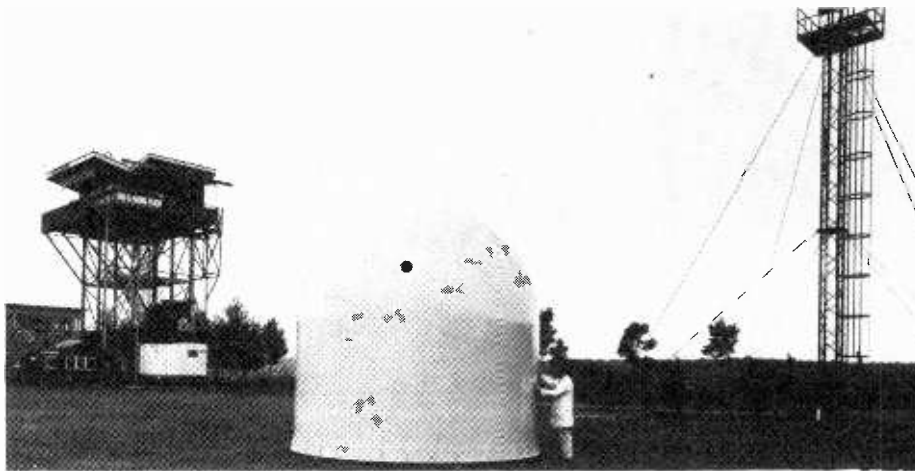
Although the main types of radome have been reviewed here there are, needless to say, many variations. The core of the A-sandwich, for example, could be made of lightweight artificial dielectric of the same ϵ_r , as the skins, thereby forming the less polarization-sensitive half-wave radome but at a much-reduced weight. Thickness and weight can again be saved by embedding wires in thin radome skins to produce lumped inductive or capacitive elements instead of the distributed transmission path through the normal radome. When one



(a)



(b)



(c)

Fig. 8. Aircraft and missile radomes of different methods of construction illustrate the wide range of radome shapes (a). Half-wave Concorde radome and part of its 3½-ton mould (b) and a large A-sandwich radome (c).

adds to these electrical design considerations the severe environmental and mechanical requirements such as imposed by most aircraft and missile systems, the design of a radome becomes a most interesting topic involving many areas of technology.

Scottish search for gravity waves

For the last few years the detection of "gravity waves" from outer space has been claimed by the American physicist J. Weber. Gravity waves are bursts of gravitational energy which are expected to be emitted when a star is swallowed by a "black hole". Gravity waves travel at the speed of light and are detectable by measuring the movement produced when they traverse a freely suspended mass. (Piezoelectric transducers convert the movements into voltages which are then amplified and recorded.)

Weber detects about one short-duration (less than 500 milliseconds) gravitational "event" per day. This has presented astronomers with a problem. If each "event" marks the destruction of a star at the centre of our galaxy, and the process has been going on indefinitely at the same rate, then the entire galaxy should have been consumed long ago. This is one reason why other attempts to check on Weber's measurements are being made.

The detection problem is difficult

because the incoming gravity waves are weak, and apt to be obscured by local noise. This noise may be caused by external (seismic) vibrations or by internal temperature effects (thermal vibrations). Seismic effects are excluded by using two detectors, spaced well apart, and correlating their outputs. Thermal noise has to be combated by signal-processing techniques.

An improved type of detector is in use at Glasgow University. In this, each freely-suspended mass (a 300kg aluminium bar) is divided into two equal parts, with the piezoelectric transducers between them, acting as mechanical couplers. The transducers detect relative movements of the two half-bars. This arrangement is much more sensitive than the earlier ones in which transducers were fixed to the surface of the suspended mass.

Thermal noise sets the detector-mass vibrating on its resonant frequency of about 1kHz. The arrival of a signal impulse from outside interferes with this resonance signal, producing an increase,

decrease, or phase shift. Any such modulation of the output requires the existence of other frequencies. If the natural resonance signal is eliminated by a notch filter, the true incoming signals can be distinguished.

In the Glasgow apparatus the outputs of the six stacks of piezoelectric transducers at each detector are pre-amplified by f.e.t. amplifiers and filtered by a broad bandpass filter centred on the fundamental resonance frequency of the detector mass. The fundamental output frequency is eliminated by a passive LCR bridged-T notch filter.

The two detectors are separated by 50 metres. Their outputs are applied to coincidence circuitry and then recorded in various forms. So far, "events" have been recorded very infrequently in comparison with Weber's results, though there is still a possibility that Weber may have detected events of much larger duration than the short (a few milliseconds) events predicted and searched for at Glasgow.

A problem of measurement

Rectifier-meter readings with distorted waveforms

by Thomas Roddam

At an exhibition last season, or maybe it was the season before, I was surprised, and then alarmed, to find quoted for a piece of equipment two figures which seemed incompatible. The alarm came when the chief engineer of the company concerned said he could see nothing wrong with them. The equipment was, if you are sitting on the edge of your chair with excitement, a sine wave power source. I have forgotten the exact numbers, but typically they were 10% distortion and an output voltage constant to within 2%. Readers who remember the old engine-driven aircraft generator with its carbon-pile regulator will also remember that the most certain way of burning out the valve heaters in flight was to set up the carbon-pile regulator using an average-reading voltmeter.

For much of the time most of us are content to use a rectifier meter, which reads, i.e. responds to, the average voltage but is calibrated to indicate the root-mean-square voltage of a pure sine wave giving the same meter reading. To what extent should we turn away from this easy and inexpensive practice now that our power supplies may no longer have the same purity of waveform as that supplied by the Generating Board?

Until twenty years ago there was no question about it. The one really critical voltage inside a piece of equipment was the valve heater voltage. If the heaters were too hot, the life was shortened: if they were too cold, some circuits, though none of mine, just would not work. Looking back more critically, however, we did accept quite wide variations by modern standards. The 12.6 volt line of a wide range of valves was a 12-volt battery, and no one expected that to be closer than $\pm 10\%$.

Technically it is not difficult to measure r.m.s. voltage, although the simple measuring techniques all have flaws. The old and tried method was the use of a thermocouple, calibrated in my young days against d.c. for each measurement or group of measurements. Accident-prone and slow, I do not regret that we no longer see this. Thermistor circuits are also slow, and I suspect that they are temperature dependent. Then there are tricks, using a number of diodes to build up the parabolic characteristic in a set of arcs.

I used this method a long time ago in a psophometer but I am not sure how good it is over a wide temperature range. More recently all kinds of clever devices have come into use. A Hall multiplier will produce V^2 , and one can also do the multipli-

cation by using length and amplitude modulation of a sampling train of pulses. In fact you can buy an expensive box of tricks.

Is this refinement necessary? How much does it really mean? In this article I propose to look at the error caused by distortion and on some of the other factors which are involved.

In order to make life easy, because, as I have never failed to preach, any examination of principles should not allow a passion for generality to complicate the argument, I shall examine only the effect of the third harmonic. As this is usually the main source of error, we do not lose much by this limitation. It is often, though not always, the predominating harmonic in an imperfect power supply. We therefore take a supply waveform

$$\sin \theta + h \sin (3\theta + \phi)$$

where h is the fraction of harmonic; θ is ωt ; and ϕ the phase of the harmonic, which is very important.

We need to consider the value of the function over the range from $\theta = 0$ to $\theta = \pi$, a half cycle, since we are dealing with only odd terms. The average value is quite simply given by

$$\begin{aligned} V_{AV} &= \frac{1}{\pi} \int_0^{\pi} \sin \theta + h \sin (3\theta + \phi) d\theta \\ &= \frac{-1}{\pi} \left[\cos \theta + \frac{h}{3} \cos (3\theta + \phi) \right]_0^{\pi} \\ &= -\frac{1}{\pi} \left(-2 + \frac{2h}{3} \cos \phi \right) \\ &= \frac{2}{\pi} \left(1 - \frac{h}{3} \cos \phi \right) \end{aligned}$$

The value of $\cos \phi$ may be anything from -1 to $+1$.

For the r.m.s. value we can do some rather more complicated mathematics. However, the whole point of using r.m.s. measurement is that it adds up the component powers, and the result is that

$$V_{rms} = 0.707 (1 + h^2)^{\frac{1}{2}}$$

or, if h is reasonably small,

$$V_{rms} = 0.707 (1 + h/2)$$

The factors $2/\pi$ and 0.707 are always wrapped up inside the measuring device, and so we see that a true r.m.s. meter will be reading $(1 + h/2)$ when an average-sensing meter reads something between $(1 + h/3)$ and $(1 - h/3)$. It is very convenient to look

at this for a waveform with 6% distortion. The r.m.s. meter indicates 1.03, while the other meter may read anything from 0.98 to 1.02. Thus the average-sensing meter may be giving an indication which is 5% low for a distortion of 6%. If the distortion were 12%, the error could be as much as 10%.

If we were to consider the fifth harmonic we should get a term of the form $1 - (h/5) \cos \phi$, which is not so bad, and similar forms for the higher harmonics.

It is this analysis which is used to justify the demand for testing the power supply with a meter which reads the r.m.s. voltage. It also gives us a rather easy way of checking our simple r.m.s. indicating systems. Let us put the fundamental at 50Hz. We add to this a small amount, 10 or 20%, of nearly third harmonic, 151Hz. A true r.m.s. meter will give a steady reading, but since the effect of the small frequency difference is to change ϕ continuously, an average-reading meter will show the beats quite clearly.

We have seen that with an impure sine-wave there is a real error in using the average value in place of the r.m.s. value. Is this of great significance in practice? A first thought is that a disadvantage of the average indication is that if the power factor of the load is varied, with the actual constituent voltages held constant, there will be a change in relative phase of the harmonic and thus a change in meter reading. I do not believe that this matters at all. The sort of load which has a significant linear phase angle is a motor, or some similar type of inductive device. We are talking, then, of current-operated systems, and the very effect which produces the deviation of the power factor from unity also reduces the flow of harmonic current. The literature is by no means agreed on the effect of even square waves on motors and my own limited experience suggests that a waveform containing no third harmonic but some 20% of fifth harmonic, together with higher harmonics, actually reduces the motor losses.

I am inclined to discount the valve heater problem. The designers of valve equipment rarely expected the precision of supply which we all seem to take for granted nowadays. In any event, they are working at constant power factor, and a once-for-all correction is all that would be needed if they were to become seriously concerned.

A good deal of the 50Hz power we put into equipment is transformed and smartly turned into d.c. Here we really do run into some very interesting problems with the

sinewave inverters which are the main alternative source of supply. When we wish to produce a sinewave under conditions of the highest efficiency, and once the power gets up into hundreds of watts we will not be in business unless the efficiency is high, we must adopt methods which have ideally 100% efficiency. Do not be misled by the "stay in business". Even if it is just a unit you rig up to keep the heating pump running off a car battery during the next power strike, you still need to eke out your limited number of ampere-hours. So any power conversion unit from d.c. to a.c. must operate in the switching mode.

I had thought that there were two basic alternatives at this point, but I find that this is not so. Or perhaps more correctly, the two alternatives are not what one imagines.

The most usual form of switching inverter produces a square wave output. This contains 33% third harmonic, 20% fifth harmonic, and so on. We do not wish to feed these harmonics through to the load. We therefore require two sub-systems. One must reflect the harmonic energy back into the inverter, while the other converts the harmonic energy back into d.c. and stores it for re-use. A small amount of energy may be used to set up special current and voltage conditions, the commutation process involved in making thyristors switch off. There is a rule about the filter and storage element which I think goes back to work by Belevitch on switching modulators: the reactive components of the two sub-systems must be of opposite signs. In the commonest form this means that the output filter has a series inductor and there is a large capacitor to accept the reflected energy.

The most economical way of regulating the output voltage of such an inverter is to maintain all the devices switched off for part of each half-cycle. This also has a very useful effect on the harmonics. If the current only flows for $\frac{2}{3}$ of the time, the third harmonic is zero. This, then, is the form of the basic a.c. input to the filter: $+V, 0, -V, 0, +V$ and so on. Diodes, one might call them flywheel diodes, come into operation during the 0 period, maintaining the interchange of energy between the filter and the storage element which is needed to avoid wasting harmonic energy.

Notice that this is a three level system. It can be generated by binary logic elements, but only if a branch is taken off the chain and brought back in what I call push-push, though I imagine the mathematicians have a classy name for it.

When I want to slow down my motor car, nowhere in particular, I let it free-wheel to rest. So I go forward, coast, or reverse: a three-level logic system. An aircraft landing on a runway simply cannot free-wheel, and the brake shoes, or whatever they have, cannot get rid of all that energy. The answer is reverse thrust. We could have modified our square wave for regulation purposes by producing the waveform shown in Fig. 2. I have put in the reference square wave to show how at the beginning and end of each half cycle there is a reverse push. But this, you will see, is only a two-state logic system. We always have either V or $-V$, never an intermediate zero. Of course the filter con-

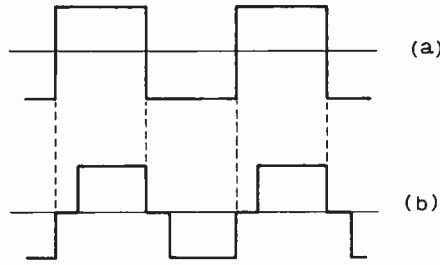


Fig. 1. The square wave (a) is modified to the three-level logic waveform (b) for the purpose of voltage regulation.

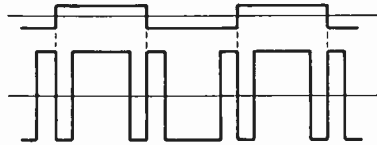


Fig. 2. Another way of regulating a square wave.

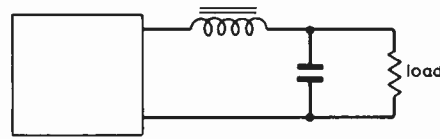


Fig. 3. The essentials of the filter.



Fig. 4. Typical current waveform in rectifier capacitance circuit.

tinues to refuse all this harmonic energy and may not be prepared to pass it back through the device which is switched on. The fly-wheel diodes are still needed.

It is clear that in modifying the waveform we have introduced some new, higher, harmonics. I think it is also clear that if the short up-down section lasts for $\frac{1}{3}$ of half a cycle it is too fast to produce third harmonic, and averages out to the zero of Fig. 1(b) which gave zero third harmonic. Do the mathematics, but do not write and tell me I am wrong. The point is that something like that happens, even if the pulses are not 30 degrees.

We can add more reversals and if we time them correctly we can get rid of successively increasing harmonics. I am not going to draw any waveforms, but one way of getting just the pattern we want is an old, and I fear a long-lost friend, the class-D amplifier. All that we have done is to restrict the signal in our class-D system to a single frequency, and state that the switching frequency is to be a multiple of the signal frequency.

The essential difference between the systems really arises from the circuit detail. It would be possible to produce a three-level logic type of waveform with the many switching operations needed to synthesize a sinewave free from all low harmonics, but it is not the economical solution. The two classes of system remain distinct from one another.

The essential job of an ideal filter is to store the unwanted energy until it can be dispatched back to the source. It can do no

other, for the ideal filter has no dissipative elements, and what it cannot send back to the source it must send on to the load. The energy storage capability must be measured in terms of storing the lowest unwanted frequency for half a cycle. It is this feature which makes the practical difference between the simple waveform of Fig. 1(b) and the very complicated one of the class-D amplifier. There is a world of difference between having to reject the third harmonic and having to reject the thirtieth.

We can represent the filter in the simple form of Fig. 3. We can have additional half sections added on before the load, and we can indulge ourselves in frequency and impedance transformations until square root signs come out of our ears. None of this will alter the fact that if most of the work of cleaning up the waveform is to be done by the filter, the inductance will be biggish, whereas if we use a lot of clever switching operations the inductance will be smallish.

Now we consider that rather common load, the rectifier and capacitor. The sort of current demand this makes is shown in Fig. 4. Before the rectifier the pulses of current are alternating. Their duration depends on the ratio of source resistance to load and the value I have chosen, which gives about 0.85 times the peak input voltage, makes the pulses last about 60 degrees. The load, in fact, is demanding third harmonic.

It is at this point that the two techniques of power generation, the square wave and filter, and the waveform synthesis type, behave quite differently. If we have a filter which is designed to stop third harmonic it will also refuse to supply it. The waveform across the load will have its top clipped off, and any connection between the r.m.s. voltage and the peak voltage will be purely coincidental.

With the synthesis type of generator this does not happen. Something much more alarming does, though. I have not got the Schade results handy, but you will remember that with this type of supply unit you must always check the rectifier peak current. Well, the rectifier peak current, some 3-5 times the load current, is also, after allowing for the transformation, the device peak current. You will need some 500W of device capability to get 100W of d.c. supplies in the load. That small inductor just will not help to make life easier.

Of course, you will never discover this.

In exploring the problem of mobile and stand-by power supply measurement I have not really expressed any conclusions. Discussions over the years have led to two simple rules, however. The first is that the higher the professional qualifications the less dogmatic the opinion on this matter tends to be. The second is that absolute certainty is expressed by people who have one, and only one, system to sell.

I suspect that there are already readers who are licking their pencils in preparation for a letter to the editor demolishing all my ideas. Remember, as you write, that once you hand one of these units over to a user you have no control at all over the mixture of loads he will connect to it. And even if you know now, what is he going to use in the future?

New Products

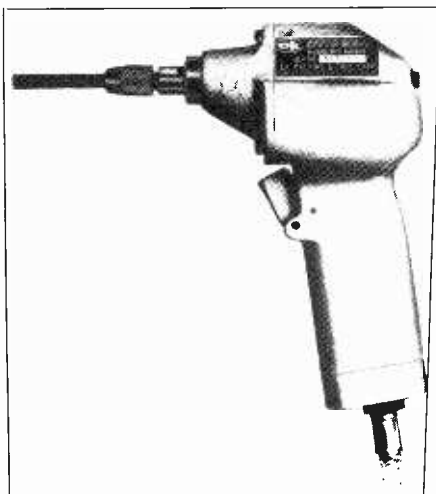
Thick-film networks

Sprague now offer standardized single in-line networks similar to the dual in-line range. All resistors are rated at $\frac{1}{8}$ watt and are available with a standard $\pm 5\%$ tolerance or up to $\pm 1\%$ on special order. Type 216C Metanet s.i.l. resistor networks for signal and data processing applications are also available especially designed for calculators, electronic clocks and gas-discharge displays. Type 206C Multi-Comp s.i.l. resistor capacitor networks are also intended for use with gas-discharge displays and for interfacing between m.o.s. logic and display drivers. Resistor ratings up to 40V are available with a typical temperature coefficient of ± 500 p.p.m./ $^{\circ}\text{C}$, while the ceramic chip capacitors are rated at 200V over the temperature range -55 to $+70^{\circ}\text{C}$. Sprague Electric (UK) Ltd, 159 High Street, Yiewsley, West Drayton, Middx.

WW306 for further details

Cermet film resistors

A new cermet film resistor from Allen-Bradley measures 0.25in long and 0.09in in diameter. The resistor, type CC, is available over the range 10 ohms to 1 megohm (E96 preferred values only) at $\pm 1\%$ selection tolerance and is rated at $\frac{1}{4}$ watt at 70°C , or $\frac{1}{8}$ watt at 125°C with a temperature coefficient of ± 100 p.p.m./



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$^{\circ}\text{C}$. The resistor is suitable for automatic insertion and can be supplied bandoliered. Allen-Bradley Electronics Ltd, Bede Industrial Estate, Jarrow, County Durham NE32 3EN.

WW304 for further details

Precision potentiometers

Beckman Instruments Ltd have introduced two single-turn precision potentiometers. Model 3371 is $1\frac{5}{16}$ in diameter; model 6671 is 2in diameter. Both models feature a new conductive plastics resistance element providing stability, fine independent linearity and immunity to adverse environmental conditions. Power ratings are 1W at 65°C for model 3371 and 8W at 70°C for model 6671. The output smoothness is 0.1% maximum for both types. In addition to model 6671's bushing-mount type, a servo-mount version is available in model 6673. Beckman Instruments Ltd, Queensgate, Glenrothes, Fife.

WW303 for further details

Continuous wire-wrapping tool

Vero Electronics are now offering a continuous wire-wrapping tool manufactured by the OK Machine & Tool Corporation. The model AW-8LS is a rugged, pistol grip, bare wire-strapping tool which is designed to make wire-wrapped continuous connections of gas-tight quality. The bare wire feeding through the tool permits interconnection of as many terminals as needed. The tool, which weighs $19\frac{1}{2}$ oz, will accommodate wire sizes a.w.g. 22 and a.w.g. 24 and comes complete with a two-metre length of flexible plastic air hose. Vero Electronics Ltd, Industrial Estate, Chandler's Ford, Eastleigh, Hants.

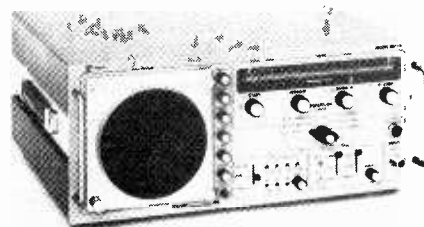
WW301 for further details

Splash-proof panel indicator lamps

A range of splash-proof panel indicator lamps manufactured by Sloan AG of Switzerland, is available exclusively from Walmore Electronics Ltd. The lamps will withstand pressures of up to $5\text{kg}/\text{cm}^2$ in



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both fresh and sea water. The lampholders, which are called the 867, can be supplied with a variety of interchangeable nickel-plated brass lens caps in either fully or partially shrouded styles with an anodized or a black finish. The four basic lens cap styles are supplied fitted with 11.6mm-diameter nylon lenses in one of six colours (blue, green, amber, red, white and clear). The body of the lampholder measures 30.1mm long (including contacts) by 13mm in diameter. The lampholders cost 92p each or 72p each for 1000+. Walmore Electronics Ltd, 11-15 Betterton Street, Drury Lane, London WC2H 9BS.

WW302 for further details

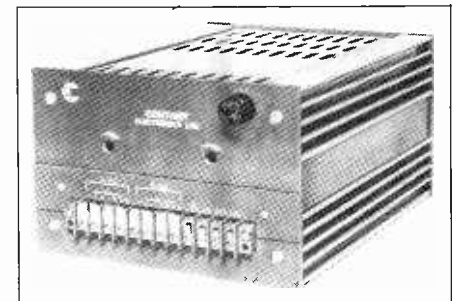
Travelling wave tube amplifiers

EMI-Varian have introduced a new range of 17in rack-mounted travelling wave tube amplifiers (t.w.t.s) suitable for laboratory and production test applications. Frequencies from 1-18GHz are covered by only three amplifiers, saving capital expense. Standard frequency ranges are 1-4GHz, 4-12GHz and 12-18GHz. Power levels of 1, 2, 5, 10 and 20 watts are available for each frequency range. Each t.w.t. has 115V and 220V power supply tapings and protective circuitry including warm-up time delay, helix overload cut-out and over-heating cut-out. The new range of t.w.t.s has a.m. and p.m. noise levels of 50dB below carrier and spurious non-harmonic noise levels are 80dB below carrier. EMI-Varian Ltd, Blyth Road, Hayes, Middlesex.

WW310 for further details

Microwave panoramic frequency analysers

The 8011 series of panoramic frequency analysers are now available from Telonic. These instruments which cover the range 0.5-30GHz enable rapid analysis of spurious products of microwave signals. Using a swept y.i.g. filter no cross modulation products or spurious signals are produced. Full tuning range of the instruments, e.g. 1-18GHz, can be covered in one sweep and controls give a choice of start/stop or centre frequency setting. The dynamic



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range of 55dB is displayed in either log or linear modes on the 5in display tube. The flat response of ± 2 dB over most of the tuning range enables accurate power measurements to be taken. Options available enable the y.i.g. filter to be used as an independent r.f. filter with input and output on the front panel of the analyser. Also available is a four-digit l.e.d. read-out of the centre frequency. The tuning ranges for the models are 1–18GHz (8011B), 1–20GHz (8011C), 3–30GHz (8011) and 0.5–5GHz (8011L). Telonic Industries UK, The Summit, 2 Castle Hill Terrace, Maidenhead, Berks.

WW309 for further details

Impulse counters

A range of impulse counters, manufactured by Hopt GmbH, are now available in the UK from Radiatron Components. Two basic types make up the ZR range, the ZR3 and ZR4; both count up to 25 impulses per second d.c. or ten impulses per second a.c., displaying three, four, five and six digits. Push-button reset facilities are available on the three- and four-digit versions and all types can be rear stud or panel mounted. The ZR6 series are six-digit instruments, panel or socket mounting, and incorporate either electrical or mechanical reset options. Counting speeds up to 50 impulses per second can be achieved with a wide range of operating voltages. Additional features include elapsed-time counting functions, multi-group mounting facilities, key reset, magnified numerals, lamp and dummy modules and a step-down ratio unit. For higher speed applications a modular predetermining electronic counter with a solid-state display can be supplied. Radiatron Components Ltd, 76 Crown Road, Twickenham, Middlesex.

WW308 for further details

Twin-output modular power supplies

Two new units, designated GPT200 and GPT500, are twin-output supplies that are complementary to Coutant's existing single-output GP range. They are both contained in standard metalwork and offer the same

principal specifications: line regulation 0.01% + 1mV for $\pm 10\%$ mains fluctuation, 0.03% + 3mV zero to full load, ripple less than 1.5mV peak-to-peak, re-entrant auto-resetting overload protection, optional overvoltage protection and an operating temperature range of 0–50°C. The 125 × 125 × 240mm GPT200 offers twin outputs of 2A at 12–15V and the GPT500 offers two 5A outputs at 12–15V in a 190 × 125 × 240mm case. Prices of the two new power supplies are £40 for the GPT200 and £58 for the GPT500. Coutant Electronics Ltd, 3 Trafford Road, Reading RG1 8JR.

WW307 for further details

Speaker matrix

Beyer Dynamic (GB) Ltd have recently introduced a four-channel synthesizer for use with loudspeakers or headphones. Up to three pairs of quadraphonic headphones may be connected to the unit, alternatively up to three stereo headphones may be used.

Headphone outputs are connected to separate three-contact jack sockets for the front and rear channels of each quadraphonic headphone. A changeover switch selects either loudspeakers or headphones, with the speakers being muted when headphones are connected.

The unit is designed to work into the following load impedances: loudspeakers, 4–16Ω; four-channel headphones, 150–300Ω and stereo headphones, 25Ω upwards. Power handling capacity is 60W/channel and the price is £20.23 plus VAT. Beyer Dynamic (GB) Ltd, 1 Clair Road, Haywards Heath, Sussex RH16 3DP.

WW 316 for further details

Illuminated push switches

From Walmore Electronics Ltd comes a range of illuminated push switches manufactured by Sloan AG of Switzerland.

They are available in on-off and momentary contact arrangements containing gold-plated silver, single-pole change-over contacts, brought out to either a printed circuit board or solder pin connections. The lamps can be either T1 base incandescent lamps, current rated from

20–60mA at 5–28V or alternatively T1 based l.e.d.s can be used. Several bezel types are available and five lens colours.

The switches are rated for a maximum current of 1A and a maximum resistive load of 100W. Voltage limitations are 110V a.c. and 30V d.c. Price in small quantities is about £3.14 each falling to £2.56 each for quantities between 100 and 999. Walmore Electronics Ltd, 11–15 Betterton Street, Drury Lane, London WC2H 9BS.

WW315 for further details

Clip contact adaptor

A perennial problem in any electronic laboratory is the connection of electronic equipment to the mains supply on a temporary basis without using a plug. A solution offered by Rendar, called "Instapower", makes such connections possible from a 13A socket to loads of up to 1kW.

Looking rather like a conventional "unbreakable" 13A plug top, the interior contains three spring clips for retaining the wire ends and 5A fusing. Access to the interior is only obtained by unplugging the unit thus rendering the unit totally safe when open.

With a case moulded in flame-retardant glass-filled nylon, the clip jaws have moulded coloured push tabs to open them for connection and are marked L, E and N. The cable entry will accept up to 0.4in dia. cables, clamping being achieved by the cover and its screw fixings. Price £2. Rendar Instruments Ltd, Victoria Road, Burgess Hill, Sussex RH15 9LE.

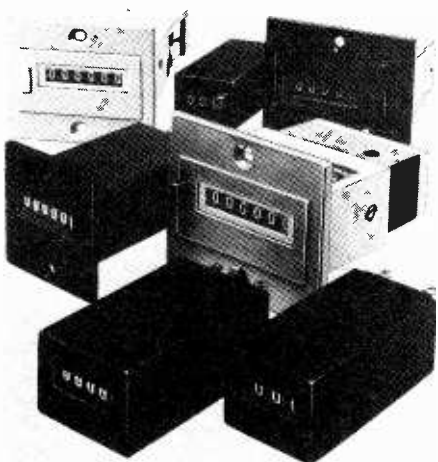
WW314 for further details

Two- and three-phase oscillator

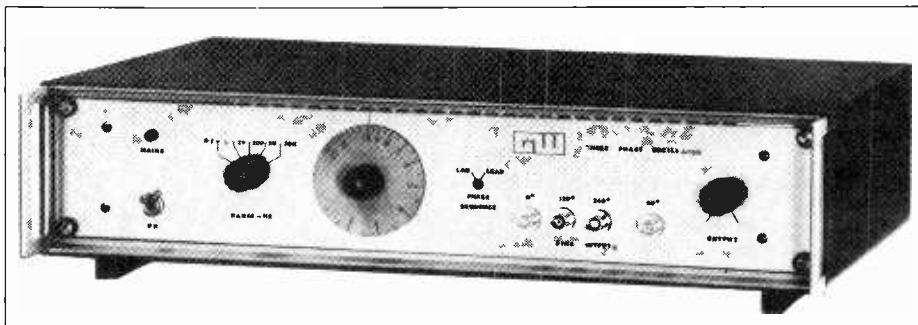
This device, produced by Gearing and Watson (Electronics) Ltd, provides the source for two- or three-phase power to be generated over the frequency range 0.2Hz–20kHz.

Designed to be used in conjunction with suitable power amplifiers, available from the same company, from 75W to several kilowatts can be produced.

A phase sequence switch is provided to reverse phase rotation and four outputs,



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0°, 90°, 120° and 240° are provided on both front and rear panels. The 90° quadrature output can be used for two-phase systems, for "Scott" connected three-phase systems and for reference purposes. The oscillator output is 1V r.m.s. with a maximum error between phases of 5° and a distortion of less than 1%. Gearing & Watson (Electronics) Ltd, Birch Close, Eastbourne, Sussex BN23 6PE.

WW312 for further details

Wide-band differential d.c. amplifiers

A new range of wide-band differential d.c. amplifiers is available from Datron Marketing Ltd. Called the 700 series, the range is based on a single common design which is offered with a wide range of options, resulting in a total of 510 different configurations within the range. The standard housing for all configurations is a 5.25in high \times 1.4in wide rack-mounting module. All models have their own internal power supply for operation on 105/220V, 50/400Hz. There are six fixed, switch-selectable or computer-controlled gains available, from 0 to 1000, with a 0.01% gain accuracy and 0.003%/°C gain stability. Common-mode voltage is given as $\pm 100V$ d.c. or $\pm 300V$ d.c. or peak a.c. to 400Hz, according to option. The common-mode rejection is 126dB with a bandwidth of 100kHz and linearity $\pm 0.005\%$ f.s. Datron Marketing Ltd, Meteor Close, Norwich Airport Industrial Estate, Norwich NR1 17B.

WW300 for further details

3½-digit multimeter

D. A. Pitman have recently released details of a 3½-digit, bi-polar, portable multimeter from DigiTec. The d.c. ranges extend from 199.9mV, full scale, to 1000V, full scale, with an accuracy of 0.1% of reading. The a.c. ranges extend from 1.999V, full scale, to 500V, full scale, with an accuracy of 0.5% of reading. Resistances from 199.9 Ω to 19.99M Ω can be measured with an accuracy of 0.5% of reading, test lead resistance being balanced out using a front panel control.

All functions are selected by push-button switches and ranges by rotary switch. An l.e.d. display is used which blanks out leaving only the decimal point illuminated when overranging occurs. Price £127. D. A. Pitman Ltd, Jessamy Road, Weybridge, Surrey.

WW311 for further details

Small power bench supplies

Intended for use where space is at a premium, the Datoda units are available from Lawtronics. The unit is 6 \times 3 \times 2½in and is available in two forms. One provides fixed output levels (Type VB1), the other has a switched output range of 5, 6, 9, 12 and 15V. Current and thermal overload protection is provided with a full load regulation of 10mV at 1A. The VB1 is priced at £11.50 and the VB2 at £16, in small quantities. Lawtronics, 139 High Street, Edenbridge, Kent TN8 5AX.

WW320 for further details

Solid State Devices

The names of suppliers of devices in this section are given in abbreviation after each entry and in full at the end of the section.

Avalanche photodiode

Epitaxial silicon photodiode type S30506 is a high-speed, light-sensitive detector with a circular photoactive area of approximately 0.5mm diameter. Internal current gain is obtained by reverse biasing the detector near to the avalanche breakdown voltage which improves sensitivity to weak light signals. A short decay time for the output current, 90%–10% in 6ns, after illumination with near infra-red radiation at modulation frequencies up to 100MHz is claimed.

WW350 for further details EMI

High-voltage rectifiers

A range of high-voltage silicon rectifier assemblies has been manufactured by Semtech. The KV-PAC PLUS series has a rating of 1 amp as a half-wave rectifier and 2 amps in a bridge circuit with a one-cycle surge current capability of 50 amps at 55°C. Peak inverse voltages are 5 to 15kV at 55°C and the reverse current at p.i.v. is 1.0 μ A at 25°C.

WW351 for further details Bourns

High-speed r.a.ms

Fairchild has added two new high-speed e.c.l. random access memories to its 10,000 series of integrated circuits. The new memories, F10410 and F10415, complement the previously announced F10405 r.a.m. The 10410 is organized as 256 \times 1 bits with typical access time of less than 20 nanoseconds. The F10415 organized as 1024 \times 1 bits has typical address times of less than 45 ns. Both memories have inputs and outputs at standard 10k e.c.l. levels and outputs drive standard 50-ohm line loads.

WW352 for further details Fairchild

Cascade amplifiers

The WJ-A5 and WJ-A7 type, 5–500MHz cascaded amplifiers are now available from Watkins-Johnson. The amplifiers exhibit a flat frequency response, temperature stability and are unconditionally stable for any source and load conditions. The WJ-A5 and WJ-A7 are guaranteed over the temperature ranges –54 to +100°C and –54 to +71°C respectively. The amplifiers are supplied in four-pin TO-8 packages and have a typical performance of 14.5dB gain with a gain flatness of

± 3 dB and a noise figure of 4dB (WJ-A5), 5dB (WJ-A7). Output power is +9dBm (A5) and +14dBm (A7), phase linearity $\pm 1.0^\circ$ from 10–500MHz, power supply range 8–20V d.c. (A5), 15–24V d.c. (A7).

Watkins-Johnson

WW354 for further details

Multi-port register file

Motorola have added the MC10143 8 \times 2 multi-port register file to their MECL 10,000 series. This device, which falls into the l.s.i. class, is capable of simultaneously reading two bits while writing another bit. The access time is typically 10ns or 5ns from clock to data out. The MC10143 employs two sets of eight latches for data storage and is fully compatible with all other members of the MECL 10,000 and MECL 3 series.

WW353 for further details Motorola

Sample and hold op-amp

A monolithic sample-and-hold op-amp has been introduced by Harris Semiconductor. Designated the HA-2425, the device has a d.t.l./t.t.l. compatible control input, 2MHz bandwidth, 50ns aperture time and a slew rate of 5V μ s. The HA02425, which is available in a 14-pin dual-in-line package, operates from 0 to 75°C and has a slew rate to droop rate ratio of 5 \times 10⁶. Internal design consists of a high-performance op-amp with its output in series with an analogue switch providing low leakage current (1nA max). The switch is then buffered with a m.o.s.f.e.t. input unity-gain amplifier.

WW355 for further details GDS

21-stage counter using c.m.o.s.

A low-voltage c.m.o.s. 21-stage counter has been introduced by RCA. The device, designated TA6152, is a timing circuit designed for use in digital equipment where low dissipation or operation in the 1.1–6V range is required. Quiescent dissipation is 0.5 μ W (typical) at $V_{DD}=1.5V$; 2.5 μ W (typical) at $V_{DD}=5V$; operating dissipation is 75 μ W (typical) at $V_{DD}=1.5V$ and $f=1MHz$. The TA6152 consists of 21 negative edge counter stages, two inverter output drivers and input inverters for use in a crystal oscillator. The device is supplied in a 16-lead dual-in-line ceramic package and samples will be available in June/July.

WW356 for further details RCA

Suppliers

EMI Electronics and Industrial Operations, Blyth Road, Hayes, Middx.

Bourns (Trimpot) Ltd, Hodford House, 17/27 High Street, Hounslow, Middx.

Fairchild Semiconductor Ltd, Kingmaker House, Station Road, Barnet, Herts.

Motorola Semiconductor Ltd, York House, Empire Way, Wembley, Middx.

Watkins-Johnson, Shirley Avenue, Windsor, Berks.

GDS Marketing Ltd, Michaelmas House, Salt Hill, Bath Road, Slough, Bucks.

RCA Ltd, Solid State Europe, Sunbury-on-Thames, Middx.

Audio Products

A selection of new equipment seen at the concurrent Sonex 74 and Hi Fi 74 exhibitions

Electrostatic headphones

Perhaps the most remarkable sight in the Sonex exhibition were the Jecklin Float headphones. Manufactured by a Swiss company and appearing by courtesy of the Lustraphone stand, these units were being displayed in an effort to gauge public reaction prior to launching the product in the UK.

The electrostatic elements were large and rectangular in shape, reminiscent of a design published by *Wireless World* in November 1971. Of doublet design, the Jecklin units radiate both towards the ear and outwards and the fit of the headband is intentionally loose.

The headband and holder for the drive units is moulded from a single piece of plastic in a silver metal sheen and lined with polyurethane foam. A power supply in a black rectangular metal box is used to polarize the electrostatic elements and also provides a connecting point for loudspeakers. Designed to be driven by



WW 360

amplifiers capable of accepting 8-Ω loads, the Jecklin float headphones have not yet been priced. Belcaire Trading, 59 Cheriton High Street, Folkestone, Kent.

WW360 for further details

Mini monitor loudspeaker

Several high-quality bookshelf speakers are now produced from various sources and in fact this seems to be the end of the market where most improvements are being made, a reflection made more apparent by the introduction of the new Rogers LS3/3A monitor loudspeaker. This measures only $7\frac{1}{4} \times 6\frac{1}{2} \times 11\frac{3}{4}$ in and weighs $9\frac{1}{2}$ lb. The speaker is necessarily inefficient but is ideal for monitoring or domestic purposes where space is lacking and high power output is not required. Two drive units are used in a sealed enclosure—a 4in bass driver with a doped Bextrene cone and a $\frac{3}{4}$ in unit. Both units are selected to meet a BBC standard.



WW 361

Cross-over frequency is 3kHz. Response extends from 60Hz to 20kHz ± 4 dB. Price is around £60. Rogers Developments (Electronics) Ltd, 4 Barmeston Road, London SE6 3BN.

WW361 for further details

New series of speakers

The Quasar loudspeakers QS1, QS2 and QS3 comprise the new range from Eagle International. These should be followed by the introduction of a deck, cartridge, amplifiers and tuners under the Quasar name. Minimization of distortion has included consideration in the reduction of Doppler distortion in conjunction with J. Moir & Associates.

The main specifications of the largest and highest performance loudspeaker (QS1) in the Quasar range are:

Dimensions $11\frac{1}{2} \times 15\frac{1}{2} \times 26$ in
Frequency response 45Hz to 20kHz

± 3 dB
Impedance 8ohm

Nominal power capacity

50W continuous
Drive units 12in, 4in, 2in and 1.5in

Harmonic distortion 100Hz 0.7%, 1kHz 0.16% both for 90dB at 1m

Doppler distortion 0.007% for 90dB at 1m, with input at 100Hz and 3kHz simultaneously

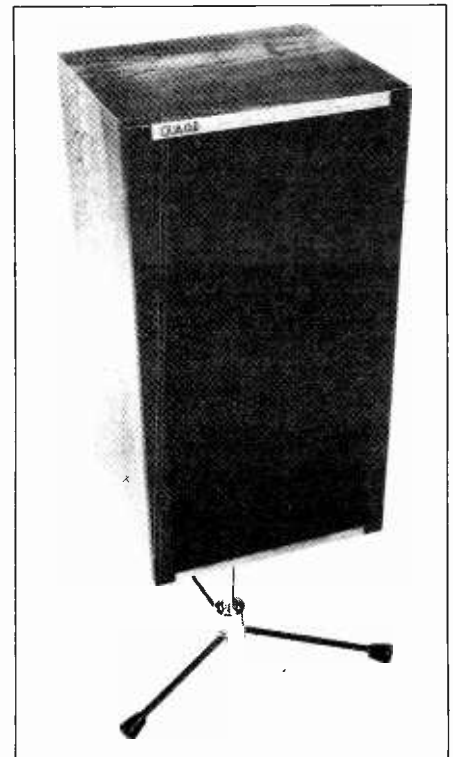
Price (inc. VAT) £92.40

Quasar Division Precision Centre, Heather Park Drive, Wembley, Middx HA0 1SU.

WW362 for further details

Denon amplifiers

Denon-brand hi-fi products, now imported from Nippon Columbia by Johnson's of Hendon, include two integrated ampli-



WW 362

fiers, a stereo tuner, pick-up arm and direct-drive turntable (see separate item). Amplifier PMA350Z has an output power of 28 watts per channel at 0.1% distortion and power bandwidth 10Hz to 40kHz (-1dB, 0.1% distortion). Type PMA500 delivers 40 watts per channel at 0.1% distortion and power bandwidth of 5Hz to 75kHz (-3dB). Intermodulation distortion is quoted as 0.06% at -3dB of rated output.

PMA350Z preamplifier section has a sensitivity of 2mV (pickup inputs) and a maximum input level of 100mV at 1kHz. Signal-to-noise ratio is 62dB (pick-up inputs) with input short-circuited. Harmonic distortion is 0.08% at rated output. Filters at 9kHz and 40Hz have slopes of 12dB per octave. PMA-500 preamplifier has an harmonic distortion of 0.05% rated output and a 65dB s/n ratio (pickup inputs). Both have muting, tone, dubbing, tape monitor and loudness controls. In addition, the 500 has a microphone input mixing facility. RIAA equalization accuracy is ± 0.5 dB. Johnson's of Hendon Ltd, Radlett Road, Colney Street, St Albans, Herts.

WW363 for further details

SQ/RM decoder-amplifier

The new Trio KSQ-400 is a quadrasonic decoder with rear-channel amplifier and costing about £70. Phase shift circuitry, having a phase-frequency response $90 \pm 10^\circ$ from 25Hz to 18kHz, is switchable to provide SQ and RM decoding. Amplifier gives 15 watts (1kHz) in both channels for 4-ohm loads with 0.6% harmonic distortion at rated output and 0.2% at -3dB. B. H. Morris & Co, Trio House, The Hyde, London NW9 6JP.

WW364 for further details

British electronic turntable

As well as a restyled version of the RD11 turntable, Ariston Audio Ltd will be marketing a two-speed electronically-governed turntable with variable speed control. With wow and flutter of 0.04% weighted r.m.s., it will cost around £136. The RD11 itself has a redesigned main bearing and the makers claim an unmeasurable rumble and hum level. The 24-pole synchronous motor drives the 9½lb table through a non-stretch belt. Ariston Audio Ltd, P.O. Box 13, Irvine, Ayrshire KA12 8JL.

WW365 for further details

ERA amplifier

Models 5770 and 5750 are new French stereo amplifiers with output powers of 40 and 24 watts per channel respectively. A power bandwidth of 30Hz to 30kHz is quoted for the ST50 together with harmonic distortion at maximum output of 0.5%. (Full details of the 5770 were not available at the time of going to press.) A stereo tuner will be marketed shortly. Current products

mainly centre around a 48-pole synchronous motor fitted to three turntables each with different pickup arms, but all with a quoted 0.04% wow and flutter (pk-pk) and a rumble level of -73dB DIN weighted. De Banks Electronics Ltd, Market House, High Street, Tring, Herts.

WW366 for further details

Professional cassette recorder

Although Jonathan Fallowfield did not have a stand at either Sonex or the High Fidelity Exhibition at Heathrow, two of their latest imports were in evidence on several stands at Sonex. These were the new and remarkable cassette machines from the Nakamichi stable. The model 1000 is intended for professional use at the very professional price of £695 inc. VAT. It would seem that an effort has been made, in designing this recorder, to include just about every feature of advanced design ever seen on other recorders, plus one or two new ones.

The deck mechanics are solenoid operated and contain memory rewind facilities and dual capstan drive. Three magnetic heads are provided, thus optimizing the requirements of record and replay gap. The replay head is wrapped around one of the pinch wheels and fits in the same cassette entry. It is therefore extremely small and requires precise alignment and high-quality cassettes to ensure reliable performance. The electronics incorporate both Dolby B and the Philips d.n.l. together with a record amplifier limiter.

Finally, as if that were not enough, there is a unique arrangement for checking the azimuth of the record head. Using a blank cassette, a test tone is recorded from an internal oscillator and the replayed signal sampled by a phase sensitive switch. Adjustment of the head is by a knurled knob and is continued until two indicator lamps flicker alternately. Jonathan Fallowfield Ltd, Strathcona Road, North Wembley London HA9 8QL.

WW367 for further details

Capacitor cartridge

As well as showing a new CD-4 demodulator and four-channel amplifier, Toshiba announced the UK marketing of the electret capacitor cartridge, type C401S. By relying on the variation of capacitance between cantilever and two fixed electrodes, attachment of electrodes or magnets to the cantilever is avoided. Relying merely on such a small capacitor size and variation would result in poor signal-to-noise ratio so Toshiba have used an electret electrode with a charge equivalent to several hundred volts, together with built-in i.c. preamplifiers. Power for the i.c. is provided by an additional lead in the screened pickup wire. The cartridge provides 40mV (at 5cm/s and 1kHz) which is then equalized by a special amplifier, SZ-200, giving an output level of 200mV and a distortion of 0.1% at ten times rated

output. Amplitude response extends to 35kHz and is virtually flat over the whole audible range, and Toshiba claim an excellent phase response that is especially appropriate for playing matrixed records. Price of cartridge and equalizer is £70.

A version of the cartridge that extends amplitude response to 50kHz is fitted in the SR-510 direct-drive turntable and pickup arm. It includes the Toshiba "extend" stylus. Wow and flutter of this deck is given as 0.03% with a signal-to-noise ratio of 60dB. Toshiba (UK) Ltd, Great South West Rd, Feltham, Middx.

WW368 for further details

Turntable with servo control

An interesting method of detecting platter speed is employed by the Denon DP 3700F direct drive turntable. The inner rim of the platter has a magnetic coating on which 1,000 pulses are recorded at accurately determined intervals. As the turntable rotates, the pulse signals are detected by a magnetic head. Comparison of the signal voltage thus generated with a reference voltage indicates any speed error. Any difference is instantly detected to produce a differential voltage which regulates the motor servo control. Wow and flutter is less than 0.03% (weighted r.m.s.) and signal-to-noise ratio is better than 60dB. Final speed is attained in half a revolution. Johnsons of Hendon Ltd, Radlett Road, Colney Street, St Albans, Herts AL2 2EA.

WW369 for further details

Amplifier with overload indicator

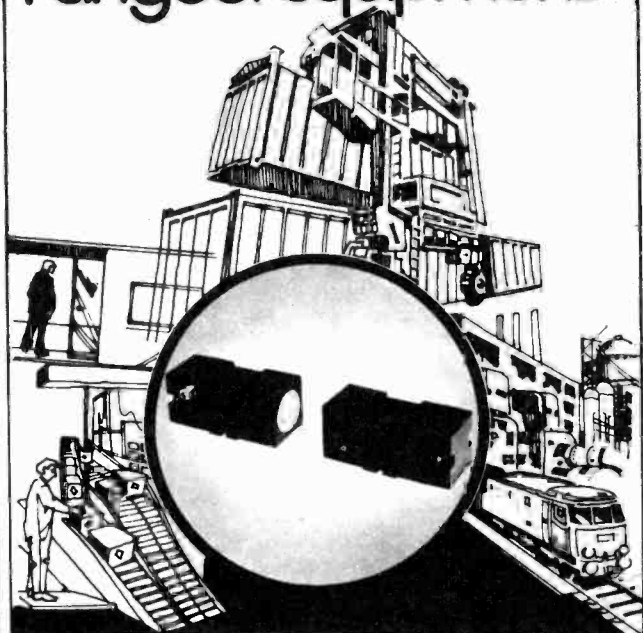
An amplifier with two unusual facilities was introduced at the show by Cambridge Audio. The P60 provides separate pre-amplifier volume and power amplifier level controls to cope with varying levels of input so that the capabilities of the power amplifier can be used to the full. Coupled with this is an i.e.d. overload indicator which doubles as a power on-off light. The i.e.d. flashes whenever either of the two power amplifiers is overloaded.

Main specifications for the P60 are:

Power output	30W continuous into 8Ω at 1kHz
Amplitude response	25Hz to 25kHz ± 0.5 dB
Harmonic distortion	less than 0.5% at 1kHz
Intermod. distortion	less than 0.1% at any level (f_1 60Hz, f_2 7kHz, amplitude ratio 4:1)
Signal-to-noise ratios	better than 60dB pickup, 70dB tuner (unaffected by volume setting)
Input overload capacity	50dB
Dimensions	16½ × 9½ × 2in
Price (inc. VAT)	£130.90.
Cambridge Audio Ltd, The River Mill, St Ives, Huntingdon PE17 4EP.	
WW370 for further details	

Industrial Action with the JAMES SCOTT

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microwave
range of equipments



The James Scott range of Microwave equipment now offers industrial users a greater choice of alternative systems in robust, industrial, cast aluminium housings, for a wide variety of applications.

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If any of the above are your problems or if you have a particular problem for which we could adapt a system please write or telephone for further information and technical literature to.

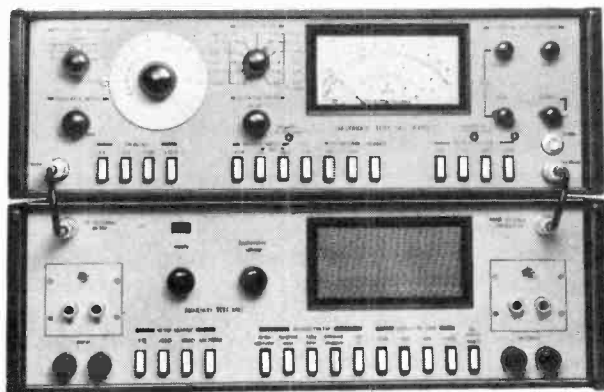


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WW-096 FOR FURTHER DETAILS

Audio Test Set



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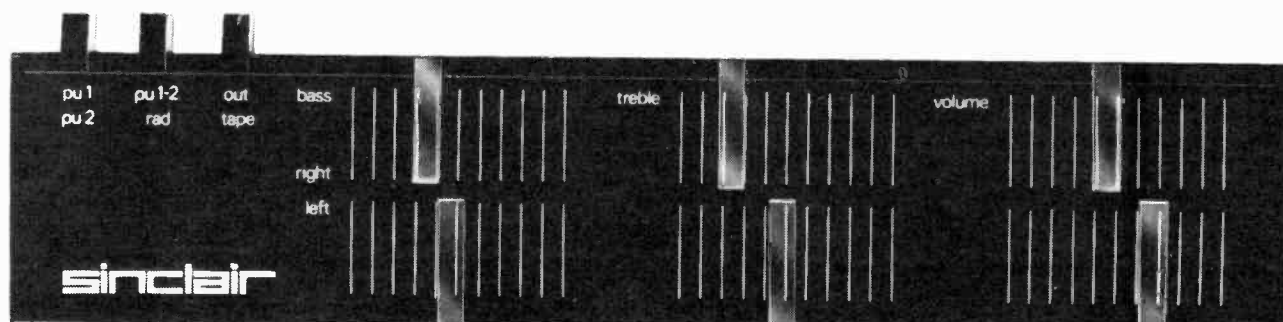
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Cippenham Slough Buckinghamshire SL1 6BB
Telephone: Burnham (062 86) 62511 Telex: 847297

FERROGRAPH

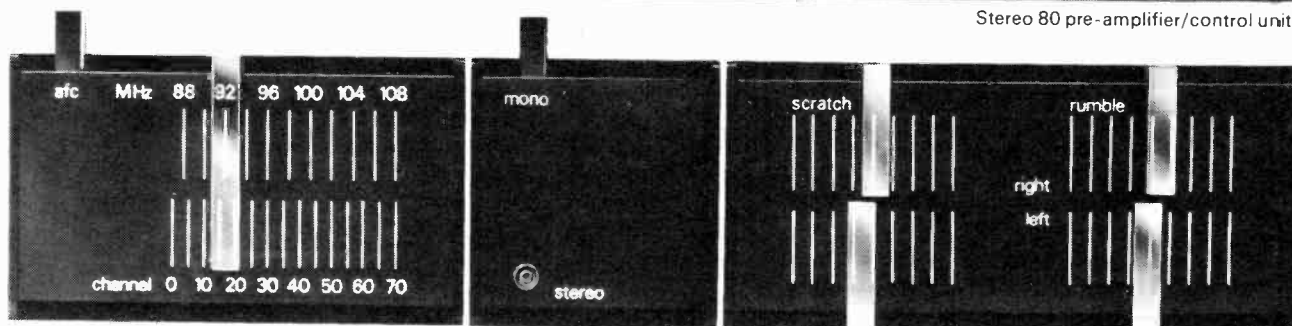
A member of the Wilmot Breeden group
WW-097 FOR FURTHER DETAILS

Sinclair Project 80

exciting



Stereo 80 pre-amplifier/control unit



Project 80 tuner

Stereo decoder

Project 80 Active Filter Unit (AFU)

only $\frac{3}{4}$ " deep x 2" high

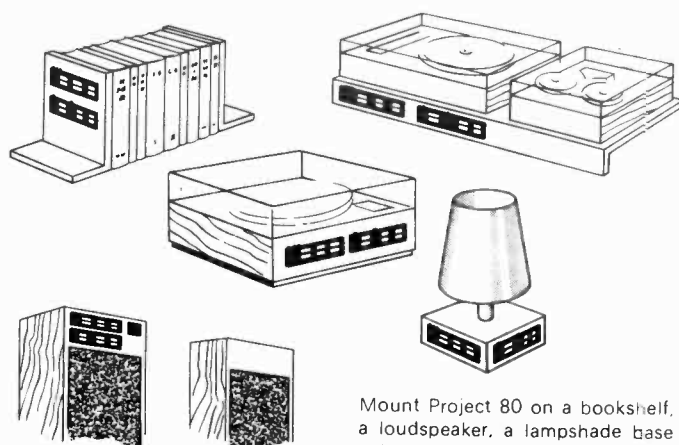
Living with hi-fi takes on new meaning with Sinclair Project 80. The electronics of these revolutionary new modules are all contained within elegantly designed matching cases no more than three-quarters of an inch deep. They are designed for mounting on any appropriate flat surface by means of 6BA bolts extending from the rear of each module and which pass through suitably drilled holes. Connections are taken away out of sight in a similar manner. The possibilities opened up by Project 80 are endless – superb hi-fi systems can be installed in ways hitherto only dreamed about and never before made practical. No more cutting out and shaping to put modules in position. A few holes drilled with the aid of templates supplied and the job is done. Now you need never again be faced with problems of keeping the hi-fi from clashing with carefully thought-out furnishing schemes. (That will surely please wives!) Slider controls have been introduced in place of knobs and all modules in the range incorporate new up-dated circuitry with emphasis on performance standards and built-in protection against overload and shorting. The aim was to re-think modular construction completely – to make it infinitely more versatile, even simpler and more reliable – the result – Project 80 – another triumph for Sinclair, and the most exciting construction modules ever.

the slimmest, most elegant hi-fi modules ever made

Typical Project 80 applications

System	The Units to use	Units cost
Simple battery record player	Z.40	£5 45 +£1.04 V.A.T.
Mains powered record player	Z.40, PZ.5	£10 43 +£1.04 V.A.T.
30W. RMS continuous sine wave stereo amp.	2 × Z.40s. Stereo 80; PZ.6	£30 83 +£3.08 V.A.T.
50W (8 Ω) RMS continuous sine wave de luxe stereo amp.	2 × Z.60s. Stereo 80; PZ.8	£33 83 +£3.38 V.A.T.
Indoor P.A.	Z.60, PZ.8	£14 93 +£1.49 V.A.T.

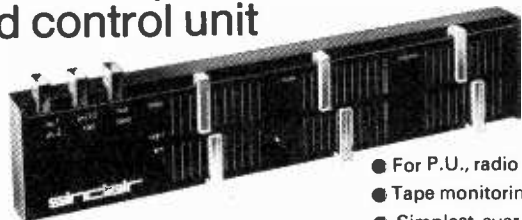
Project 80 FM tuner, decoder, and A.F.U. may be added as required



Mount Project 80 on a bookshelf, a loudspeaker, a lampshade base, a false wall with two Q.16 loudspeakers... almost anywhere.

new thinking in modular hi-fi

Stereo 80 pre-amplifier and control unit



- For P.U., radio and tape
- Tape monitoring switch
- Simplest ever fixing

Each channel has its own separate tone and volume controls operated by sliders, enabling ideal environmental matching to be obtained. A virtual earth input stage forms part of the up-dated circuitry that ensures the finest possible quality from all signal sources. Generous overload margins are allowed on all inputs. Clear instructions with template are supplied.

TECHNICAL SPECIFICATIONS

Size—260 × 50 × 20mm (10½ × 2 × ¾ins)
 Finish—Black with white indicators and transparent sliders
 Inputs—Magnetic pick-up 3mV RIAA corrected; Ceramic pick-up 300mV
 Radio 300mV; Tape 30mV
 Signal/noise ratio—60dB
 Frequency range—20Hz to 15KHz ± 1dB; 10Hz to 25KHz ± 3dB
 Power requirements—20 to 35 volts
 Outputs—100mV + AB monitoring for tape
 Controls—Press button for tape, radio and P.U. Sliders for volume, bass (+, -12dB to -14dB at 100Hz) treble (+, -11dB to -12dB at 10KHz)

R.R.P. £11.95 +£1.19 V.A.T.

Project 80 FM tuner and stereo decoder



- On the decoder, solid state stereo indicating beacon.

Making the Project 80 F.M. tuner and decoder available separately gives a wider choice of systems and saves money where stereo reception may not be required. The tuner is a triumph of electronic design and assures excellent performance. The decoder gives a 40dB channel separation with 150mV output per channel. Both units may be used with other than Project 80 systems.

TECHNICAL SPECIFICATIONS OF TUNER

Size—85 × 50 × 20mm (3½ × 2 × ¾ins)
 Tuning range—87.5 to 108 MHz
 Detector—I.C. balanced coincidence for good A.M. rejection
 One I.C. equal to 26 transistors
 Distortion—0.2% at 1 KHz for 30% modulation
 4 pole ceramic filter in I.F. section
 Aerial impedance—75 Ω or 240-300 Ω
 Sensitivity—4 microvolts for 30dB quieting
 Output—300 mV for 30% modulation
 Power requirements—23 to 33 volts

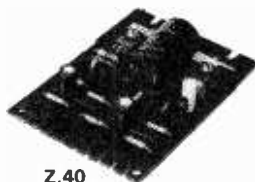
DECODER

Size—47 × 50 × 20mm (1⅞ × 2 × ¾ins)
 One 19 transistor I.C.

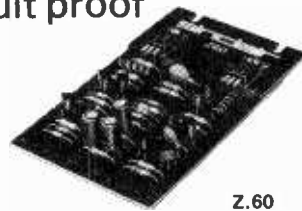
R.R.P. £11.95 +£1.19 V.A.T.

R.R.P. £7.45 +0.74 V.A.T.

Z.40 & Z.60 power amplifiers totally short-circuit proof



Z.40



Z.60

Intended for use in Project 80 installations, these modules readily adapt to an even wider range of applications. Both incorporate built-in protection against short circuiting and risk of damage from mis-use is greatly reduced.

Z.40 TECHNICAL SPECIFICATIONS

Size—55 × 80 × 20mm (2¼ × 3¼ × ¾ins) 9 transistors
 Input sensitivity—100mV
 Output—15 watts RMS continuous into 8 Ω (35v)
 Frequency response—10Hz—100KHz ± 1dB
 Signal/noise ratio—64dB
 Distortion—at 10 watts into 8 Ω less than 0.1%
 Power requirements—12 to 35 volts

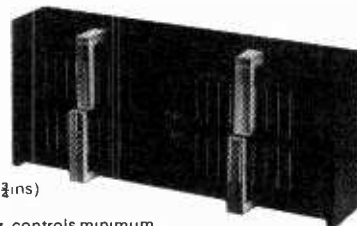
Z.60 TECHNICAL SPECIFICATIONS

Size—55 × 98 × 15mm (2¼ × 3¾ × ¾ins) 12 transistors
 Input sensitivity—100-250mV
 Output—25 watts RMS continuous into 8 Ω (45V).
 Distortion—typically 0.03%
 Frequency response—10Hz to more than 200KHz ± 1dB
 Signal/noise ratio—better than 70dB
 Built-in protection against transient overload and short circuiting
 Load impedance—4 Ω min; max. safe on open circuit

Z.40 R.R.P. £5.45 + 0.54 V.A.T.; Z.60 R.R.P. £6.95 + 0.69p V.A.T.

Project 80 active filter unit

Makes a highly desirable part of any worthwhile system where inputs may be from record, radio or tape. As with Stereo 80, separate controls applied to each channel make it easier to obtain ideal stereo balance.



TECHNICAL SPECIFICATIONS

Size—108 × 50 × 20mm (4¼ × 2 × ¾ins)
 Voltage gain—minus 0.2dB
 Frequency response—36Hz to 22KHz, controls minimum
 Distortion—at 1 KHz—0.03% using 30V supply
 HF cut off (scratch)—22KHz to 5.5KHz, 12dB/oct. slope
 L.F. cut off (rumble)—28dB at 20Hz, 9dB/oct. slope

- For scratch and rumble control
- Transistorised active circuitry

R.R.P. £6.95 +0.69 V.A.T.

Power supply units

PZ.8

Stabilised. Re-entrant current limiting makes damage from overload or even direct shorting impossible. Normal working voltage (adjustable) 45V.



R.R.P. £7.98 + 0.79p V.A.T. Without mains transformer

PZ.5 30V unstabilised R.R.P. £4.98 + 0.49p V.A.T.

PZ.6 35V, stabilised R.R.P. £7.98 + 0.79p V.A.T.

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HART ELECTRONICS

AUDIO KITS

F.M. TUNER

This latest addition to our range will be in production late March '74. It is designed to offer the best possible performance allied to the ease of operation given by push button varicap tuning. We have taken great care to look after the constructors' point of view and there are no coils to wind, no RF circuits to wire and no alignment is required, in fact the whole unit can be easily completed and working in an evening as there are only 3 transistors, one IC and two ready built and aligned modules comprising the active components. We have abandoned the concept of having a tuner as large as the amplifier and this new unit has a frontal size of only 1 1/2 in. x 4 in. It can be mounted on the side of our Bailey amplifier metalwork thus turning it into a tuner/amplifier whilst only increasing its width by 1 1/2 in. Cost of tuner chassis (no case) is £22 for mono, £25-45 for stereo. Metal case £2-55. An extended wooden case to fit tuner and amplifier will be offered shortly.

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The best engineered kit available of the combined best of three pre-amp designs. This is the kit with no wiring to the controls, switches or inputs. A complete and sophisticated 5 input signal processing stage for any power amplifier requiring up to 1 1/2v input for only £29-50. Front end only £10-44. Tone control only £11-41.

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Our best selling power amplifier, you can't better its performance or the quality of the kit and at only £9-88 per channel, it's amazing value for money.

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These are the things that convert your hobby into cost saving professional equipment. Remember if the finished job looks decent the wife won't worry about the money you spend. Complete metalwork for Stereo Bailey 30's, preamp and power supply £5-48. Metal cover £1-00. Wooden case £4-85. Front plate £1-37.

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Our printed circuits and components offer the easy way to convert any suitable quality deck into a very high quality Stereo Tape unit. Input and output levels suit Bailey pre amp. Total cost varies but around £35 is all you need. We can offer tape heads as well if you want new ones.

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19.	CA3080C.	RCA (stereo decoder)	£4-50	
30.	2N697.	Texas and Hughes	70p	
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30.	BC182L		11p	
20.	OC81D.	Mullard	10p	
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30.	2N1613.	Texas	13p	
100.	BC212L.	Texas	10p	
400.	2N377.	Sylvania	15p	
10.	2N696.	Texas	15p	
60.	VS248.	Varo (200piv 2A Bridge)	50p	
30.	2N2908.	Motorola	35p	
25.	MJ480.	Motorola	80p	
30.	2N388.	Sesco	25p	
Resistors				
25.	CLR 1106/115.	100Ω. WW Preset Colvern	30p	
800.	1W W/W 22Ω.	Plessey	80p	
28.	Trimpot 1k.	MEC	80p	
Capacitors				
50.	C437AR/A4000.	4000/2.5.	Mullard	20p
400.	C428AR/F80.	80/25.	Mullard	22p
60.	2500µf 70v.	CCL	80p	
25.	C431 BR H1600.	1600/64.	Mullard	77p
30.	2500µf 25v.	Plessey	35p	
40.	C432 FR/H2000.	2000/64.	Mullard	£1-00
Miscellaneous				
90.	50DN 0400	A100 Heatsink.	Marston	80p
100.	10DN 0400	C1 SX Heatsink.	Black anod.	48p
1.	CRT DPM9-11.	Mullard	£15-00	
1.	CRT 3AZP 31.	EI-el	£15-00	
1.	CRT 10M44A.		£5-00	
1.	CRT 10F4A.	RCA	£3-00	
2.	CRT SE14/70.	EMI	£2-00	
2.	Monitor.	BD851.	Marconi	£5-00
20.	T 502.	Eagle 2 in.	Vernier Dial	£1-12
300.	79/840.	3way Phono soc.	Carr	65p
350.	79/844.	5way Phono soc.	Carr	80p
100.	SW 1987.	3 x 3PCO.	Push button sw.	15p
200.	4P 3W.	Rotary switch		18p
200.	6P 5W.	Rotary switch		30p
1.	PE Gemini	FM Turner.	AMC	£12-00
2.	FM Turner	Front end.	Guest	£4-00
1.	Deram	loudspeaker.	Decca	£12-00

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Penylan Mill, Oswestry, Salop

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FETS: 2N3819 19p 2N3823E 20p 4416E 25p BC182/3/4 10p
BC212/3/4 11p BCY70 13p BD131/2 35p ea. BFY5 23 15p TIS43 25p
2N2926 0v 7p 2N3053 15p 2N3702/3/4/5/6/7/8/9/10/11 all 9p ea
2N3904/6 14p HEATSINKS 5f/705 18p/T018 5p. T03: 4TL 29p TPJ 14p
CAPACITORS 25V 100uf 5p. DISCS 4p. PRESETS 5p. CARBON-
POTS 1P. Switch 1P. Dual 5.5P. ULTRASONIC TRANSDUCERS £2 ea
FLUORESCENT LIGHTS 8W. 13VOLT £2.59

Trampus electronics P.O. BOX 29, BRACKNELL, BERKS.
ADD 10% VAT TO PRICES. £2P 10P CWO

WW-099 FOR FURTHER DETAILS

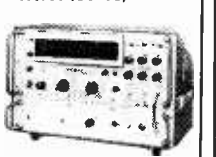


MARCONI TF 867 SIGNAL GENERATOR
Range: 15KHz to 30MHz. Output 0.4µV to 4V at 13 or 75 ohms. Impedance with termination (supplied). Built in crystal check facility with handbook. £138

TF.114H/S SIGNAL GENERATOR. Frequency range: 10 KHz-72 MHz. Stability: 0.002%. High discrimination, plus crystal calibrator. Good r.f. waveform at all frequencies. Protected thermocouple level monitor. Full spec. on request. £220.

TF.2343 QUANTIZATION DISTORTION TESTER. Checks a.f. to a.f. distortion of p.c.m. systems. Utilises system power supply. Output level: Variable in 1 dB steps, from -50 to +2 dBm. Accuracy: 0.2 dB at +2 dBm. ±0.5 dB incremental. Quantization distortion: 0 to -40 dB in 0.5 dB steps. Meter indication: True r.m.s. Input impedance: 600Ω ± 10% balanced. £245.

RACAL UNIVERSAL COUNTER/TIMER SA550 (CT488)



8 digit in-line read-out. Facilities include: direct frequency measurement up to 100 MHz; pulse, period, ratio, time interval and totalling measurements. Input sensitivity variable from 300mV to 9V, three independent inputs, self-check etc. Full spec. on request. £145.

AVO MULTIMETER Model 7X (Pancimatic). £19-80.

AVO MULTIMETER Model 8X (Pancimatic). £32. Cases, prods and leads extra.

TF. 1066A F.M./A.M. SIGNAL GENERATOR. Freq. range: 10MHz to 470MHz. Carrier generated directly at output frequency. Freq. stability: 0.0025%. Stepped as well as continuously variable. Internal modulation at 1 and 5KHz. £325.

CT. 373 TEST SET. Oscillator: 17c/s-170k/s ± 1% ± 1c/s at ambient temp. 0°C-45°C. Distortion Meter: Freq. range: 20c/s to 20k/s, distortion range: 10%, 30%, 100% f.s.d. 0.5% readable. Signal input: approx. 500mV to 130V basic range. 250mV to 1300V extreme limits. Full spec. on request. £98.

AVO MODEL 3 VALVE TESTER. Enables comprehensive characteristics to be plotted or measures valves on a simple good/bad basis. £65.

AVO CT 160 VALVE TESTER. As above but in portable valve form. £65. Viewing by appointment only.

Ireland V.A.T. add 10%. Prices include P. & P. Charge extra for overseas orders. Please phone 01-540 9534

T.F.995A/1 F.M./A.M. SIGNAL GENERATOR. Freq. range: 2 MHz to 216 MHz. Built-in crystal calibrator. Output range: 100 mV to 0.1µV. F.M. or A.M. also simultaneous f.m. and a.m. £235.

T.F.801D/1/S A.M. SIGNAL GENERATOR. Freq. range: 10 MHz to 485 MHz. Built-in crystal calibrator. Internal and external sine a.m. External pulse modulation. Calibration Accuracy: Using crystal calibrator, within ±0.2% over entire frequency range. R.F. output level 0.1µV to 1V source e.m.f. £249.

OA.1094A/3 H.F. SPECTRUM ANALYSER with L.F. extension unit type TM6448. Freq. range: 100 Hz to 30 MHz. Measures relative amplitudes up to 60 dB. Spectrum width 0.30 KHz. Sweep duration: 0.1, 0.3, 1, 3, 10, 30 sec. and manual. Full spec. on request. £895.

T.F.801B/3/S A.M. SIGNAL GENERATOR. Freq. range: 12 MHz to 485 MHz in five bands. Built-in crystal calibrator. Full spec. on request. £220.

TF.937 F.M./A.M. SIGNAL GENERATOR. Freq. range 85 KHz to 30 MHz. The carrier freq. can be standardized against a built-in dual freq. crystal calibrator, which is complete with miniature loudspeaker as an aural beat detector. £87.

OA.1094A/3 H.F. SPECTRUM ANALYSER. Freq. range: 3 MHz to 30 MHz in nine steps; spectrum width 0 to 30 KHz. Sweep duration: 0.1, 0.3, 1, 3, 10, 30, 100, 300secs. and manual. Full spec. on request. £445.

T.111 ROBAND TRANSISTORIZED SUPPLY. Mains input 110V or 230V, output 0-50V at 5 Amperes cont. variable, overload cut-out. £49.

JOHN CRICHTON Electronic Equipment
558 Kingston Road, Raynes Park, London, S.W.20

WW-100 FOR FURTHER DETAILS



AUDIOTRONIC Model ATM1

Top value 1,000 opv pocket multi-meter. Ranges: 0/10/50/250/1,000 volt AC and DC. DC current 0-1mA/100mA. Resistance: 0/150k ohms. Decibels: -10 to +22dB. Size 90 x 60 x 28mm. Complete with test leads.



OUR PRICE £2.95 P&P 15p

AUDIOTRONIC Model ATM5

Jewel movement, attractively moulded case with edgewise ohms adjustment. Ranges: 0-3/15/150/300/1200V AC. (2500 opv). 0-6/30/300/600V DC. (5000 opv). 0-300uA/0-300mA DC. Resistance: x10/8, x100, -10 to +16dB. Supplied with battery test leads and data booklet. Size: 121 x 73 x 29mm.



OUR PRICE £3.50 P&P 15p

MODEL C1092 MULTIMETER

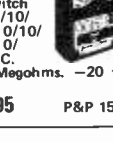
Features 5,000 opv jewel movement and a good selection of range functions. Edgewise ohms adjustment. Ranges: -0-3/15/150/300/1200V AC. (2,500 opv). 0-6/30/300/600 V DC. (5,000 opv). DC current: 0-300uA/300mA. Resistances: R x 10, R x 1,000. -10 to +16dB. Complete with battery, test leads and data booklet. Size: 120 x 73 x 28mm.



OUR PRICE £3.75 P&P 35p

MODEL TH12

20,000 opv. Overload protection. Side switch selector. 0/0.25/2.5/10/50/150/1000V DC. 0/10/50/250/1000V AC. 0/50uA/250mA DC. 0/3k/30k/300k/3 Megohms. -20 to +50dB.



OUR PRICE £5.95 P&P 15p

HIOKI Model 720X VOM

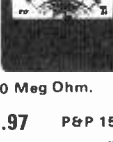
A versatile, accurate measuring instrument. 20,000 opv. 0/5/25/100/500/1000V DC. 0/10/50/250/1000V AC. 0-50uA/250mA. 0-20k/2 Megohms.



OUR PRICE £5.97 P&P 20p

MODEL PL436

20,000 opv DC. 8000 opv AC. Mirror scale. Ranges: 0-6/12/30/120/600V DC. 3/30/120/600V DC. 50/800uA/60/600mA. 10/100k/1 Meg/10 Meg Ohm. -20 to +46 dB.



OUR PRICE £6.97 P&P 15p.

U4323 MULTIMETER

20,000 opv. Simple unit with audio/1F oscillator. Suitable for general receiver tuning. Ranges: 0.5/2.5/10/50/250/500/1000V DC. 2.5/10/15/250/500/1000V AC. 0.05/0.5/5/50/500mA DC. Resistance: 5/50/500 ohms/5/10/100k ohms/1Meg. Battery operated. Size: 160 x 97 x 40mm. Supplied in carrying case complete with test leads.



OUR PRICE £7.00 P&P 20p

MODEL HIOKI 730X

30,000 opv. Overload protection. Ranges: 6/30/60/300/600/1200V DC. 12/60/120/600/1200V AC. 60uA/30mA/300mA. 2K/200K/2 Meg Ohm. -10 to +63 dB.



OUR PRICE £7.50 P&P 15p.

MODEL TE300

30,000 opv. Mirror scale. Overload protection. 0/0.6/3/15/60/300/1200V DC. 0/6/30/120/600/1200V AC. 0/30uA/6mA/60mA/300mA/600mA. 0/8k/80k/800k/8 Meg ohms. -20 to +63dB.



OUR PRICE £7.50 P&P 15p

U4324 MULTIMETER

High sensitivity, overload protected. 20,000 opv. Ranges: 0.6/1.2/3/12/30/60/120/600/1200V DC. 3/15/60/150/300/600/900V AC. Current: 0.06/0.5/6/60/600mA/3A DC. 0.3/3/30/300mA/3A AC. Resistance: 25/500 ohms/0.5/5/50/500k ohms/5 Mohms. Decibels: -10 to +12dB. Size 167 x 98 x 63mm. Supplied complete with test leads, spare diode and instructions.



OUR PRICE £8.00 P&P 20p

TMK MODEL TW50K

46 ranges, mirror scale. 50kV/50 DC 50kV/5 AC. DC Volts: 0.125/0.25/1.25/2.5/5/10/25/50/125/250/500/1000. AC Volts: 1.5/3/15/10/25/50/125/250/500. 100V DC current: 25/50uA/2.5/5/25/50/250/500mA/5/10A. Resistance: 10k/100k/1 Meg/10 Meg ohms. -20 to +81.5dB.



OUR PRICE £8.50 P&P 17p

U435 MULTIMETER

20,000 opv. Overload protected. Ranges: 75mV/2.5/10/25/100/250/1000V DC. 2.5/10/25/100/250/500/1000V AC. Current: 50uA/1/5/25/100mA/0.5/2.5A DC. Resistance: 0.3/3/15/300k ohms. Size: 205 x 110 x 84mm. Supplied complete with leads, crocodile clips and steel carrying case.



OUR PRICE £8.75 P&P 20p

U91 Clamp VOLT AMMETER

For measuring AC voltage and current without breaking circuit. Ranges: 300/600V AC. Current: 10/25/100/250/500A. Accuracy 4%. Size 283 x 94 x 36mm. Complete with carrying case, leads and fuses.



OUR PRICE £10.50 P&P 20p

U4312 MULTIMETER

extremely sturdy instrument for general electrical use. 667 opv. 0/0.3/1.5/7.5/30/60/150/300/600/900V DC & 75mV. 0/0.3/1.5/7.5/30/60/150/300/600/900V AC. 0/300uA/1.5/6/15/150/60/600mA/1/1.5/6A DC. 0/1.5/6/15/60/150/600mA/1.5/6A AC. 0/200/3k/30k ohms/3k/30k/300k/3M AC. 1.5%. Knife edge pointer, mirror scale. Complete with sturdy metal carrying case, leads and instructions.



OUR PRICE £9.75 P&P 35p

MODEL 500

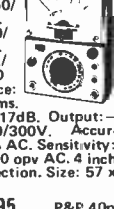
30,000 opv with overload protection. Mirror scale. Ranges: 0/0.5/2.5/10/25/100/250/500/1000V DC. 0/2.5/10/25/100/250/500/1000V AC. 0/50uA/5/50/500mA. 12A DC. 0/60k/6 meg/60 megohms.



OUR PRICE £13.95 Carr. paid

HIOKI 750X VOLT-OHM-MILLIAMETER

43 ranges: 0-0.3/0.6/1.5/3/6/12/30/60/150/300/600/1200V DC. 0-3/6/15/30/60/120/300/600/1200V AC. Current: 0-30/60uA/1.5/3/15/30/150/300mA/6/12A. Resistance: 0-3/300k/3/30Mohms. Decibels: -10 to +17dB. Output: -50,000 opv DC, 5,000 opv AC. 4 inch meter. Built in protection. Size: 57 x 102 x 153mm.



OUR PRICE £11.95 P&P 40p

HIOKI MODEL 700X

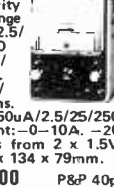
100,000 opv. Overload protection. Mirror scale. Ranges: 0.3/0.6/1.2/1.5/3/6/12/30/60/120/300/600/1200V DC. 1.5/3/6/12/30/60/150/300/600/1200V AC. 150/600A/3/6/12A DC. 15k/200k/2M/200Mohms. -20 to +63dB.



OUR PRICE £14.95 P&P20p

Model HT100B4 MULTIMETER

Overload protected, shock proof circuits. 9.5uA Meter with mirror scale. Sensitivity 100kV. Polarity change switch. Ranges: 0.5/2.5/1-50/250/500/1,000 Volts DC. 2.5/10/50/250/1,000 Volts AC. DC resistance: 0-20/200k/2/20 Meg. ohms. DC current: -10/250uA/2.5/25/250mA/10A. AC current: -0-10A. -20 to +62dB. Operates from 2 x 1.5V batteries. Size: 180 x 134 x 79mm.



OUR PRICE £15.00 P&P 40p

MODEL AS.100D VOM

100,000 opv. Mirror scale. Built-in meter protection. 0/3/12/60/120/300/600/1200V DC. 0/6/30/120/300/600V AC. 0/10uA/6/60/300mA/12 Amp. 0/2K/200K/2M/200 Meg Ohm. -20 to +17 dB.



OUR PRICE £17.50 P&P 20p.

KAMODEN HM720B FET VOM

Input impedance 10 Megohms. Ranges: 0/25/1/2.5/10/50/1000V DC. 0/2.5/10/50/250/1000V AC. 0/25uA/2.5/25/250 mA DC. 0/5k/50k/500k/5 M 500 Megohms.



OUR PRICE £21.00 P&P 30p

KAMODEN 72.200 Multitester

High sensitivity tester. 200,000 opv. Overload protected. Mirror scale. Ranges: -0/0.6/3/3/30/120/600/1200V DC. 0/3/12/60/300/1200V AC. 0/6/120/60/600mA/12A DC. 0/12A AC. -20 to +63dB. 0/2k/200k/2 Meg/200 Megohms.



OUR PRICE £22.50 P&P 30p

U4317 MULTIMETER

High sensitivity instrument for field and laboratory work. Knife edge pointer, 86mm. mirror scale. Ranges: 100mV/0.5/2.5/10/25/50/100/250/500/1000V DC. 0.5/2.5/10/25/50/100/250/500/1000V AC. Current: 50uA/0.5/1/5/10/50/250mA/1/5A DC. 0.25/0.5/1/5/10/50/250mA/1/5A AC. Resistance: 0.5/10/100/200 ohms/1/3/30/300k ohms. Decibels: -5 to +10dB. Battery operated. Size: 210 x 115 x 90mm. Supplied in carrying case complete with leads.



OUR PRICE £15.00 P&P 20p

MODEL U4311 Sub-standard Multi-range Volt-Ammeter

Sensitivity 330 Ohms/Volt AC and DC. Accuracy 0.5% DC. 1% AC. Scale length: 165mm. Ranges: 0/300/750uA/1.5/3/7.5/15/30/75/150/300/750mA/1.5/3/7.5A AC. 0/75/150/300/750mV/1.5/3/7.5/15/30/75/150/300/750V DC. 0/75mV/1.5/3/7.5/15/30/75/150/300/750V AC. Automatic cut out device. Supplied complete with test leads, manual and test certificates.



OUR PRICE £49.00 P&P 50p

TE40 HIGH SENSITIVITY AC VOLTMETER

10 Meg input. 10 ranges: 0.001/0.03/0.1/0.3/1/3/11/30/100/300V RMS. 5cps-1.2MHz. -40 to +50dB. supplied complete with leads and instructions.



OUR PRICE £17.50 P&P 25p

TE65 VALVE VOLTMETER

28 ranges. DC volts 1.5-1500V. AC volts 1.5-1500V. Resistance up to 1000 Megohms, 200/240V AC operation. Complete with probe and instructions.



OUR PRICE £17.50 P&P 30p

L83 TRANSISTOR TESTER

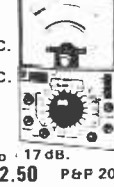
Tests ICD and B. PNP/NPN. Operates from 9V battery. Instructions supplied.



OUR PRICE £3.95 P&P 20p

MODEL AF.105 VOM

50,000 opv. Mirror scale. Meter protection. Ranges: 0/3/12/60/120/300/600/1200V DC. 0/6/30/120/300/600/1200V AC. 0/30uA/6/60/300mA/12 Amp. 0/10K/1 Meg/10m/100 Meg Ohms. -20 to +17 dB.



OUR PRICE £12.50 P&P 20p.

LB4 TRANSISTOR TESTER

Tests PNP or NPN transistors. Audio indication. Operates on two 1.5. Complete with instructions etc.



OUR PRICE £4.50 P&P 20p

U4341 Multimeter & Transistor Tester

27 ranges. 16,700 opv. Overload protected. Ranges: 0.3/1.5/6/30/60/150/300/900V DC. 1.5/7.5/30/150/300/750V AC. Current: 0.06/0.6/6/60/600mA DC. 0.3/3/30/300mA AC. Resistance: 0.08/0.6/2/6/20/60/200k ohms/2 Mohms. Battery operated. Supplied complete with probes, leads and steel carrying case. Size: 115 x 215 x 90mm.



OUR PRICE £10.50 P&P 20p

KAMODEN HMG500 insulation resistance tester

Range 0-1,000 Megohms, 500V. Battery operated. Wide range clear meter 4" x 4". Complete with deluxe carrying case, batteries and instructions.



OUR PRICE £19.95 P&P 30p

S100TR MULTIMETER TRANSISTOR TESTER

100,000 opv. Mirror scale. Overload protection. 0/0.12/0.3/1.2/30/120/600V DC. 0/6/30/120/600V AC. 0/12/600uA/12/300mA/6/12A DC. 0/10k/1 Meg/100 Meg. -20 to +50dB. 0.01-0.2 MFD. Transistor tester measures Alpha, Beta and ICD. Complete with instructions, batteries and leads.



OUR PRICE £15.95 P&P 25p

C15 PULSE OSCILLOSCOPE

For display of pulsed and periodic wave-forms in electronic circuits. VERT. AMP. Bandwidth: 0.1-120MHz. Sensitivity at 100kHz VRMS/mm: 0.1-25; HOR. AMP. Bandwidth: 500kHz. Sensitivity at 100kHz VRMS/mm: 0.3-25. Preset triggered sweep 1-3000usec. Free running 20-200 kHz in nine ranges. Calibrator pips. 220 x 360 x 430mm. 115-230V AC.



OUR PRICE £39.00 Carr. paid

RUSSIAN C116 Double Beam OSCILLOSCOPE

5 MHz pass band. Separate Y1 and Y2 amplifiers. Rectangular 5" x 4" CRT. Calibrated triggered sweep from 0.2usec. to 100 milli-sec/cm. Free running time base. 50Hz-1MHz. Built-in time base Calibrator and amplitude Calibrator. Supplied complete with all accessories and instruction manual.



OUR PRICE £87.00 Carr. paid

MODEL TE15 GRID DIP METER

Transistorised. Operates as Grid Dip, Oscillator, Absorption Wave Meter and Oscillating Detector. Frequency range 440kHz-280MHz in six coils, 500uA meter. 9V battery operation. Size: 180 x 80 x 40mm.



OUR PRICE £19.95 P&P 20p

SWR METER Model SWR3

Handy SWR meter for transmitter antenna alignment, with built-in field strength meter. Accuracy 5%, Impedance 52" Indicator 100uA DC. Full scale 5 section collapsible antenna. Size 145 x 50 x 60mm.



OUR PRICE £4.25 P&P 25p

AT201 Decade ATTENUATOR

Frequency range 0-200kHz. Attenuator 0-111dB, 0.1dB steps. Impedance 600 ohms. Input power maximum 30dBm. Size: 180 x 90 x 55mm.



OUR PRICE £12.50 P&P 37p

Also see following pages
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HIGH QUALITY CONSTRUCTION KITS
WE ARE APPOINTED STOCKISTS AT ALL BRANCHES

All kits are complete with comprehensive easy to follow instructions and covered by full guarantee.

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- AF305 Intercom..... £9.52
- AF310 Mono amplifier..... £5.99
- AT5 Automatic control..... £11.36
- AT25 Window wiper robot..... £5.82
- AT30 Photo cell switch unit..... £5.70
- AT50 400W triac light dimmer/speed control..... £4.80
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- AT65 3 channel light control..... £14.55
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- GP130 Stereo pre-amplifier for use with 2 x AF310..... £21.27
- GP312 Circuit board..... £11.45
- GU330 Tremolo unit..... £7.50
- HF10 8 detector..... £5.32
- HF65 FM transmitter..... £2.87
- HF75 FM receiver..... £2.87
- HF310 FM tuner..... £15.81
- HF325 Deluxe FM tuner..... £24.12
- HF330 Decoder (HF310/325)..... £9.96
- HF380 lwb/vhf aerial amplifier..... £4.94
- LF380 lwb/vhf aerial amp..... £11.77
- M150 Automatic device..... £11.36
- M160 Multi-vibrator..... £1.71
- M191 VU Meter..... £4.55
- M192 Stereo balance meter..... £4.97
- M1302 Transistor tester..... £8.45
- NT10 Stabilised power supply 100mA, 9V..... £6.15
- NT300 Stabilised p. supply..... £12.51
- NT305 Voltage converter..... £4.50
- NT315 Power supply 240V AC to 4.5/15V DC, 500mA..... £9.57

- Amateur Electronics by Justy-Kit, the professional book for the amateur — covers the subject from basic principals to advanced electronic techniques. Complete with circuit board for AE1 to AE10. **OUR PRICE £3.30 (No VAT) P&P 25p plus VAT.**
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- AE2 Pre-amplifier..... £1.15
- AE3 Diode receiver..... £1.82
- AE4 Flasher..... 99p
- AE5 Astable multi-vibrator..... 95p
- AE6 Monostable multi-vibrator..... 93p
- AE7 RC generator..... 97p
- AE8 Bass filter..... 90p
- AE9 Treble filter..... 90p
- AE10 CCIR filter..... 90p

- SPECIAL BARGAIN!! STEREO SOUND SPEAKERS**
- Matched pair of stereo bookshelf speakers. Deluxe teak veneered finish. Size: 368 x 229 x 190mm. 8 ohms. 8 watts RMS, 16 watts peak. Complete with Din lead. **OUR PRICE £12.95 P&P 50p**
- SPECIAL BARGAIN! FERGUSON 3406 HI-FI SPEAKERS**
- High quality 2 way speaker systems. 25 Watts. 4-8 ohms. 40Hz-18kHz. Size: 560 x 340 x 255mm. approx. Wood grain finish with black fronts. **OUR PRICE £26.95 per pair. P&P £1**

- FM TUNER CHASSIS**
- 6 transistor high quality tuner. Size only 153 x 101 x 63mm 31F stages. Double tuned discriminator. Ample output to feed most amplifiers. Operates on 9V battery. Covers 88-108MHz. Ready built, ready for use. Fantastic value for money. **OUR PRICE £5.95 P&P 20p**

- Model A1018 FM TUNER**
- 6 transistor high quality unit. 31F stages and double tuned discriminator. For use with most amplifiers. Covers 88-108MHz. Powered by 9V battery. **OUR PRICE £13.50 P&P 30p**
- Stereo multiplex adapter £5.95 extra.

- EMERSON LOUDSPEAKERS**
- Model 350 13 x 8" with single tweeter/crossover. 20-20,000Hz. 15 watts RMS. Available 8 or 15 ohms. **OUR PRICE £7.50 each P&P 37p**
- Model 450 13 x 8" with twin tweeter/crossover. 55-13,000Hz. 8 watts RMS. Available 8 or 15 ohms. **OUR PRICE £3.62 each P&P 25p**

- SPECIAL PURCHASE LIMITED QUANTITY!**
- Tannoy 12" DR/8 Bass Speakers 8 ohms. 30 watt. Heavy duty, ideal for Hi-Fi P.A. Group. **OUR PRICE £12.50 P&P 50p.**

ALL PRICES EXCLUDE VAT

Also see previous page

TRANSISTORISED L.C.R. A.C. BR/8 MEASURING BRIDGE

A new portable bridge offering excellent range and accuracy at low cost. Resistance: 6 ranges: 0.1 ohm-11.1 megohm ± 1% Inductance: 6 ranges: 1 microhenry-111 henries ± 2% Capacity: 6 ranges: 10pf-1110 mfd ± 2% Turns Ratio: 6 ranges: 1:1/1000-1:11100 ± 1% Bridge Voltage at 1,000cps. Operated from 9-volt battery. 100 microamp meter indication. Size 7 1/4" x 5" x 2" **OUR PRICE £25.00 P&P 25p.**

TE16A TRANSISTORISED SIGNAL GENERATOR

5 ranges. 400kHz to 30 MHz. An inexpensive instrument for the handy-man. Operates on 9V battery. Wide easy to read scale. 800kHz modulation. Size: 149 x 149 x 92mm. Complete with instructions and leads. **OUR PRICE £8.97 P&P 25p**

MODEL TE20 RF SIGNAL GENERATOR

Six bands. 120kHz-260MHz. Dual output RF terminals. Separate variable audio output. Accuracy ± 2%. Audio output to 8V. Power requirements: 105-125V, 220-240V AC. Size: 193 x 265 x 150mm. Complete with test leads etc. **OUR PRICE £17.50 P&P 40p**

TE-200 RF SIGNAL GENERATOR

Accurate wide range signal generator covering 120 kHz-500 MHz on 6 bands. Directly calibrated. Variable R.F. attenuator audio output. Xtal socket for calibration 220/240V a.c. Brand new with instructions. Size 140mm x 215mm x 170mm **OUR PRICE £17.50 P&P 30p**

ARF 300 AF/RF SIGNAL GENERATOR

All transistorised compact fully portable. AF sine-wave 18Hz to 220 kHz. AF square wave 18Hz to 100kHz. Output Square/Sine wave 10V. P-P RF 100kHz to 200MHz. Output 1V maximum. 220/240V AC operation. Complete with instructions and leads. **OUR PRICE £29.95 P&P 50p**

MODEL MG100 SINE SQUARE WAVE AUDIO GENERATOR

Range 19-220,000Hz Sine Wave 19-100,000 Hz Square Wave. Output Sine or Square wave 10V. P. to P. Size 180 x 90 x 90mm. Operation 220/240V. A.C. **OUR PRICE £19.95 P&P 37p.**

MCA220 Automatic Voltage Stabiliser

Input 88-125V AC or 170-250V AC. Output 120V AC or 240V AC. 200V/A rating. P&P 50p **OUR PRICE £11.97**

PS100B Regulated POWER SUPPLY UNIT

Solid state. Output 6, 9 or 12V DC up to 3 Amp. Meter to monitor current. Input 220/240V AC. Size: 100 x 82 x 159mm. **OUR PRICE £11.97 P&P 25p**

PS200 Regulated POWER SUPPLY UNIT

Solid state. Variable output 5-20V DC up to 2 Amp. Independent meters to monitor voltage and current. Output 220/240V AC. Size: 190 x 136 x 98mm **OUR PRICE £19.95 P&P 25p**

POWER RHEOSTATS

High quality ceramic construction. Windings embedded in vitreous enamel. Heavy duty brush wiper. Continuous rating. Wide range available ex-stock. Single hole fixing. 1/4" diameter shafts. Bulk quantities available.

25 WATT 10/25/50/100/250/500/1000/2500 Ohms **£1.15 P&P 10p**

50 WATT 10/25/50/100/250/500/1000/2500/5000 Ohms **£1.62 P&P 10p**

100 WATT 1/5/10/25/50/100/250/500/1000/2500 Ohms **£2.34 P&P 15p**

AUTO TRANSFORMERS

0/115/250V. Step up or step down. Fully shrouded.

80 WATTS	£2.75	P&P 18p
150 WATTS	£3.50	P&P 18p
300 WATTS	£4.50	P&P 23p
500 WATTS	£6.95	P&P 33p
1000 WATTS	£9.50	P&P 38p
1500 WATTS	£12.50	P&P 43p
2250 WATTS	£20.95	P&P 50p
5000 WATTS	£44.95	P&P £1

CP110 CHASSIS PUNCH SET



Carefully machined, top grade steel. Contains 1/2", 5/8", 3/4", 1" and 1 1/8" punches complete with gripper and accessories. **OUR PRICE £3.00 P&P 40p**

YAMABISHI VARIABLE VOLTAGE TRANSFORMERS

Excellent quality at low cost. Input: 230V 50/60Hz. Output 0-250V.

MODEL S260 BENCH MOUNTING

1A	£10.50	30p
2.5A	£12.00	35p
5A	£17.50	37p
8A	£30.35	50p
10A	£33.75	75p
12A	£29.50	75p
20A	£85.00	125p
25A	£95.00	130p
40A	£120.00	150p

MODEL S260B PANEL MOUNTING

1A	£10.00	30p
2.5A	£12.00	35p

240° Wide Angle 1mA METERS

MW 1-6 60x60mm **£6.50 P&P 15p**

MW 1-8 80x80mm **£6.90 P&P 15p**

BV05 Vernier TUNING DIAL

App. 7:1 ratio planetary drive vernier dial. Log scale 0-180 degrees. Blank scales 1-5. Dial size 128 x 76mm. Overall size 180 x 117 x 41mm. deep including knob and coupling. 1/4" diam. shaft **OUR PRICE £1.62 P&P 15p.**



WALKIE TALKIES

SKYFON 100mW
OUR PRICE £24.95 per pair

P302 Two Channel 300mW
OUR PRICE £52.50 per pair

P1003 Three Channel 1 Watt
OUR PRICE £71.25 per pair
 P&P 50p per pair

NB. Licence required for use in UK

RUH6 Reflex Horn Speaker

Built-in driver unit. Impedance 16 ohms. Power rating 10W. Response 380-7000Hz. Size app. 6" x 6". Weather and shock protected. **OUR PRICE £4.97 P&P 30p**

TRIO 9R59DS RECEIVER

Four bands covering 550kHz to 30 MHz continuous and electrical band-spread on 10, 15, 20, 40, and 80 mtrs. 8 valve plus 7 diode circuit. 4 to 8 ohm output and phone jack. SSB-CW, AM, variable BFO. S Meter and separate band spread dial. IF frequency 445kHz, audio output 1 1/2 watt. Variable RF and AF gain controls. 115/250V AC, with instructions. **Our Price £42.50 CARR. PAID**

BELTEK W5400 CAR TRANSCEIVER

Solid state mobile transceiver for 12 volt DC neg. Transmits and receives on any 12 of 28 channels between 144 and 146MHz. Power output 10W and 1W switchable. Controls: On/off/volume, squelch and channel selector. Internal 3" speaker. Complete with dynamic mic. PTT switch, three sets of crystals for 144.48, 144.6 and 145MHz, mounting bracket and instructions. Size: 150 x 70 x 220mm. **OUR PRICE £75.00 P&P 50p**

HITACHI FLUORESCENT LANTERN LI901

A portable battery operated lantern ideal for home, motoring, camping etc. Approx 10" tall. Provides brilliant light from 9 1.5v batteries (not supplied). **OUR PRICE £7.90 P&P 25p.**

DT55G DIGITAL CLOCK MECHANISM

Features 24 hour alarm setting, on/off and auto alarm 'sleep' switch. Illuminated rotary dial with hours, minutes and seconds. Automatically turns off radio, TV, light etc. and with auto-switching will turn on again when required. 240V AC operation. Switch rating 250V-3 Amp. **OUR PRICE £5.95 P&P 30p**

KE630 3 Station INTERCOM

Master and two sub-stations. Can be used on desk or wall mounted. Complete with cable and batteries **OUR PRICE £5.25 P&P 50p**

LH02S STEREO HEADPHONES

Light weight headphones with padded ear pieces. 4/16 ohms 20-20,000Hz. Complete with 6' lead and plug. **OUR PRICE £1.97 P&P 30p**

TE1018 Deluxe Mono High Impedance Headset.

Sensitive magnetic headset with soft ear pads. Impedance 2,600 ohms (600 ohms DC). Frequency response: 200-4,000Hz. **OUR PRICE £2.25 P&P 30p**

DH02S STEREO HEADPHONES

Wonderful value and excellent performance combined. Adjustable head band. Impedance 8 ohms. 20-12,000Hz. Complete with lead and plug. **OUR PRICE £2.50 P&P 30p**

TE1035 Stereo HEADPHONES

Low cost with excellent response. Foam rubber earcups. Adjustable headband. 8 ohms impedance. Frequency response 25Hz-18kHz. Complete with cable and stereo jack plug. **OUR PRICE £2.60 P&P 30p**

SH8DV MONO/STEREO HEADPHONES

Volume control for each channel. 4/16 ohms impedance. Frequency response 20Hz-18kHz. Complete with 10ft. coiled lead and jack plug. **OUR PRICE £4.97 P&P 30p**

BH001 HEADSET and Boom Microphone

Moving coil. Ideal for language teaching. Frequency communications etc. Headphone impedance 16 ohms. Microphone impedance 200 ohms. **OUR PRICE £5.95 P&P 30p**

SEW CLEAR PLASTIC PANEL METERS

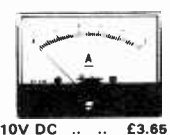
USED EXTENSIVELY BY INDUSTRY, GOVERNMENT DEPARTMENTS, EDUCATIONAL AUTHORITIES ETC.

Over 200 ranges in stock—other ranges to order. Quantity discounts available. Send for fully illustrated brochure.

CLEAR PLASTIC MODEL SD640

Size: 85 x 64mm

50uA	£3.80
100uA	£3.75
200uA	£3.70
500A	£3.65
50-0-50uA	£3.75
100-0-100uA	£3.70
1mA	£3.65
5mA	£3.65
10mA	£3.65
50mA	£3.65
100mA	£3.65
500mA	£3.65
1000mA	£3.65
10A	£3.65
5A DC	£3.65
10A DC	£3.65
5V DC	£3.65



10V DC	£3.65
20V DC	£3.65
50V DC	£3.65
300V DC	£3.65
15V AC	£3.65
30V AC	£3.75
300V AC	£3.75
VU Meter	£3.90

*Items with asterisk are Moving Iron type, all others are Moving Coil

CLEAR PLASTIC MODEL SD830

Size: 110 x 83mm

50uA	£4.30
100uA	£4.25
200uA	£4.20
500uA	£4.15
50-0-50uA	£4.25
100-0-100uA	£4.20
1mA	£4.10
5mA	£4.10
10mA	£4.10
50mA	£4.10
100mA	£4.10
500mA	£4.10
1A DC	£4.10
5A DC	£4.10
10A DC	£4.10
5V DC	£4.10

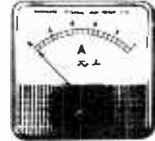


10V DC	£4.10
20V DC	£4.10
50V DC	£4.10
300V DC	£4.10
15V AC	£4.20
30V AC	£4.20
300V AC	£4.20
VU Meter	£4.40

CLEAR PLASTIC MODEL MR 65P

Size: 86 x 78mm

50uA	£3.95
100uA	£3.85
200uA	£3.80
500uA	£3.75
50-0-50uA	£3.85
100-0-100uA	£3.80
500-0-500uA	£3.70
1mA	£3.70
1-0-1mA	£3.70
5mA	£3.70
10mA	£3.70
50mA	£3.70
100mA	£3.70
500mA	£3.70
1A DC	£3.70
5A DC	£3.70
10A DC	£3.70
15A DC	£3.70
50V DC	£3.80
30A DC	£3.85
50A DC	£4.05
5V DC	£3.70
10V DC	£3.70
15V DC	£3.70
20V DC	£3.70
50V DC	£3.70
150V DC	£3.70



300V DC	£3.70
15V AC	£3.80
50V AC	£3.80
150V AC	£3.80
300V AC	£3.80
500V AC	£3.80
S Meter 1mA	£4.10
VU Meter	£3.70
1A AC	*£3.70
5A AC	*£3.70
10A AC	*£3.70
20A AC	*£3.70
30A AC	*£3.70
50mA AC	*£3.70
100mA AC	*£3.70
200mA AC	*£3.70
500mA AC	*£3.70

CLEAR PLASTIC MODEL SW100

Size: 100 x 80mm

50uA	£4.60
100uA	£4.50
500uA	£4.30
50-0-50uA	£4.50
100-0-100uA	£4.45
1mA	£4.30
1A DC	£4.30
5A DC	£4.30
20V DC	£4.30
50V DC	£4.30
300V DC	£4.30



150V AC	£4.45
300V AC	£4.45
VU Meter	£4.90

CLEAR PLASTIC MODEL MR 45P

Size: 50 x 50mm

50uA	£3.20
100uA	£3.15
200uA	£3.10
500uA	£3.05
50-0-50uA	£3.15
100-0-100uA	£3.10
500-0-500uA	£2.95
1mA	£2.95
5mA	£2.95
10mA	£2.95
50mA	£2.95
100mA	£2.95
500mA	£2.95
1A DC	£2.95
5A DC	£2.95
10V DC	£2.95
20V DC	£2.95
50V DC	£2.95
300V DC	£2.95
15V AC	£3.05



S Meter 1mA	£3.05
VU Meter	£3.40
1A AC	*£2.95
5A AC	*£2.95
10A AC	*£2.95
20A AC	*£2.95
30A AC	*£2.95

EDGWISE MODEL PE70

Size: 90 x 34mm

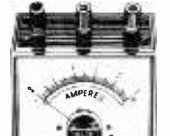
50uA	£4.15
100uA	£4.10
200uA	£4.05
500uA	£3.90
50-0-50uA	£4.10
100-0-100uA	£4.05
1mA	£3.85
300V AC	£3.95
VU Meter	£4.30



MODEL ED107 EDUCATIONAL METER

Size: 100 x 90 x 150mm including terminals

A range of high quality moving coil instruments ideal for school experiments and other bench applications. 3" mirror scale. The meter movement is easily accessible to demonstrate internal working.



50uA	£8.50
100uA	£7.90
50-0-50uA	£7.90
1mA	£7.60
1-0-1mA	£7.60
1A DC	£7.60
5A DC	£7.60
5V DC	£7.60
10V DC	£7.60
15V DC	£7.60

20V DC	£7.60
50V DC	£7.60
300V DC	£7.60
500mA/5A DC	£8.60
5V/50V DC	£8.60
5V/15V DC	£8.60
1/5A DC	£8.60
1A/15A DC	£8.60

CLEAR PLASTIC MODEL MR 38P

Size: 42 x 42mm

50uA	£3.10
100uA	£3.05
200uA	£3.00
500uA	£2.85
50-0-50uA	£3.05
100-0-100uA	£2.80
500-0-500uA	£2.80
1mA	£2.80
1-0-1mA	£2.80
2mA	£2.80
5mA	£2.80
10mA	£2.80
20mA	£2.80
50mA	£2.80
100mA	£2.80
150mA	£2.80
200mA	£2.80
300mA	£2.80
500mA	£2.80
750mA	£2.80
2A DC	£2.80
5A DC	£2.80
10A DC	£2.80
3V DC	£2.80
10V DC	£2.80
15V DC	£2.80

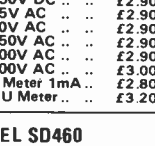


20V DC	£2.80
50V DC	£2.80
100V DC	£2.80
150V DC	£2.80
300V DC	£2.85
500V DC	£2.85
750V DC	£2.90
15V AC	£2.90
50V AC	£2.90
150V AC	£2.90
500V AC	£2.90
300V AC	£3.00
S Meter 1mA	£2.80
VU Meter	£3.20

CLEAR PLASTIC MODEL SD460

Size: 59 x 46mm

50uA	£3.50
100uA	£3.45
200uA	£3.40
500uA	£3.35
50-0-50uA	£3.45
100-0-100uA	£3.30
1mA	£3.30
5mA	£3.30
10mA	£3.30
50mA	£3.30
100mA	£3.30
500mA	£3.30
1A DC	£3.30
5A DC	£3.30
10A DC	£3.30
5V DC	£3.30



10V DC	£3.30
20V DC	£3.30
50V DC	£3.30
300V DC	£3.30
15V AC	£3.30
50V AC	£3.30
150V AC	£3.45
300V AC	£3.45
VU Meter	£3.65

BAKELITE MODEL S80 Enlarged Window

Size: 80 x 80mm

50uA	£4.50
100uA	£4.45
500uA	£4.45
50-0-50uA	£4.45
100-0-100uA	£4.40
1mA	£4.20
1A DC	£4.20
5A DC	£4.20
20V DC	£4.20
50V DC	£4.20
300V DC	£4.20
300V AC	£4.30
VU Meter	£4.70



CLEAR PLASTIC MODEL MR 52P

Size: 60 x 60mm

50uA	£3.70
100uA	£3.50
500uA	£3.35
50-0-50uA	£3.50
100-0-100uA	£3.45
1mA	£3.30
5mA	£3.30
10mA	£3.30
50mA	£3.30
100mA	£3.30
500mA	£3.30
1A DC	£3.30
5A DC	£3.30
10V DC	£3.30
20V DC	£3.30
50V DC	£3.30
300V DC	£3.30
15V AC	£3.40
300V AC	£3.40



S Meter 1mA	£3.30
VU Meter	£3.80
1A AC	*£3.30
5A AC	*£3.30
10A AC	*£3.30
20A AC	*£3.30
30A AC	*£3.30

BAKELITE MODEL MR 65

Size: 80 x 80mm

25uA	£5.25
50uA	£4.00
100uA	£3.95
500uA	£3.65
50-0-50uA	£3.95
100-0-100uA	£3.90
500-0-500uA	£3.60
1mA	£3.60
1-0-1mA	£3.60
5mA	£3.60
10mA	£3.60
50mA	£3.60
100mA	£3.60
500mA	£3.60
1A DC	£3.60
5A DC	£3.60
10A DC	£3.60
15A DC	£3.60
30A DC	£3.60
50A DC	£3.60
5V DC	£3.60
10V DC	£3.60
15V DC	£3.60
20V DC	£3.60
50V DC	£3.60
150V DC	£3.60



300V DC	£3.80
30V AC	*£3.80
50V AC	*£3.80
150V AC	*£3.80
300V AC	*£3.80
500V AC	*£3.80
VU Meter	*£4.10
1A AC	*£3.80
5A AC	*£3.80
10A AC	*£3.80
20A AC	*£3.80
30A AC	*£3.80
50A AC	*£3.80
500mA AC	*£3.80
50mV DC	*£3.75
100mV DC	*£3.75

SINCLAIR Project 80 Modules

Z40 Power Amplifier.....	£5.45
Z60 Power Amplifier.....	£6.95
Stereo 80 Pre-Amplifier.....	£11.95
Active Filter Unit.....	£6.95
Project 80S.....	£26.95
Z25 Power Supply.....	£4.98
P28 Power Supply.....	£7.98
P28 Power Supply.....	£7.98
Transformer for P28.....	£4.05

SINCLAIR Project 80 Packages

2 x Z40/Stereo 80/P25.....	£25.00
2 x Z40/Stereo 80/P26.....	£27.75
2 x Z60/Stereo 80/P28.....	£30.45

POST & PACKING 35p each.

MP7 MIXER-PREAMPLIFIER

5 Microphone inputs each with individual gain controls enabling complete mixing facilities. Battery operated. Size: 235 x 127 x 76mm. Inputs: Mics. 3 x 3mV 50k; 2 x 3mV 600 ohms. Phono. Mag. 4mV 50k; Phono Ceramic 100mV 1 Meg. Output 250mV 100k.

OUR PRICE £8.97 P&P 20p

ALL PRICES EXCLUDE VAT

1021 Stereo Listening Station

For balancing and gain selection of loudspeakers with additional facility for stereo headphones switching. Two gain controls, speakers on-off slide switch, stereo headphone socket.

OUR PRICE £2.25 P&P 15p

AUDIOTRONIC LOW NOISE CASSETTES

TYPE	5	10	25
C60	£1.57	£3.00	£7.08
C90	£2.24	£4.25	£10.00
C120	£2.73	£5.17	£12.24

AUDIOTRONIC CrO2 CASSETTES

TYPE	5	10	25
CR60	£3.92	£7.72	£19.12
CR90	£5.32	£10.46	£25.22

AUDIOTRONIC 8 TRACK CARTRIDGES

NEW DESIGN

ACTIVE FILTER CROSSOVER

FOR YOUR TOP FLIGHT SPEAKER SYSTEM

AS FEATURED IN WIRELESS WORLD Dec 1973

An essential and critical component in a high quality speaker system is the crossover unit conventionally comprising of a series of passive networks which unfortunately, through introducing reactive impedances between the amplifier and the speakers, result in the loss of the advantage of high amplifier damping factor and renders the speakers prone to overshoots and resonances. An elegant solution to this problem, described by D. C. Read in *Wireless World*, involves the use of a series of active filters splitting the output of the pre-amplifier into three channels, of closely defined bandwidth, each of which is fed to the appropriate speaker by its own power amplifier. A design for a suitable 20 Watt amplifier, based on a proven Texas circuit, was also described by Mr. Read. The printed circuit boards for this has been designed such that three amplifiers may be stacked and mounted together on a common heat sink to achieve a conveniently compact module.

<p>ACTIVE FILTER</p> <p>Pack</p> <p>1 Fibreglass PCB (accommodates all filters for one channel) 1-05</p> <p>2 Set of pre-sets, solid tantalum capacitors, 2% metal oxide resistors, 2% polystyrene capacitors 4-20</p> <p>3 Set of semiconductors 2-65</p> <p>2 off each pack required for stereo system</p> <p>SUITABLE ALSO FOR FEEDING ANY OF OUR HIGH POWER DESIGNS</p>	<p>READ/TEXAS 20w amp.</p> <p>Pack</p> <p>1 Fibreglass PCB 70</p> <p>2 Set of resistors, capacitors pre-sets (not including O/P coupling capacitors) 1-10</p> <p>3 Set of semiconductors 2-40</p> <p>6 off each pack required for stereo system</p> <p>4 Special heat sink assembly for set of three amplifiers 85</p> <p>5 Set of 3 O/P coupling capacitors 1-00</p> <p>2 off packs 4, 5 required for stereo system</p>	<p>POWER SUPPLY</p> <p>FOR 20W/CHANNEL STEREO SYSTEM</p> <p>Pack</p> <p>1 Fibreglass PCB 50</p> <p>2 Set of rectifiers, zener diode, capacitors, fuses, fuse holders 2-60</p> <p>3 Toroidal transformer 4-95</p> <p>ENQUIRIES WELCOME For quality sets of speakers</p>	<p>V.A.T. Please add 10%*</p> <p>to all U.K. orders</p> <p>(*or at current rate if changed)</p> <p>U.K. ORDERS—Post free (mail order only)</p> <p>OVERSEAS—Postage at cost + 50p special packing</p> <p>POWERTRAN</p> <p>SEE FOLLOWING PAGE</p>
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	£	P.P.		£	P.P.
Solartron Storage Scope QD 910.....	£40-00	£3-00	Beckman Digital Voltmeter Type BIE 2116 and Ratio Meters	£25-00	£2-00
Cossor D/B Rough	£6-00	£1-50	Vacuum Compressor Pump with 240V Motor.....	£15-00	£1-50
Teletrome Square Sign Wave Generator	£10-00	£1-00	RCA Marine Direction Finder and Radio.....	£10-00	£1-00
Mullard TV Line Selector Type L 190	£10-00	£1-00	Telequipment Test Card C Generator.....	£30-00	£5-00
Voltage Regulator Lang Thompson 220 or 240 out at 100 BA	£45-00	£3-00	Ferrograph 3 Speed Series 6.....	£50-00	£2-00
Pye Rangers VHF Transistorised Radio Telephones Mobiles	£10-00	£1-00	Frequency Counter Marconi TF 1345/2 Complete with Stand and 4 Plug-in Units—22 mcs. Good condition..	£60-00	£5-00
UHF Marconi Signal Generators TF 762C 299-610 mcs..	£40-00	£2-00	Beckman Frequency Time Counters Model 7360JH....	£35-00	£2-00
Wayne Kerr VHF Frequency Standard	£8-00	£1-00	Output Power Meter TF 340	£10-00	£1-00
Avo Valve Voltmeter	£10-00	£1-00	Airmec Signal Generator 300 kcs to 30 mcs 7 Bands...	£20-00	£2-00
Communication Receiver Skyrider 500 kcs-60 mcs. Poor condition	£16-00	£2-00	Standard Signal Generator GRC (USA) Type 205/B 7 Bands 9.5 kcs to 30 mcs	£35-00	£2-00
Test Card C Videcon	£10-00	£1-00	Spectrum Signal Analyser Model SB/12 with Tuning Head 2 mcs-4umcs	£150-00	£6-00
1" Videcon	£7-00	£0-50	Signal Generator TF 937 85 kcs-30 mcs 8 Bands Effective L. Length of film Scale 50 ft.....	£40-00	£2-00
Voltexion 4 Way Mixer	£8-00	£1-00	Invertors Leland Airbourne Products		
Aircraft Modulator Unit (Radio/Tel) 440-LRV 3B	£4-00	£1-00	28v DC Input Output 115/200—115v 2-2 to 6-5 amps		
Radar Aircraft No Indicator	£15-00	£1-50	400 cs 750/750 vg 3/1 Phase with Built-in Stabilisers....	£10-00	£2-00
Tape Cartridge Players Built-in 10 Watt Amp	£10-00	£1-00	600/l Electrical Gearbox High Torque 12-24v Electronic Brake. Rough exterior.....	£5-00	£1-00
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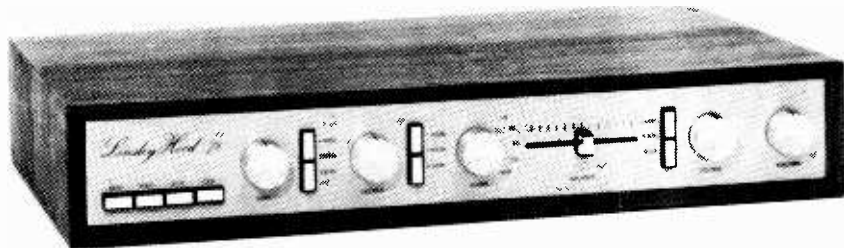
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★ 75 WATTS PER CHANNEL
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★ UNCONDITIONAL STABILITY



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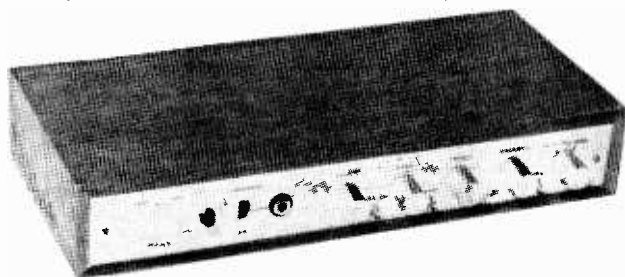
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Full circuit description in handbook

Pack	Price	Pack	Price	Pack	Price
1 Fibre glass printed circuit board for power amp.	£0.85	8 Set of potentiometers (including mains switch).	£2.05	13 Set of miscellaneous parts including DIN skts, mains input skt, fuse holder, interconnecting cable, control knobs	£4.25
2 Set of resistors, capacitors, pre-sets for power amp.	£1.70	9 Set of 4 push button switches, rotary mode switch.	£3.70	14 Set of metalwork parts including silk screen printed fascia panel and all brackets, fixing parts, etc.	£6.30
3 Set of semiconductors for power amp. (highest voltage version).	£6.50	10 Toroidal transformer complete with magnetic screen/housing primary: 0-117-234 V, secondaries: 33-0-33 V 24-0-24 V.	£9.15	15 Handbook.	£0.30
4 Pair of 2 drilled, finned heat sinks.	£0.80	11 Fibre glass printed circuit board for power supply.	£0.65	16 Teak cabinet.	£7.35
5 Fibre glass printed circuit board for pre-amp.	£1.30	12 Set of resistors, capacitors, secondary fuses, semiconductors for power supply.	£3.50	2 each of packs 1-7 inclusive are required for complete stereo system.	
6 Set of low noise resistors, capacitors, pre-sets for pre-amp.	£2.70				
7 Set of low noise, high gain semiconductors for pre-amp.	£2.40				

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Pack	Price	Pack	Price
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4 Set of miscellaneous parts including DIN sockets, fuses, fuse holders, control knobs etc.	£1.90	10 Complete chassis work, hardware and brackets	£4.20
5 Set of slide and pushbutton switches	£0.90	11 Preformed cable/leads	£0.40
6 Set of potentiometers and selector switch	£1.45	12 Handbook	£0.25
		13 Teak Cabinet	£2.75

SEMICONDUCTORS

2N699 0.25	2N4058 0.12	BC214L 0.14	MPSA66 0.40	TIP33A 1.00
2N1613 0.20	2N4062 0.11	BCY72 0.13	MPSU05 0.60	TIP34A 1.50
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2N2926G 0.10	2N5087 0.42	BD530 0.85	SN72721P 0.58	TIP42A 0.90
2N3053 0.15	2N5210 0.54	BDY56 1.60	SN72748P 0.58	TIP3055 0.60
2N3055 0.45	2N5457 0.45	BF257 0.40	TIP29A 0.50	1B08T20 0.50
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2N3703 0.10	40361 0.40	BFR79 0.25	TIP30C 0.78	IN916 0.07
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2N3705 0.10	BC107 0.10	BFY51 0.20	TIP32A 0.70	5B05 1.20
2N3706 0.09	BC108 0.10	BFY52 0.20		
2N3707 0.10	BC109 0.10	MJ481 1.20		
2N3708 0.07	BC125 0.15	MJ491 1.30		
2N3709 0.09	BC126 0.15	MJE521 0.60		
2N3710 0.09	BC182K 0.10	MPSA05 0.30		
2N3711 0.09	BC212K 0.12	MPSA12 0.55		
2N3819 0.23	BC182L 0.10	MPSA14 0.35		
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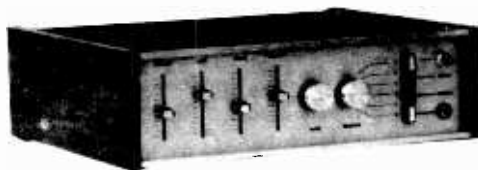
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Pk. 1 F/Glass PCB	£0.70
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Designed to house Bailey, Blomley or Linsley-Hood Class AB amplifiers with simple or regulated power supplies and Bailey Burrows pre-amp. Options of standard or hum reducing toroidal mains transformer. Also rotary control version. Details in price list.

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1/2W Iskra high stability carbon film—very low noise—capless construction. 1/4W Mullard CR25 carbon film—very small body size 7.5 x 2.5 mm. 1/2W 2% ELECTROSIL TR5.

Power watts	Tolerance	Range	Values available	Price
1/2	5%	4.7Ω-2.2MΩ	E24	1-99 100+
1/2	10%	3.3MΩ-10MΩ	E12	1p 0-9p
1/2	2%	10Ω-1MΩ	E24	3-5p 3p
1/2	10%	1Ω-3.9Ω	E12	1p 0-9p
1/2	5%	4.7Ω-1MΩ	E12	1p 0-9p
4	10%	1Ω-10Ω	E12	6p 5-5p

Quantity price applies for any selection. Ignore fractions on total order.

DEVELOPMENT PACK

0.5 watt 5% Iskra resistors 5 off each value 4.7Ω to 1MΩ.
E12 pack 325 resistors £2.40. E24 pack 650 resistors £4.70.

POTENTIOMETERS

Carbon track 5kΩ to 2MΩ, log or linear (log 1/2W, lin 1/4W).
Single, 12p. Dual gang (stereo), 40p. Single D.P. switch, 24p.

SKELETON PRESET POTENTIOMETERS

Linear: 100, 250, 500Ω and decades to 5MΩ. Horizontal or vertical P.C. mounting (0-1 matrix).
Sub-miniature 0-1W, 5p each. Miniature 0-25W, 7p each.

TRANSISTORS

AC107	15p	AF126	20p	BF115	25p	OC42	12p	2N3707	12p
AC126	12p	AF139	32p	BF173	20p	OC44	12p	2N3708	10p
AC127	15p	AF178	32p	BF177	28p	OC45	12p	2N3709	11p
AC128	15p	AF180	40p	BF178	32p	OC70	12p	2N3710	11p
AC131	12p	AF181	40p	BF179	32p	OC71	12p	2N3711	11p
AC132	12p	BC107	12p	BF180	32p	OC72	12p	2N3819	32p
AC176	15p	BC108	12p	BF181	32p	OC81	12p	2N4062	12p
AC187	22p	BC109	12p	BF194	14p	OC82D	12p	2N4286	20p
AC188	22p	BC147	12p	BF195	14p	2N2646	60p	2N4289	20p
AD140	50p	BC148	12p	BF197	15p	2N2904	20p	40360	35p
AD149	45p	BC149	12p	BF200	32p	2N2926	10p	40361	35p
AD161	35p	BC157	14p	BF750	20p	2N3054	58p	40362	40p
AD162	36p	BC158	14p	BF751	20p	2N3055	60p	40408	40p
AF114	20p	BC159	14p	BF752	20p	2N3702	13p	ZTX108	15p
AF115	20p	BC187	22p	BU105	225p	2N3703	12p	ZTX300	15p
AF116	20p	BD131	75p	OC26	45p	2N3704	13p	ZTX302	20p
AF117	20p	BD132	75p	OC28	50p	2N3705	12p	ZTX500	15p
AF118	38p	BD133	75p	OC35	50p	2N3706	11p	ZTX503	20p

ZENER DIODES

400mW 5% 3-3V to 30V, 12p.

WIRE WOUND POTS

3W, 10, 25, 50Ω and decades to 100kΩ, 45p.

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BY127	1250V	1A	12p
IN4001	50V	1A	7p
IN4002	100V	1A	8p
IN4004	400V	1A	8p
IN4006	800V	1A	10p
IN4007	1000V	1A	12p

SIGNAL

OA85	7p
OA90	5p
OA91	5p
OA202	7p
IN4148	5p
BA114	8p

BRUSHED ALUMINIUM PANELS

12in x 6in, 25p; 12in x 2 1/2in, 10p; 9in x 2in, 7p

THERMISTORS

VA 10555	15p
VA 10665	15p
VA 10777	15p
R 53	£1.35

SLIDER POTENTIOMETERS

86mm x 9mm x 16mm, length of track 59mm.
DUAL GANG, 10K + 10K etc. log. or lin. 60p.
KNOB FOR ABOVE, 12p.
FRONT PANEL, 65p.
18 Gauge panel 12in x 4in with slots cut for use with slider pots. Grey or matt black finish complete with fixings for 4 pots.

THYRISTORS

2N5060 50V 0.8A	65p
2N5064 200V 0.8A	80p
106F 50V 4A	55p
106D 400V 4A	80p

MULLARD POLYESTER CAPACITORS C296 SERIES

400V: 0.001μF, 0.0015μF, 0.0022μF, 0.0033μF, 0.0047μF, 2 1/2p. 0.0068μF, 0.01μF, 0.015μF, 0.022μF, 0.033μF, 3p. 0.047μF, 0.068μF, 0.1μF, 4p. 0.15μF, 6p. 0.22μF, 7 1/2p. 0.33μF, 11p. 0.47μF, 13p.

MULLARD POLYESTER CAPACITORS C280 SERIES

250V P.C. mounting: 0.01μF, 0.015μF, 0.022μF, 3p. 0.033μF, 0.047μF, 0.068μF, 3 1/2p. 0.1μF, 4p. 0.15μF, 0.22μF, 5p. 0.33μF, 6 1/2p. 0.47μF, 8 1/2p. 0.68μF, 11p. 1.0μF, 13p. 1.5μF, 20p. 2.2μF, 24p.

MYLAR FILM CAPACITORS 100V

0.001μF, 0.002μF, 0.005μF, 0.01μF, 0.02μF, 2 1/2p. 0.04μF, 0.05μF, 0.068μF, 0.1μF, 3 1/2p.

CERAMIC DISC CAPACITORS

100pF to 10,000pF, 2p each.

ELECTROLYTIC CAPACITORS—MULLARD O15/6/7

(μF/v) 1/63, 1-5/63, 2-2/63, 3-3/63, 4-7/63, 6-8/63, 8-8/63, 10/25, 10/63, 15/16, 15/40, 15/63, 22/10, 22/25, 22/63, 33/6-3, 33/16, 33/40, 47/4, 47/10, 47/25, 47/40, 68/6-3, 68/16, 100/4, 100/10, 100/25, 150/6-3, 150/16, 220/4, 220/6-3, 220/16, 330/4, 6p. 47/63, 100/40, 150/25, 220/25, 330/10, 470/6-3, 7p. 68/63, 150/40, 220/40, 330/16, 1000/4, 10p. 470/10, 680/6-3, 11p. 100/63, 150/63, 220/63, 1000/10, 12p. 470/25, 680/16, 1500/6-3, 13p. 470/40, 680/25, 1000/16, 1500/10, 2200/6-3, 18p. 330/63, 680/40, 1000/25, 1500/16, 2200/10, 3300/6-3, 4700/4, 21p.

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	12p
0.1μF 35V	22μF 16V
0.22μF 35V	33μF 10V
0.47μF 35V	47μF 6-3V
1.0μF 35V	100μF 3V

VEROBOARD

0-1 0-15	
2 1/2 x 3 1/2	22p 16p
2 1/2 x 5	24p 24p
3 1/2 x 3 1/2	24p 24p
3 1/2 x 5	27p 27p
17 x 2 1/2	75p 57 1/2p
17 x 3 1/2	100p 78p
17 x 5 (plain)	82p
17 x 3 1/2 (plain)	60p
17 x 2 1/2 (plain)	42p
2 1/2 x 5 (plain)	12p
2 1/2 x 3 1/2 (plain)	11p
Pin insertion tool	52p 52p
Spot face cutter	42p 42p
Pkt. 50 pins	20p 20p

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Standard screened	28p	2.5mm insulated	12p
Standard insulated	18p	3.5mm insulated	12p
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2 pin, 3 pin, 5 pin 180°, 5 pin 240°, 6 pin, 7 pin
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9V mains power supply. Same size as PP9 battery.

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POLYSTYRENE CAPACITORS 160V 2 1/2%

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Ideal EXTENSION Telephones with standard GPO type dial, bell and lead coding. £1-75 ea. P. & P. 25p.

All telephones complete with bell and dial.

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COLVERN 3 watt. Brand new, 25; 50k all at 13p ea.

MORGANITE Special Brand new, 2-5; 10; 100; 250; 500K; 1 in. sealed, 17p ea.

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RELIANCE P.C.B. mounting: 270; 470; 500 ohms; 10K at 35p ea. ALL BRAND NEW.
ALMA precision resistors 200K; 400K; 497K; 998K; 1 meg—0-1% 27p ea.; 3-25k, 5-6k, 13k-0-1% 29p ea.

CAPACITORS. Brand New. 10,000mfd 50V 60p ea. P & P 15p.

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2N709	0.38	2N4289	0.10	BC158	0.13	BF259	0.55
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2N718A	0.40	2N4921	0.73	BC167B	0.13	BF531	0.20
2N720	0.58	2N4922	0.84	BC168	0.13	BF538	0.20
2N721	0.55	2N4923	0.83	BC169	0.11	BF539	0.20
2N914	0.22	2N5172	0.12	BC168C	0.11	BFX29	0.30
2N916	0.41	2N5174	0.22	BC1698	0.13	BFX30	0.25
2N918	0.47	2N5175	0.26	BC169C	0.13	BFX44	0.33
2N929	0.30	2N5176	0.32	BC170	0.11	BFX63	2.48
2N1302	0.19	2N5190	0.92	BC171	0.13	BFX68	0.30
2N1303	0.19	2N5191	0.95	BC172	0.11	BFX84	0.24
2N1304	0.24	2N5192	1.24	BC182	0.12	BFX85	0.30
2N1305	0.24	2N5195	1.46	BC182L	0.12	BFX87	0.28
2N1306	0.31	2N5245	0.43	BC183	0.09	BFX88	0.25
2N1307	0.22	2N5457	0.49	BC184	0.09	BFX89	0.45
2N1308	0.25	2N5458	0.45	BC184A	0.11	BFY18	0.35
2N1309	0.36	2N5459	0.49	BC186	0.25	BFY20	0.50
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2N1671A	1.54	40362	0.50	BC208	0.11	BFY50	0.23
2N1671B	1.72	40363	0.61	BC209	0.12	BFY51	0.19
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2N1711	0.45	40394	0.56	BC212L	0.16	BFY53	0.16
2N1807	5.50	40395	0.65	BC214L	0.21	BFY90	0.60
2N2102	0.50	40406	0.44	BC237	0.09	BRV39	0.23
2N2147	0.70	40407	0.33	BC238	0.09	BU104	1.42
2N2148	0.94	40408	0.50	BC259	0.09	BU105	2.25
2N2150	0.60	40409	0.60	BC259	0.09	BU106A	0.55
2N2192	0.40	40410	0.52	BC261	0.20	BU109	0.40
2N2192A	0.40	40411	0.25	BC262	0.18	CA3089E	1.96
2N2513	0.60	40414	3.55	BC263	0.23	CA3090E	4.23
2N2193A	0.41	40430	0.85	BC300	2.12	LM301A	0.48
2N2194	0.73	40583	0.23	BC301	0.34	LM304A	2.03
2N2194A	0.30	40601	0.67	BC302	0.29	LM309K	1.89
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2N2219A	0.60	40604	0.56	BC308	0.09	80DL	0.38
2N2220	0.45	40636	1.10	BC308A	0.09	140DL	0.33
2N2221	0.41	40669	1.90	BC308B	0.12	LM723C	0.75
2N2221A	0.40	40673	0.70	BC309	0.09	LM741T039	0.40
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2N2369A	0.41	AC127	0.25	BC337	0.19	MC1305P	1.26
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2N2646A	0.77	AC129	0.25	BC338	0.43	MC1458CP1	0.79
2N2646B	0.77	AC151V	0.11	BCY30	0.52	MJ480	0.90
2N2804	0.55	AC152V	0.17	BCY31	0.52	MJ481	1.14
2N2904A	0.70	AC153	0.25	BCY32	1.15	MJ481	0.98
2N2905	0.48	AC153K	0.25	BCY33	0.34	MJ490	0.98
2N2905A	0.50	AC154	0.28	BCY34	0.27	MJ491	1.28
2N2906	0.31	AC176	0.25	BCY38	0.53	MJE340	0.42
2N2906A	0.37	AC176K	0.25	BCY39	1.05	MJE2955	1.12
2N2907	0.40	AC187K	0.23	BCY40	0.87	MJE3055	0.68
2N2907A	0.45	AC188K	0.34	BCY42	0.15	MP8111	0.32
2N2924	0.14	AC128	0.24	BCY58	0.21	MP8112	0.40
2N2925	0.17	AC129	0.22	BCY59	0.22	MP8113	0.47
2N2926	0.17	AC129	0.22	BCY70	0.17	MPF102	0.39
Green	0.12	ACY21	0.26	BCY71	0.22	MPSA05	0.25
Yellow	0.11	ACY28	0.20	BCY72	0.13	MPSA06	0.26
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2N3053	0.32	A0142	0.50	BCY98	0.97	MPSA56	0.27
2N3054	0.60	A0143	0.45	BCY99	0.97	NE555V	0.90
2N3055	0.35	A0149V	0.66	BD115	0.75	NE560	4.48
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2N3391A	0.29	A0162	0.45	BD123	0.32	DC23	0.56
2N3392	0.13	A0162	1.05	BD124	0.67	DC28	0.76
2N3393	0.13	A0162	1.05	BD131	0.40	OC35	0.60
2N3394	0.13	AF109R	0.40	BD132	0.50	OC42	0.35
2N3402	0.18	AF115	0.24	BD135	0.43	OC45	0.32
2N3403	0.19	AF116	0.25	BD136	0.49	OC71	0.12
2N3440	0.99	AF117	0.20	BD137	0.55	OC72	0.13
2N3442	1.69	AF124	0.24	BD138	0.63	OC81	0.20
2N3414	0.10	AF125	0.20	BD140	0.71	OC83	0.20
2N3415	0.10	AF126	0.19	BDY20	0.87	ORP12	0.50
2N3416	0.15	AF127	0.20	BF115	1.05	SC35D	1.68
2N3417	0.21	AF139	0.39	BF116	0.25	SC36D	1.46
2N3638	0.15	AF170	0.23	BF117	0.43	SC40D	1.69
2N3638A	0.15	AF172	0.25	BF119	0.58	SC45D	1.89
2N3639	0.27	AF178	0.55	BF121	0.25	SC46D	1.96
2N3641	0.17	AF179	0.65	BF123	0.27	SC50D	2.60
2N3702	0.11	AF180	0.50	BF125	0.27	SC51D	2.39
2N3703	0.12	AF185	0.40	BF126	0.24	SI414A	1.80
2N3704	0.14	AF200	0.45	BF152	0.20	SI623	4.59
2N3705	0.12	AF239	0.51	BF154	0.21	SL623	4.59
2N3706	0.09	AF240	0.72	BF158	0.23	TAA263	0.70
2N3707	0.13	AF279	0.54	BF159	0.27	TAA621	2.03
2N3708	0.13	AF280	0.54	BF180	0.27	TAA621B	1.32
2N3709	0.11	AL102	0.75	BF181	0.42	TAA621D	1.50
2N3710	0.12	AL103	0.75	BF182	0.40	Filter	0.70
2N3711	0.11	BC107	0.16	BF166	0.32	TBA271	0.64
2N3712	0.06	BC108	0.15	BF167	0.21	TBA641B	2.25
2N3713	1.20	BC109	0.19	BF173	0.24	TBA800	1.50
2N3714	1.33	BC113	0.13	BF177	0.23	TBA810	1.01
2N3715	1.50	BC115	0.15	BF178	0.35	TIB05	0.35
2N3716	1.60	BC116	0.15	BF179	0.43	TIP29A	0.49
2N3717	2.20	BC116A	0.18	BF180	0.35	TIP30A	0.58
2N3772	1.80	BC117	0.21	BF181	0.34	TIP31A	0.62
2N3773	2.65	BC118	0.11	BF182	0.40	TIP32A	0.74
2N3779	3.15	BC119	0.29	BF183	0.40	TIP33A	0.81
2N3790	2.15	BC121	0.18	BF184	0.30	TIP34A	1.51
2N3791	2.35	BC125	0.15	BF185	0.17	TIP35A	2.90
2N3792	2.69	BC126	0.20	BF194	0.16	TIP36A	3.70
2N3794	0.10	BC132	0.30	BF196	0.17	TIP41A	0.79
2N3819	0.37	BC134	0.11	BF196	0.15	TIP42A	0.90
2N3820	0.38	BC135	0.11	BF197	0.15	TIP295	0.93
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SN7405N	0.20	0.18	0.10
SN7405AN	0.44	0.44	0.38
SN7406N	0.40	0.38	0.25
SN7407N	0.40	0.38	0.25
SN7408N	0.25	0.22	0.10
SN7409N	0.33	0.33	0.28
SN7410AN	0.44	0.44	0.38
SN7411N	0.25	0.23	0.21
SN7412N	0.28	0.28	0.25
SN7412AN	0.38	0.38	0.33
SN7413N	0.30	0.27	0.25
SN7414N	0.72	0.72	0.63
SN7415AN	0.27	0.27	0.32
SN7417N	0.30	0.27	0.25
SN7420N	0.20	0.18	0.10
SN7422N	0.28	0.28	0.25
SN7422AN	0.38	0.38	0.33
SN7423N	0.37	0.34	0.32
SN7425N	0.37	0.37	0.32
SN7427N	0.37	0.37	0.32
SN7428N	0.43	0.43	0.37
SN7430N	0.20	0.18	0.10
SN7432N	0.37	0.37	0.32
SN7433N	0.43	0.43	0.37
SN7433AN	0.43	0.43	0.37
SN7437N	0.43	0.43	0.37
SN7438N	0.43	0.43	0.37
SN7438AN	0.57	0.57	0.50
SN7440N	0.20	0.18	0.10
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SN7442N	0.85	0.78	0.73
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SN7444N	1.50	1.27	1.13
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590 SWR meter	6.60
630 STAB Power supply 6-12v 0.25-0.1A	9.24
690 DC motor speed Gov.	3.31
700 Electronic Chaffinch	7.92
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780 Metal Detector (electronics only)	10.61
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825 120-160mHz VHF timer	11.31
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190 Quartz XTAL checker	9.99
220 Signal injector	2.30
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432 Testakit	19.30
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All types of Transistors Rectifiers—Bridges SCR's—Triacs Integrated Circuits F.E.T.—Light Devices OVER 1500 DIFFERENT DEVICES ENTIRELY NEW 1973 EDITION More Devices ★ New Prices ★ New Ranges ★ This is a must for all Semi-conductor Users. (Ask for booklet No. 3f.)



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TBA980 5 WATT IC

Suitable alternative to SL4030 5/30 volt operated. 816 With 5 watt output. With circuits and data. £1.50. Complete with printed circuit boards and components £2.75.

STROBE TUBE

ZFT4A. Suitable for Dec. '73 Pract. Electronics £3.00 STZ (D32) DMAC 25p CR51/40 SCR 45p ZFT4 £3.60 ZFT3 £3.50 ZFT12 £4.50

Sinclair IC12

With circuits and data. 6 watt IC with printed circuit board, 28 volt. operated. £2.90

Ultrasonic Transducers

Operate at 40KHz up to 100 yds. Ideal remote switching and signaling. Complete with data transmitter and receiver new I.C. circuits. Per pair £5.90. TA960 with socket £1.00

ZN414 IC

Integrated circuit radio as featured by many magazines (PW Jan. 73 Reprint Ref. No. 19 for 10p). £1.20.

3615F 7 SEG.

I.C. size complete with data price £1.70 each (digital clock circuits Ref. No. 31, 15p).

TIL200 LED 24p ea. 22p ea. per 10

LARGER QUANTITY AND O.E.M. PRICES PHONE (01) 723 3646. PRICING OF SN7400 SERIES CALCULATED ON THE TOTAL NUMBER ORDERED REGARDLESS OF MIX. SN74... HIGH POWER... SN74... LOW POWER SERIES IN STOCK... SEND FOR LIST 36, FREE ON REQUEST. LOW PROFILE SOCKETS 14 PIN... 15p. 16 PIN... 17p. 8 PIN... 14p.

ALL KITS OFFERED SUBJECT TO STOCK AVAILABILITY Prices correct at time of preparation. Subject to change without notice.

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MW/LW CAR RADIO + or — Earth with speakers and fixings. £8.50 carr/pack 30p.
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PORTABLE BATTERY CASSETTE TAPE PLAYER £7.25
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ROTEL STEREO PHONES RH630 £4.50; RH700 £8.75; RH430 £3.50. ROTAL RA310 15+15 watt Stereo Amplifier (List £52.00) £24.32
AKA1 GX46
Stereo cassette recorder £50.95 carr/pack 50p.
Pair Akai ADM microphones £8.95 carr/pack 20p.
WEIN W590 BATTERY/MAINS CASSETTE RECORDER £12.75
PORTABLE CASSETTE TAPE Player—for car or carry around. £7.25 carr/pack 20p.
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Hanimax HI1 STEREO COMPACT RECORD PLAYER 2x7 watts. Complete with speakers (List £54.50) Price £39.95 Plus free pair of stereo phones.

NEW RANGES BRIDGE RECTIFIERS

FEATURES SMALL SIZE AND LOW COST. Sizes are approximate.

250M/A QUARTER AMP	2 AMPS P.I.V.
B025/05 50 PIV 16p	B2/05 100v 35p
B025/10 100 PIV 18p	B2/10 150v 46p
1 1/2" x 1 1/2" dia.	B2/20 200v 45p
1 AM P.I.V. Pricing	B2/60 600v 54p
Type P.I.V. Price ea.	B2/100 1000v 53p
B05/05 50v 28p	4 AMPS P.I.V.
B05/10 100v 22p	B4/10 100v 55p
B05/20 200v 23p	B4/200 200v 57p
B05/40 400v 25p	B4/400 400v 65p
B05/60 600v 27p	B4/800 800v 75p
1 1/2" x 1 1/2" dia.	B4/800 800v 81.60
1 AM P.I.V.	6 AMPS P.I.V.
B1/05 50v 25p	B6/05 50v 65p
B1/10 100v 25p	B6/10 100v 70p
B1/20 200v 28p	B6/20 200v 80p
B1/60 600v 36p	B6/40 400v 86p
1 1/2" x 1 1/2" dia.	B6/80 800v 91.60
1 AM P.I.V.	8 AMPS P.I.V.
W005 50v 28p	B8/05 50v 85p
W01 100v 30p	B8/10 100v 90p
W02 200v 32p	B8/20 200v 96p
W06 600v 35p	B8/40 400v 102p
1 1/2" Tubular	

BUILD YOURSELF A POCKET CALCULATOR

A complete kit, packaged in a polystyrene container and labelling about 3 hours to assemble—that's the Sinclair Cambridge pocket calculator from Henry's. Some of the many features include interface chip, thick-film resistor pack, printed circuit board, electronic components pack. Size 4 1/2" long x 2" wide x 1/2" deep. Free of charge with the kit for the more advanced technologist is a 32-page booklet explaining how to calculate Logs, Tangents, Sines etc.



Price £19.95 + VAT Also available assembled ready to use £22.50 + VAT.

LIVING SOUND LOW NOISE TOP QUALITY CASSETTES MADE BY EMI TAPES LTD TO INTERNATIONAL STANDARDS ESPECIALLY FOR HENRY'S. ALL POST PAID LESS THAN 1 REC. PRICES. COMPLETE WITH LIBRARY CASES.

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C60	£1.10	£1.90	£3.00	£7.40
C90	£1.40	£2.80	£4.80	£11.25
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Quantity and trade enquiries invited.
LEARN A LANGUAGE—complete with phrase book. German—French—Spanish—Italian £1.30 per course. £5 for any 4.

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16" Twin spring unit	£8.85 p & p 25p
VHF 105 Aircraft Band Converter	£4.50 p & p 15p
B2005 4 ch. mic. mixer	£4.20 p & p 15p
B2004 2 ch. Stereo mixer	£4.75 p & p 15p
PK3 kit. Etch your own printed circuits	£1.95 p & p 20p
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TRIACS

Type P.I.V. Each	Price	Std. mounting with accessories
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SC35B 200v 85p		SC45D 400v £1.45
SC35C 400v 80p		SC45E 500v £1.85
SC35E 500v £1.20		
SC40B 200v 85p		15 AMP RANGE
SC40C 400v £1.20		SC50A 100v £1.45
SC40E 500v £1.50		SC50B 200v £1.85
		SC50D 400v £1.85
		SC50E 500v £2.25
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		Additional Types
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Type	ONE AMP (T05) P.I.V.	Price
CRS 105AF	50v	30p
CRS 110AF	100v	30p
CRS 120AF	200v	35p
CRS 140AF	400v	45p
CRS 180AF	800v	55p
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CRS 305AF	50v	40p
CRS 310AF	100v	40p
CRS 320AF	200v	45p
CRS 340AF	400v	55p
CRS 380AF	800v	65p
		FIVE AMP
CRS 5400	400v	80p
		SEVEN AMP (T048)
CRS 7100	100v	80p
CRS 7200	200v	87p
CRS 7400	400v	85p
CRS 7600	800v	85p
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CRS 16100	100v	70p
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All prices correct at time of press 10% VAT to be added to all orders (UK only) Expert & UK Manufacturers/Colleges supplied. E.&O.E.

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ELECTRONICS FOR EVERY PURPOSE

See facing page for addresses

ZENER DIODES

400 mW BZV75/BZX83. From 3.3 volt—33 volts 10p each.
1.3 watts 5% Miniature Tubulars IN4700 series. From 3.3 volt—33 volt 10p each.
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1 amp series IN4001 to IN4007. From 4p ea
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Due to rapid price changes, shortages of paper and raw materials, all prices in the existing catalogues no longer apply. Call or phone for latest prices. A new catalogue will be available for Aug/Sept. 1974.



You pay less VAT with Henry's Low Prices
Now built and used by thousands of satisfied customers. Features slim design overall size in cabinet 15 1/2" x 2 1/2" x 6 1/2" 6-IC's, 10 transistors, stabilisers. Gardeners low field transformer. Fibre Glass PC Panel, complete chassis work. Now available built and tested as well as in kit form. **HIGH QUALITY AND STABILITY ARE PRE-**

DOMINATE FEATURES—DEVELOPED BY TEXAS ENGINEERS FOR PERFORMANCE, RELIABILITY AND EASE OF CONSTRUCTION FACILITIES.

On/off switch indicator, headphones socket, separate treble, bass, volume and balance controls, scratch and rumble filters, mono/stereo switch, input selector; Mag. P.U., Radio Tuner, Aux. Can be altered for Mic., Tape, Tape-head, etc. Constructional details Ref. No. 21 30p. Distributed by Henry's throughout UK.

FREE — Teak cabinet with complete kit.

BUILD THE TEXAN

20 + 20WATT IC STEREO AMPLIFIER
As featured by *Practical Wireless* 1972



Kit Price £28.50 (+VAT+50p carr/packing) or built and tested £35.00 (+VAT+50p carr/packing), as illustrated.

BUILD THE NEW HENELEC

STEREO FM TUNER

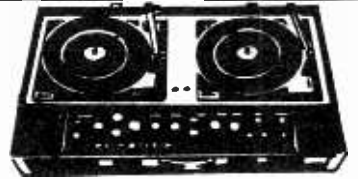
A completely new high stability stereo FM tuner. Features variable capacity diode tuning, stabiliser power supply, IC Decoder, high gain low noise, IF stages, LED indicators, Tuning meter, AFC, easy to construct and use. Mains operated. Slim modern design with fibre glass PC, teak cabinet etc. Available as a kit to build or ready built. Overall size 8" x 2 1/2" x 6 1/2". Produced to give high performance with a realistic price. (Parts list and constructional details Ref. No. 5 30p.) Henry's are sole distributors UK and Europe.



Kit price £21.00 (+VAT)
OR BUILT AND TESTED £24.95 (+VAT)

EARN YOURSELF EASY MONEY, WITH PORTABLE DISCO EQUIPMENT

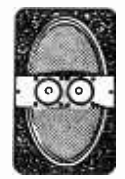
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- AKG/RESLO/DJ/CARLSBRO/EAGLE Mics, Stands, Mixers, Cabinets, Chassis and complete Speaker Systems, Megaphones, Turntables, Public Address Components.

LOW COST HI-FI SPEAKERS

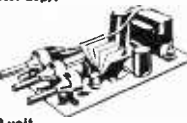
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350 20 watt C/o Tweeters 8 or 15 ohms £7.00 ea.
* Polished wood cabinet £4.00 post 35p.



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| GLENDALE 3 | £32.95 pair |
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 - E1206, 5 watt 12 volt £5.10
 - 606, 10 watt 24 volt £4.95
 - 410, 10 watt 28 volt £4.95
 - E1206, 30 watt 45 volt £9.75
 - E1210, 24 + 24 watts 12 volt £7.75
 - RE500, 5 watt IC mains operated Amplifier with controls £8.30
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 - SAC15, 15 + 15 watt Stereo with controls £14.95
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 - SP40-5 2Z40/Stereo 80/P25 £25.90
 - SP40-6 2Z40/Stereo 80/P26 £27.75
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0-01 diam. Mono Filament £1.50 per 25 metre reel.
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UHF TV TUNERS CHANNELS 21 TO 64
Brand new transistorised geared tuners for 625 line Receiver IF output. £2.50 post 20p.



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HENRY'S CATALOGUE
Due to rapid price changes, shortages of paper and raw materials, all prices in the existing catalogues no longer apply. Call or phone for latest prices. A new catalogue will be available for Aug./Sept. 1974.

GARRARD BATTERY TAPE DECK

GARRARD 2 speed 9 volt tape decks. Fitted record/play and oscillator/Eraser heads. Wind and rewind controls. Takes up to 4" spools. Brand new complete with head circuits. £9.50 carr. 30p.



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60mm stroke high quality controls complete with knobs (post, etc., 15p any quantity).
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4 TRACK MONO or 2 TRACK STEREO. 1 1/2" High impedance £2.50. 1 1/2" Medium impedance £2.30. '36' £3.00. R750/E73 2 track mono Record/Eraser, low imp. 75p pair. Erase Heads for '17', '18' and '36' £1.00. '63' 2 track mono Hi imp. £1.75. '43' Erase Head for '63' 75p. (Post etc., 15p any quantity.)

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NEW REVOLUTIONARY SUPER TESTER 600R

The complete testing system
Volts AC—11 ranges from 2V to 2500V
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Amp DC—12 ranges from 500A to 10A
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Ohms—6 ranges from one tenth of Ohm to 100MΩ
Resistance—1 range from 0 to 10MΩ
Capacity—6 ranges from 0 to 500pF and from 0 to 0.5μF and from 0 to 50-000pF
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Output Voltage—9 ranges 10V to 2500V
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PRICE £18.50

- ACCESSORIES**
- Transistor tester 11.00
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12 watt speaker Tweeter systems. 8in. Bass/Midrange and Melinex Domed HF radiator plus crossover £12.50 per pair of systems (carr./lpgs. 40p) or built into veneered cabinets, size 18x12x6 1/2in. £19.50 pair (carr. £1).

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U.K.'s largest range with discount and demonstrations for callers. Latest stock lists on request (Ref. No. 17) Phone 01-402-4736 for Barclay/Access Card Direct orders and latest prices.

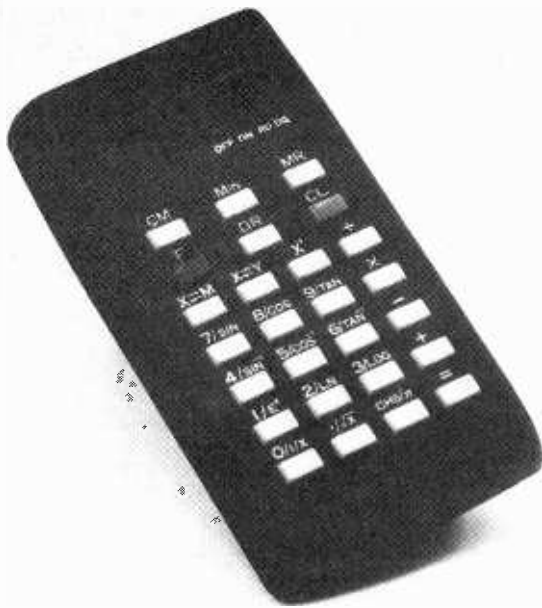
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7-day trial offer—Money-back guarantee

This fully portable scientific calculator is on special offer for a limited period. The QI 1015 is a fully proven calculator with the following functions:

Arithmetic Functions

- *4 standard (+, -, X, ÷)
- *Chain operation
- *Intermixed operation
- *Repeated operation
- *Constant operation
- *Memory operation
- *The interchange of X and Y register (X ↔ Y)
- *The interchange of X register and memory (X ↔ M)

Trigonometric Functions

- *Sine (Sin)
- *Cosine (Cos)
- *Tangent (Tan)
- *Arc sine (Sin⁻¹)
- *Arc cosine (Cos⁻¹)
- *Arc tangent (Tan⁻¹)
- *Exponential Function (E^x)
- *Natural logarithm (LN)
- *Log (Log)
- *Reciprocal (1/X)
- *Square root (√X)
- *Power (X^y)
- *PI (π)
- *Trg facility of answers in radian or degrees

General

Display: 9-digit light emitting diodes. **Capacity:** 8 digits for all factors and results in operation. **Decimal Point:** Full floating system. **Negative Numbers:** True value indication with minus sign at ninth digit. **Overflow and Error Indicator:** sign at ninth digit, indicating the result of operation is over 8 digits, or the argument of operation is out of range. **Function Mode Indicator:** (decimal point) at ninth digit indicating the scientific function mode is activated. **Battery—low indicator:** sign at ninth digit. **Operating Temperature:** 0°C–40°C. **Power Supply:** 4 x 1.5 volt batteries (SP7); 6 volt AC adaptor. **Power Consumption:** DC 0.30 watts. **Size:** 145mm x 77mm x 32.5mm. **Weight:** 207 grms. (7.29 ozs) with batteries.



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ALLOW 7/10 days for delivery

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WW—123 FOR FURTHER DETAILS



SR352



SP352

MK50250N—NEW MOSTEK ALARM CLOCK IC £6.00 + VAT = £6.60
24hr format—Alarm—Snooze—Multiplexed 4- to 6-digit display—etc. This is a high performance clock IC from Mostek Corporation at a break-through price.

BUILD AN ATTRACTIVE DIGITAL ALARM CLOCK WITH RADIO TURN-ON

A kit of all parts except case and switches for a digital alarm clock with radio turn-on using the MK50250N and highly attractive SP352, 55" displays (see above). The kits include: Building instructions, MK50250N, SP352 displays, all semiconductors, resistors and capacitors, radio turn-on relay, miniature loudspeaker for alarm, soldercon pins for IC socket, main PCB and digit mounting PCB. Both PCBs have been designed so that constructors of the 4-digit clock may easily expand their unit to 6 digits at a later date.

- 4-digit kit £26.00 + VAT = £28.60
- 6-digit kit £31.40 + VAT = £34.54

Send for free information on low-cost kits using the MK50250N with LEDs, Minitrans, etc. For details of the SP352 and other Beckman Displays available from us, see our WW April or PE June ads or send for free information.

CT5001 4-FUNCTION CALCULATOR IC £5.00 + VAT = £5.50

We have designed an exciting low-cost calculator for the amateur constructor using this device—send for free information.

SLA7.33" RED LED DIGITAL DISPLAYS plug-in replacements for DL707

- Pack of 4: 4 x £1.70 £6.80 + VAT = £7.48
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MM5316N ALARM CLOCK IC £15.00 + VAT = £16.50

RCA TA8055T LIQUID CRYSTAL DISPLAY (Note: Extended delivery)

- Transmissive 4-digit clock-format, similar to AN4132; supplied with socket. £11.60 + VAT = £12.76

MM5316N + TA8055T (Extended delivery)

- together, ONLY £21.00 + VAT = £23.10

PCB for P.E. Digital Clock with RCA L-C £1.50 + VAT = £1.65

N.B. CONSTRUCTORS OF THE P.E. DIGITAL CLOCK. With minor modifications an RCA Liquid Crystal may be substituted for the Siemens Liquid Crystal, and RCA L-Cs bought from us will include clear instructions on how this may be done.

Data supplied with all devices. Also available separately at 10p per device
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WW—124 FOR FURTHER DETAILS

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a high quality colour television receiver.

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*less cabinet, which can be manufactured yourself from normal DIY sources.

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WW—125 FOR FURTHER DETAILS

THE NEW NELSON-JONES FM TUNER

**PUSH-BUTTON VARICAP DIODE TUNING
(6 Position)** (WW' JUNE '73)



Exclusive Designer Approved Kits

What are the important features to look for in an FM tuner kit? Naturally it must have an attractive appearance when built, but it must also embody the latest and best in circuit design such as:—

- MOSFET** Front end for excellent cross modulation performance and low noise.
- 3 GANG VARICAP** Tuning for high selectivity
- CERAMIC** tuning diodes in back to back configuration for low distortion.
- INTEGRATED** IF filters for defined IF response.
- circuit IF amplifiers for reliability and excellent limiting/AM rejection.

- PHASE LOCKED** Stereo decoder with Stereo mute, see below.
- LED** fine tuning indicators.
- PUSH BUTTON** tuning (with AFC disable) over the whole FM band.
- IC STABILISED** and S/C protected power supply.
- CABINET** veneered inside and out.

The Nelson-Jones Tuner has all of these features and many more, and more importantly the design is fully proven not just with a few prototypes but with many thousands of working tuners spread across the world.

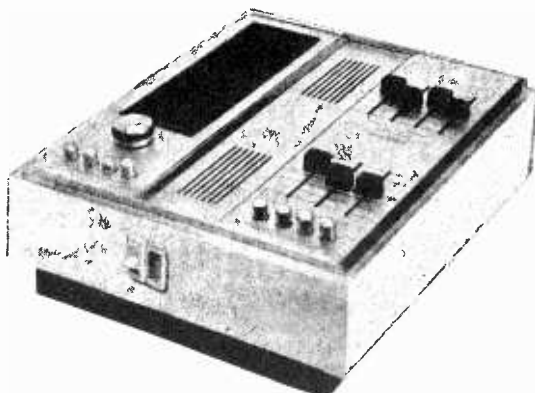
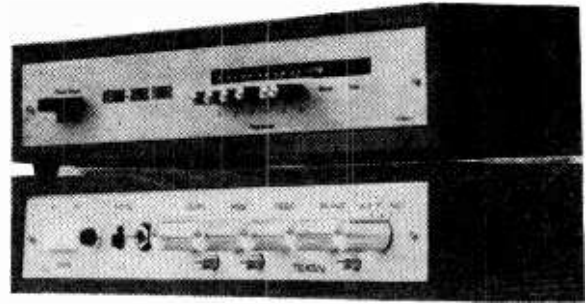
Type Specn: 20 dB quieting 0.75uV. Image rejection —70dB.I.F. Rejection —85 dB

Basic tuner module prices start as low as £10.79, with complete kits starting at £23.95 (mono) + PP 50p. and of course all components are available separately. Our low cost alignment service is available to customers without access to a signal generator. Please send large SAE for our latest price lists which detail all of the many options and special low prices for complete kits. All our other products remain available. PORTUS AND HAYWOOD PHASE LOCKED DECODER (W.W. Sept. '70). Still the lowest distortion P.L. decoder available. THD typically 0.05% (at Nelson-Jones Tuner O/P level) I Supplied complete with Red LED. Price £5.50 when bought with a complete N-J tuner kit or £7.68 if bought separately (P.P. 19p.)

PLEASE NOTE. Existing tuners are readily convertible and kits/parts are available for this purpose.

TEXAN AMPLIFIER. We have designed the tuner case and metalwork to match the Texan amplifier (see photograph). Complete designer approved Texan kits are available at £28.50 plus p.p 50p including Teak Sleeve.

Available Shortly: Varicap tuner using Mullard LP1186 module—no alignment required. Image Rejection —40dB. I.F. Rejection —65dB.



THE RONDO QUADRAPHONIC SYSTEM (20 WATTS/CHANNEL)

Complete designer approved kits for this outstanding Quadraphonic Sound System ('P.E.' Sep. '73, etc.) with the following features:—

- ★ SWITCHING FACILITIES AND MODULES FOR SQ, QS AND CD4.
- ★ COMPLETE LOUDSPEAKER ENCLOSURE DESIGN.
- ★ INDIVIDUAL KITS MAY BE INCORPORATED IN EXISTING EQUIPMENT.
- ★ LOW COST, FULLY ENGINEERED, INTEGRAL DESIGN.
- ★ COMPLETE LOUDSPEAKER SYSTEMS AVAILABLE.
- ★ MODULAR BUILT IN-AM/FM RADIO.
- ★ KITS AVAILABLE AS PUBLISHED—SEE BELOW.

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PREAMPLIFIER BOARD	Complete Kit	£3.00	Post Free	VAT Extra
MASTER VOL./TONE/BALANCE BOARD	Complete Kit	£8.50	Post Free	VAT Extra
POWER AMP. BOARD AND HEATSINK <small>STEREO PAIR</small>	Complete Kit per Board	£7.50	Post Free	VAT Extra
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Panel mounting LED's.		7 Seg LED's	
RED	1-9	29p	10-24 23p
GREEN	1-9	59p	10-24 49p

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071 14472	10	4700	2.5 amps	1oz	15p
071 14682	10	6800	4 amps	1oz	17p
071 15332	16	3300	2.4 amps	1oz	15p
071 15472	16	4700	3.9 amps	1oz	17p
071 15682	16	6800	5.8 amps	1½oz	22p
071 14113	10	11000 + 11000	10.6 amps	3oz	37p
072 14173	10	16500 + 16500	13.4 amps	4oz	49p
072 15752	16	7500 + 7500	10.5 amps	3oz	37p
072 15113	16	11000 + 11000	13.8 amps	4½oz	49p
072 16592	25	5000 + 5000	9.6 amps	3½oz	37p
072 16752	25	7500 + 7500	12.6 amps	4½oz	49p
071 18681	63	680	2.1 amps	1oz	15p

Please calculate the weight of your order and include appropriate postage.

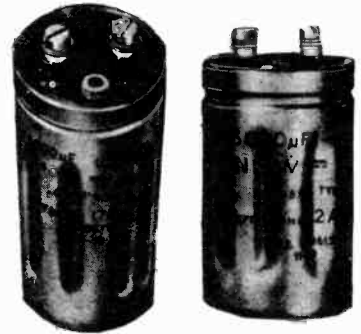
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2lb	22p
4lb	27p
6lb	32p
8lb	37p
10lb	42p
14lb	52p
18lb	62p
22lb	72p

106 and 107 Series

106 14153	10	15000	7 amps	4oz	57p
106 17103	40	10000	12 amps	7½oz	94p
107 10222	100	2200	10 amps	5½oz	74p

Type No.	Voltage	Capacitance	Weight	Price
102 15163	16	16000	8oz	20p
104 90003	20	39000	16oz	30p
102 16802	25	9000	7oz	25p
104 90001	45	20000	16oz	50p

A discount of 10% may be deducted from above prices on lots of 100 of any one type.



SMALL ELECTROLYTICS

Ref. No.	Capacity	Voltage	Price
H8/2	2.2 μ f	25v	4p
H8/2A	3.3 μ f	25v	4p
H8/3	3 μ f	50v	4p
H8/3A	4 μ f	50v	4p
H8/4	4.7 μ f	25v	4p
H8/4A	5 μ f	64v	4p
H8/5	5 μ f	10v	4p
H8/5A	5 μ f	150v	4p
H8/6A	10 μ f	10v	4p
H8/7	10 μ f	70v	4p
H8/8	16 μ f	35v	4p
H8/8A	16 μ f	16v	4p
H8/9	20 μ f	6v	2p
H8/9A	20 μ f	70v	4p
H8/10	22 μ f	50v	4p
H8/10A	22 μ f	100v	4p
H8/11	25 μ f	12v	4p
H8/12	32 μ f	15v	4p
H8/12A	30 μ f	10v	4p
H8/13A	32 μ f	50v	4p
H8/14	40 μ f	25v	5p
H8/14A	40 μ f	16v	4p
H8/15	47 μ f	50v	4p
H8/15A	40 μ f	35v	4p
H7/1	50 μ f	6v	3p
H7/1A	50 μ f	10v	4p
H7/2A	64 μ f	2.5v	2p

Ref. No.	Capacity	Voltage	Price
H7/3A	64 μ f	25v	4p
H7/4	64 μ f	15v	4p
H7/4A	64 μ f	35v	5p
H7/5	80 μ f	16v	4p
H7/7	100 μ f	25v	4p
H7/8	125 μ f	16v	5p
H7/8A	100 μ f	35v	6p
H7/9	100 μ f	63v	6p
H7/9A	125 μ f	4v	4p
H7/10	125 μ f	25v	6p
H7/10A	160 μ f	2.5v	3p
H7/11	160 μ f	25v	6p
H7/11A	150 μ f	16v	5p
H7/13A	200 μ f	25v	8p
H7/14	220 μ f	50v	10p
H7/15	220 μ f	25v	5p
H7/15A	220 μ f	35v	10p
H6/1A	250 μ f	4v	3p
H6/2A	320 μ f	2.5v	3p
H6/4	320 μ f	10v	4p
H6/4A	330 μ f	16v	5p
H6/5	330 μ f	25v	10p
H6/5A	330 μ f	35v	15p
H6/6	470 μ f	25v	10p
H6/8A	470 μ f	35v	20p
H6/9A	400 μ f	40v	20p
H6/13A	1000 μ f	25v	16p

NEW! NEW! NEW! NEW!

An aerosol spray providing a convenient means of producing any number of copies of a printed circuit both simply and quickly.

Method: Spray copper laminate board with light sensitive spray. Cover with transparent film upon which circuit has been drawn. Expose to light. (No need to use ultra-violet.) Spray with developer, rinse and etch in normal manner.

Light sensitive aerosol spray £1.00 plus Developer and Etchant 50p postage

Copper-clad Fibre-glass Board—50p sq. ft. (max. 3' x 4')

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Fibre Glass Board pre-treated with light-sensitive lacquer enabling you to produce prototype printed circuits within five minutes.

75mm x 100mm	33p
150mm x 100mm	66p
150mm x 200mm	£1.32
250mm x 200mm	£2.20

SILICON P.N.P.	Type	Frequency	Price
BCY 71	45	200 MHz	12p
BFS 92	100	70 MHz	20p
BFS 95	40	70 MHz	17p
BFX 12	25	210 MHz	10p
2N 2906	60	200 MHz	15p
2N 3702	40	100 MHz	11p
2N 3703	50	100 MHz	12p

SILICON P.N.P.	Type	Frequency	Price
2N 3053	60	100 MHz	17p
2N 3707	30	900 MHz	12p
2N 5179	20	900 MHz	40p

GERMANIUM P.N.P.	Type	Frequency	Price
ACY 44	50	1 MHz	10p
ADY 26	80	75 watts	£1
AF 124	20	75 MHz	20p
AFY 19	32	350 MHz	20p
ASZ 21	25	5 MHz	10p
ASZ 21	15	450 MHz	20p
GET 113	32	2 watts	10p
GET 120	32	1 MHz	10p
OC 123	50	1 MHz	10p
QCP 70	Light-sensitive	20p	
2N 1307	30	10 MHz	15p
2N 1309	30	15 MHz	15p
2N 443	60	150 watts	£1

HIGH FREQUENCY POWER	Type	Power	Price
BFR 64	40	1,200 MHz	£1
BLY 89A	35	650 MHz	£5
BLY 93A	60	500 MHz	£5
BLY 218	36	1,200 MHz	£2
2N 709	15	800 MHz	15p
2N 3926	36	250 MHz	£1

MICROWAVE DEVICES	Type	Price
CL 8300	Gunn effect oscillator	9.4 GHz £40
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CL 8380	ditto	10.5 GHz £10
CL 8390	ditto	11.5 GHz £10
CL 8430	ditto	9.35 GHz £40
CL 8450	ditto	9.35 GHz £40
CL 8470	ditto	9.35 GHz £40
BXY 27	Varactor Diode. "S" Band. Cut-off	70 GHz £1
BXY 28	Varactor Diode. Cut-off	100 GHz £1
BXY 32	Frequency Multiplier. "X" Band	150 GHz £1
BXY 35A/C	ditto	25 GHz £1
BXY 36C/D	ditto	75 GHz £1
BXY 37C/D	ditto	100 GHz £1
BXY 38C/E	ditto	120 GHz £1
BXY 39C/D	ditto	150 GHz £1
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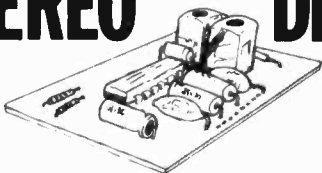
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STEREO DECODER

£4.95



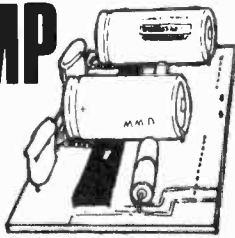
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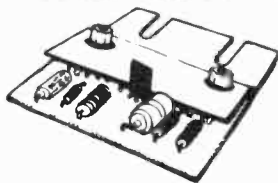
3 W_{R.M.S.} I.C. AMP

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On P.C. Board with all components or 2 on one board for £2.86. Order Code I.C.A. 1/S. These amps. are supplied with a free booklet on connecting up, specifications and easy to build projects using the I.C.A. 1.



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5W ONLY £1.98
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These matchbox size amplifiers have an exceptionally good tone and quality for the price. They are only 2¼" x 1¾". The 5W amp will run from a 12V car battery making it very suitable for portable voice reinforcement such as public functions. Two amplifiers are ideal for stereo. Complete connection details and treble, bass, volume and balance control circuit diagrams are supplied with each unit. Discounts are available for quantity orders. More details on request. **Cheapest in the U.K. Built and tested.**

Now available for 5 & 10W AMPS

Pre-assembled printed circuit boards 2" x 3" available in stereo only, will fit .15 edge connector.

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I enclose £ _____ for _____ for
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 _____ Stereo Pre-Amps 2 _____ Stereo Tone Controls
 (Please insert quantities and delete those not applicable)
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SAFETY MAINS ISOLATING TRANSFORMERS

Ref. No.	VA (Watts)	Weight lb oz	Size cm.	£	P & P
149	60	3 12	7.0x7.0x6.0	2.55	30
150	100	5 8	9.9x7.7x8.6	3.79	36
151	200	8 0	9.9x8.9x8.6	4.17	52
152	250	13 12	12.1x11.8x10.2	7.09	52
153	350	15 0	12.1x11.8x10.2	9.25	67
154	500	19 8	14.0x13.4x11.8	12.32	82
155	750	29 0	17.2x14.0x14.0	24.31	*
156	1000	38 0	17.2x16.6x14.0	29.87	*
158	2000	60 0	21.6x15.3x18.1	49.25	*
159	3000	85 0	23.5x17.8x19.7	76.53	*
160	6000	78 0	35.0x20.4x29.3	125.89	*



AUTO TRANSFORMERS

Ref. No.	VA (Watts)	Weight lb oz	Size cm.	Auto Taps	£	P & P
63	20	1 0	5.8x5.1x4.5	0-115-210-240	1.34	22
64	75	2 4	7.0x6.7x6.1	0-115-210-240	2.64	36
4	150	3 4	8.9x7.7x7.7	0-115-200-220-240	3.18	36
66	300	6 4	9.9x9.6x8.6	"	6.19	52
67	500	12 8	12.1x11.2x10.2	"	9.20	67
68	1000	19 8	14.0x13.4x11.8	"	16.71	82
93	1500	30 4	14.0x15.9x14.3	"	24.19	*
95	2000	32 0	17.2x16.6x14.0	"	31.57	*
73	3000	40 0	21.6x13.4x18.1	"	39.17	*

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115V 500VA cased transformer, with mains lead and two 115V outlet sockets, £9.49. P & P 7p. A 20 Watt version. £2.02. P & P 22p.

LOW VOLTAGE TRANSFORMERS

Ref. No.	Amperes	Weight lb oz	Size cm.	Secondary Windings	£	P & P
111	0.5	0 25	4.8x2.9x3.5	0-12V at 0.25A x2	1.34	22
113	1.0	0 5	6.1x5.8x4.8	0-12V at 0.5A x2	1.58	22
71	2	1 12	7.0x6.6x6.1	0-12V at 1A x2	2.09	22
18	4	2 12	8.3x7.7x7.0	0-12V at 2A x2	2.95	36
70	6	3 3 8	8.9x8.0x7.7	0-12V at 3A x2	3.52	42
08	8	4 5 8	9.9x8.9x8.6	0-12V at 4A x2	3.96	52
72	10	5 6 4	9.9x9.6x8.6	0-12V at 5A x2	4.67	52
116	12	6 12	9.9x10.2x8.6	0-12V at 5A x2	5.61	52
17	16	8 9 12	12.1x9.9x10.4	0-12V at 8A x2	7.22	52
115	20	10 18 8	14.0x9.6x11.6	0-12V at 10A x2	9.20	67
187	30	15 15 8	14.0x12.1x11.6	0-12V at 15A x2	16.94	82
226	60	30 32 0	17.2x15.3x14.0	0-12V at 30A x2	31.28	*

30 VOLT RANGE

Ref. No.	Amperes	Weight lb oz	Size cm.	Secondary Taps	£	P & P
112	0.5	0 5	6.1x5.8x4.3	0-12-15-20-24-30V	1.56	22
79	1.0	1 0	7.0x6.7x6.4	"	2.11	36
3	2.0	3 4	8.9x7.7x7.7	"	3.18	36
20	3.0	4 8	9.9x8.3x8.5	"	3.96	42
21	4.0	6 4	9.9x9.6x8.5	"	4.67	52
51	5.0	6 12	12.1x8.6x10.2	"	5.83	52
117	6.0	8 0	12.1x9.3x10.2	"	6.94	52
88	8.0	12 0	12.1x11.8x10.2	"	9.00	67
89	10.0	13 12	14.0x10.2x11.6	"	11.36	67

Ref. No.	Amperes	Weight lb oz	Size cm.	Secondary Taps	£	P & P
102	0.5	1 12	7.0x6.4x6.1	0-19-25-33-40-50V	2.09	30
103	1.0	2 12	8.3x7.4x7.0	"	3.08	36
104	2.0	5 8	9.9x8.9x8.6	"	4.28	42
105	3.0	6 12	9.9x10.2x8.6	"	5.79	52
106	4.0	10 0	12.1x10.5x10.2	"	7.69	52
107	6.0	12 0	14.0x10.2x11.8	"	11.38	67
118	8.0	18 0	14.0x12.7x11.8	"	12.40	97
119	10.0	25 0	17.2x12.7x14.0	"	18.62	*

Ref. No.	Amperes	Weight lb oz	Size cm.	Secondary Taps	£	P & P
124	0.5	2 4	7.0x6.7x6.1	0-24-30-40-48-60V	2.12	36
126	1.0	3 4	8.9x7.7x7.7	"	2.97	36
127	2.0	6 4	9.9x9.6x8.6	"	4.67	42
125	3.0	8 12	12.1x9.9x10.2	"	7.11	52
123	4.0	13 12	12.1x11.8x10.2	"	9.29	67
40	5.0	12 0	14.0x10.2x11.8	"	10.83	67
120	6.0	15 8	14.0x12.1x11.8	"	13.35	82
121	8.0	25 0	14.0x14.7x11.8	"	15.01	*
122	10.0	25 0	17.2x12.7x11.0	"	22.10	*
189	12.0	29 0	17.2x14.0x11.0	"	24.74	*

MINIATURE TRANSFORMERS WITH SCREENS

Ref. No.	MA	Weight lb oz	Size cm.	VOLTS	£	P & P
238	200	2	2.8x2.6x2.0	3-0-3	1.44	10
212	1A 1A	1 4	6.1x5.8x4.8	0-6-0-6	1.67	22
13	100	4	3.9x2.6x2.9	9-0-9	1.23	10
235	330, 330	4	4.8x2.9x3.5	0-9-0-9	1.67	10
207	500, 500	1 00	6.1x5.4x4.8	0-8.9-0-8.9	2.23	22
208	1A, 1A	1 12	7.0x6.6x6.1	0-8.9-0-8.9	3.00	30
236	200, 200	4	4.8x2.9x3.5	0-15-0-15	1.87	10
214	300, 300	1 4	6.1x5.8x4.8	0-20-0-20	1.76	22
221	700 (D.C.)	1 8	7.0x6.1x6.1	20-12-0-12-20	3.55	30
206	1A, 1A	2 12	8.3x7.7x7.7	0-15-20-0-15-20	4.05	38
203	500, 500	2 4	8.3x7.7x7.7	0-15-27-0-15-27	3.10	38
204	1A, 1A	3 4	8.9x7.7x7.7	0-15-27-0-15-27	3.15	38

BATTERY CHARGER TYPES

Ref. No.	Amperes	Weight lb oz	Size cm.	Secondary 2V, 6V, 12V	£	P & P
45	1.5	1 8	7.0x6.1x6.1		1.61	30
5	4.0	3 4	8.9x7.7x7.7		2.93	42
86	6.0	6 4	9.9x9.6x8.6		4.40	52
146	8.0	6 12	9.9x10.2x8.6		5.02	52
50	12.5	12 0	14.0x10.2x11.8		7.53	67

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0.068, 0.1, 0.15
0.22, **5p**, 0.33, **7p**, 0.47, **8p**, 0.68, **11p**, 1.0, **14p**, 1.5, **21p**, 2.2, **24p**

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0.1, 0.22, 0.47, 1.0 mF/35V ea. **13p**
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10/25V, 22/16V, 47/6.3V, 100/3V ea. **18p**

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WORKING VOLTAGE 100V d.c.

0.1; 0.12; 0.15 4p; 0.18 5p; 0.22 6p; 0.27 7p; 0.33 8p; 0.39; 0.47 9p; 0.56 12p; 0.68 13p

SILVERED MICA

Working voltage 500V d.c.
Values in pF—2.2 to 820 in 32 stages ea. **6p**
1000, 1500 7p; 1800 8p; 2200 10p; 2700, 3600 12p; 4700, 5000 15p; 6800 20p; 8200, 10,000 25p

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- Miniature 3.5mm 2 circuit, (black) 2 break contacts S6/BB **9p**

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- side entry SEP1 **36p**
- Line socket mono 231 **40p**
- Line socket stereo 244 **45p**
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- 3 circuit screen top entry P3 **53p**
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Code	Watts	Ohms	1 to 9	10 to 99	100 up
C	1/3	4.7-470K	1.3	1.1	0.9 nett
C	1/2	4.7-10M	1.3	1.1	0.9 nett
C	3/4	4.7-10M	1.5	1.2	0.9 nett
C	1	4.7-10M	3.2	2.5	1.9 nett
MO	1/2	10-1M	4	3.3	2.3 nett
WW	1	0.22-3.9Ω	9	9	8
WW	3	1-10K	7	7	6
WW	7	1-10K	9	9	8

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2.2	—	—	—	—	—	—	—	8p
4.7	—	—	—	11p	—	—	—	8p
10	—	—	—	—	8p	—	—	8p
22	—	—	—	—	—	8p	—	8p
47	8p	—	—	—	—	—	8p	10p
100	9p	8p	8p	8p	8p	8p	10p	12p
220	8p	8p	8p	10p	10p	11p	17p	28p
470	9p	10p	10p	11p	13p	17p	24p	45p
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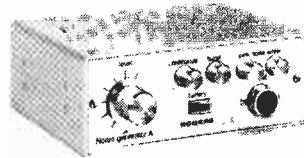


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AC126 0-19	AF116 0 27	BC156 0-13	BD138 0 50	BF195 0-13	OC20 0-70	2G372 0-13	2N2222 0-22	2N3093 0-16	2N4285 0-19
AC127 0-20	AF117 0 27	BC159 0-13	BD139 0 61	BF196 0-13	OC21 0-54	2G373 0-19	2N2265 0-19	2N3094 0-18	2N4286 0-19
AC128 0-20	AF118 0 33	BC160 0-50	BD140 0 66	BF197 0-18	OC22 0-52	2G374 0-19	2N2369 0-16	2N3095 0-18	2N4287 0-19
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AC134 0-16	AF125 0 33	BC167 0-13	BD175 0 66	BF222 1-05	OC25 0-42	2G378 0-18	2N2411 0-27	2N3403 0-23	2N4289 0-19
AC137 0-16	AF126 0 31	BC168 0-13	BD176 0 66	BF227 0-50	OC26 0-32	2G381 0-18	2N2412 0-27	2N3404 0-31	2N4290 0-19
AC141 0-20	AF127 0 31	BC169 0-13	BD177 0 72	BF228 0-66	OC28 0-55	2G382 0-18	2N2416 0-52	2N3406 0-48	2N4291 0-19
AC141K 0-32	AF128 0 55	BC170 0-13	BD178 0 72	BF229 0-66	OC29 0-55	2G401 0-33	2N2711 0-23	2N3414 0-17	2N4292 0-19
AC142 0-20	AF128 0 55	BC171 0-16	BD179 0 77	BF282 0-61	OC32 0-46	2G412 0-33	2N2712 0-23	2N3415 0-17	2N4293 0-19
AC143 0-20	AF129 0 55	BC172 0-16	BD180 0 77	BF263 0-61	OC35 0-46	2G417 0-28	2N2714 0-23	2N3416 0-31	2N4294 0-19
AC142K 0-28	AF178 0 55	BC173 0-18	BD185 0 72	BF270 0-39	OC36 0-62	2G420 0-33	2N2904 0-19	2N3417 0-31	2N4295 0-19
AC151 0-17	AF180 0 55	BC174 0-18	BD186 0 72	BF271 0-33	OC42 0-27	2N388 0-39	2N2904A 0-23	2N3525 0-33	2N4296 0-19
AC154 0-22	AF181 0 55	BC175 0-24	BD187 0 77	BF272 0-38	OC44 0-17	2N404 0-22	2N2905 0-23	2N3525 0-33	2N4297 0-19
AC155 0-22	AF182 0 55	BC177 0-13	BD188 0 77	BF273 0-39	OC45 0-14	2N404A 0-22	2N2906 0-17	2N3526 0-33	2N4298 0-19
AC156 0-22	AF183 0 55	BC178 0-21	BD189 0 83	BF274 0-39	OC45 0-14	2N404A 0-22	2N2907 0-22	2N3527 0-33	2N4299 0-19
AC157 0-22	AF184 0 55	BC179 0-21	BD190 0 83	BF275 0-39	OC70 0-11	2N404A 0-22	2N2908 0-20	2N3528 0-33	2N4300 0-19
AC158 0-22	AF185 0 55	BC180 0-27	BD196 0 94	BF276 0-39	OC72 0-16	2N404A 0-22	2N2909 0-22	2N3529 0-33	2N4301 0-19
AC159 0-27	AF186 0 55	BC181 0-27	BD196 0 94	BF277 0-39	OC74 0-16	2N404A 0-22	2N2910 0-22	2N3530 0-33	2N4302 0-19
AC160 0-27	AF187 0 55	BC182 0-11	BD197 0 99	BF278 0-39	OC75 0-17	2N404A 0-22	2N2911 0-22	2N3531 0-33	2N4303 0-19
AC161 0-27	AF188 0 55	BC183 0-11	BD198 0 99	BF279 0-39	OC76 0-17	2N404A 0-22	2N2912 0-22	2N3532 0-33	2N4304 0-19
AC162 0-27	AF189 0 55	BC184 0-11	BD199 0 05	BF280 0-39	OC77 0-28	2N404A 0-22	2N2913 0-16	2N3533 0-33	2N4305 0-19
AC163 0-27	AF190 0 55	BC185 0-11	BD200 0 05	BF281 0-39	OC77 0-28	2N404A 0-22	2N2914 0-16	2N3534 0-33	2N4306 0-19
AC164 0-27	AF191 0 55	BC186 0-11	BD200 0 05	BF282 0-39	OC81 0-17	2N404A 0-22	2N2915 0-16	2N3535 0-33	2N4307 0-19
AC165 0-27	AF192 0 55	BC187 0-11	BD205 0 88	BF283 0-39	OC82 0-17	2N404A 0-22	2N2916 0-16	2N3536 0-33	2N4308 0-19
AC166 0-27	AF193 0 55	BC188 0-11	BD205 0 88	BF284 0-39	OC82 0-17	2N404A 0-22	2N2917 0-16	2N3537 0-33	2N4309 0-19
AC167 0-27	AF194 0 55	BC189 0-11	BD205 0 88	BF285 0-39	OC82 0-17	2N404A 0-22	2N2918 0-16	2N3538 0-33	2N4310 0-19
AC168 0-27	AF195 0 55	BC190 0-11	BD205 0 88	BF286 0-39	OC82 0-17	2N404A 0-22	2N2919 0-16	2N3539 0-33	2N4311 0-19
AC169 0-16	AF196 0 55	BC191 0-11	BD205 0 88	BF287 0-39	OC82 0-17	2N404A 0-22	2N2920 0-16	2N3540 0-33	2N4312 0-19
AC170 0-16	AF197 0 55	BC192 0-11	BD205 0 88	BF288 0-39	OC82 0-17	2N404A 0-22	2N2921 0-16	2N3541 0-33	2N4313 0-19
AC171 0-22	AF198 0 55	BC193 0-11	BD205 0 88	BF289 0-39	OC82 0-17	2N404A 0-22	2N2922 0-16	2N3542 0-33	2N4314 0-19
AC172 0-22	AF199 0 55	BC194 0-11	BD205 0 88	BF290 0-39	OC82 0-17	2N404A 0-22	2N2923 0-16	2N3543 0-33	2N4315 0-19
AC173 0-22	AF200 0 55	BC195 0-11	BD205 0 88	BF291 0-39	OC82 0-17	2N404A 0-22	2N2924 0-16	2N3544 0-33	2N4316 0-19
AC174 0-22	AF201 0 55	BC196 0-11	BD205 0 88	BF292 0-39	OC82 0-17	2N404A 0-22	2N2925 0-16	2N3545 0-33	2N4317 0-19
AC175 0-22	AF202 0 55	BC197 0-11	BD205 0 88	BF293 0-39	OC82 0-17	2N404A 0-22	2N2926 0-16	2N3546 0-33	2N4318 0-19
AC176 0-22	AF203 0 55	BC198 0-11	BD205 0 88	BF294 0-39	OC82 0-17	2N404A 0-22	2N2927 0-16	2N3547 0-33	2N4319 0-19
AC177 0-22	AF204 0 55	BC199 0-11	BD205 0 88	BF295 0-39	OC82 0-17	2N404A 0-22	2N2928 0-16	2N3548 0-33	2N4320 0-19
AC178 0-31	AF205 0 55	BC200 0-11	BD205 0 88	BF296 0-39	OC82 0-17	2N404A 0-22	2N2929 0-16	2N3549 0-33	2N4321 0-19
AC179 0-31	AF206 0 55	BC201 0-11	BD205 0 88	BF297 0-39	OC82 0-17	2N404A 0-22	2N2930 0-16	2N3550 0-33	2N4322 0-19
AC180 0-32	AF207 0 55	BC202 0-11	BD205 0 88	BF298 0-39	OC82 0-17	2N404A 0-22	2N2931 0-16	2N3551 0-33	2N4323 0-19
AC181 0-32	AF208 0 55	BC203 0-11	BD205 0 88	BF299 0-39	OC82 0-17	2N404A 0-22	2N2932 0-16	2N3552 0-33	2N4324 0-19
AC182 0-32	AF209 0 55	BC204 0-11	BD205 0 88	BF300 0-39	OC82 0-17	2N404A 0-22	2N2933 0-16	2N3553 0-33	2N4325 0-19
AC183 0-32	AF210 0 55	BC205 0-11	BD205 0 88	BF301 0-39	OC82 0-17	2N404A 0-22	2N2934 0-16	2N3554 0-33	2N4326 0-19
AC184 0-32	AF211 0 55	BC206 0-11	BD205 0 88	BF302 0-39	OC82 0-17	2N404A 0-22	2N2935 0-16	2N3555 0-33	2N4327 0-19
AC185 0-32	AF212 0 55	BC207 0-11	BD205 0 88	BF303 0-39	OC82 0-17	2N404A 0-22	2N2936 0-16	2N3556 0-33	2N4328 0-19
AC186 0-32	AF213 0 55	BC208 0-11	BD205 0 88	BF304 0-39	OC82 0-17	2N404A 0-22	2N2937 0-16	2N3557 0-33	2N4329 0-19
AC187 0-32	AF214 0 55	BC209 0-11	BD205 0 88	BF305 0-39	OC82 0-17	2N404A 0-22	2N2938 0-16	2N3558 0-33	2N4330 0-19
AC188 0-32	AF215 0 55	BC210 0-11	BD205 0 88	BF306 0-39	OC82 0-17	2N404A 0-22	2N2939 0-16	2N3559 0-33	2N4331 0-19
AC189 0-32	AF216 0 55	BC211 0-11	BD205 0 88	BF307 0-39	OC82 0-17	2N404A 0-22	2N2940 0-16	2N3560 0-33	2N4332 0-19
AC190 0-32	AF217 0 55	BC212 0-11	BD205 0 88	BF308 0-39	OC82 0-17	2N404A 0-22	2N2941 0-16	2N3561 0-33	2N4333 0-19
AC191 0-32	AF218 0 55	BC213 0-11	BD205 0 88	BF309 0-39	OC82 0-17	2N404A 0-22	2N2942 0-16	2N3562 0-33	2N4334 0-19
AC192 0-32	AF219 0 55	BC214 0-11	BD205 0 88	BF310 0-39	OC82 0-17	2N404A 0-22	2N2943 0-16	2N3563 0-33	2N4335 0-19
AC193 0-32	AF220 0 55	BC215 0-11	BD205 0 88	BF311 0-39	OC82 0-17	2N404A 0-22	2N2944 0-16	2N3564 0-33	2N4336 0-19
AC194 0-32	AF221 0 55	BC216 0-11	BD205 0 88	BF312 0-39	OC82 0-17	2N404A 0-22	2N2945 0-16	2N3565 0-33	2N4337 0-19
AC195 0-32	AF222 0 55	BC217 0-11	BD205 0 88	BF313 0-39	OC82 0-17	2N404A 0-22	2N2946 0-16	2N3566 0-33	2N4338 0-19
AC196 0-32	AF223 0 55	BC218 0-11	BD205 0 88	BF314 0-39	OC82 0-17	2N404A 0-22	2N2947 0-16	2N3567 0-33	2N4339 0-19
AC197 0-32	AF224 0 55	BC219 0-11	BD205 0 88	BF315 0-39	OC82 0-17	2N404A 0-22	2N2948 0-16	2N3568 0-33	2N4340 0-19
AC198 0-32	AF225 0 55	BC220 0-11	BD205 0 88	BF316 0-39	OC82 0-17	2N404A 0-22	2N2949 0-16	2N3569 0-33	2N4341 0-19
AC199 0-32	AF226 0 55	BC221 0-11	BD205 0 88	BF317 0-39	OC82 0-17	2N404A 0-22	2N2950 0-16	2N3570 0-33	2N4342 0-19
AC200 0-32	AF227 0 55	BC222 0-11	BD205 0 88	BF318 0-39	OC82 0-17	2N404A 0-22	2N2951 0-16	2N3571 0-33	2N4343 0-19
AC201 0-32	AF228 0 55	BC223 0-11	BD205 0 88	BF319 0-39	OC82 0-17	2N404A 0-22	2N2952 0-16	2N3572 0-33	2N4344 0-19
AC202 0-32	AF229 0 55	BC224 0-11	BD205 0 88	BF320 0-39	OC82 0-17	2N404A 0-22	2N2953 0-16	2N3573 0-33	2N4345 0-19
AC203 0-32	AF230 0 55	BC225 0-11	BD205 0 88	BF321 0-39	OC82 0-17	2N404A 0-22	2N2954 0-16	2N3574 0-33	2N4346 0-19
AC204 0-32	AF231 0 55	BC226 0-11	BD205 0 88	BF322 0-39	OC82 0-17	2N404A 0-22	2N2955 0-16	2N3575 0-33	2N4347 0-19
AC205 0-32	AF232 0 55	BC227 0-11	BD205 0 88	BF323 0-39	OC82 0-17	2N404A 0-22	2N2956 0-16	2N3576 0-33	2N4348 0-19
AC206 0-32	AF233 0 55	BC228 0-11	BD205 0 88	BF324 0-39	OC82 0-17	2N404A 0-22	2N2957 0-16	2N3577 0-33	2N4349 0-19
AC207 0-32	AF234 0 55	BC229 0-11	BD205 0 88	BF325 0-39	OC82 0-17	2N404A 0-22	2N2958 0-16	2N3578 0-33	2N4350 0-19
AC208 0-32	AF235 0 55	BC230 0-11	BD205 0 88	BF326 0-39	OC82 0-17	2N404A 0-22	2N2959 0-16	2N3579 0-33	2N4351 0-19
AC209 0-32	AF236 0 55	BC231 0-11	BD205 0 88	BF327 0-39	OC82 0-17	2N404A 0-22	2N2960 0-16	2N3580 0-33	2N4352 0-19
AC210 0-32	AF237 0 55	BC232 0-11	BD205 0 88	BF328 0-39	OC82 0-17	2N404A 0-22	2N2961 0-16	2N3581 0-33	2N4353 0-19
AC211 0-32	AF238 0 55	BC233 0-11	BD205 0 88	BF329 0-39	OC82 0-17	2N404A 0-22	2N2962 0-16	2N3582 0-33	2N4354 0-19
AC212 0-32	AF239 0 55	BC234 0-11	BD205 0 88	BF330 0-39	OC82 0-17	2N404A 0-22	2N2963 0-16	2N3583 0-33	2N4355 0-19
AC213 0-32	AF240 0 55	BC235 0-11	BD205 0 88	BF331 0-39	OC82 0-17	2N404A 0-22	2N2964 0-16	2N3584 0-33	2N4356 0-19
AC214 0-32	AF241 0 55	BC236 0-11	BD205 0 88	BF332 0-39	OC82 0-17	2N404A 0-22	2N2965 0-16	2N3585 0-33	2N4357 0-19
AC215 0-32	AF242 0 55	BC237 0-11	BD205 0 88	BF333 0-39	OC82 0-17	2N404A 0-22	2N2966 0-16	2N3586 0-33	2N4358 0-19
AC216 0-32	AF243 0 55</								

-the lowest prices!

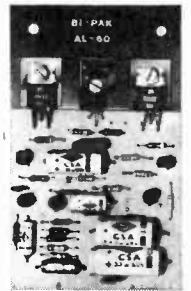
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SN7416	0.48	0.44	0.42	SN7488	£3.50	£3.40	£3.30	SN74166	£2.20	£2.10	£2.00
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SN7425	0.50	0.46	0.44	SN7492	0.74	0.71	0.64	SN74180	£1.50	£1.40	£1.30
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SN7447	£1.10	£1.07	£1.05	SN74122	£1.50	£1.45	£1.40				
SN7448	£1.10	£1.07	£1.05	SN74123	£3.00	£2.90	£2.80				
SN7460	0.18	0.17	0.16	SN74141	0.85	0.82	0.79				

NOW WE GIVE YOU 50w PEAK (25w R.M.S.) PLUS THERMAL PROTECTION! The NEW AL60 Hi-Fi Audio Amplifier FOR ONLY £3.95



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- Distortion better than 1% at 1KHz
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- Load - 3, 4, 8 or 16 ohms
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STABILISED POWER MODULE SPM80

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AP80 is especially designed to power 2 of the AL50 Amplifiers, up to 15 watt (r.m.s.) per channel simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Main Transformer MT80, the unit will provide outputs of up to 1.5 amps at 35 volts. Size: 63 mm x 105 mm x 20 mm. These units enable you to build Audio Systems of the highest quality at a hitherto unobtainable price. Also ideal for many other applications including: Disco Systems, Public Address, Intercom Units, etc. Handbook available, 10p.

TRANSFORMER BMT80 £2.15 p. & p. 25p

STEREO PRE-AMPLIFIER TYPE PA100

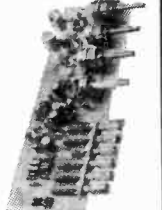
Built to a specification and NOT a price, and yet still the greatest value on the market. The PA100 stereo pre-amplifier has been conceived from the latest circuit techniques. Designed for use with the AL50 power amplifier system, this quality made unit incorporates no less than eight silicon planar transistors, two of these are specially selected low noise NPN devices for use in the input stages. Three switched stereo inputs, and rumble and scratch filters are features of the PA100, which also has a STEREO/MONO switch, volume, balance and continuously variable bass and treble controls.

SPECIFICATION:

Frequency response	20Hz-20kHz ±1dB	Bass control	±15dB at 20Hz
Harmonic distortion	better than 0.1%	Treble control	±15dB at 20kHz
Inputs:	1. Tape head 1-25mV into 50KΩ	Filters: Rumble (high pass)	100 Hz
	2. Radio, Tuner 35mV into 50KΩ	Scratch (low pass)	8kHz
	3. Magnetic P.U. 1.5mV into 50KΩ	Signal/noise ratio	better than +65dB
		Input overload	+26dB
All input voltages are for an output of 250mV.		Supply	+35 volts at 20mA
Tape and P.U. inputs equalised to RIAA curve within ±1dB from 20Hz to 20kHz.		Dimensions	292 x 82 x 35 mm

SPECIAL COMPLETE KIT COMPRISING 2 AL50's, 1 SPM80, 1 BMT80 & 1 PA100 ONLY £25.30 FREE p.&p.

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INTEGRATED CIRCUIT PAKS

Manufacturers "Fall Outs" which include Functional and Part-Functional Units. These are classed as "out-of-spec" from the maker's very rigid specifications, but are ideal for learning about I.C.'s and experimental work.

Pak No.	Contents	Price	Pak No.	Contents	Price	Pak No.	Contents	Price
UIC00	-12 x 7400	0.55	UIC46	-5 x 7446	0.55	UIC90	-5 x 7490	0.55
UIC01	-12 x 7401	0.55	UIC48	-5 x 7448	0.55	UIC91	-5 x 7491	0.55
UIC02	-12 x 7402	0.55	UIC50	-12 x 7450	0.55	UIC92	-5 x 7492	0.55
UIC03	-12 x 7403	0.55	UIC51	-12 x 7451	0.55	UIC93	-5 x 7493	0.55
UIC04	-12 x 7404	0.55	UIC53	-12 x 7453	0.55	UIC94	-5 x 7494	0.55
UIC05	-12 x 7405	0.55	UIC54	-12 x 7454	0.55	UIC95	-5 x 7495	0.55
UIC06	-8 x 7406	0.55	UIC60	-12 x 7460	0.55	UIC96	-5 x 7496	0.55
UIC07	-8 x 7407	0.55	UIC70	-8 x 7470	0.55	UIC99	-5 x 7499	0.55
UIC10	-12 x 7410	0.55	UIC78	-8 x 7478	0.55	UIC100	-5 x 74100	0.55
UIC12	-12 x 7420	0.55	UIC79	-8 x 7479	0.55	UIC141	-5 x 74141	0.55
UIC15	-12 x 7430	0.55	UIC74	-8 x 7474	0.55	UIC151	-5 x 74151	0.55
UIC40	-12 x 7440	0.55	UIC76	-8 x 7476	0.55	UIC154	-5 x 74154	0.55
UIC41	-5 x 7441	0.55	UIC80	-5 x 7480	0.55	UIC193	-5 x 74193	0.55
UIC42	-5 x 7442	0.55	UIC81	-5 x 7481	0.55	UIC198	-5 x 74198	0.55
UIC43	-5 x 7443	0.55	UIC82	-5 x 7482	0.55	UIC199	-5 x 74199	0.55
UIC44	-5 x 7444	0.55	UIC83	-5 x 7483	0.55			
UIC45	-5 x 7445	0.55	UIC86	-5 x 7486	0.55	UICX1	-25 Assorted 74's	1.55

Packs cannot be split, but 25 assorted pieces (our mix) is available as PAK UIC X1.

LINEAR I.C.'S-FULL SPEC.

Type No.	Case	1	25	100+
72702	DIL 14	0.50	0.48	0.45
72709	DIL 14	0.35	0.33	0.30
72710	DIL 14	0.45	0.43	0.40
72741	DIL 14	0.40	0.38	0.35
72741C	TO-5	8	0.45	0.43
72741P	DIL 8	0.38	0.36	0.34
72748P	DIL 8	0.38	0.36	0.34
SL201C	TO-5	8	0.50	0.45
BL701C	TO-5	8	0.50	0.45
SL702C	TO-5	8	0.50	0.45
TAA263	TO-72	4	0.80	0.70
TAA293	TO-74	10	£1.00	0.95
TAA350A	TO-5	10	£1.85	£1.80
µA703C	TO-5	6	0.28	0.26
µA709C	TO-5	8	0.35	0.33
µA711	TO-5	10	0.45	0.43
ZN414	TO-18	4	£1.20	-

DTL 930 SERIES LOGIC I.C.'S

Type	1	25	100+
BP930	0.15	0.14	0.13
BP932	0.16	0.15	0.14
BP933	0.16	0.15	0.14
BP935	0.16	0.15	0.14
BP936	0.16	0.15	0.14
BP944	0.16	0.15	0.14
BP945	0.30	0.28	0.25
BP946	0.15	0.14	0.13
BP948	0.30	0.28	0.25
BP951	0.70	0.65	0.60
BP952	0.15	0.14	0.13
BP9093	0.45	0.43	0.40
BP9094	0.45	0.43	0.40
BP9097	0.45	0.43	0.40
BP9099	0.45	0.43	0.40

DUAL-IN-LINE SOCKETS

Type	Description	Price
3015F	Minitron 7 Segment Indicator	£1.50
MAN 3M	L.E.D. 7 Segment Display 0.127" High Characters	£1.90
CD 66	Side Viewing 'Nixie' Type 'Tube 16 mm.	£1.87
GR 116	Side Viewing 'Nixie' Type 'Tube 18 mm.	£1.70

NUMERICAL INDICATOR TUBES

Type	Description	Price
3015F	Minitron 7 Segment Indicator	£1.50
MAN 3M	L.E.D. 7 Segment Display 0.127" High Characters	£1.90
CD 66	Side Viewing 'Nixie' Type 'Tube 16 mm.	£1.87
GR 116	Side Viewing 'Nixie' Type 'Tube 18 mm.	£1.70

3 TERMINAL POSITIVE VOLTAGE REGULATORS

TO3 Plastic Encapsulation O/P 1.5 Amps.	µA7805 5V (Equip. to MVR5V)	£1.78
µA7812 12V (Equip. to MVR12V)		£1.78

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TEAK VENEERED CABINETS for:

- STEREO 20
- TC 20. £3.95 p&p 30p
- MK 50 KIT
- TC 100. £6.50 p&p 30p

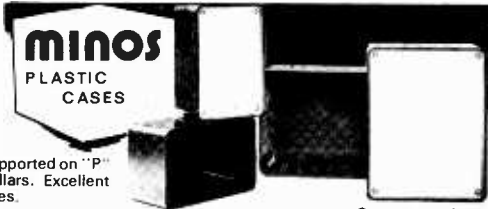
E.M.I. LEK 350 Loudspeaker System Enclosure kit in teak veneer, including speakers.

Rec. retail price £45.50 per pr. OUR SPECIAL PRICE £35.50 per pair P. & P. £1. ONLY WHILE STOCKS LAST!

The STEREO 20

The 'Stereo 20' amplifier is mounted, ready wired and tested on a one-piece chassis measuring

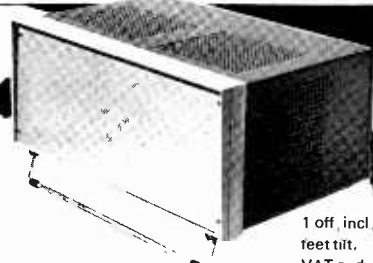
A smart miniature case in tough, rigid, high-gloss black ABS. Front panels in either aluminium or white PVC/Steel. Built-in slots for PC cards, dividers, or screens. Chassis or PC boards can be supported on "P" clips for internal pillars. Excellent as encapsulation boxes.



M2 65mm x 100mm x 50mm 2 1/2" x 3 3/4" x 2"
 M3 100mm x 130mm x 50mm 3 3/4" x 5" x 2"
 Prices include P. & P. and VAT.
 Also available less panel and screws. Prices correct to May 31.

One off 10 off
 47p 40p
 63p 55p
 Less for quantities. Min. order £1.

AMTRON VENTILATED METAL CASES



AMTRON METAL CABINETS GIVE EXTRA VENTILATION

Ideal for Stabilised Power Supply Units. A lightweight case with perforated sides and top. The front panel is of heavy-gauge anodised aluminium. The top, bottom, sides and back interlock, secured by four screws. The front frame is a clever moulding holding the panels, allowing for four hidden fixings for a chassis (not supplied). Integrally moulded front feet also form the mounting for the tilt support which is standard with this matt blue painted case.

Height Length Depth Code P. & P.
 120mm 284mm 138mm 00/3009-00 £6-40
 120mm 224mm 138mm 00/3009-10 £5-61
 120mm 284mm 188mm 00/3009-20 £7-07
 Less for quantity. Prices correct to May 31.

BRADRAD DRILLING AND DEBURRING TOOL



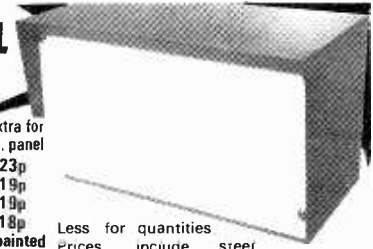
BRADRAD DRILLING & DEBURRING TOOL equals eleven drills. One cut drills and deburs the normal run of steels, aluminium, brass, copper and all types of plastics, perspex, fibreglass, etc., and hardboard should the need arise it is designed to overcome all the problems associated with drilling thin materials—it drills interlocking holes for instance.
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 Also 1 1/2"-2 1/2" and 36-60mm £27-88

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 Q-MAX PUNCHES
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 5/8" £1-47
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 The Adel cuts holes of virtually any shape and size starting from a 2/64" hole, cutting cleanly by a punch and die. Ideal for notching clearances on flanges of cabinets or chassis £6-76. All prices include P. & P. and VAT.

Prices correct to May 31.

CONTIL TEXTURED CASES



Available in a range of six sizes in 21-gauge Zintec with blue Acrylic texture. Front panels white Zintec steel or PVC/Aluminium.

Width	Depth	Height	No.	Case cost	Extra for all. panel
7"	5"	5"	755	£5-59	23p
8"	6"	7"	867	£6-12	19p
9"	7"	5"	975	£6-12	19p
12"	7"	7"	1277	£6-73	18p
12"	7"	7"	1277	£5-56	unpainted
16"	12"	7"	16127	£9-55	50p
19"	10"	10"	191010	£13-17	—

Less for quantities
 Prices include steel panel with feet and screws. P. & P. and VAT.
 Prices correct to May 31

CONTIL MOD-2



The design of these cases permits the instrument to be built or serviced within their external panels. 48 shapes. Low cost. Blue PVC/steel with white PVC-coated aluminium panels.

Width	Height	Depth	1 off	Width	Height	Depth	1 off
A 4-5"	3"	6-5"	£3-17	M 4-5"	3"	13"	£3-91
B 4-5"	7"	6-5"	£3-91	N 4-5"	7"	13"	£4-79
C 4-5"	10"	6-5"	£4-32	O 4-5"	10"	13"	£6-07
D 9"	3"	6-5"	£4-32	P 9"	3"	13"	£4-79
E 9"	7"	6-5"	£4-79	Q 9"	7"	13"	£6-07
F 9"	10"	6-5"	£5-52	R 9"	10"	13"	£7-39
G 13"	3"	6-5"	£4-79	S 13"	3"	13"	£6-07
H 13"	7"	6-5"	£5-52	T 13"	7"	13"	£7-39
I 13"	10"	6-5"	£6-07	U 13"	10"	13"	£8-95
J 18"	3"	6-5"	£5-52	V 18"	3"	13"	£7-39
K 18"	7"	6-5"	£7-39	W 18"	7"	13"	£8-95
L 18"	10"	6-5"	£8-95	X 18"	10"	13"	£10-70

Woodgrain: D @ £4-79, E & G @ £5-52, H @ £6-07.
 Prices include screws, rubber feet, one or two chassis according to size, and P. & P. and VAT.
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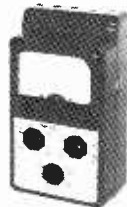
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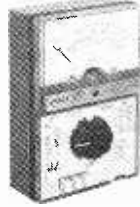
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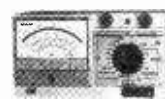
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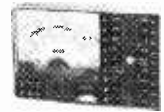
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AC128	0-25	BC154	0-18	BF160	0-45	CRS1/40	0-45	2N3905	0-18	BY127	0-17	IN4005	0-09
AC141K	0-27	BC157	0-15	BF161	0-22	ME6001	0-16	2N3906	0-1	BY133	0-23	IN4006	0-11
AC142K	0-19	BC158	0-13	BF163	0-45	ME6002	0-17	2N4036	0-52	OA47	0-07	IN4007	0-14
AC154	0-20	BC159	0-15	BF167	0-25	ME8001	0-18	2N4046	0-35	OA81	0-10	IN5400	0-15
AC176	0-25	BC167B	0-15	BF173	0-25	MJE340	0-68	2N4289	0-20	OA91	0-08	IN5401	0-17
AC187	0-25	BC168B	0-13	BF177	0-30	MJE341	0-72	2N4291	0-18	OA95	0-07	IN5402	0-20
AC188	0-25	BC169C	0-13	BF178	0-33	MJE370	0-65	2N4292	0-20	OA200	0-10	IN5403	0-22
AC193K	0-30	BC170	0-15	BF179	0-33	MJE520	0-85	2N5296	0-37	IN914	0-07	IN5404	0-25
AC194K	0-32	BC171	0-15	BF180	0-35	MJE521	0-95	2N5298	0-38	IN4148	0-05	IN5405	0-27
ACY39	0-68	BC172	0-14	BF181	0-33	MJE2955	1-20	2N5457	0-30	IN4448	0-10	IN5406	0-30
AD140	0-50	BC173	0-20	BF183	0-44	MJE3055	0-74	2N5458	0-35	IS44	0-07		
AD142	0-52	BC176	0-16	BF184	0-26	MPE102	0-40	2N6027	0-65				
AD149	0-50	BC177	0-16	BF185	0-26	OC28	0-65						
AD161	0-38	BC178	0-20	BF194	0-15	OC36	0-55						
AD162	0-38	BC179	0-20	BF195	0-15	OC44	0-15						
AF114	0-25	BC182L	0-11	BF196	0-15	OC45	0-15						
AF115	0-25	BC183	0-11	BF197	0-17	OC70	0-15						
AF116	0-25	BC183L	0-11	BF198	0-20	OC71	0-15						
AF117	0-20	BC184L	0-13	BF199	0-25	OC72	0-15						
AF118	0-50	BC186	0-25	BF200	0-35	OC75	0-25						
AF139	0-35	BC187	0-25	BF222	1-08	OC81	0-25						
AF147	0-35	BC212L	0-12	BF240	0-20	OC81D	0-30						
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AF180	0-50	BC214L	0-15	BF244	0-18	OC170	0-25						
AF239	0-40	BC261	0-28	BF256	0-45	OC171	0-30						
AL100	1-10	BC263	0-25	BF257	0-49	ON236A	0-65						
AL102	1-10	BC300	0-58	BF258	0-66	R2008B	2-05						
AL103	1-10	BC303	0-60	BF259	0-93	R2010B	2-10						
AU103	1-40	BC308	0-62	BF263	0-70	TIP31A	0-65						
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BC107	0-12	BC360	0-95	BF596	0-70	TIS43	0-30						
BC108	0-12	BC433	0-36	BFT43	0-55	2N706	0-12						
BC109	0-13	BD115	0-65	BFW10	0-55	2N706A	0-15						
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BC115	0-20	BD132	0-50	BFX85	0-26	2N1305	0-21						
BC116	0-20	BD135	0-40	BFX88	0-24	2N2646	0-53						
BC117	0-20	BD136	0-46	BFY50	0-25	2N2904	0-22						
BC125	0-22	BD137	0-48	BFY51	0-23	2N2904A	0-26						
BC126	0-20	BD138	0-50	BFY52	0-23	2N2905	0-72						
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BC135	0-15	BD234	0-75	BPX29	1-60	2N3019	0-75						
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				TAA570	1-39
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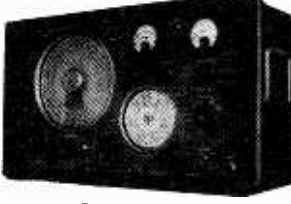
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TF 810D/IS SIGNAL GENERATOR. Range 10-485 MHz in five ranges. R.F. output 0.1-µV-V source e.m.f. Dial calibrated in volts, decibels and power relative to thermal noise. Piston type attenuator. 50Ω output impedance. Internal modulation at 1 kHz at up to 90% depth, also external sine and pulse modulation. Built-in 5MHz crystal calibrator. Separate R.F. and mod. meters. P.O.A.

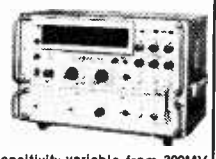
TEKTRONIX OSCILLOSCOPES 571A-600MHz, separate P.S.U. £150 complete. 561A-10MHz, solid state, complete with 3A1 dual trace vert. and 3B3 delay time base plug-ins P.O.A. 541A-33MHz. Choice of plug-ins. P.O.A. LA265A(545A)-33MHz, separate time bases with delay. P.O.A. 545-15MHz. Separate time bases with delay. Price on application. PLUG-IN UNITS CA-24 MHz dual trace 50MV-20V. G-20 MHz differential 50MV-20V. L-30 MHz fast rise time 5MV-20V. O-High gain differential 1MV-50V. N 600MHz sampling 10MV-cm. 53/54C. Dual trace 33MHz, 60MHz, 0.05-20v. 3 PHASE AUTO TRANSFORMER, wye input 400v, wye output 241.5/230/218.5v 50c 18kVA. Made by Westinghouse of USA. Brand new in original cases £60.00 including UK transport. 894 TF AUDIO TESTER. Combined A.F. Generator (0-25kHz), Output meter (up to 2W, at 600, 15 and 3Ω), and valve voltmeter (0-800V), with stepped and variable attenuators. £60.

TF 1400S DOUBLE PULSE GENERATOR WITH TM 6000'S SECONDARY PULSE UNIT. For testing radar, nucleonics, scopes, counters, filters, etc. SPEC. TF 1400S. Rep. freq. 10Hz to 100kHz, pulse width 0.1 to 100µ sec., delay -1.5 to +3000µ sec. rise time 30N sec. SPEC. TM 6000'S. As for TF1400S except pulse width 0.5 to 25µ sec., delay 0 to +300µ sec. £230.

TF 526B OSCILLATOR AND DETECTOR UNIT £50.00. TF 1228B, TF1225A, TF 577A. WHITE NOISE TEST SET £150.00. Full spec. on request.

RACAL UNIVERSAL COUNTER/TIMER SA550 (CT488)

8 digit in-line read-out. Facilities include: direct frequency measurement up to 100MHz; pulse, period, ratio, time interval and totalising measurements. Input sensitivity variable from 300MV to 9V, three independent inputs, self-check etc. Full spec. on request. £145.



PLEASE NOTE Unless offered as "as seen"

ALL EQUIPMENT

ordered from us is completely overhauled mechanically and electrically in our own laboratories

FOR EXPORT ONLY TRANSmitters:

BC 810 Hallicrafters. RCA ET 4338 also modified version of increased output to 700W. COLLINS TYPE 231D 45kw, 10 channel, autotone and manual tuning. All above complete installation and spare parts. TRANSCEIVERS 19, 19HP, 38, 62, C-13 TRANSmitters RACAL COMMUNICATIONS EQUIPMENT. We are able to offer a comprehensive selection from the range of this modern high class equipment including, receivers, L.F. Converters, SSB adaptors, panoramic adaptors, diversity switches, transmitter driver units, linear amplifiers can be built to customers' requirements. Please send us your enquiries.

ARM SPARES. We hold the largest stock in U.K. Write for list. R.F. METER 0-8 amp. 2 1/2" (U.S.A.) £1.88 P. & P. 15p.

29/41FT. AERIALS each consisting of ten 3ft. 3/8in. dia. tubular screw-in sections. 11ft. (6-section) whip aerial with adaptor to fit the 7in. rod, insulated base, stay plate and stay assemblies, pegs, reamer, hammer, etc. Absolutely brand new and complete ready to erect, in canvas bag. £7.50 new or £4.50 slightly used. Carriage £1.50.

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50 line AUTOMATIC PRIVATE TELEPHONE SWITCHBOARD

Price of each of the above on application.

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TELEPHONE ENQUIRIES relating to TEST EQUIPMENT should be made to 01-748 8006 Extension 23. To view TEST EQUIPMENT please phone for appointment

MARCONI SIGNAL GENERATOR TYPE TF-144G: Freq. 85 Kc/s-25 Mc/s in 8 ranges. Incremental: $\pm 1\%$ at 1 Mc/s. Output: continuously variable 1 microvolt to 1 volt. Output Impedance: 1 microvolt to 100 millivolts, 10 ohms 100mV - 1 volt - 52.5 ohms. Internal Modulation: 400 c/s sine wave 75% depth. External Modulation: Direct or via internal amplifier. A.C. mains 200/250V, 40-100 c/s. Consumption approx. 40 watts. Measurements $29 \times 12\frac{1}{2} \times 10$ in. Secondhand condition. £27-50 each, Carr. £2-00.

POWER SUPPLY UNIT PN-12A: 230V a.c. input 50-60c/s, 513V and 1025V at 420mA o/p. With 2 smoothing chokes 9H, 2 Capacitors, 10Mfd 1500V ar d 10Mfd 600V. Filament transformer 230V a.c. input. 4 Rectifying valves type 5Z3. 2 $\times 5$ V windings at 3Amps each and 5V at 6Amp and 4V at 0-25Amps. Mounted on steel base 19in. W \times 11in. H \times 14in. D. (All connections at the rear.) Excellent cond. £8-50 each, Carr. £2.

MODULATOR UNIT: 50 watt, part of BC-640, complete with 2 \times 811 valves, microphone and modulator transformers etc. £7-50 each, Carr. £2-00.

CATHODE RAY TUBE UNIT: With 3in. tube, Type 3EG1 (CV1526) colour green, medium persistence complete with nu-metal screen, £3-50 each, post 50p.

APN-1 INDICATOR METER, 270° Movement. Ideal for making rev. counter. £1-25, post 30p.

AIRCRAFT SOLENOID UNIT S.P.S.T.: 24V, 200 Amps, £2 each, 30p post.
VARIAC TRANSFORMERS: Input 115V, output 0-135V at 2 Amps. £3 each. 75p post.

RACK CABINETS: (totally enclosed) for Std. 19 in. Panels. Size 6 ft. high \times 21 in. wide \times 16 in. deep, with rear door. £12 each, Carr. £2-50.

INSTRUMENT CABINETS: 19"W. \times 16"H. \times 16"D. £5-00 + £1-25 carr.

CLASS "D" WAVEMETER NO. 1 MK. II: Crystal controlled heterodyne frequency meter covering 2-8MHz. Power supply 6V d.c. Good secondhand cond. £7-50 each. Post 60p.

ROTARY INVERTERS: TYPE PE.218E—input 24-28V d.c., 80 Amps. 4,800 rpm. Output 115V a.c. 13 Amp 400 c/s. 1 Ph. P.F.9. £17-50 each. Carr. £2-00.

REDIFON TELEPRINTER RELAY UNIT NO. 12: ZA-41196 and power supply 200-250V a.c. Polarised relay type 3SE1TR. 80-0-80V 25mA. Two stabilised valves CV 286. Centre Zero Meter 10-0-10. Size 8in. \times 8in. \times 8in. New condition £7-50, Carr. 75p.

WESTON INDUSTRIAL THERMOMETER MODEL 221: 0-100°C. 3in. dia. scale. Accuracy 1%. Precision made coil within-coil structure. Changes in temperature cause a rotary action of the Helix turning the shaft to which the pointer is mounted. £2-80 each 30p post. Unused condition.

TS 15C/AP FLUXMETER: Used to provide qualitative measurements of flux densities between pole faces of magnets. Range 1200-9600 gauss. $\pm 2\%$. S/hand good cond. £25 + 60p post.

AUTO TRANSFORMER: 230V 50c/s, 1000 watts. Mounted in strong steel case 5in. \times 6in. \times 7in. Bitumen impregnated. £10 each, Carr. £1.

UHF ASSEMBLY: (suitable for 1000MHz conversion) incl. UHF valves; 2C42, 2C46, 1B40. Complete with associated capacitors and screening; 3 manual counters 0-999. Valves 6AL5 and 8 \times 6AK5. £10 each, 60p post.

TELEPRINTER TYPE 7B: Pageprinter 24V d.c. power supply, speed 50 bauds per min. 'as new' cond. in original packing case, £25 each; or second hand cond. (excellent order) no parts broken, £15 each. Carriage either type £3-00.

INSULATION TEST SET: 0-10 kV negative, earth with amplifier provision for checking ionisation. 110/230V a.c. input. S/hand good cond. £30 + £1 carr.

APN-1 ALTIMETER TX/RX: Freq. approx. 410MHz. Complete with 28V dynamotor, 3 relays, precision resistors, 11 valves. Useful breakdown for parts. £4 each + 75p carr.

AUTOMATIC VIBRATION EXCITER CONTROL UNIT TYPE 1016: Manufactured by Bruel & Kjoer. 5-5000c/s per sec. S/hand V. good cond. £90, Carr. £2.

TF-1041B VALVE VOLTMETER: Measure 25mV-300V, 20c/s-1500Mc/s a.c. Also 10mV-100V d.c. Resistance 0.02 ohms-500Meg. chms. Power requirements 200-250V a.c. S/Hand excellent cond. £35 each, Carr. £1.

AN/ARC-27 TRANSMITTER/RECEIVER (FOR EXPORT ONLY): Frequency 225-400 mc. 1750 channels 100 Kc apart with 18 preset channels. Modulation: am. Power output 9 watts. Receiver is superheterodyne. Max. output 2 watts. Antenna: 50 ohm impedance. Power requirements 24V d.c. Complete transmitter with operating cables, control box, headphones, microphone. Price £250-00 each secondhand, excellent condition.

POWER SUPPLY suitable for AN/ARC-27: 100 volts to 250 volts a.c. input. 24V d.c. output @ 41 amps fully smoothed. £45-00 each.

CRYSTAL TEST SET TYPE 193: used for checking crystals in freq. range 3000-10,000KHz. Mains 230V 50Hz. Measures crystal current under oscillatory conditions and the equivalent resistance. Crystal freq. can be tested in conjunction with a freq. meter. £15, Carr. £1-50.

DELPENA RF GENERATOR TYPE E.15: 15kW at 500Hz; input 440V 3 ph. 50Hz. £275, Carr. at cost.

H.V. TRANSFORMER: 8000/8000. Output 300mA. rms. Size: 12in. \times 12in. \times 36in. 230V input. £35, Carr. £4-00.

COPPER WIRE AERIAL: with insulators, 100ft. long. £1-50. Post 40p.

TELEPHONE CABLE: (Twin) PVC covered suitable for extension speakers, burglar alarms etc. 200 yds. per roll. £2-50 a roll. Post 50p.

TELEPHONE CABLE: (Twin) 1,350ft. on metal reel. £5 per reel. Carr. £1.

ANTENNA MAST 30ft. consisting of 10 \times 3ft. tubular screw sections ($\frac{3}{8}$ " dia.) with base, guyropes and stays etc. £5 each, Carr. £2.

ANTENNA MAST 12ft. 3 sections with suitable base to mount on the above Mast. Extends to 42ft. £1-50 each, Carr. £1.

APN-1 ALTIMETER TX/RX: Freq. approx. 410MHz. Complete with 28V dynamotor, 3 relays, precision resistors, 11 valves. Useful breakdown for parts. £4 each, Carr. £1-50.

CT.216 STANDING WAVE METER: 2-30MHz, complete in strong portable case. £40 each, Carr. £1-50.

AVO VALVE TESTER CT.160: (Portable) similar to Avo Mk. 3 Characteristic Meter. Good cond. £35 each, Carr. £1-50.

MODULATOR UNIT: Complete with mod. transformer and 2 \times 807 Valves. Mounted 19" chassis, 8" \times 8". "As new" cond. £8 each; or secondhand £5 each. Carr. both types £1-50.

LISTS OF EQUIPMENT AVAILABLE: MOTORS; TELEPRINTERS; AR88 SPARES; TEST EQUIPMENT ETC. Send 10p for above lists.

ALL CARRIAGE QUOTES GIVEN ARE FOR 50 MILE RADIUS OF LONDON ONLY.

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Type	Sec. Taps	Amps	Price	Postage
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1B	25-33-40-50v	10	£12-00	75p
1C	25-33-40-50v	6	£8-50	60p
1CA	25-33-40-50v	3	£7-50	60p
2A	4-16-24-32v	12	£10-00	75p
2B	4-16-24-32v	8	£8-00	60p
2C	4-16-24-32v	4	£4-95	45p
2D	4-16-24-32v	2	£3-50	40p
3A	24-30-36v	10	£8-00	60p
3B	24-30-36v	5	£7-50	50p
3C	24-30-36v	2	£3-50	40p
4A	12-20-24v	20	£12-00	75p
4B	12-20-24v	10	£7-50	60p
4C	12-20-24v	5	£4-95	40p
5A	3-12-18v	20	£10-00	60p
5B	3-12-18v	10	£8-95	60p
5C	3-12-18v	5	£4-50	40p
6A	48-56-60v	2	£4-50	40p
6B	48-56-60v	1	£3-50	40p
7A	6-12v	20	£7-90	60p
7B	6-12v	10	£4-50	40p
7C	6-12v	5	£3-50	40p
8A	17-32v	8	£8-00	60p
9A	12-24v	1	£2-50	30p
10A	9-15v	2	£2-50	30p
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3000 watts. Built into steel case with two American 2 pin grounded socket outlets. Carry handle. 6 ft. mains lead. £29-50, carr. £2. Without case and fittings £22-80, carr. £1-50. Other Types Available. 80-1500 watts, fully shrouded, with American socket outlet and 6 ft. mains lead. Let us know your requirements.

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H.T. TRANSFORMERS by Famous Manufacturers. All Primaries 220-240v.

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GRESHAM 'C' CORE 10H 350 MVA

£3-50 carr. 50p. Potted Type 10H 300 mVA £3-00 carr. 50p. 9 H 500 mVA 5 kv DC wkg £6-50 carr. £1.00.

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PARMEKO Potted types No 1 tapped 24-30-32v. 2a. £2-25, p.p. 35p. No. 2 24v. 1a. and 12.5v. 0.7a. and 6.3v. 0.5a. £2-25 p.p. 35p. No. 3 Sec. tapped 9-10v. 0.42a. and 6.3v. 3.5a. 6.3v. 1.5a. £1-50 p.p. 40p. No. 4 Pri. 115-230v. Sec. 6.6v. 6a. twice and 5v. 6a. £4-00 carr. 75p.

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12 volt 2 amp TRANSFORMER

enclosed in metal case. Size 5x4x3 ins. with fitted input and output lugs. On/off switch. Output sockets and 4ft. 240v. mains lead. £2-75 p.p. 35p.

LEMARQ Pri. 240v. Sec. 40v. 6a. 5-0-5v 2a. 5-0-5v. 1a.

Open frame design. £5.50 with fitted input and output lugs. 2.5a. 24v. 630 mVA twice. 24v. 65 mVA and 115v. 2a. auto tap on primary. Open frame table top connections £3-50 carr. 50p. Pri. 240v. Sec. 20-0-20 v. 5-0-5 2a. £1-75 carr. 35p. All above transformers have a screen winding.

BORDON SOLENOIDS

12v. DC. 1in. Pull. Size 1in. dia., length 2in. 50p, post 10p. Reg. 20Ω



BENSONS SOLENOIDS

AC 240v 25% duty. Approx 2 ins. 1/2 in. pull. Size 2x1 1/2 x 1 1/2 ins. Res. 350Ω 75p p.p. 10p. Similar to 12v DC Type above.

NEW-THE HIGH DEPENDABILITY POWER SUPPLY. BYJOHNSTEE

In a single unit. Choice of 12v. DC. at 4a. 24v. DC at 2a. or simultaneously, 12v. and 24v. DC. Each with total drain of 50 watts. Basic unit £8-25 p.p. 45p. Encased with switch, fuse, pilot light, mains cord, output connector. £13-75 p.p. 50p.

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Type 250CX 2500 ohm 2 H.D. CO contacts set to pull in at 22v. with base and cover. 60p, post. 5p.



KEYSWITCH KMK1 AC. 230v. One 5 amp. change over contact. 45p, post. 10p.

AUTO TRANSFORMERS

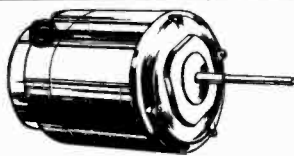
Partridge. Tapped 0-220-230-240-250v. 500 watts unshrouded table top connections £2-50 carr. 40p. Unshrouded 0-240-115v. 500 watts unshrouded table top connections £5-00 carr. 60p 300 watts £3-50.

LIMIT SHADED POLE MOTORS

AC 110-240v 50Hz; 1500 RPM Double end spindle. Length 1ins. and 1 1/2 ins. £2-25 p.p. 25p overall size 3x2 1/2 x 3 1/2 ins

GRESHAM MULTI TAPPED L.T. TRANSFORMERS

Pri. 110-220-240v. Sec. 21-22-23-27-28-30v 10a and 23-24-26v 2.5a. Twice and 15-16-18v 5a and 15-16-18v 5a and 25-0-25v 50 mVA three times. C. core type. Table top connections £10-00 carr. £1.



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Type SS15. These fine motors are easily reversed, starting and stopping in less than 5° without electrical or mechanical braking. Simple relay circuit can be applied to give D.C., to winding for a maximum holding torque of 300oz/in with 35v at 0.35amps through winding. For A.C. (synchronous) operation at 120v, 50Hz. Speed 60 rpm at 60Hz., 72 rpm. STEPPING. Holding torque at 60 steps per second—100 oz.in. Can be wired to give 100 or 200 steps per revolution with accuracy of 0.1° per step non-cumulative. Torque characteristics can be modified by simple R.C. circuits. Dimensions: dia. 4", body length 4 1/2", spindle length 2 1/2" x 1/8" dia. Weight 6 1/2 lbs. BRAND NEW in maker's packing. Offered at less than 1/2 maker's price. **£15**

OPEN FRAME shaded pole GEARED MOTORS

(Dural gear case) 240 A.C., 28rpm. NEW HIGH TORQUE, approx. overall size: 3 1/2" x 2 1/2" spindle dia. as illustrated. £3. P. & P. 30p. Similar to above, 19rpm. £3. P. & P. 30p. 110rpm with pressed steel gear case (similar to above but slightly smaller). £3. P. & P. 30p.



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Similar to above with alloy gear case. 60 r.p.m. This item is ex-equipment but perfect. **£1.85**, P & P 30p.



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Reliable 15 minute timer, spring wound (concurrent with time setting) 15x1min divisions, approximately 1/2 between divisions. Panel mounting with chrome bezel 3 1/2" dia. **£1.40**, 15p. P. & P.

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Fully stabilised "Labgear" Power Supply Unit. Input 90-240v, 50Hz. Outputs 6v, 6a D.C., and 6v+2v, 100mA. Hum and ripple at full load—less than 3mV peak to peak. Stability improvement ratio for 15% mains change—1000:1. Output impedance 0.55 ohms. 9 1/2" x 9 1/2" x 2 1/2". Weight 20lb. **£39.50**. Carr. & Pkg £1.50. In manufacturer's carton.

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P.S.U. 200-250v. 40/60Hz. Alternative outputs fully variable (variac incorporated). Output 1. 12v at 5a D.C. fully smoothed. Output 2. 12v at 8a D.C., with ripple content. Output 3. 20v at 10a A.C. 2 1/2" x 2 1/2" flush 0-20v D.C. mic motor. In attractive grey hammer finish case. In maker's carton. **£41.50**. Carr. & Pkg. **£1.50**.

SHADED POLE MAINS MOTOR

A quality shaded pole motor. Open frame. 3" high x 2 1/2" x 2". Spindle 1" x 1/8". 1,420r.p.m. **£1.85** P & P 20p.

SOLENOIDS by WESTOOL

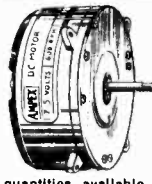
240AC type MM6. 3lb. pull, 2 1/2" x 1 1/2" x 1 1/2" Travel 1" 80p each. P.&P. 10p.



240AC type MM4. 2lb. pull, 1 1/2" x 1 1/2" x 1 1/2". Travel 1" 70p each. P. & P. 10p. Quantity discounts; 10-50 10%, 50 upwards 25%

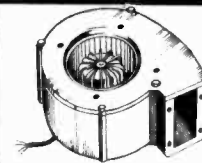
MAINS SOLENOID

This little unit gives vertical lift of approximately 1" through hinged "elbow". Bracket incorporates 2 fixing screws. Length of arm, 2 1/2". 240V A.C. Pull at coil is approximately 1lb. **£1**. FREE P. & P. Special quotes for quantities.



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An ultra precision tape motor designed for use in the AG20 portable recorder. Torque 450GM/CM. Stall load at 500ma. Draws 60ma on run. 600rpm ± speed adjustment. Internal AF/RF suppression. 1/2" dia. x 1 1/2" spindle motor 3" dia. x 1 1/2". Original cost £16.50. OUR PRICE **£3.30**. P. & P. 25p. Large quantities available (special quotations). Mu-metal enclosure available. 75p each. FREE P. & P.



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30 segments individually balanced in heavy cast alloy case. 2,300 r.p.m. 240v A.C. Very powerful and silent running. 5 1/2" dia. 3" inlet dia. Outlet flange 3" x 2 1/2".

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Now complete with reference magnet!

A magnetically activated switch, vacuum sealed in a glass envelope. Silver contacts, normally closed. Rated 3amp at 120v. 1 1/2amp at 240v. Size: (approx.) 1 1/2" long x 1/2" dia. Ideal for burglar alarms, security systems etc., and wherever non-mechanical switching is required. 10 for **£2**; P & P 15p. 50 for **£8.80**; 100 for **£16.50**. FREE P.&P. over 10.

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Impedance approx. 200Ω, output 60 or 80 DB at 1 Kc. As used in deaf aids, bugging devices, etc. Size (60 DB) 7/32" x 5/32" x 1/4"; (80 DB) 1/2" x 5/32" x 1/4". Ex-equipment, all tested. **£1.50** each. P. & P. FREE.

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RIBBON CABLE (8 colours)

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8 cores. 7/-mm. bonded side by side in ribbon form.

SMALL MOTOR (1/50 H.P.) 900 R.P.M. 230/250v. A.C. **£1.50**. P.P. 30p.

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SIEMENS/VARLEY PLUG-IN. Complete with transparent dust covers and bases. 2 pole c/o contacts 35p ea.; 6 make contacts 40p ea.; 4 pole c/o contacts 50p ea. 6-12-24-48v types in stock.

12 VOLT H.D. RELAYS (3 x 2 x 1 in.) with 10 amp. silver contacts 2 pole c/o 40p ea.; 2 pole 3 way 40p. P.P. 5p.

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M.f. to highest W.D. spec. Auto wound, and tapped 0-130, 160-200-250 at least 2kVA. Can also be used as 230-240V. input, 115V. out for U.S.A. equipment, or reverse to obtain 240V. from 115V. The ideal transformer for making up solid state constant voltage unit, by use of taps the following voltages may be obtained: 30-40-50-70-90 Volts at 10 amps. Weight 40 lbs., length 260 mm., height 190 mm., width 230 mm. In original maker's wooden case, £8.00, carr. £1.

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200/250 Volt 2-ON/2-OFF every 24 hours at any manually pre-set time. 20 amp contacts. Fitted die-cast case. Tested and in good condition £4.75 Post 25p.

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Based on an electric clock with 25 amp single-pole switch, which can be preset for any period up to 12 hrs. ahead to switch on for any length of time, from 10 mins. to 6 hrs. then switch off. An additional 60 min. audible timer is also incorporated. Ideal for Tape Recorders, Lights, Electric Blankets, etc. Attractive satin copper finish. Size 135 mm x 130 mm. 60 mm. Price £2.00. Post 20p. (Total inc. VAT & Post £2.42)

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50 easy to build Projects. No soldering, no special tools required. The Kit includes Speaker, meter, Relay, Transformer, plus a host of other components and a 56-page instruction leaflet. Some examples of the 50 possible Projects are: Sound level Meter, 2 Transistor Radio, Amplifier etc. etc. Price £7.75 post 25p.

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Each bank comprises of a change-over rated at 10 amps 240 V A.C. Black knob 1 in. dia. Fixing hole ½ in. Prices: 1-bank 30p, 2-bank 40p, 3-bank 50p. (Illustrated) inc. P. & P. Special quotes for quantities.

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Unit containing: 1 heavy duty solenoid approx. 25 lb. pull at 1 in. travel, 2 solenoids at approx. 1 lb. pull at ½ in. travel, 6 solenoids of approx. 4 oz. pull at ½ in. travel. Plus 1 24V D.C. 1 heavy duty 1 make relay. Price: £2.50. Post 60p. ABSOLUTE BARGAIN.

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52	4-6	6M	60p*
58	5-9	6 c/o	700
150	4-9	2 c/o	70p*
185	8-12	6 M	60p*
308	9-14	4 c/o	75p*
700	16-24	4M2B	80p*
700	16-24	4 c/o	80p*

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ITT LOW PROFILE RELAY 500 ohm coil. 12-24 volts D.C.. 4 c/o. Price 85p. Post 5p each.

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M.f.g. by ERG 12 volt D.C. encapsulated. Single c/o 65p. Post Paid. Two c/o 85p. Post Paid.

STC 280 ohm coil 612 V D.C. 3 make contacts metal shrouded 60p. Post Paid. Large range of other types available.

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A.C. MOTOR M.f.g. AEI Smooth running, powerful, continuously rated, reversible motor. 230/250V. A.C. 50 cycle 1/50th H.P., 0.25 amp. 900 r.p.m. £3.50. Post 30p.

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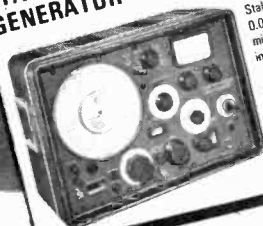
MARCONI TF867 STANDARD SIGNAL GENERATOR

Carrier Frequency Range: 15Kc/s - 30Mc/s in 11 bands. Calibration Accuracy: ± 1%. Output Voltage: 0.4µV-4V Impedance: 75 ohms nominal for outputs from 2-4V. 75 ohms for outputs from 4µV-2V. 13 ohms for outputs from 0.4µV-0.4V. Accuracy: below 3Mc/s ± 0.25dB to ± 0.1µV. 3-10Mc/s ± 0.5dB or 0.02µV. 10-30Mc/s ± 1.0dB or ± 0.5µV. Power Supply: 100-125V, 200-250V. 40-100c/s. Dimensions: 18 1/2" high x 21" wide x 14 1/2" deep.



MARCONI Type TF144H STANDARD SIGNAL GENERATOR

Frequency range: 10KHz-72MHz. Crystal Check: 400KHz and 2MHz crystals. Stability: 0.002% in 10 minute interval.



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THE VERY, VERY LATEST COSSOR

4000-50MHz DUAL TRACE OSCILLOSCOPE

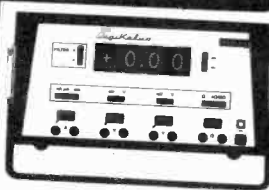


5mV/cm Sensitivity. 10ns/cm to 2s/cm Timebase. Calibrated Sweep. Gated Trigger. SPECIAL PRICE FOR THIS MONTH ONLY **£325**

Also Available: A LIMITED QUANTITY OF CDV 120 DC-60MHz DOUBLE BEAM OSCILLOSCOPES OUR INCREDIBLE PRICE **£275**

£245

SMITHS INDUSTRIES DIGIKELVO AC/DC DIGITAL MULTI-RANGE METER.



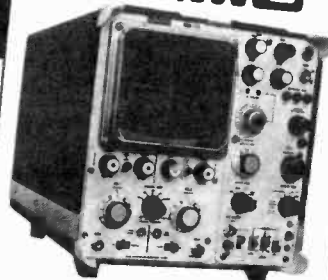
★ With 4 independent inputs
★ 3 digits plus polarity
★ range switching without breaking current measuring circuit
★ High input impedance on voltage
★ low input impedance on current.

Frequency Range 300Hz-500Hz on volts. Measures 0.01mV-600VDC. 1nA-999mA current. 1mV-600VAC. 100nA-999mA

NEW CONDITION IN MANUFACTURER'S ORIGINAL PACKING

£49.50

Made for N.A.T.O.



(STOCK NO. 6625-99-223-1190)

Yours at a fraction of original cost.

COSSOR COU150/CT531 (JOINT SERVICES NO.) RUGGEDISED DOUBLE BEAM 5MV/cm Sensitivity DC to 35MHz. Delayed timebase cascade - 1MM/cm to 8MHz. Fully transistorised

OUR PRICE **£375** FULLY TESTED GUARANTEED

Computers & Accessories

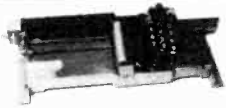
80 COLUMN HAND PUNCHES



Ideal for stock control, sales analysis, back-up in existing computer installations, DP training centres, schools, etc. New low cost model **£69.50** plus carriage.

DE LUXE MODEL

Incorporating tabulating mechanism. **£89.50** plus carriage.



ELECTRIC HAND VERIFIER



£96.00 plus carriage. All machines supplied with numeric keytops and dust-cover and covered by our three month guarantee. Delivery ex-stock. Optional extras alpha keytops and chip tray. Send for free descriptive leaflet NOW!

SAVE 75% OF LIST PRICE ON THIS DEC PDP SYSTEM

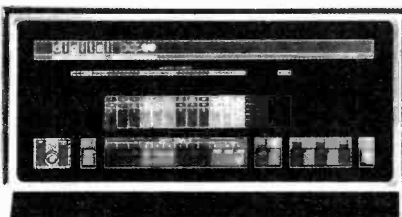
DEC PDP8 4K 1.5 microsecond **£1250**. PDP8S 8K CPU plus Teletype **£1395**. PDP8 4K CPU plus VDU P.O.A.

WIDE RANGE OF SPARES FOR THE FOLLOWING COMPUTERS: ICL 1500, ICL 1900, SYSTEM 4, 4100, 803, AMPEX, etc.

COSSOR VISUAL DISPLAY DID400. Consisting of Keyboard & Display 402 stand alone capability for alphanumeric data entry. Available from **£500**. Please phone for details.



BRAND NEW PDP8e SYSTEM



Delivered at the end of 1973 but never installed—the equipment is in fact in its original manufacturer's packing. The configuration is as follows:—

- PDP8e AF 8K Processor
- Additional 8K Memory MM8 EJ
- KP8E Power Fail
- M18E Boot Strap
- KA8E Extl + VE Bus
- KD8E Data Break
- KE8E Arithmetic
- BE8A 2nd Omnibus Block
- H960 BC Option Cabinet with Power Distribution

The list price of this system is **£6,730**. Offered at a discount of 20%. **£5,384**

Limited number secondhand units—phone for prices

VERMONT & SPERRY MEMORY DRUMS AVAILABLE—PHONE FOR DETAILS.



MINITRON

K.G.M. Type 3015F 7 Segment display showing figures 0-9 plus decimal point. Character of 9mm height. In 16 DIL case.

NEW LOW PRICE **£1.25** SN7447N BCD Decoder Driver **£1.00**.

TELETYPE PUNCH

BRPE High-speed punch. Self-contained, consists of punch unit, base, motor unit. For use in many data communication systems. Operating speeds up to 100 characters per second. (1100 words per minute). Available for punching 5, 6, 7, or 8, level codes, into 1/2" tape Synchronous, parallel-wire input. **£145**



WELMEC 7 & 8 HOLE ELECTRO-MECHANICAL PUNCHES & READER

Models S110 and R82C. 17 char. per sec. Rebuilt, available from stock. **£45**.

ICT KEYBOARDS

In original packing—Numerical from **£4.50**.

ICT KEYBOARDS

In original packing—Alpha-numeric. Prices from **£15.00**.

Magnetic Tape Transporters AMPEX TM4, TM2, TM7, FR300, IBM 7330, POTTER, ICL Magnetic Drums. From **£75.00**.

IBM PUNCH CARD EQUIPMENT FULLY GUARANTEED

Prices from
024 Automatic alphanumeric keypunch **£340.00**
026 Automatic alphanumeric printing keypunch **£820.00**
056 Verifier features and operation same as 024, 026 **£380.00**
082 Sorter 500 cards per minute are sorted **£740.00**
Carriage extra.

HEWLETT PACKARD DIGITAL RECORDER MODEL 565A

Data Entry, parallel to 11 columns. Print speed 5 lines per second. PRICE **£85.00**.

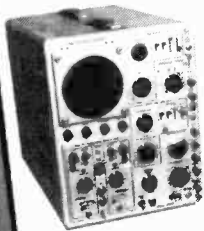
PYE HIGH RESISTANCE OHMMETER MODEL 10B

Range from 0.3-20,000 Megohms in 4 ranges at 500V. Used for the measurement of components or circuits having high parallel capacitance. PRICE **£20.00**



30 YEARS

LIMITED QUANTITY TEKTRONIX WIDE-RANGE OSCILLOSCOPES



THE WORLD FAMOUS 545 in the DC to 30MHz range. Can be used to operate with Tektronix letter series plug-in unit for virtually any application.

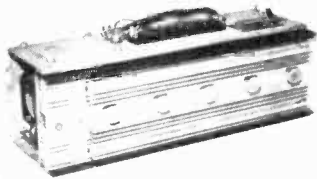
Fantastic value at **£175** (Main Frame only)

Tektronix 545 complete with CA Double Beam Time Base

£235

Also available:
TEKTRONIX 545A with CA plug-in **£255**
TEKTRONIX 535 with CA plug-in **£175**

HIGHLY STABILISED POWER SUPPLIES. YOURS AT A FRACTION OF ORIGINAL COST

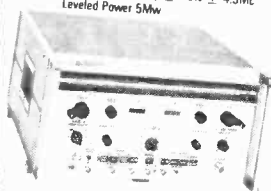


These modular units incorporate overload protection on both INPUT and OUTPUT. Load regulation of 1% or better. Low ripple and fast response time. Input voltage 120-130 50 Hz. Available in the following types:

6 Volt 8 Amp	£12.00	12 Volt 12 Amp	£22.00
8 Volt 12 Amp	£17.00	12 Volt 20 Amp	£24.00
6 Volt 16 Amp	£20.00	30 Volt 7 Amp	£19.00
12 Volt 4 Amp	£20.00		

PRECISION ELECTRONICALLY TUNED MICROWAVE SIGNAL SOURCES Hewlett Packard 690 SWEEP OSCILLATORS

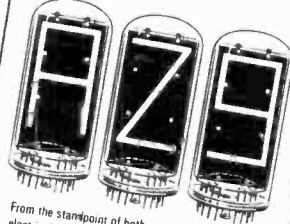
3.7Gc to 8.3Gc \pm 25Mc Δ f Sweep Width—continuously adjustable from zero to approximately 10% of frequency range. Δ f Width Accuracy \pm 10% \pm 4.3Mc Levelled Power 5mW



£495

ALPHANUMERIC NIXIE TUBES B7971

The Alphanumeric NIXIE tube has the ability to display all the letters of the alphabet, numerals 0 thru 9 and special characters in a single tube.



From the standpoint of both readability and electrical characteristics, the Alphanumeric NIXIE tube provides many unique benefits including:

- ★ All DC operation
- ★ Uniform, continuous line characters of equal height
- ★ Memory with simple solid state drive circuits
- ★ Readability in high ambient light
- ★ Long life with no loss of brightness
- ★ Character height 2 1/2 ins.

Price only **99p** each plus 16p p&p

Power Supplies

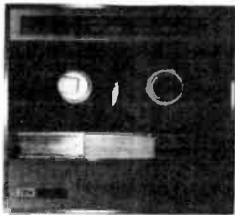


28V 20A £39.50
6V 25A £25

VARIABLE VOLTAGE HIGH CURRENT HIGH STABILITY HIGH RELIABILITY

These power supplies were designed for continuous operation in computer equipment. Manufactured to highest engineering standard for long-term reliability and stability. Independent voltage and current meters. Core Transformer. Manufacturers' price probably in excess of £200.

7-TRACK DIGITAL MAGNETIC TAPE STORAGE DECK



These machines, originally ex-computer, are multi-track recording units, ideal for data storage. Record and Replay Heads encased in one common unit. Low resistance heads. Frequency response approximately 0 Kc/s to 50 Kc/s. Bit density 557 b.p.i. 1/2 in., 10 1/2 in. spools. 230 V to 380V. Capstan motor speed 1,500 r.p.m. 48 V

DC rewind motors complete with vacuum assembly. Finished in brush aluminium and matt black. Size 27 in. X 26 in. X 8 in. Weight 90 lbs. Price **£89.50**.

WEE MEGGERS BY EVERSHED & VIGNOLE

100 volt 0.02 Ω -20M Ω Series 3 Mk III **£25**

250 volt 0.01 Ω -10M Ω Series 3 only **£16**

250 volt 0.01 Ω -20M Ω Series 3 only **£18**



VENNER 3334 Digital Frequency Meter 0-1MHz **£45.00**



VENNER 3336
Digital Counter Six Digit 0-1MHz **£55.00**.
With 15 Meg Counter extension for above **£85.00**.

Potentiometers

TEN TURN 360° ROTATION

Res Ohms	Linearity Per cent	Manufacturers	Model	Price
100	0.5	Beckman	A.S.	£2.00
200	0.5	Beckman	A	£2.00
500	0.1	Beckman	S	£2.50
500	1.0	Relcon	HEL107-10	£2.25
1K		Relcon	HEL0710	£2.25
2K	0.5	Beckman	SA1101	£3.00
2K	0.25	Beckman	7216	£3.00
2K		Reliance	GPM15	£2.00
2K		General Controls	GPA15/4	£2.00
5K		Relcon	07-10	£2.50
5K		Colvern	CLR2503	£3.00
15K	0-1	Colvern	A	£3.50
25K	0.5	Helipot	SAJ337	£3.00
25K	0-05	Beckman	SA1244	£4.50
30K	0.1	Beckman	A.88	£3.50
30K	0.1	Beckman	SA1082	£3.00
50K	0.5	Reliance	07-10	£2.25
50K			07-5	£2.25
50K	0.5	Beckman	A	£3.00
100K	0.1	Beckman	A	£3.50
100K		Colvern	2501	£2.25
290K	0.1	Beckman	8A3902	£3.50
300K	0.1	Beckman	A	£3.50

THREE TURN 780° ROTATION

25 Ω	Beckman	Type C	£2.25
100/100	Beckman	Type C	£3.00
300	Beckman	9303	£2.25
1K	Fox	PK2/H3	£2.25
10K	Beckman	C.S.	£2.25
20K/20K	Beckman	C.S.	£3.00
10K/10K	Beckman	C.	£3.00
50K	Beckman	C.S.	£1.75

FIFTEEN TURN 5400° ROTATION

25K/25K	Beckman B	10 watts	£6.50
46K/46K	Beckman B	10 watts	£6.50

AC CLAMP VOLTAMMETER

Clamp-on Voltammeter is used for measurements of AC voltages and currents without breaking circuits.

Specification

Measurement ranges—Current 10-25-100-250-500 Amps. Voltage 300, 600 V. Accuracy 4%. Scale length 60mm. Overall dimensions 283 X 94 X 36mm. Weight 1.5 lbs.



£10.50

WANDEL & GOLTERMANN

Distortion Measuring Set VZM-1 for colour t.v. 625 lines PAL **£750**.
Distortion Measuring Set VZM-2 556KHz-12MHz **£250**.
Distortion Measuring Set VZM-83 52/304/556KHz comprises a generator and receiver used mainly to measure transmission distortion on FM radio link systems. **£245**.

Voltage & Level Meter 10KHz-14MHz TFPM 43 measuring range 8v. 40uv (+20-86dB) **£339**.
Selective Level Oscillator 10KHz-14MHz TFPS 42 **£349**.

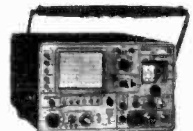


HEWLETT PACKARD Microwave Power Meter Type 430C

Fast readings. Read power directly in mW and dBm. Use 100- or 200-ohm, positive or negative temperature coefficient bolometers. Read CW and modulated power from 0.01 mW to 10 mW or dBm -20 to +10 dBm. **£65.00**

TELE EQUIPMENT D43 OSCILLOSCOPE **£89.50**

TEKTRONIX Spectrum Analyser 10MHz-40GHz Type 491 One only **£1,250**



Stop Press

AVOMETERS—Few only available.

These world-famous and much sought after AVOMETERS are fully guaranteed with 1 year free service included.

Model 7	£24.00	Model 8	£32.00
Model 7X	£26.00	Model 8X	£35.00

Cases, leads and batteries extra.

Carriage and packing charge extra on all items unless otherwise stated.

ELECTRONIC

ADD 10% VAT TO ALL PRICES

ROKERS LIMITED

49-53 Pancras Road, London NW1 2QB. Telephone 01-8377781

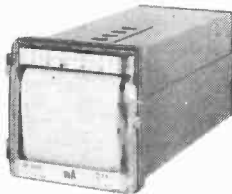
PROMPT DESPATCH MAILORDER. CALLERS
WELCOME MON-FRI 9 A.M. to 5.30 P.M.

WIRELESS WORLD

ALL ITEMS BRAND NEW AND

PEN RECORDERS

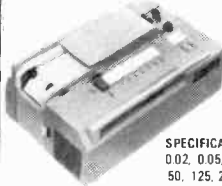
JUST OUT—NEW CATALOGUE ON FULL RANGE OF PEN RECORDERS. SEND READER'S CARD FOR FREE COPY (WW 117)



MINIATURE PEN RECORDER

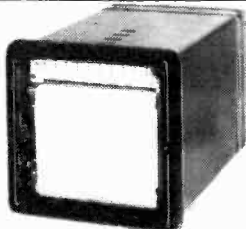
Provides permanent record of DC currents up to 1mA. Eminently suitable for use where space is limited. Separate time marker pen provided. Chart width 80mm. Chart length 40ft. Chart speeds: Slow 20-60-180 mm/hour. Fast 600-1800-5400 mm/hour. Dimensions 120x120x285mm. Weight 7.7 lbs. (3.5 Kg). Price complete with accessories

£39.00



NEW HIGH SPEED PEN RECORDERS 3 MODELS AVAILABLE:
SINGLE CHANNEL £180 · **THREE CHANNEL £310** · **FIVE CHANNEL £420**
 Frequency range DC to 100Hz. Recording presented in curvilinear coordinates by means of ink on paper. Built in solid state amplifier (one per channel) provides 8 calibrated sensitivity steps. Two marker pens are provided; one of these can be connected to internal time marker oscilla or providing 1 second pulses. This pen can also be used as a projects marker to mark a desired event on the chart. Second marker pen can be used as 'zero' (reference) line marker or as another event marker. Full range of chart speeds is immediately available by means of push button control.

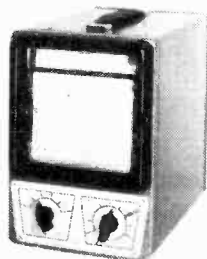
SPECIFICATION: Basic error 4%. Frequency response from DC to 100Hz 2 db. Calibrated sensitivity $\mu\text{V/cm}$: 0.02, 0.05, 0.1, 0.2, 0.5, 1, 2, 5. Width of each recording channel 40mm. Chart speeds mm/sec: 1, 2, 5, 10, 25, 50, 125, 250. Internal calibrating voltage: 40mV. Chart length: 50 meters. Voltage: 220/250. **COMPLEMENT OF ACCESSORIES AVAILABLE.**



10 CHANNEL EVENT RECORDER

Designed for recording sequences of up to ten different operations, e.g. sequence of machine tool operation, switching sequences, etc. Record is presented in the form of square "pulses". When energised, pen moves by approximately 4mm, to the right of zero line. Response time 100 milliseconds. Chart width 110mm. Chart length 50ft. Inw capacity 72 hours. Chart speeds 20-60-180-600-1800-5400 mm/hour. Size 160x160x256mm. Weight 9 lbs. Price complete with accessories

£52.00



PORTABLE AC/DC RECORDING VOLTAMMETER

Fitted with separate zero marking pen. Accuracy 1.5% DC, 2.5% AC. Measurements ranges — AC and DC: 5-15-150-250-500mA 1.5-5 Amps 5-15-50-150-250-500V. DC only 150mV. Frequency range 45 to 1000 c/s. Chart width 100mm. Chart speeds 20-60-180-600-1800-5400 mm/hour. Weight 22 lbs. Price complete with accessories

£78.00



SINGLE PEN RECORDER

A most versatile pen recorder producing a trace on a curvilinear 3 in. strip chart. Two synchronous speeds: 1 in. and 6 in. per hour.

Fitted with high and low alarm contacts operated by the moving coil. Basic movement 1mA DC coil resistance 400 ohms. Fitted with rectifier to allow operation on AC effective coil impedance at 50Hz: 1800 ohms.

TYPE 230

Power supply required: 230V 50Hz. Applications: Ideal for recording relatively slow changing phenomena such as: Temperature: Gas or Liquid Flow Rates, Sound Levels, Speed variations, Power Demand, Rainfall, humidity, etc.

PRICE £25.00

Clockwork version also available £29.50



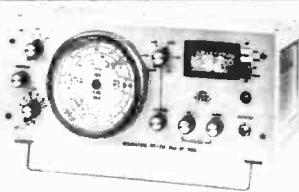
MINIATURISED STRIP CHART RECORDER

Indicates the magnitude of applied currents or voltages by a continuous distortion-free line on pressure sensitive paper. Moving coil movement, scale calibrated 0.1 milliamp d.c. internal resistance 100 ohms. Chart drive motor 240V 50Hz. Chart speed 1" per hour. Complete with handbook.

Price £25.00

TES EQUIPMENT

OBTAINABLE ONLY FROM ELECTRONIC BROKERS. SEND READER'S CARD FOR FREE CATALOGUE OF TEST EQUIPMENT (WW 118)



AM-FM GENERATOR Type AF 1065

Permits fast and accurate calibration of modern radio receivers. Suitable for calibration and testing in the laboratory. AM frequency range: from 140 KHz to 46 MHz in 6 ranges expanded range 430-530 KHz. FM frequency range: 9.5-12 MHz; 85-110 MHz. Frequency accuracy: better than 1%. RF output voltage: adjustable from 0.1 μV to 0.1V. Output impedance: 75 Ohm constant. Modulation: AM: FM: AM + FM. Amplitude modulation: 400 Hz: from 0-50% adjust. Frequency modulation: 1000 Hz adjust. Deviation from 0 - +/- 50 KHz. External modulation: AM: FM: from 30 Hz to 15 KHz.

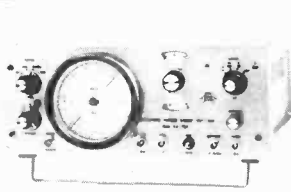
£259.00



RCL BRIDGE Type P 966

For measurement of RCL and capacitor dissipation factor and inductors figure of merit Q. Consists of a system of switchable bridges, a 1 KHz generator, and a sensitive tuned detector. Particularly suitable for testing of small production batches and selection of component parameters. Measurement ranges: Resistance: from 0.1 Ohm to 11 MOhm. Capacitance: from 1 pF to 1100 μF . Inductance: from 10 μH to 1100 H. Accuracy: +/- 1%. Dissipation factor D: from 1.10^{-3} to 50. Quality Factor Q: from 0.02 to 1000. Internal oscillator: 1 KHz.

£245.00

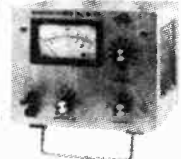


TV SWEEP MARKER GENERATOR Type VU 167

Suitable for alignment of tuned circuits in television sets. Incorporates a sweep generator, a marker generator and a crystal-controlled oscillator operating at 5.5 MHz. Sweep frequency range 1-30 MHz. 170-260 MHz Fund. 470-780 MHz Harmonic. Marker frequency range 2-266 MHz. 480-800 MHz.

£259.00

Many other models available
Send for list



OUTPUT POWER METER TYPE M J 964.

This instrument basically consists of a transistorized amplifier voltmeter which measures the voltage across a specified load. It is provided with 40 load values ranging from 2.50hm to 20K Ohm. As the loads are purely resistive, their value keeps constant with varying frequency. A special negative feedback loop allows a nearly linear scale to be obtained. No damages to the instrument result from errors in presenting the load values or the power ranges. Power measuring range (in 4 ranges) from 1mW to 10 W. Level measuring range Ref. 1mW from -3 dB to +44 dB. Frequency range from 20 Hz to 50KHz. Accuracy Within 0.5 dB. Load input resistances 40 Values. Resistances accuracy better than 5%. Instrument Calibration R.M.S.

£129.00

ADD 10% VAT TO ALL PRICES

Carriage and packing charge extra on all items, unless otherwise stated.

30 WAYS

GUARANTEED FOR 12 MONTHS



Sole agents for **I.C.E.**

FREE NEW CATALOGUE NOW AVAILABLE
SEND READER'S CARD WW 119

THESE ACCESSORIES CAN BE USED IN CONJUNCTION WITH THE SUPRETESTER 680R. ALSO IN MANY CASES WITH POPULAR MAKES OF TEST METERS.

Amperclamp
For measuring a.c. currents from 250mA to 500 amps.
£11.95



Signal Injector
Producing 1KHz and 500 KHz signals for circuit testing. £5.95



Transistor Tester
For transistors and diodes.
£11.00.



Gauss Meter
For measuring magnetic field strengths.
£11.95

Phase Sequence Indicator
To indicate the phase sequence of a 3 phase supply. £5.95



Temperature Probe
Covering the range -50 to +200°C. £11.95



Electronic Voltmeter
Input resistance of 11Mohms for d.c. and 1.6Mohms shunted by 10pF for a.c. £18.00



OTHER ACCESSORIES AVAILABLE
SHUNTS D.C. 25, 50 and 100 amps. £4.50 each.
CURRENT TRANSFORMERS A.C. 25 and 100 amps. £7.00 each.
E.H.T. PROBE Extends D.C. voltage to 25,000v. £5.95.

THE REVOLUTIONARY SUPRETESTER 680R

FOUR INTERNATIONAL PATENTS — SENSITIVITY 20,000 Ohms per Volt
10 FIELDS OF MEASUREMENT
AND 80 RANGES. ACCURACY 1% in D.C. 2% in A.C.
OUTSTANDING FEATURES:
20,000 Ohm per Volt sensitivity • Fully screened against external magnetic fields • Scale width and small case dimensions (128 x 95 x 32mm) • Accuracy and stability (1% in D.C., 2% in A.C.) of indicated reading • Simplicity and ease of use and readability • Full ranges of accessories • 1000 times overload • Printed circuit board is removable without de-soldering • More ranges than any other meter. VOLTS A.C. = 11 ranges: 2-10-50-250-1000-2500. Volts and 4-20-100-500 and 2000 Volts. VOLTS D.C. = 13 ranges: 100mV-2V-10-50-200-500-1000 Volts 200 mV-4V-20-100-400 and 2000 Volts. AMP. D.C. = 12 ranges: 50µA-500µA-5 mA-50 mA-500 mA-50 Amp and 100µA-1 mA-10 mA-100 mA-1 Amp and 10 Amp. AMP. A.C. = 10 ranges: 250µA-2.5 mA-25 mA-250 mA-2.5 Amp and 500µA-5 mA-50 mA-500 mA-5 Amp. OHMS REACTANCE = 8 ranges: $\times 1-10-100-1000-10,000$ and Low Ohms. DETECTOR = 1 range: from 0 to 10 Megahms. FREQUENCY = 2 ranges: from 0 to 500 and from 0 to 5000 Hz. V. OUTPUT VOL% AGE = 9 ranges: 10-50-250-1000-2500 Volts. DECIBELS = 10 ranges: from -24 to +70 db. CAPACITY = 8 ranges: from 0 to 50,000 and from 0 to 500,000 pF using the mains anc. from 0 to 20. from 0 to 200, from 0 to 2,000 and from 0 to 20,000 Micro farad using the incorporated 3Volts battery. Bold figures indicate depress button.



£18-50
with shockproof case

ALL I.C.E. EQUIPMENT POST FREE

METERS PROBES, ETC.

FANTASTIC VALUE



AC/DC MULTI-METER

With taut band suspension movement. Sensitivity 20,000 ohms per volt on DC and 4,000 ohms per volt on AC.
Technical Data:
0.06-0.6-6-60-600mA-3 Amps DC.
0.3-3-30-300mA-3 Amps AC. 0.6-1.2-3-12-30-60-120-600 DC. 1200 Volts.
3-6-15-60-150-1300-600-900 Volts AC. 45 to 20,000 Hz.
500Ω-5-50-500kΩ resistance. Decibel range -10 to +12dB Accuracy (% of F.S.D.):—DC and resistance measurements +2.5. Price with test leads, and storage case **£8.00 POST FREE**



MODEL 300 LOGIC PROBE

A compact easy-to-operate logic probe. As a light-emitting diode is used the unit operates with low power. It does not affect the circuit under test because of high input impedance. Up to as high a frequency as 12 MHz.
POST FREE £5.50

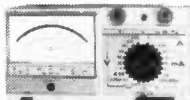
AMPERTEST 690



NEW CLAMP TYPE AMMETER

With unique self-locking meter system retains reading until released, enabling engineer to obtain accurate results after testing inaccessible places etc.
Designed for use in one hand, measures without breaking the circuit. It has six current ranges from 3A to 600A f.s.d. with the first division at 100mA a 10-to-1 current transformer supplied with the instrument provides ranges from 300mA to 60A f.s.d. with the first division at 10mA. Two a.c. voltage ranges of 250V and 600V f.s.d. are provided.
£39.50 POST FREE inc. leather case

MULTIMETER WITH FULLY AUTO CUT-OUT



With taut suspension movement and full coverage of AC and DC current and voltage ranges. The instrument incorporates all facilities needed for field and laboratory measurements. Knife edge pointer and 86mm long mirror scale allow the high inherent accuracy of the instrument to be utilized in full. The movements and circuits are fully protected by transistorized triggering circuit.
Scale length: 86mm D.C. current ranges: 50µA, 0.5, 1, 5, 10, 50, 250mA 1, 5 Amps. A.C. current ranges: 0.25, 0.5, 1, 5, 10, 50, 250mA, 1, 5 Amps. D.C. voltage ranges: 100mV, 0.5, 2.5, 10, 25, 50, 100, 250, 500, 1000V. A.C. voltage ranges: 0.5, 2.5, 10, 25, 50, 100, 250, 500, 1000V. Transmission level: -5 to +10db. Resistance ranges 0.5, 200; mid-scale reading 13 10Ω-3kΩ; mid-scale reading 200Ω, 100Ω, 30kΩ; mid-scale reading 2000Ω, 1kΩ-300kΩ; mid-scale reading 20kΩ. Accuracy, % of F.S.D.: D.C. ranges -1.5 A.C. ranges -2.5. Sensitivity: D.C. ranges, 20,000Ω/V. A.C. ranges, 4,000Ω/V for all ranges except 2.5V and 10V 1000Ω/V for 10V range 200Ω/V for 2.5V range. Batteries required: 2 dry cells 1.5V for automatic cut-out, 1 dry cell 1.5V for resistance range. Overall dimensions: 210 x 115 x 90mm in carrying case, complete with test leads.
POST FREE £15-00

UNIQUE MULTI-METER/SIGNAL GENERATOR



Taut suspension movement. Simple multimeter combined with audio/F. Test Oscillator providing AC and DC Voltage ranges. D.C. current ranges and resistance ranges. 1kHz and 465kHz oscillator output makes the instruments suitable for general tuning of receivers etc.
Scale length: 85mm. D.C. voltage ranges: 0.5, 2.5, 10, 50, 250, 500, 1000V. A.C. voltage ranges: 2.5, 10, 15, 250, 500, 1000V. D.C. current ranges: 0.05, 0.5, 5, 50, 500mA.
Sensitivity: 20,000Ω/V. Resistance ranges: 5-1000Ω mid-scale reading 50Ω 500Ω 10k; mid-scale reading 500Ω, 500Ω-100kΩ; mid-scale reading 5kΩ 5kΩ-1mΩ mid-scale reading 50kΩ.
Accuracy: 5% of F.S.D. Internal battery: 3V dry cell.
Oscillator output: 1kHz squarewave, 465kHz sinewave modulated by 1kHz squarewave signal. Output voltage: 1V minimum.
Overall dimensions: 160 x 97 x 40mm. in carrying case, complete with test leads.
£7-00 POST FREE

ADD 10% VAT TO ALL PRICES

Carriage and packing charge extra on all items, unless otherwise stated.

ELECTRONIC ROYALTY LIMITED

49-53 Pancras Road, London NW1 2QB. Telephone 01-837 7781
PROMPT DESPATCH MAIL ORDER. CALLERS WELCOME MON-FRI 9 A.M. to 5.30 P.M.

Canada calls Mult £1 Million

Contract signed against international competition.

The Multitone Electric Company Limited have announced that their Canadian subsidiary, Multitone Electronics Limited of Toronto, have signed a contract with Bell Canada—one of the largest users of mobile communications equipment in Canada. This contract, worth approximately £1 million, is for digital selectively called communications receivers and digital base station equipment. The contract has been won against considerable international competition.



Most sophisticated equipment of its type in the world.

The equipment will form part of an area-wide paging system, believed to be the largest and most sophisticated in use anywhere in the world, operating throughout Ontario and Quebec. About 60 transmitters are co-ordinated throughout the system by two central computers which store incoming calls, automatically decide which transmitters are to be used for each outgoing call and access the correct transmitters over the public telephone system.

British technology to the fore

The Multitone group Research and Development facility in London was responsible for the design of the re-

ceivers and the associated digital equipment. Their unique expertise in designing low power-consumption RF circuitry, allied with high packaging density and rugged mechanical design has made possible the high performance receivers required by this contract. In fact, the whole package weighs only 5 ounces, including batteries and occupies a volume of 7 cubic inches.

Design Philosophy

The receiver section consists of an internal antenna, and a double conversion high performance communications receiver operating in the 150 MHz band with 25 kHz channelling. Particular care has been taken to

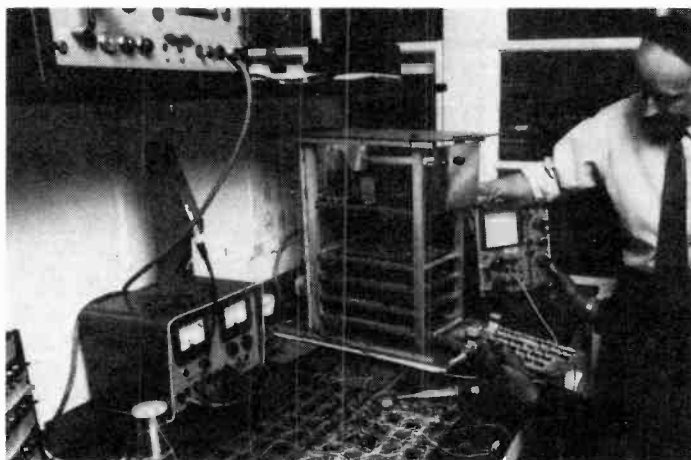
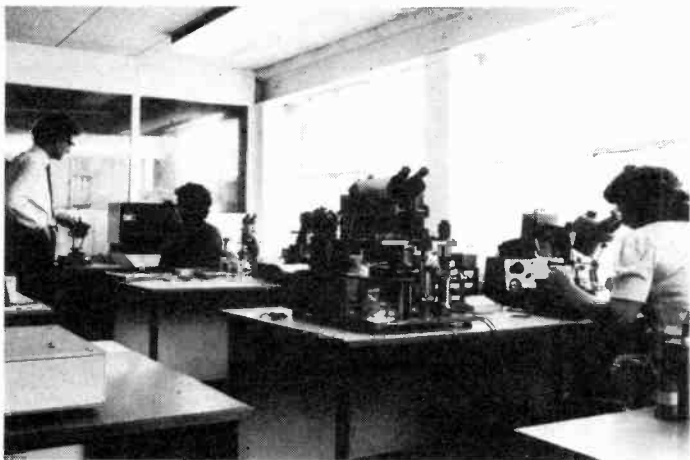
minimize spurious responses so that the performance is unaffected by interference in a crowded urban radio-communications environment. C-MOS technology is used to achieve the complex decoding and internal timing requirements with a minimum of power consumption. Battery power is also conserved by a system whereby the power supply is only switched on for short periods, during which time the receiver senses whether a signal is present or not. If it is, the receiver locks on until the signal ceases.

High Speed— High Integrity

The address code has been developed by Multitone specifically for selective calling purposes. It combines the high traffic rate of up to 4 calls per second with virtually complete freedom from false calling. In addition to addressing the individual receivers, the code contains additional data which allows the receiver to pass up to eight messages to the user to indicate, for example, the urgency or the origin of the call. Also the code permits the calling of receivers in groups in addition to their being called individually.



one to the sound of



Bell's intentions

In the Bell system, the code is generated by special code converter units designed by Multitone. They convert incoming data from the computer terminal to the receiver address code. These code converters form a part of the existing transmitter controllers, which in turn pass the address code to the transmitters. These controllers also receive data regarding the transmitter operating status for transmission back to the terminal.

Plans for the future

The British headquarters of Multitone are naturally delighted with the success, but a spokesman for the company expressed the view that this would only generate more pressure in terms of research and development. "As an expanding company, our attitude is one of ensuring that we are always one step ahead. Naturally, this makes demands on our manpower resources, and doubtless with the confidence which has been shown in our products we shall be looking for more people to join us and apply their expertise to what is an ever-increasing market."

From the Managing Director

Reaffirming the point, I. H. Karten, Managing Director of Multitone Electric Company, stated, "The wide-area paging market opens up broad new horizons for our company both in sales growth and product sophistication. Multitone will bring to the wide-area market, products which will

extend to this field the leadership we have already established world-wide in on-site applications."

Prospects

All in all, it looks very much as though people, particularly engineers, will be warmly welcomed at Multitone. The world-wide explosion of the radio

paging market and the universal acceptance of this form of data transmission as a prime communications aid is leading to unique technical developments. This is a new field waiting to be exploited both by those who enjoy the challenge of innovation, and those who find satisfaction in master-minding a well designed product into large scale production.

A NEW TECHNOLOGY

Today a new technology is being developed. From small beginnings has come the possibility of real personal communications—not communications with vehicles or buildings, but directly with people.

Radio Selective Calling and Paging are being applied to a vast number of communication problems—for Public Safety, Business Efficiency, Hospital Administration etc. etc.

To develop the potential of this new activity we need engineers with a flair for innovation, engineers with a flair for project administration, engineers whose experience has brought them into close contact with radiocommunications.

Some of the tools of the trade which are making these developments possible are:

- ★ High performance radio receiver/transmitter design
- ★ Frequencies from HF to UHF
- ★ Custom integrated circuit design
- ★ C/MOS technology
- ★ Thick film development
- ★ Ultra high density packaging
- ★ High speed data transmission

If you have experience of the design or development of radio receivers, radio transmitters, or digital circuits why not get in touch with us?

Salaries are good, ranging from £2000 to £4000+, and so are the prospects, because Multitone is an expanding international group of companies—British owned.

If you would like more information just ring our R & D manager—Peter Coles—on an informal basis.



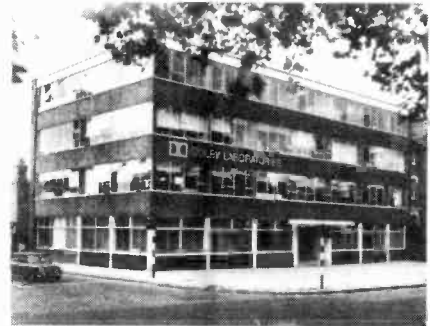
Multitone Electric Co. Ltd.

10-28 Underwood Street, London N1 7JT. Tel: 01-253 7611

APPOINTMENTS VACANT

DISPLAYED APPOINTMENTS VACANT: £11.88 per single col. inch.
LINE advertisements (run-on): 66p per line (approx. 7 words), minimum two lines.
BOX NUMBERS: 30p extra. (Replies should be addressed to the Box number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London, S.E.1. 9LU.)
PHONE: Allan Petters on 01-261 8508
Classified Advertisement Rates are currently zero rated for the purpose of VAT

Advertisements accepted up to 12 noon Tuesday, June 3rd for the June issue subject to space being available.



Noise Reduction in Recording and Communications

Dolby Laboratories manufacture professional noise reduction equipment which has been accepted by all major recording companies in the world. The same techniques have been applied to consumer products which are being built in several countries by licensees, and are now widely available.

We have vacancies in the engineering department for talented engineers to continue research and development in these fields. The department is expanding but is still small (a dozen people) in an organization of 100. We are situated in a modern building south of the river with excellent communications to the centre of London and main railway stations.

Project Engineer
 Professional Products
 £3,000-£4,000

This position is suited to an engineer inclined towards professional audio. He will work on the design of new products aimed at the recording, broadcasting and communications industry using appropriate Dolby system noise reduction techniques. He should be capable of and interested in following his design through to prototype models and later of advising the production department throughout the life of the product.

The ideal candidate will probably be about 25-35 with an honours degree in engineering or physics, and with experience in some of the areas mentioned above, together with a personal interest in music and quality sound reproduction.

Project Engineer
 Licensed Product
 Evaluation
 £2,500-£3,000

The rapid increase in licensees (now over 40) of the Dolby B-type consumer noise reduction system has resulted in a corresponding increase in our liaison activities.

Part of the continuing licensing programme involves evaluation of a wide variety of consumer products incorporating our circuit, and we are looking for an engineer to be part of the team which performs these evaluations. He will be responsible for planning and executing the testing programme, which requires some familiarity with the design and construction of consumer products. He will be 25-35 and have a degree, together with experience of and a high level of interest in quality tape recording and sound reproduction.

Write with brief details in the first instance or telephone

David Robinson, Chief Engineer
Dolby Laboratories Inc, 346 Clapham Road, London SW9. Telephone: 01-720 1111

Dolby and the Double-D symbol are trade marks of Dolby Laboratories Inc

Customer Engineers

As one of the largest and most successful computer manufacturers, we place particular importance on the maintenance of a high level of customer service. Our equipment is among the most advanced in the world today. Highly sophisticated hardware used by top companies and organisations in commerce, industry, science and government.

Our Customer Service organisation is, therefore, immensely important to us if we are to maintain the high standards we have set ourselves over the years, during which we have pioneered much of the advanced technology in use today throughout the industry.

We're looking for Customer Engineers to carry out, to a high professional standard, all electronic and electro-mechanical work concerned with installation, modification, refurbishing, preventive and remedial maintenance on Sperry Univac equipment in the UK.

We require men with a knowledge of electronic or mechanical

fault-finding techniques. In addition to technical competence, essential requirements are a pleasant personality and the ability to maintain a good relationship with customers. Full product training will be given.

To Engineers looking for the best in salaries, vacancies exist in most parts of the country. Conditions and fringe benefits are what you would expect when you join a company within the international Sperry Rand organisation. Future career prospects in the computer field are excellent.

For vacancies in London or the South write with full personal and career details to Personnel Manager, Ref. WW, Sperry Univac, Univac House, 160 Euston Road, London NW1. Telephone 01-387 0911. For vacancies in the Midlands and North write with full personal and career details to Personnel Manager, Ref. WW, Sperry Univac, Lynnfield House, Church Street, Altrincham, Cheshire. Telephone 061-928 7731.



SPERRY  **UNIVAC**
PROFIT FROM EXPERIENCE

RADIO OPERATORS JOIN THE POST OFFICE FROM AGE 19

A job in the Post Office Maritime Service is the key to an interesting career, whether you have recently qualified and are looking for a shore-based job, or are seagoing and wish to swallow the anchor. A progressive future in the Post Office could be yours if you hold a General Certificate in Radiocommunication, issued by the Ministry of Posts and Telecommunications, or an equivalent certificate issued by a Commonwealth Administration or the Irish Republic.

Starting pay at age 19 is £1,450 a year, including contributions to a compulsory pension scheme, with an additional allowance averaging £300 for shift duties. After two years, satisfactory service your pay becomes £1,840, rising to a maximum of £2,450 at age 26 years. If you are over 19 years of age your salary is dependent upon age at entry.

There are opportunities for further promotion to positions with a basic salary of £3,475 and prospects for advancement into Senior Management.

For further information, write to the Inspector of Wireless Telegraphy (L523), MRSD/ET17. 1. 1. 3, Room 643, Armour House, St. Martins-le-Grand, London EC1A 1AR.

**Post Office
Telecommunications**

91

Electronics Appointments Register

We know a lot of companies who would like to meet you.

Even if you scour the Sits Vac columns you won't find all the good jobs to fit your qualifications. Because the best jobs aren't always advertised.

More and more companies are using the Electronics Appointments Register to find qualified men and women.

Join one of our Registers and soon you could be on a short list for a better job. Our confidential service costs you nothing.

Send in the coupon—we'll mail you by return.

G A R Graduate Appointments Register

Please send me details of how to enrol on one of your Appointment Registers:

Name

Address

Age limits 20-45.

WW8

Post to G.A.R. 76 Dean Street London W.1. 01-734 6536

13682

CIRCUIT DEVELOPMENT ENGINEERS TELEVISION SYSTEMS SALARY RANGE £7,000 (OPEN)

The Grass Valley Group, Inc. (USA), a leading manufacturer of television line and terminal equipment, has immediate openings for highly qualified circuit development engineers. Specifically, we are looking for creative and resourceful people who are capable of carrying ideas through to completed products. Applicants are expected to be familiar with the latest solid state devices and techniques, and preferably should have experience in the design of video switching systems, video processing systems, and possibly digital video systems. Some experience in television studio operations and techniques is also desirable. Educational requirements are a C.E. or a B.Sc. in electronic engineering. A minimum of five years' design experience is required.

If you are interested in a challenging and rewarding career with an expanding company, please airmail a resume of your educational and technical background, work experience, and personal history to William L. Rorden, Chief Engineer, The Grass Valley Group, Inc., P.O. Box 1114, Grass Valley, California 95945, USA. Resumes need not be formal; however, we are interested in learning as much about you and your experience as possible. Immediate consideration will be given and response made to suitable applicants, with a view toward arranging personal interviews in London in early 1974. All resumes will be treated in confidence. References will be required at or prior to the time of interview.

Grass Valley is a small town located in the foothills of the Sierra Nevada mountains in northern California, adjacent to summer resort and ski areas, and 2 1/2 hours from San Francisco.

THE GRASS VALLEY GROUP, INC. 

3611

FIELD SERVICE ENGINEERS

The Computer Division of Redifon Electronic Systems Limited is a leader in the Key-Disc market in the United Kingdom, manufacturing and selling Key-Check and See-Check.

We invite applications from experienced Field Engineers or competent factory-based System Test Engineers/Trouble Shooters, who desire a career in Field Service Engineering.

Thorough training in our factory at Crawley will be given to successful applicants, who should reside in the Home Counties or Swansea area.

We offer opportunities for overseas travel, excellent salaries, Life Assurance, Pension Scheme and other fringe benefits.

Please apply, quoting reference number; Ref: WW/21, to:

Tony Cox, Personnel Manager,
Redifon Electronic Systems Limited,
P.O. Box 2, Manor Royal, Crawley, Sussex.

REDIFON 

A Member Company of the Rediffusion Organisation



3734

DESIGN ENGINEER



An established Radio Company situated on the South side of Birmingham requires an enthusiastic electronics engineer to join its design and development department.

Applications are invited from engineers who have industrial experience in V.H.F. circuit design associated with communication equipment.

The successful applicant will be involved from the initial design stage to production, this providing an opportunity for considerable initiative.

Please apply in writing in the first instance to **The Employment Officer, Eddystone Radio Limited, Alvechurch Road, West Heath, Birmingham, B31 3PP.**

A member of Marconi Communication Systems Ltd.

Eddystone Radio



13739

Electronics Test Engineers

Pye Telecommunications of Cambridge and Haverhill have immediate vacancies for Production Test Engineers. The work entails checking to an exacting specification VHF, UHF radio-telephone equipment before customer delivery; applicants must therefore have experience of fault finding and testing electronic equipment, preferably communications equipment. Formal qualifications, while desirable, are not as important as practical proficiency. Armed service experience of such work would be perfectly acceptable.

Pye Telecommunications is the world's largest exporter of radio-telephone equipment and is engaged in a major expansion programme designed to double present turnover during the next five years. There are, therefore, excellent opportunities for promotion within the company. Pye also encourages its staff to take higher technical and professional qualifications.

These are genuine career opportunities in an expansionist company, so write or telephone without delay for an application form to:

Mrs A E Darkin at
Cambridge Works, Elizabeth Way,
Cambridge CB4 1DW
Telephone: Cambridge 58985

or

Mrs C Dawe at
Colne Valley Road, Haverhill,
Suffolk CB9 8DU
Telephone: Haverhill 4422



Pye Telecommunications Ltd

A member of the Pire of Cambridge Group

3741

SIEMENS

We are Siemens Limited, the UK company of the Worlds most diversified electronic and electrical engineering organisation. We are expanding rapidly and urgently require

Customer Service Engineers for Scientific Instruments

To work on analytical x-ray equipment, electron microscopes and chromatographs. Ideally applicants will be educated to HNC level in electronics or physics, but sufficient relevant experience would be favourably considered. If necessary training will be given to

the successful candidates. This is a unique position in a large well established multi-national concern. Excellent salary and fringe benefits. Vacancies are based in London and Glasgow, interviews can be arranged at either centre. If you are interested and feel you have the

experience and necessary qualifications then write or phone for an application form to Roger Kingsley, Personnel Manager, Siemens Limited, Great West House, Great West Road, Brentford TW8 9DG, Middlesex. Telephone 01-568 8281 Ext. 34

13680

HAYDEN LABORATORIES LIMITED

exclusive U.K. agents for NAGRA tape recorders and SENNHEISER microphones.

A vacancy has arisen in our London Service Department for an engineer to carry out servicing work on the above products. We are seeking an enthusiastic and conscientious worker with a good understanding of microphones and tape recorders and a standard of workmanship consistent with the quality and reputation of these products.

Good working conditions. Four weeks' annual holiday. Holiday arrangements will be honoured for this summer. Salary by negotiation. Interviews in London. *Please apply in writing to*

Managing Director, **HAYDEN LABORATORIES LTD.**, Hayden House, 17 Chesham Road, Amersham, Buckinghamshire

13748

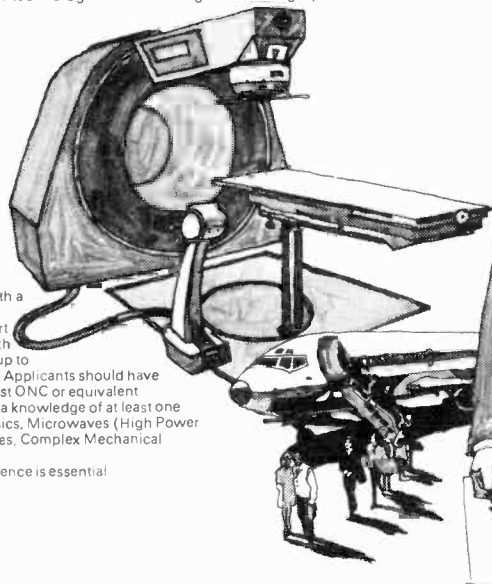
THE M.E.L. SL75

One of the most advanced Linear Accelerators for world users

The M.E.L. Equipment Company Limited situated at Crawley, Sussex, is that part of the Philips Group involved in the development, manufacture and marketing of professional electronic equipment.

The SL75 series is the latest of a long line of medical Linear Accelerators which have been used for the treatment of cancer in hospitals throughout the world for over twenty years.

Further technological breakthroughs in this highly successful area of the Company's activities have created the following opportunities.



Technical Support Engineers

They will be required to work with a team based at Crawley, on the installation and technical support of the accelerator equipment both at home and abroad. Periods of up to 3 months will be spent overseas. Applicants should have a technical qualification to at least ONC or equivalent and it is desirable that they have a knowledge of at least one of the following: Radiation Physics, Microwaves (High Power Radar), High Vacuum Techniques, Complex Mechanical Assemblies. Semi Conductor Circuitry experience is essential

Sales Support Engineer (Export)

An experienced Sales Support Engineer is required to assist with the promotion of export sales of Linear Accelerators and associated peripheral equipment to medical, industrial and scientific customers overseas with values of between £100,000 and £300,000. He will give specialist advice on the product to the National Sales Organisations of the International Philips Group.

In view of the type of equipment and the markets concerned, a degree in Science and experience in electronic, scientific and electro-medical markets would be strong assets but the Company is predominantly seeking an engineer with experience of sales and export marketing.

Applicants must be prepared to spend up to a total of six months a year overseas, mostly in short periods but with occasional trips up to two months.

The Company offers attractive salaries and fringe benefits for these positions including at least four weeks holiday a year and assistance towards moving to Sussex if required.



Initially, applicants should write or telephone for an application form to:- Mr. M. A. Burns, Personnel Officer (DT/109), The M.E.L. Equipment Co., Ltd., Manor Royal, Crawley, Sussex. Tel: Crawley 28787.

Installation Engineering with IAL up to £3,000 Worldwide Travel

The chance for advancement is open to ENGINEERS AND TECHNICIANS looking for a UK based job with worldwide travel opportunities.

As a member of our new installation team you may have your first job in Singapore or it could be in Dubai for IAL's contracts are in all parts of the world. For the most part your trips will be of around one month's duration but some may be extended depending on job requirement and complexity.

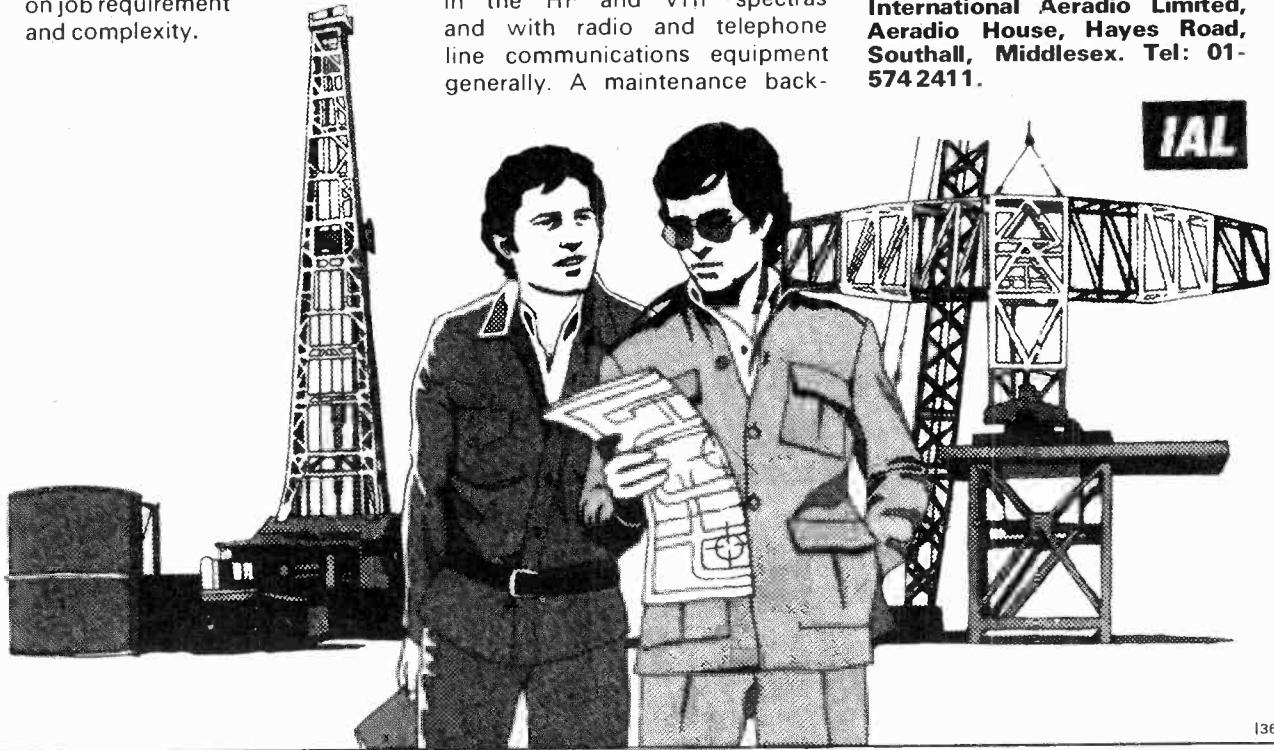
We have positions for ENGINEERS to head the teams whose experience covers the installation and commissioning of FDM in the VHF, UHF, and SHF spectra and/or radar and sophisticated ground based aeronautical navigational equipment.

There are also interesting positions available for TECHNICIANS who will supervise projects. Here we require experience in the installation and commissioning of single channel radio equipment in the HF and VHF spectras and with radio and telephone line communications equipment generally. A maintenance back-

ground in these areas would be useful.

The positions offer real job responsibility and satisfaction, generous overseas allowances will be paid. Other benefits include membership of a sound contributory pension and life insurance scheme and opportunities for holiday air travel at nominal rates worldwide.

Please apply by phoning or writing to Mr Rodney Radcliffe, Personnel Officer (Ref: IE/WW), International Aeradio Limited, Aeradio House, Hayes Road, Southall, Middlesex. Tel: 01-574 2411.



13694

SONY®

A Career with Sony

A unique opportunity to join a world-famous Company, renowned for its product Quality and Reliability.

We are looking for 6 young men aged 16-17

years, educated to between CSE Grade 4 and "O" level standard, preferably with Maths and Physics to become

Apprentice Bench Service Engineers

The four-year Apprenticeship, which leads to City and Guilds Certificate, commences in September with a 13-week full-time course at Kingston College (Surrey).

For full details of a Career with SONY tele-

phone or write to: **The Personnel Officer, SONY (UK) LIMITED, Pyrene House, Staines Rd. West, Sunbury on Thames, Middx. Telephone: Sunbury 87644.**

13743

Electronics Engineers

Do something completely different—become a Lecturer.

We are looking for several Electronics Engineers whom we can train to teach the practicalities of computer servicing.

You will be based at our training centre in Letchworth, Herts – the largest of its kind in Europe. Here, you will be given a comprehensive grounding in computer technology in general and ICL equipment in particular. You will also be taught how to teach and therefore be thoroughly prepared to train Engineers to the point where they will be capable of maintaining computers at the optimum operational specification.

Ideally, you will have an HNC or Forces' training in electronic engineering. Any experience in digital electronics or computers, while not essential, will be useful.

We'll start you as an Assistant Lecturer on a salary between £2200 and £2756. You'll be encouraged and expected to progress to the position of Senior Lecturer which carries a salary of up to £3840. Relocation expenses will be considered where appropriate.

For an application form, write to A E Turner, quoting reference WW at International Computers Limited, 85/91 Upper Richmond Road, Putney, London SW15 2TE.

International Computers



think computers—think ICL

[3681

ELECTRONICS TECHNICIAN

required to join a small team dealing with most aspects of medical electronics including safety, calibration, purchase, design and modifications.

The technician appointed will be expected to gain experience by working in various hospitals in South and Central Liverpool.

Salary scale will be on the Medical Physics Technician Grade III (£719 £2,211).

Applicants should have O.N.C. C & G Certificates or equivalent and have experience in electronics.

Application forms and job description obtainable from the District Administrator, 80 Rodney Street, Liverpool, L1 9AP, to be returned by the 4th June 1974.

[3737

RAILWAY SIGNAL ENGINEER

required by a firm of Consulting Engineers on the South Coast.

Applicants should be graduates and members of the Institution of Railway Signal Engineers and have had experience in a responsible position of the design and execution of modern railway signalling systems, train describers and automatic routing systems. Experience of signalling under 25kV a.c. traction conditions is desirable.

Duties would include the preparation of signalling and train description specifications from outline drafts, preparation of signalling schemes, analysis of tenders and technical supervision of signalling works.

Salary will be according to qualifications and experience.

Applications should be addressed to the Personnel Manager, Messrs. Preece Cardew & Rider, Paston House, 165-167 Preston Road, Brighton, BN1 6AF, Sussex, quoting reference: GET/Pers/3080.

[3689

RADIO OFFICERS

Do you have PMG I, PMG II, MPT 2 years operating experience?

Possession of one of these qualifies you for consideration for a Radio Officer post with composite signals organisation.

On satisfactory completion of a 7month specialist training course, successful applicants are paid on a scale rising to £3,096 pa; commencing salary according to age—25 years and over £2,245 pa. During training salary also by age, 25 years and over £1,724 pa with free accommodation.

The future holds good opportunities for established status, service overseas and promotion.

Training courses commence at intervals throughout the year. Earliest possible application advised.

Applications only from British-born UK residents up to 35 years of age (40 years if exceptionally well qualified) will be considered.

Full details from:

Recruitment Officer,
Government Communications Headquarters,
Room A/1105, Priors Road, Oakley,
Cheltenham, Glos GL52 5AJ
Telephone Cheltenham 21491 Ext 2270

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OPPORTUNITIES FOR ELECTRONIC TECHNICIANS IN SOUTH AFRICA

Uitenhage Municipality requires the services of a qualified electronic technician to work in the Test Section of the Electricity Department. Applicants should preferably be in possession of a H.N.C. and have had experience in digital supervisory systems as related to a distribution authority.

Uitenhage is situated 30 km from Port Elizabeth in the Cape Province and has an excellent climate which is conducive to the many outdoor amenities provided.

Benefits of employment include pension and medical schemes, housing loans at a reduced interest rate, annual bonus, six weeks annual leave and assisted passage and removal expenses for the successful applicant and family. It is expected the salary will be up to R6,498.00 per annum (R1 = £0.61).

Applicants shall, in the first instance, write to Mertz & McLellan, Carrier House, Warwick Row, London, SW1E 5EN, giving age, marital status, qualifications and a career resume. Interviews will be held in London during June/July.

[3703]

BIAS ELECTRONICS LTD.

have recently moved to larger premises and to meet the demand for our internationally acclaimed professional tape recorders require

TEST ENGINEERS

with experience on high quality audio and tape recording equipment;

JUNIOR TEST ENGINEERS

with plenty of enthusiasm and the desire to gain experience in professional audio;

ELECTRONIC WIRE MEN/ASSEMBLERS

capable of working to high standards and with the opportunity to progress to test and inspection.

Take this opportunity to join a dynamic expanding company where you will be regarded as one of the team and not just a number. Good rates of pay and profit sharing scheme.

For further information write or phone

BIAS ELECTRONICS LTD.
572 KINGSTON ROAD
LONDON, SW20 8DR
01-540 8808 or 01-540 9818

[3700]

School leavers- learn while you earn at Pye Telecom

You could train for a professional career, gain help in obtaining further qualifications – and earn good money at the same time. Pye Telecom is part of the Pye Group, leading manufacturers in the electronics industry. Joining will bring you extensive opportunity stemming from Pye Telecom's vigorous growth. You can start as either of the following:

Student Engineer

'A' level Maths and Physics plus 3 'O' levels including English, or ONC/OND with credits, are essentials. You will embark on a 'thin sandwich' course (6 months' practical experience at Pye Telecom, Cambridge, alternating with 6 months at a college of your choice,) which will lead to a B.Sc. or HND in Electronic Engineering. After qualifying your career path could include Design Engineering, Systems Engineering, Production Engineering or Junior Management. If necessary, lodgings will be found for you during periods spent at Cambridge.

Trainee Technician

Entry qualifications: 'O' level English, Maths, Physics, plus another science-based subject, preferably Engineering Drawing, or alternatively good equivalent CSE passes. A 4-year practical training course will combine with day release to take ONC/HNC or City & Guilds Telecommunications Technicians courses. You could become a Test Engineer, Production Engineer, Production Planner, Draughtsman, Engineering Laboratory Technician or Service Engineer. There are some opportunities to progress as a Student Engineer, and take a degree.

For further information and your application form please write immediately to Mrs. Rowan Turnbull, Training Officer,



Pye Telecommunications Ltd

Newmarket Road, Cambridge, CB5 8PD.
Tel: Cambridge 61222

A member of the Pye of Cambridge Group

[3715]

GLASGOW COLLEGE OF TECHNOLOGY

DEGREE in ELECTRICAL AND ELECTRONIC ENGINEERING
by PART-TIME STUDY

Applications are invited from holders of a good H.N.C. in Electrical or Electronic Engineering to enrol for the course:

B.Sc. in Electrical Engineering (CNA A)

This four-year part-time degree course is the first of its type to be offered in Scotland, and a start is proposed for August 1974.

Full details and application form from:

**The Academic Registrar,
Glasgow College of Technology,
North Hanover Place, Glasgow, G40BA.**

The College is only a few minutes walk from the City Centre and Queen Street Station giving easy access from the West of Scotland and Edinburgh.

[3744]

Grow with Pye as a development engineer

We at Pye Audio Products are making a whole new range of sophisticated audio products, at our modern Stevenage plant, including car radios, radiograms and stereo equipment. We now have an interesting and rewarding opportunity for a Development Engineer.

Because of the continual demand for our equipment, and therefore expansion of our product range, we need someone to work in our laboratory, who is capable of self-motivation and possesses the ability to work on a complete project with the minimum of supervision. Ideally the person we are looking for will be qualified to a minimum of HNC in Electronic Engineering and have experience in design techniques for R.F. (A.M. and V.H.F. stereo reception)

and A.F. (powers up to 20 watts) applications, as applied to equipments for domestic markets. He will be dealing mainly in equipment for large volume production with costs playing an important part of the approach to a project.

Salary level and benefits are commensurate with a major company serving an international market. Are YOU looking for a position with good prospects and opportunity for career development? Come and grow with PYE.

Write briefly to: Gillian Charter, Pye Limited, Audio Products Division, Caxton Way, Stevenage or telephone for an application form: Stevenage 50241.



Pye Limited

Pye Audio Products, Caxton Way, Stevenage.
Tel: Stevenage 50241

A Member of the Pye of Cambridge Group

13736

CROWN AGENTS

CONTRACTS ENGINEERS— RADIO COMMUNICATIONS

required by the CROWN AGENTS for their London (Westminster) Office.

Candidates should preferably have had five year's experience as a Contracts Engineer in one or more of the areas of communications detailed below and possess ONC or equivalent in an appropriate discipline. Practical experience of the equipment desirable.

- (a) Sound Navigational Aids (Radar, ILS, VOR/DME, etc)
- (b) HF, VHF, UHF Communication Equipment.
- (c) Microwave Equipment and Systems.

The duties include the checking of specifications, preparation of tender documents, technical and commercial correspondence connected with contracts, the evaluation of tenders and the placing of contracts. Candidates must be prepared to undertake occasional visits to works and to overseas principals.

Commencing salary according to age, qualifications and experience up to £2,557 rising to £2,891. Non-contributory pension scheme.

Write for further details and application form to the CROWN AGENTS, 4 Millbank, London SW1P 3JD stating brief details of qualifications and experience and quoting reference number MIS/OFFICE VI (RADIO COMM) WF

13727

The AGRICULTURAL RESEARCH COUNCIL

require a

SCIENTIFIC OFFICER

in the Electronics Section of their LETCOMBE LABORATORY.

Duties will involve the repair and routine maintenance of a variety of laboratory instruments, in particular equipment for the measurement of radioactive tracers used in the research programme, and also assisting with the development of new equipment. The Laboratory is well equipped with both manual and automated modern instruments.

Minimum qualifications: HNC, Pass degree or equivalent in Electronics or Applied Physics.

Salary Scale £1,435-£2,329 according to qualifications and experience. Super-annuation Scheme with a non-pensionable allowance to offset contributions. Application forms and further particulars may be obtained from the Secretary, ref: 1/74, Agricultural Research Council, Letcombe Laboratory, Wantage, OX12 9JT. The closing date for application is 12 June 1974.

[3716

UNIVERSITY COLLEGE CARDIFF

Applications are invited for the following post:

TECHNICIAN GRADE 3 (ELECTRONICS)

for C.C.T.V. and Audio Studio in the Centre for Educational Technology.

Salary range: £1,650-£1,920. Duties include maintenance and operation of T.V., Audio and Projection Equipment; qualification standard O.N.C. or equivalent; interest in photography and Hi-Fi desirable. Duties to commence as soon as possible. Closing date for applications is one week from insert.

Applications, together with the names and addresses of two referees, should be forwarded to The Registrar, University College, P.O. Box 78, Cardiff, CF1 1XL. Please quote 0555. [3725

C.C.T.V. JUNIOR TECHNICIAN

required to assist studio engineer in operation, maintenance and development of a 3-camera colour CCTV system incorporating telecine and U-matic videocassette copying facilities.

Basic knowledge of T.V. theory essential, experience in servicing VTR's and cameras an advantage.

Day release available if required. Salary c. £1,400 p.a. according to age and experience. Luncheon vouchers. Non-contributory pension, free life assurance.

Phone: PETER MAKOSZ

at (01) 499 0031, ext. 274.

or write with details of experience to:—

T.V. DEPT.,
HAMBRO LIFE ASSURANCE LTD.,
7 OLD PARK LANE,
LONDON W1Y 3LJ.

[3728

ELECTRONIC VACANCIES

Engineers

Draughtsmen ● Designers

Service and Test Engineers

Technicians ● Technical Authors

Sales Engineers

£1,600-£5,000 pa

Permanent or Contract

Phone **MICHAEL NORTH**
01-388 0918

**MALLA TECHNICAL
STAFF LIMITED**

334 Euston Rd., London NW1 3BG
195



WIRELESS TECHNICIAN

required for
EDINBURGH CITY POLICE

Salary Scale £1,644-£2,040 with placing according to qualifications and experience.

Applicants should have knowledge of V.H.F. and U.H.F. apparatus, also be able to diagnose and repair faults on such apparatus. A current driving licence is also essential. Applications to the: **Recruiting Officer, Edinburgh City Police, Recruiting Department, 7 Chambers Street, Edinburgh, EH1 1HR.**

[3711]

SENIOR VIDEO ENGINEER

Senior Video Engineer wanted to operate and maintain tele-cine and video tape recording equipment for company in Basildon. A.C.T.T. rates honoured. 40-hour week. 18-20 working days holiday p.a. Relocation assistance given. For further particulars contact:

THE E.V.R. PARTNERSHIP

Christopher Martin Road,
Basildon Industrial Estate,
Basildon

[3717]

Find your place in British Gas

TELECOMMUNICATIONS

—Field Maintenance

Eastern Gas are seeking to recruit Technicians for their Communication and Instrumentation Section based at Hertford.

These posts will involve all aspects of maintenance on the Eastern Gas Integrated Communication System.

Technician II (Communications/Instrumentation)

Proven ability in Communications/Instrumentation is a prime requirement for this post. Previous experience with an appropriate equipment manufacturer or user would also be desirable.

Technician II (Message Switching)

The person appointed would specialise in the repair and maintenance of an extensive teleprinter network. He will also, on occasions, assist with the maintenance of the Communications equipment associated with this network.

The salaries for both posts will be about £2,000 per annum depending on age and experience with excellent prospects for promotion to higher grades and salaries rising to approximately £2,500 per annum. A current driving licence is essential.

Write or telephone for application forms quoting reference 3703/4228 to Mr. H. A. Lloyd, Personnel Officer, Eastern Gas, Star House, Potters Bar, Herts., within ten days of this advertisement.

EASTERN GAS



[3724]

Join the EMI Service Team at Hayes

We urgently require

Electronic Repair & Calibration Engineers



The international music, electronics and leisure Group.

required for the repair and calibration of a wide range of electronic instrumentation, including oscilloscopes, DVMs, pulse generators, power supplies etc.

Applicants should be aged at least 18 years and should have had at least two years background in electronics. Further training will be given in appropriate cases.

Close Circuit Television Engineers

for the servicing and commissioning of CCTV, VTRs etc.

Applicants should be aged at least 19 years, and must have had some experience in television receiver servicing.

For both of these positions, starting salary will be up to £2,300 per annum according to age, experience and ability. 37½ hour week, plus paid overtime.

Don't delay, for further details telephone or write to M. Ford, 01-573 3888 Ext. 2268, EMI Service, 254 Blyth Road, Hayes, Middlesex.

3738

We're not absolutely certain that the men we're looking for even exist.

We are Racal-Mobilcal – a world-famous name in radio communications equipment.

We are looking for seven outstanding men to take up new posts as our Technical Managers in seven Middle Eastern countries.

And frankly, the qualities we consider necessary for these positions are so demanding, we know for a fact that there can only be very few men who could make it. Each man must be qualified technically in radio communications, because he will supervise the commissioning, installation and maintenance of mobile radio systems. He will liaise with the armed services and other Government agencies of his particular country. And train their local operatives. He must have the management ability and the diplomatic presence to be able to represent the Company in discussions at the highest level with the country's government and armed services.

He will, in fact, be Racal-Mobilcal's front man, technical adviser and diplomat in residence.

And therefore, ideally, he should have a command of Arabic. (But we'll settle for at least the ability and willingness to learn something of the language rapidly).

That is what we're looking for – seven outstanding men to become Racal-Mobilcal in the Middle East.

In return, this is what we're offering:

An initial four year tour of duty, with generous leave arrangements.

An excellent salary which lines up with the job.

Full accommodation for each successful applicant and his family.

And very good prospects for further promotion within the Racal Group after the initial four year tour.

Joining Racal would be joining a world-famous Group which has achieved record profits for the last eighteen

successive years. A world name in electronics. And a world leader in many product areas.

Can you convince us that at least one of the seven men we're looking for does, in fact, exist?

Write in strictest confidence, giving all relevant details, to **David Elsbury, Managing Director, Racal-Mobilcal Ltd, 464 Basingstoke Road, Reading, Berks, RG2 0RY, England.**

Preliminary interviews will be set up at convenient locations.

RACAL
The Electronics Group



13699

FARINON ELECTRIC OF CANADA

is a leading manufacturer of Microwave Radio and Multiplex equipment located outside Montreal.

Openings presently exist in our Field Department for Commissioning Engineers.

The Job

- Installation, alignment, testing and commissioning of Microwave radio and multiplex systems.
- Involves extensive travel throughout Canada including the Northern Regions.

The Applicant

- Experienced in field system testing of solid state radio in the range 150 MHz to 12 GHz having baseband capabilities to 960 channels or video.
- Fully conversant with state of the art tests and capable of evaluating results obtained.
- Knowledgeable on Microwave propagation phenomenon such as multipath.
- Be eligible for Canadian Landed Immigrant status and driver's licence.

This is a responsible career position offering unusual benefits to the right person.

Please send complete resume to:—

Farinon Electric
657 Orly Avenue
Dorval, Quebec,
H9P 1G1
Canada
Attention: Chas. Henry

[3690]

Computer Machinery Company Ltd

require a

Systems/Engineering Instructor

Computer Machinery Company Ltd, the leading UK manufacturer of Key-to-disk data preparation equipment are expanding their Education and Training Department at their new Education Centre, located in Hemel Hempstead, Herts.

The successful applicant will be required to assist the training team with existing courses, the development of new courses and modern training aids.

Essential qualifications for the position include training experience, preferably with electronic digital systems and an ability to absorb new system detail quickly and create new aids and methods to meet our training objectives.

The position offers excellent career prospects and job satisfaction with some UK and Overseas travel. Salary will be negotiable according to relevant experience and relocation expenses could be given where necessary.

Apply in writing or telephone with personal career details to:

Ken Abbott,
Education and Training Manager,
Computer Machinery Company Ltd.,
Maxted Close,
Hemel Hempstead, Herts.
Tel: Hemel Hempstead 61266 Ext. 284

[3704]

South Africa TV Design/ Development

A well-known international group requires a capable Design/Development Engineer for its new monochrome TV factory at Pietersburg. He will be responsible for:—

- managing the development laboratory;
- establishing production quality standards;
- ensuring that the model, designed in Europe, conforms to South African design specifications, and
- new components evaluation, including supplier assessment.

Candidates, aged over 30, should have HNC Electronic Engineering with at least five years experience in modern TV development. Experience of solid-state techniques is highly desirable and a knowledge of German would be useful. Two to three months training in Europe will precede appointment to South Africa. Subsequent promotion to Chief Engineer is a possibility.

Pietersburg is a pleasant town in an area of magnificent scenic beauty. At a height of 4,000 feet, it has a superb climate and every amenity.

Please write with full details which will be sent direct to our client. Please list separately any company to whom your application should not be sent.

R. Llewellyn,
MSL ADVERTISING SERVICES LIMITED,
17 Stratton Street, London, W1X 6DB.

[3710]

TELEVISION ENGINEER

required to join a small but enthusiastic team operating a

TELEVISION UNIT FOR HORSERACING

If you have an HNC, City and Guilds, or equivalent qualification and have experience in operating and maintaining outside broadcast television equipment and VTRs together with a willingness to travel and to work in a demanding field, then this Company offers you:—

- 1 the opportunity to join an organisation that is forward looking and is planning to develop and expand in the field of television and electronics;
- 2 a job that is located in varied surroundings on British racecourses;
- 3 a basic salary of between £2,700-£2,900 plus expenses when on location.

If you are interested, please write or telephone for a Company form to:—

Mr. F. T. Dixon, Racecourse Technical Services Ltd.,
88 Bushey Road, London, S.W.20

Tel: 01-947 3333

[3712]

TELEFUNKEN: SOUTH AFRICA

Television transmission will commence for the first time in South Africa at the end of 1975. Electra Television, the franchise Telefunken distributors in South Africa, will be marketing Telefunken Colour and Black and White receivers during 1975. Our Service Organisation is being vastly expanded, and we are recruiting the following key personnel:—

SERVICE MANAGERS

To be in charge of Service Branches in the major cities in South Africa. Thorough knowledge of all service procedures such as budgeting, costing and invoicing, work progress, stock and staff control as well as a good technical background with particular reference to semi-conductor colour receiver circuitry would be desirable. Salaries negotiable from £5,500 per annum.

T.V. INSTRUCTORS

To instruct technicians, apprentices, field service operators as well as trade staff, in the theory and practice of colour television installations and repairs at their respective required levels. Salaries negotiable from £4,000 per annum.

TELEVISION TECHNICIANS

To take charge of all repairs of colour receivers in various centres throughout the Republic of South Africa and in some instances to take charge of a smaller branch or to supervise a group of learner technicians.

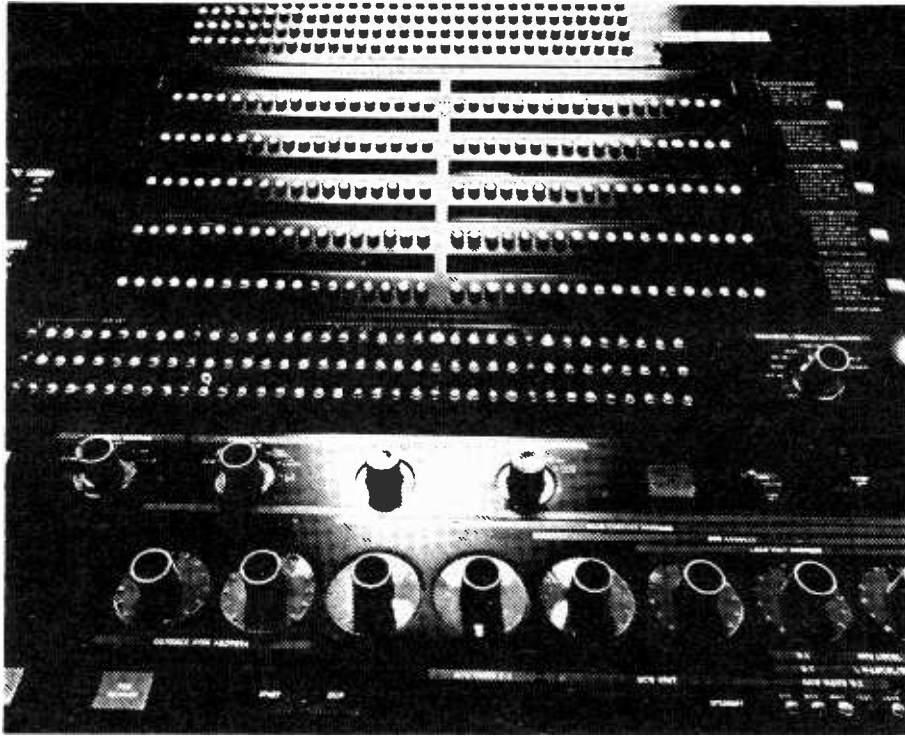
Thorough knowledge of the PAL colour systems especially in respect of semi-conductor circuitry is required. Salaries negotiable from £3,500 per annum.

As Telefunken will be a major brand in the South African Market, rapid expansion is expected, leading to promotion and increase in responsibilities. The company operates a Medical Aid Scheme, a Pension Fund and other fringe benefits. Removal and immigration assistance will be provided.

As interviews will be arranged in May and June, 1974, your application should be addressed as soon as possible to:—

Mr. R. B. Hartog,
C/o Messina (Tvl.) Development Co. Ltd.,
29/30 St. James's Street,
LONDON, SW1A 1HB.

[3713]



We want to meet Customer Engineers who understand people as well as machines

Today, IBM Computers play a vital role in industry, science, government and commerce. Just as vital are the skilled Engineers who keep them running. Because of their close involvement with the customer, we call them Customer Engineers. This could be your first step to a highly rewarding future with one of the world's most successful companies.

Your job as a Customer Engineer

There are several avenues within IBM Customer Engineering. At present most of the opportunities lie with our General Systems Group. Here you will be responsible for the servicing and maintenance of medium and large scale Computer Systems. You'll receive a first class training—initial and continuous.

Qualifications

Ideally you should be educated to ONC/

HNC or equivalent. Essential requirements are a logical mind, a good mechanical aptitude, and a knowledge of electronics and a current driving licence. A Service background though not essential is desirable.

Your Prospects

Starting salaries are excellent. In addition IBM offer many fringe benefits such as a non-contributory Pension Scheme and free Life Assurance. It is also IBM policy to promote from within.

Write today

Write with details of your age, qualifications and experience to: Anne Dare, IBM United Kingdom Limited, 389 Chiswick High Road, London W.4.

[3684]

MARINE RADIO SERVICE ENGINEER

As one of the world's leading companies in radio communications equipment and navigational aids, and one of Britain's biggest exporters in this field, we are constantly developing, constantly expanding. Due to this continual expansion we now require Service Engineers at our Tilbury and Grimsby depots and at our headquarters in Wandsworth to service our marine communications equipment. Formerly an experienced radio officer, you will have had at least three years experience at sea in the servicing and maintaining of all types of ship borne communications equipment. We offer an excellent salary and fringe benefits such as contributory pension scheme and sickness benefits. Write or telephone giving details of career to date to:

DAVID R. STILES
Personnel & Training Officer
Redifon Telecommunications Limited
Broomhill Road, Wandsworth,
London SW18 4JQ
Tel: 01-374 7281

[3753]

BRUNEL UNIVERSITY
Dept. of Electrical Engineering
and Electronics

RESEARCH IN ELECTRONIC SYSTEMS DESIGN

Applications are invited from recent graduates, preferably with some industrial experience, who hold good honours degrees in Mathematics, Electrical Engineering or Physics to undertake research leading to a higher degree in the following areas:

- Computer Aided Design of Digital Systems
- Information Processing Systems
- Power Electronics Systems
- Control Systems Design
- Communication Systems

Research studentships will be available for suitably qualified candidates.

Please write to Professor Douglas Lewin, Dept. of Electrical Engineering and Electronics, Brunel University, Uxbridge, Middlesex.

[3732]

PROJECT & COMMISSIONING ENGINEER

SHOULD HAVE GOOD THEORETICAL TRAINING IN ELECTRONICS PLUS ACTUAL EXPERIENCE OF PROFESSIONAL AUDIO EQUIPMENT IN BROADCASTING, RECORDING, OR WITH A SPECIALIST MANUFACTURER.

Apply in writing to

MR. R. SWETTENHAM
HELIOS ELECTRONICS LTD.
161 HIGH STREET, TEDDINGTON
MIDDLESEX, TW11 8HT

[3701]

AN ENTHUSIASTIC

Electronics Engineer is required for the servicing of a range of computer-assisted medical equipment. The candidate should have a sound electronic background with some basic knowledge of computer techniques and digital circuitry. Training will be given both in England and in the U.S.A. Preference will be given to applicants residing in the West London area.

Please write for application form to:

SIMONSEN & WHEEL LTD.,
Hatherley House,
Hatherley Road,
Sidcup,
Kent.

3735

WORK IN CENTRAL AMERICA**RADIO ENGINEERS AND
TECHNICIANS NEEDED
IN HONDURAS AND
GUATEMALA**

The local Radio Stations in Guatemala and Honduras transmit classes in agriculture, adult literacy, and simple health topics, to the people in the rural areas—approximately 90% of the population.

The training of local people to maintain the transmitters and to deal with the technical production of the programmes is being carried out by four British volunteers. We need people to replace them for a further two-year period.

Information: Frances Chadwick, Overseas Volunteers/CIHR, 41 Holland Park, London, W.11. Tel: 01-727 3195. Visitors welcome.

[3630]

**ELECTRONICS
TECHNICIAN-
ENGINEER**

Young systems company seeks intelligent junior technician-engineer of HNC/ONC or equivalent standard. Suitable for 19-24 year old having completed industrial training or equivalent in one of the services.

Job involves commissioning/development on Mini-Computer based Data Communication systems. Some travel. Training in Mini-Computer hardware/software arranged.

Salary range £1,750-£2,250. Write or telephone Steve Clifford or Peter Rogers for informal discussion.

TASK TERMINALS LTD.,
117 Cleveland Street,
London, W.1
01-637 4516

[3714]

**JOHN KING require
NEW WORTHING SHOP**

Senior Technical Salesman for Hi-Fi, Tape Department. Terrific scope, superb facilities. Full details in confidence to

JOHN KING
71 East Street, Brighton. Tel: 25918/27674.
[3688]

**THE CONTINUALLY
EXPANDING
MILLBANK ELECTRONICS
GROUP**

Bellbrook Estate, Uckfield, Sussex,
TN22 1PS
Tel: Uckfield (0825) 4166

REQUIRES A

TEST ENGINEER

Must be experienced in the testing and servicing of audio power amplifiers, mixers and associated equipment.

This is a Staff position and carries full benefits including membership of a private medical scheme.

If you are interested please apply in writing enclosing curriculum vitae to Mr Keith Goodsell, Production Manager.

[3742]

**CROWN
agents****PROFESSIONAL AND
TECHNOLOGY OFFICERS**

required by the Crown Agents to plan and control projects overseas. Candidates *must* be either M.I.E.E., or M.I.E.R.E., and must be prepared to serve abroad.

**1. P. & T.O.I.—
(Telecommunications—Radio Transmission)**

Candidates must have had overseas experience of radio propagation, systems planning, high frequency microwave line of sight and tropospheric scatter systems. Experience of line carrier and cable systems traffic analysis and forecasting techniques and television requirements an advantage.

REFERENCE—MIS/OFFICE VIII/WF

**2. P. & T.O.I.—
(Telecommunications)**

Candidates must have had overseas experience in a senior position with a Telecommunications organisation or operating company. They should have a knowledge of telecommunications administration and traffic matters, telephone, telegraph and telex operations and a knowledge of switching, transmission or radio engineering.

REFERENCE—MIS/OFFICE VI/2/WF

**3. P. & T.O.I.—
(Telecommunications)**

Candidates must have been responsible for the preparation of transmission network schemes and have a knowledge of some of the following:

- Openwire line carrier systems;
- Multiplex systems on coaxial cables or radio bearers;
- Microwave engineering including propagation studies;
- UHF or VHF radio systems suitable for public networks;
- Telegraph transmission including automatic error correction;
- HF radio systems including LINCOMPEX;
- Data transmission

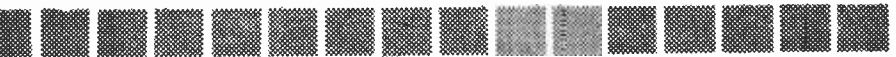
REFERENCE—MIS/OFFICE VI/3/WF

**4. P. & T.O.II.—
(Telecommunications)**

Candidates must have had experience with a telecommunications administration or major manufacturer of telephone switching equipment. A knowledge of Common Control switching systems and of national and international systems is desirable.

REFERENCE—MIS/OFFICE VI/4/WF

Current salary scales are as follows:

P. & T.O.I.—£3,451 to £4,373**P. & T.O.II.—£2,891 to £3,451**

Write for further details and application form to the Crown Agents, 4 Millbank, London SW1P 3JD stating brief details of qualifications and experience and quoting the relevant reference number of the post in which you are interested.

3692

telesonic marine ltd.**MARINE ELECTRONICS ENGINEER**

Are you experienced in installing and servicing marine electronic equipment such as Radar, Navigation Equipment, and radio telephones? We require such a man for a fascinating job travelling to luxury yachts, etc., all round the country. If you live near London and are able to drive, a good salary awaits you working in idyllic friendly atmosphere.

Apply **Telesonic Marine Ltd.**

Tel: 01-387 7467

3608

RADIO RENTALS AUSTRALIA NEEDS COLOUR TELEVISION TECHNICIANS.

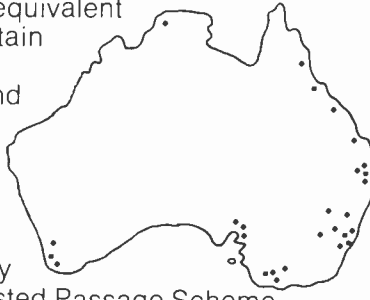
Colour television starts officially in Australia on 1st March, 1975, and Radio Rentals Pty. Ltd., Australia's largest television rental organisation, have an expansion programme which will create vacancies for suitably qualified technicians in Sydney, Melbourne, Brisbane and other centres. Radio Rentals Pty. Ltd. is a member of the Thorn Group of Companies and is associated with the British Radio Rentals organisation.

The vacancies will be of interest to experienced colour television technicians holding the City and Guilds/R.T.E.E.B. Final Servicing Certificate with colour endorsement, or equivalent qualifications, who wish to settle and obtain permanent employment in Australia. All enquiries will be carefully considered and suitable applicants interviewed by an executive of the Company who will be visiting Britain in the near future.

Successful applicants will be given firm offers of employment but will make their own arrangements for migration, possibly through the Australian Government Assisted Passage Scheme.

Applications for further information should include full details of personal status and qualifications and be addressed to:—

Mr. H. D. Wallace, Technical Director, Radio Rentals Pty. Ltd., P.O. Box No. 395, Crows Nest, New South Wales 2065, Australia.

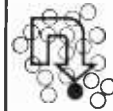


13726

OPPORTUNITIES in the ELECTRONICS FIELD

Men with analogue or digital qualifications/experience seeking higher paid permanent posts in: TEST — SERVICE — DESIGN — SALES.

Phone Roger Pearce, Ref WW4.



NEWMAN APPOINTMENTS
360 Oxford St., W.1.
01-629 7306.

3685

ELECTRONIC TECHNICIAN

required at

NORTHWICK PARK HOSPITAL AND CLINICAL RESEARCH CENTRE

To service and calibrate a wide range of equipment used for medical, surgical and engineering purposes. The successful applicant will work closely with medical and other professional staff.

Salary—Grade III—£1,845-£2,337.

The hospital will have over 800 beds by 1975 and is closely allied with the Clinical Research Centre. Good staff facilities and a pleasant working atmosphere. Active social club. Temporary single accommodation may be available.

Further particulars and application forms, returnable by June 14th, from Personnel Department, Watford Road, Harrow, Middlesex, HA1 3UJ. Tel: 01-864 5311. [3740]

TECHNICIANS AND ENGINEERS FOR ST. ALBANS AND LUTON

QUALIFIED OR NOT!

OPPORTUNITIES for challenging work on testing and calibrating valve and solid-state electronic measuring equipments embracing all frequencies up to u.h.f. in Production, Service and Calibration departments.

APPLICATIONS are invited from people of all ages with experience or formal training in electronics and from Ex-Services technicians.

HIGHLY COMPETITIVE SALARIES, negotiable and backed by valuable fringe benefits. Overtime normally available.

GENEROUS RE-LOCATION EXPENSES available in most instances.

CONDITIONS excellent; free life assurance, pension schemes, canteen, social club.

37½ hour, 5-day, working week.

WRITE or phone for application forms quoting reference WW



MARCONI INSTRUMENTS LTD,
Longacres, St. Albans, Herts
Tel: St. Albans 59292
Luton Airport, Luton, Beds
Tel: Luton 33866

A GEC-Marconi Electronics Company



THE QUALITY AWARD TO INDUSTRY 1974

94

DEVON AREA HEALTH AUTHORITY PLYMOUTH HEALTH DISTRICT

ELECTRONICS TECHNICIAN

required to work on a varied and interesting range of biomedical tasks in an expanding well-equipped maintenance and development laboratory at Freedom Fields Hospital, Plymouth. The person appointed will join a small team responsible (to the Chartered Electronics Engineer) for the successful operation of a wide range of patient-orientated equipment. Development, construction and testing of special-purpose equipment is undertaken and safety and purchase decisions are made on new equipment. Some travel in South Devon and in Cornwall necessitates a current driving licence. Relevant experience is desirable and the minimum qualification is ONC (equivalent). The appointment will be in either of the following grades, depending on experience. (Salary scales are under review).

Medical Physics Technician IV— £1,530-£1,953

Medical Physics Technician III— £1,719-£2,211

Further details of the work may be obtained from Mr. L. R. Jenkin, Telephone PLYMOUTH 68080, Ext. 369.

Application forms from the Hospital Secretary, North Friary House, Greenbank Terrace, Plymouth PL4 8QQ.

[3693

Electronics Engineers up to £5000

Many jobs which would suit you down to the ground – either in the U.K. or overseas – are never advertised. Yet it will cost you nothing whatever to give yourself the opportunity to be considered for them.

Join the Lansdowne Appointments Register – used by hundreds of employers to select electronics engineers. You have nothing to lose, everything to gain – and it's all conducted in strict confidence. So post the coupon – find out exactly how you can make use of a service which is all the more valuable for being free!

To: Stuart Tait, Lansdowne Appointments Register, Design House, The Mall, London W5 5LS. Tel: 01-579 6585 (anytime – 24 hour answering service).

Please send me further details.

Name

Age (20-45 only)

Address

..... WW 22/5

Lansdowne
Appointments Register

97

Opportunities in Telecommunications

Men with a good telecommunications knowledge are required to be responsible for the telephone switching and transmission equipment on London Transport.

The work involves shift duties and consists of maintaining, testing and fault finding on the following types of equipment:—

- (a) Automatic Telephone Exchanges and associated equipment.
- (b) Multi-channel Carrier Systems and associated equipment.

A sound knowledge and experience of one of these categories of work is required. The possession of City and Guilds Certificates (or equivalent) in telecommunications subjects would be an added advantage.

The rate of pay, including variable bonus, averages £35.00 for a 5 day (40 hour week). Additional payments are made for overtime, night work and rostered Saturday and Sunday duties. Current weekly earnings, including payment for rostered overtime at week-ends, average £45.00. (These rates of pay are currently under review).

These positions offer valuable free travel on and off duty, certain privilege conditions for employees and dependants, and sick pay and pensions schemes.

Please apply in writing to:—London Transport (Ref: ATL), Chief Signal Engineer's Department, 270 Bollo Lane, Acton, W.3. or Telephone: Mr. Crowder, 01-748 9564.

 **LONDON TRANSPORT**

3698

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Applicants must have had at least five years' experience in the design of broadcast television equipment using both analogue and digital circuit techniques.

The successful candidate will lead a team devoted to the development of large complex digital video processing equipment.

Conditions of service and salary will be commensurate with the level of responsibility inherent in this post.

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The company provides first class opportunities for career development in modern well-equipped laboratories situated in the centre of Newbury, Berkshire.

Please apply to:

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[3702

LABORATORY TECHNICIANS

BBC requires resourceful and energetic Laboratory Technicians for Equipment Department, Power Road, Chiswick (within easy reach of Gunnersbury Station).

The work is interesting and involves testing new electronic equipment made by the BBC for its colour television and stereo radio services. The work also covers analogue and digital techniques over a frequency range from d.c. to U.H.F.

Salary in the range £1,575 to £1,989, rising to a maximum of £2,268 per annum. Good opportunities for promotion to Senior Technician (salary max. £2,565) and Engineering Technician (salary max. £2,940).

Applicants lacking suitable experience may be placed initially on a training grade. Facilities available to obtain approved technical qualifications.

Good club and canteen facilities. 3 weeks annual leave initially. Pensionable posts.

Write for application form to: Engineering Recruitment Officer, BBC, Broadcasting House, London, W1A 1AA quoting reference 74E4028WW and enclosing addressed foolscap envelope. Closing date for completed application forms. 10th June 1974.

3683

BBC

DIRECTOR- COMMUNICATIONS BRANCH

... to represent the Scottish Home and Health Department on Central Government Committees and to discuss telecommunication systems with police, fire, prison and other Services for which the Department is responsible. The successful candidate will manage a professional branch engaged in the examination of problems associated with the planning, design, progressing of installation and maintenance of such systems. These include mobile radio, message switching and telephone systems, and networks and terminals to interface with computer based data processing and command and control systems. R & D work in these fields is also involved.

Candidates must be competent administrators with a wide knowledge of modern telecommunication practice both radio and line, and have appropriate experience of systems planning. They must be corporate members of IEE or IERE (1962 Regulations), or have equivalent academic qualifications. A broad knowledge of computer systems and peripherals an advantage.

Starting salary within the scale £6,300-£7,141. Non-contributory pension scheme.

For full details and an application form (to be returned by 17 June 1974) write to **Scottish Office, Room 213, Personnel Division, 22/25 Queen Street, Edinburgh, EH2 1LY,** quoting reference T/8617.

Scottish Home and Health Department [3719]

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CAN YOU WRITE CLEAR, concise technical handbooks? If you think you could, and have a thorough understanding in electronics, why not join us as a technical author. Obviously, previous experience would be an advantage but is not necessary as full training would be given. We have vacancies in many parts of the country. Starting salaries are high with excellent prospects for advancement. Box No. WW 3414.

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MEDICAL Physics Technician Grade III or II required in a small electronics laboratory with an existing staff of three. The laboratory is responsible for the maintenance and modification of all types of measuring and recording equipment. Good opportunities exist for original work in this area. Salary scale £1,719 to £2,211 or £2,040 to £2,661 p.a. plus £126 p.a. London Weighting. Application forms from: Mr. J. Norman, National Heart Hospital, Westmoreland Street, London, W1M 8BA. [3687]

OXFORD University. Nuclear Physics Laboratory. Electronic Technician. A vacancy exists for a Technician in the Electronics workshop. Duties include servicing and maintaining a wide range of digital and analogue electronic equipment used in nuclear structure research, and the development and construction of new equipment. Applicants should possess a theoretical knowledge of about H.N.C. standard and a formal qualification would be an advantage. Proven practical ability in the field is

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PIANO P.C.B.'s for W.W. Electronic pianos. Enquiries to Baldock Electronics, 23 Turpins Way, Baldock, Herts. Tel: Baldock 2559. [3670]

SEPTEMBER 74. Radio & Television Engineer. with full C & G Certificate or HNC Electrical Engineering plus Teaching Qualification and industrial and teaching experience. Apply Principal, Bermuda College Dept. of Commerce and Technology, Friswell's Hill, Devonshire, Bermuda 4-04. [3385]

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[3654]

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CONSTRUCTION AIDS—Screws, nuts, spacers etc., in small quantities. Aluminium panels punched to spec. or plain sheet supplied. Fascia panels etched aluminium to individual requirements. Printed circuit boards—masters, negatives and board, one-off or small numbers. Send 6p for list. Ramar Constructor Services, 29 Shelbourne Road, Stratford on Avon, Warwks. [28]

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[3596]

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[3751]



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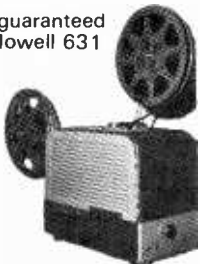
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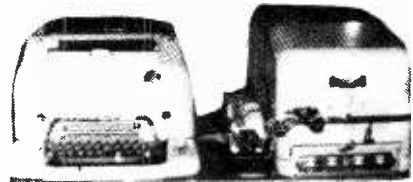
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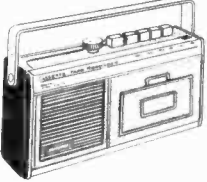
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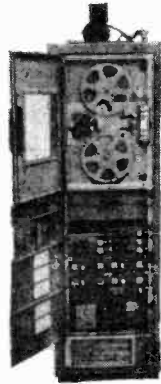
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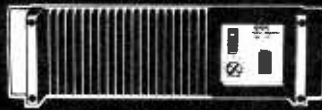
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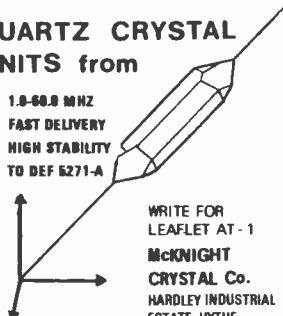
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Plug-in facilities	YES	NO
Sensitivity	5mV/cm— 10V/cm (Cascaded 500 μ V/cm calibrated with 4% accuracy.)	5mV/cm— 5V/cm (Cascaded 1mV/cm approximate, uncalibrated.)
Y Accuracy	$\pm 2\%$	$\pm 3\%$
Inversion facility	Y1 + Y2	Y2 only
Phase difference (X/Y plotting)	1° DC to 50kHz	3° DC to 50kHz
TIMEBASES		
Timebase accuracy	$\pm 3\%$	$\pm 2\%$
Input impedance	1M Ω into 18pF	1M Ω into 20pF
Main and delaying timebases	YES	YES
Mixed sweep	YES	YES
Timebase ranges	5ns/cm— 1.0s/cm	5ns/cm— 0.5s/cm
Mixed trigger facilities	YES, independent of shift controls	YES, but not independent of shift controls
Variable hold-off	YES	YES
External trigger level control range	± 10 V with <i>automatic</i> attenuator	± 20 V with <i>manual</i> attenuator
Automatic trigger	Preset level adjustment	Manual level adjustment
GENERAL		
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Calibrator — Voltage	0.3mV, 30mV and 3V ($\pm 0.5\%$)	0.3V ($\pm 1\%$)
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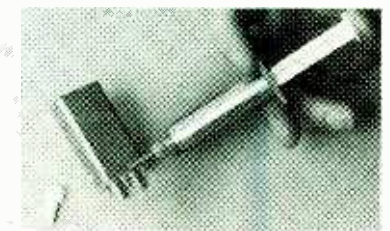
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Approved USA Federal Specification QQ-S-571E

Multicore Product Ref.	XM 27330	XM 27298	XM 27328
Alloy Composition	62/36/2 Sn/Pb/Ag	60/40 Sn/Pb	96/4 Sn/Ag
Melting Point or Liquidus °C	179	188	221
Recommended Flow Temperature °C	239	250	280
Typical Application	Low Melting Point Soldering of silver and gold-plated surfaces	General purpose joints requiring high quality solder cream	Higher temperature resistant joints. Lead free. Higher joint strength than Sn/Pb



For full information on these or any other Multicore products, please write on your company's letterhead direct to: **Multicore Solders Limited**, Maylands Avenue, Hemel Hempstead, Hertfordshire HP2 7EP. Tel: Hemel Hempstead 3636. Telex: 823663.