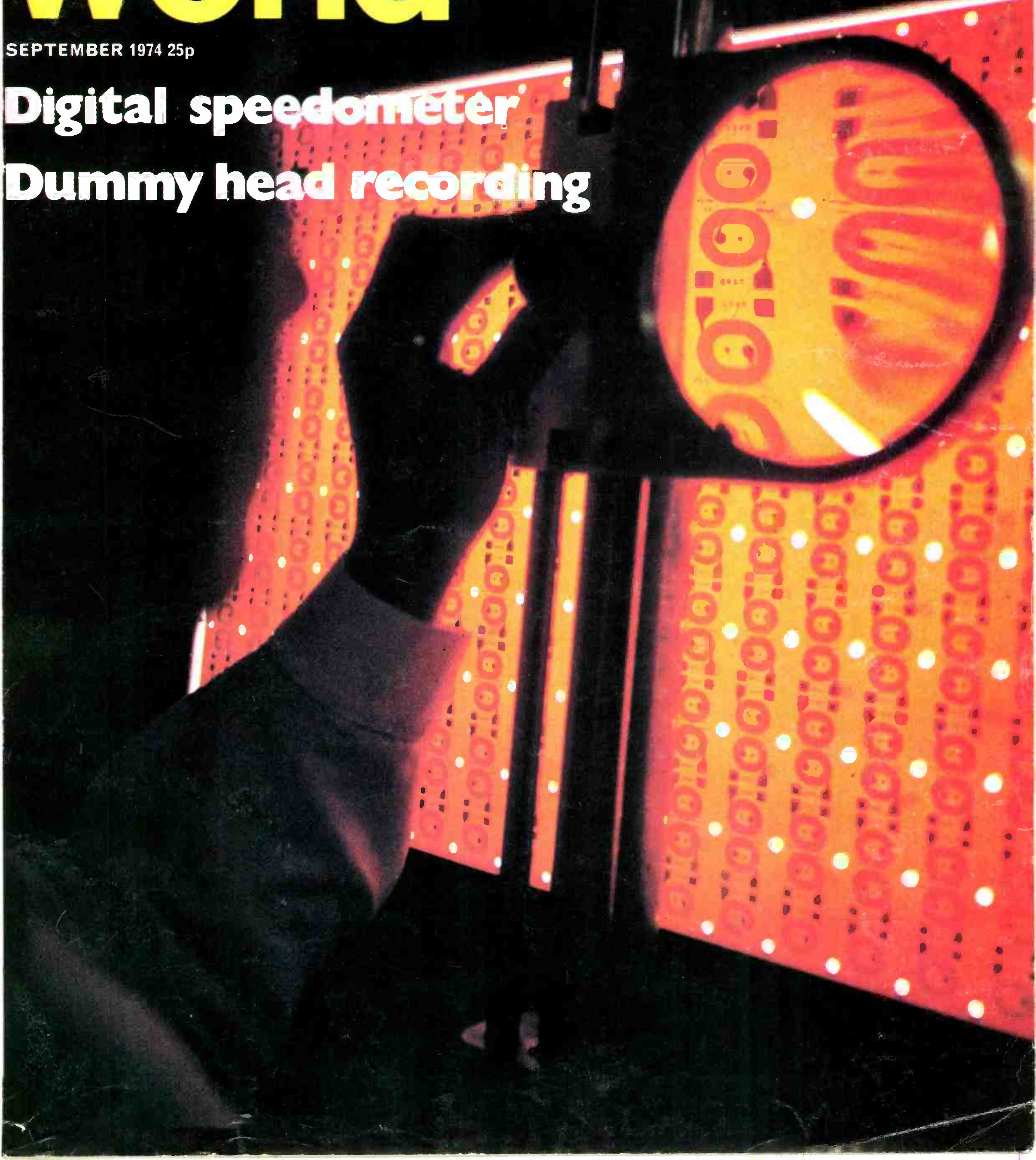
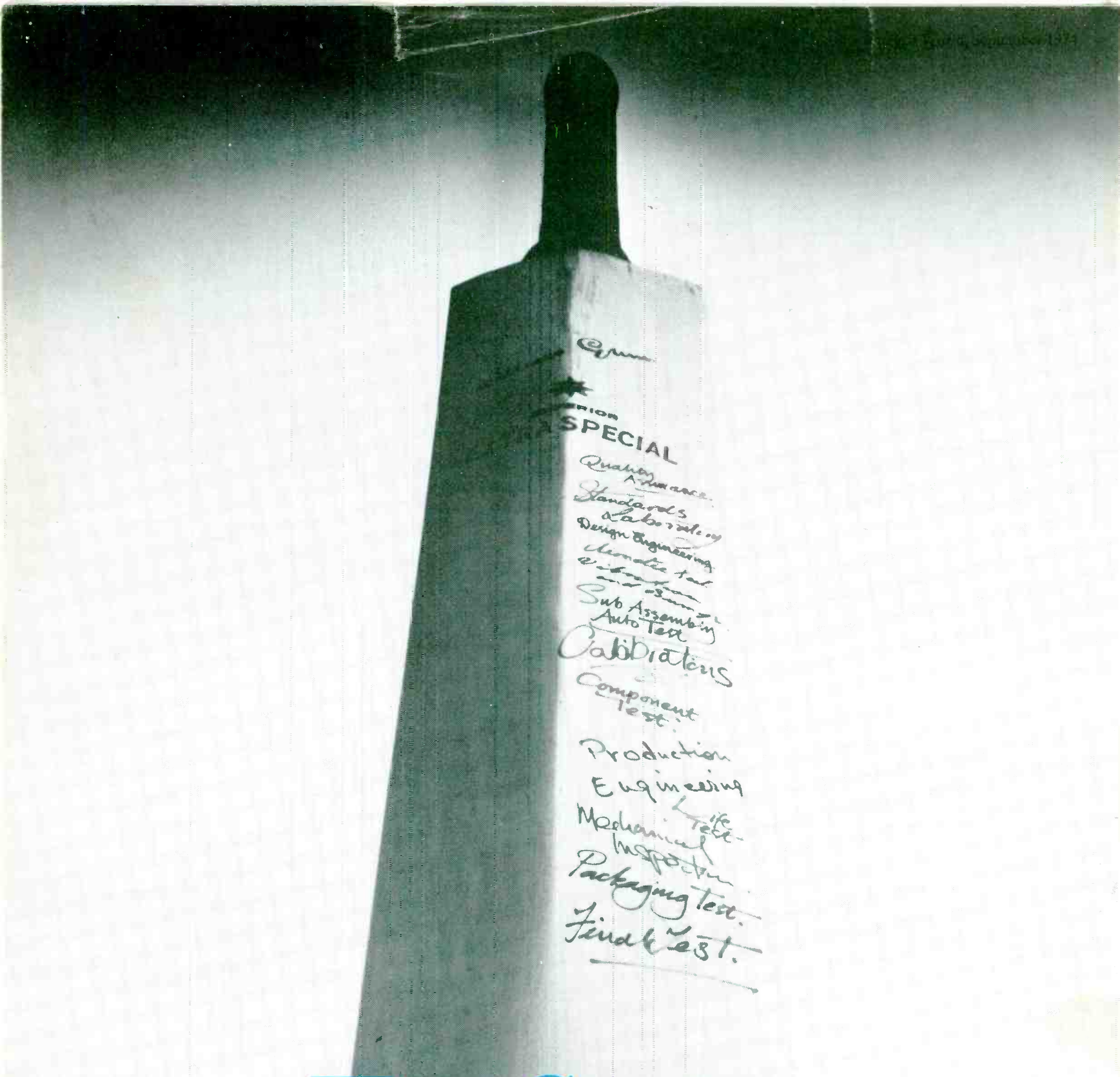
# wireless world

SEPTEMBER 1974 25p

## Digital speedometer

## Dummy head recording






# Test Series

There's no fun in being an **mi** product. Long before it begins its working life – way back as a design prototype, in fact – it's being vibrated, bumped, sent hot and cold, and subjected to other horrid experiences. And very much the same sort of things have happened to its components long before they got anywhere near it at all.

That's only the start. For instance during production, an instrument may undergo as many as 60 separate electrical and mechanical inspections – adding up to 120 hours on inspection alone – after having endured 500 hours of those shock tactics at design and trial batch stages.

That's typical **mi** thoroughness for you. In fact, when it comes to reliability you can be quite sure of one thing: at **mi** we're not playing at it.

## mi : THE PERFECTIONISTS

MARCONI INSTRUMENTS LIMITED

Longacres · St. Albans · Hertfordshire AL4 0JN · England · Telephone: St. Albans 59292 · Telex: 23350

A GEC–Marconi Electronics company.

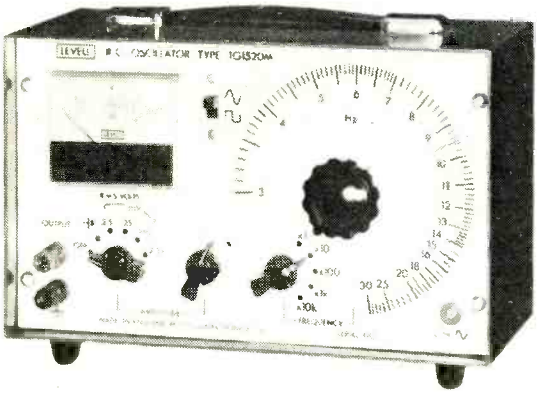
WW—001 FOR FURTHER DETAILS

# LOW COST RC OSCILLATORS

**SEE US AT:**
COVENTRY E.P.G. EXHIBITION, 17–19 SEPT., '74
SOUTHAMPTON E.P.G. EXHIBITION, 24–26 SEPT., '74

LEVELL
PORTABLE INSTRUMENTS

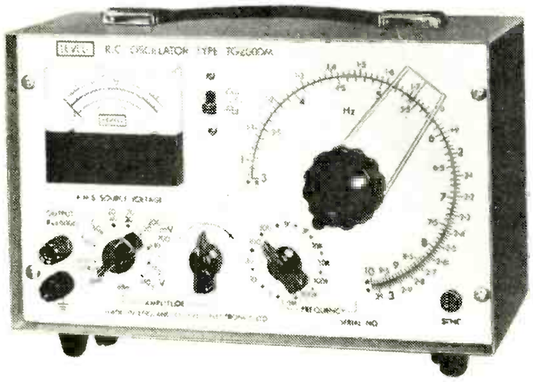
## ANALOGUE



| | |
|---|---|
| FREQUENCY | 3Hz to 300kHz in 5 ranges. |
| ACCURACY | ±2% ±0.1Hz up to 100kHz, increasing to ±3% at 300kHz. |
| SINE OUTPUT | 2.5V r.m.s. down to <200µV. |
| DISTORTION | <0.2% from 50Hz to 50kHz. |
| SQUARE OUTPUT | 2.5V peak down to <200µV. |
| SYNC. OUTPUT | 2.5V r.m.s. sine. |
| METER SCALES | 0/2.5V & −10/+10dB on TG152DM. |
| SIZE & WEIGHT | 7" high x 10¼" wide x 5½" deep. 8 lbs. |

**TG152D** Without meter. **£46**

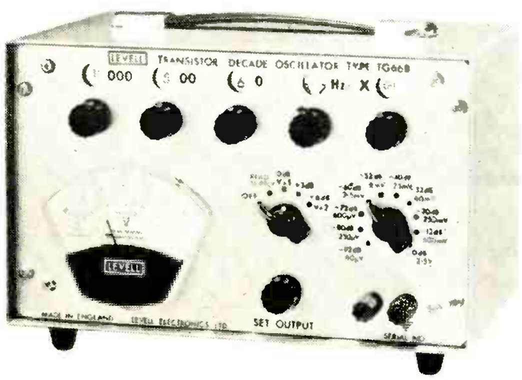
**TG152DM** With meter. **£56**



| | |
|---|---|
| FREQUENCY | 1Hz to 1MHz in 12 ranges. Acc. ± 2% ±0.03Hz. |
| SINE OUTPUT | 7V r.m.s. down to <200µV with Rs = 600 Ω |
| DISTORTION | <0.1% to 5V, <0.2% at 7V from 10Hz to 100kHz. |
| SQUARE OUTPUT | 7V peak down to <200µV. Rise time <150nS. |
| SYNC. OUTPUT | > 1V r.m.s. sine in phase with output. |
| SYNC. INPUT | ±1% freq. lock range per volt r.m.s. |
| METER SCALES | 0/2V, 0/7V & —14/+6dBm. on TG200M & DM only. |
| SIZE & WEIGHT | 7" high x 10¼" x 5½" deep. 10 lbs. |

| TG200 | TG200D | TG200M | TG200DM |
|---|---|---|---|
| Sine O/P | Sine & Sq. O/P. | Sine O/P +meter. | Sine & Sq.O/P + meter. |
| **£55** | **£58** | **£65** | **£68** |

## DIGITAL



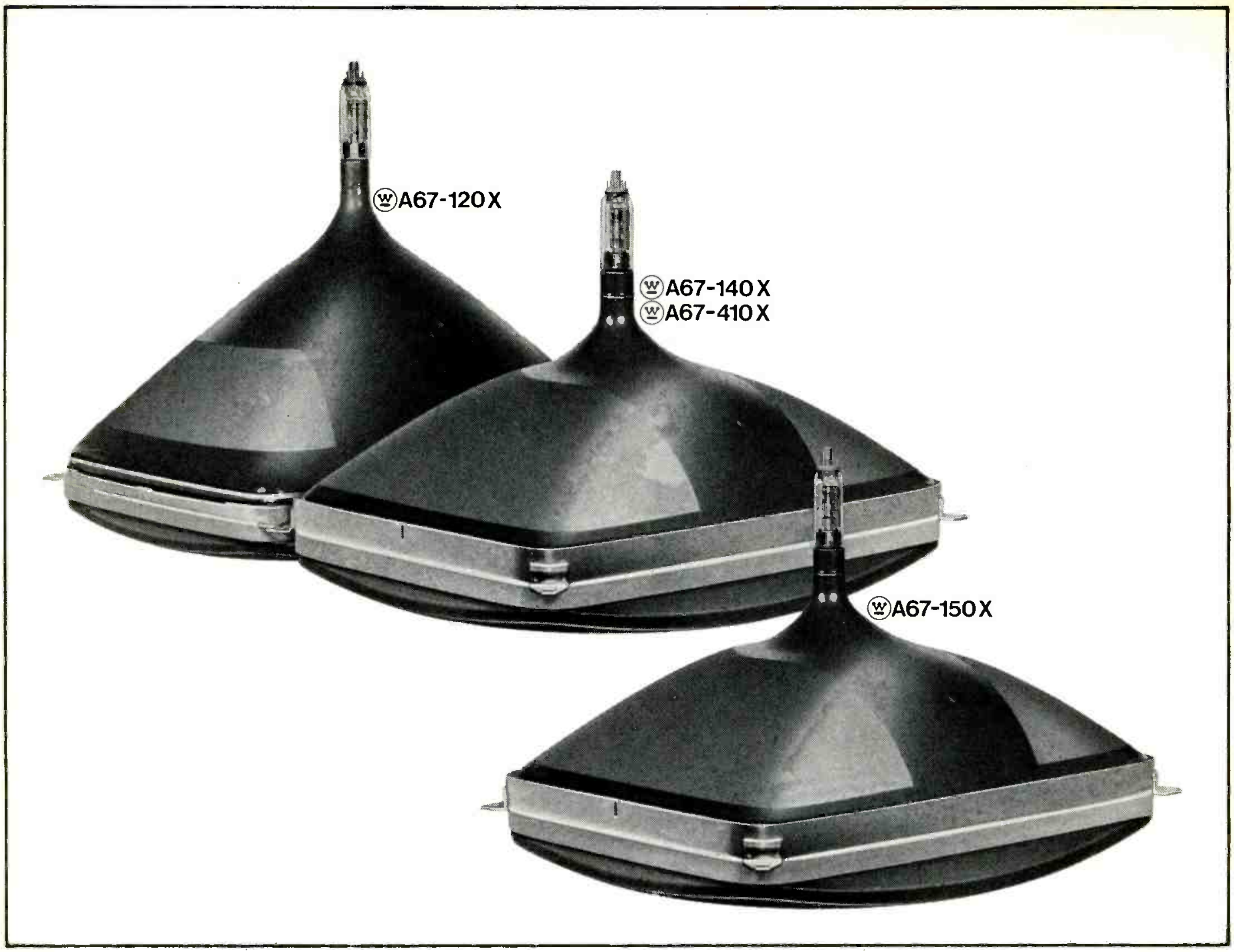
| | |
|---|---|
| FREQUENCY | 0.2Hz to 1.22MHz on four decade controls. |
| ACCURACY | ±0.02Hz below 6Hz<br>±0.3% from 6Hz to 100kHz<br>±1% from 100 kHz to 300 kHz<br>±3% above 300 kHz. |
| SINE OUTPUT | 5V r.m.s. down to 30µV with Rs = 600 Ω |
| DISTORTION | <0.15% from 15Hz to 15 kHz.<br><0.5% at 1.5Hz and 150kHz. |
| METER SCALES | 2 Expanded voltage & —2/+4dBm. |
| SIZE & WEIGHT | 7" high x 10¼" wide x 7" deep. 12 lbs. |

**TG66B** Battery model. **£150**

**TG66A** Mains & battery model. **£170**

**LEVELL ELECTRONICS LTD.**
Moxon Street, High Barnet, Herts. EN5 5SD
Tel: 01-449 5028/440 8686

Prices include batteries and U.K. delivery. VAT extra. Optional extras are leather cases and mains power units. Send for data covering our range of portable instruments.




# 3 sizes...4 solutions

Four Westinghouse 67 cm diagonal TV colour tubes. Each one directly responding to the requirements of the European market.

In 1971 we came out with the 90° A67-120X to meet set manufacturers' need for a 67 cm diag. tube. 1972 saw widespread construction of the "slim-line" set and we responded with the 10 cm shorter profile 110° A67-140X.

This year an improved version of this tube is available – the A67-410X.

Its "fast-on" technology for solid-state circuitry permits European viewers to obtain a full colour image within 4–5 sec. following switch-on of their receiver.

And recently, owing to the employment by many manufacturers of a narrow neck system, we've introduced the compatible 110° narrow neck A67-150X.

All proving that at Westinghouse we make a point of developing finer products to match the dynamic needs of the industries we serve. Here in Europe and throughout the world.

For further information on these tubes and the many hundreds of other precision devices for industrial and defense application, please write or call:

Electronic Tube Division,
Westinghouse Electric S.A. No.1
Curfew Yard, Thames Street, Windsor
Berks. Phone: 63392.

**Westinghouse**
**helps make it happen**

WW—069 FOR FURTHER DETAILS

# Take a Quad 50E Amplifier

## (a good start for any installation)


plug it into your monitor system and it bridges 600Ω lines to drive your speakers.

Take that same amplifier and, without changing it in any way, plug it into another installation to deliver 50 watts into 100 volt line * from a 0.5 volt unbalanced source. This versatility and its attendant easing of stocking and maintenance problems is one reason why large organisations use the Quad 50E.

* or indeed any other impedance from 5 to 250 ohms.

Other advantages appropriate to users of all sizes include: Excellent power and frequency response (–1dB).
Low distortion (0.1% at 1kHz at all power levels).
Low background (better than 83 dB referred to full output).
Pre-set level control adjustable from front panel.
Unconditionally stable with any load.
Proof against misuse including open or short circuited output.
Small size ($4\frac{3}{4}''$ x $6\frac{1}{4}''$ x $12\frac{3}{4}''$) – (120mm x 159mm x 324mm).

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**Products of**

**The Acoustical Manufacturing Co. Ltd.**

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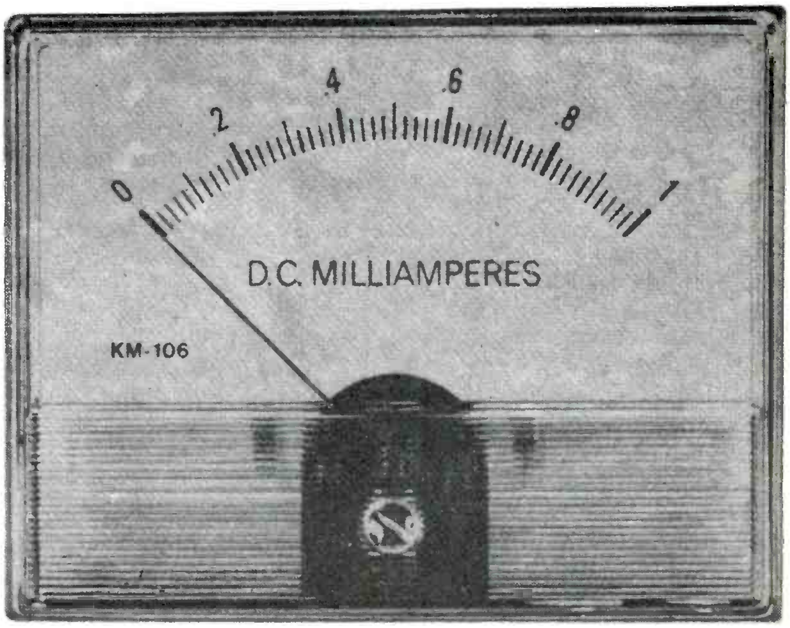
# ANDERS MEANS METERS...

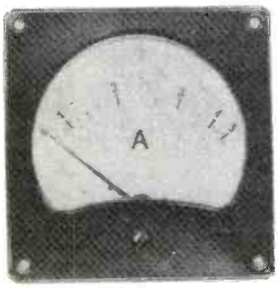



## KESTREL RANGE

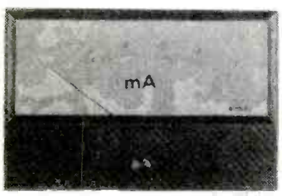
- Modern styling, with clearfront plastic case.
- Seven models, scale lengths from 1.3" to 5.25".
- Extensively used by many leading manufacturers of electronic and electrical equipment.
- Available in all ranges, moving coil and moving iron.
- Competitive prices.

Anders provide what is probably the largest range of meters available from a single source in Europe: MC/MI, dynamometer, vibrating reed, electrostatic, etc. in over 100 case styles and sizes, a few of which are shown below.

Popular models and ranges are stocked in depth while a specially equipped instrument department enables swift production of non-standard ranges and scales, to suit individual customer requirements, in large or small quantities.

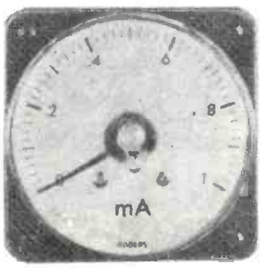



Vulcan Moving Iron. 4 models, 1·5", 1·8", 2·7", 3·7" scales. Voltmeters, ammeters and motor starting meters.

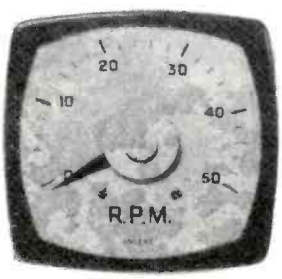



Regal Range 100° flattened arc. 2 models 2.5" and 3.2" scales. Taut band. DC moving coil and AC moving coil rectified.

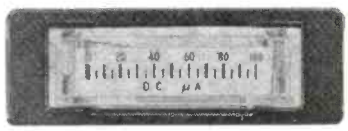

Profile 350 edgewise 4·3" scale. DC moving coil and AC moving coil rectified. Horizontal or vertical mounting.




Oxford Long Scale 240°. 2 models, 5·5", 8" scales. DC moving coil and AC moving coil rectified.




Stafford Long Scale 240 6 models, 3·5"—11·5" scales. DC moving coil, AC moving coil rectified, AC moving iron. Also 98° scale.



Models KE1 and KE2 Miniature Edgewise Meters. Nominal scale lengths 1.2" and 2". Available in sensitivities from 50 microamps Moving Coil.


Lancaster Long Scale 240°. 2 models, 4", 5·5" scales. DC moving coil and AC moving coil rectified.

**ANDERS ELECTRONICS LIMITED** 48/56 Bayham Place, Bayham Street, London, N.W.1. Telephone 01-387 9092.

Manufacturers and distributors of Electrical Measuring Instruments. Sole U.K. distributors of FRAHM Resonant Reed Frequency Meters and Tachometers. Manufacturers of purpose built electrical and electronic equipment to customers requirements.

WW—051 FOR FURTHER DETAILS

500 kW carrier tetrode, 12 kV.

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# Hypervapotron* cooling + Pyrobloc* grids

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Italy - THOMSON-CSF Tubi Elettronici SRL / Viale degli Ammiragli 71 / ROMA / Tel. (6) 38 14 58
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Sweden - THOMSON-CSF Elektronrör AB / Box 27080 / S 10251 STOCKHOLM 27 / Tel. (08) 22 58 15
U.S.A. - THOMSON-CSF Electron Tubes Inc. / 750 Bloomfield Avenue / CLIFTON NJ 07015 / Tel. (201) 779 1004

**WW—013 FOR FURTHER DETAILS**

2079

# At last, what you've been waiting for. The new Heathkit catalogue.

Since receiving the last Heathkit catalogue you've no doubt spent quite a time thumbing through it and deciding which models to build.

You've probably also been waiting in expectation for the next catalogue. And wondering what goodies it holds in store for you.

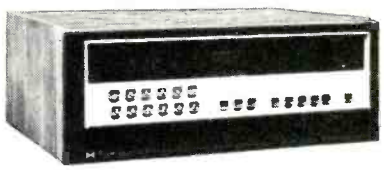
Believe us, it's been well worth the wait.

The new Heathkit catalogue is now out. And it's the largest ever (64 pages of it). Bulging with new models, new innovations and new ways to make building Heathkit even more interesting.

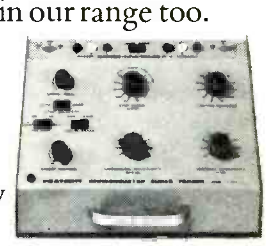

All the familiar faces will be there too. Like our very popular digital clock for instance – the one on the cover of the catalogue.

There's also a de-luxe version available now. The GC-1029AE. With features like an automatic display dimmer for night operation and an automatic stand-by battery in case of power failure.

Another new model is the AJ-1510A digital FM stereo tuner. In fact, we call it our 'Computer Tuner' because to select stations you simply tap out the frequency on a keyboard. And the AJ-1510A will lock on to the selected station instantly and precisely.



There's a new instrument in our range too. In the shape of a Semiconductor Curve Tracer–the IT-1121. Connect it up to an oscilloscope and it'll accurately display operating parameters of virtually any type of semiconductor.



Send us the coupon now and we'll send you your free catalogue, with details of these and other exciting, new models. Or, if you happen to be in London or Gloucester, call in and see us. The London Heathkit Centre is in Tottenham Court Road (where else?) at no. 233.

The Gloucester showroom is next to our factory in Bristol Road.

Either way, we're waiting to hear from you soon.

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Tel: Gloucester (0452) 29451.

## The new Heathkit catalogue. Out now. FREE.

To: Heath (Gloucester) Limited, Dept WW-94, Gloucester, GL2 6EE. Please send me my free Heathkit catalogue.

Name__________ Address__________

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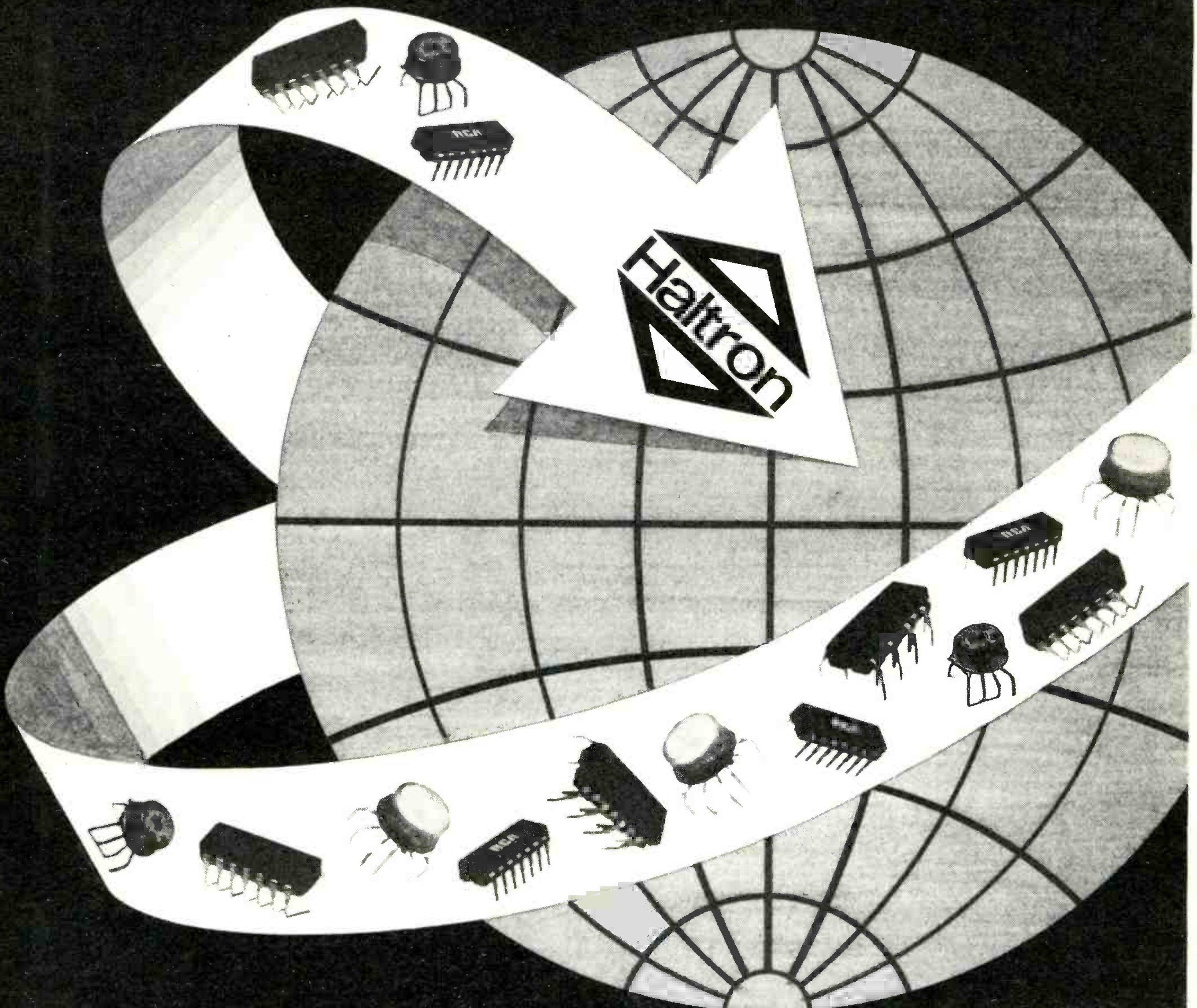
Remember easy terms are available with the Heathkit Monthly Budget Plan

HEATH Schlumberger

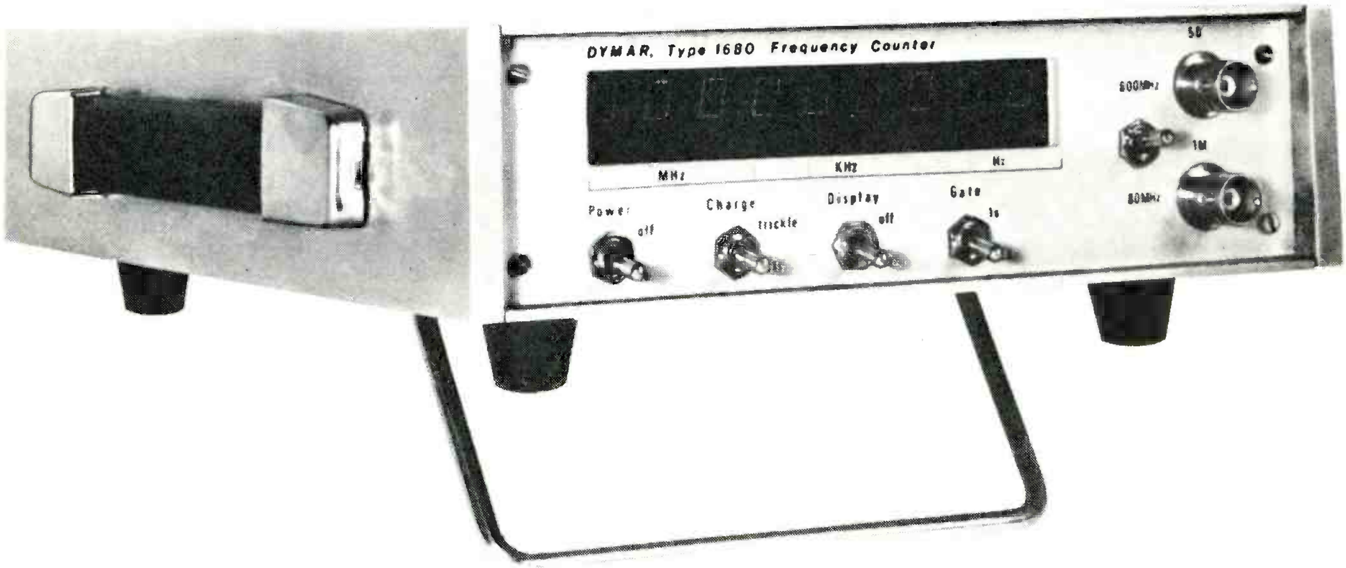

Haltron


**MOTOROLA Semiconductors**

Motorola Semiconductors Ltd., York House.
Empire Way, Wembley, Middlesex. Telephone: 01-902 8836.
European manufacturing facilities at Toulouse and East Kilbride.
Distributors: Celdis Ltd., Reading, East Kilbride:
GDS (Sales) Ltd., Slough, Dublin: Jermyn, Sevenoaks:
Lock Distribution, Oldham: Semicomps Ltd., Wembley.

WW—054 FOR FURTHER DETAILS

# The Dymar 1680 portable frequency counter




## You're working miles from base, there's no power handy, and enough AM about to drive you crazy...

You don't have to have problems in order to appreciate the Dymar 1680 frequency counter. But if they arise you'll know you've got a friend.

At home or away, the 1680 offers a frequency range of from 30Hz to 600MHz with exceptionally high sensitivity right across the range.

A high stability crystal time base provides laboratory standard accuracy in workshop or on location – accuracy which is maintained even in the presence of a large proportion of AM on the carrier wave.

The nine-digit LED display reads in MHz, kHz and Hz, with automatically positioned decimal point, and the front panel controls are simple and easy to use.

In the field, the 1680 really comes into its own. Operating from AC mains supply or its own rechargeable batteries, it provides genuine portability at only 5.5lbs weight and 7.2 x 10.6 x 1.9in dimensions.

Want to know more? Use the Reader Reply Service or contact Dymar direct.

**DYMAR**
**the name in radiotelephones**

*Designed for the mobile land, marine and air communications industry by*

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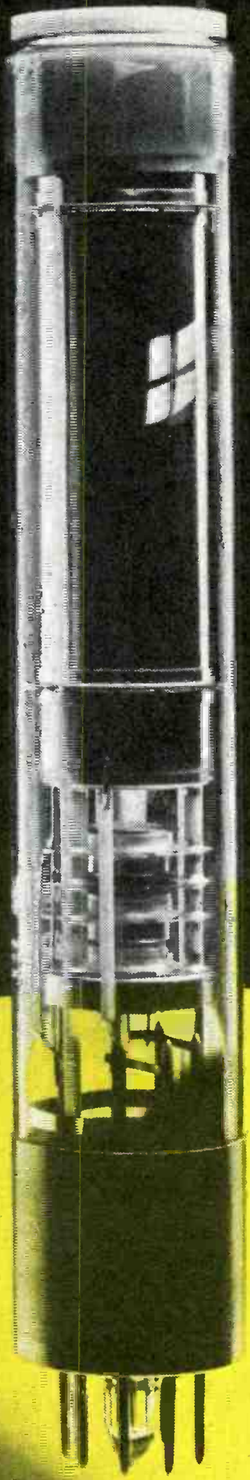
WW—064 FOR FURTHER DETAILS

# From millions of hours operating experience come four NEW Plumbicon* Camera Tubes.



Just because over 80% of the world's colour TV cameras use our Plumbicon Camera Tubes, doesn't mean that we can rest on our laurels. At Mullard, experience has taught us to anticipate your needs, to keep that extra step ahead. Hence we now offer you four NEW 25mm Plumbicon Tubes (XQ1083 to 1086) ; that's in addition to a range already 16 strong. The most advanced 25mm camera tubes available anywhere in the world, they feature the anti-comet-tail gun, enhanced red response, anti-halation discs and low output capacitance producing improved signal to noise performance. They also incorporate a light biassing system for reduced lag.

## Behind Mullard's capability

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, Torrington Place, London WC1E 7HD.**

*registered trade mark for Television Camera Tubes

**Mullard** components for communications

**BROADCASTING · TELECOMMUNICATIONS · RADAR · NAVAIDS · MILITARY**

M 82

# If you're looking for trouble you needn't look any further.

It's not only technicians who can see the finer points of Eagle multi-meters.

Every handyman notices them too.

They're easy to read.

They're tough.

Their construction comes up to laboratory standards.

Even our inexpensive pocket sized models have features you'd usually only find on professional equipment.

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You'll see over twenty models.

Specifications that would impress the most experienced technician.

And a price range that takes in amateurs as well as professionals.

We guarantee every one for two years.

With parts to service them in no time.

So you can confidently find fault in anything.

**Eagle** International

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Please send me the Eagle electronics catalogue containing the complete range of test equipment.

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WW2

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WW—074 FOR FURTHER DETAILS

# No half measure!

D.C. VOLTS
100 μV to 1000V

D.C. VOLTS
1μV to 1000V

A.C. VOLTS
10 μV to 1000V

EVENTS TO
1 MILLION COUNTS
PER SECOND

FREQUENCY
to 8MHz

FREQUENCY
to 100MHz

RESISTANCE
.001Ω to 1,000MΩ

CAPACITANCE
1pF to 10,000μF

TIME INTERVALS
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MILLION SECONDS

D.C. CURRENT
0.1nA to 10A


The Farnell Digital Measuring System provides a wider range of measurement than is generally possible with digital multimeters.

There's a choice of 3, 4 or 6 digit main frames and any module may be used with any frame. The module slips into the main frame on runners and is secured by a locking shaft. Simply and quickly in this way, the instrument is converted to measure voltage, frequency, period, events, resistance, capacitance etc.

An obvious choice when equipping a new laboratory because the display section and power supplies are bought just once —in the main frame. Additional functions are obtained at far less cost than complete single purpose digital instruments by purchasing the required modules.

*To obtain a 16 page brochure describing this equipment contact:-*

Farnell

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*TELECOMMUNICATIONS DIVISION,*
SANDBECK WAY, WETHERBY, YORKSHIRE.
TELEPHONE 0937 3541 · TELEX 557294

LONDON OFFICE: TELEPHONE 01-802 5359

**Tubes**

**LAMPES**

**VALVES**

**Röhren**

**Buizen**

**VALVOLE**

**LAMPARAS**

| TUBE TYPE | UNIT PRICE DM | UNIT PRICE US $ |
|---|---|---|
| EM 83 | [illegible] | [illegible] |
| EM 84 (6FG6) | [illegible] | [illegible] |
| EM 87 (6HU6) | 2.30 | —.92 |
| EY 51 (6X2) | 2.— | —.80 |
| EY 81 (6V3) | 1.34 | —.54 |
| EY 82 | 2.56 | 1.02 |
| EY 83 | [illegible] | [illegible] |
| EY 86 (6S2) | 1.28 | [illegible] |
| EY 87 (6S2A) | [illegible] | [illegible] |
| EY 88 (6AL3) | 1.39 | [illegible] |
| EY 500 A (6EC4A) | 3.44 | 1.37 |
| EY 802 | 2.78 | 1.11 |
| EZ 2 | 3.52 | 1.41 |
| EZ 11 | 3.52 | 1.41 |
| EZ 12 | 3.80 | 1.52 |
| EZ 35 (6X5[illegible] | [illegible] | [illegible] |
| EZ 40 (6BT4) | [illegible] | [illegible] |
| EZ 80 (6V4) | [illegible] | —.32 |
| EZ 81 (6CA4) | —.96 | —.38 |
| EZ 90 (6X4) | 1.08 | —.43 |
| G 1064 | [illegible] | [illegible] |
| GY 501 | [illegible] | [illegible] |
| GZ 32 (5V4G) | [illegible] | [illegible] |
| GZ 34 (5AR4) | 3.12 | [illegible] |
| HAA 91 = 12AL5 | | |
| HABC 80 = 19T8 | | |
| HBC 90 = 12AT6 | | |
| HBC 91 = [illegible] | | |
| HCC 85 = [illegible] | | |
| HF 93 = 12[illegible] | | |
| HF 94 = 12AU6 | | |
| HK 90 = 12BE6 | | |
| HL 92 = 50C5 | | |
| HL 94 = 30A5 | | |
| HY 90 = 35W4 | | |
| LC 900 (3HA5) | [illegible] | [illegible] |
| LCC 82 (9AU7) | 1.98 | [illegible] |
| LCF 80 (6LN8) | 1.64 | —.65 |
| LCF 801 (5GJ7) | 2.18 | —.87 |
| LCF 802 (6LX8) | 1.64 | —.65 |
| LCL 82 (11BM8) | 1.76 | —.70 |
| LCL 84 (10[illegible]8) | [illegible] | [illegible] |
| LCL 85 (10[illegible]8) | [illegible] | [illegible] |
| LF 183 (4E[illegible] | [illegible] | [illegible] |
| LF 184 (4EJ7) | 1.58 | —.63 |
| LFL 200 (11Y9) | 3.75 | 1.50 |
| LL 84 (10BO5) | 1.47 | —.59 |
| LL 8[illegible] | [illegible] | [illegible] |
| LL 52[illegible] | [illegible] | [illegible] |
| LY 8[illegible] | [illegible] | [illegible] |
| PABC[illegible] | [illegible] | [illegible] |
| PC 8[illegible] | [illegible] | [illegible] |
| PC 8[illegible] | [illegible] | [illegible] |
| PC 9[illegible] | [illegible] | [illegible] |
| PC 9[illegible] | [illegible] | [illegible] |
| PC 9[illegible] | [illegible] | [illegible] |
| PC 9[illegible] | [illegible] | [illegible] |
| PCC [illegible] | [illegible] | [illegible] |
| PCC 85 (9AQ8) | 1.47 | —.59 |
| PCC 88 (7DJ8) | 1.86 | —.74 |

| TUBE TYPE | UNIT PRICE DM | UNIT PRICE US $ |
|---|---|---|
| [illegible] 82 [illegible] | 1.25 | —.50 |
| [illegible] | 2.17 | —.87 |
| [illegible] 200 [illegible] | 2.07 | —,83 |
| PCF 201 (8U9) | 2.07 | —.83 |
| PCF 801 (8GJ7) | 1.86 | —.74 |
| PCF 802 (9JW8) | 1.66 | —.66 |
| PCF 805 (7GV7) | 3.42 | 1.37 |
| PCF 808 | [illegible] | [illegible] |
| PCH 200 (9V9) | [illegible] | [illegible] |
| PCL 81 | [illegible] | [illegible] |
| PCL 82 (16A8) | 1.25 | —.50 |
| PCL 84 (15DQ8) | 1.41 | —.56 |
| PCL 85 (18GV8) | 1.75 | —.70 |
| PCL 86 (14GW8) | 1.53 | —.61 |
| PCL 200 | 2.61 | 1.04 |
| [illegible] 805 | 1.75 | —.70 |
| [illegible] | 6.45 | 2.58 |
| PD 510 | 9.— | 3.60 |
| PF 86 (4CF8) | 1.76 | —.70 |
| PFL 200 (16Y9) | 2.45 | —.98 |
| PL 36 (25E5) | 2.20 | —.88 |
| PL 81 (21A6) | [illegible] | [illegible] |
| PL 82 (16A5) | [illegible] | [illegible] |
| PL 83 (15A6) | [illegible] | [illegible] |
| PL 84 (15CW5) | [illegible] | [illegible] |
| PL 95 | 1.75 | —.70 |
| PL 500 (27GB5) | 2.90 | 1.16 |
| PL 504 | 2.90 | 1.16 |
| PL 508 (17KW6) | 2.95 | 1.18 |
| [illegible] 509 (40KG6A) | 5.70 | 2.28 |
| [illegible] 519 | 7.10 | 2.84 |
| [illegible] 521 (29KQ6) | 3.61 | 1.44 |
| PL 802 | 3.86 | 1.54 |
| PL 805 | 3.05 | 1.22 |
| PM 84 | 1.47 | [illegible] |
| PY 81 (17Z3) | 1.18 | [illegible] |
| PY 82 (19Y3) | 1.10 | [illegible] |
| PY 83 (17Z3) | 1.18 | [illegible] |
| PY 88 (30AE3) | 1.28 | [illegible] |
| PY 500 (42EC4) | 3.28 | 1.31 |
| PY 500A (42EC4A) | 3.28 | 1.31 |
| PY 800 | 1.32 | —.53 |
| PY 801 | 1.32 | —.53 |
| [illegible] | 1.57 | —.63 |
| [illegible] | 2.45 | —.98 |
| UBC 41 (14L7) | 2.25 | —.90 |
| UBC 81 (15BD7A) | 1.40 | —.56 |
| UBF 80 (17C8) | 1.44 | —.58 |
| [illegible] | [illegible]22 | [illegible] |
| [illegible] | [illegible]62 | [illegible] |
| [illegible] | [illegible]88 | [illegible] |
| [illegible] | [illegible]40 | [illegible] |
| [illegible] | [illegible]44 | [illegible] |
| [illegible] | [illegible]66 | [illegible] |
| [illegible] | [illegible]88 | [illegible] |
| [illegible] | [illegible]20 | [illegible] |
| [illegible] | [illegible]12 | [illegible] |
| [illegible] | [illegible]14 | [illegible] |
| [illegible] | [illegible]55 | [illegible] |
| [illegible] | [illegible]34 | [illegible] |
| UCL 11 | 2.56 | 1.02 |
| UCL 82 (50BM8) | 1.62 | —.61 |

| TUBE TYPE | UNIT PRICE DM | UNIT PRICE US $ |
|---|---|---|
| UF 41 (12AC5) | 2.34 | —.93 |
| UF 80 (19BX6) | 1.44 | —.58 |
| UF 85 (19BY7) | 1.44 | —.58 |
| UF 89 (12DA6) | 1.28 | —.51 |
| UL 41 (45A5) | 2.25 | —.90 |
| UL 84 (45B5) | 1.25 | —.50 |
| UM 11 | 1.60 | —.64 |
| [illegible] | [illegible] | —.56 |
| [illegible] | [illegible] | —.38 |
| [illegible] | [illegible] | —.77 |
| UY 21 | 2.24 | —.90 |
| UY 41 | 1.46 | —.58 |
| UY 82 (55N3) | 1.41 | —.56 |
| UY 85 (38A3) | —.96 | —.38 |
| UY 8[illegible] | —.96 | —.38 |
| U [illegible] | | |
| U [illegible] | | |
| U 70 = 6X5GT | | |
| XC 900 (2HA5) | 1.50 | —.60 |
| XCC 82 (7AU7) | 1.98 | —.79 |
| XCF 80 (4BL8) | 1.83 | —.73 |
| [illegible] | [illegible] | —.61 |
| [illegible] | [illegible] | —.87 |
| [illegible] | [illegible] | —.75 |
| XF 183-(3EH7) | 1.58 | —.63 |
| XF 184 (3EJ7) | 1.58 | —.63 |
| XL 84 (8BQ5) | 1.44 | —.58 |
| XL 86 (8CW5) | 1.70 | —.68 |
| [illegible] | 1.78 | —.71 |
| [illegible] | 2.30 | —.92 |
| 1 A 3 | 1.28 | —.51 |
| 1 A 5 GT | 1.28 | —.51 |
| 1 [illegible] | [illegible] | —.57 |
| 1 [illegible] | 2.35 | —.94 |
| 1 [illegible] | [illegible] | —.58 |
| 1 [illegible] | 1.41 | —.56 |
| 1 DN 5 | 1.66 | —.66 |
| 1 G 3 GT | 1.45 | —.58 |
| 1 J 3 | 1.45 | —.58 |
| 1 K [illegible] | 145. | —.58 |
| [illegible] | | |
| 1 L[illegible] | 1.60 | —.64 |
| 1 LB 4 | 2.40 | —.96 |
| 1 LC 6 | 1.41 | —.56 |
| 1 LD 5 | 1.02 | —.41 |
| 1 LF 3 | 1.44 | —.58 |
| [illegible] | [illegible] | —.79 |
| [illegible] | [illegible] | —.45 |
| [illegible] | [illegible] | —.42 |
| [illegible] | [illegible] | —.41 |
| [illegible] | [illegible] | —.42 |
| [illegible] | [illegible] | —.66 |
| [illegible] | [illegible] | —.56 |
| [illegible] | [illegible] | —.50 |
| [illegible] | [illegible] | —.77 |
| 2 AF 4 B | 2.08 | —.83 |
| 2 AH 2 | 2.64 | 1.06 |

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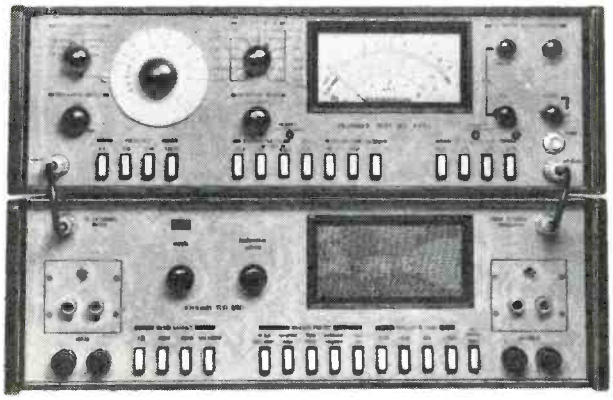

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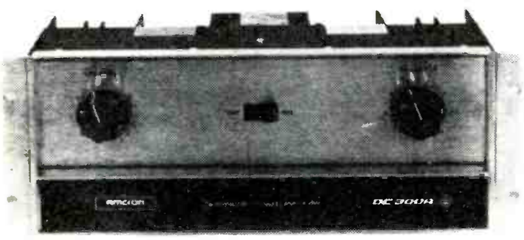


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| | | | |
|---|---|---|---|
| Power Bandwidth | DC-20kHz @ 150 watts + 1db, – 0db. | Slewing Rate | 8 volts per microsecond |
| Power at clip point (1 chan) | 500 watts rms into 2.5 ohms | Load impedance | 1 ohm to infinity |
| Phase Response | +0, –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, 9¾" Deep |

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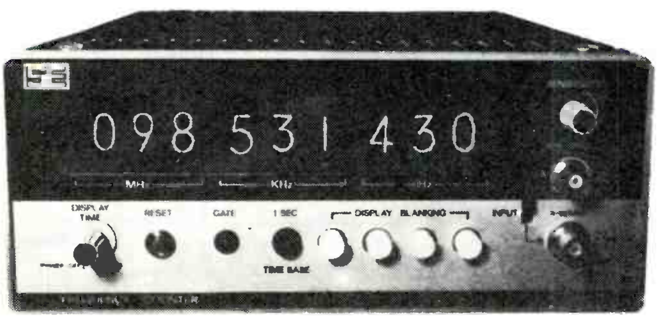



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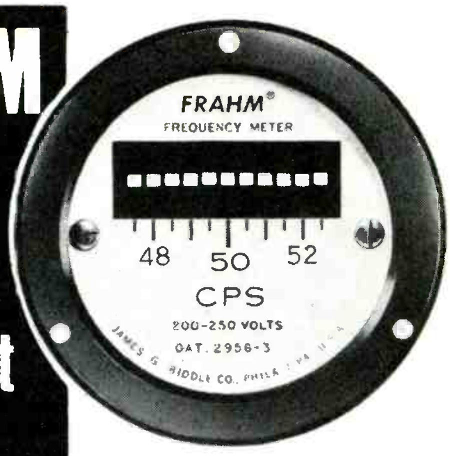


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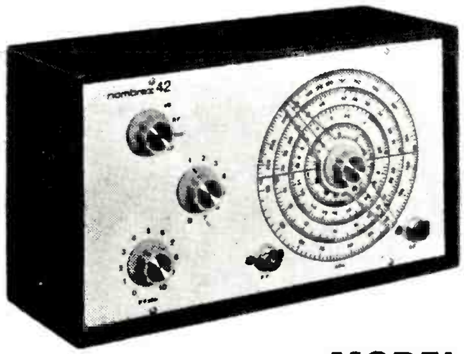


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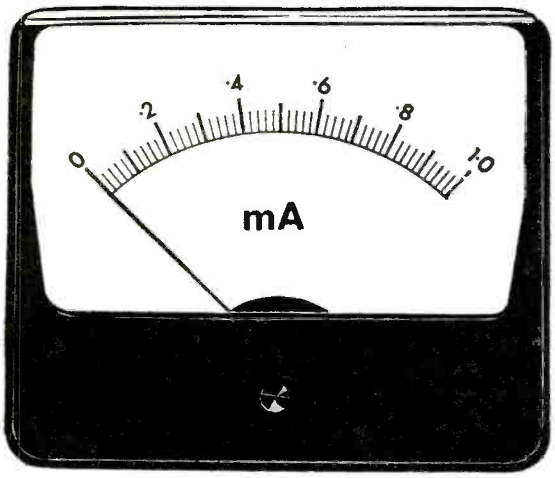
# METER PROBLEMS?

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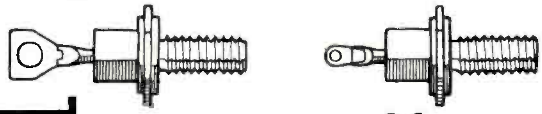
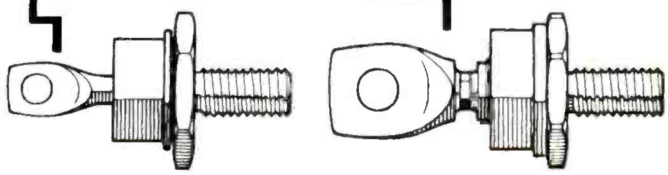


**Current/Voltage/Type No.**

| $I_{F(AV)}$ Amps | Type No. | | | | |
|---|---|---|---|---|---|
| | $V_{RRM}$ | | | | |
| | 100 | 200 | 400 | 600 | 800 |
| 6 | M6-100<br>M6-100R | M6-200<br>M6-200R | M6-400<br>M6-400R | M6-600<br>M6-600R | M6-800<br>M6-800R |
| 16 | M16-100<br>M16-100R | M16-200<br>M16-200R | M16-400<br>M16-400R | M16-600<br>M16-600R | M16-800<br>M16-800R |
| 25 | M25-100<br>M25-100R | M25-200<br>M25-200R | M25-400<br>M25-400R | M25-600<br>M25-600R | M25-800<br>M25-800R |
| 40 | M41-100<br>M41-100R | M41-200<br>M41-200R | M41-400<br>M41-400R | M41-600<br>M41-600R | M41-800<br>M41-800R |
| 70 | M71-100<br>M71-100R | M71-200<br>M71-200R | M71-400<br>M71-400R | 71-600<br>M71-600R | M71-800<br>M71-800R |

Suffix 'R' indicates reversed polarity (i.e. Stud Anode)



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| **3** | $\frac{5}{32}$" | SK2 | Nickel | **32p** |
| **4** | $\frac{1}{16}$" | SK2 | Nickel | **32p** |
| **50** | $\frac{3}{32}$" | X25 | Iron | **44p** |
| **51** | $\frac{1}{8}$" | and | Iron | **44p** |
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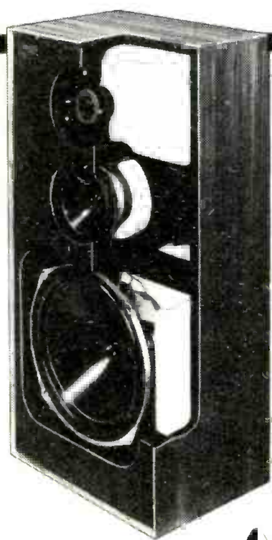

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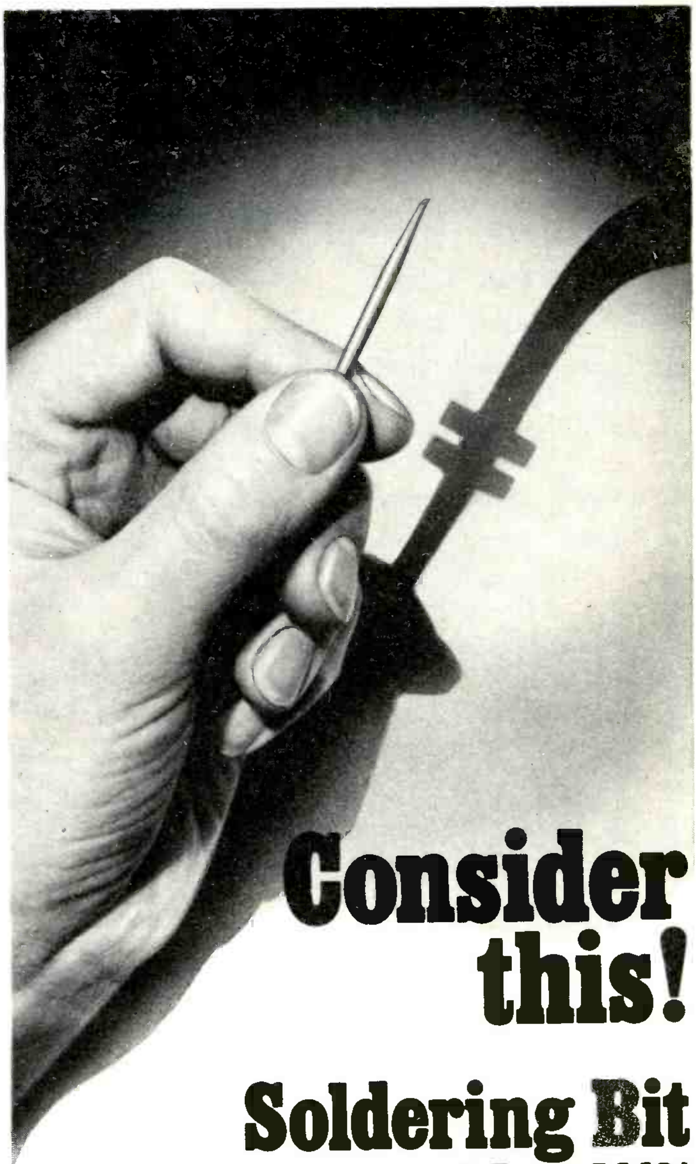

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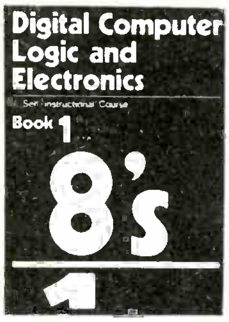


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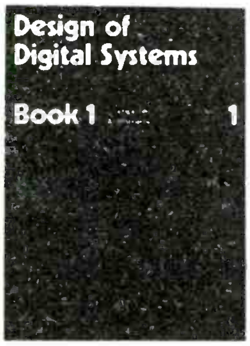


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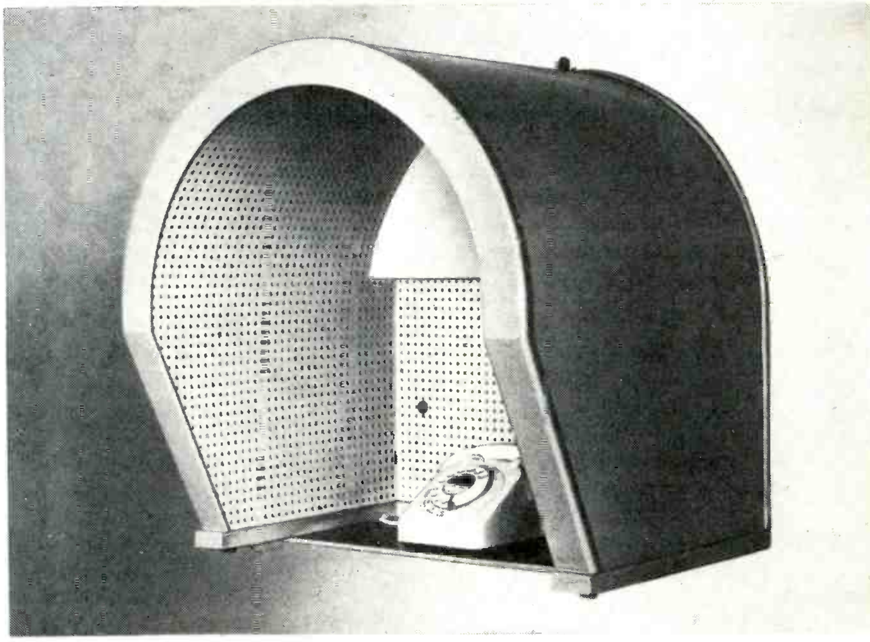

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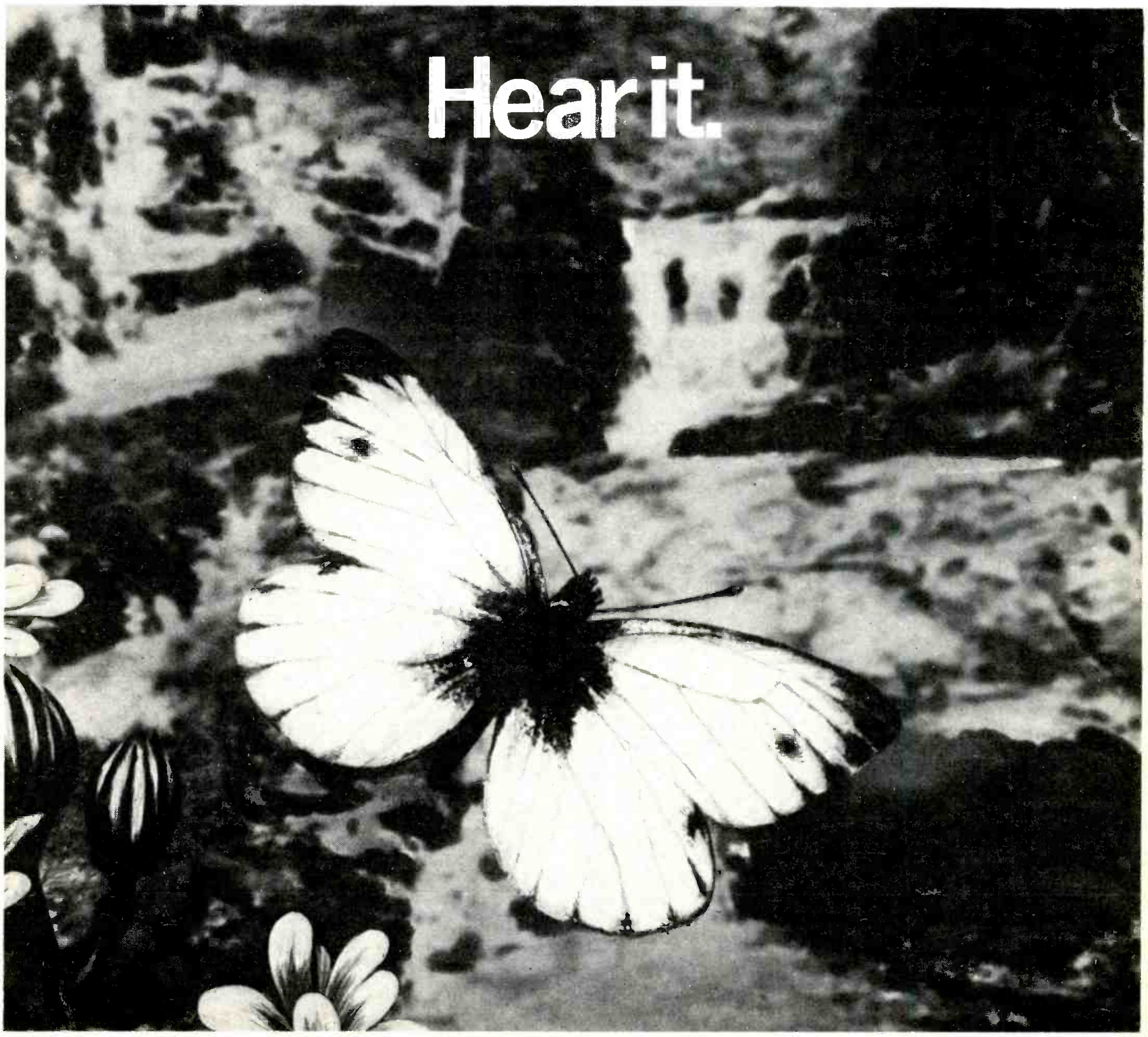


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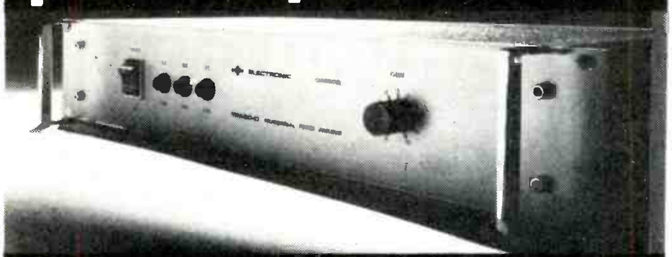

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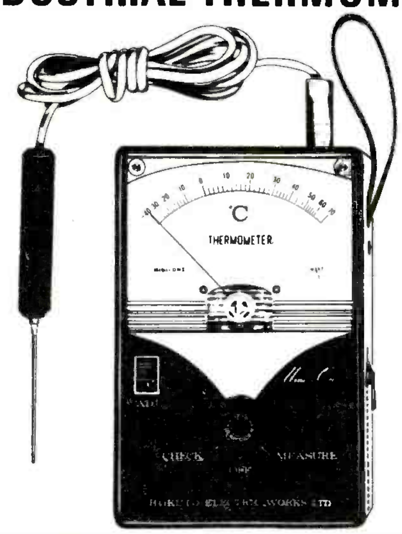


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Operating the SV 630 couldn't be easier. Once the cartridge is popped in, the keys operate at the touch of a finger putting you in complete command of play, record, fast forward and stop functions . . . the tape rewinds as soon as the programme has finished . . . and pops out upon the completion of rewinding.

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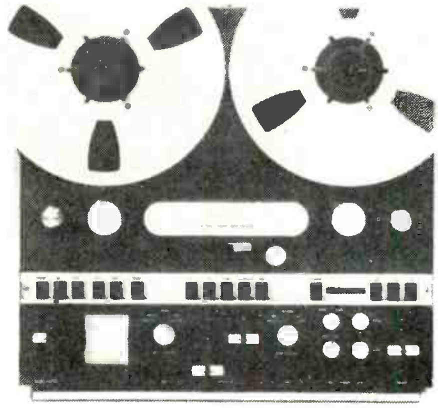

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# 50mHz OSCILLOSCOPE TYPE C1-64

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Summing mode: 1mV/div. max.

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Highest attainable in cassette performance.
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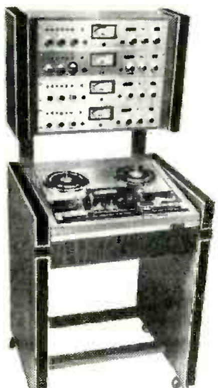

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3-SPEED — $3\frac{3}{4}/7\frac{1}{2}/15$ ips or $7\frac{1}{2}/15/30$ ips. Electronic speed change. Cast aluminium deck — 1" thick. Sel-sync. Cannon inputs, optional balanced or unbalanced. Balanced line outputs. Built-in tone oscillator — 700 Hz or 10 kHz. Vu meter reads input, output or bias current. Equalisation and bias controls on front panel. Headphone output. F.E.T.S. all inputs. 2 or 4 channel.

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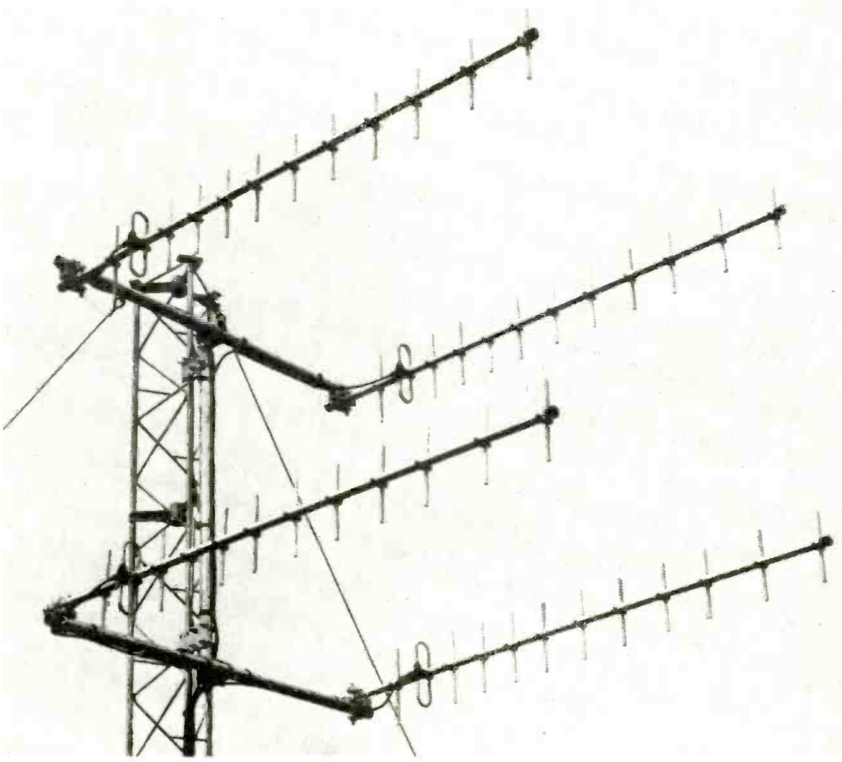

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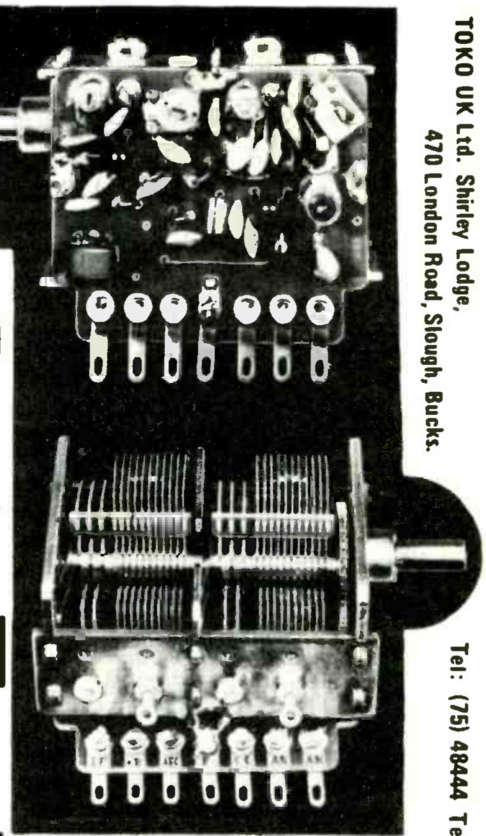

**Type 703UA is an FM Tuner with an associated AM gang. 87-109 MHz supply voltage +6 IF Bandwidth 400 KHz noise 10dB max. AFC ± 150 KHz at 108 MHz. 3 : 1 reduction gear 360° rotation AM gang 2 x 323 pf plus 12 pf trimmer.**

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## Spectrum Analyser Module ST858

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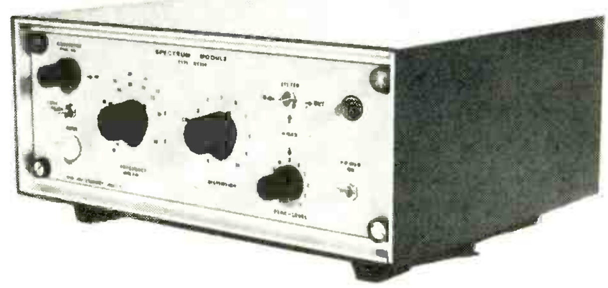

**SPECIFICATION: Frequency range** 10 MHz to 850 MHz in two calibrated ranges **Sensitivity** Better than 50 mv for 0.5V per cm **Resolution** Better than 25 KHz. **Dispersion** From less than 1 MHz to 400 MHz variable **Input** Via 50 ohm BNC connector on front panel **Output 1** Coax cable for connection to Y input on scope **Output 2** Coax cable for connection to sync. input on scope **Power requirements** 240 volts AC 50 Hz 10 watts. (Other voltages and frequencies available as required) **Size** Width 11in (28cm.) Height 4.375in. (11.2cm.) Depth 8.5in. (21.6cm.) **Nett weight** 7.5lbs (3.4 Kg) **Gross weight** 10lbs (4.5 Kg.)

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# You've asked for it!

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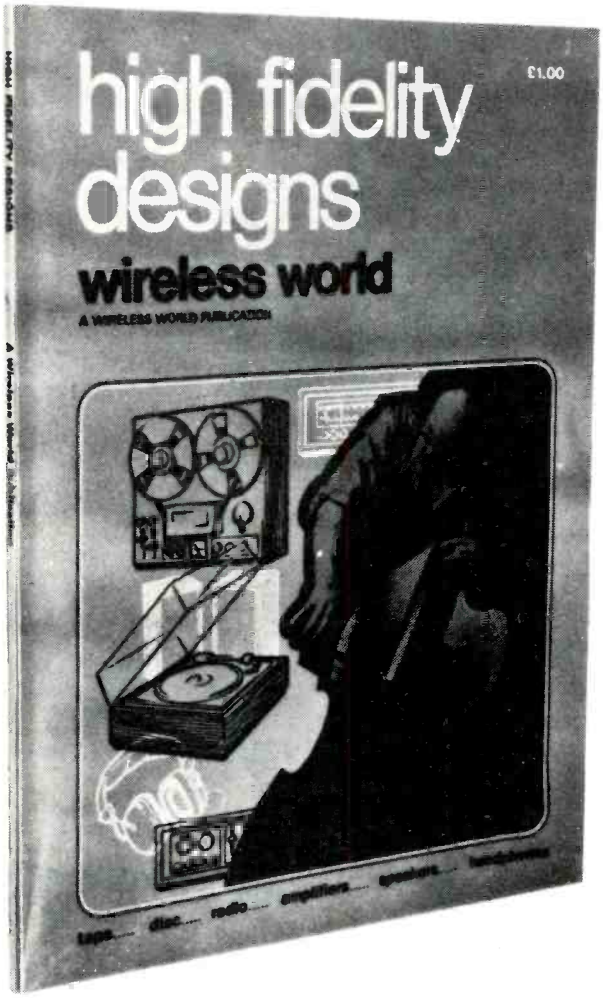


## high fidelity designs

**£1 from newsagents and bookshops or £1.35 (inclusive) by post from the publishers. A book from**

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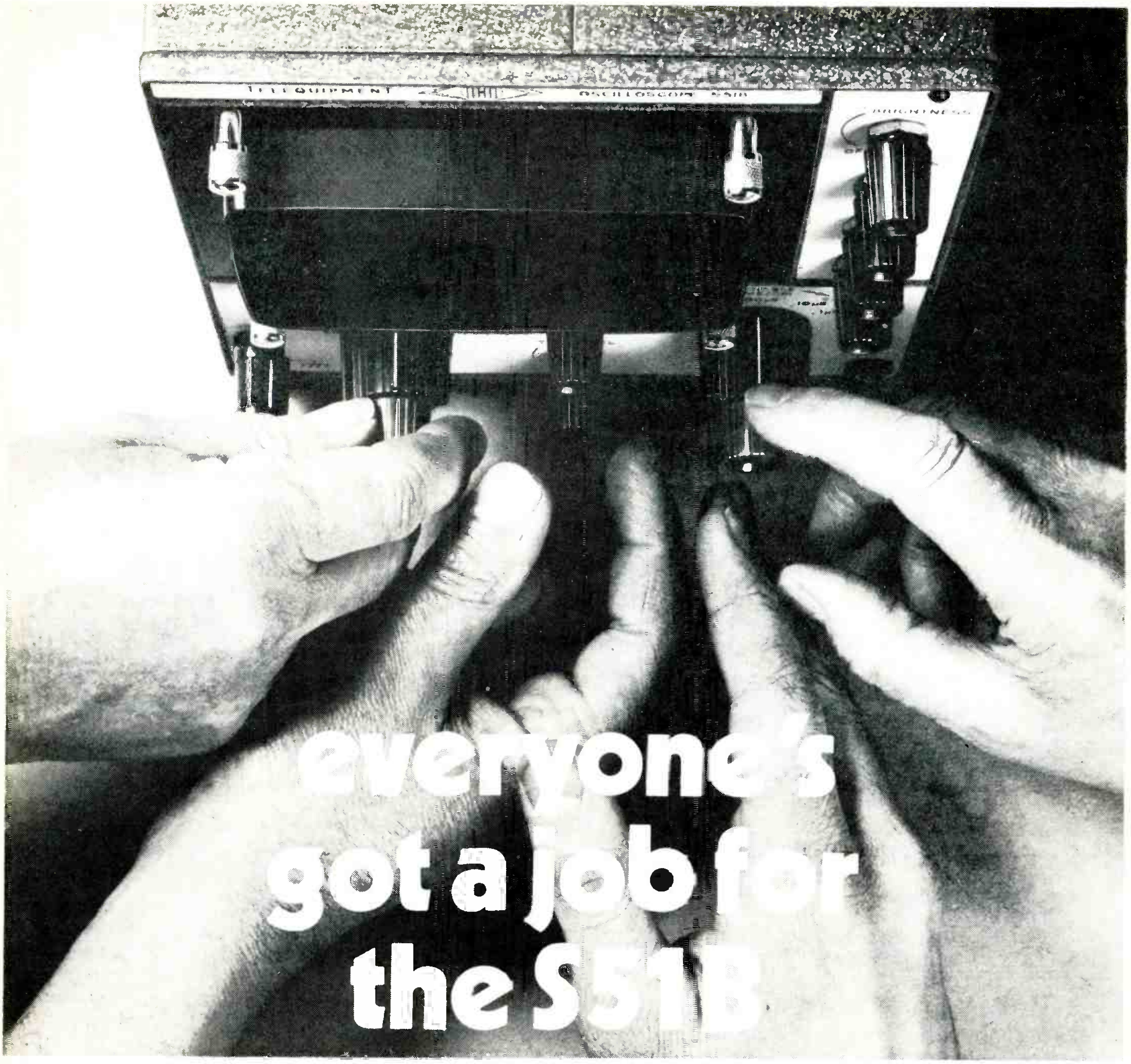


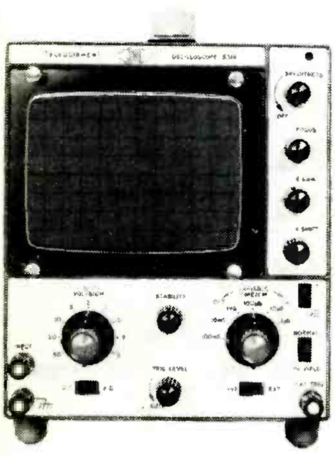

As soon as you try out one of these versatile little scopes, you'll think of dozens of jobs it can do for you. And at £80, you can afford to use it everywhere—in training, inspection, production control and monitoring for example. For a small scope, the S51B has an exceptionally big 10cm by 8cm viewing area, with a really bright trace. Band width is DC-3MHz. Its sturdy construction and easy-to-use controls make it ideal for non-technical operators. It weighs 19½ lbs and measures just 8" by 7" by 15". The versatility of S51B springs from its combination of low price, big flat screen, plus excellent linearity and calibration. It takes Telequipment to line up a package like that! Ask us for full information.

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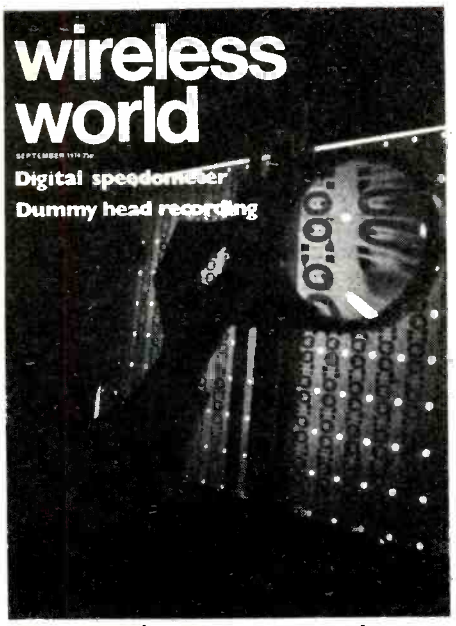
Prices are exclusive of VAT

# wireless world

**Electronics, Television, Radio, Audio**

SEPTEMBER 1974 Vol 80 No 1465

SIXTY-FOURTH YEAR OF PUBLICATION


This month's cover picture shows a checking process in the manufacture of printed circuits for Grundig equipment.

## Contents



### IN OUR NEXT ISSUE
(published October 2)

**Balloon broadcasting and communications.** A system is described which uses helium-filled, tethered balloons as platforms to provide broadcast coverage over large areas.

**Digital speedometer using c.m.o.s.** The second part of the article will describe the average-speed indication circuitry, calibration and practical details.

**Microphone survey.** High quality, semi-professional and professional microphones form the heart of this collation, coupled with a state-of-the-art résumé article.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**wireless world**

## Concepts in electronics



The recent correspondence in this journal on which way current flows, if it did nothing else, served to remind us of the illusive nature of much of our knowledge. A layman reading the letters might well have been shocked to see obviously learned and intelligent gentlemen taking completely opposite points of view. Surely, the layman might say, this is not a matter for debate; it should be possible to determine which way current flows by observation or experiment. He might then be shown some kind of indicator in a circuit, say a pointer meter or an electrolytic cell, and he would be quite right in saying that observation of such things only tells us that electric current is a directional phenomenon, it doesn't tell us the actual direction of the current. He would finally discover that the whole thing is a matter of convention, and which convention you adopt, negative to positive or positive to negative, depends on who you are.

Much of our physical knowledge does in fact rest on *a priori* concepts. We start off with a concept of how things are, then we try to fit into it our empirical observations, which in electronics are basically sense data obtained from instruments. If the empirical observations do fit we say that the concept is the truth. This was how the phlogiston theory of matter survived as a coherent system for a good many years before Lavoisier —all the observed facts seemed to support it. But, as we know, this concept proved to be wrong. Very often the *a priori* concepts are mathematical ones. The concept in the equation $e = E \sin \theta$ is self-sufficient and does not need any empirical support. It is just fortuitous that the behaviour of a certain type of oscillator matches the graphical evaluation of $e = E \sin \theta$, and because of this we say that the output of this oscillator *is* a sine wave. And we often make the consequent mental jump of thinking that the behaviour of the hardware is *governed* by the mathematical equation.

Then there is the strange world of logic. Deductive logic is an artificial pattern of relationships in which things are true or false by definition, independently of empirical observations of the "real" world. The patterns can be written out symbolically in the form of truth tables and it is just a fortunate circumstance that we can make electronic devices act as physical models of these truth tables. The hardware merely mimics the concepts but we sometimes make the mistake of thinking that it is controlled by them.

Perhaps the greatest enigma of all is the nature of the electron itself. We have one concept which sees it as a particle and another which sees it as a packet of waves. What is the truth? Is it a thing or is it an event? The fact that a multi-million-pound industry is based on the electron doesn't help us to decide. We cannot get outside our concepts, except when they are no longer the truth.

# A Digital speedometer using c.m.o.s.

## 1—Speed-measuring circuits using inductive pickup

by Adrian Bishop* and Alan Woodruff†
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**Complementary-symmetry m.o.s. integrated circuitry is well suited to use in the hostile electrical environment of the average car. The authors describe in this two-part article an electronic speedometer and average-speed indicator with numerical readout which can be easily installed, while retaining the existing speedometer.**

The vast majority of conventional car speedometers use what is known as a "drag cup" system. A flexible drive cable from the gearbox or a road wheel enters the back of the speedometer and rotates a permanent magnet (or magnets) mounted within a light metal "cup". As the magnet rotates, its magnetic field drags the cup round, but this tendency is counteracted by a restraining spring attached to the cup. The result is that the extent of rotation of the cup is proportional to the speed of rotation of the magnet, and by adding a pointer moving over a fixed scale we get the familiar dial speedometer, shown in Fig. 2.

We decided that it would be interesting to design an electronic speedometer that would indicate speed in digital form. It has the value of being an unambiguous display to the point of being authoritarian. At least one of our test drivers commented that whereas 33 miles per hour does not look too bad on a conventional dial speedometer, that speed appearing in figures when travelling through town was, for him, a highly restraining influence! A digital electronic speedometer can be extended to include a circuit that can calculate and display average speed in the course of a journey. To avoid the possible confusion that could be caused by showing both speed and average speed together we chose to use only two digits; a switch allows either speed or average speed to be shown on the display.

Before proceeding with the detailed circuit design, it is worthwhile explaining briefly the characteristics of the integrated circuits that are used.

Reliable and economical use of electronic circuits in difficult environments such as automobiles requires that they be capable of operation in very noisy conditions and with wide variations in supply voltage and temperature. C.m.o.s. integrated circuits* are well suited for these stringent requirements, possessing, as major characteristics, (a) operation from a single power supply, between 3 and 15V, (b) very low power consumption—10nW in gates, (c) high noise immunity—typically 4.5V with a 10V supply, and (d) wide operating temperature— −55°C to +125°C.

The properties of wide supply voltage range and very low power can be translated in practical terms to the use of a simple power supply and the elimination of cooling for the logic. These combine with the high noise immunity and wide operating temperature range of c.m.o.s. to offer cost and performance advantages not only in tough environments but in the broad spectrum of logic applications.

### Outline of speedometer

The operation of the digital speedometer is summarized in Fig. 3. A sensing coil picks up variations in the magnetic field produced outside the mechanical speedometer head by a magnet rotating within a drag-cup system. The resulting regularly varying signal is amplified and squared

*An article on the properties and applications of c.m.o.s. circuitry, written by P. A. Johnson, appeared in our August, 1973, issue.

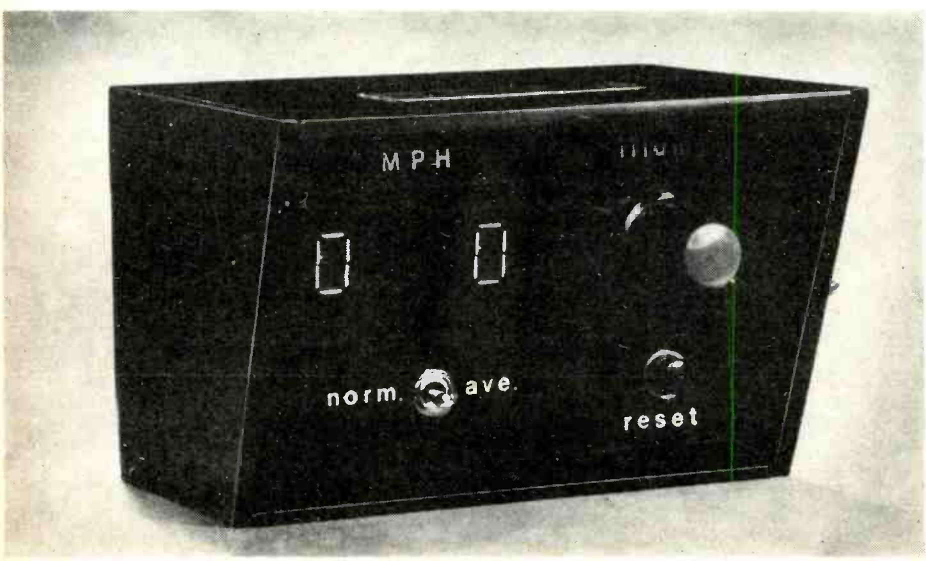



*Fig. 1. The completed speedometer and average speed indicator.*

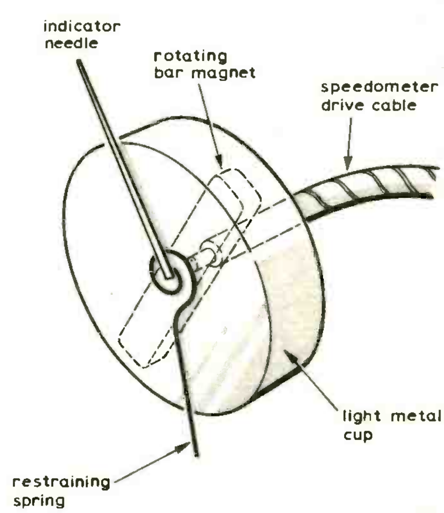



*Fig. 2. A conventional mechanical speedometer.*

up to produce a pulse train whose frequency is proportional to the speed of rotation of the speedometer magnet. The signal frequency is multiplied to produce a system with a suitably rapid response, and the number of pulses produced over a period of time (determined by a variable oscillator) is counted to give an indication of speed. The readout takes the form of two seven-segment digital displays. The digital speedometer is calibrated against the original mechanical speedometer by adjusting the period over which pulses are counted.

This is the basic speedometer; the speed averaging option operates by taking the multiplied output pulses, dividing them down, and storing them in a counter as an indication of distance travelled. At the same time a master clock generates pulses that are stored in a counter as an indication of elapsed time. Distance is divided by time at regular intervals to give a continually updated display of average speed. True speed is normally indicated on the two digits, with average-speed readout obtained by operating a switch. Several refinements have been built in, including a display dimmer and a sampling rate switch to vary the rate at which the speed readout is updated.

**Signal sensing.** The first consideration was to decide how to obtain a suitable input signal for the electronic speedometer. The simplest system, and the one which we decided on, uses a coil to sense the rotation of the magnet.

It is almost essential not to have to dismantle the speedometer and this means that the pickup coil must be located outside the case, preferably out of sight behind the facia. As a result the number of turns on the coil has to be of the order of thousands to pick up the weak changes in magnetic field produced by the rotating magnet within the shielding speedometer case.

An optical method may be more elegant, but it would require a specially designed speedometer head, as would a magnetically actuated switch such as a reed relay. More exotic sensing systems using some form of Doppler radar are relatively expensive in do-it-yourself quantities and rather too sophisticated for our needs. It is also necessary to keep the original speedometer within the car for calibration of the digital speedometer and retention of the odometer.

The coil that we decided to use was the familiar British Post Office 3,000 relay coil. We found that it was satisfactory to mount the coil, with tape, horizontally on the rear of the speedometer with the axis of the coil parallel to the back of the speedometer. The best position seemed to be directly above the point of entry of the speedometer drive cable into the head. The use of coaxial cable between the coil and amplifier affords some degree of shielding from electrical noise.

**Frequency multiplication.** A typical speedometer head produces only tens of pulses per second (i.e., a signal of tens of hertz) when the car is travelling at 50m.p.h. The time taken to accumulate 50 pulses at this speed and thereby register 50m.p.h. is of the order of a second. This can be verified by some order-of-magnitude calculations. Disregarding any gearing within the speedometer head, a car driving a speedometer cable from its final transmission drive may thereby generate perhaps 3000r.p.m. at 50m.p.h., or only 60Hz. A car with a wheel perimeter of 6ft travelling at about 50m.p.h. (say 150f.p.s.) generates only 25Hz and will take 2s to acquire sufficient pulses to register its speed.

This means that if pulses from the speedometer are used directly there may be substantial errors, especially if the car is accelerating hard or decelerating, and under such circumstances the delay in registering speed would be particularly annoying. Unless this problem is tackled the speedometer is in danger of being termed an event recorder.

The solution adopted was to multiply the frequency of the pickup pulses by a factor of ten. This means that it takes only tenths of a second to register 50m.p.h.—a response which is perfectly adequate for the most extreme speed changes which occur in even abnormal motoring.

**Displays.** There are many ways of presenting the final information on vehicle speed; the final choice is dictated both by technical consideration and personal preferences. Operation from the 12V automobile battery dictates the use of a low voltage display, and a seven-segment type is an obvious choice. Technically such displays fit nicely with standard counter/decoder logic and give an accurate and unambiguous indication of speed; they are also compact and easy to locate in odd-shaped dashboard fascias. An incandescent filament type was chosen after some thought—it remains visible in sunlight and is relatively inexpensive.

Originally the prospect of a "head-up" type of display seemed very attractive, but its value and safety in a motor-car presently remains a fairly open question. Setting aside any other influences, such as Road Traffic Act, it is technically possible to rejig the logic to get a digital readout reflected from the windscreen.

**Power supply.** Although the direct operating voltage supplied by an automobile battery is nominally in the range 11–13V, it can vary from 0 to 22V. (We decided that we could not include details of designs for the relatively small number of 6-V electrical systems now on the road, and offer our apologies to, among others, owners of elderly Volkswagens and motor-cycles.) In addition to the voltage variations, under certain conditions car electrical systems can generate very nasty transients.

The low power consumption of c.m.o.s. makes it possible to use relatively simple schemes to protect the circuits from these transients. In our scheme we chose a simple zener diode (11V) clamping system and this seemed satisfactory in all our travelling test beds.

## Speed-indicating logic

The circuit diagram for the speed-indicating part of the speedometer is shown in Fig. 4. The signal from the pickup coil has a peak voltage of typically 5–10mV, and the amplitude variation in the voltage is dependent on the speed of the magnet (induced e.m.f. proportional to the rate of cutting lines of flux). At low speed the signal is less than 5mV.

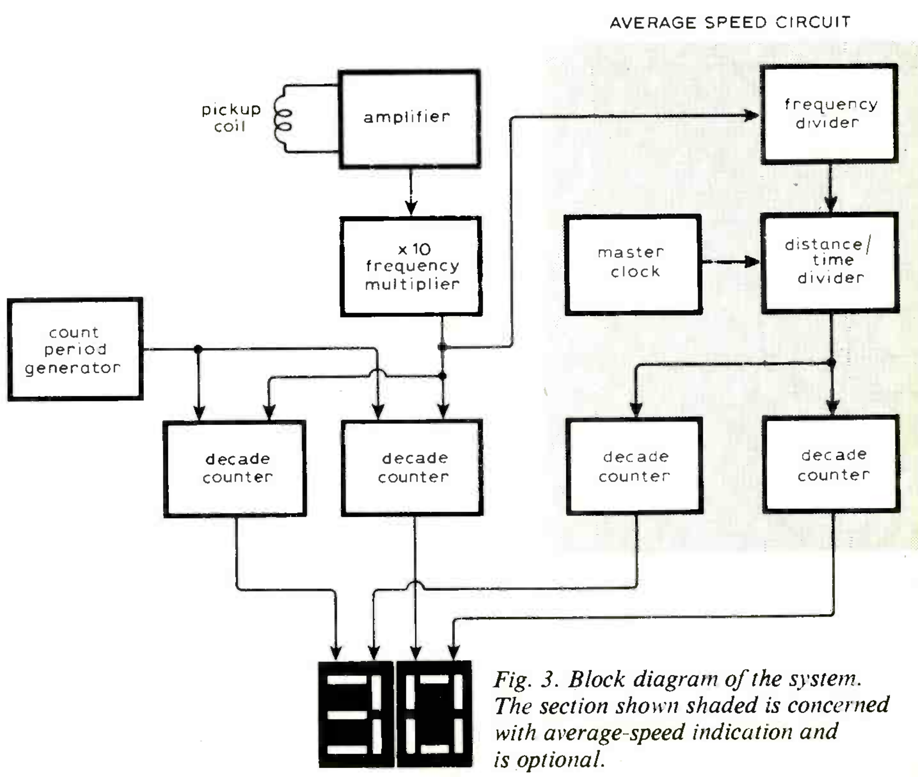



*Fig. 3. Block diagram of the system. The section shown shaded is concerned with average-speed indication and is optional.*

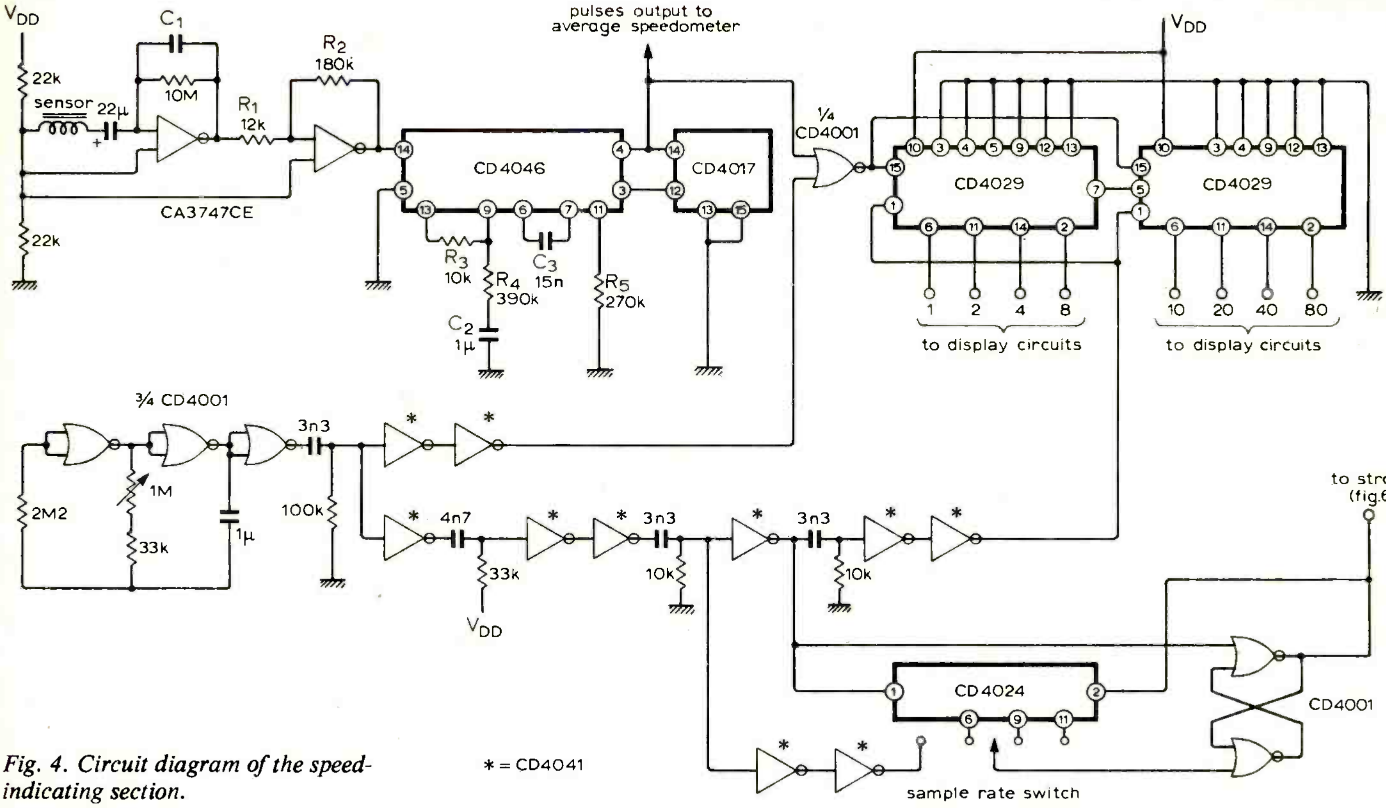



*Fig. 4. Circuit diagram of the speed-indicating section.*

The waveform of the signal from the coil strapped to a speedometer rigged up in the laboratory seemed to be a square wave with a sagging top. Amplification is essential, and because of the sagging and also noise from the ignition, the first amplifier is made into an integrator. In doing this initial tidying up the output waveform from the amplifier becomes somewhat triangular at very low speeds, and therefore a further gain stage with some Schmitt triggering to square things up a bit follows the first amplifier. The industry-standard 747 dual op. amp. in the form of the 14-lead RCA CA747CE is used here. The value of the integrating capacitor $C_1$ is dependent on the design of the speedometer and the positioning of the coil, and some experimentation is required to obtain the optimum sensitivity. The integrating amplifier is operated with 100% d.c. feedback via a 10MΩ feedback resistor to give excellent bias point stability, and the a.c. gain is determined by the ratio of the integrator capacitor reactance and the impedance of the coil bias network. The second amplifier is of the classical design in which the gain is controlled by the ratio of the resistors $R_1$ and $R_2$. The resistors chosen endow the second amplifier with a 10% Schmitt triggering effect, but it is mainly a gain block.

The frequency of the squared signal must now be multiplied up to a suitable value. The method of frequency multiplication uses a c.m.o.s. phase-locked loop (p.l.l.). The value of the technique is that the loop can multiply over a wide range of frequencies and does not need legion resistors and capacitors. The loop is not sensitive to the mark/space ratio of the input, and produces an evenly spread train of pulses of unity mark/space ratio.

Other methods of frequency multiplication, e.g., successive frequency doubling, usually produce a burst of pulses for each transition of the input. If the period over which such pulses are counted terminates close to a burst, an erroneous number of pulses are counted. This can be seen from Fig. 5, which shows, in accentuated form, the sort of thing that can happen. The essentials of a p.l.l. are neatly integrated within a COS/MOS (RCA name for c.m.o.s.) CD4046A.

As its name suggests, a phase-locked-loop circuit produces a signal at its output that is locked onto the phase of the signal at its input; any change in the frequency of the input signal is reproduced by the output signal. The key to this facility is the phase comparator.

Consider the phase comparator first of all in isolation. It has two inputs and one output. If the two input signals are of the

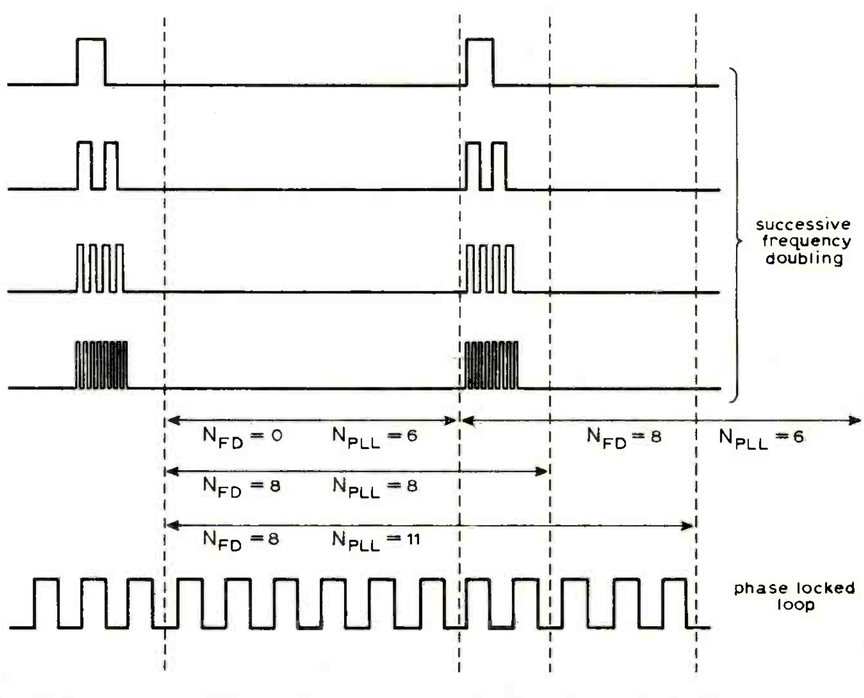



*Fig. 5. Frequency-doubling techniques compared with a p.l.l. method of frequency multiplication. $N_{FD}$ and $N_{PLL}$ are the number of pulses obtained by each method.*

same frequency but out of phase, a pulse is produced, the width of which is equal to the difference in phase between the two signals. If one of the input signals is defined as the principal input, and if the other is the secondary input, and if the phase of the secondary input lags behind that of the principal input, a positive-going pulse is produced at the output of the comparator. If the secondary input leads the principal input, a negative-going pulse is produced. The comparator only senses rising edges in the inputs. In between output "phase" pulses the output is switched off (i.e., floating). Similarly, when the two inputs have the same frequency and are exactly in phase the output is floating. The output of the comparator is said to give three-state logic levels—high, low, and off.

If the secondary input has a lower frequency than the principal input, the output of the phase comparator is maintained high continuously until the two frequencies are equal. Conversely, if the secondary input has a higher frequency than the principal input, the output of the comparator remains continuously low to rectify the situation.

Whatever the output of the phase comparator, it is filtered using an *RC* network to provide a control voltage for the analogue voltage-controlled oscillator (v.c.o.). The v.c.o. produces a square-wave signal with a frequency which is proportional to its direct input voltage—the output frequency increases as the direct control voltage increases, and decreases as the control voltage decreases. The frequency range is determined by $C_3$ and $R_5$. For example, with $R_5$=270kΩ and $C_3$=15nF, the frequency range of the v.c.o. runs from 0 to 500Hz. When the v.c.o. input is zero, the v.c.o. produces no signal; when the v.c.o. input is 10V it produces a signal of frequency 500Hz.

Now, if the secondary input signal to the phase comparator is obtained by feeding back the output of the v.c.o., a digital feedback loop is fashioned and a phase-locked loop is produced, the output of which is equal in phase and frequency to the input signal.

Suppose that now the comparator is deceived by sending back, say, only every tenth pulse from the v.c.o. output. The comparator reacts by supplying a voltage to the v.c.o. until it once again receives what it believes to be the correct number of pulses, and the result is that the output frequency is multiplied by ten. This is exactly what happens in the speedometer circuit; the mild deception of the p.l.l. is achieved by using the CD4017AE decade counter to divide the output frequency of the v.c.o. by ten and then feeding the divided signal back to the comparator.

In practice, an important factor that greatly influences the success or otherwise of the frequency-multiplying p.l.l. is the design of the filter between the phase comparator and the v.c.o. In general, *RC* filters are quite adequate and provide the necessary compromise between avoidance of jitter in the oscillator frequency while retaining a rapid response to changes in p.l.l. input frequency. It was this compromise that dictated the adoption of filter $R_3$, $R_4$, $C_2$ rather than the more common simple *RC* filter, which has an inferior response time. It is important that the v.c.o. tracks the input changes rapidly to give the speedometer a good response, and the value of $R_4$ is the controlling influence here. The value of $C_2$ is determined by the minimum frequency of the input signal.

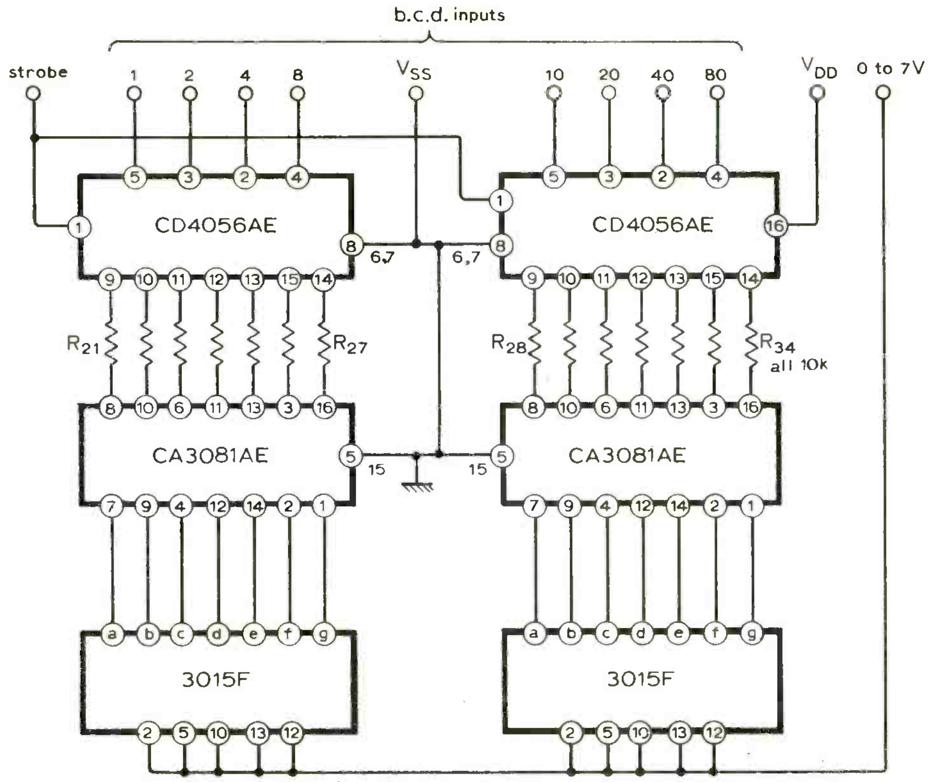


*Fig. 6. Decoder, driver and display.*

A square wave with a frequency ten times that of the signal from the sensing coil has now been obtained. The next task is to count the number of cycles of this signal over a suitable period of time to get an indication of the speed of the car. The length of the timing period is chosen so that the number of pulses counted is equal to the numerical value in miles per hour of the speed of the car. The timing period is determined by an *RC* oscillator, the design of which will be dealt with later.

As the speedometer is to have a two-digit display, pulses are counted by two CD4029AE binary-coded decimal (b.c.d.) counters. (CD4019AE input-selecting circuits must precede the CD4029s if the average speed option is included; their role will be discussed later.) They are arranged in series so that the first counter registers the "units", and the "tens" overflow into the second counter. The count must be stored for the duration of the subsequent timing period and this can be done in b.c.d. format by using only two CD4056AE latch/decoders, shown in Fig. 6. The counting sequence is as follows:

(1) The counters are reset to zero at the start of the timing period; this also allows the counters to begin counting the input pulses.

(2) At the end of the timing period the "clock" for the counters is disabled and the counter outputs are strobed into the latches, thereby storing the speed for that timing period.

(3) There is then a short period during which the latches are allowed to settle and then the next timing period begins.

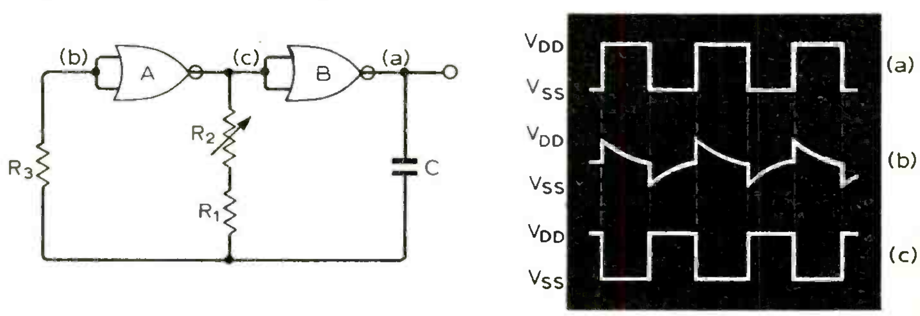


*Fig. 7. c.m.o.s. timing oscillator circuit, with waveforms. $R_2$ varies the frequency.*

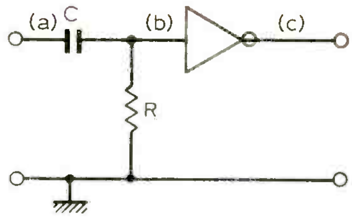
At this time the counters are reset to zero and the counters begin to accumulate pulses again. This action is termed "clock enable".

The CD4056AE integrated circuit is, essentially, a b.c.d. to seven-segment decoder with latches on the b.c.d. inputs. The b.c.d. counter outputs are entered into the latches by a "low" signal on the strobe input. The circuit also has a logic-level shifting facility that enables it to deliver up to 15V at the output when driven from signals as low as 3V. The 10kΩ resistors between the CD4056AE and CA3081 limit the current that can be drawn from the c.m.o.s. circuits. Normally the outputs are "high" or "low", but the CD4056AE can also provide a suitable alternating supply for liquid crystal displays, by use of the display frequency input. The low resistance of the display segments requires the use of a bipolar driving circuit between the CD4056AE and the display. The RCA CA3081 seven-transistor array is used for this purpose.

**Timing oscillator.** The timing signals to enable and reset the display counters and to latch the count into the latch decoder are obtained from a master low-frequency oscillator. The oscillator, which is shown in Fig. 7, is the usual c.m.o.s. configuration. It is formed by connecting an *RC* timing network around two invertors connected in series. (The invertors are formed by connecting the inputs of two NOR gates together; invertors formed in this way have a lower output impedance than the simple two-transistor invertor.)

When the output of invertor B is high, capacitor *C* is charged up, and as a result the input to invertor A is high, and the output of A is low. However, as the capacitor discharges through $R_1$ and $R_2$ the voltage generated passes through the transfer point of invertor A. As soon as the transfer point is reached, the output of A goes high, the output of B is forced low, and capacitor *C* is charged "low". However, $R_1$ and $R_2$ provide a charge path from the output of A to the capacitor, and as soon as the capacitor is charged to the transfer point of the output invertor A, the output of A drops low, forcing the output of A high, and the cycle begins again. The period of the oscillator is approximately $1.4C\,(R_1 + R_2)$ seconds, and can be varied by altering the 100kΩ potentiometer resistance $R_2$. This permits the calibration of the digital speedometer against the original one. Resistor $R_3$ is included to preserve the stability of the oscillator against power supply and temperature variations. The high input impedance of c.m.o.s. enables the use of high-resistance, low-capacitance timing components. The only proviso is that the capacitor *C* must be non-polarized.

**Control pulses.** The general approach here is to use the decay characteristic of an *RC* network to determine the point at which a c.m.o.s. invertor switches. A simple monostable circuit is used and the resulting waveforms are shown in Fig. 8.



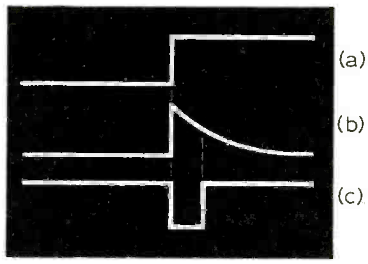




*Fig. 8. Differentiating circuit and NOR gate used as a monostable delay element.*

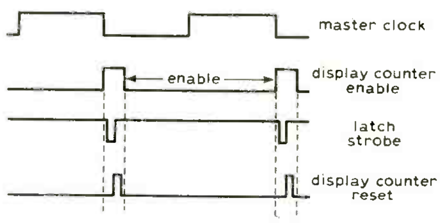



*Fig. 9. Timing of the enable, latch and reset pulses.*

If a positive-going voltage step (a) is fed into the input of the *RC* network, the point (b) will follow the positive-going edge instantaneously because there is no charge on the capacitor *C*. The capacitor then begins to charge through the resistor *R*, causing the potential of point (b) to fall on an exponential curve to zero. When the potential at point (b) reaches the switching point of the invertor, the output of the invertor, point (3), changes state, so that the output is an inverted, shorter version of the original pulse (provided that the *RC* time constant is less than the width of the input pulse). The rising edge of the invertor output can be fed into a further *RC* network to produce another pulse that is delayed with respect to the input pulse.

This is the technique that is used in the speedometer to separate the enable, latch and reset pulses. The timing diagrams are shown in Fig. 9. The CD4041AE quad buffer, which has true and inverted outputs for each of the four buffers, is very useful in this type of application.

**Sampling rate.** The rate of updating of the speedometer display is a matter of personal preference, and also traffic conditions, and it seems desirable to be able to control the rate at which data is presented. Otherwise, the display changes with every cycle of the master oscillator (i.e., about once a second) and this might prove irritating to the driver in slow-moving traffic. To avoid this a dividing circuit is introduced which allows the display to change for either 1, 2, 4 or 8 cycles of the master clock, although with the devices used other values (up to 64 cycles) could be achieved.

The dividing circuit consists of a CD4024AE seven-stage binary counter and two 2-input NOR gates, with the counter outputs selected by a four-pole switch. For example, if the fourth stage output of the counter is selected, every eighth clock pulse is fed to one of the NOR gate inputs, enabling the pulse to strobe the latches in the display decoder. This clock pulse also resets the CD4024AE and allows the counter to recommence dividing the clock pulse derived from the master clock. At the other extreme, if sampling at every clock pulse is desired, the CD4024AE is bypassed completely and clock pulses are fed directly into the decoders via the NOR gates.

The design of the speed averaging circuit, and details of the power supply and speedometer calibration will be dealt with in Part 2 of the article.

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# Circuit Ideas

## An l.e.d. synchroscope

In attempting to tune an oscillator to a standard frequency it is convenient to be able to sense the direction of a phase error as one approaches the correct setting. Some instruments provide a cathode-ray tube Lissajous figure display for this purpose, but the hardware required is rather inconvenient and expensive.

It is possible to generate something similar to a Lissajous figure using a few lamps and this is very familiar to power engineers in the form of a lamp synchroscope. With the advent of light emitting diodes, a low consumption version is possible for electronic applications.

A three-lamp system gives the neatest and most elegant display, but it is generally more convenient to generate four phases from an existing signal source than three phases. Thus the circuit described is a four-lamp system.

The four lamps generate a display rotating once per cycle at the reference frequency. The display brightness is modulated at the frequency of the oscillator to be adjusted. The apparent display is therefore a rotation which appears to have a frequency equal to the difference between the two signal frequencies concerned and a direction indicative of the sense of the frequency difference.

The display is most effective when the lamps are mounted on the smallest practicable pitch-circle diameter.

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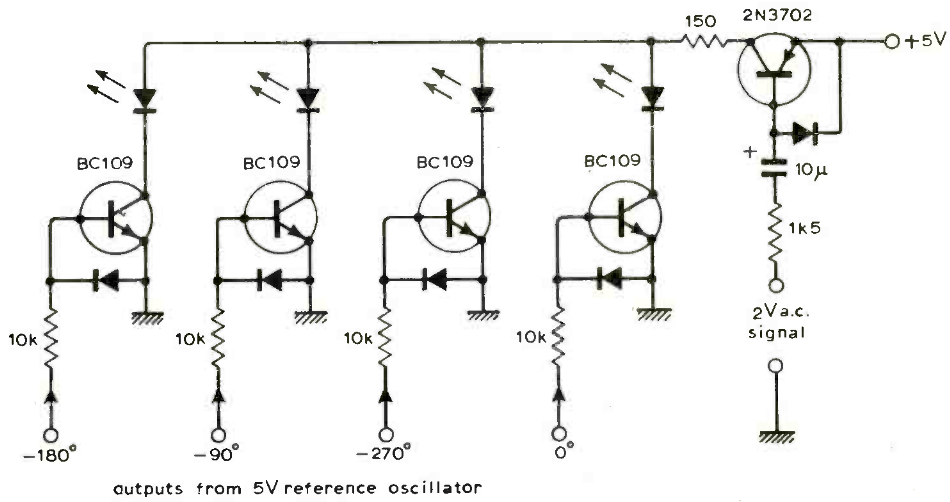


## Improved accuracy for digital clocks

J. M. Osborne's high-standard low-frequency source (January 1973) can be adapted for use in digital clocks by replacing the NE561B with another phase-locked loop, the NE567V. This i.c. is cheaper, it will run on the same 5-V supply rail as the divider i.cs, and it gives a t.t.l.-compatible output which indicates whether its v.c.o. is locked to the incoming carrier. This latter feature can be used to switch pulses from a stand-by frequency source (e.g. a crystal oscillator) into the divider chain during breaks in transmission of the primary standard. The diagram shows how this can be done using a 7401; the l.e.d. goes out when the 567's v.c.o. is "locked". The v.c.o's free-running frequency is set by *R* and *C*. As the 567 is less sensitive than the 561, the r.f. amplifier may be necessary in some parts of the country.

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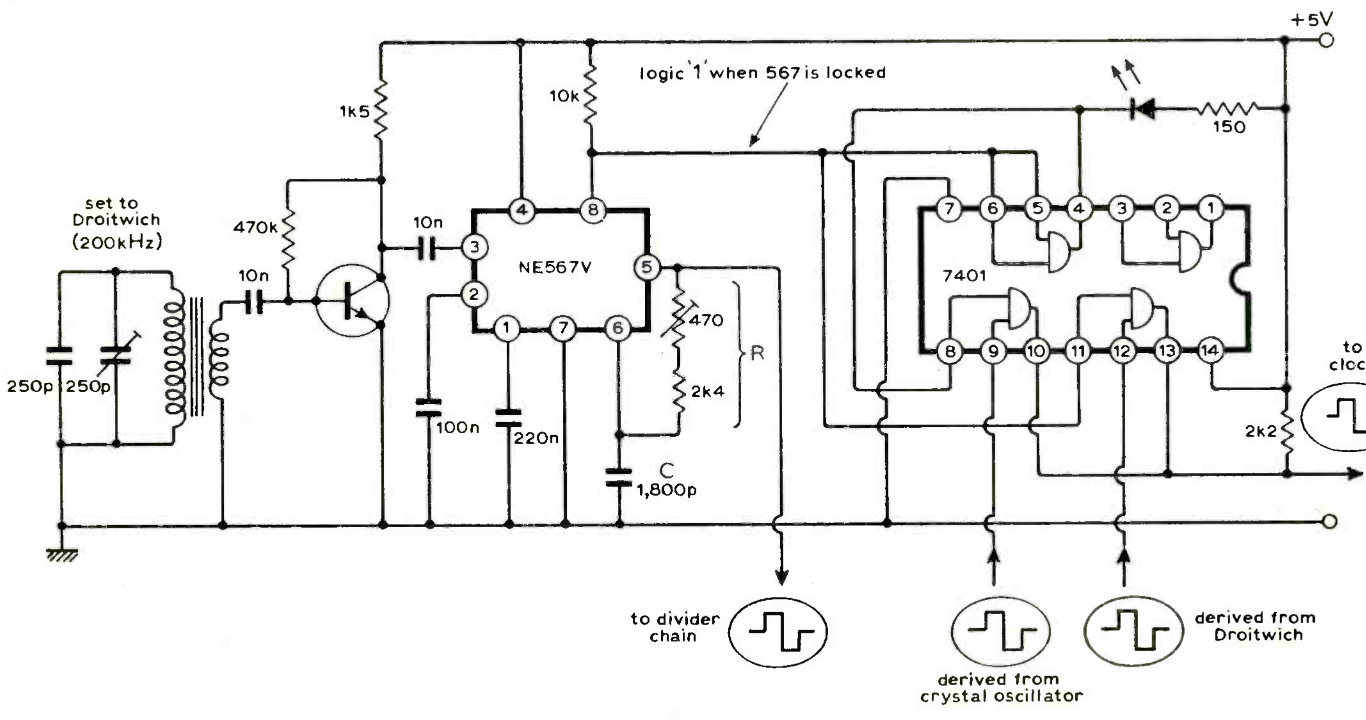


# Mobile amateur radio

## A progress report on British activity

by N. A. S. Fitch, G3FPK

In recent years there has been a large increase in the professional use of mobile radio. Many organizations operate radio-controlled fleets of vehicles in order to achieve greater efficiency. Undertakings such as regional electricity and gas boards, television rental companies, ambulance and fire brigades, police forces, etc., come to mind.

Mobile operation by radio amateurs has also become increasingly popular during the last two decades and figures published earlier this year by the Ministry of Posts and Telecommunications reveal that over 20% of British radio amateurs also hold mobile licences. There appears to be no predominant reason why so many amateurs "go mobile" and all amateur bands from 160 metres to 70 centimetres have their devotees.

### Why mobile?

Detailed examination of various factors contributing to the popularity of mobile operation reveals that there are many amateurs who find this their only way of satisfactorily enjoying their hobby. This situation may be due to any or several of the following reasons. Firstly, some operators find that the erection of outside aerials is not permitted, which means that the fixed station operator must rely upon indoor aerials. Secondly, in densely populated areas, the amateur who can boast that he causes no broadcast or television interference is a very rare, and lucky, individual. Thirdly, some amateurs live in areas from which h.f. and v.h.f. propagation is difficult, such as valleys and heavily wooded districts.

### Licence conditions

Although a few radio amateurs experimented with mobile operation back in the 1920s[1] a general interest in the opportunities offered by mobile radio did not develop until some time after World War II. Mobile operation by British amateurs was not permitted from a moving vehicle until 1954 and amateur licences were very restrictive especially concerning operation away from the fixed address. After protracted negotiations between the GPO and the Radio Society of Great Britain, there emerged new licences effective on June 1, 1954, which liberalized amateur activities and in particular created the mobile licence as we know it today.

In the UK the Ministry of Posts and Telecommunications will now issue a mobile licence to any licensed radio amateur for an annual fee of £1.50. The call sign remains that of the fixed station but with the suffix /M, e.g., G3FPK/M. While this licence permits operation from any vehicle or vessel on inland waterways, a separate Mobile Marine licence is available to those wishing to operate from a sea-going vessel. In this case the call sign would be G3FPK/MM. At present amateur radio operation from aircraft is not permitted by the British authorities although it is allowed in other countries including the USA. While there are certain restrictions in the Mobile Marine licence, the ordinary Mobile licence conditions are the same as those for the fixed station as regards power limits and frequencies. Mobile enthusiasts use all the popular amateur bands comprising 160 metres (1.8–2.0MHz) also known as "Top Band"; 80m (3.5–3.8MHz); 40m (7.0–7.1MHz); 20m (14.0–14.35MHz); 15m (21.0–21.45MHz); 10m (28.0–29.7MHz); 4m (70.025–70.7MHz); 2m (144–146MHz) and 70cm (430–440MHz).

### Early equipment

After WW2, large quantities of military radio surplus came on to the market and was sold at "give-away" prices to radio enthusiasts. From the late forties on, the numerous international amateur radio publications printed many articles dealing with the conversion of such surplus to amateur mobile operation, examples being the well known "ZC1" and "B2". It is a tribute to the reliability and ruggedness of such equipment that relics occasionally appear at today's mobile rallies.

As the economy swung back to a peacetime footing, small firms started up, manufacturing amateur radio equipment including, from the mid-fifties, items suitable for mobile use. A few of these firms still exist and have prospered, but the majority are just memories to the older amateurs and meaningless names to the younger generation. One of the first pieces of British equipment specifically designed for amateur, mobile operation was the P.C.A. Radio "Hamobile" 2-metre transceiver, advertised for the first time at the beginning of 1955 and later manufactured by K. W. Electronics Ltd. Looking back through the advertisements in the amateur radio press, with the exception of the "Hamobile", it seems that the British manufacturers were somewhat slow off the mark in producing mobile equipment. It was not until mid-1959 that the Minimitter Co announced its complete range of amateur mobile gear, including a multiband a.m. transmitter, multiband converter plus a range of aerials.

While the manufacturers were slow in producing commercial mobile equipment, the growing band of active mobiles soon made their own "home-brewed" gear, either by converting surplus military sets or by custom building, using surplus and/or new components. 160 metres and 2 metres soon became established as the predominant mobile bands, the former because of the inherent simplicity of the gear, the latter having the attraction of being a more exclusive amateur band with no coastal radio stations and Loran interference to avoid. 160-metre gear was quite simple, the transmitter usually crystal controlled, while the receiving side was often just a simple converter using the long waveband of the car radio as a tunable i.f. strip. Two-metre equipment was always crystal controlled and the circuitry was kept as simple as possible. The receivers could use a high i.f. as selectivity was not a prime requirement. In this period, amplitude modulation was invariably used in 160- and 2-metre gear.

### Mobile rallies

Once mobile operation from a moving car was legalized mobile enthusiasts realized the need for a method of discussing ideas, both technical and operational. Whilst occasional articles appeared in the amateur press on home-built equipment for various bands, it became obvious that meetings were desirable. Thus the idea of the mobile rally was born and it is generally agreed that the first such meeting took place at the Perch Inn, Binsey, near Oxford on October 9, 1955, with an attendance of 23 cars.

During the remainder of the fifties mobile rallies became a feature of the British amateur radio scene. Probably for the first time they provided occasions which could be enjoyed by the wives and children too, unlike the field days, conventions and exhibitions which tended to be exclusively amateurs.

Towards the end of the fifties there was a group of dedicated mobile operators who were disappointed by the lack of serious interest in mobile matters by the amateur radio press. The result was the formation of a group devoted solely to this branch of the hobby and the birth of the Amateur Radio Mobile Society. From modest beginnings the ARMS has grown today to an international organization with members in all continents and many countries, producing a monthly magazine, *Mobile News*, with an awards programme and a comprehensive information service.

### Developments in the 1960s

The decade of the 1960s saw the steady growth of mobile activity as more manufacturers in the UK, USA, and, towards the end of the period, Japan, also produced equipment either specifically for or suited to mobile use. This encouraged more clubs and societies to promote mobile rallies which gradually became more ambitious. Some of these have become annual events, like Longleat, Derby and Woburn. As equipment and components became plentiful, some of the more important rallies started to include trade shows, a trend pioneered by the ARMS.

Such mobile rallies, whilst offering a pleasant outing for the family, provided ideal venues for mobiles to meet, inspect each other's installations, compare various aerial systems, discuss such important matters as the suppression of electrical interference and the performance of various commercial products. There are many cases where amateurs, not then very interested in mobile operation, learned with some surprise of the excellent results obtained by their mobile confrères, so much so that they were soon "bitten by the bug".

### Reciprocal licensing

During the first decade of British mobile operation there was a great increase in the number of motorists taking their cars on touring holidays in Europe. A proportion of these were mobiles who could not, however, normally obtain official permission to operate either fixed or mobile stations in the countries they visited. The stumbling block was the stubborn refusal of successive British governments to grant any amateur licence to non-British subjects. Understandably, no European country felt inclined to grant a licence to a British tourist, with the exception of the Principality of Monaco.

It seemed unlikely that the British government would make the first move, nevertheless somehow the impasse had to be overcome since several continental countries had already concluded agreements allowing reciprocal operation which were proving to be quite satisfactory. The breakthrough eventually occurred in April 1963 when influential Belgian and Dutch members of the ARMS persuaded their respective governments to grant temporary mobile licences to British amateurs who wished to attend the international mobile rally at Verviers in Belgium. The event was a great success, attracting many UK mobiles who, being issued with unique call signs, were eagerly contacted by amateurs world wide.

In the following year, the then Postmaster-General announced in Parliament that amateur licences would be issued to aliens on a reciprocal basis since when many such agreements have been concluded between Britain and other countries. The result has been a great increase in "mobiling" holidays on the continent since British amateurs can now obtain mobile licences for many European countries including some in Eastern Europe. There are many benefits arising from the opportunity to operate whilst abroad. Firstly, it enables an amateur and his family to keep in touch with home by arranging schedules with local friends; it may be comforting to learn that the tomatoes are doing fine and that grannie's pet budgie is well again! Secondly, it gives the roving mobile an opportunity to meet some local amateurs following casual contacts on the air, something which is often completely lacking on more conventional holidays. Thirdly, it enables the mobile station to try out different aerials in conjunction with a friend back home so that test results can be compared personally upon return.

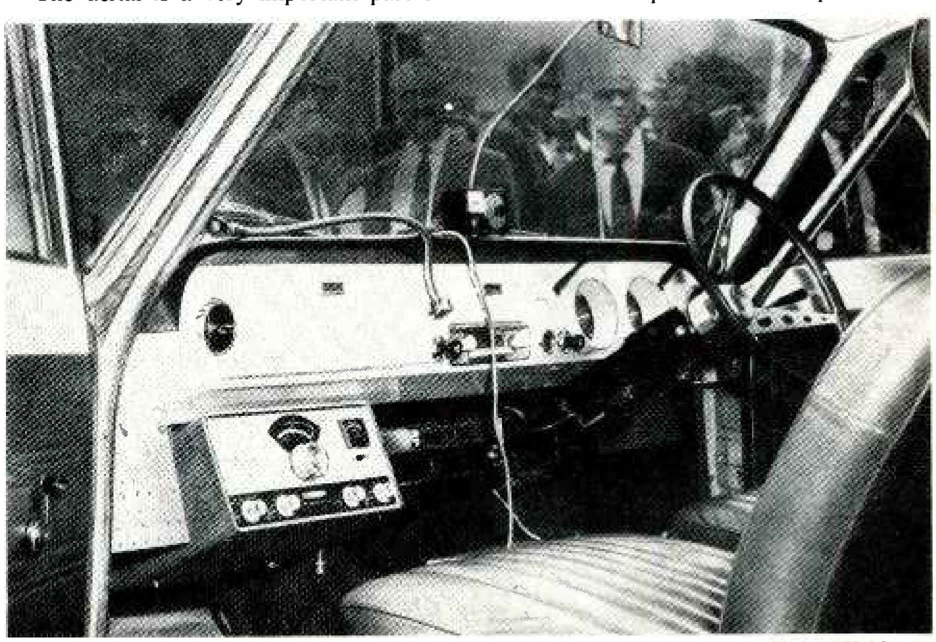
### The equipment of the sixties

There is little dispute that the sixties, as far as amateur radio is concerned, was the era of single sideband even though this method of transmission was far from new. This period saw a proliferation of s.s.b. transmitters and transceivers from American manufacturers and from one or two British firms as well. It is true to say that the advent of the compact, high-powered s.s.b. transceiver revolutionized h.f. band mobile operation, the undisputed efficiency of the system enabling "DX" to be worked with comparative ease by mobiles on the move. The first generation of these transceivers did not always cover all the popular 10- to 80-metre bands and they all used valves, although transistorized power supplies supplanted the inefficient rotary converters and vibrator supplies.

Later on, transceivers such as the Sideband Engineers "SB-33" appeared featuring fully transistorized receiver sections, the only valves being in the transmitter driver and output stages. Towards the end of the sixties the Japanese manufacturers were exporting similar equipment in increasing numbers. A useful feature of many s.s.b. transceivers was the inclusion of or provision for voice-operated change over or VOX circuitry, whereby transmission was initiated by the start of speech thus avoiding the need to operate a send-receive switch by hand or foot. This, together with one-knob control, has enabled very safe mobile operation to be achieved.

The aerial is a very important part of the mobile installation. On 28MHz and above, quarter wavelength whip aerials are practical but for operation on the 160 through 15-metre bands, some kind of loaded aerial must be used. During this decade, many successful commercial mobile aerials appeared, the more ingenious designs allowing limited multiband operation to be achieved from a single device, obviating the need for stopping the car to swop aerials when changing bands. Probably the most efficient type of aerial for mobile use is the helical or continuously loaded type. Mobiles not wishing to buy expensive commercial aerials resorted to making their own. While many were neat and efficient, others were unsightly and dangerous, fiendish contraptions which did nothing to enhance the reputation of mobile operators.

A factor which influenced the development of new equipment for the v.h.f. bands was the availability of large quantities of surplus business-radio mobile sets, both mobile and base station gear. Due to the ever-increasing demands for more business radio v.h.f. channels, new regulations were enforced which enabled more channels to be accommodated in the designated bands. Although it would have been possible to modify some of the existing sets to make them comply with the new standards, users disposed of their old sets and re-equipped their base stations and fleets with the latest models. There were some fine bargains to be picked up; the author and a dozen other local amateurs, for example, bought a number of early Pye "Ranger" transreceivers for 30 shillings apiece in 1966. These high-band models were very easy to re-tune to the two-metre band and several are still in use. Even so, new firms appeared in the sixties which developed and marketed amateur v.h.f. equipment, probably the best known being the "TW" range from Withers Electronics. It's probable that the development of new amateur v.h.f. mobile apparatus was somewhat stifled by the large variety of cheap and excellent professional surplus which



*The mobile installation of G3WRV, Grahame Harding, comprising a Heathkit HW-32 200W, 14MHz transceiver and an Eagle RF-40 field strength meter.*

was eagerly bought by the new class "B" licensees from 1964 onwards, particularly when the 2-metre band was made available to them.

### Developments in the seventies

There are two distinct roads down which the British mobile seems to be travelling depending on whether it is h.f. or v.h.f./u.h.f. operation which is his main interest. Firstly, considering the h.f. bands devotee, the 1970s to date has seen the virtual takeover of the s.s.b. transceiver market by Japanese companies whose products, until the recent less favourable Pound/Yen exchange rate, represented almost unbeatable value for money. While the earliest productions were generally agreed to be technically inferior to current British and American equipment, the latest models are capable of excellent performance.

The favourable reciprocal licensing situation created a demand for a compact, lightweight, portable multi-band s.s.b. transceiver with built-in a.c. and d.c. power supplies, which has been met by such products as the Yaesu-Musen FT-101. More and more British and foreign cars are being supplied with alternators having outputs of 45 ampères or more. This, combined with the much lower average battery consumption of the solid-state transceivers, greatly lessens the possibility of flattening the car battery when operating mobile. In fact, some amateurs have installed linear amplifiers in their cars capable of the maximum permissible output power of 400 watts peak envelope power. However, high power should be used with a little caution as it has been observed that the short mobile aerials are liable to produce a pretty corona effect.

Secondly, considering the v.h.f./u.h.f. enthusiasts, they have rediscovered narrow-band frequency modulation and here again, there has been a rapid growth in the number of Japanese f.m. transceivers being bought by 2-metre operators. This popularity of n.b.f.m. has led to the modification of the band plan to incorporate several channels for f.m. stations whilst 145.000MHz has become the international mobile calling channel. Many 4-metre and 2-metre operators who do not wish to buy brand new gear continue to purchase the comprehensive range of mobile radio telephones being disposed of by commercial concerns as the latter modernize their radio-controlled vehicle fleets in accordance with the latest ministry regulations. This equipment can be converted quite easily to amateur use with satisfactory results. Once again, the Japanese have jumped upon the bandwagon by producing a s.s.b. transceiver for the 2-metre band and it is the author's belief that 2 metre s.s.b. operation will increase significantly in this decade.

### The repeater concept

In several European countries, v.h.f. repeater networks have become established in the amateur bands, probably the most comprehensive being the West German system.[2] In August 1972, the Ministry of Posts and Telecommunications issued a licence to the Radio Society of Great Britain for GB3PI, a repeater installation designed and installed by members of the Pye Telecom Amateur Radio Group and currently operating very satisfactorily from a good location in north Hertfordshire.[3] The input/output channel spacing is the 600kHz agreed at the IARU Scheveningen Conference in May 1972 and it is the author's expectation that several more UK v.h.f. and u.h.f. repeaters will be in operation by the end of this decade. These repeaters are a great boon to mobile operators for they make possible contacts over much greater distances from car to car or car to fixed station than would otherwise be possible. Access to this repeater is gained by transmitting a half second, 1750Hz tone, usually generated by a tone burst circuit or even a whistle for those with perfect pitch.

Repeaters are not new and they are used extensively by police forces, for instance. However, the input/output frequencies are usually several megahertz apart whereas amateur systems are inevitably much closer spaced, which poses quite severe technical problems for co-sited receivers and transmitters. While these technical problems can be overcome, there remains an administrative one in that someone must be on hand at all times the device is operational in case it should develop a fault.

### Mobile operating techniques

Over 4,000 UK radio amateurs hold mobile licences and their operating techniques vary widely. Mobile operating is particularly attractive to those motorists who frequently have to undertake long boring journeys on their own. While many drivers have a car radio or stereo cassette system at their fingertips, both of which alleviate the tedium of a lengthy trip, it is far more satisfying to be able to communicate from the driving seat to the outside world.

Basically there are three types of amateur mobile operator. Firstly, there is the driver who prefers to motor to a suitable location and operate while parked. As long as he uses the car aerial and car electrics he is "mobile" within the terms of his licence. Some take this a stage further and erect a more efficient aerial system outside the car in which case they should sign -/P for Portable. This is a popular pastime with v.h.f./u.h.f. enthusiasts who are frequently to be heard on the 2-metre and 70-centimetre bands transmitting from high ground using portable yagi beam aerials. Secondly, there is the amateur who lets somebody else drive while he devotes his attention to operating from the passenger seat. There are many blind and physically handicapped radio amateurs who enjoy their hobby this way as well as those who feel it safer to not drive and operate. Finally there is the competent motorist who operates while driving. With modern "one-knob" control tuning which the single sideband transceivers offer and the fixed channel a.m. and f.m. equipment for the v.h.f. bands, this is no more hazardous than driving while talking to a passenger.

Operating methods also vary. For example, on the 2-metre band, the majority of mobiles seem to be content to monitor a fixed channel or two whereon they communicate with other mobile or fixed stations. Activity is high at commuting times and during the evenings when amateurs may be travelling to club meetings. 70.26Mhz and 145.0MHz are the agreed mobile calling frequencies in the 4-metre and 2-metre bands respectively. Once contact has been established it is usual for the stations to "QSY", that is to change to another channel. Most operating on the h.f. bands these days is co-channel. Either the mobile station tunes to a clear frequency and calls "CQ" inviting replies, or he answers a "CQ" call from another station. The majority of such contacts over longer distances are with fixed stations although a number of mobiles have managed mobile-to-mobile contacts with all six continents. Most mobiles who operate while driving use microphones attached to their head thus leaving their hands free. This, combined with voice-operated change-over, makes for very safe operating.

### Conclusions

It may be thought that there is not much more that can be developed in the field of amateur radio mobile communications but the author thinks this to be far from true. There is the challenge of suppressing the electrical interference from one's own car which will be more difficult if and when plastic-bodied cars appear. A more recent problem, and one likely to increase in numbers, is not that of interference with reception from the car engine, but that of the malfunctioning of electronically controlled fuel injection systems caused by transmitter r.f. energy getting into their "computers" or "brains".

Mobile aerials for the lower frequencies usually exhibit quite narrow bandwidths and so there remains a great deal to be done in perfecting an economic system of automatically tuning such aerials when changing operating frequency. Then there is the quest for the ultimate in noise blankers—devices which eliminate pulse-type interference from sources such as ignition circuits—an essential when operating in heavy traffic. Even if the mobile operator has successfully suppressed his own car, he cannot expect every other motorist to do the same. For v.h.f./u.h.f. mobiles, there is the challenge of inter-continental contacts on s.s.b. via the "Oscar" satellites.

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# Thyristor control of shunt-wound d.c. motors

by F. Butler, B.Sc., M.I.E.E., M.I.E.R.E., O.B.E.

**Practical design details are given for a controller which provides over 2kW output from 230V single-phase mains. It is conservatively rated and will smoothly vary the speed of any motor, up to 2hp, from standstill to 90% of the rated full speed. It incorporates simple protective devices and, by omitting a few components, required only for motor control, it can be used as a high-power lamp dimmer or heat regulator.**

Many readers will be familiar with the principles of thyristor-controlled lamp dimmers or speed regulators for conventional power tools which incorporate a.c.–d.c. series-wound motors. A characteristic of the series motor is that, as the load on it is increased, the machine slows down, whereas it will tend to race on no-load. For some purposes these are acceptable or even desirable properties but in other applications we require a motor which can be set to any desired speed and maintain this speed in spite of load changes. A shunt-wound d.c. machine comes close to meeting these requirements though there is some inevitable drop in speed as the load increases, the fall being most noticeable in small machines with high-resistance armatures. The speed may be controlled by adjustment of the field current or by variation of the armature voltage. Weakening the field serves to increase the speed; reducing the armature voltage, with a fixed field, reduces the speed. For a given motor, torque is proportional to armature current while the horsepower is proportional to the product of torque and speed. Speed reduction necessarily results in reduced power for a fixed maximum armature current.

### Electronic speed control

One method of electronic speed regulation calls for constant shunt field excitation while the motor armature is supplied with a train of current pulses of variable shape or duration and hence of variable mean and r.m.s. value.

Two methods of supplying fixed power to one resistive load and controlled variable power to another are shown in Fig. 1. With minor modifications these methods are directly applicable to motor speed control. The diode rectifier bridge supplies fixed mean power to $R_1$ which might represent the shunt field winding of a motor. Adjustable mean power in $R_2$ is obtained by varying the timing of the thyristor trigger pulses. Although both circuits give identical waveforms, that using the single thyristor has some advantages and, in what follows, will be used in preference to the other.

When a motor armature is substituted for $R_2$, a number of problems are encountered. First, the rotating armature generates a back-e.m.f. and it will only pass current if the thyristor is triggered on and if, at the same time, the instantaneous forward voltage from the rectifier bridge exceeds the motor back-e.m.f. Next, the armature is inductive and a free-wheel diode must be connected across it to allow circulating current to continue even when the thyristor is blocked. The thyristor gate trigger signal is normally a short-duration pulse with an amplitude of 3 volts or so from a 20-ohm source. A longer pulse would simplify matters but would require much more mean power from the generator and would cause excessive gate-circuit energy-dissipation.

When used for speed regulation the circuits of Fig. 1 give a poor performance, manifested by gross instability of motor speed, with dangerously high transient currents in the system. On starting from rest, the motor back-e.m.f. is zero and, even with retarded trigger pulses, a relatively large armature current is drawn. The motor speed quickly rises, with the result that the next few trigger pulses fail to turn on the thyristor because, at the firing instant, the motor back-e.m.f. exceeds the output voltage from the rectifier bridge. The speed therefore drops and in due course the thyristor fires again with another current pulse of damaging amplitude. The resulting hunting, overshoot and undershoot or stop-go working is such as to rule out this simple scheme. What is needed is some means of triggering the thyristor, with any desired gate-pulse delay, independently of the motor back-e.m.f. A simple modification which allows this to be done is shown in Fig. 3. The main rectifier-bridge diodes

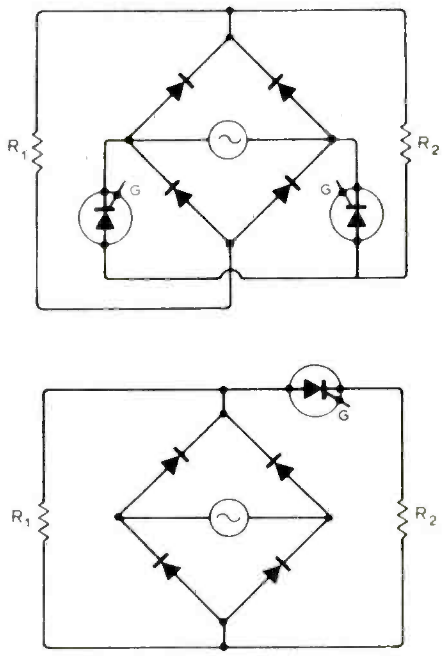



*Fig. 1. Diode-thyristor bridges to produce fixed power in $R_1$ and variable power in $R_2$.*

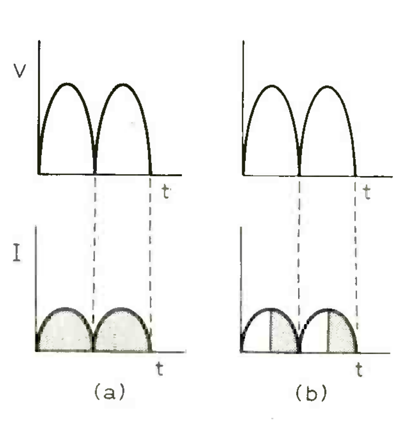



*Fig. 2. (a) shows current and voltage in $R_1$, while that in $R_2$ is shown in 2(b).*

*D* supply the motor field directly and feed the armature through the thyristor, while *FWD* represents the free-wheel diode.

Two auxiliary diodes $D_1$ are used to feed the thyristor anode through a resistance *R*. Regardless of the presence of the motor, the mean power in *R* is controllable by the thyristor trigger pulse delay, exactly as in a lamp dimmer. There are no back-e.m.f. problems associated with the resistive load. The thyristor is fired regularly at times dictated only by the properties of the trigger module. If at any instant, after triggering, the motor back-e.m.f. exceeds the bridge output voltage, the motor simply draws no current; otherwise it takes current proportional to the net voltage round its own circuit loop. This apparently trivial modification at once guarantees complete stability and smoothness of operation at all speeds and loads. In practice the resistance *R* must at all times draw a current which exceeds the thyristor holding current, typically 100mA. It is convenient to use a low-power mains-voltage lamp, say 40W, the brilliance of which serves as a visual indication of speed, useful if the motor is remote-controlled.

The combination of diodes *D* and $D_1$ effectively isolates the motor and resistor from each other, and it will be seen later that the diodes $D_1$ also provide a convenient source of power for the trigger pulse generator, which itself must be unaffected by the back-e.m.f.

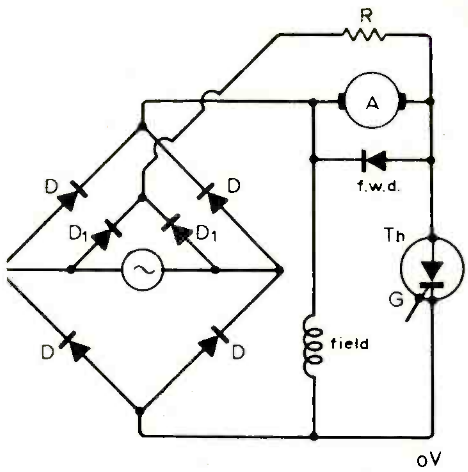



*Fig. 3. Basic circuit of power unit showing auxiliary diodes $D_1$ and resistive load R.*

## Main power unit

This is virtually a repeat of Fig. 3, with the addition of switches, meters and protective devices. The complete circuit is shown in Fig. 4. On the a.c. side, the line wire includes a switch, a current-limiting fuse, a circuit breaker and a small iron-cored reactor with a shunt capacitor to mains neutral. The circuit breaker is in effect a quick-break switch actuated by a bi-metal strip. The working current is set by the makers at a specified value and the unit will carry this current indefinitely. A 15% overload causes it to trip after about 20 minutes. It will clear a short circuit in 10 milliseconds but will sustain brief overloads, e.g. motor starting currents, up to three times normal, for about 4 seconds without tripping. The *RC* combination connected across the armature serves two purposes. With small motors, having armatures of high impedence, the values chosen (22 ohms and 6 microfarads) are such as to shunt away from the armature a substantial portion of the a.c. components of the pulsed current. The capacitor is almost ineffective for this purpose with large machines but it tends to reduce sparking, improve commutation, and cut down r.f. interference.

As regards physical construction, the whole assembly is mounted on an aluminium sole-plate 18in × 8in × $\frac{1}{4}$in, with $\frac{7}{8}$in ventilation holes drilled below the rectifier bridge. The front panel, 8in × 7in × $\frac{3}{16}$in, carries the armature current meter (0–20A d.c.), the mains switch, a motor switch and the speed control rheostat.

Two of the four main rectifier diodes and the free-wheel diode share a common heat sink, 6in × 3$\frac{1}{2}$in × $\frac{1}{4}$in aluminium. The remaining two power diodes are mounted on insulated plates, each 3$\frac{1}{2}$in × 2$\frac{3}{4}$in × $\frac{1}{4}$in. The two auxiliary diodes do not require special cooling arrangements. The controller cabinet has louvred sides to promote free air circulation and the power resistors are mounted near the top, clear of other components. Construction follows normal practice, avoiding multiple earths and ground loops, and ensuring that go and return wires lie side by side, well clear of the trigger module.

## Trigger circuit module

Various trigger circuits have been tried, including unijunctions, two-transistor equivalents of unijunctions and blocking oscillators. The best has been found to be a simplified version of the Mullard trigger module, type MY 5001. This is available ready made, although it is easily constructed using a few discrete components. The circuit actually used is given in Fig. 5. The unit, which includes only one active device, a silicon p-n-p transistor, type BFX29 or similar, is capable of triggering thyristors of all types, including the very largest. It provides a train of pulses of variable delay with respect to the zero-crossing instants of the a.c. supply. From the full-wave rectified supply, a 20-volt zener diode, fed through a 10Ω, 10W resistor, produces a flat-topped trapezoidal waveform, clipped at +20V, which dips sharply to zero at twice the supply frequency. The transistor is connected to a small oscillator transformer, collector winding 300 turns, base winding 100 turns, each 36swg wire, wound on an audio-grade ferrite cup core 1$\frac{3}{8}$in dia. $\frac{7}{8}$in long. The transistor base is biased to about +10V mean with respect to the negative line by two 4.7kΩ resistors connected across the zener diode. At the start of a trigger cycle, the voltage across *C* (0.25µF), is zero. The capacitor begins to charge up exponentially through the 100kΩ rheostat and 1.8kΩ resistor. As soon as the voltage across *C* exceeds its base bias, the transistor starts to conduct. Provided that the transformer windings are properly phased, positive feedback starts a self-oscillation. So much current is drawn that the capacitor is rapidly discharged through the transistor, producing a single pulse in the collector winding. This pulse, fed through 22Ω, triggers the thyristor. Multiple pulses may be produced during some particular half-cycles of the supply frequency but this is of no consequence since the thyristor has already been turned on by the first pulse of the sequence. Pulse-burst trigger signals may indeed be desirable with inductive loads. However, we wish to start timing the next master trigger pulse from the zero-crossing instant of the supply voltage. The circuit provides for this automatically. Whenever the trapezoidal wave across the zener dips to zero, the 50µF capacitor, charged to about 10V, retains this charge long enough to drive the transistor base voltage negative with respect to the emitter, causing heavy conduction and very rapid discharge of the timing capacitor.

The small silicon diode across the base winding suppresses pulses of undesired polarity while the damping resistor across the collector coil controls ringing or pulse

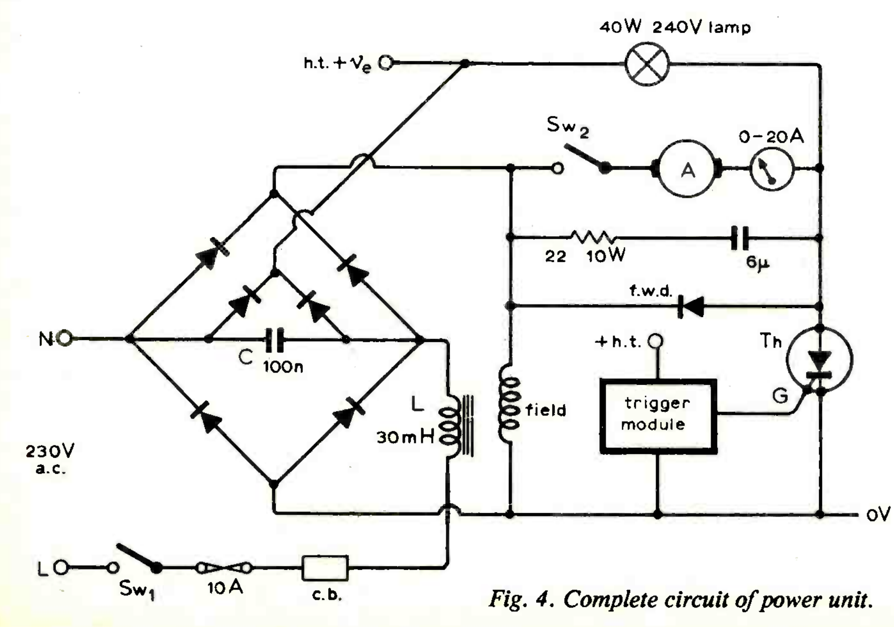



*Fig. 4. Complete circuit of power unit.*

overshoot. Peak base current is limited by the 120Ω resistor.

It is clear that another transistor could be substituted for the 100kΩ variable timing resistor. This opens up new control possibilities. The extra transistor could simply form a linear (constant-current) charging device or could be used in a feedback system to give current-limiting in the load circuit. With a little more design effort it would be possible to tailor the motor speed-torque characteristic to meet any reasonable requirement. Several such schemes have been tried successfully but most of them require transformers with associated rectifier bridges, *RC* delay circuits or preset controls. For the task in hand the added complexity is not really justified.

## Protective measures

Semiconductor devices, otherwise reliable, are easily destroyed by faults which cannot be cleared fast enough by ordinary fuses or circuit breakers. High-voltage line, transformer or load transients can also cause diode and thyristor breakdown. Special current-limiting fuses are available from several companies but in the case of equipments rated only at a few kilowatts it is worth spending a little more money on the semiconductor devices, choosing those with higher than normal peak voltage and current ratings. Normal fuses or circuit breakers then give adequate protection if the equipment is used sensibly.

One point about thyristors is worth stressing. Even in the absence of gate drive, the sudden application of a high voltage is liable to cause forward breakover into conduction. This is non-destructive if the applied voltage does not exceed the peak forward voltage rating of the device, and if the current is limited by the load to a safe value. To avoid this trouble the rate of rise of voltage ahead of the thyristor can be limited by a suitable *RC* network or perhaps by a rudimentary *LC* filter. Unfortunately such measures tend to spoil the voltage regulation or to lower the overall efficiency of the system.

In the present case a small filter reactor of about 30mH followed by a 0.1µF capacitor gives an acceptable compromise. The inductor, consisting of 100 turns of 16swg wire wound on a laminated Stalloy core with a centre-limb cross-section $\frac{7}{8}$in × $\frac{7}{8}$in (no air gap), saturates with less than full load current and in fact drops about 12 volts at all loads above 1A r.m.s.

## Construction and testing

The main rectifier bridge, auxiliary diode, free-wheel diode and thyristor assembly was built first and wired up as a self-contained unit. Heavy-gauge well-insulated wire was used, with solder-lug terminations. Substantial bolts with nuts and lock washers were used to ensure permanent, low-resistance connections.

The trigger unit was then built as a separate module and tested off-line with a temporary power supply. The output pulses, though of large amplitude, are so narrow that they are difficult to see on an oscilloscope. A check was made that the unit would actually trigger a thyristor with a lamp load. Failure to work will almost certainly be due to reversed polarity of one of the pulse-transformer windings.

The controller was then assembled in its final form, fitted with a 3A fuse and checked first with a 100W lamp load and then with a fractional horsepower motor. The fuse was then replaced by one of 10A rating and the controller tested with a 1kW heater load.

Some caution is necessary when running large motors. The mains switch on the controller should turn on the trigger pulse generator and motor field supply. When these have settled down, a second switch with the motor armature can then be closed, the trigger module being set for the maximum possible firing delay angle. The motor can then be started slowly by advancing the speed control knob.

When shutting down the motor, the speed control is backed off to zero, the motor switch opened and the mains switch turned off. Attempts to start a large motor at full speed will instantly blow fuses, open circuit breakers or destroy the semiconductor devices. There is nothing remarkable in this since it would be almost equally disastrous to switch a large d.c. motor directly on line without a starter resistance in series with the armature. It is an interesting thought that a conventional starter, with field regulator, no-volt release, overload trip and stepped starter resistance, but with no provision for speed control, costs more than the parts for an electronic controller which performs both starting and speed control functions. Moreover, the electronic unit calls for little or no maintenance.

Since completion, the controller has been tested for long periods with three different motors. The smallest was a DELCO machine, conservatively rated at 1/6hp but easily capable of delivering $\frac{1}{4}$hp. Fitted with sleeve bearings, the machine ran smoothly and quietly at all speeds up to 1,500rpm. The armature was of relatively high resistance and reactance and it was found that the shunt capacitor took an appreciable part of the alternating component of the pulsed armature current. This capacitor also does something to reduce r.f. interference due to commutation.

The next test was on a Metropolitan-Vickers motor rated at 230V, 1hp, 2,850rpm. This ran well at all speeds from crawling up to 2,500rpm, with a surprisingly high torque at quite low speeds, although at this end of the range the motor slowed down with an increased load. The last machine to be tried was an aircraft engine-driven generator rated at 100V, 600W. Its field was intended to be energised from a 24V supply and not directly from the brushes. Strictly speaking, to run this as a motor calls for a change in the brush position but this adjustment proved to be impossible because the brush rocker was already at the wrong end of its travel.

The armature impedance was very low and the shunt capacitor thus virtually inoperative. The machine was designed for forced-air cooling and so could only be tested for short periods at anything like full load. Nevertheless it was operated between 0V and 200V (twice the rated maximum), at speeds between 0 and 8,500rpm. At top speed, friction and windage losses were such that the motor, running light, drew about 200W from the supply.

In every case, commutation was sparkless at all speeds and loads although sudden load changes provoked mild, harmless sparking until the machines settled down to the new conditions.

With the controller fitted in a grounded metal case and with screened cables to the motor there is surprisingly little radio interference on medium or long waves and nothing is audible on the v.h.f. and television bands. With the controller wiring exposed, no earth on the motor frame and with unscreened cables, interference is of course easily detectable. Listening to this on a transistor receiver allows one to check the regularity of firing of the trigger pulse generator. An erratic note calls for a methodical check of the entire system.

## Conclusion

A good deal of work has gone into the development of this controller. The use of auxiliary diodes to feed current to the thyristor anode through a resistance load (in practice a lamp), eliminated an intract-

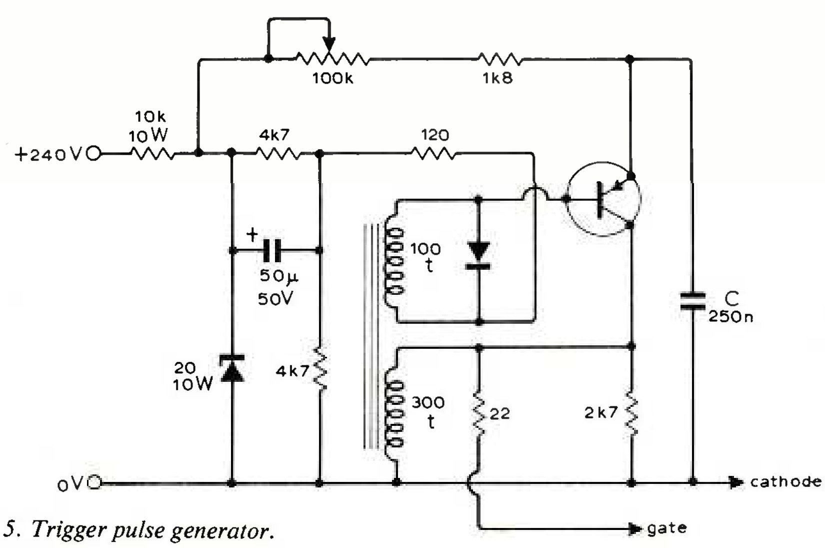



*Fig. 5. Trigger pulse generator.*

able hunting phenomenon which took the form of wild fluctuations of armature current and motor speed. The supplementary diodes are in any case required to supply the pulse generator with a full-wave rectified sinusoidal voltage, uncontaminated by the variable d.c. back-e.m.f. of the motor. This latter, if present, results once more in erratic firing, unsynchronized with the supply frequency.

Merely by up-rating the semiconductor devices the scheme appears to be applicable to large motors, certainly up to tens of horsepower, operating from single-phase mains, and without limit from polyphase lines, though of course the trigger module becomes more complicated.

Without modification, the controller also works satisfactorily with resistive loads (lamps or heaters), up to 2kW, or, by changing fuses and circuit breakers, up to 7kW at low ambient temperatures. Larger heat sinks are required at loads much above 3kW. If resistive loads only are to be used, the free-wheel diode, shunt capacitor and resistance and the built-in lamp load can be removed as well as the two auxiliary diodes. We are of course then left with a simple, well-known circuit which has no novel features.

There are known methods of compensating for the voltage drop across the motor due to its armature resistance. This is responsible for the drop in speed which is observed when the load is increased. One simple scheme uses feedback, from a low-value resistor in series with the armature, to advance the firing angle of the thyristor in proportion to the load. The idea must be used with caution since it can easily lead to gross overloading of the controller and the motor. Complete safety requires the addition of an overriding control which will limit the circuit current to a safe value. It must come into action only when this limit is reached, otherwise it tends to counter the effect of the first control.

A word of caution must be given about the techniques of current and voltage measurements on equipments of this type. Moving coil d.c. meters and rectifier-type a.c. instruments read the arithmetic mean values of current and voltage. In the a.c. case the meter readings are calibrated in terms of the r.m.s. equivalent for a sinusoidal source. Their readings with pulsed sources must be treated with caution. Thermocouple, dynamometer or moving-iron instruments measure true r.m.s. values but in the last two cases, the calibration normally holds good only at low frequencies. High harmonics can cause errors of reading. When measurements of input power, output power and efficiency are being made, there is really no substitute for a wattmeter.

## Parts list

**Resistors** ($\frac{1}{2}$W except where specified)
1 10kΩ, 10W
1 22Ω, 10W
1 22Ω
1 120Ω
1 1.8kΩ
1 2.7kΩ
2 4.7kΩ
1 100kΩ wirewound potentiometer

**Capacitors**
1 6μF 1000V working
1 0.1μF 1000V
1 0.25μF 350V
1 50μF50V (tantalum)

**Semiconductors**
5 Silicon power diodes 35A 600PIV
2 Silicon power diodes 5A 600V
1 Thyristor 30A 600V
1 Small signal silicon diode
1 Silicon p-n-p transistor (Mullard BFX29 or similar)
1 Zener diode 20V 10W

**Miscellaneous**
2 10A single pole switches
1 10A fuse and fuseholder
1 10A circuit breaker (BCE. Type K, Catalogue Number A/490)
1 Ammeter $2\frac{1}{2}$in, 0–20A d.c.
1 40W 240V lamp with batten holder
1 Ferrite cup core (audio grade) $1\frac{3}{8}$in × $\frac{7}{8}$in
1 Lamination stack (Stalloy or similar), $2\frac{3}{4}$in × 2in × $\frac{7}{8}$in

**Acknowledgment**
Although many British and foreign companies offer a wide range of thyristor-controlled motor drives (the record for size is probably held by the Americans with a 12,000hp reversible rolling mill motor), it is still difficult to find much practical information in the literature about small installations. In developing the present unit valuable background material has been gathered from the (American) General Electric Company publication "Silicon Controlled Rectifier Manual".

The Mullard Technical Handbook series also contains a wealth of useful information, particularly Book I, Part 5, "Thyristors and Thyristor-Stacks".

Finally, reference must be made to articles by J. Merrett in *Mullard Technical Communications*, Vol8, No80, March 1966 on "Thyristor Speed Control of DC Shunt Motors from a Single-Phase Supply", and "Instructions for Selecting a DC Motor for Thyristor Speed Control". These two papers serve to highlight the subtlety and complexity of the problems in developing this control technique.

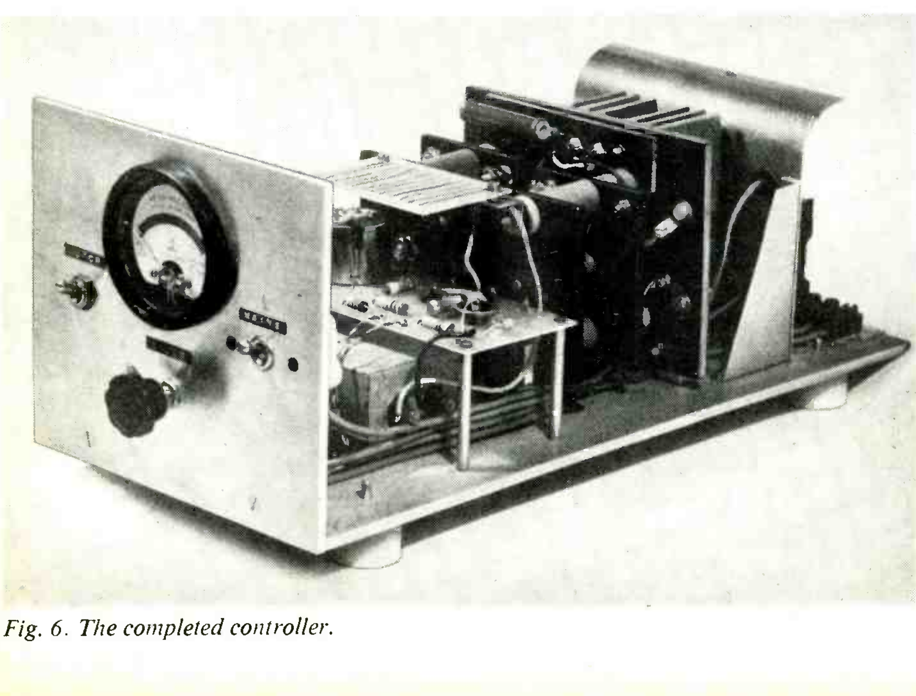


*Fig. 6. The completed controller.*

# News of the Month

## Data control on the APT

A computer controlled data acquisition and processing system is to be used by British Rail to evaluate the performance of various experimental vehicles in a programme of fundamental studies of wheel/rail interaction. The equipment is based on the System 90 midi computer manufactured by Computer Instrumentation Ltd and is due for installation in a laboratory instrumentation coach at the BR Technical Centre in Derby. This latest system will complement data acquisition and analysis now continuing on board the experimental Advanced Passenger Train. The heart of the system is an 8k processor equipped with two direct memory access (DMA) block transfer channels for high speed data transfer to and from the processor. Principle peripherals include a 32-channel differential input multiplexer/analogue-digital converter and a Pertec 75 i.p.s. 9 track, 800BP1, NRZ1 magnetic tape unit. Other peripherals include a 390 Teletype terminal to provide operator control and data printout facilities, and a high speed 500 character per second paper tape reader and a paper tape punch, both of which are mainly intended for programme development and loading operations.

The system incorporates four 100kHz digital-analogue 12-bit converters, to be used in conjuction with an *x-y* plotter, and a 16-bit parallel output register for the control of other external equipment. Provision is made for up to eight external priority interrupt channels, which can be linked to other electronic equipment or to manual control switches to provide direct programme control. A variable real-time clock or interval timer with a resolution down to 1μs provides the real time synchronizing and time code signals.

In operation, the CIL computer system will be linked, via signal conditioning equipment, to numerous force, strain, and displacement measuring transducers mounted on the wheels, axles and chassis. During a test run under controlled speed and track conditions, the analogue signals generated by the transducers will be digitized via the 32-channel 100kHz multiplexer/a-d converter. The resulting 12-bit words will be fed to the DMA channel for high speed block transfer to the "System 90" processor where the data will be formatted, together with the timing and channel identifying information, into a form suitable for recording on the nine-track 60kHz digital magnetic tape system.

During the data acquisition period, there is a capacity for limited real time data analysis such as preset signal level crossing counts to be carried out. Once recorded, however, the data can be replayed using an appropriate analysis software package to perform further processing such as power density spectral analysis. In this way, tabular print-outs can be obtained of channel by channel power density distributions, while the d-a converters enable this information to be plotted out on an analogue *x-y* plotter. This is typically carried out at the end of each trial on the test train. Further detailed analysis will subsequently be carried out on this data by a large IBM 370 main frame computer.

## Electrical fatalities in the home

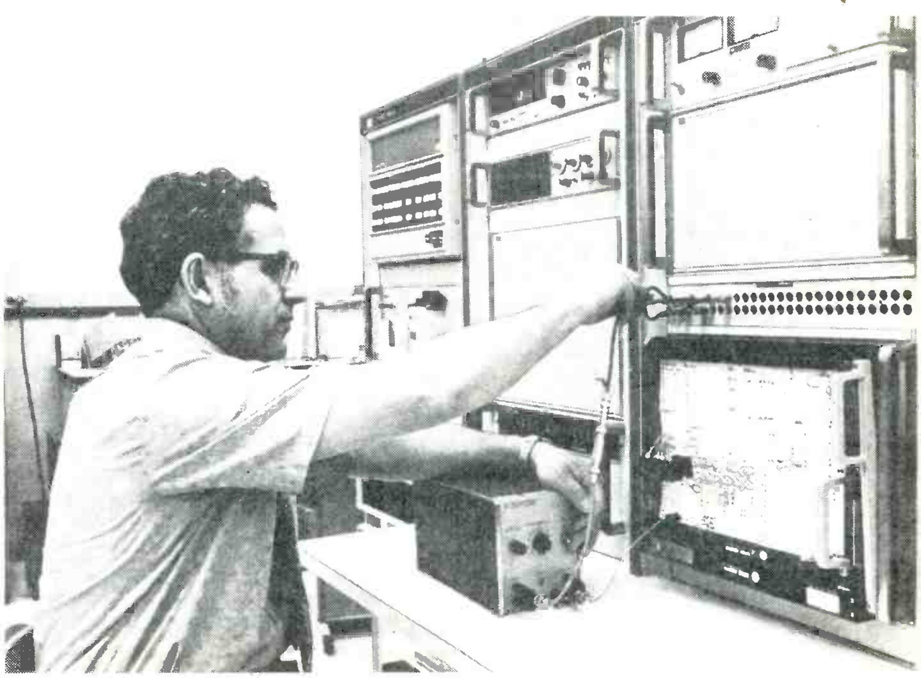
The major causes of death in the home from electric shock are a lack of appreciation of the dangers and the inadequate supervision of children. This is the implication of an analysis of electric shock fatalities between 1967 and 1971 carried out by Electrical Research Association Ltd. The analysis revealed that about 44% of fatalities in England and Wales were caused by "contact with a normally functioning live part". A typical item in this category would be contact with an exposed live conductor of a worn flexible cable.

The report is particularly topical in view of the fact that a new EEC directive is shortly to be implemented in the UK. This directive requires that only safe electrical equipment shall be placed upon the market. No longer is the buyer of electrical equipment so reliant on the old adage that "the buyer beware"—it is even possible that the British buyer may soon be in the position of US consumers who can not only prosecute manufacturers for faulty design or manufacture but can under some circumstances also prosecute them for the consequences of misuse of their products. British manufacturers have made substantial efforts to improve the safety standards of their products, but it now appears that the only major step forward in home safety in this area will be by an effective publicity campaign to reduce the incidence of carelessness, neglect and lack of supervision in the home. "A perspective on fatalities from electric shock in the home in England and Wales for the five years 1967–1971" is available from the Electrical Research Association Limited, Cleeve Road, Leatherhead, Surrey KT22 7SA. Price £12.50 (£7.50 to members).

## Sputtering techniques improve

A process of sputtering a chromium-nickel film on to the inside surfaces of conical X-ray concentrators has been developed for MIT's Center for Space Research. These glass devices are used in satellite-

*This automatic test system designed for testing at component, subsystem and system levels can provide up to 400 complex tests in minutes. The system, designed by Hewlett-Packard, includes measurement of voltage, resistance, frequency and distortion covering signals from d.c. to 500MHz.*



borne astronomical instruments that measure X-rays from celestial sources. To metallize them effectively, Varian Associates in Palo Alto, California, devised a method for maintaining a uniform plasma discharge along a rod-shaped cathode, which deposits chromium-nickel on to the inside surface of the glass cone.

The growing use of silicon-doped aluminium in semiconductor manufacture is another field which has led to the development of a precise, dependable commercial process for depositing silicon-saturated aluminium on large silicon wafers. The deposition of aluminium conductors is one of the most common operations involved in semiconductor manufacture but which also presents an important problem. When the junction is heat-treated after bonding, silicon from the wafer may migrate into the aluminium conductor. In a thin junction, this process can remove so much silicon from the wafer that the junction may be shorted out. A thick junction is less susceptible to this effect, but reduces the device's speed. To build thin, fast junctions that will not be ruined by heat-treatment, semiconductor manufacturers are turning to the use of aluminium that is virtually saturated with silicon. Since this alloy can accept little or no additional silicon, there is no significant loss from the wafer during heat-treatment. Varian's contribution to this approach has been to develop a process involving the simultaneous evaporation of aluminium and silicon sources. Each source is monitored and controlled independently of the other, but their evaporation rates are regulated so as to control with precision the ratio of the two metals in the deposited film.

## Heart-rate computer

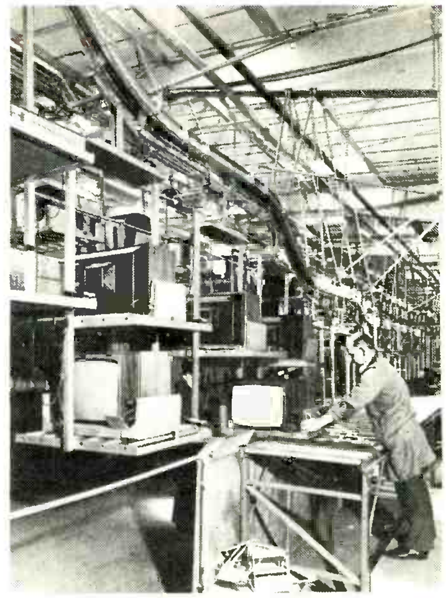
A device first used by NASA physicians to monitor instantaneously the pulse rates of astronauts performing underwater training activities, is now being used in non-space medical applications.

The digital cardiotachometer was originally developed to observe on a beat-to-beat basis the heart rates of astronauts undergoing training in a neutral buoyancy simulator, an underwater training laboratory used to simulate the weightless conditions encountered in space. The device provides a numerical display of a subject's pulse rate 0.3 seconds after detecting the second heart beat. The time between two consecutive heart beats is used to calculate a patient's pulse rate in beats per minute. The unit has been designed to operate in conjunction with a standard electrocardiograph unit.

## Dating ancient ceramics

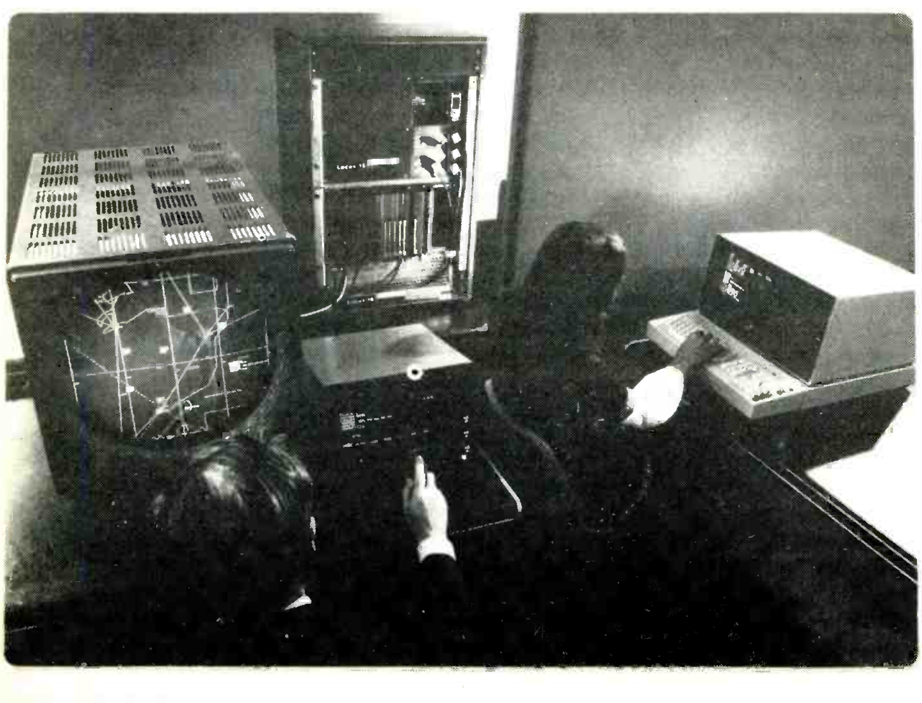
A method of detecting forged "ancient" pottery involves the use of a high sensitivity, low dark-current photomultiplier tube to convert very low light levels into useable electric current. The technique dependent on this property is thermoluminescent dosimetry and was pioneered by the Research Laboratory for Archaeology and the History of Art at Oxford University.

The authenticity problems, relating particularly to early Chinese ceramics, are largely due to the re-use of original moulds found intact when ancient clay kiln sites were opened up. As pottery or ceramics age, grains of quartz in the clay absorb energy from radioactivity. When a specimen is heated, the stored energy is released in the form of light. This luminescence is very weak and is proportional to the amount of absorbed radiation and therefore to the age of the specimen, since initial firing of the ceramic sets the thermoluminescent "clock" to zero. A photomultiplier tube manufactured by EMI and which makes virtually no contribution to the background count is being used at Oxford to provide very accurate dating. It will be difficult in future to produce forgeries of archaeological specimens such as the T'ang horses and Chinese tomb furniture currently undergoing tests at Oxford.



*End of the production line at the Telefusion Group's fully mechanized factory at Kearsley, Lancashire. Hytrac conveyers link the stages of assembly—printed circuit board construction, test and inspection, cable loom, plug and socket assembly, chassis sub-assembly, chassis assembly and a thorough eight-hour soak test of the completed sets.*

*Massive information flows into and out of a conventional central computer can be eliminated by the use of a distributed data processing system, Locus 16, primarily designed for air traffic control and air defence. The Locus 16 developed by Marconi Radar Systems can be seen (centre background) driving a variety of displays.*



## Electret cartridge introduced

Yet another record cartridge has been launched here in the UK. This one at least has some claim to being unique since the transducing mechanism relies upon the electret principle, but applied in a very unusual way.

The stylus is mounted on two rubber pivot studs which permit the normal orthogonal degrees of movement required of a stereo pick-up. Directly above these rubber studs are two plastic lugs which bear against the ends of two flexible beams which are attached firmly at the upper end. Movement of the stylus causes these beams to flex and the stress in the electret material of the beams produces a change in the standing polarizing voltage across the electret. A passive network is used to convert the output to the characteristic expected of a conventional magnetic cartridge, thus making it suitable for direct replacement. Manufactured by Micro-Acoustics Corporation and imported by Gale Electronics, the new cartridge in its standard form (the QDC-1e) has an 0.002×0.007 elliptical stylus, has a frequency range from 5Hz-20kHz and operates with a tracking force of 0.75gm to 1.5gm. Separation is nominally 30dB at 1kHz and 20dB at 10kHz. Output is 3.5mV at 5cm/sec recorded velocity, into a load impedance of 47k ohms.

Two other versions will become available, a spherical stylus version and a stylus suitable for CD-4 reproduction.

## Diagnosis by ultrasonic waves

A computerized system for ultrasonic wave diagnostic images to be memorized on a cassette tape and transmitted to a central hospital via telephone lines for remote diagnosis has been developed jointly by the Nissei Hospital and Toshiba.

Ultrasonic pulses are transmitted into the affected parts of the patient's body and internal tissues are reproduced on a picture tube screen from the reflected echoes. The images are memorized on a cassette tape and processed at a later date when necessary. The telephone line transmitting system makes it possible to form an information-processing network for ultrasonic wave images to be sent to a central computer from a hospital at a remote location, processed there and returned. Through such a network, a remote hospital can receive diagnosis from the relevant specialist physicians in a short space of time.

University College Hospital, London is developing a similar system which does not utilize the intermediate tape medium. Information is transmitted direct to a central computer for storage and image processing.

## New record factory in Scandinavia

A new record and tape duplicating factory is to be built by EMI at Amal in Sweden, to serve the fast-growing Scandinavian market. The cost will be approximately £2m (21 million kroner) and construction work will start later this year so that the plant can be in production by the end of 1975.

The new factory will supply Norway, Sweden, Denmark and Finland with records and pre-recorded tapes. It will have an initial production capacity of 5 million 12in records, 1.2 million 7in records and 850,000 recorded tape units per year.

## Moscow TV for N.E. Siberia

Residents of the gold mining town of Aldan in Yakutia, north Siberia, which lies 8,500km from Moscow can now view black-and-white and colour TV programmes direct from Moscow. This has become possible thanks to an Orbita re-transmitting station which receives programmes via communication satellites. Over 50 Orbita re-transmitters operate in different parts of the country.

In the near future, "TV bridges" will connect nine socialist countries. Ground receiving-transmitting stations have already been built in Mongolia, Cuba and Czechoslovakia. This system will also be used for multi-channel telephone and telegraph communications.

## Electronica 74

On May 31 the total hall space for the sixth International Trade Fair for Components and Production Facilities (Munich, November 21 to 27) was completely booked up despite the strict rules stipulated in the terms of admission. The largest number of foreign exhibitors will come from France, Italy, Japan, Spain and Switzerland, many of these being new to the show and being part of more than 860 main exhibitors.

The sixth International Congress of Microelectronics will take place at the Munich Exhibition Grounds from November 25 to 27. Its programme will centre on issues of topical interest in the fields of components, assemblies, the related technologies and the application of microelectronics. Organizers of the Congress include the Institute of Electrical and Electronic Engineers.

## Carphone service extended

From the first week in August motorists equipped with car radiophones are able to make telephone calls from their cars within a 3,000 square-mile area which includes Wolverhampton, Birmingham, Coventry, Rugby, Northampton and Banbury. This is part of a £600,000 Post Office project to extend this type of service to five new centres which has previously been available only in London and South Lancashire. Controlled from Birmingham, the new service can handle up to 300 users. Transmitters at Turner's Hill near Birmingham and Charwellton, near Rugby, beam telephone calls to and from drivers using the service. The Post Office plans to open four more radiophone services during the next two years.

*By early 1976 the Post Office's car telephone service will be available from seven major centres.*

## TV sales down

Deliveries to UK distributors of UK-made colour television receivers reached 136,000 in June—a 21% decrease on June 1973 (172,000), according to the latest statistics compiled by the British Radio Equipment Manufacturers' Association. This brought the total for the first six months to 869,000, a fall of 14% compared with the same period of 1973 (1,015,000). UK made monochrome television deliveries for June of 35,000 brought the total for the year to 283,000, a fall of 47% compared with January to May 1973 (529,000).

These figures show details of UK-made deliveries only, and exclude imported deliveries.

## Seminex week in Stockholm

Five days of semiconductor seminars covering new applications and the state of the art are to be presented during Seminex week in Stockholm later this year. The event is to be held at the Sheraton Hotel between September 30 and October 4, 1974. Each day a different semiconductor technology will be covered by a programme of co-ordinated seminars presented by leading international manufacturers. Engineers, designers, and buyers wishing to attend the Seminex seminars can obtain full information from Seminex '74 Sweden, Sveavägen 53, Box 3177, S103 62 Stockholm, Sweden, telephone 08-348522, telex 17473.

## Briefly

**TV moves to the bedroom.** Figures prepared by Marketing Advisory Services indicate that about one in eight of British households own more than one TV set. Usually the second set is in the bedroom, adding more fuel to the saying, "When I was young we made our own entertainment".

**3D c.r.t. displays.** Included in a £55,824 research grant awarded to the University of Essex is £11,170 from the Science Research Council for research into three dimensional cathode ray tube displays.

**Water Music.** The Rank Organization has patented an idea for lightening the load of heavy duty speaker systems. When set up, hollow walls are filled with water making the cabinet extremely heavy. For transport, the walls are drained and removed from the frame.

# Pattern recognition circuits

## Simple programmable circuits for optical character recognition and other applications

by W. K. Taylor and J. J. Witkowski

*University College London*

**This article describes a procedure for designing and programming simple operational amplifier circuits for general pattern recognition and optical character recognition. The simplicity is due to the use of constant resistance balanced circuits that are particularly suited for realization as mask or field programmable large-scale integrated circuits.**

Methods of designing pattern recognition circuits based on resistors and operational amplifiers have been described[1,2] but they have the disadvantage that many of the resistor values depend in a complex way on the patterns to be recognized. In the new method described here the resistors associated with each amplifier have the same constant value irrespective of the patterns selected for recognition, which may range from a single light spot on a dark background to a single dark spot on a light background. Correct operation is obtained over a wide range of contrast and illumination since only the shape of changes in contrast is significant.

The method will be illustrated by application to the recognition of the digits

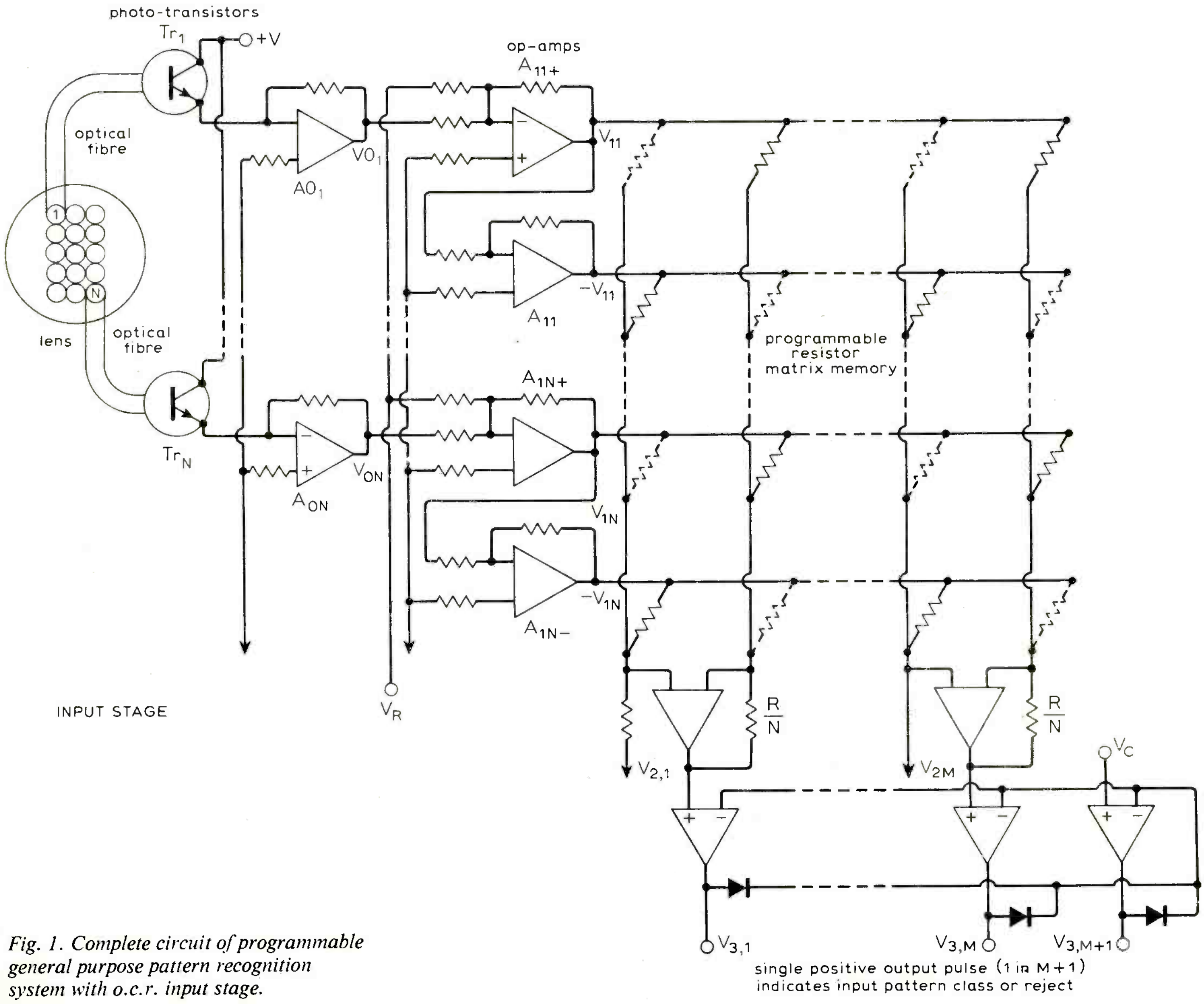



*Fig. 1. Complete circuit of programmable general purpose pattern recognition system with o.c.r. input stage.*

0 . . . 9, shown in Fig. 1, that are projected by a lens onto a 3×5 matrix of optical fibres. The fibres terminate on $N$ phototransistors $Tr_1$ . . . $Tr_N$. In this relatively low resolution system with $N=15$ it is necessary to use specially designed characters but a considerably higher resolution system that operates correctly with optical character recognition B fount has also been constructed. The phototransistors supply current to the operational amplifiers $A_{01}$ . . . $A_{0N}$ to produce the negative output voltages $V_{01}$ . . . $V_{0N}$. A positive reference voltage $V_R$ is added to each and the sums are amplified and inverted to produce voltages $V_{11}$ . . . $V_{1N}$ so that $V_{1r} = V_{0r} - V_R$ is positive for inputs higher than the reference level and negative for inputs darker than the reference level. The voltages $V_{11}$ . . . $V_{1N}$ are inverted to produce $-V_{11}$ . . . $-V_{1N}$ as shown in Fig. 1. The $N$ pairs of voltages $\pm V_{11}$ . . . $\pm V_{1N}$ form the inputs to $M$ summing amplifiers through equal summing resistors $R$.

The circuit is programmed by presenting each pattern to be recognized, in this case each of the ten digits, to the input field and noting the sign of each $V_{1r}$. If, for example, output $V_{21}$ is required to indicate the presence of digit 1 in the position shown in Fig. 1 then amplifier $A_{21}$ has input resistors to maximize the output $V_{21}$. For digit 1 the phototransistor $Tr_1$ receives light from a relatively dark region making $V_{11}$ negative and $-V_{11}$ positive. Thus a positive contribution to $V_{21}$ is obtained by removing the resistors connecting $V_{11}$ to the positive input of $A_{21}$ and $-V_{11}$ to the negative input of $A_{11}$.

In producing the circuit it is preferable to include all resistors initially so that the above programming step leaves the resistors connecting $V_{11}$ with the negative input of $A_{21}$ and $-V_{11}$ with the positive input of $A_{21}$. Since, however, $V_{11}$ is negative the net effect is a positive contribution to $V_{21}$. If the phototransistor $Tr_1$ had received a signal from a relatively light area $V_{11}$ would have been positive and $-V_{11}$ negative. In this case the two resistors represented by the broken line would have been left intact and the two resistors represented by the full line removed. When this process is repeated for all $N$ differential pairs of inputs and for all the $M$ input patterns the circuit is fully programmed.

The voltages $V_{21}$ . . . $V_{2M}$, being analogue, must be converted to a digital "one out of $M$" code which can then be given a binary code to reduce the number of outputs. This is achieved by the output amplifiers $A_{31}$ . . . $A_{3M}$ operating with common negative feedback produced by the amplifier with the largest positive input. Thus only the amplifier supplied by max ($V_{21}$ . . . $V_{2M}$) has unity gain, the remainder being driven into negative saturation by the excess common negative input.

In practical applications such as the reading of printed information into computers or the sorting of letters it is necessary to increase $M$ considerably above the number of characters to be read in order to include variations in style, fount size and vertical position. With large-scale integration, however, this would not present any new problems since the same circuit is used with OR gates combining all the versions of each character in a single output, or a single output code word, so that six final outputs would cover a complete alphanumeric and symbol set.

The circuit as described only functions correctly when the character being read is in the position (or positions) employed during programming. It is convenient, however, to move documents at a constant speed and this presents characters and parts of characters in all possible horizontal positions and combinations of parts of adjacent pairs of characters. A reject circuit is arranged to overcome this difficulty by presenting a large positive voltage $V_c$ to an additional output amplifier $A_{3M+1}$ when the characters are not near the centre of the input matrix. The output $V_{3M+1}$ thus indicates the reject class and is present for blank paper in addition to off-centre characters. The recognition pulses at the final output thus occur when the characters are approximately central, although the duration of the pulse varies with the character, as shown in Fig. 2. The analogue voltages $V_{21}$ . . . $V_{2M}$ ($M=10$ in this example) are shown (inverted) above the output pulse waveforms and it can be seen that the maximum voltage always occurs at the output of the $A_2$ amplifier programmed for the particular character image appearing centrally on the retina at the instant of recognition, as determined by the removal of the reject voltage.

The circuit is readily adapted to mask programming techniques during manufacture but experiments have also shown that reliable fusing of the unwanted resistor circuits can be achieved by coincident voltage electrical programming. This field programming method is preferable since the programming is carried out by the user under actual operating conditions. If internal decoding matrices for the desired recognition class inputs are included in the circuit the number of programming inputs is equal to the number of binary coded outputs so that 20 leads would be sufficient for the complete programmable optical pattern recognition unit.

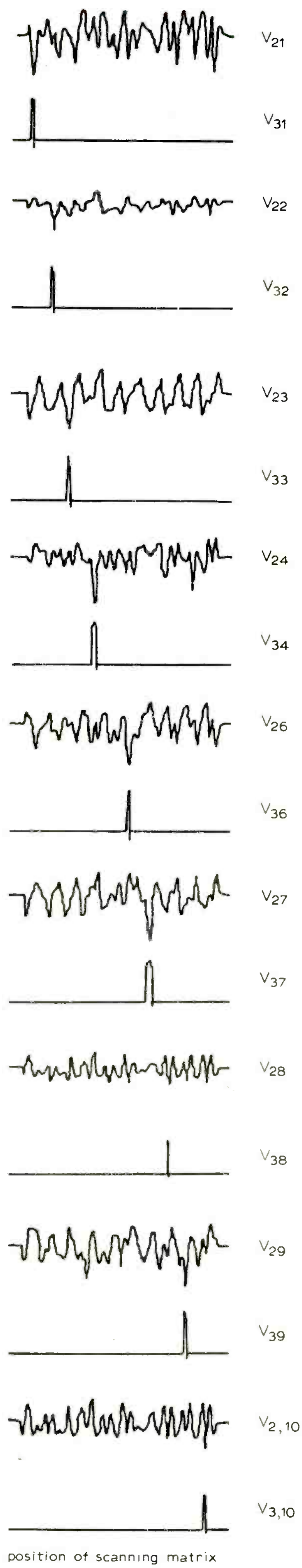



*Fig. 2. Analogue voltages $V_{21} - V_{2,10}$ (inverted) produced by constant velocity scanning of the digits 0–9 from left to right and the corresponding digital recognition pulses $V_{3,1} - V_{3,10}$ (Waveforms $V_{25}$ and $V_{35}$ are omitted to save space.)*

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1. Taylor, W. K. "Pattern Recognition by means of Automatic Analogue Apparatus", *Proc. I.E.E.* 106, B No. 26 pp. 198–209, 1959.
2. Taylor, W. K. "Learning characteristics of a trainable pattern recognition machine", IEE/NPL Conference on Pattern Recognition, 1968.

# Calculator offer modifications

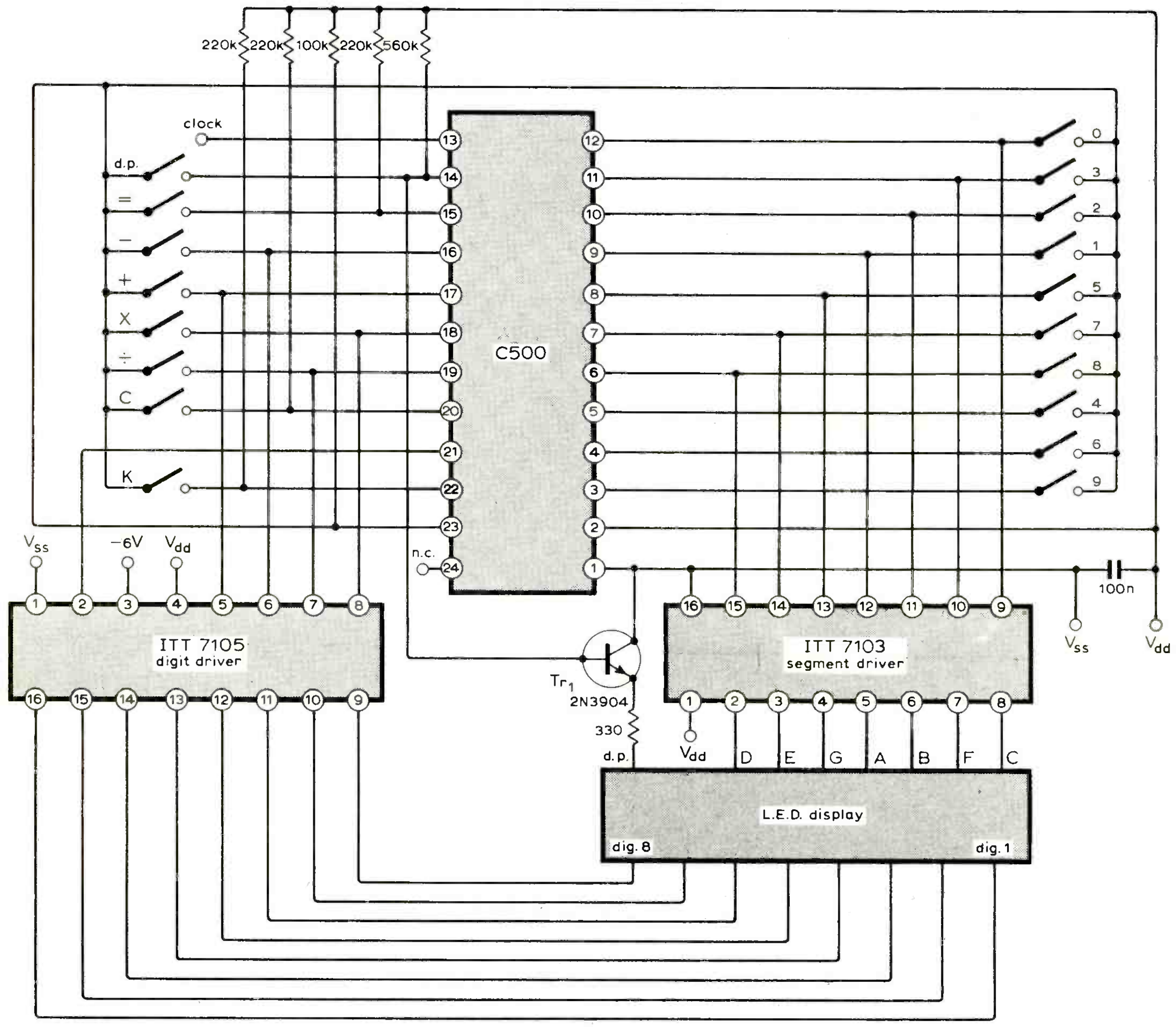
## Simpler display drive; power supply; clock generator

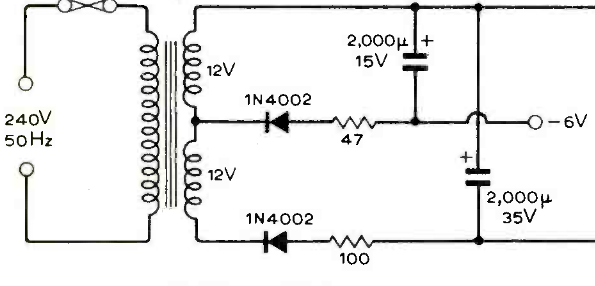
Since the announcement of our calculator components offer in the March issue (p.49), the manufacturers of the C500 calculator i.c., General Instrument Microelectronics, have devised a simpler method of driving the l.e.d. display. Instead of the discrete transistors shown in the March issue they suggest the use of two integrated circuit drivers. These, the ITT 7105 digit driver and ITT 7103 segment driver, are shown, with appropriate circuitry for connection to the calculator chip, in the accompanying diagram.

General Instrument Microelectronics have also supplied a circuit for a suitable power supply and a circuit for a clock generator of 80 to 100kHz. These are shown at the bottom of the diagram.

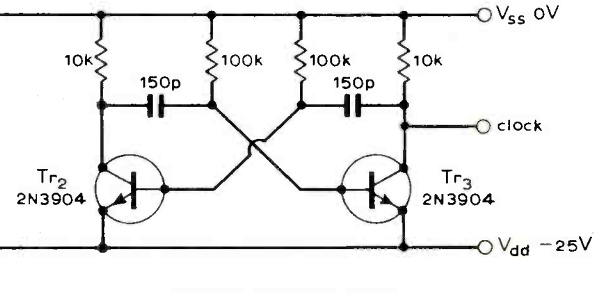
**Correction:** In the March article, p.50, left-hand column, penultimate paragraph, the reference to the frequency of the clock generator should read "80 to 100kHz". Apologies for this error.

*Calculator system modified to use i.c. drivers for the l.e.d. display; showing also suggested power supply and clock generator circuits. (Power supply transformer is a Radiospares Miniature type with 0-12V and 0-12V secondaries.)*




POWER SUPPLY




CLOCK GENERATOR

# Not such a dummy head

## A potted history of artificial head sound recording

by D. J. Meares, B.Sc.

*BBC Research Department*

Several recent articles[1] have extolled the virtues and potentials of "artificial head" recording as a means of producing "surround-sound" effects and, as most enthusiasts will be aware, Sennheiser have recently released two documentary discs which demonstrate some of these effects. This article is intended to fill in some of the history of artificial head recording and to look at recent developments in this field.

The concept of using an artificial head for recording stereophonic types of signal is not new; as far back as 1940 De Boer[2] was experimenting in this field. In the early days of stereophony, the BBC looked into the use of a relatively crude artificial head, fitted with microphones, as a means for improving the spatial presentation of stereo reproduced by loudspeakers. Although some interesting effects were produced, the stereo results were not significantly different from those produced by the simple spaced-microphone technique, and so this work was discontinued. (High quality stereo headphones were not available at that time.)

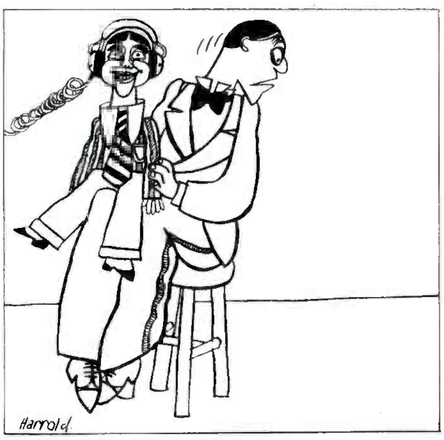
More recently two teams of workers in Germany have been concentrating on artificial head recording[3,4] in connection with work on speech intelligibility, auditory acuity and the evaluation of the acoustic qualities of concert halls, etc., using only aural information (i.e. the listener has no visual information to bias his judgement). One of these teams, the one based at the Heinrich Hertz Institute in Berlin, gave a demonstration of some of their recordings at the time of the 1971 AES Convention. They demonstrated a concert-hall recording made using an artificial head fitted with microphones, the replayed signals being fed directly to a pair of headphones. The second images created by this technique exhibited good left-to-right separation with a marked lack of "in-the-head" sensations. Front-to-back separation, however, was rather poor, and there were frequent occasions where images, which should have been created at the front, appeared to be located behind the listener; further, the images generated by this arrangement were rather broad and diffuse.

In 1973, at the Berlin Radio Show, Sennheiser released a demonstration disc, which was made using the latest "Heinrich Hertz" artificial head (the one shown on the record sleeve). This comprises a skull construction attached to which are the flesh-like artificial pinnae—facial features and hair are all realistically modelled. The head attempts to match the acoustic properties of a real human head, both externally and internally, as far as the ear drums. At this point the model's ear canals are terminated by an acoustic impedance such that, in the presence of a microphone placed at that point, the correct sound pressure is produced.

The intended method of reproduction, for the demonstration disc, is over Sennheiser "open-air" headphones and this implies that the acoustic signals will have passed through ear canals twice, once in the artificial head and once, during replay, in the listener's head. The signals from the artificial head were therefore processed in an attempt to reduce the errors introduced by this double passage through ear canals.

The recording is, comparatively, a significant improvement on the earlier-mentioned demonstration, and is extremely intriguing in the subjective impressions that it generates. The section of the recording where the narrator moves behind the listener and whispers in his ear is particularly impressive, and offers considerable potential for audience involvement in, say, radio drama.

When examined analytically, however, there are still some errors in the reproduced sound images. In the recording the narrator is intended to walk in a circle around the listener; in fact his image moves in an ellipse with the major axis going from left to right and with considerable elevation of the image (approximately 70° on average) in front of the listener. There are also occasions when the image of his voice does not occupy a position consistent with the activity verbally described (e.g. the noise made when switching on a light seems rather far from the narrator).



*The section of the recording where the narrator moves behind the listener and whispers in his ear is particularly impressive.*

These are the sound impressions given to a listener using open-air (super-aural) headphones. Limited tests have been carried out using "closed-air" (circum-aural) headphones and much poorer results were obtained, to the extent that front-to-back ambiguity was once more noticeable.

A most significant point is the fact that different people perceive different things from the recording. This is particularly true of intended front-centre sounds. Here the subjective impressions appear to vary from in front and elevated by 45°, to slightly behind and close to the listener. This is probably due to the complex way in which the ear perceives the direction of arrival of sound, the most important factor being the intricate changes introduced into the sound waves by the pinnae and ear canals[5,6]. Since these changes will vary from person to person, it is hardly surprising that a single model of the ear is unable to produce a recording which completely satisfies all listeners. That it goes as far as it does is a considerable achievement.

Due to the impressiveness of the Sennheiser recording several radio dramas have been (or are being) recorded in Germany. At least one of them has already been broadcast as an experiment, and German radio stations plan more such events. The dramas were, in general, recorded using an artificial head manufactured by Neumann and Co of Berlin. This is, in principle, very similar in design to the Heinrich Hertz artificial head, inasmuch as the ears are reasonably life-like and the ear canals are terminated in a combination of acoustic impedance and microphone. In detail, however, the two heads have slight but possibly significant differences; for example, the Neumann ears are made of a harder rubber and the rest of the head is more stylised. In use the head is intended to be placed on top of its carrying case, to simulate the effect of a half-torso, in a good seat in a concert hall or wherever the recording is to be made.

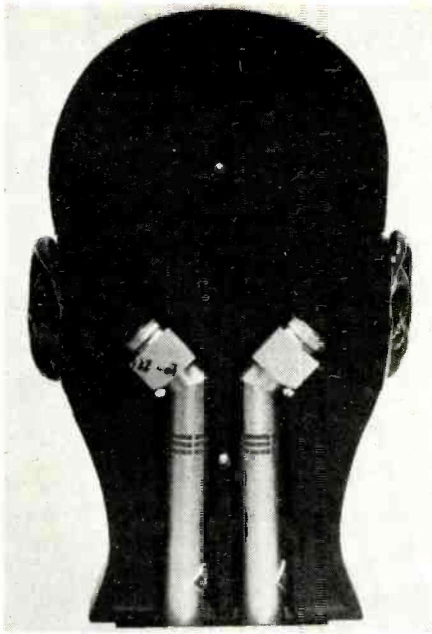
The author has had limited access to material recorded on the Neumann head and has found, generally, that it is less satisfying than the previously-mentioned Sennheiser disc. In particular, front centre sources are much more difficult to locate, and usually become confused with back centre sources. Whether this is due to the "possibly significant" differences between the Neumann and Heinrich Hertz heads, or whether it is the lack of correction for the double passage through ear canals has not yet been established.

The second Sennheiser documentary disc, released at the 1974 Hannover-Messe, demonstrates a slightly different approach to "dummy head" recording. This method requires a real head and a lightweight stereo microphone assembly. Two condenser microphones are fitted in a curved framework, which is hung loosely in the outer ear, so that the microphone diaphragms are within 10 mm of the entrance of the ear canal. In this way an attempt is made to record the precise nature of sounds at a person's ears. The recording is reproduced in exactly the same way as the artificial head recordings, viz. on open-air headphones. The sound impressions produced by this method are satisfying, inasmuch as a convincing sense of spaciousness and distribution of images is reproduced, but unfortunately the images are blurred and front/back ambiguity is experienced by most listeners, even though the record sleeve shows precisely where the images ought to be. So compared to the first demonstration disc, the second is rather disappointing.

The same idea, i.e. that of using a real head, has been investigated in some detail by Dr E. T. Rolls of Oxford University[7]. His recordings are made with miniature microphones actually inside the ear canals of the subject. I had the slightly painful pleasure of being involved in one such recording session with some rather surprising results. For me, this recording not only demonstrated extremely good azimuth and distance information, but also a remarkably realistic sense of height, on both the main sound sources and the incidental environmental noises, such as the tape recorder noises and attenuator clicks. The directional acuity was, however, not duplicated nearly as well for other listeners to the recording, implying that each person is attuned, by the process of learning, to the individual characteristics of his own ears[5].

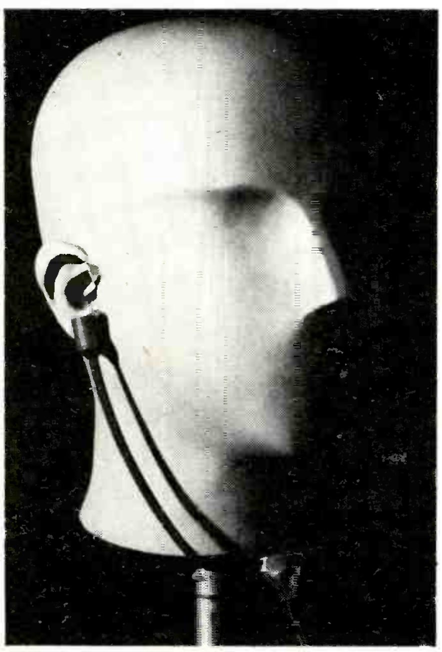
To quantify these results the recording was used in a crude subjective test to establish the accuracy with which the position of sounds could be reproduced. On average the results were better than those obtained in recent tests[8] on some matrixed quadraphony systems. Unfortunately, however, the positional errors for this form of head-related recording were concentrated in the front quadrant, other positions being reproduced with greater accuracy. So once again the front-centre images seem to be the illusive ones.

Supposing, however, that future experimentation with one, or other, of the above systems can solve the problem of creating front-centre images with headphones, there still remains the difficulty of adapting the technique for use in normal recording situations. Much of the light music and pop music that is recorded at present is obtained under conditions of gross acoustic imbalance by using many microphones placed fairly close to the individual (or grouped) instruments. Even with orchestral music in "good" concert halls, difficulties have been encountered[9], in quadraphonic work, in finding acoustically balanced positions for placing coincident groups of microphones, and the same difficulty may arise with the artificial head recordings. Furthermore, there is the problem of audience reaction to this sort of device. A normal stereo microphone suspended above one's head at a concert is fairly unobtrusive, but the same cannot be said of an artificial head.



*Showing the ear/microphone assembly of the Neumann "head".*

*Neumann's artificial head shown mounted on its case.*



*Sennheiser microphone and artificial head assembly.*

The most likely long-term development of this idea is that the artificial head work may enable investigators to acquire a greater understanding as to how the ear/brain combination locates a sound from a particular direction, and thence to determine whether it would be possible to simulate the artificial-head sounds (or even better, to simulate true three-dimensional sound sensations) by electrical processing of normal microphone signals[3]. If this could be achieved and if compatible monophonic and stereophonic listening on loudspeakers were possible, we would most certainly have an interesting alternative to the presently proposed quadraphonic arrangements.

**Acknowledgement**

The author wishes to thank the Director of Engineering of the British Broadcasting Corporation for permission to publish this article.

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PROJECT

# A digital clock and calendar

## Part 2. The logic programme described for the calendar days and months display.

by J. F. K. Nosworthy, M.A., Grad.I.E.E., and N. J. Roffe

It is with this section of the project that it becomes necessary to embark on a logic-programme, since the loop-cycle count becomes variable. The variation lies in the number of days in a month, and the laws governing this variation can be conveniently dealt with in two parts:

1. The "April–June–September–November" 30-day rule, which is constant for all years. In this context February is normalized at 28 days.
2. The rules governing leap-years, also century leap-years, which give February an additional day.

Listing therefore the exact logic requirements for Part 1 of the programme:

1. January, March, May, July, August, October, December shall each contain 31 days.
2. April, June, September, November shall each contain 30 days.
3. February shall contain 28 days.
4. The display required for Day 1 in each month is (decimal) 01. Display 00 is not required, i.e. reset to 01 must be provided at the end of each month.
5. The same condition as (4) applies also to the months display, i.e. the reset must be to 01, not 00.

Similarly the logic requirements for Part 2:

1. Considering the last two digits of the year, if the first of these is 0, 2, 4, 6 or 8 (i.e. even number) and the last is 0, 4 or 8, leap-year conditions exist unless (3) below applies.
2. Again in the last two digits of the year, if the first of these is 1, 3, 5, 7 or 9 (i.e. odd number) and the second is 2 or 6, leap-year conditions exist.
3. If the last two digits of the year are 00, i.e. century, then the tests in (1) and (2) above shall be repeated on the first two digits, and the same criteria shall be applied to them for selection of leap-year conditions.
4. Leap-year conditions entail the insertion of an extra day into the month of February; this day to be numbered and displayed as 29, which shall supersede 28 as the terminal day for re-set requirements.

The above are of course merely a breakdown of the common rules which we apply to determine whether a year is a leap-year, and therefore contains February 29. In fact, although most people know well enough the rule governing ordinary leap-years, that the year number shall be divisible by four, they do not know the rule governing century-leap-years. This is formally stated above, but in colloquial parlance could be given as "a century-year is *not* a leap-year unless its first two digits are divisible by four". This means that only every third century-year is a leap-year—1700, 1800, 1900 were not, 2000 will be.

These then are the total logic-programme requirements for the calendar, and consideration of them will show that Part 1 should be regarded as the definitive and permanent programme, with Part 2 added to it as a rider which affects only the month of February. This is in fact how we have treated the programme design. Reference should now be made to Fig. 5, the block diagram for the calendar logic. A data store is provided in the form of a read-only memory (r.o.m.), and in this is stored the data on the number of days in each month, i.e. the information as to the days count at which reset should occur; an extra line of data for leap-year February, which is selected when necessary by the leap-year logic gates; display data for each month. The latter is necessary because, although at first sight a simple ÷ 12 sequential count could suffice for the months display, in fact if this were done there would be a great danger of the months display getting out of step with the days-in-the-month data. The data provided therefore ensures that, for any given month, its correct decimal display is given, and this is firmly tied to its correct number of days. The detailed circuitry and operation

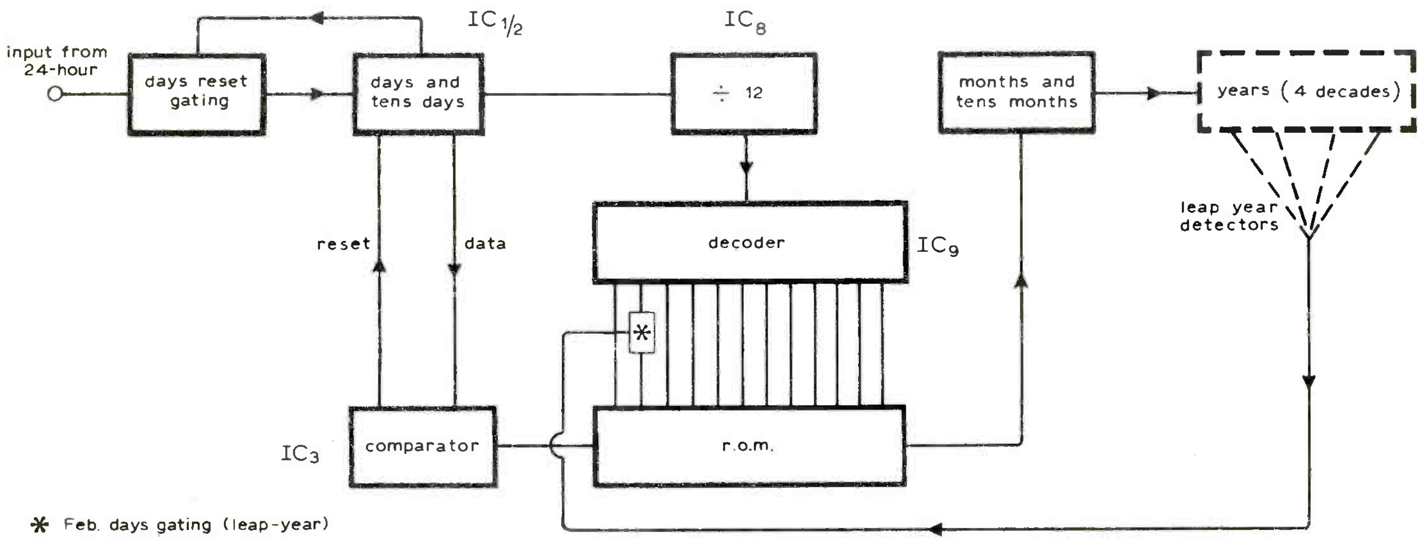



*Fig. 5. Block diagram for the overall calendar logic.*

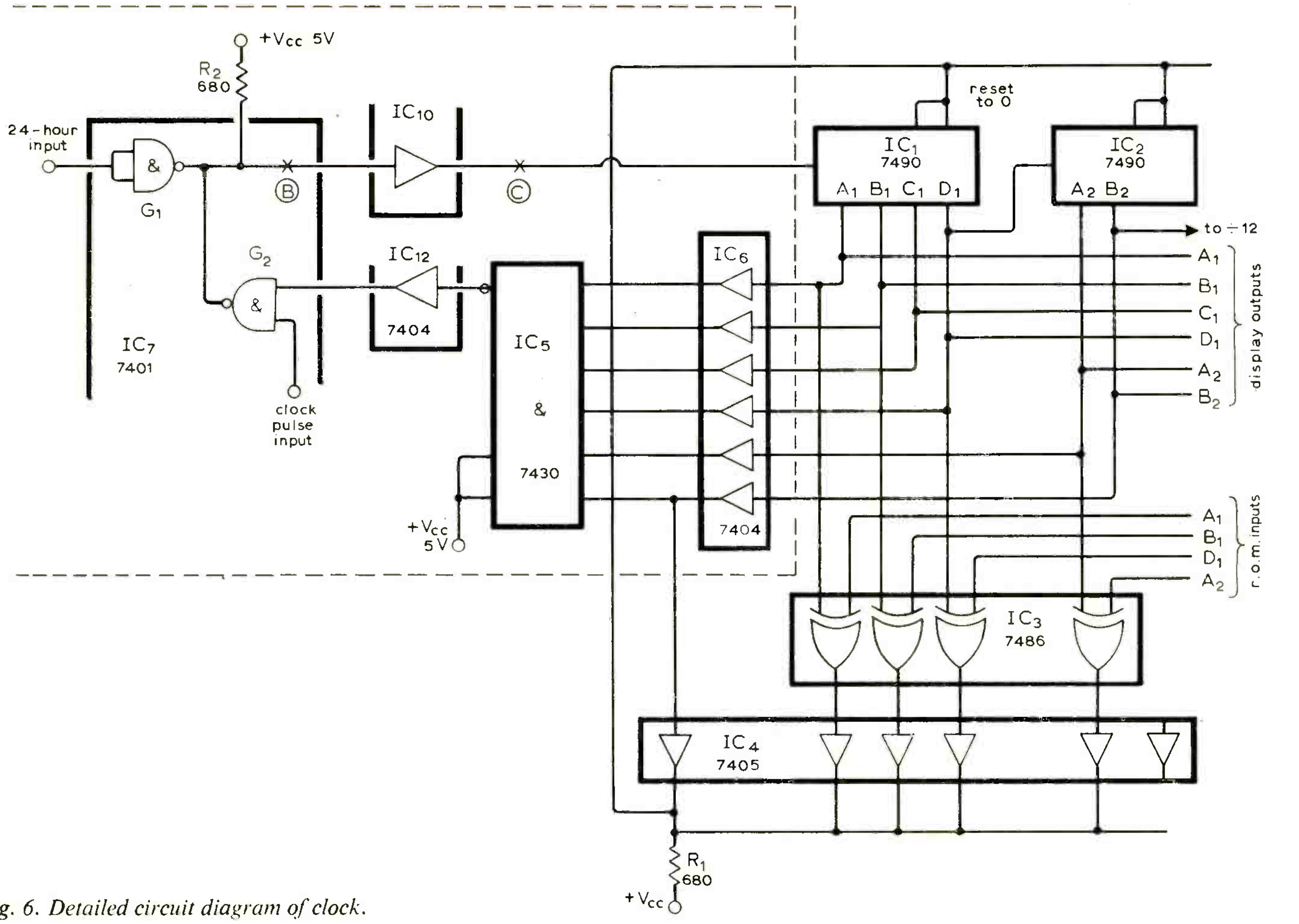



*Fig. 6. Detailed circuit diagram of clock.*

of the r.o.m. will be dealt with later, but its principles should be considered at this stage, as follows:
the data stored in the r.o.m. regarding the number of days in the month is in the form of an "error condition", one too many days being stored against each month. This data is continually compared with the current day-count display, and equality between the two actuates both the days reset circuitry and a ÷ 12 counter which selects the next month's data line in the r.o.m. Thus, at midnight on January 31 the incoming clock pulse moves the days on by 1 digit to show 32; but since this number is that which is stored in the r.o.m. under the January line, and the comparator therefore receives an equality signal, this is immediately cleared and reset to start the next month.

There is one practical difficulty which must be overcome in this process. This lies in the fact that, with the i.c.s which we selected for use as being commonly and economically available, reset to any number other than 0 is not available; and the days display requires of course a reset to 1. Previous designs have overcome this difficulty by wiring the display devices out of step with their decoder/drivers, so that a 0 output from the decoder is displayed as 1. However, we preferred not to do this, and instead we have used an additional logic loop which, when a 00 is detected in the days display, allows an extra clock pulse through to clear this condition. Thus the days display will in fact read 00 at the beginning of each month, but this will be immediately advanced to 01; the time interval involved being 1 second, since access to the clock divider chain at this point happened to be convenient (in principle, there is no reason why the 00 error should not be cleared by the next output pulse direct from the oscillator, so that the error would persist for only 1/200,000th of a second instead of 1 second, but in practice there is little point in labouring the matter).

From the output of the months, division to the four years digits is carried out conventionally. There are no reset difficulties, since 0000 is acceptable as the initial years loop indication. It is, of course, necessary to sample the years display in order to actuate the leap-year logic; this is done simply by applying the requisite number of NAND gates to the b.c.d. outputs from the years counters and programming these in accordance with the rules for leap-year selection already given. Indication of a leap-year then results in an output from these screening gates, which selects the alternative February line in the r.o.m. as well as illuminating the leap-year indicator (which is simply a l.e.d. driven directly from the output of the gates).

The above describes the principles used in the calendar chain, and detailed descriptions of the various elements involved now follow.

| No. of days in month | Data outputs from $IC_{1,2}$ at actual reset no. (= days+1) $A_1$ | $B_1$ | $C_1$ | $D_1$ | $A_2$ | $B_2$ |
|---|---|---|---|---|---|---|
| 28 | 1 | 0 | 0 | 1 | 0 | 1 |
| 29 | 0 | 0 | 0 | 0 | 1 | 1 |
| 30 | 1 | 0 | 0 | 0 | 1 | 1 |
| 31 | 0 | 1 | 0 | 0 | 1 | 1 |

*Fig. 7. $IC_1/IC_2$ data outputs to comparator. Note mutual cancellation of $C_1 - B_2$.*

### Days logic

Clock pulses for the days are derived from the 24-hour output from the clock section, so that actuation is by a (falling) pulse at midnight. Fig. 6 shows the detailed circuitry. The incoming pulse is gated through $G_1$ of $IC_7$, which forms part of the reset circuitry and is not relevant at this stage; is inverted twice in order to preserve the pulse polarity; and is passed to the clock input of $IC_1$, a 7490 decade counter, which it therefore advances by 1. The tenth (i.e. terminal) pulse from $IC_1$ in turn drives $IC_2$. The A, B, C, D outputs from $IC_1$ and the A, B outputs from $IC_2$ are decoded conventionally to drive the days display. Thus, $IC_1$ counts the unit days, $IC_2$ the tens of days. Additionally, these outputs must be fed to the memory comparator $IC_3$; but it will be noticed that in fact only outputs $A_1$, $B_1$, $D_1$, $A_2$ are used for this purpose. The reason for this becomes plain on reference to Fig. 9, since output $C_1$ is always 0 and $B_2$ is always 1. No comparison between these two outputs is therefore required, since they effectively represent fixed conditions. The four relevant outputs are fed to $IC_3$, together with four outputs from the r.o.m.; $IC_3$ providing an EXCLUSIVE OR function whose truth table is given in Fig. 8. It will be seen that, taking any pair of inputs, when these are equivalent the resultant output is logic 0, so that $IC_3$ acts as a coincidence-comparator between the days display and the data stored in the r.o.m. When coincidence is complete, i.e. when the days show a surplus of 1 and reset is required, all outputs from $IC_3$ are at logic 0. These outputs are combined by $IC_4$, a hextuple inverter with open-collector outputs providing wired-or logic; as also is output $B_2$ from $IC_2$ after inversion by one section of $IC_6$. The outputs from $IC_4$ are combined into a common load resistor $R_l$; and consideration will show that the result is a logic 0 at all times except for the condition that all $IC_4$ inputs are at 0, when it will become logic 1. This condition only arises when the days count/r.o.m. coincidence is complete, plus a logic 1 output being present from the $B_2$ output of $IC_2$; and this is the condition required for actuation of the reset circuitry.

| A | B | Q |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

*Fig. 8. Exclusive OR truth table.*

The high state thus arising at the output of $IC_4$ is used to reset the two days counters $IC_1$ and $IC_2$ to zero, using the normal reset facility on these blocks. However, as has been said, this reset in itself is inadequate, since it leaves the days display showing 00 when in fact 01 is required. A further logic network is therefore necessary to detect the 00 when it arises and change this to 01; this being achieved by the circuitry within the dotted outline in Fig. 6. All the 6 relevant outputs from $IC_1$ and $IC_2$ (the remaining 2 outputs from $IC_2$ are not relevant, since the tens-of-days count always stops at 3 or less) are, after inversion by $IC_6$, taken to $IC_5$, which is an 8-input NAND gate. The two remaining inputs to $IC_5$ are strapped high (i.e. to $V_{cc}$). In all conditions other than a 00 on $IC_1$ and $IC_2$, one or more of the inputs to $IC_5$ will be low (because of inversion by $IC_6$) and the output from $IC_5$ will therefore remain high. For 00, however, all inputs to $IC_6$ go low; all inputs to $IC_5$ go high, including the two strapped to $V_{cc}$; and the output from $IC_5$ therefore goes low. This is inverted by (part of) $IC_{12}$ and fed to $G_2$, another NAND gate (i.c. numbers around this part of the circuit overlap with those in the next sequence, Fig. 9, since multiple blocks are employed). The other input of $G_2$ is fed by 1 Hz clock pulses, as previously described. Since the output of $IC_{12}$ is now high, these pulses are routed through $G_2$ and injected into the beginning of the days counter chain at point B, providing a negative-going pulse ($G_2$ being a NAND as opposed to AND gate). This pulse advances $IC_1$ by one step, changing the display to 01 and simultaneously, via the route just described, closing $G_2$ so that no further pulses are gated through. One further gate, $G_1$, is a practical necessity in this circuitry—since the driving source for the calendar chain is a t.t.l. output, a buffer with open-collector output must be interposed in order to allow the momentary pull-down of the driving line to zero whilst the main drive remains in a high state. $IC_7$ (which contains both $G_1$ and $G_2$) is therefore an

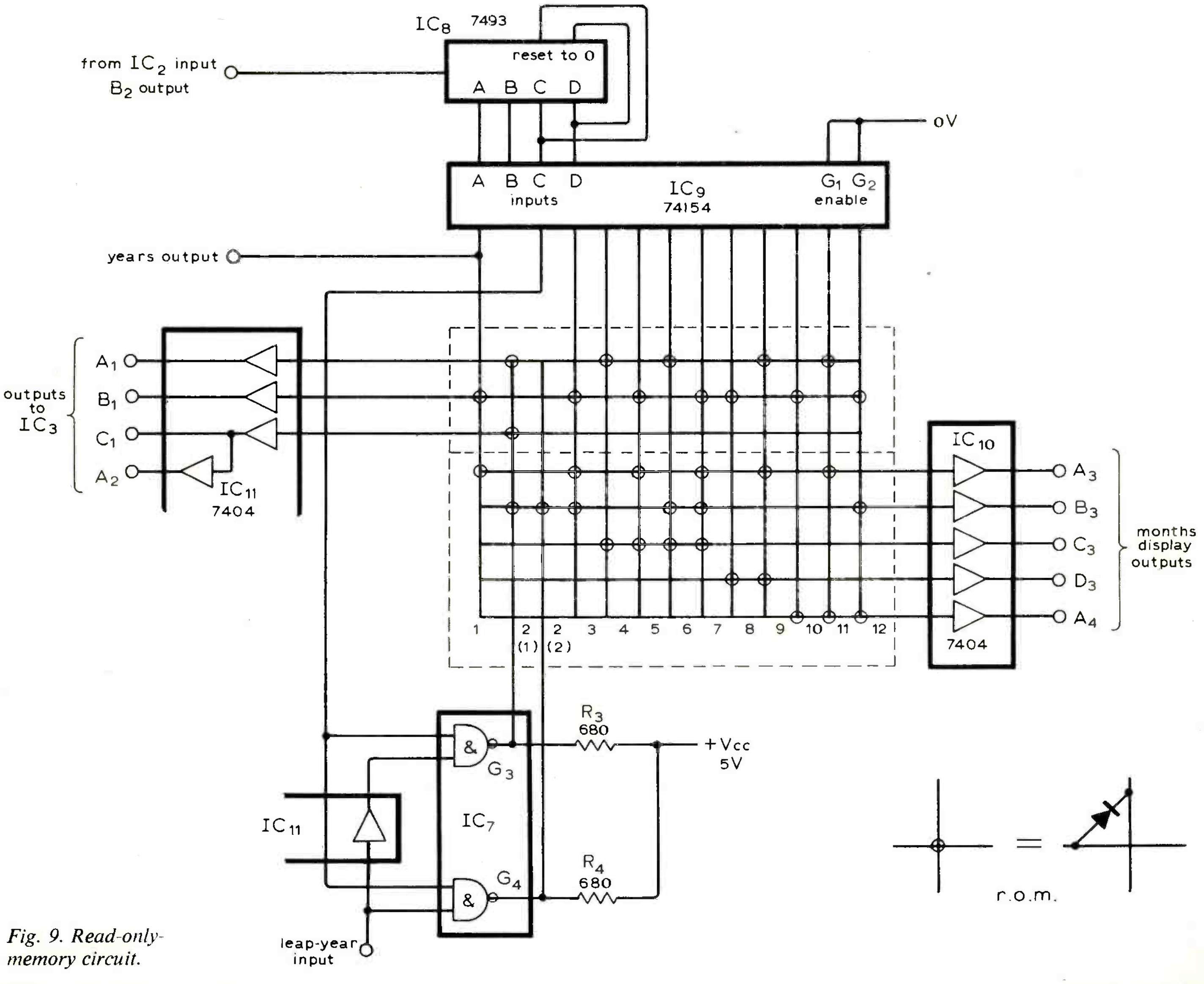



*Fig. 9. Read-only-memory circuit.*

open-collector type (i.e. the circuitry is wired-OR).

This particular "dodge" for obtaining a 1, as opposed to 0, reset has, so far as the authors are aware, not been published before. Possibly it will be found to be of use in applications other than the present one. In that case, when possibly a convenient quick-sequence advancing pulse might not be readily available, we would suggest that the clock pulse input to $G_2$ be fed from a local oscillator, which would of course allow the 0 condition to be cleared at any desired speed.

### Months logic

The circuit for this, including that of the diode-matrix r.o.m., is given in Fig. 9. The $B_2$ output from $IC_2$ is used to drive the 7493, 4-bit binary counter $IC_8$, which is wired as a ÷ 12 counter (n.b. the usual 7492 ÷ 12 counter cannot be used for this purpose, as its truth table becomes incorrect above the count of 5). The $IC_8$ therefore receives one pulse at the end of each month, advancing its count by 1. The binary output from $IC_8$ is fed to $IC_9$, which is a 4–16-line decoder in a 24 d.i.l. package, decoding any binary input into a one-of-sixteen output. Twelve of these outputs are employed to select a "month" line in the r.o.m. matrix, so that as $IC_8$ steps on at the end of each month the new month's data is selected. The output corresponding to February, however, has to receive intermediate processing, since alternative February lines are provided in the r.c.m. for a 29-day February (leap-year) and a 28-day February (non-leap-year). The output for this month from $IC_9$ is therefore routed through a gating system, $IC_7$, which routes the signal to whichever of the two February lines is called for according to the condition of the years display. Thus, the 12 "month" lines of the r.c.m. matrix are scanned sequentially by $IC_9$ in the order shown, which corresponds to the order of the months (Jan = 1, Dec = 12), the February alternatives being labelled 3(1) and 2(2), the latter being the leap-year condition.

The r.o.m. matrix itself consists simply of an array of diodes arranged as shown. The precise type of diode used is unimportant provided that the forward conductance is high; this factor is essential. In analysing its operation it is convenient to consider it in two halves, the separation being indicated by the dotted line in Fig. 9. Dealing with the top half of the matrix first, this contains the data on the number of days allowable in each month before reset. A diode in the top line for a given month indicates reset required at (last digit) 1, for months containing 30 days (remembering that reset is required at allowable days +1); a diode in the second line indicates reset required at (last digit) 2, for months containing 31 days. A diode in the third line changes the reset requirements for the first digit of the days count from 3 to 2—this facility being required only for the 28-day February (reset on 29), since for all other months the first digit of the reset number is a 3. In the absence of a matrix connection, the three top (in Fig. 9) inputs to $IC_{11}$ are floating and therefore assume a high state. This would continue to be the case in the absence of an input signal to the matrix from $IC_9$. When, however, a signal from $IC_9$ is received on one of the matrix vertical month lines, it will be routed through to an $IC_{11}$ input if a diode is present at the intersection; and in this case, since the output signal from $IC_9$ is a logic 0 it will ground, via the diode, the floating-high $IC_{11}$ input, which will therefore assume a logic 0 state. (This is the reason for the requirement previously stated that the diodes must have high forward conductance, since any residual voltage remaining on a supposedly grounded $IC_{11}$ input would result in incorrect operation.) Thus for example, taking the month of January, the (logic 0) output from $IC_9$ will be on output no.1 which is connected to vertical line no.1 on the matrix; the top input to $IC_{11}$ has no diode at its intersection with this line, is therefore not connected to it, and will remain at its floating high; the second input will be connected to $IC_9$ output via the diode at its intersection, its floating potential will be grounded, and it will be at logic 0; the third input, like the first, will remain high. An input code of 101 to $IC_{11}$ thus results. This is inverted (by $IC_{11}$) to 010 and passed to $IC_3$ for coincidence-comparison, as previously described.

The lower half of the r.o.m. matrix contains the data for the months display. This is arranged straightforwardly in b.c.d., the top four lines containing the last digit of the month and the bottom line the extra digit required for the two-figure months. Again, strobing of a vertical line by $IC_9$ gives a coded horizontal output to $IC_{10}$ which actuates the months display appropriately.

*(To be continued)*

Note: Corrections for parts 1 and 2 together with a parts list will be published in the concluding part.

# Literature Received

**ACTIVE DEVICES**

Brimar have discontinued the loose-leaf presentation of their cathode-ray tube data and have introduced a bound volume to replace volumes 3 and 4. Tubes are listed in alphabetical order and there is a "tab" index for category indication. The subscription for the book and up-dating service is £1 per year. Brimar Data Service, Publicity Dept., Thorn Radio Valves & Tubes Ltd, Mollison Avenue, Brimsdown, Enfield, Middlesex EN3 7NS.

A wall-chart giving broad specifications of a range of silicon photodetectors is available from RCA. Devices described include PIN diodes, avalanche types, photovoltaic diodes and detector/preamplifier modules. Electronic Components Division, RCA Ltd, Lincoln Way, Sunbury-on-Thames, Middlesex. .......... WW401

**GENERAL CATALOGUES**

Cavern Electronics have sent us a copy of their mail order catalogue of electronic components, containing active and passive components, kits, and assorted hardware. The price is 30p. plus 11p postage, the 30p being refunded with the first order of £3 or more. Cavern Electronics, 94 Stratford Road, Wolverton, Milton Keynes MK12 5LU.

**EQUIPMENT**

Transducers, input amplifiers and *x-y* recorders of various types are described in a new short-form catalogue by Bryans Southern Instruments Ltd, Willow Lane, Mitcham, Surrey CR4 4UL. . WW402

Gardners have compiled a new catalogue of stabilized power supplies, inverters, converters and wound components, obtainable from Gardners Transformers Ltd, Christchurch, Dorset BH23 3PN. .......... WW403

Full technical details of a range of electronic measuring instruments, power supplies and industrial controls are presented in the 1974 Advance Electronics Data Book, available from Advance Electronics Ltd, Raynham Road, Bishop's Stortford, Herts . WW404

A very small, high performance data acquisition module is described in leaflet AN6912 from Analogic. The unit contains scanning, signal conditioning, a-to-d conversion and control functions. Analogic Ltd, Monument House, 25–27 Monument Hill, Weybridge KT13 8RT. .......... WW405

**APPLICATION NOTES**

Two booklets have been published by Mullard on d.c.-d.c. converters for switched-mode power supplies (TP1442) and radio-frequency interference suppression in these circuits (TP1443). The booklets are available from Instrumentation and Control Electronics Division, Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD. The reference numbers should be quoted ....... WW410

**MISCELLANEOUS**

A group of new publications has just been released by the International Telecommunications Union.

"The proceedings of the Seminar on the Planning of Broadcasting Stations, Sao Paulo, 1973", available at 122 Swiss francs.

"General Graphical Symbols for Radiocommunications" at 26 Swiss francs.

"List of Coast Stations—LV" at 69 Swiss francs.

"List of Ship Stations" 14th edition, at 24 Swiss francs.

All available from General Secretariat of the ITU, Place des Nations, CH-1211 Geneva 20, Switzerland.

Two leaflets produced by 3M describe a range of Hedlok plastic fasteners and a selection of self-adhesive, moulded buffers for the protection of equipment from vibration and scuffing. 3M United Kingdom Ltd, 3M House, Wigmore Street, London W1A 1ET .......... WW413

# Baxandall tone control revisited

## Improvements for greater flexibility in tailoring audio signals

by M. V. Thomas, B.A.

**The main disadvantage of the Baxandall tone control circuit is that if boost and cut are required at a particular frequency a much greater effect occurs at the extremes of the audio range. Modifications are described to limit the degree of this effect.**

The Baxandall configuration has for some time been the almost universal choice of audio amplifier manufacturers for their tone control circuits. This is due in no small measure to its simplicity of construction and ease of use, and it is difficult to envisage any improvement of the circuit whilst retaining only two controls. However, once a decision to increase the number of controls is made, the field becomes wide open, the most obvious development being to have each control affecting the level of a limited band of frequencies. Such circuits are obviously much more elaborate than the basic Baxandall type, and require careful design to prevent excessive interaction between the controls. This article describes a modification to the basic Baxandall circuit which greatly increases its versatility whilst maintaining its simplicity.

The main disadvantage of the basic circuit is that it has its greatest effect at the extremes of the audio range, as shown in Fig. 1. For example, if a 6dB boost is required at 4kHz, one must simultaneously tolerate a much greater boost of perhaps 18dB at 16kHz. Furthermore, the turnover frequency of the bass control depends on its setting, but this does not apply to the treble control! This effect is also shown in Fig. 1, and the reason can be seen in Fig. 2, which shows the basic circuit. At very low frequencies the impedances of the capacitors are high and the circuit is essentially resistive. The bass control then acts as a simple gain control and the treble control has no effect. As the frequency is increased, the bass control is progressively decoupled by $C_1$ and $C_2$, the relevant time constants being $C_1R_3$ and $C_2R_2$. But the relative values of $R_2$ and $R_3$ obviously depend on the setting of the control, this causing the variation in turnover frequency as shown in Fig. 1. For example, to increase the bass boost, $R_2$ must be increased, thereby increasing the $C_2R_2$ time constant and increasing the turnover frequency. At higher frequencies (above 1kHz) the bass control is completely decoupled by $C_1$ and $C_2$, and the impedance of $C_3$ has fallen to a value where the treble control begins to have a significant effect (capacitor $C_3$ is often replaced by two capacitors, one at each end of the track of the treble control, but the effect is basically the same). Resistor $R_5$ prevents the bass control from loading the treble control, and the time constant which primarily decides the treble turnover frequency is $C_3R_5$, which is independent from the control settings. At very high frequencies (above 10kHz) the treble control acts as a gain control. Resistors $R_1$, $R_4$, $R_6$ and $R_9$ serve to limit the effect of the controls at their extreme settings, and are comparatively small in value, so they do not affect the basic operation of the circuit.

Whether this difference in mode of action of the bass and treble controls, is advantageous is a difficult question, and one could no doubt argue either way. However, it is about all one can do with a simple $RC$ network, unless completely separate boost and cut controls are used[1]. Using this approach it is possible to synthesise "step" responses as shown in

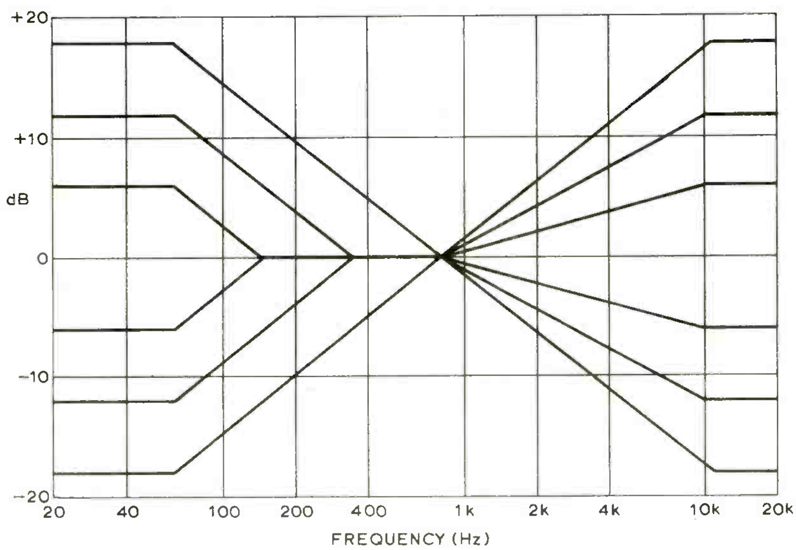



*Fig. 1. Idealized responses of the Baxandall-type tone control circuit.*

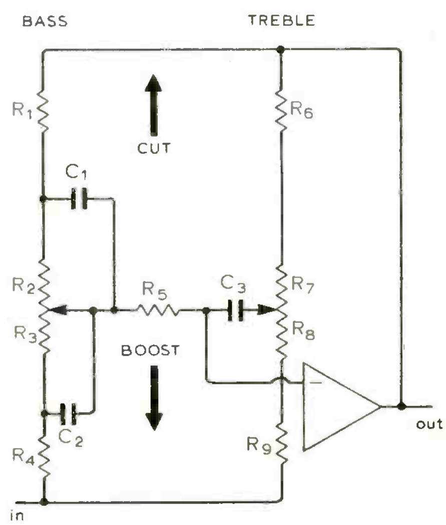



*Fig. 2. Baxandall-type tone control network.*

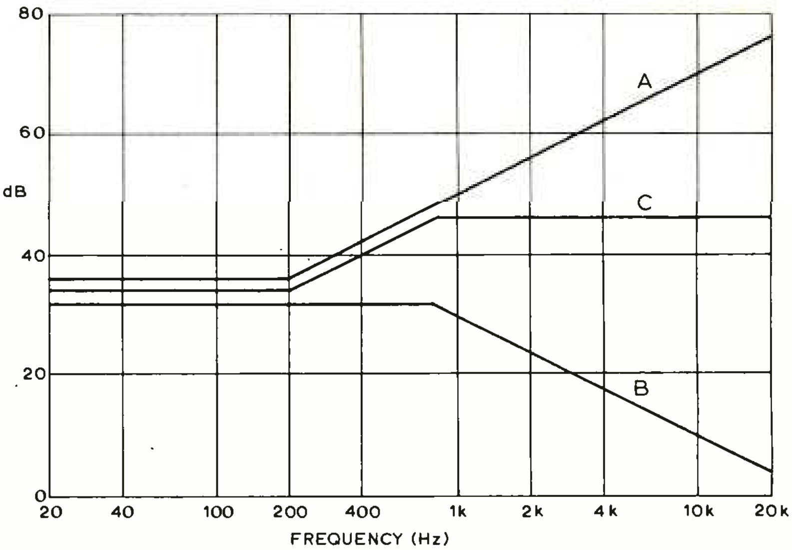



*Fig. 3. Synthesis of "shelf" responses using completely separate boost and cut networks. In the example shown, the maximum overall boost is +12dB (curve C), but at 20kHz this overall boost is obtained by applying 40dB boost and 28dB cut (curves A and B), thereby causing overload or noise problems, depending on which operation is performed first.*

Fig. 3, but in order to obtain a flat response it is necessary to simultaneously boost and cut the signal, which can cause overload and noise problems as the two operations are performed in different parts of the circuit, in contrast to the Baxandall arrangement.

Possible modifications of the circuit to limit its effect at the extremes of the audio range were therefore considered. It was decided that the most useful addition would be of separate "effect" controls for bass and treble, which would limit (in a symmetrical fashion) the maximum degree of boost and cut obtainable from the bass and treble controls, and further reference to Fig. 1 shows how this may be done. The maximum boost and cut of the bass control are decided by $R_1$ and $R_4$ respectively, so the desired result could be obtained by replacing these with variable resistors, but this arrangement has two disadvantages. Firstly, two controls are required, and secondly, changing the values of these resistors will cause some change in the turnover frequency of the bass control. However, the same result can be achieved with neither of these disadvantages, by connecting a single variable resistor directly across the bass control, as shown in Fig. 4. This control

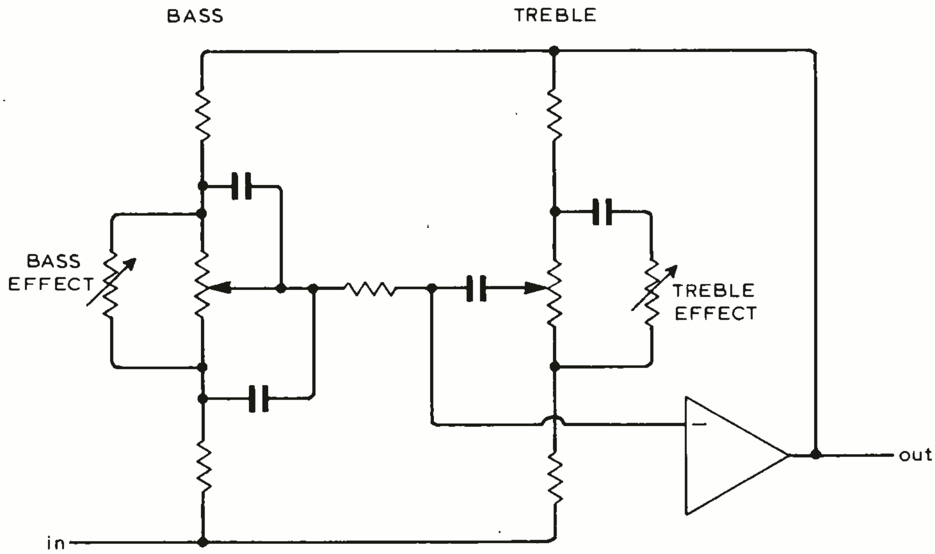



*Fig. 4. As Fig. 2, but with the addition of the two effect controls.*

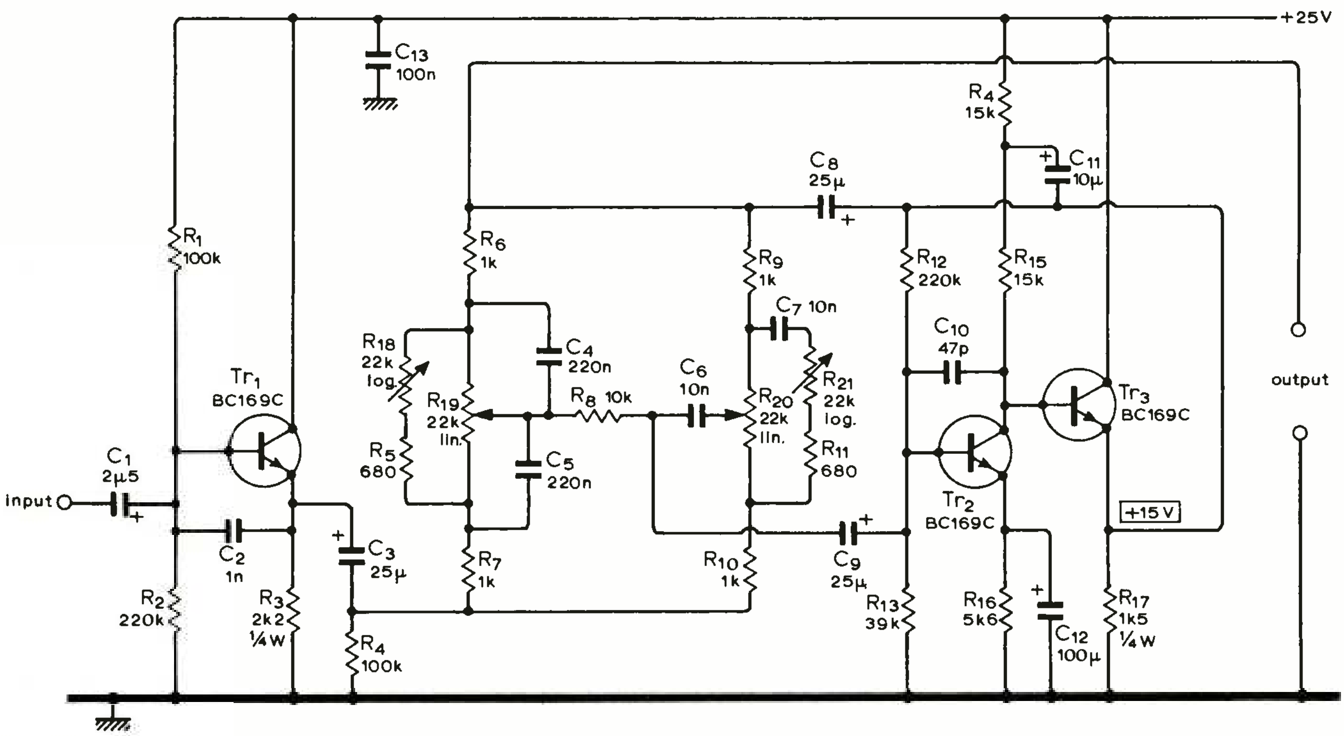



*Fig. 5. Complete circuit. Resistors can be ⅛ watt unless shown otherwise.*

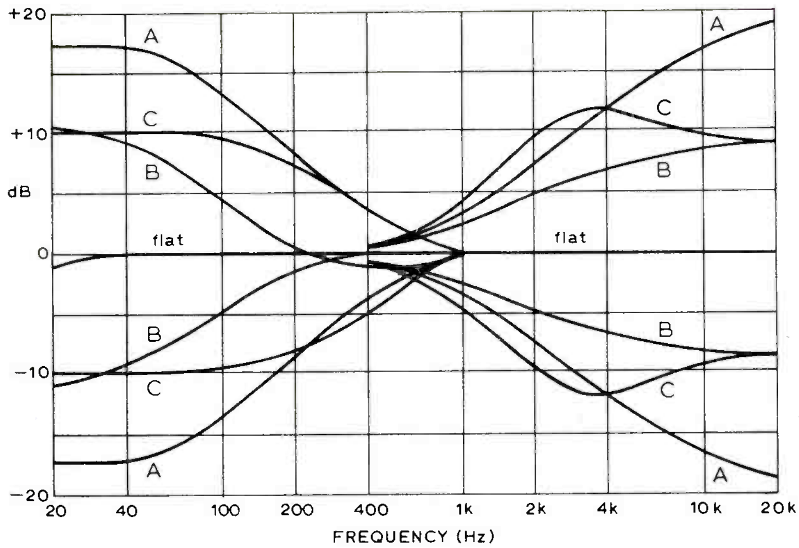



*Fig. 6. Selection of the frequency responses obtainable with the circuit. See text for further details.*

simply acts as a potential divider in conjunction with $R_1$ and $R_4$. As the resistance of the control is reduced, the fraction of the input and feedback signals appearing across the bass control is also reduced, thereby limiting its maximum effect. A similar modification to the treble control will not have the desired result, because of the fixed turnover frequency of this control; it would indeed reduce the maximum boost and cut of the control, but one could obtain exactly the same frequency response by removing the "effect" control and by having the treble control at a less extreme setting! This state of affairs can be prevented by including a series capacitor, as shown in Fig. 4, so that the "effect" control is operative only above a turnover frequency decided by the values of this capacitor, $R_6$ and $R_9$.

The complete circuit incorporating these modifications is shown in Fig. 5, and apart from the additions it is quite conventional. The only extra precaution necessary is to ensure that it has a reasonably high drive current capability, as the impedance of the control network can be comparatively low at some control settings. However, the worst-case maximum output of the circuit is approximately four volts r.m.s. before clipping, which should be perfectly adequate. The transistors used in the prototypes were BC169Cs; these have a $V_{ces}$ of 30V, which allows the use of a fairly high supply voltage for the circuit. Transistor $Tr_1$ provides a low impedance drive to the network while $Tr_2$ and $Tr_3$ form a bootstrapped amplifier. The low distortion and low output impedance of this configuration make it an ideal choice for this application[2]. The circuit has a gain of unity with the controls set flat, and $C_2$ and $C_{10}$ reduce the r.f. gain to prevent instability. Resistors $R_{12}$ and $R_{13}$ provide d.c. feedback to hold the emitter of $Tr_3$ at 15V, this being a useful point to check when testing the circuit. Logarithmic pots are recommended for the two effect controls. The "top" end of each track should be left unconnected so that the controls will then have their smallest modifying effect when fully clockwise. Resistors $R_5$ and $R_{11}$ in Fig. 5 prevent the effect controls from completely swamping the bass and treble controls when the former are fully anticlockwise; the values shown set the limits at the audio extremes to ± 4dB.

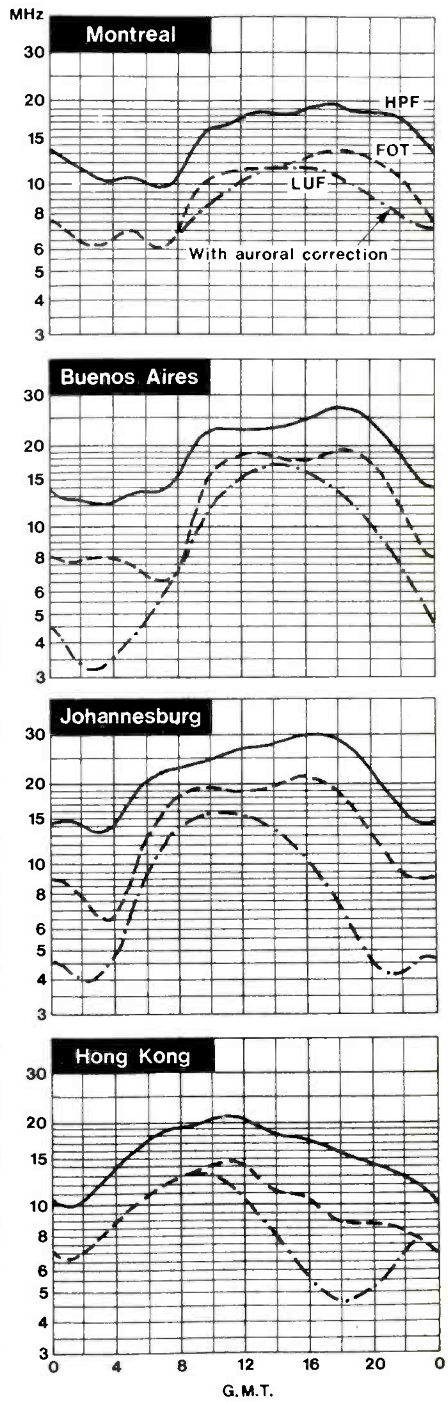
Fig. 6 shows a selection of the frequency response curves which can be obtained from the circuit. The set of curves marked "A" obtained with the effect controls fully clockwise shows the responses with the bass and treble controls at their extreme settings, and set "B" is similar except that this shows the responses with the bass and treble controls at approximately half maximum settings. These curves are almost identical to those obtainable from a conventional circuit—compare for example with those of the tone control circuit in ref. 3. The only difference is that the bass and treble responses have been deliberately arranged to overlap rather more than usual, so as to take fuller advantage of the effect controls. Set "C" is obtained with the bass and treble controls at their extreme settings but with the effect controls set to limit the responses at the audio extremes to the same as those of set "B", and this clearly shows the advantages of the extra controls. Basically, by the use of these controls it is possible to alter the level of a band of frequencies far more uniformly than with a conventional circuit, and this advantage is very noticeable in use, being considered well worth the extra complexity.

**References**

1. Hutchinson, P. B., "Tone control circuit", *Wireless World*, Nov. 1970, pp.538–540.
2. Quilter, P. M., "Low distortion tone control circuit", *Wireless World*, April 1971, pp.199–200.
3. Walker, H. P., "Stereo mixer", *Wireless World*, June 1971, Part 2, pp.295–300.

# HF Predictions September

There is no sign of abatement in the current prolonged spell of high magnetic activity. During June and July 40 days were disturbed compared to 24 for the same period of the last sunspot cycle. Comparing with last year there were 30 disturbed days in June and July followed by about ten days per month until February of this year when the current high activity commenced. These disturbances cause a reduction in FOTs shown on the charts. Low latitude circuits are hardly affected, however, and can even show an improvement under these conditions. FOTs on trans-equator routes are at their highest during September.



# Letters to the Editor

## Dolby f.m. broadcasting

I read with interest your article on the use of the Dolby B system in broadcasting (July issue, page 237).

Any proposal that may result in an improved signal-to-noise ratio, particularly for stereo reception in fringe areas, must receive careful attention. In the well-known Dolby B system, as normally applied in tape recording, low-level signals are boosted in a special way before recording, while a complementary decoder or expander in the replay chain restores the balance at all levels. Compression of the dynamic range before transmission, with a complementary expansion at the receiver, can permit the largest possible signal to be transmitted over the noisy part of the system and there seems to be no technical reason why "companding" should fail to be successful in f.m. broadcasting.

The real question to be faced by the broadcaster in considering schemes of this sort is whether, in order to bring about an improvement for relatively few listeners towards the fringe of a service area, there can ever be a justification for requiring all the owners of existing receivers to replace their equipment or have it modified. I would not deny that the Dolby B system is an effective method of noise reduction, given proper instrumentation at both sending and receiving terminals; the worry is that the introduction of companding at the sender without sophisticated complementary treatment at the receiver inevitably involves a degradation of the overall fidelity.

Band II/f.m. broadcasting in this country has rightly come to be regarded as a very accurate transmission system and the compatibility of any proposed change in the specification of the transmitted signal is of paramount importance to the owners of the twelve million or more existing v.h.f. receivers. Any realistic appraisal of the possibility that a significant proportion of these receivers would ever be modified must lead to the conclusion that they would not.

Your article does not give sufficient weight to the compatibility aspects of the proposal. Given the simultaneous introduction of Dolby B and a reduction of time constant to 25μs in the transmissions it is claimed that adequate compatibility is obtained with a 75μs (American style) de-emphasis receiver, although others have expressed doubt on this subject. I wonder whether a combination of compander and time constant could be found to match up to the present quality standard given by a respectable-fi, 50μs, European tuner. You call the result "bright"—forgive me if I stick to the old-fashioned word "distorted" and note that you say our millions of established listeners wouldn't get any improvement in signal-to-noise ratio either.

Hence, the responsible broadcaster must consider options that can improve the service for the use of ordinary, existing receivers. As a result of a great deal of work behind the scenes, the BBC has recently installed "variable de-emphasis" limiters for services carrying most of the stereo transmissions. The principle is that for an overwhelming proportion of the time the broadcast is carried out with the conventional 50μs pre-emphasis, with the assurance that all receivers are fitted with the complementary 50μs de-emphasis, but when under exceptional circumstances there is a very large amplitude, high frequency, content, a momentary reduction of pre-emphasis (*not* clipping) is automatically introduced. Over-modulation difficulties arising from the use of pre-emphasis in the f.m. system can be avoided without having to reduce the gain at low audio frequencies. Very careful testing has shown that the action of this special limiter is barely detectable subjectively by the most expert observer, even when he has access to the original material.

For stereo transmissions we normally allow a smaller margin against over-modulation than we do for mono; this has the effect of improving signal-to-noise ratio by 2dB or 3dB and as we gain experience with the variable de-emphasis limiter we may find that a further improvement of perhaps 3dB or 4dB can be gained without running into difficulties. The aim will always be to ensure that the ordinary listener with a standard receiver receives the maximum signal level possible, consistent with the minimum distortion of the spectrum for all listeners.

The situation in the United States, where they have a 75μs. time constant as standard and the well-known very severe propagation and reception problems with commercial stations fighting to be heard in their big cities, is hardly a guide to optimum practice here. I believe our army of v.h.f./f.m. listeners can put their wallets away.

Head of Engineering Information
Department, BBC.

## Quadraphonic quandary

I have just read Mr Shelley's article in your July issue. I wish to point out that the contrast he makes between my statement with respect to 90° inter-channel phase shift (Ref. 3, B.B.Bauer *et al.*, "Compatible Stereo Quadraphonic Recording System", *J. Audio Eng. Soc.*, Sept. 1971) and that made by Drs Cooper and Shiga (Ref. 4, Cooper and Shiga, "Multichannel Stereo", *J. Audio Eng. Soc.*, June 1972) is not accurately defined. My paper, referring to experiments performed a decade ago in which we had noted the image spread caused by 90° phase shift, reports on further experiments in which we established that quadrature images, in addition, exhibit a certain amount of lateral shift toward the loudspeaker carrying the leading phase signal. Cooper and Shiga do not directly contradict this result as assumed by Shelley. In their paper they merely state that application of 90° of relative phase shift shows no statistically significant *increase* in image spread compared to 45° and 22:5° phase angles, which is an entirely different statement.

Referring to the paper of Kohsaka, Satch and Nakayama (volume 20 of the *J. Audio Eng. Soc.*, page 542) from which Cooper and Shiga draw their conclusions, we note that the image spread they observed for the above-mentioned angles is 60°, 45°, and 40°, respectively, with the larger angle bracketing a range of observations of 45 to 90°. Kohsaka *et al.* used noise signals for their experiments. A subsequent study by Takeshi K. Matsudaira and Takeshi Fukami (in volume 21 of the *J. Audio Eng. Soc.*, page 792) under similar conditions of listening, but with signals comprising orchestral sounds, individual musical instruments, and human voice, has established mean image shifts for 90° phase, which average some 30° with standard deviation range varying from 20° to 120° about this average. In the Matsudaira study, the image spread for zero degrees phase shift, in general, is inconsequential; while in the Kohsaka study, 40° spreads have been observed. Why the disparity between the Matsudaira and the Kohsaka data? We don't know. But, we observe that Matsudaira gives us a detailed description of his room and equipment. Kohsaka does not provide us with any relevant information. Therefore we are more willing to accept Matsudaira's data, especially since it closely matches our own experience.

With respect to my 1971 position that the particular system of quadraphonic matrix encoding and decoding should well replicate the sound of the original master tape, this still is an important objective of the SQ system; and indeed it is truer with today's improved full-logic decoders than ever before. However, there is an important difference in attitudes: With greater increase of quadraphonic sophistication in which signal channel blending is employed, it has become evident that slight differences between the master tape and the reproduced quadraphonic performances are always likely to exist. This has led to a change in recording procedures whereby a producer will mix the master tape in such a manner that the decoded image, albeit not necessarily offering a precise match with the discrete tape mix, nevertheless, becomes his primary standard of artistic excellence. With this change in emphasis, in auditing the disc with a suitable decoder the listener by definition hears the approved version of the reproduced sound. I realize that questions will arise about this procedure, because of the uncertainty about the performance of the reproducing characteristics of the commercial decoder compared with those of the studio decoder. This is not a primordial dilemma, however, for it also exists in the art of mixing stereophonic records. It is well known that the producer mixes the stereo record employing a studio monitor setup which practically never is exactly duplicated in the home of the listener. Thus, an uncertainty exists with respect to the producer's actual intentions even in the stereophonic medium. Quadraphony merely adds a new dimension to this problem which will diminish with time as the better grade of home decoders more closely match in quality the performance of studio decoders.

It seems to me, that with the shift of quadraphonic philosophy from the mere replication of a discrete quadraphonic tape to the creation of the final decoded product, many of the questions raised by Mr Shelley become academic. The producer and the recording director make and approve the SQ record, which, in essence, is their principal function. The various mathematical and philosophical arguments about quadraphony, therefore, become inconsequential.

Benjamin B. Bauer,
CBS Laboratories,
Stamford, Conn.,
USA.

## Horn loudspeaker design

I have been following Mr Dinsdale's series on horn loudspeakers (March, May, June) with great interest as I have recently designed and built a three unit horn system, and I thought my experiences might be of interest to those intending to build the Dinsdale loudspeakers.

Coincidentally, I also chose to base the design on the three KEF units used by Dinsdale. The low frequency horn is folded in a similar manner to the Klipschorn[1] and uses a compression chamber behind the B139 driver as well as a small air chamber in front of it connected to a rapid initial flare section, as suggested by Klipsch. This exponential horn was designed for corner use and has a flare cut-off frequency of 50Hz and a mouth area of 550sq. in. In use this horn gives an apparently smooth response from 400Hz down to about 35Hz, with very high efficiency and an overall clear, undistorted sound. Any resonances present are less noticeable than the natural resonances of the small rooms in which it has been used.

The problems with the system come at the top end and are caused by two factors: colouration and poor dispersion. The colouration, which takes the form of audible resonances in the mid and high frequency ranges, seems to be due to transverse reflections between the walls of the horn, especially in the throat region where the cross-section is almost square. This was confirmed by using a microphone probe which picked out standing waves across the horn whereas longitudinal resonances were not noticed (the mouth area being sufficiently large to obviate reflections). The T27 tweeter simply refused to sound right with any form of horn loading. In fact if the T27 is mounted flush in a baffle as suggested by KEF and is fed with white noise, audible colouration occurs as soon as any hard object is placed within about six inches of the diaphragm!

The top end horns were intended to give good horizontal dispersion over an angle of 90°. This is necessary to preserve the off-axis response which otherwise falls at high frequencies. To this end the mid-range horn was made with a mouth 10in high and 20in wide and incorporated four splitters in the throat section to give better angular dispersion of the high frequencies. This technique had only moderate success.

It should be noted that the "plane wavefronts" advocated by various authorities must by their very nature give rise to highly directional propagation, especially at high frequencies. This gives poor mono reproduction and a small stereo listening area. For this reason cinema horn loudspeakers invariably employ some form of diffraction on the high frequency unit, either by a multicellular design[2, 3] or by means of an acoustic diverging lens[4].

The above faults made the system sound characteristically coloured when compared with professional monitor loudspeakers (the Spendor BC1 and Rogers BBC monitor) although it sounded fairly reasonable on its own. For any further development of a horn top end I would personally opt for a drive unit specifically intended for "pressure loading" (which means in effect a smaller, lightweight diaphragm loosely suspended) and work along the lines indicated by Klipsch[5]. Conventional speakers do not seem to take kindly to horn loading.

One point which Mr Dinsdale does not seem to have covered in his historical survey is the effect of a time delay due to the length of the low frequency horn; if this is several feet long the low frequencies will be delayed by several milliseconds. In the 1930s it was noticed that this can cause audible echos on some transients and thenceforth the high frequency horns of cinema loudspeakers were moved back so that the drivers were in line rather than the horn mouths. While this is not entirely practical for folded domestic systems, the high frequency horns should be set back as far as possible. Phase matching at the crossover frequency is still desirable, of course, taking into account the phase shifts in the crossover network itself.

I would like to end by suggesting that in order to minimize the size of bass horns more research should be done into the design of corner standing units. The corner horn can be thought of as an acoustic coupling between the drive unit and the conical horn formed by the corner of the room. Freehafer[6] has analysed a horn of this form, the true hyperbolic horn (not to be confused with the more common family of horns characterized by hyperbolic trigonometric functions and often called "hyperbolic" or "hypex" horns). He was able to do this without making the usual plane wave assumptions and found that the low frequency response was much better than that of the conical horn to which it is asymptotic. He states that "... hyperbolic horns favour the low frequencies to a much greater extent than do the corresponding conical ones. Since the hyperbolic horn differs in shape from the conical only in the curvature near the throat, its better performance must be attributed to that curvature. It appears that the ideal horn shape approaches that of a uniform tube near the throat." This is potentially very interesting for the designer of corner horns as the throat is the only part of the horn over which he has control. Unfortunately due to the complexity of the mathematics involved it would seem that computer simulation of the system is the most promising approach to an optimal corner horn.

D. C. Hamill,
Wimbledon,
London SW19

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3. H. F. Olson, "Acoustical engineering". Van Nostrand (1957).
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5. P. W. Klipsch, "A high quality loudspeaker of small dimensions". *J. Acous. Soc. Am.* 17, p.254 (1946).
6. J. E. Freehafer, "The acoustical impedance of an infinite hyperbolic horn". *J. Acous. Soc. Am.* 11, p.467 (1940).

*The author replies:*

Mr Hamill provides some valuable comments on his experiences with horn-loading the KEF units. In my opinion the B139 is the best available driver for bass horns, and even more impressive results can be obtained from using two or even four such units (connected in parallel) at the throat of a suitably-designed horn. For those with limited space, a single bass horn driven by two (or four) B139s, with one (or two) drivers handling the bass range up to (say) 400Hz for each channel, employing acoustic mixing within the horn itself, can provide a useful compromise. There is little stereo information below 1kHz, so this compromise is quite legitimate.

The formation of standing waves across rectangular mid-range horns is all too common an experience, and I feel that the only real solution to this problem is to employ horns of circular section, in spite of the greatly increased difficulty of manufacture. Nevertheless, I have not personally experienced undue distress due to this cause from horns of similar dimensions to those described in my article. Recent experience has now confirmed to me that the Lowther PM6 and PM7 provide the most natural sound in this middle-frequency range, especially when driving circular horns.

I entirely agree with Mr Hamill's comments about the T27, and confirm that it sounds best when mounted flush in a baffle. I would also recommend the

Eagle HT21 (which comes complete with its own diecast rectangular horn) as providing a useful addition to the top range.

The point about time delay is an interesting one: clearly the length of the low-frequency horn will cause phase distortion on transients, and I like the idea of setting the high-frequency horns back so that the drivers are in line. Regrettably, as Mr Hamill points out, this is not entirely practical in the domestic situation. I have of course stressed the importance of phase matching at the crossover frequency, and fully agree that phase shifts in the crossover network itself must also be taken into account.

Finally I endorse wholeheartedly Mr Hamill's call for a concerted attack on the optimum design of the corner horn using computer techniques, and I would be pleased to act as a "clearing house" for any ideas and results which readers of *Wireless World* may have on this subject.
J. Dinsdale.

## Calculator i.c.

Regarding the letter from A. M. Coppin in your May issue, it is possible to purchase a seven-segment to b.c.d. encoder chip. National Semiconductor recently announced the DM 86L25 which provides the function in lower power t.t.l. Not having seen detailed specs, I can't say whether the chip would handle the decimal point in a manner suitable for a calculator.

It would certainly be simpler if the calculator chip had b.c.d. output. Furthermore, most calculator chips require that data be entered by simulating keyboard operation. This is another area where some changes could be useful. Also, only one calculator chip that I know of (National's MM 5738) has a "ready" signal to indicate when calculations are complete. This chip is also supposed to permit defeating the keyboard de-bounce circuitry to provide for faster data entry by keyboard simulation.

Reader Coppin should consider publishing the calculator design in *Wireless World*. It sounds very interesting.
R. E. Smallwood,
Calgary,
Alberta,
Canada.

## Electrostatic forces on pickups

As I do not use a record turntable having a plastic dust cover I do not experience the trouble described by Mr M. P. Hide (Letters, June issue) but this fact does not deter me from proposing a solution to his problem. The same cause has given rise to drastic inaccuracies and long-term spurious deflections in indicating instruments with plastic windows. I have found that smearing the plastic with only slightly diluted liquid washing-up detergent, such as Fairy Green, and very lightly polishing-off to leave an extremely thin film on the plastic surface, has been completely effective for many months after treatment. After treatment, breathing on the surface removes any appearance of smearing. The turntable can, of course, be treated on the underside so that the film is less liable to damage and where dust is less likely to adhere to it.

The maker's recommended playing weights for my Shure V15 type II cartridge are as for the V15 type III unit. Like Mr Hide I use the SME arm. I find no real advantage in using less than 1gm playing weight, so if he does not already play above the 0.75gm minimum recommendation I suggest that he so does as a partial solution to his problem.
John A. Young,
Girlsta,
Shetland Isles.

First reaction to Mr Hide's problem of the galumphing pickup arm (Letters, June), why not "paste" some domestically available aluminium foil to the inside surfaces of the plinth cover connected via a pigtail between the hinges to the underside of the pickup arm mounting?

Without even considering the rules of electrostatics it seems highly unlikely that any electrostatic force could exist between two metallic objects tied to the same potential, and electrostatic forces elsewhere should be balanced. If the handling of the somewhat cussed foil to give a wrinkle-free finish should prove a problem, or the choice of an appropriate adhesive, what about aerosol aluminium paint, possibly matting the surfaces first with pumice powder. The pigtail can be attached with masking tape, "spotting in" over this afterwards.
C. Bradshaw,
Cookham,
Berks.

## Tuning the electronic piano

I would like to suggest the following method of tuning any locked-divider electronic polyphonic keyboard instrument.
1. Ensure vibrators or tremulants are "off". Tune middle A to 440Hz, using a fork or BBC test tone transmission.
2. Tune the D below so that it sounds a perfect fifth (zero beat) with the A440. (This should be easily recognized as the commonly heard violin tuning procedure.)
3. Sharpen the D (increase frequency) until it beats with the A at approximately 1 beat per second.
4. Now play the D and the G below it and tune the latter (first to a perfect fifth, then sharpened to 1 beat per sec.).
5. Continue sounding the G *one octave above* (392) and tune the C below in like manner.
6. Confine the sequences to the middle octaves (by jumping up one octave as required) and carry on tuning in fifths (adjusting the lower note each time) until the final interval is reached, which is E (659) sounded with the fifth below (your original A440). This should sound like the other intervals (a perfect fifth slightly diminished).

The musical reason for diminishing each interval is simply that all modern keyboard instruments are "equal temperament" tuned so that they can be played in any key.

To prove the point; if the instrument is tuned in fifths as described without diminishing each interval the final check interval (E to A) will be so diminished as to sound appalling!

For greater precision, if the instrument can be made to sustain, the beats can be counted over 10 seconds, as per the table given in the interesting book by Richard H. Dorf, *Electronic Musical Instruments*.
Kenneth Palmer,
Kensal Rise,
London.

## Rectifier meter errors

I was interested to read Thomas Roddam's article pointing out the errors which arise when rectifier meters are used to estimate r.m.s. values of distorted waveforms (May issue).

Roddam deals with the case of a voltage waveform containing fundamental plus third harmonic, the amplitude of the third harmonic being 0.06 times the fundamental. He obtains an r.m.s. value which is 1.03 times the amplitude of the fundamental. Allowing for all possible values of the phase relation between fundamental and third harmonic, Roddam obtains a maximum possible error for the rectifier meter reading of 5%.

I suggest that these values exaggerate the possible error, since a rather more conventional approximation for the square root, viz:

$$(1+h^2)^{\frac{1}{2}} \approx 1+\tfrac{1}{2}h^2 \; (h^2 \ll 1)$$

gives a true r.m.s. reading of 1.0018 times the fundamental, giving a maximum possible error for the rectifier meter reading of 2.2%.

Using the same approximation with $h=0.12$ the true r.m.s. reading is 1.0072 times the fundamental, giving a maximum possible error of just under 5%.

Perhaps Mr Roddam would care to comment.
P. Williams,
UWIST,
Cardiff.

*The author replies:*
Mr Williams is, of course, quite right. I cannot explain or excuse my stupidity, because I have always used, for guidance, the simple rule that you cannot trust a meter to better than $(d/3)$%, if the distortion might be third harmonic, or $(d/n)$% if you know it is all the $n$th harmonic. My choices of 6% and 12% in the article were intended to give 2% and 4%, and to show that with 12% distortion there is no real room for manoeuvre when claiming a 5% tolerance.
Thomas Roddam.

# Electricity and Magnetism? (Part 1)

## Riding on an electron: a relativistic approach to the nature of magnetism

by "Cathode Ray"

From a literary quiz: Which book title has been chosen by the largest number of authors?

My guess would be "Electricity and Magnetism". For this purpose I think we might be allowed to include all those who, either to display their striking originality or possibly their sense of priorities, chose "Magnetism and Electricity". These unadorned titles have appeared on the covers of quite a large number of different books, and if we added (as well we might) those really vain attempts to disguise the essential sameness of the subject matter by such expressions as "Elementary . . .", "Introduction to . . ." (a favourite device for the more advanced and difficult treatises), "Short Course on . . .", " . . . for Beginners", etc., the total would be quite formidable.

Why is it that these two things are as inseparable as bacon and eggs or Morecambe and Wise? Or rather, have become so? For both were well known separately for thousands of years as curious but unconnected phenomena. During all that time electricity was noticed as mysterious attractions and repulsions, and even sparks, when certain substances (such as amber—Greek: *elektron*) were rubbed together. This was what we call static electricity—the segregation of unlike charges. Current electricity came much later and at first was not identified as having anything to do with it. Magnetism was noticed in the naturally-occurring iron-bearing mineral lodestone, and was named after the Aegean district of Magnesia, where lodestone was found. It too was an affair of attractions and repulsions, and when magnetism and static electricity began to be studied scientifically (17th and 18th centuries) it was found that they conformed to similar laws, notably the laws of inverse squares.

Meanwhile, current electricity had been discovered, and in 1820 Oersted established the first link-up by showing that electric currents produced magnetic effects. Ampère, with prophetic insight, surmised that the magnetic effects of lodestone and other permanent magnets might also be due to electric currents, on a sub-microscopic scale within the magnet material. (This, though much later it proved to be true, must have seemed most unlikely at the time, as electric currents needed batteries to produce them, and of course the electrical nature of matter was then unknown.)

Faraday tried to perform the reverse experiment, to produce an electric current by a magnet. He was unable to do this with a stationary magnet, but in 1931 he made the discovery that an electric current could be produced by a *moving* magnet, and in so doing he laid the foundation stone of electrical engineering. He also did quite a bit towards proving that current electricity is just static electricity in motion, so that they are essentially the same thing.

The link between electricity and magnetism was tightened when Moxwell produced his famous equations defining electromagnetic waves. More recently, in a television broadcast, the late Sir Lawrence Bragg remarked that magnetism is electricity looked at sideways. And so we come to the question: Are electricity and magnetism closely related but fundamentally separate things? Or are they two aspects of one thing, and if so what thing?

Does it matter? Scientifically it certainly does, and even people who have no interest in science that is just theoretical and academic must admit that today's useful things have come out of yesterday's abstract theory. Scientific progress is often made by putting together isolated facts and finding that they fit, like a jigsaw puzzle, into some general design. Newton made a big step forward when he found that a lot of pieces fitted together into a Law of Universal Gravitation. This seemed to be one of those things that had to be accepted as fundamental, rather than following from something else. But Einstein (of whom more anon) came along with his General Theory of Relativity, in which gravitation was a side effect. The rest of his life he was searching for a still more unified design.

Much in all those books on Electricity and Magnetism is devoted to expounding the relationships between the two things. They appear as equal partners in a beautifully symmetrical system of mutual support. Oersted showed that (what was later discovered to be) moving electric charges caused magnetism, and Faraday showed that moving or varying magnetism caused electricity. In radio waves a moving electric field is creating a moving magnetic field, and the moving magnetic field is creating the moving electric field, and who is to say which comes first or is the more fundamental?

The most significant thing that both do is to produce forces. The lodestone attracted iron filings, and the rubbed amber or glass attracted pith balls or bits of paper. These forces are independent of matter between the attracted bodies; they occur even across empty space. Which is very mysterious indeed.

We try to disguise our ignorance by saying that the forces are due to electric and magnetic fields. But while that is convenient for discussing the facts, it adds nothing to knowledge. Although electric and magnetic fields (and forces) are similar to one another in many respects, there are some essential differences.


*Fig. 1. $q_1$ and $q_2$ represents two electric charges concentrated at points. The force between them is proportional to $q_1 q_2/d^2$.*

The starting point is Coulomb's law, which says that two isolated point charges, $q_1$ and $q_2$ in Fig. 1, separated by distance $d$, exert a force on one another proportional to

$$\frac{q_1 q_2}{d^2}$$

If the charges are of the same sign the force repels them from one another; if unlike, it attracts. Although there are no such things as point charges, electrons and even positive ions are very close approximations to them.

From the principle that the total force on a charge is the vector sum of all those acting, one can work out the forces between other configurations of charges, such as parallel plates. For convenience it is all done in terms of the fields that are said to surround charges. One isolated point or spherical charge has a radial field; parallel plates have a uniform field; etc. The force on a point charge in an electric field is proportional to the strength of the charge and the intensity of the field (without the charge).

Theoretically there is a counterpart of Coulomb's law in magnetism, but it suffers the serious disadvantage that in practice there is nothing even approximately like an isolated magnetic pole at a point. However, one gets magnetic fields of the same shapes as electric fields, and the forces work on the same principles.

Coming now to the link-up, we note that a magnetic field has no effect on a stationary charge, but directly the charge moves it experiences a force. That is because a moving charge (usually one of many forming a procession called an electric current) generates a magnetic field, which reacts with the magnetic field already there, just as the electric fields of $q_1$ and $q_2$ react on one another. So if two charges move relative to one another they experience forces due to both electric and magnetic fields. This makes things rather complicated. But in practice we are interested in moving charges most often when they are currents in wires or some other conductor. Here each moving negative charge (electron) is exactly offset electrically by a positive charge fixed in the structure of the wire. So the wire as a whole is electrically neutral, and the forces that current-carrying wires exert on one another are wholly magnetic.

Correspondingly, when magnets move they cause electric fields. We rely on this very heavily, as it is the principle on which power stations work.

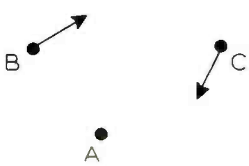


*Fig. 2. Two point charges at B and C are moving relative to one another. The accounts given of this state of affairs by observers B fixed to B, C fixed to C, and A stationary at A, disagree fundamentally.*

In trying to summarize Electricity and Magnetism in a few paragraphs I have omitted to specify just what is meant by "moving". Take the two "moving" charges, *B* and *C* in Fig. 2. So far as an observer *A* is concerned they are both moving, but if observer *B* happens to be travelling along with one of them he will say it is at rest and only the other charge is moving. So his charge can't be causing a magnetic field, so it can't affect or be affected by the other charge magnetically. *A* disagrees totally with this. Observer *C* travelling with the other charge agrees with *B* so far as the absence of any magnetic reaction is concerned, but disagrees flatly with him on which charge is causing the magnetic field that all three agree is present.

It should be clear from this example that until we can sort out this problem the study of Electricity and Magnetism is futile.

One thing we can say definitely is that the velocities of charge-carrying and magnet-carrying objects, and the kind (electric or magnetic) and strength of any field present, depend on the state of motion or non-motion of the instruments used for observing these things.

I started writing this article in November 1962. No; I didn't forget about it or lose it. I've been trying all this time (on and off!) to answer the title question without letting down those kind people who tell me they can understand most of what I write. All the treatises I could find on the subject were either in the mathematical stratosphere or were too vulnerable to the persistent questioner. Even now I fear you may find I have just added to the number of these.

Imagine that there are two observers, equipped with means for measuring strength and direction of electric field (*E*) and magnetic field (*H*) or, more likely, magnetic flux density *B*, which is equal to $\mu H$, $\mu$ being the local permeability. They are operating in the gap between the poles of a vast magnet (Fig. 3) which maintains

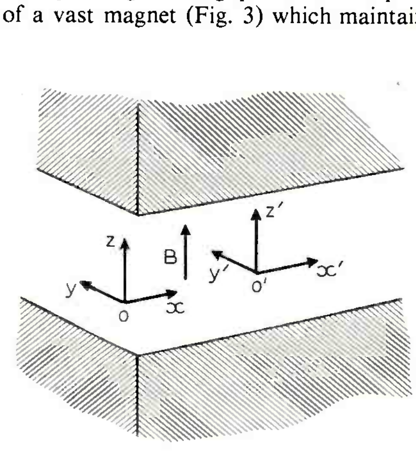


*Fig. 3. Two observers, O and O', are measuring electric and magnetic fields between the poles of an extensive magnet. O' is moving along direction x with velocity v relative to O. They too disagree over their findings.*

a uniform *B* vertically upward. Observer *O* is stationary relative to the magnet, but *O'* is moving away from him with constant velocity *v*. As fields are three-dimensional, the observers need to agree on their "frames of reference", having *x*, *y* and *z* axes all mutually at right angles as shown. And to make things as simple as possible *x'*, *y'* and *z'* are parallel to *x*, *y* and *z*, and *O'* is moving along *x* which is in the same line as *x'*.

*O* reports that there is a positive *B* along his positive *z* axis, none along *x* or *y*, and no *E* at all. *O'* reports the same with one exception. His *y'* axis is cutting the magnetic flux. The well-known electrical engineers' generator rule predicts an e.m.f. *e* equal to *Bvl*, where *l* is the length of a conductor cutting the flux. But the e.m.f. is the result of a field *E* equal to *e/l*, which exists by virtue of the motion in *B*, whether there is a conductor or not. So *O'* finds an electric field along the *y'* axis, and Fleming's right-hand rule tells us that it will be negative along $+y'$. In his shorthand he would say

$$E'_y = -vB_z$$

or, since the counterpart of *E* is *H*,

$$E'_y = -v\mu H_z$$

If there was also an electric field along the same axis, $E_y$, detectable by *O*, the total $E'_y$ would be $E_y - v\mu H_z$. And if there was a magnetic field $H_y$ and also an $E_z$, by the same arguments we would be able to say

$$E'_z = E_z + v\mu H_y$$

But any magnetic component along *x* would not be cut by movement in that direction, so $E'_x$ would be the same as $E_x$, if any. Putting all these together we get

$$E'_x = E_x\,;\; E'_y = E_y - v\mu H_z\,;$$
$$E'_z = E_z + v\mu H_y \qquad (1)$$

Next we ask *O'* for a magnetic report. Having already considered the possible existence of an electric field specified in magnitude and direction by $E_x$, $E_y$ and $E_z$, we must be prepared to hear that *O'* finds his movement through such a field causes magnetic effects unknown to *O*. Suppose, for example, that the lower pole-piece was charged positively and the upper one negatively, so that there was a positive $E_z$. *O'* would have reported this, along with anything due to cutting a *y* component of magnetic field, as in (1). But, unlike *O*, he would see the + and − charges moving past him in the $-x'$ direction. So far as he was concerned they would be electric currents, and the corkscrew rule tells us he would see a magnetic field due to these currents, along the *y'* axis. Reference to the textbooks would confirm the *O'* report of a magnetic field equal to $v\epsilon E_z$ along the $+y$ axis, $\epsilon$ being the local permittivity. This is in addition to any $H_y$ noted by *O*. Similarly, any $E_y$ would give rise to a magnetic field $-v\epsilon E_y$ along *z* besides any $H_z$ noted by *O*. But the existence of an electric field along *x* is not seen by *O'* as a current, so $H'_x = H_x$.

Putting these together we have

$$H'_x = H_x\,;\; H'_y = H_y + v\epsilon E_z\,;$$
$$H'_z = H_z - v\epsilon E_y \qquad (2)$$

(1) and (2) together are a complete formula for predicting how any combination of fields we see will look to someone else moving away from us with constant velocity *v*. If he happens to be moving towards us, that is covered by a negative value of *v*. And if his movement is not along or parallel to our *x* axis, then all we have to do is reorient both our frames of reference so that he is.

After that achievement we may be tempted to put it away for (improbable) future reference. But if we have the true scientific insistence on cross-checking everything, we (*O*) will change places with *O'* and solve our set of equations (1) and (2) for *E* and *H*, to see how our observations *E'* and *H'* will look to the new Mr *O*. For example, we pick out from (1)

$$E'_y = E_y - v\mu H_z$$

and from it immediately get

$$E_y = E'_y + v\mu H_z \qquad (3)$$

Then, to deal with $H_z$ we pick out from (2)

$$H'_z = H_z - v\epsilon E_y$$

which gives us

$$H_z = H'_z + v\epsilon E_y$$

and substituting this in (*3*) we get

$$E_y = E'_y + v\mu H'_z + v^2\mu\epsilon E_y$$

So

$$E_y(1 - v^2\mu\epsilon) = E'_y + v\mu H'_z$$

and

$$E_y = \frac{E'_y + v\mu H'_z}{1 - v^2\mu\epsilon} \qquad (4)$$

If we are in empty space, $\mu$ and $\epsilon$ will be $\mu_o$ and $\epsilon_o$, the permeability and permittivity of space, or the space constants as one ought to call them. (For our comfort, almost the same values apply to air.) One of their basic relationships is

$$\mu_o \epsilon_o = \frac{1}{c^2}$$

$c$ being the speed of light in space. So we can substitute $(1 - v^2/c^2)$ *for* $(1 - v^2 \mu\epsilon)$.

Either way, this result is very disturbing. When we changed places with $O'$ we saw $O$ moving with velocity $-v$ along our axis $x'$. Working out the equations for $E$ and $H$ as we did for $E'$ and $H'$ from position $O$ we would expect them to be the same except for the reversal in sign of $v$ and the interchange of dashed and undashed letters. That is indeed true of (4) except for the factor $(1 - v^2 \mu_o \epsilon_o)$ or 1 $(1 - v^2/c^2)$. *We* will find this same factor intrudes into every equation involving $v$. But it oughtn't to! There is a downright contradiction between the results of solving equations (1) and (2) to give $E$ and $H$ in terms of $E'$ and $H'$, which gives us the intruder every time, and deriving the inverse equations for $E$ and $H$ in the same way as we derived those for $E'$ and $H'$.

This is quite mad and impossible! Unless perchance the value of the intruder turns out to be 1. But it only is when $v = 0$! Admittedly any practical velocity even up to rocket speeds is so much less than the speed of light that the discrepancy would seem to be negligible. But there oughtn't to be *any* discrepancy between what $O$ sees of $O'$ and $O'$ sees of $O$, apart from the reversal of $v$!

At least we can get rid of the lack of balance between the sets of equations, (1) and (2), and their $E$ and $H$ counterparts if we split the intruder into two equal parts by taking its square root and attaching this to *all* the equations. For convenience we can give this half-intruder a single symbol, $\beta$:

$$\beta = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

Then our original (1) and (2) become

$$\left.\begin{array}{l} E'_x = E_x;\ E'_y = \beta(E_y - v\mu H_z);\ E'_z = \beta(E_z + v\mu H_y) \\ H'_x = H_x;\ H'_y = \beta(H_y + v\epsilon E_z);\ H'_z = \beta(H_z - v\epsilon E_y) \end{array}\right\} (5)$$

and if we derive from these their $E$ and $H$ counterparts, either by solving the above simultaneous equations or by reversing the sign of $v$ to take account of the reversal of viewpoint, we get a set corresponding to (5), with the factor $\beta$ in the same places.

That gives them a nice symmetrical appearance, but how can we justify the insertion of $\beta$ when it has no place in the well-tried laws of electro-magnetic induction which we used to arrive at (1) and (2)?

It must be admitted that we are not the first people to puzzle over this. As long ago as 1895 the physicist Lorentz had reached the conclusion that the laws of electricity and magnetism needed to be supplemented by $\beta$ before the estimates made by observers in motion relative to one another could be reconciled.

This was one of the pieces that Einstein put together a few years later to compose his Special (or Restricted) Theory of Relativity. Velocity is of course length divided by time, and Einstein showed that the behaviour of Nature could not be accounted for exactly if the basic quantities length, time and mass were, as hitherto assumed, independent of their relative motion. You can hardly expect me to insert a complete treatise on this rather involved subject right here, but there is a simple explanation in "The Electron in Electronics", by M. G. Scroggie, Chap. 10 (Butterworth, 1965). The main results are:

(1) Bodies moving relative to the observer appear to him to have shrunk in the direction of motion by the factor $1/\beta$.

(2) The time interval between two events occurring in a system in motion relative to an observer appears to him longer by the factor $\beta$ than it does to an observer moving with it.

(3) A moving mass appears $\beta$ times greater than the same mass at rest relative to the observer.

(4) Because no frame of reference has any "absolute" status, all have equal status, so while observer A sees B's spaceship has shrunk in the direction he is going, according to (1) above, B notices exactly the same thing about A's. Assuming they have identical models, each sees the other's ship is shorter and heavier than his own and his clocks run slower.

All very well, you may say, but aren't we moving at rather high velocity away from our question of which comes first, the electric egg or the magnetic chicken?

Well, frankly, no. We shall be needing Lorentz-Einstein before we've finished. Meanwhile it may encourage us on our way to note that we already have an answer to the title question. It is the very basis of relativity that no frame of reference has any higher status than another; in other words, all velocities are relative—there can be no fixed point from which to reckon absolute velocity. So although in Fig. 3 Mr $O$ says there is no electric field, Mr $O'$ says there is, and both are equally right. Although therefore it is in practice convenient to have the separate names "electricity" and "magnetism", they are parts of one whole, in the way Bragg meant.

As to priority, electricity must be a hot favourite. Electric charges are things that are there and can be manipulated one by one. Unlike those apparently absolute things, length, time and mass, electric charge is absolute and unaffected by velocity or anything else. It needs no magnetic or other action to bring it into existence.

How about electric power generators, which depend on moving magnets? Well, it is true that they need these for separating already existing charges of opposite sign. But it is not the only way of doing that—there are such things as batteries and rapidly-taken-off nylon underwear—and anyway the magnets rely wholly on electric currents in the first place. Even permanent magnets owe their magnetism to internal electrical action.

So we can conclude that electricity is the fundamental thing and magnetism a by-product.

Can one go even further than that and say that the two things are the same—the forces that pull magnets together and activate magnetic compasses and pull electric motors round (or, in the case of Professor Eric Laithwaite, straight along) are identical with the electrostatic forces that draw pith balls and gold leaves together in electroscopes and make the rapidly-taken-off vest behave as if it was trying to get back on again?

This seems obviously going too far; if it were so, how is it that one can distinguish between electric and magnetic fields? An electrically charged droplet placed in an electric field is urged thereby into motion, but if placed in a magnetic field it takes no notice.

This delicately poised state of our inquiry is perhaps the right moment at which, as Reginald Bosanquet would say, to take the break. Be with us in Part 2 to see the answer to the question, how is it possible to hold that things which can be distinguished are the same.

# Sixty Years Ago

The leader page of the September 1914 issue voiced a problem which has recently become a familiar one again but for a different reason. "Our readers will notice that the present issue is a slimmer volume . . . due to the anticipated shortage of printing paper, which is one of the consequences of the war."

Elsewhere in the issue the war occasionally sank into the background. K.K.G., relating his experiences with a kite aerial, "Found that a two-foot kite would take with ease a 36-gauge 600-foot aerial in a normal wind and keep it there without any trouble. A stouter aerial is somewhat better, but has the disadvantage of requiring a larger kite, and should a gust of wind raise the kite suddenly there is a danger of its soaring off with the receiving set."

Finally, who can argue with the unfathomable depths of wisdom which concluded a piece on psychology and telegraphy "In conclusion, the sub-conscious mind may be likened to the phonograph. The impression made upon the wax record has a conscious source, and from the record it is reproduced mechanically" . . . Pardon?

## Corrections

**"Electronic ignition techniques"**. In the article of the above title in our July issue the address given for Future Tecmatics in reference No. 6 should be 4 Arkwright Road, Launton Industrial Estate, Bicester, Oxon.

In the article **"Coloursound System"**, by J. R. Penketh, May 1974, pin 4 of the first amplifier in Fig. 7 should be connected to line 10 not 9.

# Transmission lines for the birdwatcher

## Basics and relevance of techniques for the Radio Amateur with introductory construction details

by P. I. Day, B.A.

*Jesus College, Cambridge*

**A short article on the basics of transmission lines, including a derivation of several equations. Construction details will be of interest to anyone considering building circuits in stripline form. The title is based on a suggestion by Francis Crick, recorded in the book *The Double Helix*, by James Watson, that he would write a book on Fourier Transforms for the non-mathematician to be entitled "Fourier Transforms for the Birdwatcher".**

For many years considerable effort has been devoted by the electronics industries and research laboratories throughout the world to developing and perfecting transmission systems capable of handling the rapidly increasing communications traffic. Britain, France, America and Japan amongst others are developing systems which will operate on overmoded $TE_{01}$ circular waveguides in the range 30–130GHz, the intermediate frequencies for this equipment lying in the range 1–5GHz. This is a compromise between the bandwidth needed to cope with projected rates of digital transmission per channel and the rapidly increasing costs of amplifiers as the frequency is raised. Japan has chosen a starting frequency of 4GHz whereas Britain has chosen 1.25GHz. Many of the techniques involved at these lower frequencies have applications in the Radio Amateur bands at 23cm and above which at present are little used. The frequency range quoted is conveniently covered by stripline or microstrip, the lower frequency being limited by size considerations of the distributed elements, the upper by losses which can rise rapidly with the substrate materials available for amateur use at a reasonable price.

Fig. 1 shows the method of construction of three types of transmission line which may be used at these frequencies; triplate and coaxial lines have the disadvantages that the final circuit form is relatively permanent, not easily adjustable and difficult for mounting discrete components. None of these disadvantages apply to stripline and for this reason it has been chosen as the transmission medium. In addition, its construction is compatible with printed circuit techniques which are already familiar to many people.

A transmission line may be characterized by two quantities, impedance and propagation constant. These can be understood by considering an infinite length of line. On applying a voltage to one end of the line, a wavefront will propagate down the line at a speed and with an attenuation determined by the propagation constant. The current flowing into the line is simply the voltage divided by the characteristic impedance. If we now apply a sinewave to this line, two points separated by a distance $x$ will have a phase difference between them of $2\pi x/\lambda_m$ at any instant of time; $\lambda_m$ is the wavelength in the transmission line at the applied frequency. There will also be an attenuation in amplitude. These two components are combined by stating that the wave propagates as $e^{-\gamma x}$, where $\gamma=\alpha+j\beta$, $e^{-\gamma x}$ is the attenuation component, $\alpha$ measured in Nepers/metre and $e^{-\beta x}$ is the phase variation, $2\pi/\lambda_m$ radians/metre.

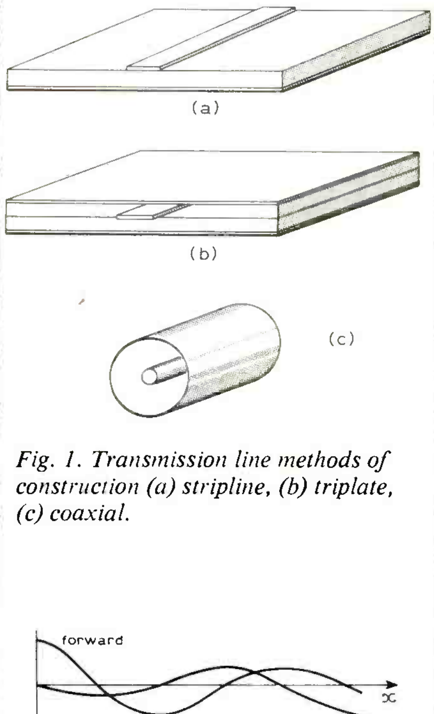


*Fig. 1. Transmission line methods of construction (a) stripline, (b) triplate, (c) coaxial.*

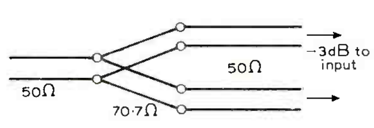


*Fig. 2. Forward and backward reflected waves on a transmission line.*




*Fig. 3. Simple means of forming a power splitter.*

Fig. 2 shows an example of a forward propagating wave, and a wave travelling in the reverse direction due to a generator at the opposite end of the line which will progress as $e^{\gamma x}$. Due to these two waves we will have a total voltage and current at any point on the line given by

$$V_T=V_+e^{-\gamma x}+V_-e^{\gamma x}$$

$$I_TZ_0=V_+e^{-\gamma x}-V_-e^{\gamma x} \quad \ldots\ldots\ldots (10)$$

The voltage measured across the line is in the same sense for both waves, whereas the current flowing is of opposite sense. For our purposes we can usually neglect the attenuation of the line and consider only the phase variations.

In the Appendix the impedance has been derived at the input to a line terminated by an arbitrary load. From this we will consider four conditions of termination which are of further interest. For a correctly terminated line

$$Z_L=Z_0 \quad Z_{IN}=Z_0$$

for a short-circuit $Z_L=0$, $Z_{IN}=-jZ_0\tan\beta x$,

for an open-circuit $Z_L=\infty$, $Z_{IN}=jZ_0\cot\beta x$

and if $\beta x=\pi/2$ $\quad Z_{IN}=Z_0^2/Z_L$

The first three conditions are self explanatory, the last is one which needs some clarification. It may be loosely referred to as the quarter-wavelength transformer effect; $\beta x = \pi/2$ is equivalent to $x = -\lambda/4$, the load $Z_L$ is transformed by the line to $Z_0^2/Z_L$. We have chosen our reference such that the distances measured away from the generator are positive and those away from the load are negative; this is a common convention and explains the apparently odd use of the negative sign in the transformer example.

Now that we have derived some of the basic situations to be met in transmission lines, we can look at practical uses for them. The quarter-wavelength transformer may be used where power has to be transferred from one impedance level to another. As an example we will consider the situation where power in one line has to be equally split between two other lines of the same impedance with minimum loss; such a circuit is shown in Fig. 3. The lengths of the matching sections of the line are $\lambda/4$ at the required frequency and have an impedance such that the input to each arm is $100\Omega (70.7^2/50 = 100\Omega)$ and when these two arms are joined in parallel the input impedance matches the line impedance. This particular example is a member of an infinite series of power splitters using varying numbers of matching lines in each arm and with resistances connected between the arms. Using a quarter-wavelength transformer and a stub we can match any complex impedance into a 50Ω line; such a situation may arise when we have to match a transistor into a distributed circuit. The input impedance to a transistor in common base mode is a low complex impedance which we will denote as $Z_1 + jZ_2$. We can remove the imaginary component with a stub and then transform the remaining real impedance to the required level. A circuit to perform this function is shown in Fig. 4; the input impedance to the circuit consisting of the transistor and stub in series is

$$Z_{in} = (1/jZ_{stub} + 1/(Z_1 + jZ_2))^{-1}$$
$$= Z_1 + Z_2^2/Z_1 \text{ if } Z_{stub} = -(Z_2 + Z_1^2/Z_2)$$

To match this $Z_{in}$ to 50Ω we require a line of impedance

$$Z_0 = \sqrt{50(Z_1 + Z_2^2/Z_1)}$$

and length $\lambda/4$.

Using some typical values $Z_1 = Z_2 = 5\Omega$
$Z_0 = 22.4\Omega$
$Z_{stub} = -10\Omega$

If the stub impedance is derived from an open circuit 50Ω line then the length should be $0.22\lambda$. This transformer section will have a 25% bandwidth for a v.s.w.r <1.5, and proportionately less for reduced v.s.w.r. limits; this is dependent on the impedance ratios involved (0.45 in our example), the nearer to unity the wider the bandwidth. Wideband transformers may be constructed by using several impedance transformation steps instead of the single step considered here.

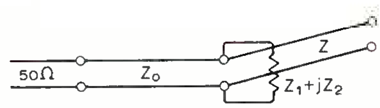


*Fig. 4. Transistor matching circuit.*

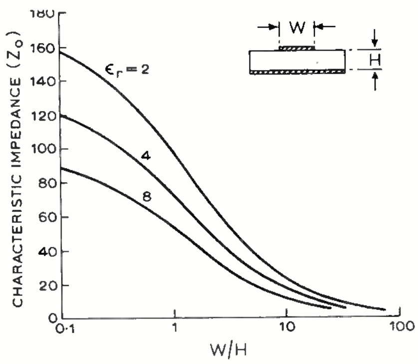


*Fig. 5. Characteristic impedance curves of a stripline construction.*

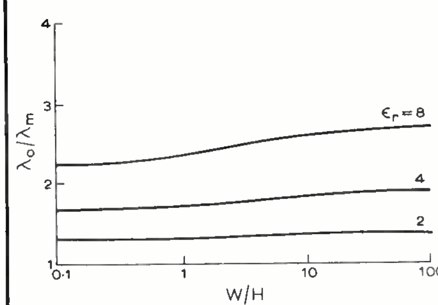


*Fig. 6. Ratio of free space wavelength ($\lambda_0$) to stripline wavelength ($\lambda_m$).*

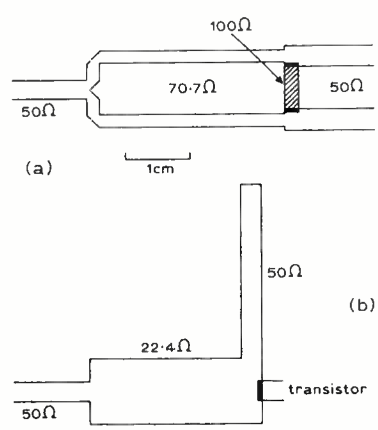


*Fig. 7. Stripline methods of construction for (a) power splitter, and (b) transistor match.*

From the theoretical circuits which we have reached we need some means to realize the practical circuit form. This is best provided by using graphs rather than theory which is inexact for stripline although in other constructions accurate theories can be considered. The graphs we require are those relating the wavelength and impedance to the width of line used and the dielectric constant of the substrate material. Extracts from typical curves are shown in Figs. 5 and 6 for a small range of dielectric constants. If for our examples the board is $\frac{1}{16}$in thick (metrication is somewhat lagging in certain fields) and with a dielectric constant of 4 and our design frequency is 1.25GHz; assuming the speed of light is $3 \times 10^8$ metres/sec then our free space wavelength is 240mm ($\lambda_0$). For the particular lines in which we are interested:

| $Z_o$ | H\W | $\lambda_o/\lambda_m$ | W | $\lambda_m$ |
|---|---|---|---|---|
| 22.4 | 6.5 | 1.85 | 10.3 | 130 |
| 50 | 2.0 | 1.75 | 3.2 | 137 |
| 70.7 | 1.05 | 1.70 | 1.7 | 141 |
| Ω | | | mm | mm |

The final appearance of the power splitter and of the transistor match is shown in Fig. 7. Note that a resistor has been added between the arms of the power splitter; this is to match any reflected waves in either of the output arms to prevent any further reflections which would otherwise degrade the performance. The actual lengths of the lines are not exactly as those given in the table due to the presence of end effects. This is particularly noticeable at the point where the stub joins the transformer in our second example: a further set of tables is needed to apply these corrections but a useful guide is to assume that at a junction the lines penetrate one another to 25% of the line width. This approximation is sufficient for our purposes and for this reason the curves are not included.

As a final example we will consider a band-pass filter, which although it may not be directly applicable to amateur use, is nevertheless typical of a particular class of filter, namely a quarter-wavelength shorted stub filter. A series of quarter-wavelength stubs are placed at quarter-wavelength spacing on the main transmission line. The number to be used is determined by the bandwidth and rate of cut-off outside the band. At the design centre frequency the impedance of these stubs appears infinite at the point where they join the main transmission line and consequently have no effect on the signal, but as the frequency alters there is an increasing interaction due to line lengths no longer being a quarter-wavelength long. This type of filter is of the reflection class, all the power either passes straight through or is reflected back, there is no lossy element to absorb any power other than the inherent attenuation in the transmission line and this we have chosen to ignore to simplify the analysis. Fig. 8 shows a filter with eight shorted stubs, designed for a centre frequency of 1.25GHz and a bandwidth of 600MHz,

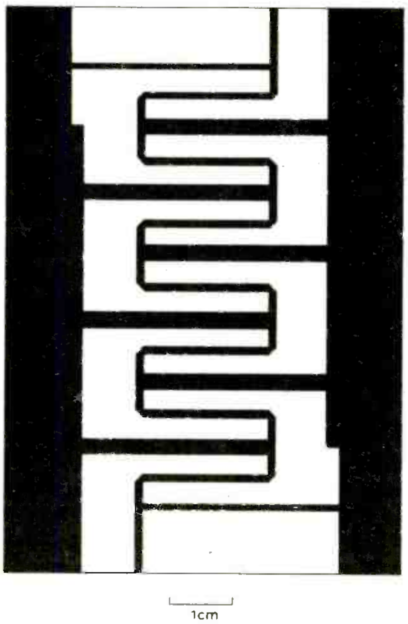


*Fig. 8. Stripline band-pass filter outline.*

constructed on a fibreglass board of $\frac{1}{16}$ in thickness and with a dielectric constant close to 7. The thinner stubs, those of higher impedance, are slightly longer due to the variation of wavelength with thickness as given in Fig. 6. The impedance of the six centre stubs is 33Ω, that of the other two 95Ω. The main line at 50Ω is folded to save space and connections may be made to the line either by connectors fed through from the opposite side or by edge connectors. The large areas at the end of the stubs must be adequately connected to the ground plane on the other side, this is probably best achieved by soldering a plate at right angles to the board so that it makes contact to both surfaces.

If the amateur is to attempt construction projects using stripline then he will have to face several problems not encountered by the professional. The design curves are not readily available on a market open to the amateur but are collected in "The Microwave Engineers Handbook" and other similar publications; most research establishments interested in microwaves will have an edition of this handbook which contains all the curves mentioned and much else besides. It is slightly easier to obtain substrate material as the fibreglass board advertised fairly widely in magazines is suitable at the frequencies considered. It must be copper-clad on both sides and will probably have a dielectric constant in the range three to eight, but individuals will have to determine the exact value for themselves. There are many magazines available whose primary function is advertising and many will contain information on suitable materials. A suggested method of construction is to obtain some "cut and strip" material on which it is possible to cut out the circuit and leave opaque lines on a clear base material, or vice versa as required: this can be used as a photographic mask to produce the finished circuit. The tolerances on the line widths are sufficiently large for non-critical applications that the mask may be produced using a sharp knife and steel rule. A complete circuit can be readily adjusted with the same knife, some adhesive copper tape and a little care. As might be expected the results will depend very much on the quality and accuracy of the design and construction.

It is worth noting that an extremely useful device called a Smith Chart is in existence which allows an analysis of a transmission line network to be carried out geometrically; if any serious work is contemplated the use of such a chart is essential and should be explained in many textbooks on microwaves which will cover the theoretical aspect of this work in far greater detail than is necessary or justified in an article of this type. Unfortunately, as with many subjects, there is no practical manual on the subject. Familiarity with this subject will show that there is more than one approach to any problem, in particular the transistor-matching circuit could have been achieved with a simple matching line without a stub. It is hoped that this article will help to stimulate interest in a subject which is relatively new to many people.

### Appendix

The total line voltage and current is given by the two equations

$$V_T = V_+ e^{-j\beta x} + V_- e^{j\beta x}$$

$$I_T Z_0 = V_+ e^{-j\beta x} - V_- e^{j\beta x}$$

The backward wave $V_-$ may be caused by a mismatched termination to the line. The impedance at any point on the line is given by $V_T/I_T$, due to the presence of $V_-$ this is no longer simply given by $Z_0$, but by

$$Z_{IN} = Z_0 (V_+ e^{-j\beta x} + V_- e^{j\beta x}) / (V_+ e^{-j\beta x} - V_- e^{j\beta x})$$

$$= Z_0 [(V_+ + V_-)\cos\beta x - j(V_+ - V_-)\sin\beta x] / [(V_+ - V_-)\cos\beta x - j(V_+ + V_-)\sin\beta x]$$

If the load $Z_L$ is at $x = 0$ then

$$Z_L = Z_0 (V_+ + V_-)/V_+ - V_-)$$

Substituting,

$$Z_{IN} = Z_0 (Z_L - jZ_0 \tan\beta x)/(Z_0 - jZ_L \tan\beta x)$$

This is the principal transmission line equation and every condition of interest may be developed from it.

The voltage standing wave ratio on the line is given by $Z_L/Z_0$ or $Z_0/Z_L$, whichever is greater than unity.

$$\text{v.s.w.r.} = |(V_+ + V_-)/(V_+ \pm V_-)|$$


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3. Theory behind stripline—the original authoritative paper, with design graphs. Wheeler, H. A., "Transmission Line Properties of parallel wide strips separated by a Dielectric Sheet", IEEE Trans. TT-13 1965, pp. 172–185.
4. Two articles and a very useful reading list, including other transmission media, Hosking, M. W.—The Realm of Microwaves (Parts 2 and 3), *Wireless World*, Vol. 79, March and June, 1973, pp. 131–133, 286–290.


# Coming Events

**"Aspects of Technical Documentation"** is a weekend residential conference organized by the Society of Electronic and Radio Technicians, to be held at The BBC Engineering Training Centre, Wood Norton Hall, Evesham, Worcestershire, on October 26 to 28. Registration forms and further information are available from the conference secretary at SERT, Faraday House, 8–10 Charing Cross Road, London WC2H 0HP.

A **Radio Amateurs' Examination Course** is to be held at Acton Technical College, High Street, London W3 6RD, Wednesdays, 6.30–9 p.m., commencing September 25. Enrolment is on September 12 and 18, 6.15 to 8.15 p.m.

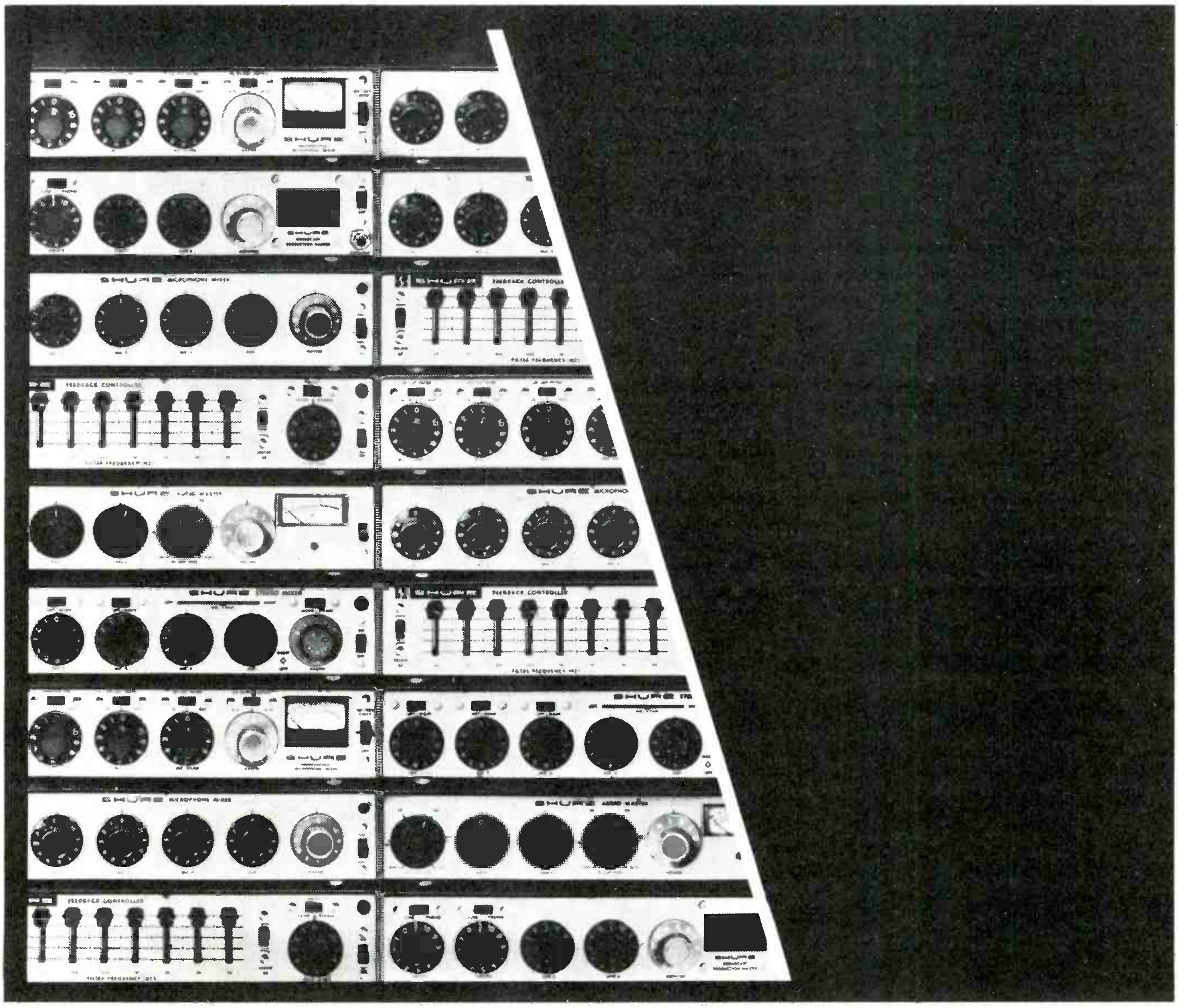
**Industrial electronics** is a basic course of 15 lectures for engineers to be held at Twickenham College of Technology on Wednesdays from 9 a.m. to 4 p.m. The course will run twice commencing September 25, 1974, and on February 19, 1975. Further information can be obtained from the course organizer, Twickenham College of Technology, Egerton Road, Twickenham, Middlesex TW2 7SJ.

A City & Guilds **Radio Amateurs' Course** (No. 765) will be held at North and West Farnborough Further Education Centre, Cove County Secondary School, St. John's Road, Farnborough, commencing on October 3 at 7.30 p.m. There will also be a **Morse Proficiency course** beginning on September 30 at 7.30 p.m. at Oak Farm School, Farnborough, Hampshire.

The City & Guilds **Radio Amateurs' Course** (No. 765) will also be held by the West Sussex Adult Education Committee at Marle Place, Leylands Road, Burgess Hill, Sussex RH15 8JD, starting September 26 at 7.30 p.m. There will be 30 classes—three terms of ten classes each.

A **Radio Amateurs' Course** will be held at the Gosforth Secondary School, Gosforth, Northumberland, commencing in September on Tuesdays and Wednesdays from 7 p.m. to 9 p.m. A prospectus and any further details can be obtained from the Principal at the School.

**"The Computer as a Design Tool"** is an exhibition and conference to be held at the Imperial College, London on September 24–27. Registration for the conference is £56 for the full programme or £28 per day. Full information on the double event can be obtained from the organizers CAD '74, IPC Science & Technology Press, 32 High Street, Guildford, Surrey GU1 3EW, telephone Guildford (0483) 71661.



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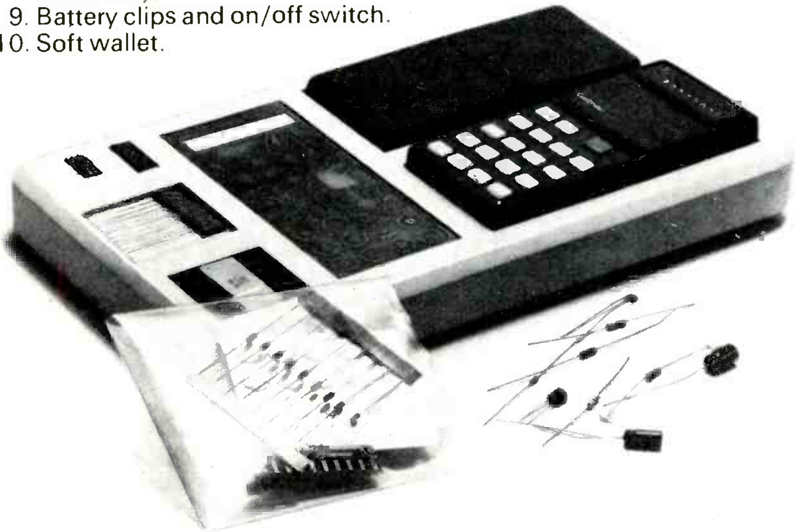

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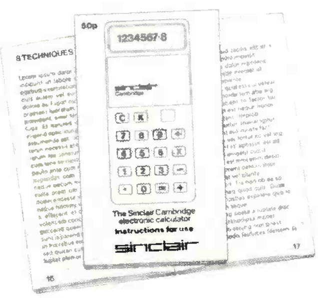

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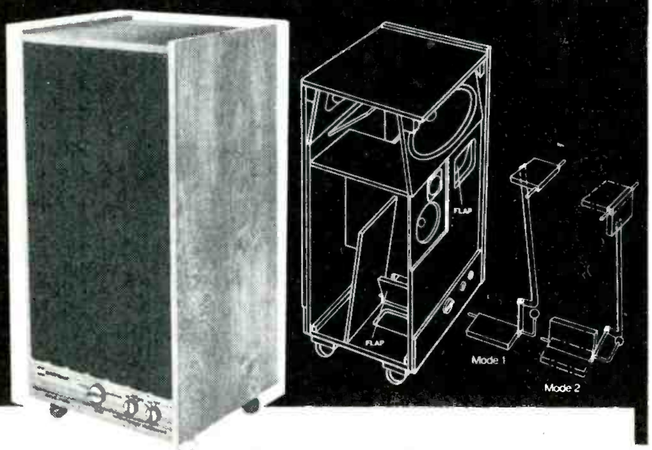


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# "Teleprinter" with a traverse display

by Brian T. Evans, B.Sc.

*Department of Medical Electronics, St Bartholomew's Hospital, London*

**A small portable teleprinter using a 32-character alphanumeric display tube has been designed for use in hospital intensive care situations to replace the "quiet mechanical" types originally used.**

A traversing-character type of display tube (Burroughs Selfscan) has been interfaced with an "electronic" keyboard (Honeywell) to provide a "teleprinter" which is both quiet and relatively inexpensive. This design eliminates the need for line-feed and carriage-return instructions because each new character received is displayed in the right-hand end of the tube and the remaining 31 characters move one place to the left. The display tube, type SSD 0132 0030, supplied with basic drive electronics, costs about £80 which compares favourably with individual l.e.d. matrix displays costing approximately £10 each. One disadvantage, however, is that the tube and electronics need +250V at 30mA, +5V at 160mA and −12V at 50mA supplies, the high voltage being hazardous to the m.o.s. read-only memory (r.o.m.) incorporated in the display.

The present design allows full or half duplex operation at 110 baud with 20 or 60mA loop current. All eight bits of each incoming character are stored allowing extra facilities to be provided. The eighth bit is used as a "flag" bit to check whether it was produced by the local keyboard or by a distant piece of equipment such as a computer. The "teleprinter" has the ability to blank characters from the display. The logic produces a blanking pulse for every control character presented to the display but this can be overridden by operating a switch at the side of the keyboard. We may therefore examine the unblanked display to check whether some control character such as line feed has been sent. Depressing the switch converts all control characters back to their display form, therefore control character S is displayed as S in the previously blank space. In addition, computer-generated characters with their eighth bit set to one may be blanked off the display leaving only keyboard-generated alphanumerics. It was convenient to use the "here is" key for this function as it is brought out as a separate d.c. contact closure at the back of the keyboard.

The "teleprinter" in Fig. 8 shows some additional features. To the left of the display, red and green indicator lamps and a thumbwheel switch are provided. In the hospital application the lamps indicate how far the computer has progressed through a nurse-generated command. "Green light on" means the nurse may input a new command; red light on, the nurse has not yet finished the command. Flashing red and green, the computer is executing the command. These lamps are driven from one of the computer's solenoid outputs but it is intended to operate them from unascribed American Standard Code for Information Interchange (ASCII) characters via the "teleprinter" receiver. The thumbwheel switch is used for patient identification so a patient in "bed four" may be selected, and all commands entered on the keyboard will then relate specifically to that patient. The b.c.d. output of the switch, together with the eight-bit parallel output of the keyboard, is fed to a data logger that multiplexes this information with digitized physiological parameters obtained from each patient. It then transmits this serially to the computer at speeds of up to 1200 baud. Single patient monitoring can be achieved by sending the keyboard output directly to a teleprinter input terminal of the computer at 110 baud.

### Mode of operation

The keyboard parallel output is first fed into a universal asynchronous receiver

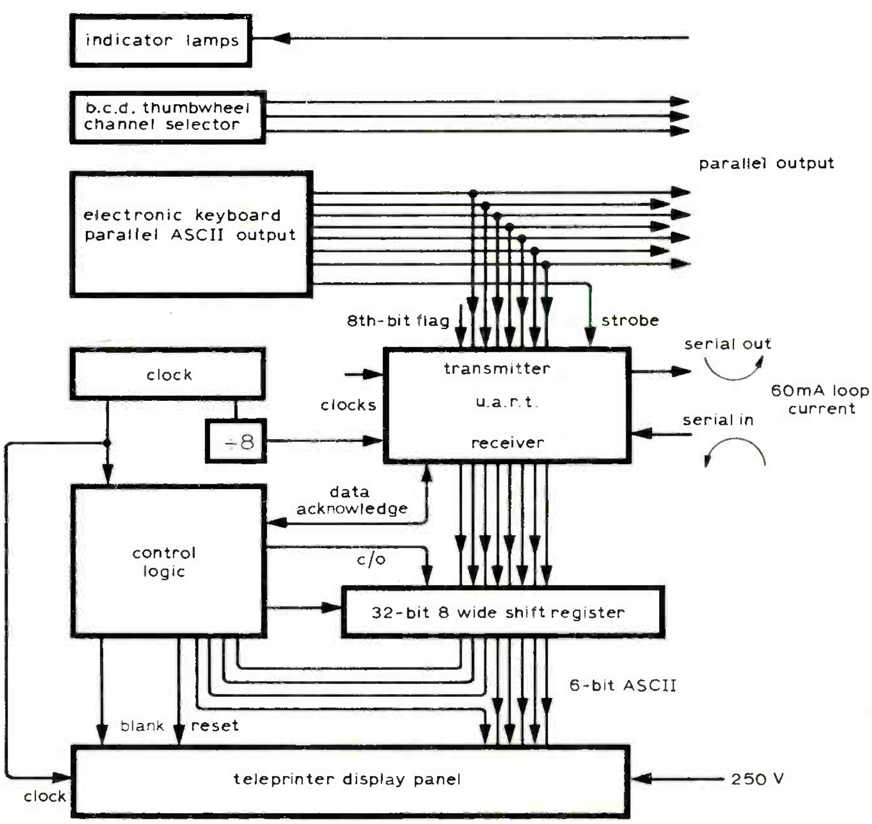



*Fig. 1. Keyboard/display block diagram.*

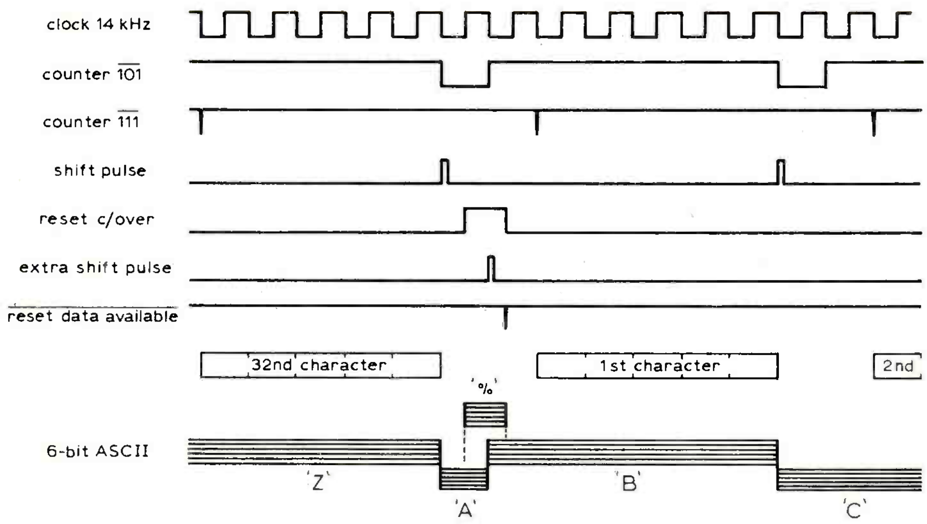



*Fig. 2. Display control logic timing diagram. Regular shift pulses output new ASCII data from the shift register to the read-only memory character generator as soon as the last column of the current character has been displayed. New characters are added during the reset period. The foremost right-hand character "A" is then lost and the next character "B" takes its place at the right-hand end of the display.*

transmitter (u.a.r.t.) integrated circuit—the General Instrument type AY 5 1012. Its serial output operates a t.t.l. compatible high-speed relay via a BC183 driver stage shown in Fig. 5. Because the relay used was not ideal (normally open) and current-operated teleprinters remain inactive during the Mark or "current flowing" state, a shorting switch across the contacts has been provided so as not to break the loop when the teleprinter is switched off. There is a similar restriction on the use of faster solid-state current loop adaptors that also need to be energized before Marking current can flow.

The current loop receiver also uses a high-speed t.t.l.-compatible reed relay shown in Fig. 4. It will just close on 3V and has an internal resistance of 500Ω (Radiospares). For 60mA operation the coil is shunted with 100Ω increasing closure current to approximately 35mA (60% of 60mA). The voltage drop at the receiver loop interface is thus about 5V, the same as a Data Dynamics 390 teleprinter but higher than that obtained using an optical isolator. One advantage of the reed relay, however, is that polarity of print and key current loops do not have to be preserved. The receiver of the u.a.r.t. is wired to accept an eight-bit word with no appended parity bit. It produces a number of status signals—Data Available (DA), Framing Error (FE) and Overrun (OR); a further line, Reset Data Available ($\overline{RDA}$), allows new data to generate a new DA pulse. If $\overline{RDA}$ is not generated before new data arrives then OR is generated. In the present design DA is always quickly followed by $\overline{RDA}$ and so OR is not needed.

The transmitter of the u.a.r.t. is also wired to accept an eight-bit word and to serialize it prefaced with a start bit and appended with two stop bits, the parity bit of this system is not used. As previously mentioned, bit eight is set to zero to denote its keyboard origination and bits one to seven are taken directly from the keyboard output which also produces a delayed strobe shown in Fig. 5. This is fed in to the data strobe (DS) pin of the u.a.r.t. Two key rollover is achieved by the u.a.r.t.'s double buffering of input data.

**The tube operation** is quite straightforward. Movement of the neon glow from left to right is achieved by three-phase clocking of the 224 vertical cathodes at the back of the tube. This is similar to the method adopted in Dekatron counting tubes. The maximum glow scan speed is restricted by the reliability of cathode-to-cathode glow transfer, and the minimum speed limited by the need of a flicker-free display. The recommended display clock frequency range of 13–18kHz results in repetition rates from 60–80 scans/sec, 14kHz has been chosen as this meets the needs of both the display tube and u.a.r.t. Transmit and receive clocks of 16 times the chosen baud rate (110) are required, dividing the display clock frequency by eight in a 7493 divider gives an output of 1.75kHz which is fed to both u.a.r.t. clock inputs. A final transmit-receive rate of 109 baud is therefore achieved from the 14kHz 555 oscillator leaving a spare ÷2 stage in the 7493 divider.

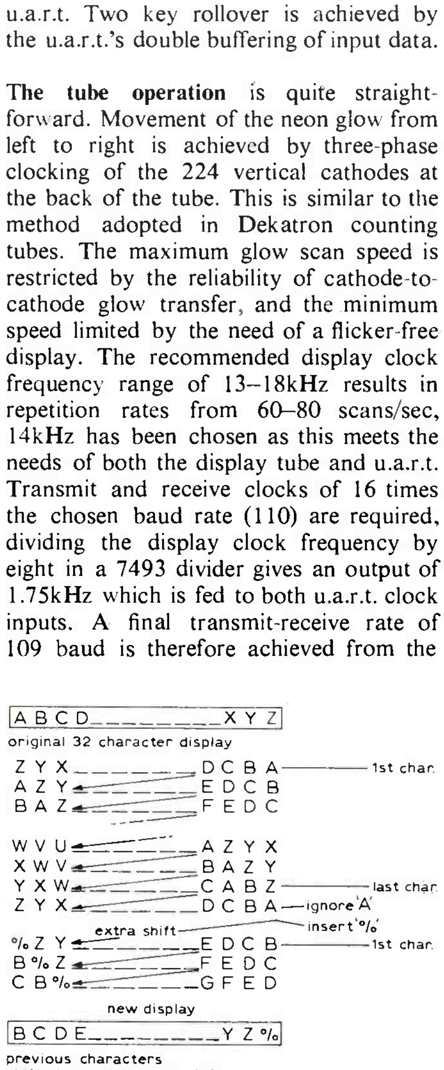



*Fig. 3. New character insertion at right-hand end of display.*

With no characters actuating the tube the glow travels unseen along the back of the cathodes. To illuminate a point on the display one of seven anodes that run horizontally along the front of the tube is selected. The glow is seen through a matrix of pin holes (seven high, 224 long) in an insulating panel separating the anodes from the cathodes. Depending on how far the glow has travelled along the tube a glow will be seen at the intersection of the selected anode as it draws the cathode glow towards it. In this way a general pattern seven high by 224 long may be displayed.

The m.o.s. read-only memory incorporated in the tube electronics generates a set of 64 characters produced one column at a time. The ASCII must not change while the character's five columns are being sequentially read onto the display tube. Code updating is made in the one or two column spaces left between characters. The tube's electronics permit 32 or 36 alphanumeric characters with a two- or one-column spacing respectively. The 32 option has been used as this has better legibility and 32 element shift registers are easily obtainable.

The most difficult part of the design was to satisfy the poorly defined reset timing requirements. Reset must occur within one clock period of the end of the last character, in this case during column six and the 32nd character as shown in Fig. 2. It may last for between 20μs and three clock periods but not terminate within 2μs of a falling clock pulse. These and other restrictions have easily been met in the present design by using both rising and falling clock pulses as a time reference. The only critical timing period being reset pulse length is well within the tolerance of the circuit which therefore requires no initial adjustment.

The display tube m.o.s. chip generates a data update pulse during the seventh (blanked) column position of each character. This, however, has not been used since it arrives too late to meet the reset timing limitations, instead the teleprinter electronics "force drive" the display tube. The first column of the first character is presented when the clock pulse falls after the reset period. Using the same clock pulse as the display, the "teleprinter" keeps a separate count of the progress of the display through columns and characters. The column counter is a 7493 ÷ 8 circuit used with feedback to produce a modulo seven counter, and each time the eight counter state is reached its 111 output operates a 7410 three input NAND gate, whose output is inverted and fed to the counter reset pin as shown in Fig. 4. The counter thus remains in state eight for about 50ns until state "one" is established (000). The 7410 output is also fed to a 7493 ÷ 16 chip via the spare ÷ 2 stage in the 7493 used as a u.a.r.t. clock frequency divider.

State six of the modulo seven counter is also detected by decoding 101 in another three-input NAND gate. This

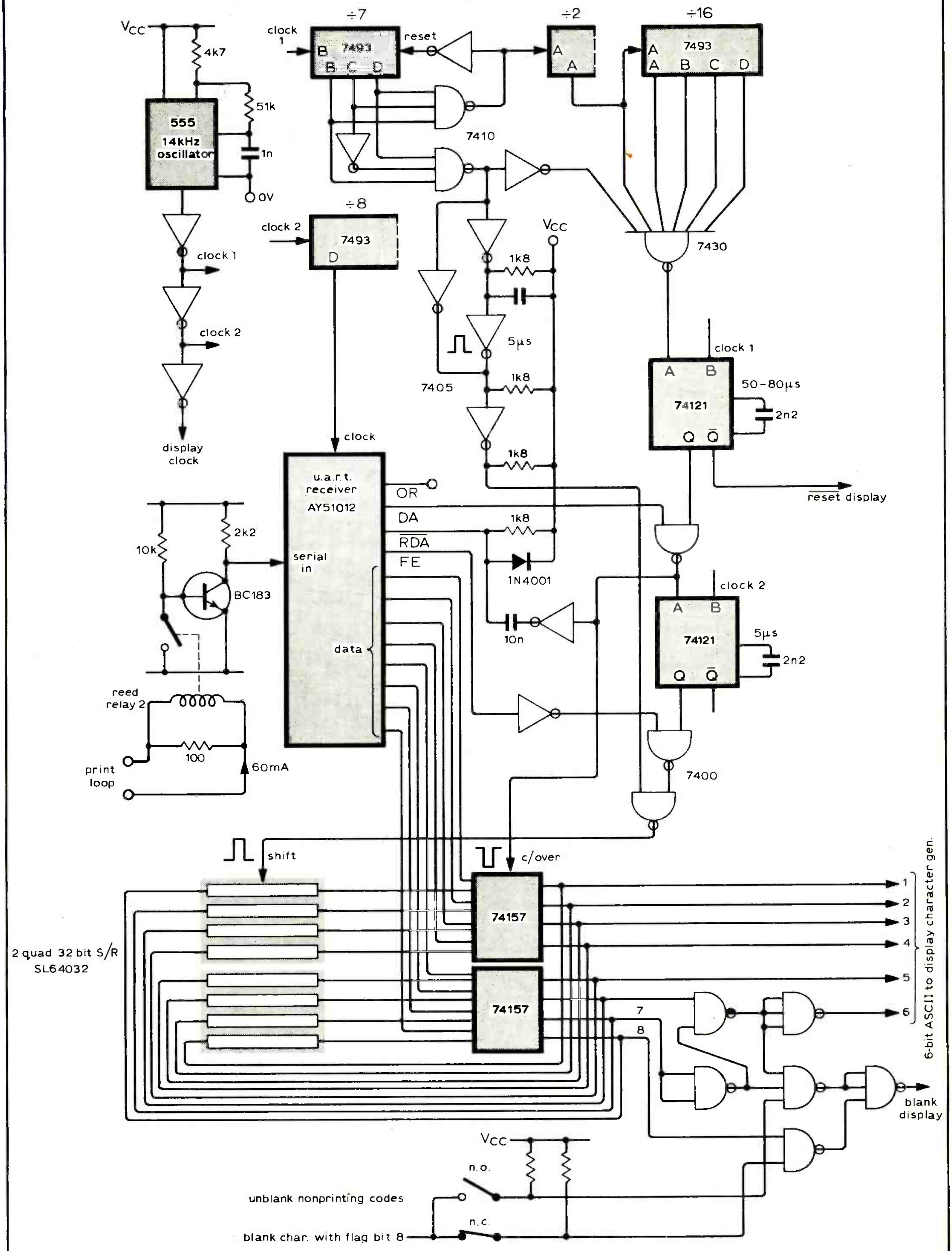



*Fig. 4. ASCH serial receiver and display driver.*

pulse is used to trigger a 7405 connected as a monostable providing a 5μs shift pulse to the refresh shift register. Therefore the SR output is correctly updated during the blanked period six of the display.

The counter's decoded state six pulse is gated with the outputs of the ÷2 and ÷16 counters in a 7430 eight-input NAND gate producing a pulse that occurs only when the sixth column of the 32nd character is on display. This pulse, which is true for a whole clock period, is fed to input A of a 74121 monostable only firing when input A is low and input B is high, in this case the display clock line is fed to input B so the monostable fires on the rising edge of the clock pulse producing the reset and $\overline{\text{reset}}$ pulses.

It is convenient for the first column of the first character to appear on the display two clock pulses after the fifth column of the last character. Therefore the reset pulse must be between ½ and 1½ clock pulses long since the first character will begin on the first falling clock pulse after the end reset.

The provision of shift and reset pulses are sufficient to maintain a refreshed display on the tube. However, we also need to update the shift register's content and to transform the incoming eight-bit ASCII into a six-bit form suitable for the display character generator.

The eight-bit ASCII refresh store consists of two General Instrument quad 32 element static shift registers that, unfortunately, do not contain their own recircular logic. This has been provided by two 74157 quad change over t.t.l. switches

| | | | |
|---|---|---|---|
| 1 | $V_{cc}$ | | +5V |
| 2 | $V_{gg}$ | | −12V |
| 3 | $V_{gr}$ | | ground |
| 4 | Received data available | RDE | ground |
| 5–12 | Received data bits 8–1 | RDB | |
| 13 | Parity error | PE | not used |
| 14 | Framing error | FE | |
| 15 | Overrun | OR | not used |
| 16 | Status word enable | SWE | ground |
| 17 | Receiver clock | RCP | |
| 18 | Reset data available | RDA | |
| 19 | Data available | DA | |
| 20 | Serial input | SI | |
| 21 | External reset | XR | ground |
| 22 | Transmitter buffer empty | TBMT | not used |
| 23 | Data strobe | DS | |
| 24 | End of character | EOC | not used |
| 25 | Serial output | SO | |
| 26–33 | Transmit data bits 1–8 | TDB | |
| 34 | Control strobe | CS | +5V |
| 35 | No parity | NP | +5V |
| 36 | Two stop bits | TSB | +5V |
| 37, 38 | Both true for eight-bit word | NB1 NB2 | +5V |
| 39 | Even parity select | EPS | not used |
| 40 | Transmitter clock | TCP | |

*Fig. 6. UART pin connections for teleprinter.*

shown in Fig. 4. These are placed between the SR output and the display tube input to avoid driving mixed logic. The SR output can only drive one t.t.l. load, being the 74157 whose output in turn feeds two m.o.s. loads. These are the display tube and SR inputs. With no new data the contents of the SR are taken via the 74157s to the display tube input. As the display moves from left to right the register is also shifted right to produce ABC, etc, at the appropriate time. These characters then re-enter

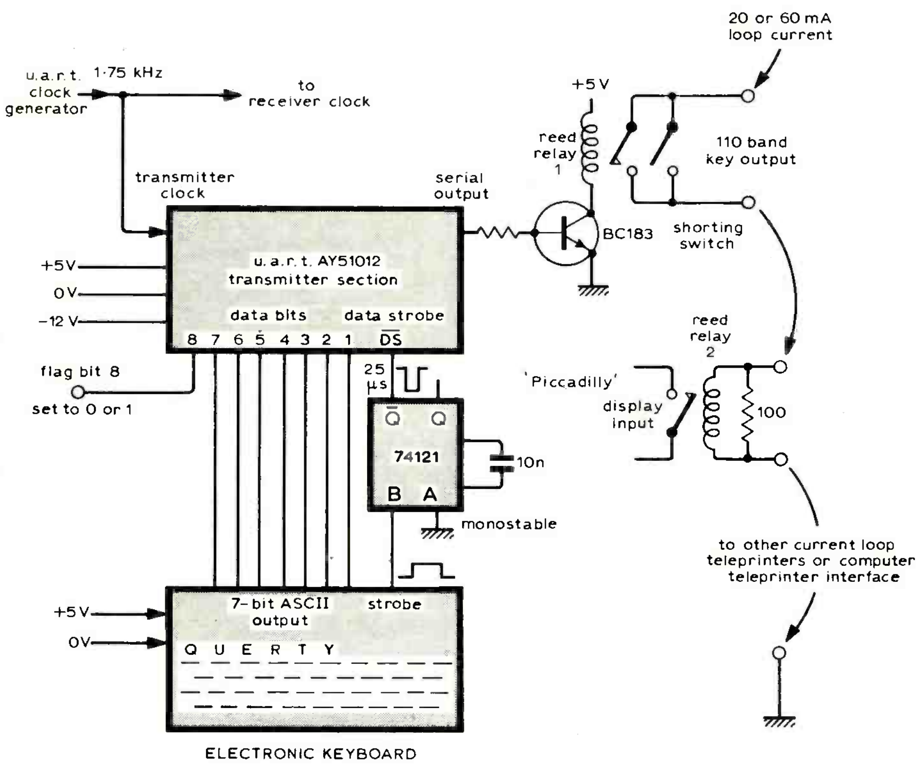



*Fig. 5. Keyboard serializer. This circuit may be used independently to provide a serial current loop output from any parallel ASCII keyboard. Maximum line speed is limited by the reed relays which may be replaced with opto isolators.*

at the left end of the SR for subsequent re-use.

To produce the traversing effect the contents of the SR must be shifted to the left therefore losing a character and adding another at the right-hand end. This can be done during the reset period after the right-hand character has been displayed (Z at the output of the SR) and the left-hand character "A" has been shifted to the SR output ready for the next scan. This is illustrated in Fig. 3.

The reset pulse also operates the 74157 changeover, temporarily removing "A" from the output lines and replacing it with the u.a.r.t.-generated "%" character. While reset is still true an extra shift pulse is generated on the falling edge of the clock pulse by means of a second 74121 monostable. Thus "%" is shifted into the SR and "B" is shifted to the output of the SR. When the reset pulse finishes, "B" is fed to the display in time for it to be treated as the first character.

The length of the extra shift pulse is not critical and 5μs was chosen quite arbitrarily. The minimum reset time must be longer than one half clock period + shift pulse length, and the maximum length is limited to 1½ clock periods at the fastest clock rate. In practice, with the component values shown in Fig. 4, reset lasts 60μs. In fact the display requires a falling pulse for reset so it is fed with the $\overline{Q}$ output of the reset monostable.

The extra shift pulse is only produced when the u.a.r.t. has generated a "data available" signal which is gated with reset to fire the second monostable. When the gate closes at the end of reset the rising edge is inverted and capacitor coupled to the "reset data available" pin of the u.a.r.t. Since the scan rate of the display is some 60 per second and new data can arrive no faster than ten characters per second (110 baud signalling speed), RDA is always serviced in time to avoid the generation of overrun.

As a precaution the framing error signal is also gated with the output of the extra shift pulse monostable so that incorrect data is not shifted into the SR. It may be preferable to insert some error-denoting character in place of the garbled data rather than ignore it altogether. It was considered that this would only be worthwhile if we were using parity checking as well. All ASCII characters use bits six and seven to define whether the previous five bits describe a numeral; bit 6 = 1, bit 7 = 0, an alphabetic 6 = 0, 7 = 1, a lower case alphabetic 1 1 or a nonprinting control character 00.

The teleprinter logic imposed between the SR outputs of bits six and seven and the transposed bit six of the display input ensures that six is only true for numeral ten characters. Other characters, alpha, lower case alpha and control set six to 0. Therefore lower case alpha will be displayed in their upper case form.

The teleprinter electronics have been assembled on a Vero d.i.p. board having a 32-way edge connector on one side. The p.c. board is mounted beneath the Honeywell keyboard in an aluminium die-cast

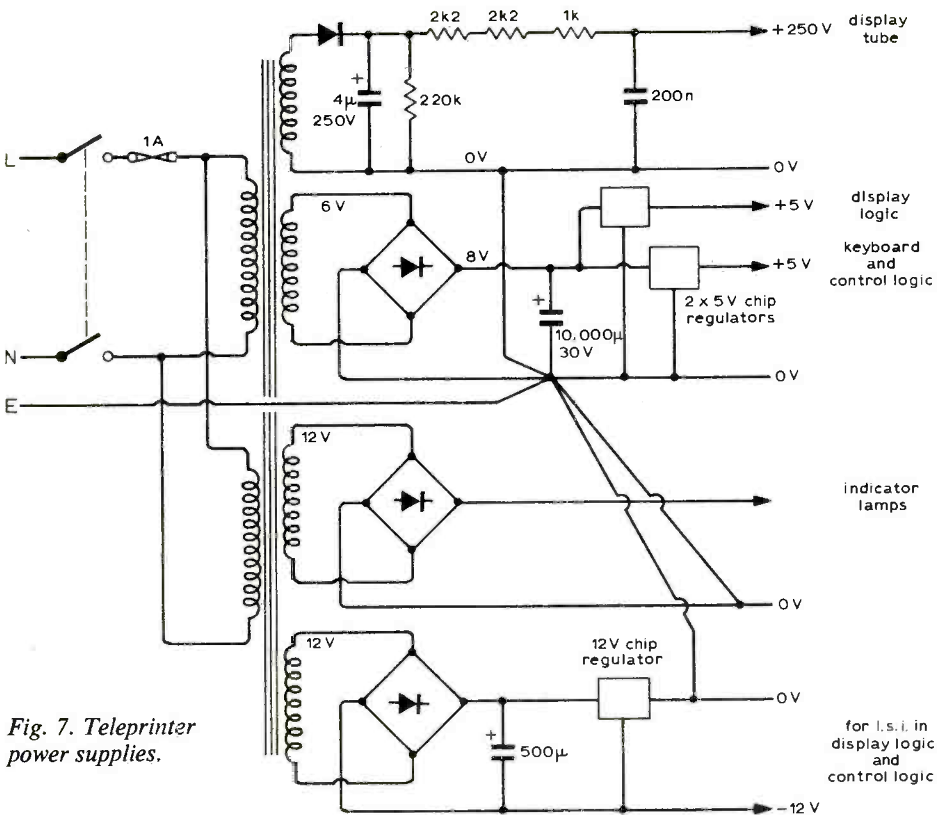



*Fig. 7. Teleprinter power supplies.*

*Fig. 8. Complete "teleprinter".*

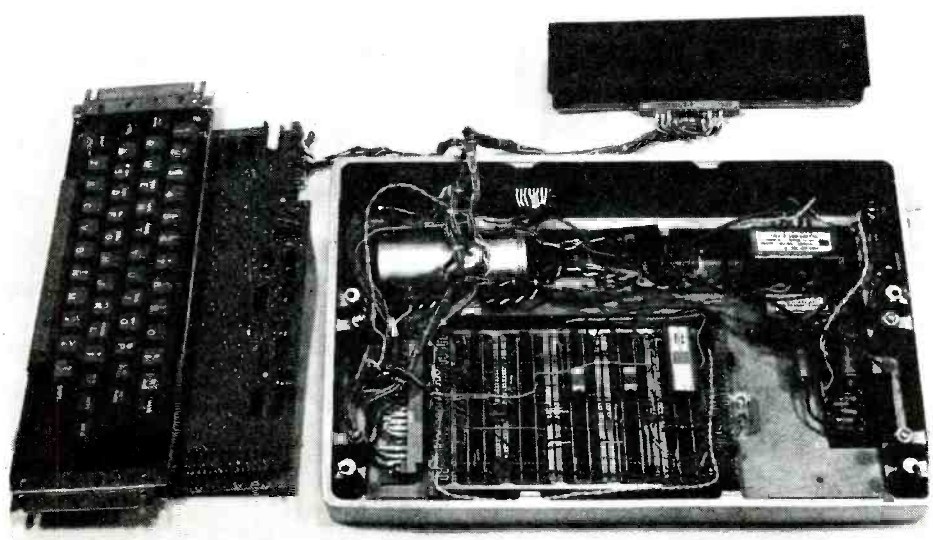


*Fig. 9. Internal view of the "teleprinter" showing general layout.*

case. Power supplies are fitted in at the back of the case which is used as a heat sink for the chip regulators. The display tube fits between the top of the case and the keyboard p.c.b. (available from Walmore Electronics Ltd, 10–15 Betterton Street, Drury Lane, London, WC1).

Future developments hope to include a keyboard with special function keys for entering information more easily, and the production of custom printed circuit boards.

# Books Received

**Transfer Function Techniques for Control Engineers**, by D. R. Towill, is suitable for both undergraduate and post-graduate courses in design. After an introductory chapter on control engineering techniques the derivation of transfer functions is dealt with. Root-locus and and pole-zero techniques form the third chapter. The second order linear system is then discussed, followed by the transfer function techniques applied to third-order linear systems. Final chapters deal with the general application of transfer function techniques to linear and non-linear control systems. Price £6.30. Pp. 514. The Butterworth Group, Borough Green, Sevenoaks, Kent TN15 8PH.

**Piezoelectric ceramics**—an application book from Mullard. This publication is a clearly written handbook explaining the piezoelectric phenomenon and describing applications of ceramic crystals. Uses include high voltage generators, pick-ups and transducers, filters and resonators. Many circuit diagrams are provided, together with graphs, colour photographs and tabular information. Price £4. Pp. 211, available from bookshops.

**Practical Triac/SCR Projects for the Experimenter** (No. 695), by R. W. Fox. As the title suggests, this publication is a collection of circuits suitable for construction by the amateur or technician. All the diagrams are supplemented with an explanatory text, and theory where applicable. The circuits include phase control, motor control, light-activated devices, alarm systems, heating controls and many other useful applications for the component. Two final chapters deal with the choice of thyristor and cooling considerations. Price $7.95 ($4.95 paperback). Pp. 192. Tab Books, Blue Ridge Summit, Pa. 17214, USA.

**Understanding Telecommunications** by Michael Overman. This is a simply-written book suitable for the newcomer to telecommunications. The history of telegraphy, telephone, and radio is traced and the current state of development discussed including multiplex telegraph, and public broadcasting. Following chapters deal with the electron and electricity/electronics showing very simple circuit arrangements and their functions. Morse code and amplitude modulation are among the various methods discussed as a means of transmitting information. Microwave links and satellites are also explained with a final chapter on telecommunications tomorrow. Price £2.25. Pp. 192. Lutterworth Press, Luke House, Farnham Road, Guildford, Surrey.

# World of Amateur Radio

## TVI—still a problem

An analysis of the radio interference complaints for 1973 issued recently by the Home Office Radio Regulatory Department shows that 1,169 complaints of interference to the reception of television and radio programmes were ascribed to "radio transmitters, amateur stations only". This represents just over 4% of the interference from identified external sources although rather less than 2% of all complaints. Over the past six years the number of complaints traced to amateur operation has remained remarkably constant: 1968 1,151; 1969 1,442; 1970 1,161; 1971 1,027; 1972 1,242; and 1973 1,169. During this period, although the number of cases of interference to Band I and Band III television has fallen quite steeply, this has been almost exactly balanced by increased interference to Bands IV and V u.h.f. television. It had been thought, a few years ago, that the growth of u.h.f. television would bring about a fairly dramatic and permanent decrease in amateur TVI.

That it has not done so convinces many amateurs that this is in large part a reflection on current receiver design. It is felt that the number of complaints would fall significantly if the modern transistorized u.h.f. television tuner had better signal handling capabilities and was less susceptible to out-of-band signals picked up on the outer-braid of the coaxial feeder cables. In the United States an increasing number of television front-ends use dual-gate MOSFETs and other devices offering wider dynamic range than conventional transistors, but there seems little indication that such devices are likely to be used in Europe.

The amateur, of course, himself suffers greatly from electrical interference and the latest report contains some evidence that general electrical noise is no longer declining as it did after the introduction of interference legislation during the 1950s but may well be increasing once again, although u.h.f. television is less susceptible and the total number of complaints continues to fall. The amateur in urban and suburban environments searching for weak signals is also having to contend with the higher levels of time-base radiation that seem to go with colour television receivers and semiconductor circuitry, producing broadly spreading signals spaced at 15.625kHz throughout the m.f. and h.f. spectrum.

## Sporadic E and sunspot minima

Further evidence of the correlation between periods of intense Sporadic E conditions in Europe and sunspot minima is suggested by such events as those of the morning of July 9 when Sporadic E reflections extended to u.h.f. and brought many signals from Eastern Europe, including Hungary and Bulgaria, roaring in to the UK on 144MHz. This particular opening may well have equalled or surpassed the Sporadic E openings of July, 1965, another year when we were near the bottom of a sunspot cycle. Signals were so strong that many contacts were made with Eastern Europe by mobile stations. Rather curiously for what should be "a year of the quiet sun" there seem to have been more ionospheric storms affecting h.f. this year than would have been expected. But then the ionosphere never does seem for long to do the expected and there are undoubtedly many secrets still left to be unravelled!

## Nell Corry—YL of history

With the recent death of Miss Nell Corry, G2YL, of Tadworth, Surrey amateur radio has lost possibly the only "YL" (young lady) operator ever to have been the first to gain a major operating achievement award: the first "worked all continents" on 28MHz (ten metres) from Great Britain. The opening of "ten metres" for long-distance communication makes a fascinating story. In October, 1928, Jimmy Mathews, G6LL (still an active amateur), made the first transatlantic contact on 28MHz and this was followed within a few days by a first contact with the Californian west coast area by Captain Rodman, G2FN. But 1928 was on the declining slope of a sunspot cycle although the significance of this was not recognized at the time. Despite a considerable increase in amateur operation on the band after the transatlantic contacts little regular DX was heard or worked. The memory of 28MHz DX grew dim and only a few faithful adherents continued to search for any signals, including the many commercial "harmonics" that were being radiated. Now the sunspot minimum was passed and "maximum usable frequencies" were rising again. Signals began to come through on 28MHz from countries and continents never heard before on the band. One of the most persistent operators on 28MHz was Nell Corry who when licensed in 1932 doubled the number of YL operators in this country (the other was Miss Barbara Dunn, G6YL). And finally from her station at Walton-on-the-Hill in October, 1935, she became the first British amateur to work all continents—an event that rated national press coverage.

## From all quarters

A low-definition television enthusiast (see "Amateur Television Topics" in the June *World of Amateur Radio*) is Mr H. J. Peachey of London NW9, who in a recent letter to *CQ-TV* suggests he may be the only person who has continued to carry out experiments in this field ever since 1928. He uses 10, 15, 30 and 50 lines for monochrome and 20 lines for colour experiments using the classical mechanical disc but with photo-transistors, transistor amplifiers and $2\frac{1}{2}$-in cathode-ray tubes.

In the UK quite a number of courses for potential radio amateurs will be opening as usual in September at technical colleges and similar adult education centres. Most of these courses cover the requirements for the Radio Amateurs Examination, although in a few places additional courses, including Morse classes, are available. One of the most complete sets of courses is that being run by E. C. Palmer, G3FVC, at the Slough College of Technology where basic courses are offered on Friday evenings (including periods of station operation and practice with G3XPL, Morse and RAE theory) and also the same evening special advanced amateur radio courses designed for those who have already passed the RAE and with laboratory facilities for practical work (G3VCT lecturer), covering such subjects as s.s.b., v.s.w.r. measurement, digital frequency meters, digital frequency synthesizers, microwave techniques, slow-scan TV and radio teleprinting. (Details of the Slough classes from: E. C. Palmer, Dept of General Studies, Slough College of Technology, Wellington Street, Slough SL1 1YG.)

## In Brief

The total number of British licensed amateurs has now risen to approximately 20,000 of whom just over 15,000 hold the general-purpose Class A licences. . . . Next year's RSGB president will be Cyril H. Parsons, GW8NP, who will become the first holder of a Welsh amateur callsign to hold this office. . . . A Welsh amateur radio convention is being held at the Community College, Oakdale, Nr Blackwood, Gwent on Sunday, September 22 (details from S. W. Rees, 10 Tudor Crescent, High Cross, Gwent NP1 9BS). . . . A Scottish VHF Convention is being held at the University of Dundee Tower Block on Saturday, September 28, and the speakers will include Geoff Stone, G2FZL, A. J. Oliphant, GM3SFH, Tom Holbert, GM3DXJ, and George Burt, GM3OXX. . . . William Eitel, WA7LRU/W6UF, and Herbert Hoover, W6APW, have offered to match, up to a total of $25,000, donations made to the ARRL Foundation for the amateur satellite programme: it is estimated that Amsat-Oscar 8 may cost $100,000 to build. . . . The Radioklub of the German Democratic Republic has become the 87th member-society of the International Amateur Radio Union.

PAT HAWKER, G3VA

# New Products

## Wiring testers

Two series of wiring testers have been designed to identify and locate faults in harness and cable assemblies. The Maze-Master series consists of low-cost, wire identification units and the AutoScan series has automatic visual identification of faults found. All the units use solid state circuitry and are self-contained. The complete series of instruments allow testing of from 49 to 9999 points anywhere on a wiring system. Prices of the units start at $395. Addison Division of Muirhead Inc., 1101 Bristol Road, Mountainside, New Jersey 07092, USA.
**WW301 for further details**

## A.c. calibrator

A frequency range of 1MHz and a quadrature phase accuracy of ±0.05 degrees are featured in the model AC-125 absolute a.c. calibrator from Datron Marketing. Output amplitude is 120V r.m.s. from 10Hz to 110kHz and 12V r.m.s. to 1.2MHz. An optional amplifier, model PA-1182, extends the basic amplitude range to 1.2kV at 110kHz. The absolute accuracy is claimed to be ±0.02% + 5 p.p.m. of range + 10μV over the midband frequency range. An additional feature sets a calibrated offset of up to ±5% for automatically determining the error, in percent, of the instrument under test. Datron Marketing Ltd, Meteor Close, Norwich Airport Industrial Estate, Norwich NOR 17B.
**WW305 for further details**

## Receiver test set

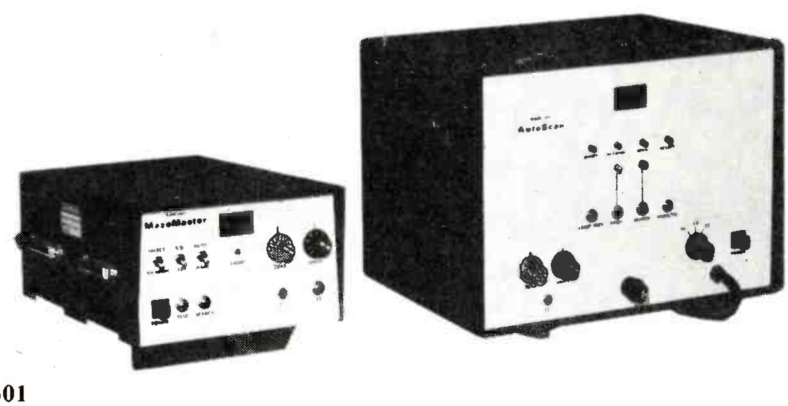
The TS5026 test set will evaluate the performance of any receiver which operates in the 5 to 1000MHz frequency range. The unit is battery operated and has two front-panel rotary switches—one for programming the various tests and the other for selecting the nominal noise figure to be tested. The signal output of the instrument is connected to the antenna input of the receiver under test into which a flat r.f. noise source is fed. The audio output of the receiver is connected to the audio input of the unit. The receiver can be set to any frequency from 5 to 1000 MHz for noise figure determination. To test intermodulation and crossmodulation distortion the TS5026 must be used in conjunction with an external band-reject filter. The instrument has a signal output impedance of 50 ohms, an audio input sensitivity of 3V r.m.s. into 600 ohms and measures 11×6×7in. Astro Communication Laboratory, Tower Street, Coventry CV1 1JP.
**WW302 for further details**

## Coaxial plug

A new type of coaxial plug called the Slimgrip has been specifically designed for use with low loss 75Ω coaxial cable. The main feature of the plug is the method in which it is connected to a cable without soldering. A contact resistance of 1.8 milliohms is claimed for the plug which costs 4.9p each (1,000-off) plus v.a.t. Safemoor Ltd, Antenna Division, Crown Road Works, 76 Crown Road, Twickenham, Middlesex TW1 3ER.
**WW304 for further details**

## Electronic speed control

An electronic speed regulator type ESA1 can be connected to either an a.c. or d.c. supply to provide a variable direct output voltage. This unit is suitable for controlling the speed of a motor by varying the input power. The regulator will compensate for variations in output load and will maintain a constant speed to within 2% for a 50% change in load. The input requirements for the a.c. versions are 50, 110 or 220–240V at 50Hz, and 12 or 24V for the d.c. model. The output provided is variable up to 12V maximum



WW301

WW305

WW302

at 0.16A. Appliance Components Ltd, Cordwallis Street, Maidenhead, Berks SL6 7BQ.
**WW324 for further details**

## Ratemeter

The type P7973 ratemeter is suitable for general purpose Geiger-Müller and scintillation counting in hospitals and laboratories. The instrument offers ten count-rate ranges from 3 to 100,000 c.p.s., seven integrating time constants from 0.1 to 100s, and two ranges of adjustable discriminator bias. Visual/audible indication of counts is by a moving-coil meter, and a built-in speaker with a muting switch. Recorder outputs are provided at the back of the unit which will supply 1mA at 100mV f.s.d. The ratemeter has a 250A positive e.h.t. supply which is stabilized to $\pm 0.5\%$ over 8 hours and adjustable over the range 100 to 2000V. Panax Equipment Ltd, Willow Lane, Mitcham, Surrey.
**WW316 for further details**

## Heat sinks

A range of hybrid heat sinks for TO-3 and TO-66 devices has been introduced by Jermyn. The heat sinks are constructed by silver-soldering an aluminium oxide heat transfer washer to preformed $\frac{1}{8}$in diameter heat pipes. Three configurations are available, either straight with $2 \times 1$in output fins, with heat pipes bent outwards and output fins of $1\frac{1}{2} \times 1$in, or with heat pipes bent outwards and terminating in a copper plate for bolting to a cold wall. The output finning arrangements can be designed to meet customers' requirements with the heat pipes being formed during manufacture to accommodate individual p.c.b. layouts. Jermyn Manufacturing, Sevenoaks, Kent,
**WW325 for further details**

## Battery powered recorder

A lightweight, battery powered chart recorder designed by Astro Med is available from SE Laboratories. The model 101-DC weighs 4lb and consumes 8W operating from a 12V battery. A single channel unit features a channel width of 50mm, with automatic chart threading, and a heated stylus activating a low-cost heat-sensitive paper. The galvanometer movement incorporates a high-torque mechanism which improves the performance at frequencies above 125Hz. Sensitivity is 10mV per mm $\pm\frac{1}{4}$V f.s.d. with 1MΩ impedance. The 101-DC costs £276·50 from SE Laboratories Ltd, North Feltham Trading Estate, Feltham, Middlesex.
**WW300 for further details**

## Frequency counter

The latest counter from R.C.S. features a measuring range in excess of 80MHz with a sensitivity of 10mV at an input impedance of 1MΩ in parallel with 20pF. The instrument, called the 701A, has a 1MHz crystal controlled oscillator, contained in an oven, providing a temperature coefficient of frequency of seven parts in $10^9$ per °C. The display is eight side-viewing numicator tubes with a display time of 1 or 8 sec selectable by push-buttons. A standard output frequency is available from a BNC socket at the rear of the instrument. The frequency is selectable by gate-time push buttons in decade steps from 0.1Hz to 1MHz. R.C.S. Electronics Ltd, National Works, Bath Road, Hounslow, Middx TW4 7EE.
**WW311 for further details**

## Modular connectors

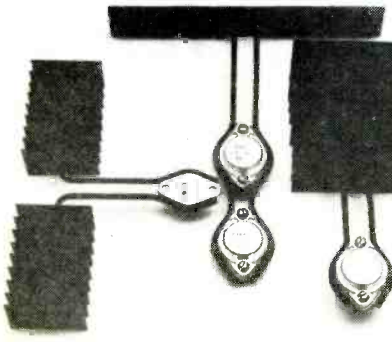
An initial range of seven "snap-in" DIN-pattern connectors has been produced by Ariel. The basic unit is a $18 \times 30$mm thermoplastic moulding which can carry any socket measuring 18sq.mm. This unit can be custom-made in larger sizes if required. Ariel Pressings Ltd, Wollaton Road, Beeston, Nottingham NG9 2PB.
**WW315 for further details**

## C.a.t.v. repeater amplifier

The type CM7006 "professional grade" repeater amplifier covers the frequency range 40–860MHz. The amplifier, which has been designed for advanced cable systems now under construction in the UK, utilizes microstrip technology and is available with either a single or double output, both options being line powered. The device offers a nominal gain of 20dB for the single and 17dB for the double output version with a noise figure of less than 10dB. Flatness of the frequency

WW316


WW300


WW325

WW311

response is $\pm 0.75$dB and cross-modulation is typically $-84$dB for a 30dBmV output level. Labgear Ltd, Abbey Walk, Cambridge.
**WW309 for further details**

## Video system

A complete video communication system comprising a c.c.t.v. camera, camera stand, 12in monitor, video compressor and expander, is capable of transmitting and receiving still television images over "dial-up" telephone lines. Sixty seconds are required to transmit a single medium-resolution image, while a magnetic disc is used in the receiver memory to allow indefinite-image storage time with good grey scale. The price of the complete system is $9,000 but components of the system may be purchased separately. Colorado Video Inc, Box 928, Boulder, Colorado 80302, USA.
**WW312 for further details**

## Digital panel meter

A d.p.m. replacement for analogue meters has been developed by Exel Electronics. Known as the XL9 it comprises one p.c.b. measuring $10\times8\times2$cm with two minitron displays mounted on the reverse side. The XL9 utilizes a feedback digital-to-analogue converter technique and is available in ranges of 1V, 100mV and 100μA with special ranges supplied on request. Although the meter is unipolar, negative signals can be indicated by reversal of the input connexions. Standard facilities include overrange blanking and user selection of the decimal point position. Accuracy is claimed to be better than 1% f.s. $\pm 1$ digit over the temperature range 10 to 40°C. Power requirement is a standard t.t.l. 5V supply, with the unit consuming 370mA for a reading of "88". For indications requiring more than two digits, further displays can be fitted. The XL9 is priced at £15 each for 100-off quantities. Exel Electronics Ltd, Wollerton Road, Branksome, Poole, Dorset.
**WW313 for further details**

## Transient suppressor

A silicon bipolar transient suppressor will provide symmetrical protection against large voltages which may cause permanent damage to components. A response time of $1\times10^{-12}$ seconds is fast enough to protect i.cs and m.o.s. devices. The component features a breakdown voltage from 10 to 110V $\pm 10$%, a peak pulse power (1ms) of 500W, and a dynamic impedance of 1.5 to 70 ohms. Bourns Trimpot Ltd, Hodford House, 17/27 High Street, Hounslow, Middx TW3 1TE.
**WW308 for further details**

## Modular rotary switch

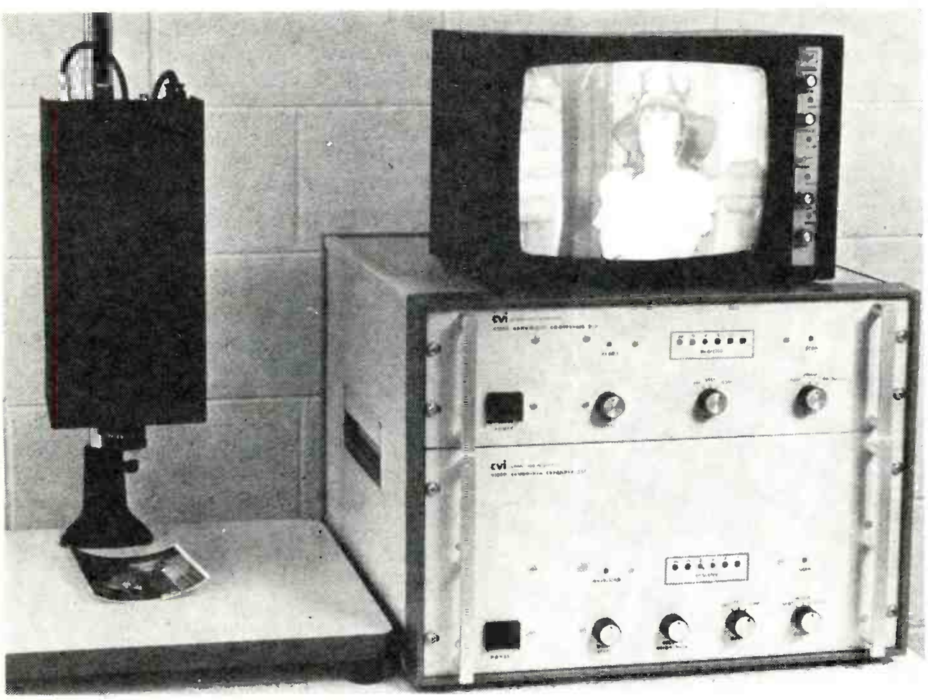
A modular rotary switch manufactured by Jeanrenaud is specifically designed for p.c.b. use, featuring d.i.l. pins at 2.54mm pitch for direct mounting. The unit is completely sealed, permitting board cleaning by immersion. Up to five switches can be coupled in many configurations. The switch is rated at 60V, 5W with a maximum switching current of 100mA. The contact resistance is less than 40 milliohms and a life expectancy of 50,000 operations is claimed. ITT Components Group Europe, Electrical Products Division, Edinburgh Way, Harlow, Essex CM20 2DE.
**WW322 for further details**

## Battery eliminator

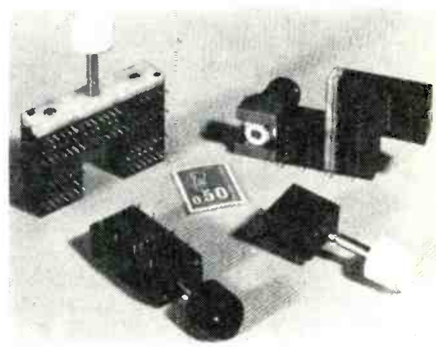
The Transipack type 306/20/K, when supplied with 240V, 50Hz, will provide a 24V d.c. 20A supply. The unit, which is suitable for energizing static inverters or charging accumulators, is available with other output voltages and currents up to 1000A to special order. The off-load output is 29.5V maximum which drops to 22V when delivering 20A. The output ripple is 250mV pk-to-pk, and protection is by fusing in the input and output circuits. The unit measures $305\times229\times356$mm deep and weighs 20kg. Industrial Instruments Ltd, Stanley Road, Bromley, Kent BR2 9JF.
**WW323 for further details**

## Video/audio distribution system

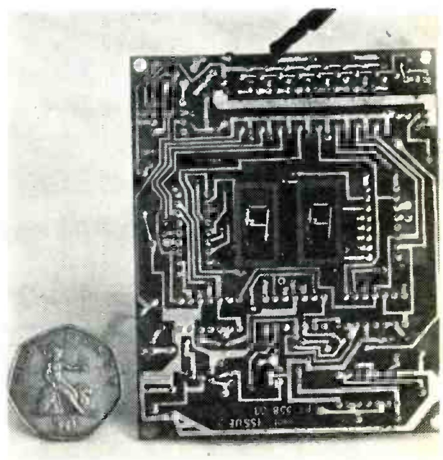
The Decca video/audio exchange system enables subscribers to select any one of eight video programmes. Each unit covers up to eight subscribers, and this number can be increased by the addition of further units. Programmes transmitted can



WW312



WW322



WW313

be from any source such as off-air or videotape. Talk-back facilities can be provided, as well as remote control with built-in timer alarm. Decca Educational and Industrial Services, Ingate Place, Queenstown Road, London SW8 3NT.
**WW314 for further details**

## Spectrum analyzer

A portable, battery operated, 1GHz spectrum analyzer from Texscan is claimed to give laboratory class performance. Known as the AL.51, the analyzer has a measurement range of 120dB, a sensitivity of better than −100dBm at 10kHz resolution and a minimum resolution of 500Hz. Dispersion is continuously adjustable from c.w. frequency to 1000MHz. Standard features on the instrument include crystal controlled markers, and automatic phase lock. Texscan Instuments Ltd, 1 North Bridge Road, Berkhamsted, Herts.
**WW306 for further details**

## Low-noise amplifier

The VSS 7451 JP is a low-noise, discrete, microstripline, solid state amplifier for use in the S-band. The device features a solid-state power supply as an integral part of the unit. Typical noise figure is 4dB and the power output at the 1dB gain compression point is +11dBm. The small signal gain is 30dB with a gain variation of ±1dB. EMI-Varian Ltd, Hayes, Middlesex.
**WW320 for further details**

## Non-polarized capacitors

Now available from Sprague is a range of miniature, plastic-film encased, non-polarized capacitors. The devices use a solid electrolyte (Tantalex) and cover the range from 1µF to 33µF with voltage ratings up to 50V. The capacitors are suitable for use in applications where voltage reversals, greater than those which can safely be applied to polarized capacitors, are encountered. The type 184D devices are available in nine case sizes with either axial or radial leads. Sprague Electric Ltd, 159 High Street, Yiewsley, W. Drayton, Middlesex.
**WW310 for further details**

## Dot matrix display

The Nippon Electric Company have introduced a series of a.c. gas discharge, *x-y* dot matrix panels for information displays, etc. The displays use either 7×8 or 5×7 matrices to form an alphanumeric character. The displays range from 32 to 256 characters per panel and employ specially developed transparent electrodes to give a greater clarity of character. By using refresher driving with these panels, only one power supply is required. Impectron Ltd, 23/31 King Street, Acton, London W3 9LH.
**WW317 for further details**

## Modular oscilloscope

The 2020 modular display oscilloscope from Autec has a 300×200mm display for up to 4 *y* channels. The *x* and *y* inputs are calibrated in a 1, 2, 5 sequence with an overall accuracy of 5%. The 200mm *y* bandwidth is 15kHz and the sensitivity is from 10mV to 20V/div. Timebase speeds cover 1s to 20s/div. The *y* channels may be displayed in the alternate or chopped mode and true *x-y* facilities may be obtained by replacing the timebase with a *y* amplifier. The instrument measures 520×450×450mm and weighs less than 23kg. The price range is from £500 to £700 depending on options. Autec Electronics Ltd, Autec House, Silver Street, Axminster, Devon EX13 5AH.
**WW330 for further details**

The type number of the Rogers loudspeaker described in the May issue New Products is LS3/5A, not LS3/3A as printed.

WW306

# 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.**

## Voltage regulators

The LAS 4000 range of thick-film voltage regulators provides protected d.c. outputs and are available in 14 models rated at 170 or 240W maximum dissipation. The d.c. outputs are 5, 6, 12, 15, 20, 24 or 28V at 10 and 15A. All the models in the LAS range are covered by a five-year guarantee.
**WW350 for further details** **Lambda**

## Thyristor/transistor array

The RCA CA3097E thyristor/transistor array comprises five independent and isolated components on one chip. The devices are an n-p-n transistor, a p-n-p/n-p-n transistor pair, a zener diode, a programmable unijunction transistor and a sensitive-gate silicon controlled rectifier. The chip is suitable for applications such as timers, oscillators, voltage regulators, etc., and operates over the temperature range −55 to +125°C. The price is £1·023 each 100 off.
**WW351 for further details** **Celdis**

## Store interface i.c.

The ZN1025 is a triple-line driver/receiver for interfacing between a computer and store units. The device functions at Schottky speeds giving a typical delay between the transmitter input and receiver output of 22ns. A power dissipation of typically 250mW is offered by the interface which is t.t.l. compatible and packaged in either 14-pin plastic flat-pack or d.i.l.
**WW352 for further details** **Ferranti**

## Diode laser

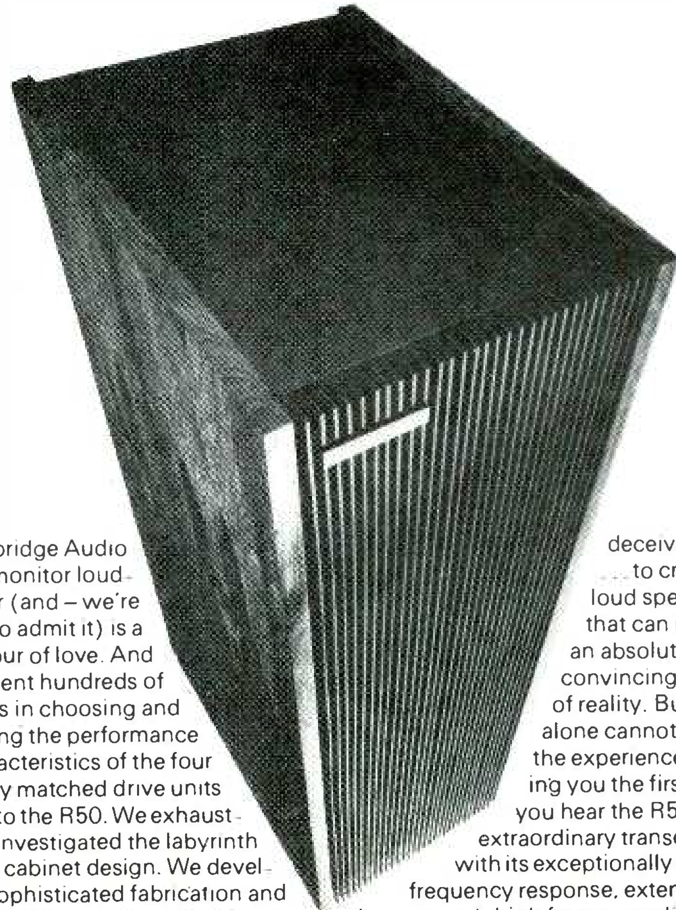
A 25W gallium arsenide diode laser has been introduced by RCA. The device, which is called SG3001, is intended for intrusion alarms, range finding, etc., and is operated by pulsing in the forward-bias direction. Radiation is near infra-red, about a band centred on 9050 angstroms. The duty factor of the pulse current, which must not exceed 0.01% at room temperature, will allow a 500Hz repetition rate at a maximum pulse duration of 200ns.
**WW354 for further details** **RCA**

## Suppliers

Ferranti Ltd, Electronic Components Division, Gem Mill, Chadderton, Oldham, Lancashire OL9 8NP.
Celdis Ltd, 37/39 Loverock Road, Reading, Berkshire RG3 1ED.
RCA Ltd, Lincoln Way, Sunbury-on-Thames, Middlesex.
Lambda Electronics, Abbey Barn Road, High Wycombe, Bucks HP11 1RW.

# THE ILLUSION OF REALITY

THE ILLUSION OF REALITY



Our Cambridge Audio R50 monitor loudspeaker (and – we're proud to admit it) is a true labour of love. And we've spent hundreds of hours in choosing and evaluating the performance characteristics of the four critically matched drive units that go into the R50. We exhaustively investigated the labyrinth paths of cabinet design. We developed sophisticated fabrication and testing techniques. In production we even go as far as to hand test and select each individual capacitor in the cross-over network. In short, nothing is spared in our single minded effort to deceive you ... to create a loud speaker that can produce an absolutely convincing illusion of reality. But words alone cannot convey the experience awaiting you the first time you hear the R50. This extraordinary transducer with its exceptionally smooth frequency response, extended bass, superb high frequency dispersion and extremely low distortion has to be heard to be disbelieved. Only then will you begin to understand how close we have come to reality.

Cambridge Audio

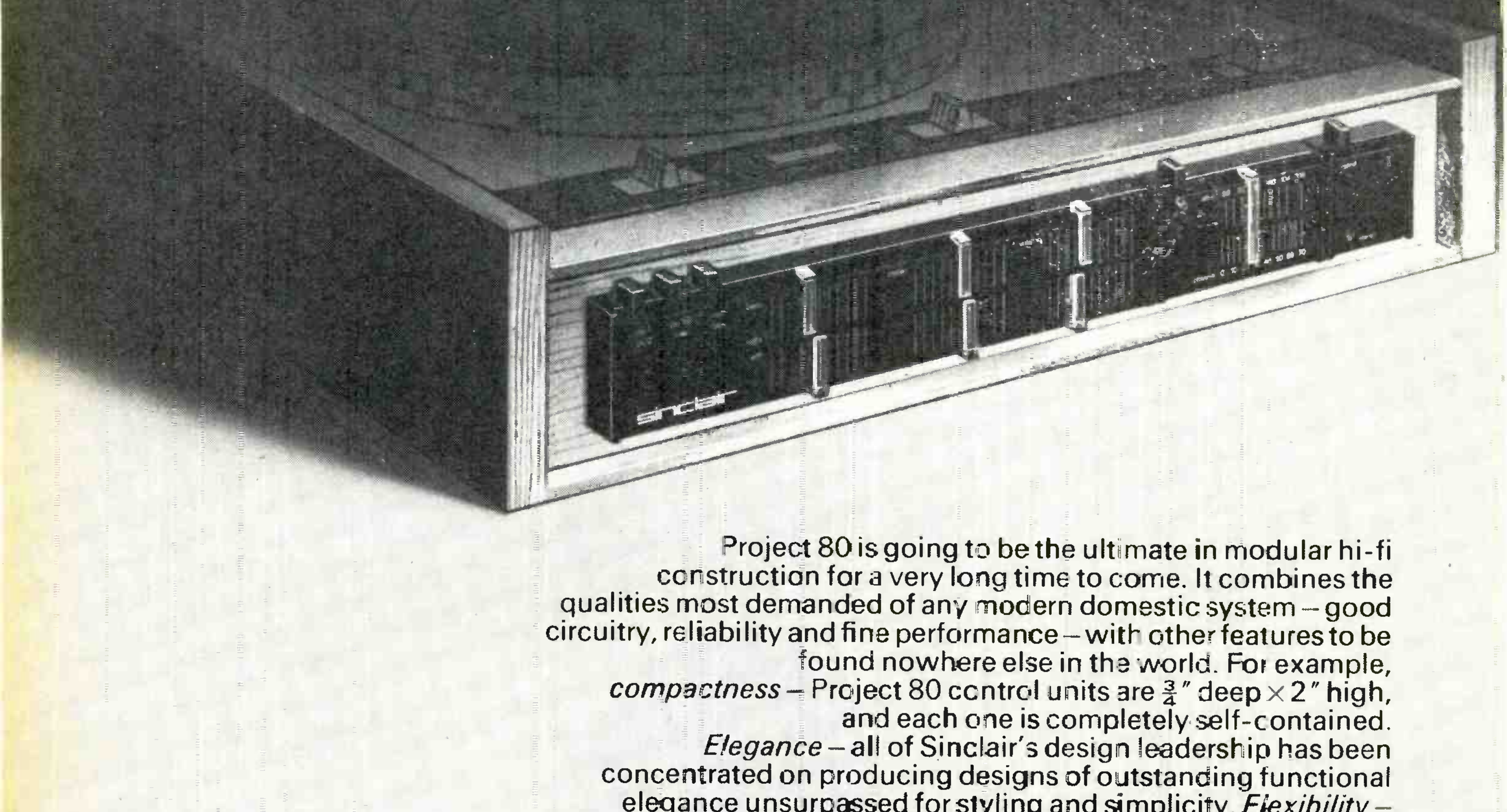
for people who listen to music

Cambridge Audio Limited
The River Mill
St. Ives
Huntingdon PE17 4EP
Telephone St. Ives 62901

**WW—103 FOR FURTHER DETAILS**

# Project 80

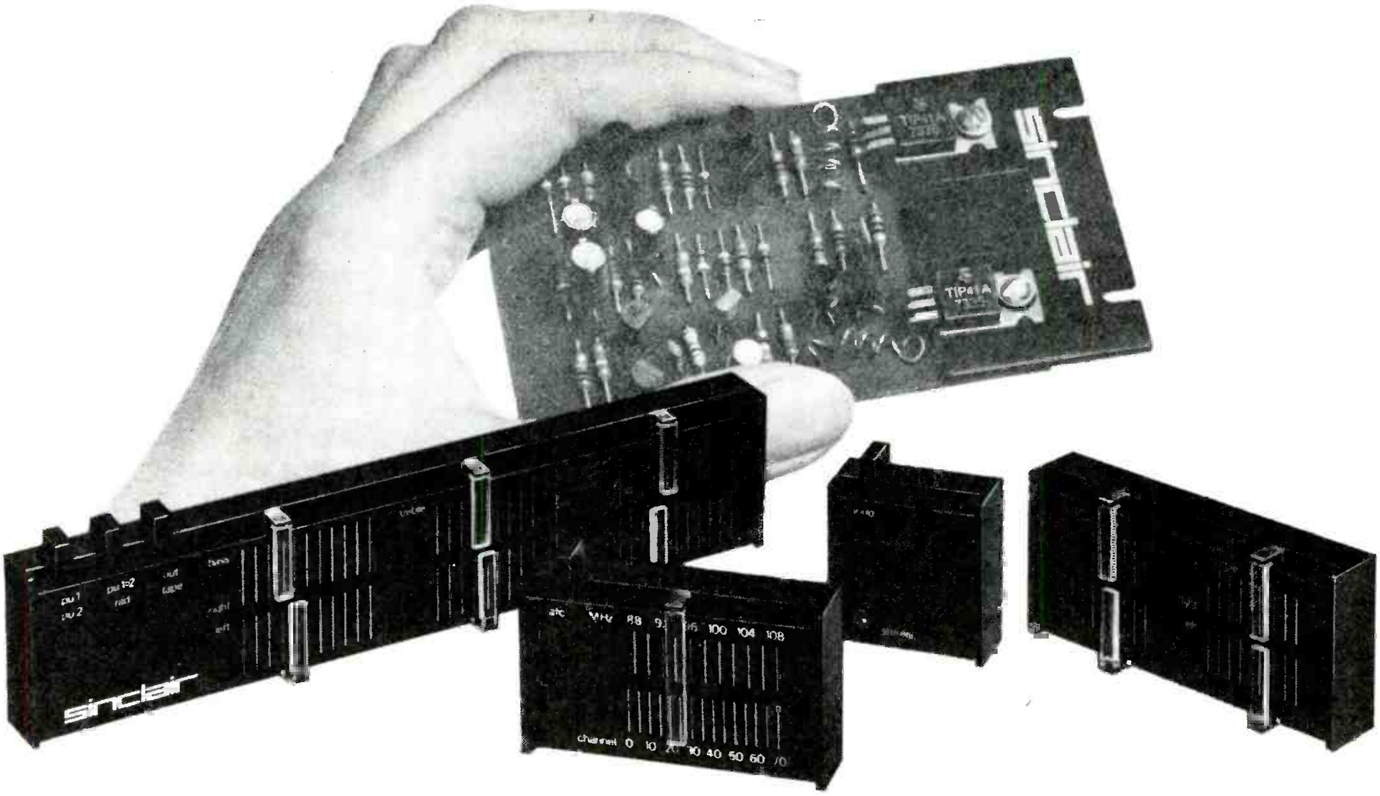
## a brilliant new concept in modular hi-fi




Project 80 is going to be the ultimate in modular hi-fi construction for a very long time to come. It combines the qualities most demanded of any modern domestic system – good circuitry, reliability and fine performance – with other features to be found nowhere else in the world. For example, *compactness* – Project 80 control units are $\frac{3}{4}$" deep × 2" high, and each one is completely self-contained. *Elegance* – all of Sinclair's design leadership has been concentrated on producing designs of outstanding functional elegance unsurpassed for styling and simplicity. *Flexibility* – the size and styling of Project 80 modules makes them the most versatile units ever. Combine them how you will, where you will, the Project 80 System of your choice gives you the best.

**sinclair**

# Sinclair Project 80




## technically the world's most advanced

Project 80 gives you choice from a range of 9 different modules for combining in a variety of ways to suit your requirements. The Stereo 80 is a versatile pre-amp control unit designed to meet all domestic hi-fi requirements including tape monitoring, high sensitivity magnetic cartridge input, and of course, individual slide controls on each channel for precise output matching. By separating the F.M. tuner and stereo decoder, useful economies can be effected where stereo radio reception is not needed. Two power amplifiers – Z.40 (18 watts RMS continuous into 4 ohms using 35V) and Z.60 (25 watts RMS continuous into 8 ohms using 50V) are available with choice of 3 different power supply units. The PZ.8 with its virtually indestructible circuitry is particularly recommended. For the final word in system building, the Active Filter Unit puts the finishing touch of quality to what are easily the world's most technically advanced hi-fi modules. Any further units likely to be added to Project 80 range will be compatible with those already available.

### Stereo 80 Control Unit

Size – 260 × 50 × 20mm ($10\frac{1}{4} \times 2 \times \frac{3}{4}$ins) Finish – Black with white indicators and transparent sliders Inputs – Magnetic pick-up 3mV RIAA corrected: Ceramic pick-up 350mV Radio 100mV: 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 tape radio and P.U. Sliders on each channel for volume bass treble R.R.P. (add £1·19 V.A.T.) **£11.95**

### Project 80 FM Tuner

Size – 85 × 50 × 20mm ($3\frac{1}{4} \times 2 \times \frac{3}{4}$ins) Tuning range Dual varicap – 87·5 to 108MHz Detector – I.C. balanced coincidence One I.C. equal to 26 transistors Distortion – 0·2% at 1KHz for 30% modulation 4 pole ceramic filter in I.F. section Aerial impedance – 75 Ω or 240-300 Ω Sensitivity – 5 microvolts for 30dB S/N ratio Output – 300mV for 30% modulation Power requirements – 25 to 35 volts R.R.P. (add £1·19 V.A.T.) **£11.95**

### Project 80 Stereo Decoder

Size – 47 × 50 × 20mm ($1\frac{7}{8} \times 2 \times \frac{3}{4}$ins) One 19 transistor I.C. Channel separation greater than 30dB Power requirements – 25V Output 150mV per channel R.R.P. (add 74p V.A.T.) **£7.45**

### Active Filter Unit

Separate controls on each channel. Size – 108 × 50 × 20mm ($4\frac{1}{4} \times 2 \times \frac{3}{4}$ins) Voltage gain – minus 0·2dB Frequency response – 40Hz to 22KHz controls minimum Distortion – at 1KHz – 0·03% using 30V supply H.F. cut off (scratch) – 22 KHz to 5·5KHz, 12dB/oct. slope L.F. cut off (rumble) – 28dB at 20Hz, 9dB/oct. slope R.R.P. (add 69p V.A.T.) **£6.95**

### Z.40 Power Amplifier

Size – 55 × 80 × 20mm ($2\frac{1}{8} \times 3\frac{1}{8} \times \frac{3}{4}$ins) 9 transistors Input sensitivity – 100mV Output 18 watts RMS continuous into 4 Ω (35V) Frequency response – 30Hz-100KHz±3dB S/N ratio – 64dB Distortion – at 10 watts into 8 Ω less than 0·1% Power requirements – 12 to 35 volts; built-in protection against overload. R.R.P. (add 54p V.A.T.) **£5.40**

### Z.60 Power Amplifier

Size – 55 × 98 × 15mm ($2\frac{1}{8} \times 3\frac{3}{4} \times \frac{3}{4}$ins) 12 transistors Input sensitivity – 100-250mV Output – 25 watts RMS continuous into 8 Ω (50V). Distortion – typically 0·03% Frequency response – 15Hz to more than 200KHz±3dB S/N ratio – better than 70dB Built-in protection against transient overload and short circuiting Load impedance – 4 Ω min. safe on open circuit R.R.P. (add 69p V.A.T.) **£6.95**

### Power Supply Units

PZ.8 Stabilised. Re-entrant current limiting makes damage from overload or even direct shorting impossible. Normal working voltage (adjustable) 50V. R.R.P. £7·98+79p V.A.T. Without mains transformer PZ.6 35V. stabilised R.R.P. £7·98+79p V.A.T. PZ.5 30V unstabilised R.R.P. £4·98+49p V.A.T.

### Guarantee

If, within 3 months of purchasing any product direct from us, you are dissatisfied with it, your money will be refunded on production of receipt of payment. Many Sinclair appointed stockists also offer this guarantee. Should any defect arise in normal use, we will service it without charge.

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WW—071 FOR FURTHER DETAILS

# AMPLIFIER KITS OF *Distinction*

## DESIGNER-APPROVED KIT

In Hi-Fi News there was published by Mr Linsley-Hood a series of four articles (November 1972–February 1973) and a subsequent follow-up article (April 1974) on a design for an amplifier of exceptional performance which has as its principal feature an ability to supply from a direct coupled fully protected output stage, power in excess of 75 watts whilst maintaining distortion at less than 0.01% even at very low power levels. The power amplifier is complemented by a pre-amplifier based on a discrete component operational amplifier referred to as the Liniac which is employed in the two most critical points of the system, namely the equalization stage and tone control stage, positions where most conventional designs run out of gain at the extremes of the frequency spectrum. Unusual features of the design are the variable transition frequencies of the tone controls and the variable slope of the scratch filter. There is a choice of four inputs, two equalized and two linear, each having independently adjustable signal level. The attractive slimline unit pictured has been made practical by highly compact PCBs and a specially designed Toroidal transformer.

Hi-Fi News Linsley-Hood 75 W Amplifier Mk III Version (modifications as per Hi-Fi News April 1974)


Full circuit description in handbook (pack 15—price 30p)

| Pack | | Price |
|---|---|---|
| 1 | Fibreglass printed-circuit board for power amp. | £0.85 |
| 2 | Set of resistors, capacitors, pre-sets for power amp. | £1.70 |
| 3 | Set of semiconductors for power amp. (now using BDY56, BD529, BD530) | £6.50 |
| 4 | Pair of 2 drilled, finned heat sinks | £0.80 |
| 5 | Fibreglass printed-circuit board for pre-amp. | £1.30 |
| 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 |
| 8 | Set of potentiometers (including mains switch) | £2.05 |
| 9 | Set of 4 push-button switches, rotary mode switch | £3.70 |
| 10 | Toroidal transformer complete with magnetic screen/housing primary: 0-117-234 V, secondaries: 33-0-33 V, 25-0-25 V. | £9.15 |
| 11 | Fibreglass printed-circuit board for power supply | £0.65 |
| 12 | Set of resistors, capacitors, secondary fuses, semiconductors for power supply | £3.50 |
| 13 | Set of miscellaneous parts including DIN skts, mains input skt, fuse holder, interconnecting cable, control knobs | £4.25 |
| 14 | Set of metalwork parts including silk screen printed fascia panel and all brackets, fixing parts, etc. | £6.30 |
| 15 | Handbook | £0.30 |
| 16 | Teak cabinet | £7.35 |
| | 2 each of packs 1–7 inclusive are required for complete stereo system | |
| | Total cost of individually purchased packs | £69.75 |

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**CV100.** 50v. at 2 amp: 50v. at 100 m/a. **£3.** P.P. 50p.

**CV250.** 25v. at 8 amp: 75v. at ½ amp. **£5.** P.P. £1.

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3 digit 12v. (Rotary Reset) 2½ x 1½ x 1½ in. **£1** each.
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**MULTICORE CABLE (P.V.C.).**
6 core (6 colours) 3 screened, 14/0048. **15p.** yd. 100 yds. **£12·50.**
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Minimum order 10 yds

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**£1·25** 10m. **£10** 100m.
8 cores, 7/·mm. bonded side by side in ribbon form.

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| | |
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### ACTIVE FILTER

| Pack | | |
|---|---|---|
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| 3 | Sets of semiconductors | £2.40 |

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| | | |
|---|---|---|
| 4 | Special heat sink assembly for set of 3 amplifiers | £0.85 |
| 5 | Set of 3 O/P coupling capacitors | £1.00 |

2 off packs 4, 5 required for stereo system

### POWER SUPPLY

FOR 20W/CHANNEL STEREO SYSTEM

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| 2N2926G | £0.10 | 2N5457 | £0.45 | BC214L | £0.14 | MPSA05 | £0.30 | TIP32A | £0.70 |
| 2N3053 | £0.15 | 2N5459 | £0.45 | BCY72 | £0.13 | MPSA12 | £0.55 | TIP33A | £1.00 |
| 2N3055 | £0.45 | 2N5830 | £0.30 | BD529 | £0.85 | MPSA14 | £0.35 | TIP34A | £1.50 |
| 2N3442 | £1.20 | 40361 | £0.40 | BD530 | £0.85 | MPSA55 | £0.35 | TIP41A | £0.74 |
| 2N3704 | £0.10 | 40362 | £0.45 | BDY56 | £1.60 | MPSA65 | £0.35 | TIP42A | £0.90 |
| 2N3707 | £0.10 | BC107 | £0.10 | BF257 | £0.40 | MPSA66 | £0.40 | IN914 | £0.07 |
| 2N3711 | £0.09 | BC108 | £0.10 | BF259 | £0.47 | MPSU05 | £0.60 | IN916 | £0.07 |
| 2N3819 | £0.23 | BC109 | £0.10 | BFR39 | £0.25 | MPSU55 | £0.70 | IS920 | £0.10 |
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**TRANSFORMER**
PRI. 0, 115, 160, 205, 225, 245. SEC. 35-0-35, 1·2A **£4·50 + 50p. p.p.**

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Price 10p ea.

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3. DT15 Japanese Transistor Characteristics. 2SA, 2SB, 2SC, 2SD numbers.
4. DVT Diode, Comparison Tables.
5. Band 1. Transistor Characteristics. European numbers AC, AF, BC, BF, etc.
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| PROM10 | Omni Directional Capacitor Microphone with 6 metres Cable. 600 ohms | £30·00 |
| PROM20 | Uni-Directional Capacitor Microphone with 6 metres Cable. 600 ohms | £32·00 |
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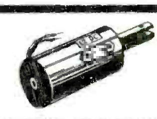

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**DRAKE L.T. TRANSFORMERS**
Pri. 240v. E.S. Sec. 26v. 10A and 12v. 0·1A, open frame, table top connections, **£5·50**, carr. 50p. Pri. 200-220-240v., Sec. 1, 37v. 6A, Sec. 2, 37v. 2A, 21v. 11A, open frame table top connections, **£9·50**, carr. £1.

**LEMARK** Pri. 240v. Sec. 40v. 6a. 5-0-5v 2a. 5-0-5v. ½a. Open frame design. **£4·50** carr. 75p. Pri. 240v. 16-0-16v. 2·5a. 24v. 630 m/a twice. 24v. 65 m/a and 115v. 2a. auto tap on primary. Open frame table top connections **£3·50** carr. 50p Pri. 240v. Sec. 20-0-20 ½a. 5-0-5 2a. **£1·75** carr 35p. All above transformers have a screen winding.

---

**MARCONI SIGNAL GENERATOR TYPE TF-144G:** Freq. 85 Kc/s-25 Mc/s in 8 ranges. Incremental: ±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 sinewave 75% depth. External Modulation: Direct or via internal amplifier. A.C. mains 200/250V, 40-100 c/s. Consumption approx. 40 watts. Measurements 29 × 12½ × 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 420m/A o/put. With 2 smoothing chokes 9H, 2 Capacitors, 10Mfd 1500V and 10Mfd 600V. Filament transformer 230V a.c. input. 4 Rectifying valves type 5Z3. 2 × 5V windings at 3Amps each and 5V at 6Amp and 4V at 0·25Amps. Mounted on steel base 19in. W × 11in. H × 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 × 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 × 21 in. wide × 16 in. deep, with rear door. **£12** each, Carr. £2·50.

**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-41195 and power supply 200-250V a.c. Polarised relay type 3SEITR. 80-0-80V 25mA. Two stabilised valves CV 286. Centre Zero Meter 10-0-10. Size 8in. × 8in. × 8in. New condition **£7·50,** Carr. 75p.

**TS 15C/AP FLUXMETER:** Used to provide qualitative measurements of flux densities between pole faces of magnets. Range 1200-9600 gausses. ±2%. S/hand good cond. **£25** + 60p post.

**AUTO TRANSFORMER:** 230V 50c/s, 1000 watts. Mounted in strong steel case 5in. × 6½in. × 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 × 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.

**AUTOMATIC VIBRATION EXCITER CONTROL UNIT TYPE 1016:** Manufactured by Bruel & Kjoer. 5-5000c/s per sec. S/hand V. good cond. **£90,** Carr. £2.

**SOLAS II SURVIVAL RADIO TX/RX:** Automatic morse key or speech. 500KHz; 2182KHz; 8364KHz. **£40** each. Carr. £2.

**RACAL OSCILLATOR:** 1-100,000KHz in 1KHz steps with digital readout BFO, CWN, FSK, CWW, LSB, USB, ISB, DSB. Line 1 and 2. **£200** each. Carr. £5.

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**10-WAY TELEPHONE LAMP STRIP:** Suitable for use with the above. **£2** each. Post 30p.
**10-WAY TELEPHONE MAGNETIC INDICATOR:** 50V. For use with the above items. **£2** each. Post 40p.
**10-WAY TELEPHONE SOCKET STRIP:** 3 connections. Takes standard P.O. Jackplugs; 201 or 316; and **10-WAY TELEPHONE LAMP STRIP, £3** the pair. Post 50p.
**20-LINE TELEPHONE UNIT:** With plugs; magnetic indicators; and switches in metal case. Size 8 × 8 × 19in. **£5** each. Carr. £1.

**BRIDGE MEGGER:** 250V. (Evershed Vignoles) series 2. **£30** each. Carr. £1.

**BRIDGE MEGGER:** 2,500V., series 1. **£30** each. Carr. £1.

**TRANSMITTER BC-624:** Complete with power supply for 230V. 5 channel, crystal controlled. Can be modified for 2 metres. Size 19 × 19 × 12in. approx. Secondhand, excellent cond. **£12·50** each. Carr. £2.

**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. × 12in. × 36in. 230V input. **£35,** Carr. £4·00.

**COPPER WIRE AERIAL:** with insulators, 100ft. long. **£1·50.** Post 40p.

**HIGH VOLTAGE TRANSFORMER:** 5000/5000 at 250mA; 230V. A.C. input. **£15** each. Carr. £2.

**TELEPHONE CABLE:** (Twin) 1,350ft. on metal reel. **£5** per reel. Carr. £1.

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**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 × 807 Valves. Mounted 19" chassis, 8" × 8". "As new" cond. **£8** each; or secondhand **£5** each. Carr. both types £1·50.

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| SN7405N | 0.22 | SN7497N | 3.87 |
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| SN7410N | 0.22 | SN74110N | 0.58 |
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| SN7427N | 0.37 | SN74150N | 1.75 |
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| SN7430N | 0.22 | SN74153N | 0.95 |
| SN7432N | 0.37 | SN74154N | 2.00 |
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| SN7444N | 1.27 | SN74164N | 1.76 |
| SN7445N | 1.60 | SN74165N | 1.76 |
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| SN7486N | 0.47 | SN74197N | 1.20 |
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| ACY17 | 0.40 | BY127 | 0.12 | ZTX300 | 0.13 |
| ACY39 | 0.78 | BYZ13 | 0.42 | ZTX302 | 0.18 |
| AD149 | 0.50 | C106D | 0.54 | ZTX500 | 0.13 |
| AD161 | 0.44 | GET111 | 0.72 | 2N697 | 0.16 |
| AD162 | 0.44 | GET115 | 0.90 | 2N706 | 0.12 |
| AF117 | 0.24 | GETB80 | 0.60 | 2N930 | 0.18 |
| AF118 | 0.57 | LM309K | 2.00 | 2N987 | 0.42 |
| AF139 | 0.41 | MAT121 | 0.25 | 2N1132 | 0.24 |
| AF186 | 0.48 | MJE340 | 0.47 | 2N1304 | 0.28 |
| AF239 | 0.44 | MJE520 | 0.63 | 2N1613 | 0.21 |
| ASY27 | 0.33 | MJE3055 | 0.77 | 2N1671 | 1.20 |
| BA115 | 0.10 | MJE2955 | 1.27 | 2N2147 | 0.78 |
| BAX13 | 0.05 | MPF105 | 0.36 | 2N2160 | 0.78 |
| BC107 | 0.14 | NKT404 | 0.66 | 2N2926 | 0.12 |
| BC108 | 0.13 | OA5 | 0.72 | 2N3053 | 0.18 |
| BC109 | 0.14 | OA81 | 0.18 | 2N3054 | 0.48 |
| BC109C | 0.16 | OA200 | 0.08 | 2N3055 | 0.45 |
| BC113 | 0.15 | OA202 | 0.06 | 2N3440 | 0.58 |
| BC147 | 0.10 | OC28 | 0.66 | 2N3442 | 1.39 |
| BC148 | 0.08 | OC35 | 0.55 | 2N3525 | 0.91 |
| BC149 | 0.10 | OC36 | 0.60 | 2N3614 | 0.65 |
| BC169C | 0.15 | OC44 | 0.20 | 2N3702 | 0.11 |
| BC182 | 0.12 | OC45 | 0.20 | 2N3714 | 1.41 |
| BCY32 | 0.85 | OC71 | 0.18 | 2N3771 | 1.77 |
| BCT39 | 1.50 | OC72 | 0.28 | 2N3773 | 2.40 |
| BCY55 | 2.64 | OC77 | 0.54 | 2N3790 | 2.10 |
| BCY70 | 0.18 | OC81 | 0.29 | 2N3819 | 0.38 |
| BCY71 | 0.22 | OC83 | 0.27 | 2N3886 | 0.72 |
| BCY72 | 0.12 | OC140 | 1.14 | 2N3903 | 0.15 |
| BD124 | 0.65 | OC170 | 0.30 | 2N4002 | 0.14 |
| BD131 | 0.42 | OC200 | 0.54 | 2N4126 | 0.15 |
| BF115 | 0.20 | OC202 | 0.90 | 2N4871 | 0.34 |
| BF180 | 0.36 | OCP71 | 1.20 | 2N5457 | 0.30 |
| BF194 | 0.10 | ORP12 | 0.60 | 2S303 | 0.60 |
| BFX13 | 0.26 | ORP60 | 0.55 | 40550 | 0.54 |
| BFX34 | 0.70 | P346A | 0.18 | 40361 | 0.45 |
| BFX88 | 0.24 | TIL209 | 0.20 | 40362 | 0.40 |
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| BFY51 | 0.20 | TIP30A | 0.57 | 40486 | 0.85 |
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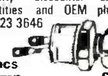

| Triacs | £ p |
|---|---|
| **3 Amp** | |
| SC35A | 0.85 |
| SC35B | 0.91 |
| SC35D | 0.99 |
| SC35E | 1.30 |
| **6 Amp** | |
| SC40A | 0.88 |
| SC40B | 0.97 |
| SC40D | 1.20 |
| SC40E | 1.50 |
| **10 Amp** | |
| SC45A | 1.09 |
| SC458 | 1.12 |
| SC45D | 1.50 |
| SC45E | 1.65 |
| **15 Amp** | |
| SC50A | 1.46 |
| SC50B | 1.57 |
| SC50D | 1.80 |
| SC50E | 2.00 |
| **Also** | |
| 40430 | 0.85 |
| 40669 | 0.90 |
| 40486 | 0.85 |

## SILICON CONTROLLED RECTIFIERS

See above for small quantity discounts. Large quantities and OEM phone 01-723 3646

| | £ p |
|---|---|
| **T05 1 Amp** | |
| CRS1/05AF | 0.42 |
| CRS1/10AF | 0.48 |
| CRS1/20AF | 0.52 |
| CRS1/40AF | 0.60 |
| CRS1/60AF | 0.78 |
| **T048 3 Amp** | |
| CRS3/025AF | 0.36 |
| CRS3/10AF | 0.48 |
| CRS3/20AF | 0.54 |
| CRS3/40AF | 0.65 |
| CRS3/60AF | 0.80 |
| **T048 7 Amp** | |
| CRS7/400 | 0.84 |
| CRS7/600 | 1.14 |
| **T048 16 Amp** | |
| CRS16/100 | 0.78 |
| CRS16/200 | 0.85 |
| CRS16/400 | 0.96 |

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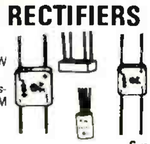

| | £ p | | £ p |
|---|---|---|---|
| **½ Amp** | | | |
| B025/025 | 0.14 | | |
| B025/05 | 0.16 | B4/10 | 0.48 |
| **1 Amp** | | B4/20 | 0.54 |
| B1/05 | 0.20 | B4/40 | 0.60 |
| B1/10 | 0.21 | B4/60 | 0.70 |
| B1/20 | 0.24 | B4/80 | 0.90 |
| B1/60 | 0.25 | **6 Amp** | |
| B1/100 | 0.30 | B6/05 | 0.50 |
| **2 Amp** | | B6/10 | 0.58 |
| B2/05 | 0.30 | B6/20 | 0.68 |
| B2/10 | 0.35 | B6/40 | 0.75 |
| B2/20 | 0.40 | B6/60 | 0.87 |
| B2/40 | 0.44 | **1 Amp Tubular** | |
| B2/60 | 0.45 | W005 | 0.27 |
| B2/100 | 0.55 | W01 | 0.29 |
| **4 Amp** | | W02 | 0.30 |
| B4/05 | 0.45 | W06 | 0.33 |

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| CA3019 | Diode array | £1.12 |
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| CA3022 | Low power video amp | £1.93 |
| CA302BA | Diff cas wide band | £1.03 |
| CA3036 | Dual Darlington pair | £1.08 |
| CA3046 | Transistor array | £1.03 |
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| CA3081 | Hi-Amp 7 seg com emit driver | £1.80 |
| CA3089E | Complete FM IF system | £2.94 |
| CA3090Q | PLL stereo decoder | £5.40 |
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| NE561B | PLL analogue multiplier | £5.00 |
| NE562B | PLL open loop for dividers | £5.00 |
| NE567B | PLL tone detector | £3.50 |
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| MC1303L | 2× low noise pre-amp | £1.42 |
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| MC1310P | PLL (coil-less) MPX decoder | £2.91 |
| MC1458CP | Twin op-amp | £0.77 |
| MC1710CG | Level detecting op-amp | £0.60 |
| MFC4000P | 250mW amp | £0.45 |
| MFC4010P | Wide band pre-amp | £0.55 |
| MFC6040P | AF attenuator | £1.00 |
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| SN76003N | 5W power amp (finned) (2 for £2.85) | £1.50 |
| SN72741P | 8 pin d.i.l. op-amp | £0.60 |
| SN72748P | 8 pin d.i.l. Hi-Z op-amp | £0.61 |
| 702C | (TO5) op-amp | £0.75 |
| 709C | (TO5 or d.i.l.) op-amp | £0.39 |
| 723C | (TO99 or d.i.l.) reg | £0.90 |
| 728C | (TO99 or d.i.l.) reg | £0.45 |
| 741C | (TO5, 8 or 14 pin d.i.l.) gen pur op-amp | £0.50 |
| 747C | (TO5 or d.i.l.) gen pur dual op-amp | £1.00 |
| 748C | Hi-Z op-amp | £0.61 |
| LM309K | 5V 1.6A reg | £2.00 |
| TAA960 | 3 st filter (ultra's'ic transd) | £1.75 |

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### for callers or by post

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| 2. | D1201 telephone amplifier CRADLE | £7.50 |
| 3. | T1206 2 station intercom | £4.95 |
| 4. | T1306 3 station intercom | £9.95 |
| 5. | T1406 4 station intercom | £12.50 |
| 6. | TAIA 2 station telephones intercom | £13.50 |
| 7. | W1.2 2 station wireless intercom | £18.20 |
| 8. | DP303 door phone intercom | £7.00 |
| 9. | PK3 ETCH your own printed circuits | £2.25 |
| 10. | EA41 reverberation amplifier | £11.75 |
| 11. | U550 ultrasonic switch | £12.75 |
| 12. | XP4002 photoelectric alarm system | £13.50 |
| 13. | Solid state tachometer | £11.30 |
| 14. | Power dash transistor assisted ignition | £13.50 |
| 15. | Car auto lock | £2.75 |
| 16. | 4 amp 6–12 volt battery charger | £4.85 |
| 17. | FF21 car radio/tape quad adaptor | £4.68 |
| 18. | Fully disappearing car aerial | £2.00 |
| 19. | Electric disappearing car aerial | £7.80 |
| 20. | ET (F1009) Morse code key/buzzer | £1.70 |
| 21. | VH105 aircraft band converter | £4.50 |
| 22. | LM300-50K disco mic. | £12.95 |
| 23. | DF50B 50K communications mic. | £5.75 |
| 24. | Car lighter plug 1w voltage adaptors 300mA (state 6/7½/9 volt) | £1.95 each |
| 25. | ST tuner delay module | £1.50 |
| 26. | Gravenire 931A photo electric unit (with data) | £3.50 |
| 27. | 3 cw. 3×500 watt sound to light | £21.50 |
| 28. | 3 cw. 3×1000 watt sound to light+over-ride | £41.25 |
| 29. | 150 watt light display projector with wheel | £23.50 |
| 30. | MM1 (8Z005) 4 channel 9 volt mixer | £4.20 |
| 31. | MX100 deluxe 4 channel mixer | £6.78 |
| 32. | H67(G1320) stereo headphone amplifier | £10.50 |
| 33. | MP12 6-CH. slider control mixer | £27.95 |
| 34. | RE208 stereo phone adaptor | £2.25 |
| 35. | MD802 stereo phones | £2.20 |
| 36. | CIS200 stereo phones | £2.75 |
| 37. | CIS250 stereo phones | £6.50 |
| 38. | G1301 and G1305 stereo phone controls | £2.95 |
| 39. | Car stereo speakers in pods. Special offer Pr. | £2.95 |
| 40. | Crystal lapel microphone | £0.60 |
| 41. | F1052 car speakers front/rear radar | £1.00 |
| 42. | Bib groove clean (ref. No. 42) | £1.76 |
| 43. | Bib record care kit (ref. No. 43) | £2.20 |
| 44. | Bib cassette recorder care kit (ref. No. 26A) | £1.96 |
| 45. | Bib cassettee tap splicing kit (ref. No. 24) | £1.64 |
| 46. | BASF reel-reel hobby box | £2.40 |
| 47. | 2000 ohm headphones | £1.50 |
| 48. | 4000 ohm headphones | £1.55 |
| 49. | Cassette recorder mic. (2½×3½mm plugs) | £1.85 |
| 50. | 420 ES microscope | £5.70 |
| 51. | UP050 low cost 9 volt eliminator | £2.25 |
| 52. | RE 527 tape head | £1.70 |
| 53. | Cambridge pocket calculator | £19.95 |
| 54. | BC808 % pocket calculator | £21.95 |
| 55. | BC817 memory pocket calculator | £28.95 |
| 56. | BCM 850 % and memory calculator | £33.25 |
| 57. | Sinclair scientific calculator | £45.00 |
| 58. | Antex soldering iron kit (SKI) | £3.30 |
| 59. | Bib record care kit (ref. No. 59) | £1.17 |
| 60. | 5pc chassis punch kits | £5.50 |
| 61. | Longs desoldering tool | £5.50 |
| 62. | 1 amp in line mains suppressors | £2.50 |
| 63. | BSS2 (E1013) 7-way stereo speaker switch | £2.20 |
| 64. | Welle 8200D-PK expert gun kit | £6.20 |
| 65. | 'S' dec breadboard | £1.98 |
| 66. | '2' dec .. | £4.29 |
| 67. | '4' dec .. | £7.50 |
| 68. | 'T' dec .. | £3.65 |
| 69. | Instant head soldering gun | £2.30 |
| 70. | 40 watt soldering iron | £1.90 |

## ELECTRONIC COMPONENTS

(Post/Packing 15p per 1–6 items GB unless stated)

**Ceramic Filters**
Miniature 10.7MHz filters **40p** pair

**IC IF Unit**
CA3089 10.7MHz IC **£2.94**

**IC Clock**
MM 5314 single chip clock with CCT **£9.00**

**Sinclair 6 watt IC**
IC12 with data and PC board **£2.10**

**Radio IC chip**
ZN414 Radio IC with circuit **£1.20**

**5 watt IC chip**
76008 5 watt amplifier with data **£1.50**
PC Panel **50p**

**Ultra sonic transducers**
with data/circuits **£5.90** pair

**Strobe tubes**
ZFT8A (similar to 4A) **£4.00**
ZFT12A **£5.00**

**7 segment indicators**
3015F with data **£1.70** each

**Spring delay units**
HP42 9" twin spring **£3.30** pp 20p
HR1 6" twin spring **£6.85** pp 25p

**Fibre optics**
0.01" dia. mono filament **£5.50** per 100 metres
0.13" dia. 64 fibres **£1** per metre
15m dia. mares tails **£10.50** each

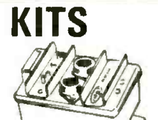
**Radio Control XTALS**
Matched pair for 465 kHz IF **£2.00** pr. for all superhet trans RX's.

**Handsets**
Lightweight telephone handsets brand new complete with diagrams for intercoms **£3.00** pr.

**Dual impedance and microphones**
50k/600 ohm quality cardiod stick mics. with HI-LO and on/off switches and cables.
RE345 Indoor/outdoor professional **£10.75**
RE350 Anti-feedback IM-quality **£11.50**

## EASY TO BUILD KITS BY AMTRON

### *Everything supplied*



ALL KITS OFFERED SUBJECT TO STOCK AVAILABILITY

| Model No. | | £ p | | | £ p |
|---|---|---|---|---|---|
| 310 | Radio control receiver | 3.29 | 700 | Electronic Chaffinch | 7.92 |
| 300 | 4-channel R/C transmitter | 6.61 | 707 | Windscreen wiper timer | 7.97 |
| 345 | Superhet R/C receiver | 6.61 | 760 | Acoustic switch | 12.57 |
| 65 | Simple transistor tester | 1.66 | 780 | Metal Detector (electronics only) | 10.91 |
| 115 | 8 watt amplifier | 4.50 | | | |
| 120 | 12 watt amplifier | 4.73 | 790 | Capacitive Burglar alarm | 7.92 |
| 125 | Stereo control unit | 6.61 | 835 | Guitar preamp. | 4.99 |
| 127 | Noise reduction unit | 9.55 | 840 | Delay car alarm | 6.99 |
| 130 | Mono control unit | 4.16 | 875 | CAP. Discharge ignition for car engine (–Ve Earth) | 13.19 |
| 157 | Private TV loop trans | 4.95 | | | |
| 605 | Power supply for 115 | 5.31 | 80 | Scope Calibrator | 2.65 |
| 610 | Power supply for 120 | 5.31 | 255 | Level indicator | 6.98 |
| 615 | Power supply for 2×120 | 6.64 | 525 | 120–160mHz VHF timer | 11.31 |
| 230 | AM/FM aerial amplifier | 3.29 | 715 | Photo cell switch | 8.07 |
| 240 | Auto packing light | 6.90 | 795 | Electronic continuity tester | 4.97 |
| 275 | Mic. preamplifier | 6.98 | 860 | Photo timer | 15.51 |
| 525C | 120–160MHz VHF tuner | 11.31 | 235 | Acoustic Alarm for driver | 8.61 |
| 570S | LF generator 10Hz–1mHz | 21.45 | 465 | Quartz XTAL checker | 9.90 |
| 575S | Sq. wave generator 20Hz–20kHz | 19.77 | 220 | Signal Injector | 2.65 |
| | | | 390 | VOX | £13.62 |
| 590 | SWR meter | 9.47 | 432 | Testakit | 21.83 |
| 630 | STAB Power supply 6–12v 0.25–0.1A | 9.24 | 670 | Buffer Battery Charger | 7.59 |
| 690 | DC motor speed Gov. | 3.31 | 850 | Electronic Keyer | 16.37 |

ALL TYPES OFFERED SUBJECT TO AVAILABILITY. PRICES CORRECT AT TIME OF PRESS. E & OE. 8% VAT TO BE ADDED TO ALL ORDERS.

# Henry's RADIO

**EDGWARE ROAD, W2**

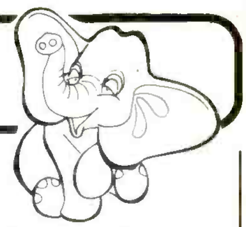
CONTACT HENRY'S FIRST
see facing page for addresses

ELECTRONIC COMPONENTS AND EQUIPMENT
Retail · Trade · Educational · Export · Industrial Supplied
*Let us quote for your requirements*

10% VAT TO BE ADDED TO ALL ORDERS (EXPORT VAT FREE)

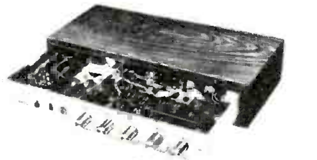
# Henry's

**LARGEST SELECTION OF ELECTRONIC COMPONENTS AND EQUIPMENT. LOW PRICES– MEAN LESS VAT.**



## You can build the Texan and Stereo FM Tuner

### TEXAN 20+20 WATT IC STEREO AMPLIFIERS



Features glass-fibre PC board, Gardners low field transformer, 6-IC's, 10 transistors plug diodes etc. Designed by Texas Instruments engineers for Henry's ad. P.W. 1972. Supplied with full chassis work, detailed construction handbook and all necessary parts. Full input and control facilities. Stabilised supply, overall size 15¼in × 2¾in × 6⅝in mains operated. Free teak sleeve with every kit. **£28.50** (GB post paid).

### STEREO FM TUNER

Features capacity diode tuning, led and tuning meter indicators, stabilized power supply—mains operated. High performance and sensitivity with unique station indication IC stereo decoder. Overall size in teak sleeve 8in × 2¾in × 6⅝in.
Complete kit with teak sleeve **£21.00** (GB post paid). Join the large band of happy constructors!

## TRANSISTORISED MODULES

### Tuners—Power Suppliers—Amplifiers

**Amplifiers** (All single channel unless stated)

| | | | | | |
|---|---|---|---|---|---|
| 4-300 | 9 volt | 300 MW | o/p 3–8 ohm, 1–10mVi/p | Special offer | £1.75 |
| 2004 | 9 volt | 250 MW | o/p 3–8 ohm, 10–10mVi/p | Special offer | £2.70 |
| 104 | 9 volt | 1 watt | o/p 8–10 ohm, 10mVi/p | | £3.10 |
| 304 | 9 volt | 3 watt | o/p 1–8 ohm, 10mVi/p | | £3.95 |
| 555 | 12 volt | 3 watt | o/p 8–16 ohm, 150mVi/p | | £4.10 |
| 555ST | 12 volt | 1½ × 1½ watt | o/p 8 ohm, 150mVi/p | Stereo module | £5.95 |
| E1208 | 12 volt | 5 watt | o/p 4–16 ohm, 25–60mVi/p | | £5.10 |
| 608 | 24 volt | 10 watt | o/p 4–8 ohm, 30–50mVi/p | | £4.95 |
| 410 | 28 volt | 10 watt | o/p 8 ohm, 160mVi/p | | £4.95 |
| 620 | 45 volt | 30 watt | o/p 1–8 ohm, 150mVi/p | | £9.95 |
| Z40 | 30/35 volt | 15 watt | o/p 1–8 ohm, 100mVi/p | | £5.45 |
| Z60 | 45/50 volt | 25 watt | o/p 1–8 ohm, 100–250mVi/p | | £6.95 |
| SA6817 | 24 volt | 6+6 watt | o/p 8 ohm, 100mVi/p | Stereo module | £10.20 |

**Amplifiers with controls**

| | | | |
|---|---|---|---|
| E1210 | 12 volt 2½+2½ watts 8 ohms | Stereo | £8.25 |
| R500 | Mains 5 watts 4–16 ohms | Mono | £6.30 |
| SAC14 | Mains 7+7 watts 8 ohms | Stereo | £11.75 |
| SAC30 | Mains 15+15 watts 8 ohms | Stereo | £14.95 |
| CA038 | 9 volt 1½+1½ watts 8 ohms | Stereo | £6.95 |
| CA068 | 12 volt 3+3 watts 8 ohms | Stereo | £10.50 |

**FM Modules**

| | |
|---|---|
| Mullard LP 1186 FM tuner (front end) with data 10.7MHz o/p | £4.85 |
| Mullard LP 1185 10.7MHz IF unit | £4.50 |
| Gorler Permability FM tuner (front end) 10.7MHz o/p | £4.20 |

**FM and AM tuners and decoders**

| | |
|---|---|
| FM 5231 (tu 2) 6 volt FM tuner | £7.95 |
| TU3 12 volt version (FM use with decoder) | £7.95 |
| SD4912 Stereo Decoder for Tu 3.12 volt | £7.95 |
| SP62H 6 volt stereo FM tuner | £14.95 |
| A1007 9 volt MW–AM tuner | £4.80 |
| Sinclair 12/45 volt FM tuner stereo recorder for above | £7.45 |
| A1018 9 volt FM tuner in cabinet | £13.95 |
| A1005M (S) 9–12 volt stereo decoder FM for above | £7.50 |
| 106Z 12 volt stereo decoder. General purpose | £6.50 |

{ All models fitted dials supplied with instructions

**Preamplifiers**

| | | | |
|---|---|---|---|
| Sinclair | Stereo 60 Preamplifier | With Controls | £6.75 |
| E1300 | CART/TAPE/MIC INPUTS 9 volt | Module | £2.85 |
| E1310 | Stereo 3–30mV mal cart 9 volt | | £4.75 |
| FF3 | Stereo 3mV tape head 9 volt | | £4.95 |
| 3042 | Stereo 5–20mV Mag. cart. mains | | £5.95 |
| EQ25 | Mono 3–250mV Tape/cart/flat. 9 volt | | £1.95 |

**Power Supplies**—Mains input (*chassis-rest cased)

| | |
|---|---|
| 470C 6/7½/gear 300mA with adaptors | £2.25 |
| P500 9 volt 500mA | £3.20 |
| HC244R 3/6/7½/9 volt 400mA stabilised | £5.50 |
| *P11 24 volt ½ amp 3.30 *P15 28 volt ½ amp | £3.30 |
| *P1080 12 volt 1A 4.70. *P1081 45 volt 0.9A | £7.80 |
| P12 4½–12 volt 0.4–1 amp | £7.15 |
| SK01A 3/6/8/12 volt 1 amp stabilised | £12.75 |
| P1076 3/4½/6/7½/9/12 volt ½ amp | £4.20 |
| Sk800A 1–15 volt 0–½A stabilised | £17.50 |

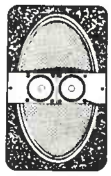
## QUALITY CASSETTE TAPES

"Living Sound" made specially for Henry's by EMP Tapes Ltd.
5 screw type with library case. Post paid (GB)

| | 3 for | 6 for | 10 for | 25 for |
|---|---|---|---|---|
| C60 | £1.10 | £2.00 | £3.15 | £7.50 |
| C90 | £1.47 | £2.85 | £4.65 | £11.37 |
| C120 | £1.83 | £3.54 | £5.60 | £14.00 |

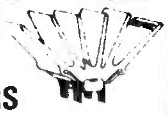
## EMI SPEAKERS

### Special Purchase



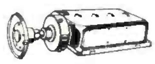
13×8 chassis speakers (carr/packing 30p each or 50p pr)
★150 TC 10 watt 8 ohm twin cone **£2.20**
★450 10 watt 4, 8, 15 ohm with twin tweeters and crossover **£3.85** each
FW 15 watt 8 ohm with tweeter **£5.25**
350 20 watt 8, 15 ohm with tweeter **£7.80** each
*Polished wood cabinet **£4.80** carr., etc., 35p each or 50p pair

## EXCLUSIVE 5 WATT IC AMPLIFIERS



Special purchase 5 watt output 8–16 ohm load. 30 volt max DC operation complete with data.
Price **£1.50** ea.
or 2 for **£2.85.**

## UHF TV TUNERS



625-line receiver UHF transistorised tuners FM. UK operation. Brand new. (Post/packing 25p each)
TYPE A Geared variable as illustrated **£2.50**
TYPE B 4-button push-button (adjustable) **£3.50**

## SPECIAL EQUIPMENT

Brand new ex-WD portable radiation detectors 0–10r complete with power unit, haversack and probe (CV2247) PRICE **£9.97** carr/packing £1.00.
Brand new seal photo multiplier units (designed FM fuel tank fire detective) **£3.50.**

## SPECIAL OFFER Cassette Storage

Rotating unit up to 32 cassettes stackable **£3.60** pp 15p
Car unit with bracket for 10 cassettes **£2.80** pp 10p

## TEST EQUIPMENT

### MULTIMETERS

(carr/packing 35p)

| | |
|---|---|
| U4324 20KV with case | £9.25 |
| U435 20KV with steel case | £8.75 |
| U4313 20KV with steel case | £12.50 |
| U4317 20KV with case | £16.50 |
| U4341 33KV plus transistor tester steel case | £10.00 |
| U4323 20KV plus IKHzd 465KHz OSC with case | £7.70 |
| ITI-2 20KV slim type | £5.95 |
| THL33D (L33DX) 2KV robust | £7.50 |
| TP5SN 10KV (Case £2.00) | £8.25 |
| AF105 50KV De-luxe (Case £1.90) | £12.50 |
| S100TR 100KV plus transistor tester | £22.50 |

## General Test Equipment

(* carr/packing 30p † carr/packing 50p) unless stated

| | |
|---|---|
| † 3100 IMA strip chart recorder | £44.00 |
| † Tk40 AC multivoltmeter | £19.75 |
| † Tk15 Grid dip meter 440KHz–28MHz | £16.50 |
| † Tk65 28 range valve voltmeeter | £22.50 |
| † Tk200 RF generator 120KHz–500MHz | £18.95 |
| † Tk22D AF generator 20Hz–200KHz | £19.95 |
| * HM350 In circuit transistor tester | £19.50 |
| * C3025 Compact transistor tester | £6.95 |
| * TT145 De-luxe meter 1–300 MHz | £14.75 |
| † G3-36 R/C osc 20Hz–200KHz | £19.75 |
| * C3042 SWR Meter | £5.75 |
| * SE350A De-luxe signal tracer | £12.95 |
| * SE400 Mini-lab all in one tester | £15.50 |
| C1–5 Scope 500,000KHz (carr £1.00) | £43.00 |
| * C3043 5 CH F/A meter 1–300MHz | £5.75 |
| Resistance sub box { Post etc | £2.40 |
| Capacitator { 20p | £2.10 |
| 2 amp variable transformers (carr £1) | £6.55 |
| Radio activity counter 0–10r (carr £1) | £9.97 |
| Mains unit for above (carr 50p) | £3.75 |

## JOSTY KITS IN STOCK

(Post, etc., 15p each)

| | | |
|---|---|---|
| AF20 | Mono transistor amplifier | £4.80 |
| AF25 | Mixer | £3.60 |
| AF30 | Mono transistor pre-amp | £2.61 |
| AF35 | Emmiter amplifier | £2.27 |
| AF80 | Small 0.5W amplifier for mic. | £4.22 |
| AF305 | Intercom | £9.52 |
| AF310/2 | Mono amplifier (for stereo use two) | £6.87 |
| M180 | Multivibrator | £1.71 |
| M1302 | Transistor tester | £8.45 |
| M191 | Vu-Meter | £4.56 |
| M192 | Stereo balance meter | £4.97 |
| LF380 | Quadrophonic device | £11.36 |
| AT60 | Psychedelic light control, single channel | £7.80 |
| AT65 | Psychedelic light control, 3 channel | £14.55 |
| AT25 | Window wiper robot | £5.82 |
| AT30 | Photo cell switching unit | £5.70 |
| AT50 | 400w Triac light dimmer speed control | £4.80 |
| AT56 | 2.200w Triac light dimmer speed control | £6.90 |
| AT5 | Automatic light control | £2.58 |
| GU330 | Tremelo unit for guitars, etc. | £7.50 |
| HF61 | Diode detector | £3.32 |
| HF65 | Frequency modulated FM transmitter | £2.70 |
| HF75 | FM transistor receiver | £2.87 |
| HF310 | FM tuner unit | £15.81 |
| HF325 | De-luxe FM tuner unit | £24.12 |
| HF330 | Stereo decoder for use with HF310/325 | £9.96 |
| GP310 | Stereo pre-amp for use with 2. AF 310 | £21.27 |
| GP312 | Basis circuit board | £11.45 |
| GP304 | Basis circuit board | £4.94 |
| HF380 | Aerial amplifier for LW to VHF | £4.94 |
| HF395 | Broadband aerial amplifier | £1.77 |
| NT10 | Power supply 100m/a 9v stab and 12v unstab | £6.15 |
| NT300 | Professional stab. power supply | £12.51 |
| NT310 | Power pack 2×15 volt 2A | £5.71 |
| NT305 | Voltage converter | £4.50 |
| NT330 | Power pack AF310/GP304 | £6.07 |
| NT315 | P/S 240v a.c. to 4.5–15v d.c. 500m/a | £9.57 |
| AE1 | Output stage 100mW | £1.50 |
| AE2 | Pre-amplifier | £1.15 |
| AE3 | Diode-receiver | £1.82 |
| AE4 | Flasher | £0.99 |
| AE5 | A stable multivibrator | £0.95 |
| AE6 | Monostable multivibrator | £0.93 |
| AE7 | RC generator | £0.97 |
| AE8 | Bassfilter | £0.90 |
| AE9 | Treblefilter | £0.90 |
| AE10 | CCIR—filter | £0.90 |

AMATEUR ELECTRONICS by Josty Kit, the professional book for this amateur—covers the subject from basic principals to advanced electronic techniques. Complete with circuit board for AE1 to AE10 (see above). PRICE £3.30 (no VAT).

## SINCLAIR MODULES AND KITS

Sinclair Project 80

| | |
|---|---|
| ST80 stereo pre-amplifier | £11.95 |
| Audio filter unit | £6.95 |
| Z40 15 watt amplifier | £5.45 |
| Z60 25 watt amplifier | £6.95 |
| PZ5 power supplies for 1 or 2 Z40 | £4.98 |
| PZ6 power supplies (S. Tab) for 1 or 2 Z40 | £7.98 |
| PZ8 power supplies (S. Tab) for 1 or 2 Z60 | £7.98 |
| Transformer for PZ8 | £3.95 |
| FM tuner | £11.95 |
| Stereo decoder | £7.45 |

All above post paid (GB only).

**PACKAGE DEALS** (Carriage/packing 35p)

| | |
|---|---|
| 2×Z40, S780, PZ5 | £25.00 |
| 2×Z60, S780, PZ6 | £27.75 |
| 2×Z60, S780, PZ8 + Trans. | £34.40 |

**Sinclair Special Purchases**
* Project 60 stereo preamplifier **£6.75** post 20p
* Project 605 kit **£19.95** post 25p
* Cambridge calculator kit **£13.59** post 15p

## SINCLAIR CALCULATOR KIT

Complete kit NOW **£13.59** + VAT
Also built **£19.95** + VAT

## HENRY'S HOME ENTERTAINMENT CENTRES LTD

**London**

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| 354/6 Edgware Rd. W2 | 01-402 5854 |
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| 372 Edgware Rd. W2 | 01-402 8140 |
| 120 Shaftesbury Ave. W1 | 01-437 9692 |
| 230 Tottenham Court Rd. W1 | 01-580 1785 |
| 144 Burnt Oak B'way, Burnt Oak, Edgware | 01-952 7402 |
| 190/4 Station Rd. Harrow, Middlesex | 01-863 7788 |

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| | |
|---|---|
| 256 Banbury Rd. Summertown, Oxford | (0865) 54181 |
| 55 Gloucester Rd. Bristol 7 | (0272) 45791 |

## FREE STOCK LISTS

**No 36** Transistors/valves/semiconductors.
**No 18** Disco lighting high power sound.
**No 17** Hi-Fi, TV-tape equipment.
Send large stamped addressed envelope with all enquiries.

# Henry's RADIO
**EDGWARE ROAD, W2**

*Electronic Centres*
404-406 Electronic Components & Equipment 01-402 8381
309 PA-Disco-Lighting High Power Sound 01-723 6963
303 Special offers and bargains store
*All mail to 303 Edgware Road, London W2 1BW*

*Hi Fi and Electronics Centres Open 9 am - 6 pm*

*Prices correct at time of preparation. Subject to change without notice. E.&O.E.*

# VALVES

| | £ | | £ | | £ |
|---|---|---|---|---|---|
| | | | | EY88 | 0·40 |
| | | | | EZ40 | 0·70 |
| | | | | EZ41 | 0·75 |
| | | | | EZ80 | 0·28 |
| | | | | EZ81 | 0·30 |
| | | | | GY501 | 0·80 |
| A1065 | £1·25 | ECH42 | 1·00 | GZ34 | 0·65 |
| AR8 | 0·50 | ECH81 | 0·30 | GZ37 | 1·00 |
| ATP4 | 0·50 | ECH83 | 0·45 | KT66 | 2·50 |
| B12H | 3·00 | ECH84 | 0·45 | KT88 | 3·00 |
| CY31 | 0·50 | ECL80 | 0·55 | MH4 | 0·75 |
| DAF96 | 0·50 | ECL82 | 0·35 | ML6 | 0·50 |
| DF96 | 0·50 | ECL83 | 0·70 | OA2 | 0·40 |
| DK96 | 0·60 | ECL86 | 0·40 | OAF70 | 0·55 |
| DL92 | 0·40 | EF36 | 0·65 | OB2 | 0·40 |
| DL96 | 0·60 | EF37A | 1·20 | PABC80 | 0·40 |
| DM70 | 0·60 | EF40 | 0·62 | PC97 | 0·45 |
| DY86/87 | 0·35 | EF41 | 0·65 | PCC84 | 0·40 |
| DY802 | 0·35 | EF80 | 0·25 | PCC85 | 0·40 |
| E88CC | 0·70 | EF83 | 1·10 | PCC88 | 0·55 |
| E92CC | 0·55 | EF85 | 0·35 | PCC89 | 0·50 |
| E88CC/01 | 1·15 | EF86 | 0·30 | PCC189 | 0·60 |
| E180CC | 0·65 | EF89 | 0·27 | PCF80 | 0·40 |
| E182CC | 1·25 | EF91 | 0·37 | PCF82 | 0·35 |
| EA50 | 0·25 | EF92 | 0·50 | PCF84 | 0·60 |
| EABC80 | 0·38 | EF95 | 0·35 | PCF86 | 0·60 |
| EAF42 | 0·75 | EF183 | 0·30 | PCF200 | 0·75 |
| EB91 | 0·20 | EF184 | 0·35 | PCF201 | 0·75 |
| EBC33 | 1·00 | EFL200 | 0·60 | PCF801 | 0·55 |
| EBC41 | 0·75 | EL34 | 0·60 | PCF802 | 0·50 |
| EBF80 | 0·40 | EL36 | 0·50 | PCF805 | 0·90 |
| EBF83 | 0·40 | EL41 | 0·90 | PCF806 | 0·75 |
| EBF89 | 0·30 | EL81 | 0·55 | PCF808 | 0·85 |
| EC52 | 0·35 | EL82 | 0·55 | PCH200 | 0·80 |
| EC93 | 0·60 | EL84 | 0·30 | PCL81 | 0·60 |
| ECC81 | 0·40 | EL85 | 0·44 | PCL82 | 0·40 |
| ECC82 | 0·33 | EL86 | 0·38 | PCL83 | 0·65 |
| ECC83 | 0·33 | EL90 | 0·45 | PCL84 | 0·45 |
| ECC84 | 0·30 | EL504 | 0·70 | PCL86 | 0·50 |
| ECC85 | 0·40 | EM31 | 0·60 | PCL805 | 0·60 |
| ECC86 | 0·80 | EM80 | 0·45 | PFL200 | 0·70 |
| ECC88 | 0·40 | EM84 | 0·35 | PL36 | 0·60 |
| ECC189 | 0·65 | EM87 | 0·70 | PL38 | 1·00 |
| ECF80 | 0·35 | EY51 | 0·40 | PL81 | 0·50 |
| ECF82 | 0·35 | EY81 | 0·40 | PL82 | 0·45 |
| ECF801 | 0·60 | EY86 | 0·40 | PL83 | 0·45 |

A lot of these valves are imported and prices vary for each delivery, so we reserve the right to change prices for new stock when unavoidable.

| | £ | | £ | | £ | | £ | | £ | | £ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PL84 | 0·40 | TT21 | 4·20 | UL84 | 0·40 | 1T4 | 0·30 | 5Z3 | 0·80 | 6BQ7A | 0·55 |
| PL504 | 0·75 | U25 | 0·85 | UY41 | 0·45 | 1X2A | 0·60 | 5Z4 | 0·80 | 6BR7 | 1·00 |
| PL508 | 1·00 | U26 | 0·85 | UY85 | 0·40 | 1X2B | 0·60 | 5Z4GT | 0·45 | 6BW6 | 0·90 |
| PL509 | 1·50 | U27 | 0·60 | VR105/30 | 0·40 | 2K25 | 8·00 | 6AB7 | 0·50 | 6BW7 | 0·90 |
| PL802 | 0·95 | U191 | 0·75 | X66 | 0·50 | 3A4 | 0·50 | 6AC7 | 0·50 | 6C4 | 0·35 |
| PY33 | 0·63 | U801 | 0·80 | VR150/30 | 0·40 | 3D6 | 0·40 | 6AH6 | 0·60 | 6C6 | 0·40 |
| PY80 | 0·40 | UABC80 | 0·40 | Z800U | 2·00 | 3S4 | 0·40 | 6AK5 | 0·40 | 6CB6 | 0·40 |
| PY81 | 0·35 | UAF42 | 0·60 | | | | | 6AK8 | 0·38 | 6CH6 | 1·40 |
| PY82 | 0·35 | UBC41 | 0·60 | | | | | 6AL5 | 0·25 | 6CL6 | 0·65 |
| PY83 | 0·40 | UBF80 | 0·40 | | | | | 6AL5W | 0·50 | 6D6 | 0·40 |
| PY88 | 0·45 | UBF89 | 0·40 | | | | | 6AM6 | 0·37 | 6EA8 | 0·70 |
| PY500 | 1·00 | UBL1 | 0·70 | | | | | 6AN8 | 0·65 | 6F7 | 1·00 |
| PY800 | 0·45 | UBL21 | 0·70 | | | | | 6AQ5 | 0·45 | 6FSG | 0·50 |
| PY801 | 0·50 | UCC85 | 0·45 | | | | | 6AQ5W | 0·65 | 6F23 | 1·00 |
| QV03-12 | 0·50 | UCF80 | 0·70 | | | | | 6AS6 | 0·50 | 6F32 | 0·50 |
| QQVO3-10 | 1·25 | UCH42 | 0·75 | | | | | 6AT6 | 0·45 | 6F33 | 3·25 |
| QQVO6-40A | 8·00 | UCH81 | 0·40 | Z801U | 2·00 | 3V4 | 0·70 | 6AU6 | 0·30 | 6H6 | 0·30 |
| R19 | 0·60 | UCL82 | 0·35 | Z803U | 1·35 | 5B/254M | 5·00 | 6AX4GT | 0·75 | 6J4WA | 1·00 |
| SC1/400 | 3·06 | UCL83 | 0·65 | Z900T | 1·20 | 5B/255M | 3·20 | 6AX5GT | 0·80 | 6J5 | 0·65 |
| SC1/600 | 5·00 | UF41 | 0·70 | 1A3 | 0·45 | 5R4GY | 0·80 | 6B7 | 0·60 | 6J5GT | 0·45 |
| SP61 | 0·70 | UF80 | 0·35 | 1L4 | 0·25 | 5U4G | 0·40 | 6BA6 | 0·30 | 6J6 | 0·30 |
| SU4 | 0·60 | UF85 | 0·40 | 1R5 | 0·40 | 5V4G | 0·50 | 6BE6 | 0·35 | 6J6W | 0·45 |
| | | UF89 | 0·40 | 1S4 | 0·30 | 5Y3GT | 0·45 | 6BG6G | 0·70 | 6J7 | 0·45 |
| | | UL41 | 0·75 | 1S5 | 0·30 | 5Y4G | 0·40 | 6BJ6 | 0·55 | 6J7G | 0·40 |

**VAT 10% EXTRA**

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| 6K6GT | 0·75 | | | | |
| 6K7 | 0·45 | | | | |
| 6K7G | 0·30 | | | | |
| 6K8GT | 0·50 | | | | |
| 6K25 | 0·75 | | | | |
| 6L6 | 1·50 | | | | |
| 6L7G | 0·40 | | | | |
| 6Q7G | 0·45 | | | | |
| 6SA7 | 0·45 | | | | |
| 6SA7GT | 0·30 | | | | |
| 6SC7GT | 0·30 | 19G3 | 8·00 | 866A | 1·10 |
| 6SG7 | 0·45 | 19G6 | 6·60 | 931A | 5·80 |
| 6SJ7 | 0·50 | 19H4 | 7·00 | 954 | 0·50 |
| 6SJ7GT | 0·30 | 20P3 | 0·75 | 955 | 0·40 |
| 6SK7 | 0·50 | 20P4 | 1·00 | 956 | 0·30 |
| 6SK7G | 0·45 | 25L6GT | 0·60 | 957 | 0·40 |
| 6SL7GT | 0·45 | 30C15 | 1·00 | 1629 | 0·50 |
| 6SN7GT | 0·45 | 30C17 | 1·00 | 2051 | 0·80 |
| 6SQ7 | 0·50 | 30C18 | 0·90 | 5933 | 3·00 |
| 6V6G | 0·15 | 30F5 | 1·00 | 6057 | 0·60 |
| 6V6GT | 0·45 | 30FL1 | 0·80 | 6060 | 0·60 |
| 6X4 | 0·40 | 30FL12 | 1·05 | 6064 | 0·50 |
| 6X5G | 0·40 | 30FL14 | 0·90 | 6065 | 0·70 |
| 6X5GT | 0·50 | | | 6080 | 2·20 |
| 6Y6G | 0·80 | | | 6146 | 2·00 |
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| 11E2 | 5·00 | | | 9006 | 0·30 |
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| 12AU7 | 0·33 | 30P12 | 1·05 | MW13-35 | 15·00 |
| 12AV6 | 0·50 | 30P19 | 1·00 | VCR139A | 8·00 |
| 12AX7 | 0·33 | 30PL1 | 0·95 | 3BP1 | 4·00 |
| 12BA6 | 0·45 | 30PL13 | 1·20 | 88D | 9·00 |
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| 12BH7 | 0·50 | 35L6GT | 0·75 | 88L | 9·00 |
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| 12Y4 | 0·30 | 803 | 5·50 | | 28·00 |
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| | | | | | | |
|---|---|---|---|---|---|---|
| AC113 | AF178 | BF167 | GET116 | OC36 | SX754 | 2N2062 |
| AC126 | AF186 | BF185 | GEX66 | OC42 | ZR11 | 2N2147 |
| AC127 | AFZ12 | BFY51 | NKT222 | OC44 | ZR21 | 2N2411 |
| AC128 | ASY26 | BFY52 | OA5 | OC45 | 1N23A | 2N2989 |
| AC176 | ASY27 | BFY90 | OA47 | OC70 | 1N25 | 2N3053 |
| ACY18 | ASY28 | BSY27 | OA70 | OC73 | 1N32A | 2N3054 |
| ACY19 | BC108 | BSY38 | OA71 | OC78 | 1N38A | 2N3055 |
| ACY20 | BC118 | BSY95A | OA73 | OC78D | 1N43 | 2N3390 |
| ACY28 | BC119 | BYZ16 | OA79 | OC81 | 1N70 | 2N3391 |
| ACY39 | BC136 | CRS1/10 | OA91 | OC82 | 1N277 | 2N3730 |
| ACY40 | BC137 | CRS1/20 | OA200 | OC82D | 1N415C | 2N3731 |
| AD149 | BC148A | CRS1/30 | OA202 | OC82DM | 1N4148 | 2N3819 |
| AD161 | BC172 | CRS1/40 | OAZ200 | OC83 | 2N456A | 2N4038 |
| AD162 | BC172A | CRS3/10 | OC22 | OC139 | 2N708 | 2N4058 |
| ADZ11 | BC212A | CRS3/20 | OC22 | OC140 | 2N918 | 2N4061 |
| ADZ12 | BCY31 | CRS3/30 | OC26 | OC170 | 2N1304 | 2N4785 |
| AF114 | BCY33 | CRS3/40 | OC28 | OC172 | 2N1305 | 2N5295 |
| AF115 | BCY72 | CRS25/025 | OC29 | OC200 | 2N1307 | 3N128 |
| AF116 | BF115 | GET115 | OC39 | OC206 | 2N1309 | 3N154 |
| AF117 | | | | | | 3N159 |
| AF118 | | | | | | 2S303 |
| AF124 | | | | | | 404 |
| AF125 | | | | | | 2082 |
| AF126 | | | | | | 40250 |
| AF127 | | | | | | 40251 |
| AF139 | | | | | | 40668 |

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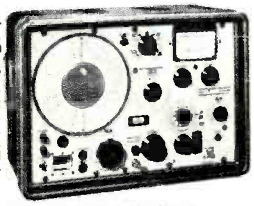

**TF144H SIGNAL GEN.** Freq. range 10 KHz-72 MHz. R.F. output 2µV to 2V at 50 ohms 400 and 1000 Hz internal mod. Limited qty. only available. Full spec. and price on request.

**TEXTRONIC 585 OSCILLOSCOPE**
DC to 100MHz. Separate time bases with delay and 5X magnifier. Time base A: 0·05 microsecs to 2 sec/cm in 24 stages also continuously variable between steps. Time base B: 2 microsecs to 10 sec in 18 stages. Delay 1 microsec to 10 sec. Complete with type 81 adaptor enabling use of all letter series plug ins. Type 80 plug-in (less probe) also available.

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**SOLOTRON CD 1400 OSCILLOSCOPE SYSTEM**
Available with a choice of "Y" or "X" plug-ins: wide band 1MHz, high gain differential, standard time base, slow spread, delayed sweep. Prices on application depending on combination selected.

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**SCHLUMBERGER B 1200 99db UHF ATTENUATOR.** £55·00

**SCHLUMBERGER 0 500a SYNC. OSCILLATOR 200-500MHz.** £95·00

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**TF1041C** VTVM A.C. voltage range 300 MV to 300V in 7 ranges, 20 Hz-1500 MHz. D.C. voltage ranges 300 MV 1000V in 8 ranges. D.C. resistance 50 ohms to 500 ohms. Price £62·50.
**TF 1041B.** Spec. as for 1041C. £52·50.

**HEWLETT—PACKARD**
**185A 800 MHz SAMPLING OSCILLOSCOPE WITH 188A DUAL TRACE PLUG-IN.** Full spec. and P.O.A.
**175A 50MHz Oscilloscope.**
**5248 COUNTER FREQUENCY MEASUREMENT:** 10Hz to 10,1MH2. Accuracy : 1 count. Automatic positioning of decimal point. Period measurement: 0-10kHz, reads in seconds, milliseconds or microseconds, decimal point automatically positioned. Display on 6 neon lamp decades and 2 meters. Complete with manual and following plug-ins: 525A 10 to 100MHz, 525B 100 to 220MHz, 526A video amplifier. Price on application.
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**571A-600MHz,** separate P.S.U. £150 complete.
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**L**—30 MHz fast rise time 5MV-20V.
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**TF 1400S DOUBLE PULSE GENERATOR WITH TM 6600/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 6600/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.

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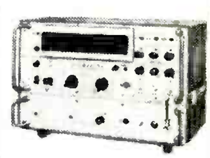

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C-13 TRANSMITTERS
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**R.F. METER** 0-8 amp. 2½" (U.S.A.) £1·80 P. & P. 15p.

**29/41FT. AERIALS** each consisting of ten 3ft., ⅞in. 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. Carriage £1·50.

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1 Kilowatt etc.
S.A.E. with requirements.

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**AMERICAN SWEEP GENERATOR** type TRM 3 15 to 400 MHZ. £300.

**AMERICAN AM GENERATOR** type 497. 4 to 400 MHZ. Supplied with leads, etc., for 240V 50 HZ operation £35.

**BRAND NEW 12″ LONG PERSISTENCE TUBES**
New stocks—new price. Only **£6·50** (whilst stock lasts)
Ideal for SSTV; educational purposes. Type 12DP7A, connections, voltages etc. Price includes carriage & VAT.

**SPECIAL 40 MHZ SCOPE SOLARTRON CD1212 ONLY £50.** Has to be a snag. There is—no plug—in Y amps available.
TB-100 nanosecs per cm. to 5 secs. per cm. In 24 calibrated ranges. 20 nanosecs per cm. with times 5 expansion. 5″ flat faced tube. Trace locator. 0-2 microsec. signal delay. Built in calibrator. 1 KHZ square wave. 200 micro volts to 100 volts in 18 calibrated ranges. Tube sensitivity 3 V/CM MAIN FRAM Y AMP boosts this to better than 200mV per cm. at 40 MHZ. 240V. 50 HZ Input. Complete with full manual including plug-in circuits. Come and see one working or Carriage £1·50.

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Oscilloscope type CD643. DC–15MHz. 5in. Flat face tube. **£45** each.

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**MARCONI VVM TF 1300.** Measures AC 50MV to 100V, 20 HZ to 300 MHZ, DC 100MV to 300V. Ohms 50 to 5 Meg Ohm. In fine condition **£18** each.

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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. 25k at **13p** ea.

**MORGANITE** Special Brand new, 2·5; 10; 100; 250; 500K; 1 in. sealed, **17p** ea.

**BERCO** 2½ Watt. Brand new, 5; 10; 50; 250; ohms; 1; 2·5; 10; 25; 50K at **15p** ea.

**STANDARD** 2 meg. log pots. Current type **15p** ea.

**INSTRUMENT** 3 in. Colvern 5 ohm **35p** ea.; 50k and 100K **50p** ea.

**BOURNS TRIMPOT POTENTIOMETERS.** 20; 50; 100; 200; 500 ohms; 1; 2; 2·5; 5; 10; 25K at **35p** ea. ALL BRAND NEW.

**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% **20p** ea.

**RELAYS**

Varley VP4 Plastic covers 4 pole c/o. 15K—**33p** ea.

**CARPENTERS** polarised Single pole c/o 20 and 65 ohm coil as new **37p** each. 14 ohm coil **33p** each. 45 ohm coil **33p** each.

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**FANTASTIC VALUE**
Miniature Transformer. Standard 240V input. 3Volt 1 amp output. Brand New. **65p** ea. P & P 15p. Discount for quantity.

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Also 450K 0·5% with dial **£2·13** ea.

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**ELECTROSTATIC VOLTMETERS** from 0–300 Volts to 0–10KV. S.A.E. with your requirements.

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Primarily intended for the alignment of AM Radios; Communication Receivers; Filters, etc., in the range of 250 KHZ to 5 MHZ, but can be effectively used to 30 MHZ. Can be used with any general purpose oscilloscope. Requires 12V AC input. Three controls—RF level; sweep width and frequency. Price **£8·50.**
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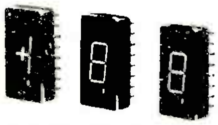

Filament Indicators; 16 Pin DIL 10mm Character Height.
0-9 Digit Ref 3015F
± 1 Overflow/Polarity Ref 3015G

**NEW PRICE £1.29**

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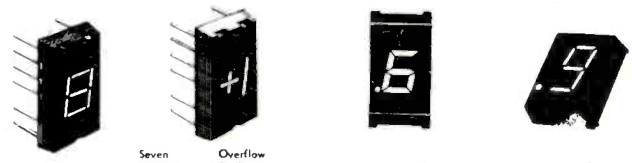

| | Seven Segment | Overflow (± 1) |
|---|---|---|
| Red | MAN 71 | MAN 73 |
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All Common Anode; Left Hand Decimal Point Character Height 0.3"

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DL 707
0.3" high character
14 pin DIL
DL 701
(± 1)
Common Anode
Red Only
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LIQUID CRYSTAL DISPLAY complete with socket and removable reflective backing; Ref AN4132R 13mm character height. Can be directly driven by National Semiconductors Alarm Clock chip MM5316.

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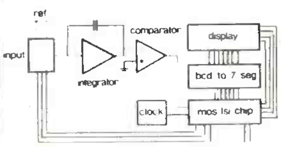


This state-of-the-art MOS LSI chip contains all the logic necessary for a 3½ decade, dual slope integrating, automatic polarity detecting DVM. Supplied with free data and circuit booklet.

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(booklet alone 10p)

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**all at £7.45 for 5**

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2N5777
Vceo, Vcbo 25v; Vebo 8v
Vceo, Vcbo 25v; VEBO 6v
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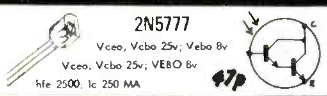

**47p**

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The Stabilized Power supply for which demand always exceeds supply switched 3; 6; 7½ & 9 volts up to 400 mA

Polarity reversal switch, Neon Mains Indicator; on/off switch; 4 ft head Multi-Way output plug adaptor; Metal Case; Rubber Feet

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| L036 | £1.65 |
| L037 | £1.65 |
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| L130 | £1.65 |
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| LM339 | £3.76 |
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| NE561B | £4.92 |
| NE562B | £4.92 |
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| SL415 | £2.29 |
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| AA120 | 10p | Series | |
| AA129 | 10p | BZY88 | 11p |
| BA100 | 10p | Series | |
| BA102 | 27½p | 0A47 | 11p |
| BA110 | 45p | 0A79 | 10p |
| BA115 | 19p | 0A81 | 8p |
| BA144 | 20p | 0A85 | 10p |
| BA145 | 22p | 0A90 | 8p |
| BA148 | 22p | 0A91 | 8p |
| BA154 | 20p | 0A200 | 11p |
| BA155 | 15½p | 0A202 | 12p |
| BA156 | 16½p | ZS120 | 8p |
| BAX16 | 10p | ZS140 | 25p |
| BB104 | 46p | ZS141 | 43p |
| BB105B | 42p | ZS142 | 33p |
| BY100 | 16½p | ZS170 | 10p |
| BY103 | 22p | ZS270 | 11p |
| BY105 | 16½p | ZS271 | 16p |
| BY126 | 16p | ZS278 | 37p |
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| AC176 | 15p | BC109 | 12p | BC268 | 15p | BF185 | 28p |
| AC187 | 22p | BC117 | 22p | BC407 | 16p | BF194 | 15p |
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| TIP31A | 68p | 2N3055 | 52p | 2N6076 | 16½p |
| TIP32A | 81p | 2N3375 | £3.63 | 2N6111 | 55p |
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| TIS88A | 37p | 2N3702 | 13p | 3N153 | 89p |
| TIS91 | 33p | 2N3703 | 12p | 40321 | 55p |
| ZTX107 | 10p | 2N3704 | 13p | 40430 | £1.39 |
| ZTX108 | 10p | 2N3705 | 12½p | 40673 | 55p |

## REGULATORS

| | 100mA (TO-39) | 500mA * (TO-3) | 500mA * (SOT-32) | 1A (TO-220) |
|---|---|---|---|---|
| 5V | TBA625A | L005T1 (MVR5V) | L129 TDA1405 | 7805UC |
| | £1.30 | £1.65 | £1.65 | £2.42 |
| 12V | TBA625B | L036T1 (MVR12V) | L130 TDA1412 | 7812UC |
| | £1.30 | £1.65 | £1.65 | £2.42 |
| 15V | TBA625C | L037T1 (MVR15V) | L131 TDA1415 | 7815UC |
| | £1.30 | £1.65 | £1.65 | £2.42 |

## THYRISTORS SCR's

| V | 800mA | | 4A | | 8A | |
|---|---|---|---|---|---|---|
| 30v | MCR102 | 32p | 106Y | 39p | | |
| 50v | | | 106F | 46p | 2N4441 | 87p |
| 60v | MCR103 | 44p | | | | |
| 100v | MCR104 | 49p | 106A | 48p | | |
| 200v | MCR120 | 51p | 106B | 53p | 2N4442 | £1.06 |
| 400v | | | 106D | 67p | 2N4443 | £1.45 |
| 600v | | | 106M | £1.50 | 2N4444 | £2.09 |

## RECTIFIERS

| V | 1A | | 3A | | 6A | | 12A | |
|---|---|---|---|---|---|---|---|---|
| 50 | IN4001 | 6½p | IN5400 | 15½p | | | BYX61 - 50 | £3.21 |
| 100 | IN4002 | 7½p | IN5401 | 16½p | | | BYX61 -100 | £3.48 |
| 200 | IN4003 | 9p | IN5402 | 17½p | BYZ13 | 58p | BYX61 -200 | £3.76 |
| 400 | IN4004 | 9p | IN5404 | 22p | BYZ12 | 66p | BYX61 -400 | £4.29 |
| 600 | IN4005 | 11p | IN5406 | 26p | BYZ11 | 73p | BYX62 -600 | £4.29 |
| 800 | IN4006 | 13½p | IN5407 | 28p | BYZ10 | 85p | | |
| 1000 | IN4007 | 16½p | IN5408 | 31p | | | | |

## TRIACS

| | 4A | |
|---|---|---|
| 25v | 2N6068 | 45p |
| 50v | 2N6069 | 52p |
| 100v | 2N6070 | 58p |
| 200v | 2N6071 | 63p |
| 400v | 2N6073 | 68p |
| 600v | 2N6075 | £1.49 |

## BRIDGES

| V | 1A | 2A | 6A |
|---|---|---|---|
| 50 | 20p | 35p | 75p |
| 100 | 20p | 40p | 78p |
| 200 | 22p | 45p | 90p |
| 400 | 25p | 50p | £1.05 |
| 600 | 25p | | £1.20 |
| 1000 | 38p | | |

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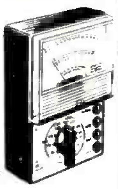
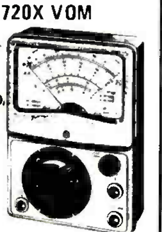
### AUDIOTRONIC Model ATM1

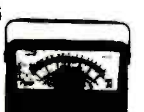
Top value 1,000 opv pocket multimeter. Ranges:– 0/10/50/250/1,000 volt AC and DC. DC current 0-1mA/100mA. Resistence: 0/150k ohms. Decibels: –10 to +22dB. Size 90 x 60 x 28mm. Complete with test leads.
**OUR PRICE £3.25** P&P 15p

### 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). 0-300 uA/0-300mA DC. Resistance: x 10 & x 100. –10 to +16dB. Supplied with battery test leads and data booklet. Size: 121 x 73 x 29mm.
**OUR PRICE £3.95** P & P 20p

### MODEL TH12

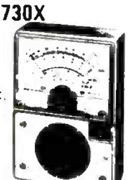
20,000 opv. Overload protection. Slide switch selector. 0/0.25/2.5/10/50/150/1000V DC. 0/10/50/250/1000V AC. 0/50uA/25/250mA DC. 0/3k/30k/300k/3 Megohms. –20 to +50dB.
**OUR PRICE £5.95** P&P 30p

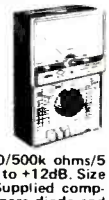
### HIOKI Model 720X VOM

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 30p

### MODEL PL436

20,000 opv DC. 8000 opv AC. Mirror scale 6/3/12/30/120/600V DC. 3/30/120/600V DC. 50/600µA/60/600mA. 10/100K/1 Meg/10 Meg Ohm. –20 to +46 dB.
**OUR PRICE £6.97** P&P 30p

### U4323 MULTIMETER

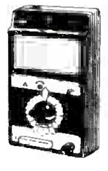
20,000opv. Simple unit with audio/IF oscillator. Suitable for general receiver tuning. Ranges: 0.5/2.5/10/50/250/500/1000V DC. 2.5/10/15/250/500/1000V AC. 0.05/0.5/5/50/500mA DC. Resistance: x 10, x 100, x 1,000, x 10,000 (50Ω, 500Ω, 5kΩ, 50kΩ centre scale) Battery operated. Size: 160 x 97 x 40mm. Supplied in carrying case complete with test leads.
**OUR PRICE £7.00** P&P 30p

### MODEL HIOKI 730X

30,000 opv. Overload protection. 6/30/60/300/600/1200V DC. 12/60/120/600/1200V AC. 60/µA/30mA/300mA 2K/200K/2 Meg Ohm. 10 to 63 dB.
**OUR PRICE £7.50** P&P 30p

### U4324 MULTIMETER

High sensitivity, overload protected. 20,000opv. Ranges: 0.6/1.2/3/12/30/60/120/600/1200V DC. 3/6/15/60/150/300/600/900V AC. Current: 0.06/0.6/6/60/600mA/3A DC. 0.3/3/30/300mA/3A AC. Resistence: 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 30p

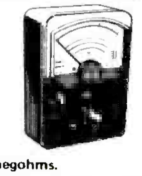
### U435 MULTIMETER

20,000opv. Ranges: 75mV/2.5/10/25/100/250/500/1000V DC. 2.5/10/25/100/250/500/1000V AC. Current: 50uA/1/5/25/100mA/0.5/2.5A DC. 5/25/100mA/0.5/2.5A AC. Resistance: 3/30/300k ohms. Size: 205 x 110 x 84mm. Supplied complete with leads, crocodile clips and steel carrying case.
**OUR PRICE £8.75** P&P 30p

### U4312 MULTIMETER

extremely sturdy instrument for general electrical use. 667opv. 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. DC accuracy 1%. AC 1.5%. Knife edge pointer, mirror scale. Complete with sturdy metal carrying case, leads and instructions.
**OUR PRICE £9.75** P&P 50p

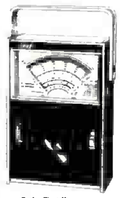
### U91 Clamp VOLT AMMETER

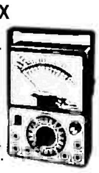
For measuring AC voltage and current without breaking circuit. Ranges: 300/600V AC. Current: 10/25/100/250/500A. Accuracy 4%. Size 283 x 94 x 36mm. Complete with carrying case, leads and fuses.
**OUR PRICE £10.50** P&P 30p

### MODEL 500

30,000 opv with overload protection. Mirror scale. 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
Leather case for above £1.75

### HIOKI 750X VOLT-OHM-MILLIAMETER

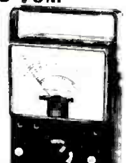
43 ranges: 0–0.3/0.6/1.5/3/6/12/30/60/150/300/600/1,200V DC. 0–3/6/15/30/60/120/300/600/1,200V AC. Current: 0–30/60uA/1.5/3/15/30/150/300 mA/6/12A. Resistence: 0–3/300k/3/30Mohms. Decibels: –10 to +17dB. Output:– 0–3/6/15/30/60/120/300V. Accuracy ± 3% DC, ± 4% AC. Sensitivity: 50,000 opv DC, 5,000 opv AC. 4 inch meter. Built in protection. Size: 57 x 102 x 153mm.
**OUR PRICE £11.95** P&P 40p

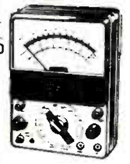
### TMK MODEL TW50K

46 ranges, mirror scale. 50k/V DC 50k/V AC. DC Volts: 0.125/0.25/1.25/2.5/5/10/25/50/125/250/500/1000. AC Volts 1.5/3/5/10/25/50/125/250/500/1000. DC current 25/50uA/2.5/5/25/50/250/500mA/5/10A. Resistence: 10k/100k/1 Meg/10 Meg ohms. –20 to +81.5dB.
**OUR PRICE £12.50** P&P 20p

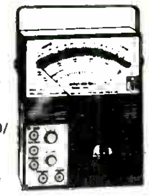
### HIOKI MODEL 700X

100,000opv. Overload protection. Mirror scale. 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. 15/30uA/3/6/30/60/150/500mA/6/12A DC. 2k/200k/2M/20MOhms. –20 to +63dB.
**OUR PRICE £14.95** P&P 30p

### 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 resistence 0–20/200k/2/20 Meg. ohms. DC current:– 10/250uA/2.5/25/250 mA/10A. AC current:–0–10A. –20 to +62dB. Operates from 2 x 1.5V batteries. Size: 180 x 134 x 79mm.
**OUR PRICE £17.50** 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. 0/10µA/6/60/300mA/12 Amp. 0/2K/200K/2 M/200 Meg Ohm. –20 to +17dB.
**OUR PRICE £17.50** P&P 30p.

### KAMODEN HM720B FET VOM

Input impedence 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 40p

### KAMODEN 360 MULTIMETER

High sensitivity. DC 100kohm/V AC 10kohm/V 5" mirror scale, overload protected. Ranges: 0.5/2.5/10/50/250/1000V DC. 5/10/50/250/1000V AC. Current: 0.01mA/0,5/5/50/500mA/10A. Resistance: 0.1/1/10/100 ohms/1/10/100k ohms/10/100M ohms. Decibels –20 to +62dB. Battery operated. Size: 180 x 140 x 80mm. Supplied complete with, test leads etc.
**OUR PRICE £17.50** P & P 40p

### TMK MODEL 117 FET ELECTRONIC VOLTMETER

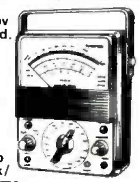
Battery operated. 11 Meg input, 26 ranges. Large 4¼" mirror scale. Size: 149 x 117 x 60mm. 0.3–1200V DC. 3–300V RMS AC. 8–800V P-P. DC current 0.12–12mA. Resistence up to 2000MOhms. Decibels: –20 to +51dB. Supplied complete with leads and instructions.
**OUR PRICE £18.50** P&P 20p

### TMK 100K LAB TESTER

100,000opv. 6½" scale. Buzzer short circuit check. Sensitivity 100,000 opv DC. 5k/V AC DC Volts: 0.5/2.5/10/50/250/1000V AC. 3/10/50/250/500/1000V DC. current 10/100uA/10/10/100/500mA/2.5/10A. Resistence: 1k/10k/100k/10 Meg/100 Meg ohms. Decibels: –10 to +49dB. Plastic case with carrying handle. Size: 190 x 172 x 99mm.
**OUR PRICE £19.95** P&P 30p

### 370WTR MULTIMETER

Features AC current ranges. 20,000opv. 0/0.5/2.5/10/50/250/500/1000V DC. 0/2.5/10/50/250/500/1000V AC. 0/50uA/1/10/100 mA/1/10A DC. 0/100mA/1/10A AC. 0/5k/50k/500k/5 Meg/50 Meg. Decibels: –20 to +62dB.
**OUR PRICE £19.95** P&P 30p

### KAMODEN 72.200 Multitester

High sensitivity tester. 200,000 opv Overload protected. Mirror scale. Ranges:–0/.06/.3/3/30/120/600/1200V DC. 0/3/12/60/300/11200 V AC. 0/6uA/1.2mA/120mA/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. Overload protection. Ranges: 100mV/0.5/2.5/10/25/50/100/250/500/1000 V 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 40p

### MODEL U4311 Sub-standard Multi-range Volt-Ammeter

Sensitivity 330 Ohms/Volt AC and DC. Accuracy 0.5% DC. 1% AC. Scale length: 165mm. 0/300/750uA/1.5/3/7.5/15/30/75/150/300/750mA/1.5/3/7.5A DC. 0/3/7.5/15/30/75/150/300/750mA/1.5/3/7.5A AC. 0/75/150/300/750mV/1.5/3/7.5/15/30/75/150/300/750V DC. 0/750mV/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

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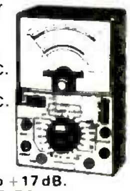
### TE65 VALVE VOLTMETER

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 50p
Additional probes available: RF £2.12, HV £2.50

### LB3 TRANSISTOR TESTER

Tests ICD and B. PNP/NPN. Operates from 9V battery. Instructions supplied.
**OUR PRICE £3.95** P&P 20p

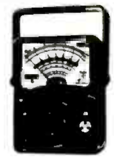
### MODEL AF.105 VOM

50,000 opv. Mirror scale. Meter protection. 0/3/3/12/60/120/300/600/1200V DC. 0/6/30/120/300/600/1200V DC. 0/30µA/6/60/300 mA/12 Amp. 0/10K/1m/10m/100 Meg Ohms. –20 to +17dB.
**OUR PRICE £12.50** P&P 30p.

### LB4 TRANSISTOR TESTER

Tests PNP or NPN transistors. Audio indication. Operates on two 1.5V batteries. Complete with instructions etc.
**OUR PRICE £4.50** P&P 20p

### U4341 Multimeter & Transistor Tester

27 ranges. 16,700opv. 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: 0.06/0.6/2/6/20/60/200k 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 30p

### S100TR MULTIMETER TRANSISTOR TESTER

100,000opv. Mirror scale. Overload protection. 0/0.12/0.6/3/12/30/120/600V 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 ICO. Complete with instructions, batteries and leads.
**OUR PRICE £19.95** P&P 25p

### C15 PULSE OSCILLOSCOPE

For display of pulsed and periodic waveforms in electronic circuits. VERT. AMP. Bandwidth: 10MHz. Sensitivity at 100kHz VRMS/mm: 0.1–25; HDR. AMP. Bandwidth: 500kHz. Sensitivity ay 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 CI16 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

### SWR METER Model SWR3

Handy SWR meter for transmitter antenna alignment, with built-in field strength meter. Accuracy 5%, Impedence 52' Indicator 100uA DC. Full scale 5 section collapsible antenna. Size 145 x 50 x 60mm
**OUR PRICE £4.25** P&P 30p

Also see following pages

Also see previous page

# SEW PANEL METERS

SEW PANEL METERS ARE STOCKED AT 3 LISLE ST., 311 EDGWARE RD., & 152 FLEET ST., or order by post from head office.

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Over 200 ranges in stock—other ranges to order. Quantity discounts available. Send for fully illustrated brochure.

*Items with asterisk are Moving Iron type, all others are Moving Coil

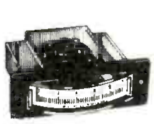
## CLEAR PLASTIC MODEL SD640
Size: 85 x 64mm

| | |
|---|---|
| 50uA | £3.80 |
| 100uA | £3.75 |
| 200uA | £3.70 |
| 500uA | £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 |
| 1A DC | £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 | £3.75 |
| 300V AC | £3.75 |
| VU Meter | £3.90 |

## 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 |

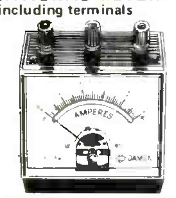
## EDGWISE MODEL PE70
Size: 90 x 34mm



| | |
|---|---|
| 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 |

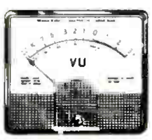
## MODEL ED107 EDUCATIONAL METER
Size: 100 x 90 x 150mm including terminals

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 85P
Size: 120 x 110mm



| | |
|---|---|
| 50uA | £5.45 |
| 100uA | £5.40 |
| 200uA | £5.35 |
| 500uA | £5.25 |
| 50-0-50uA | £5.40 |
| 100-0-100uA | £5.35 |
| 500-0-500uA | £5.20 |
| 1mA | £5.20 |
| 1-0-1mA | £5.20 |
| 5mA | £5.20 |
| 10mA | £5.20 |
| 50mA | £5.20 |
| 100mA | £5.20 |
| 500mA | £5.20 |
| 1A DC | £5.20 |
| 5A DC | £5.20 |
| 15A DC | £5.20 |
| 30A DC | £5.40 |
| 10V DC | £5.20 |
| 20V DC | £5.20 |
| 50V DC | £5.20 |
| 150V DC | £5.20 |
| 300V DC | £5.20 |
| 15V AC | £5.30 |
| 300V AC | £5.30 |
| S Meter 1mA | £5.20 |
| VU Meter | £5.55 |
| 1A AC | * £5.20 |
| 5A AC | * £5.20 |
| 10A AC | * £5.20 |
| 20A AC | * £5.20 |
| 30A AC | * £5.20 |

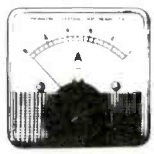
## CLEAR PLASTIC MODEL SD830
Size: 110 x 83mm

| | |
|---|---|
| 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 |
| 300V AC | £4.20 |
| VU Meter | £4.40 |

## CLEAR PLASTIC MODEL MR 45P
Size: 50 x 50mm

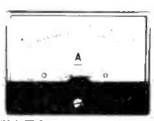
| | |
|---|---|
| 50uA | £3.20 |
| 100uA | £3.15 |
| 200uA | £3.10 |
| 500uA | £3.00 |
| 50-0-50uA | £3.15 |
| 100-0-100uA | £3.10 |
| 500-0-500uA | £2.95 |
| 1mA | £2.95 |
| 5mA | £2.95 |
| 10mA | £2.95 |
| 50mA | £2.95 |
| 100mA | £2.95 |
| 500mA | £2.95 |
| 1A DC | £2.95 |
| 5A DC | £2.95 |
| 10V DC | £2.95 |
| 20V DC | £2.95 |
| 50V DC | £2.95 |
| 300V DC | £2.95 |
| 15V AC | £3.05 |
| 300V AC | £3.05 |
| S Meter 1mA | £2.95 |
| VU Meter | £3.40 |
| 1A AC | * £2.95 |
| 5A AC | * £2.95 |
| 10A AC | * £2.95 |
| 20A AC | * £2.95 |
| 30A AC | * £2.95 |

## 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 | £3.00 |
| 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 | £ 280 |
| 1A DC | £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 |
| 300V AC | £2.90 |
| 500V AC | £3.00 |
| S Meter 1mA | £2.80 |
| VU Meter | £3.20 |

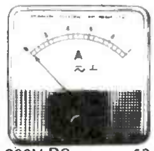
## CLEAR PLASTIC MODEL SD460
Size: 59 x 46mm



| | |
|---|---|
| 50uA | £3.50 |
| 100uA | £3.45 |
| 200uA | £3.40 |
| 500uA | £3.35 |
| 50-0-50uA | £3.45 |
| 100-0-100uA | £3.40 |
| 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 | £3.45 |
| 300V AC | £3.45 |
| VU Meter | £3.65 |

**POSTAGE & PACKING 15p**

## 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 |
| 20A 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 | £3.90 |
| 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 |

## BAKELITE MODEL S80 Enlarged Window
Size: 80 x 80mm

| | |
|---|---|
| 50uA | £4.50 |
| 100uA | £4.45 |
| 500uA | £4.20 |
| 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 |
| 2A DC | £3.60 |
| 5A DC | £3.60 |
| 10A DC | £3.60 |
| 15A DC | £3.60 |
| 30A DC | £3.60 |
| 50A DC | £3.80 |
| 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 | £3.60 |
| 30V AC | * £3.60 |
| 50V AC | * £3.60 |
| 150V AC | * £3.60 |
| 300V AC | * £3.60 |
| 500V AC | * £3.60 |
| VU Meter | £4.10 |
| 1A AC | * £3.60 |
| 5A AC | * £3.60 |
| 10A AC | * £3.60 |
| 20A AC | * £3.60 |
| 30A AC | * £3.60 |
| 50A AC | * £3.60 |
| 500mA AC | * £3.60 |
| 50mV DC | £3.75 |
| 100mV DC | £3.75 |

**240° Wide Angle 1mA METERS**
MW1-8 80 x 80mm
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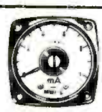

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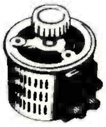

| | | P&P |
|---|---|---|
| 1A | £10.50 | 50p |
| 2.5A | £12.00 | 50p |
| 5A | £17.50 | 50p |
| 8A | £30.35 | £1.00 |
| 10A | £33.75 | £1.00 |
| 12A | £35.40 | £1.00 |
| 20A | £85.00 | £1.50 |
| 25A | £95.00 | £1.50 |
| 40A | £120.00 | £1.50 |

MODEL S260B PANEL MOUNTING

| | | |
|---|---|---|
| 1A | £10.00 | 50p |
| 2.5A | £12.00 | 50p |

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| 207 EDGWARE RD. W2 | 01-723 3271 |
| 311 EDGWARE RD. W2 | 01-262 0387 |
| 346 EDGWARE RD. W2 | 01-723 4453 |
| 382 EDGWARE RD. W2 | 01-723 4194 |
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| 40 Watt | 33p | 31p | 29p |
| 90 Watt | 38½p | 36½p | 33p |

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|---|---|---|---|
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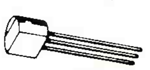
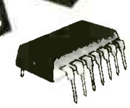
| H39 | 6 | Integrated circuits, 4 Gates BMC 962, 2 Flip Flops BMC 945 | 55p |
| H41 | 2 | Power Transistors Comp. Pair BD 131/132 | 55p |
| H63 | 4 | 2N3055 Type NPN Sil. power transistors. Below spec. devices | 55p |
| H65 | 4 | 40361 Type NPN Sil. transistors TO-5 can comp. to H66 | 55p |
| H66 | 4 | 40362 Type PNP Sil. transistors TO-5 can comp. to H65 | 55p |



## Unmarked Untested Paks

| | | | |
|---|---|---|---|
| B1 | 50 | Germanium Transistors PNP, AF and RF. | 55p |
| B66 | 150 | Germanium Diodes Min. glass type | 55p |
| B84 | 100 | Silicon Diodes DO-7 glass Equiv. to OA200, OA202 | 55p |
| B86 | 100 | Sil. Diodes sub. min. IN914 and IN916 types | 55p |
| B83 | 200 | Transistors, manufacturers rejects, AF, RF, sil and germ. | 55p |
| H26 | 40 | NPN Silicon Trans. 2N3707-11 range, low noise amp. | 55p |
| H34 | 15 | Power Transistors, PNP, Germ. NPN Silicon TO-3 Can. P & P 5p extra. | 55p |
| H67 | 10 | 3819 N Channel FET's plastic case type | 55p |



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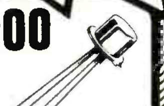

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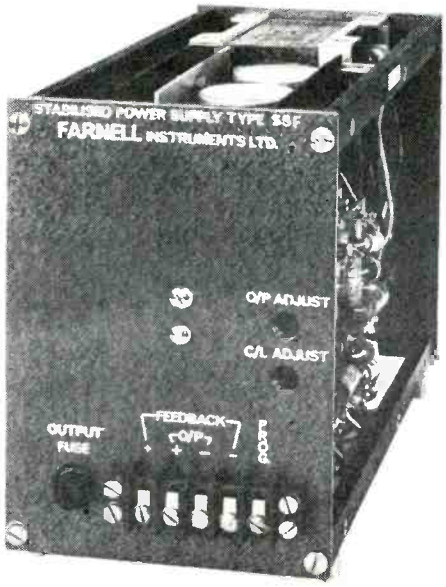


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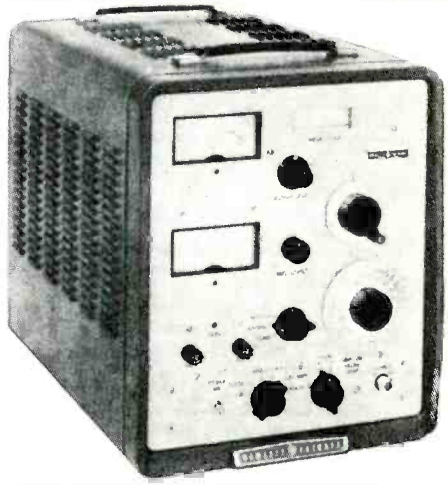

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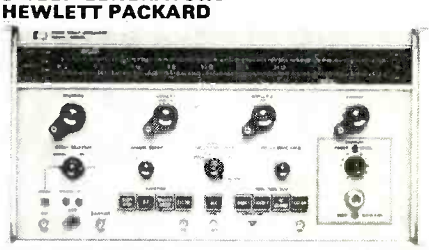

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| 6F12 | 0·37 |
| 6F13 | 0·55 |
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| 6F24 | 0·85 |
| 6F25 | 1·00 |
| 6F26 | 0·34 |
| 6F28 | 0·60 |
| 6F32 | 0·65 |
| 6G6G | 0·75 |
| 6GH8A | 0·75 |
| 6GK5 | 0·65 |
| 6GU7 | 0·75 |
| 6H6GT | 0·25 |
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| 6Q7GT | 0·50 |
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| 6R7(M) | 0·75 |
| 6SA7M | 0·44 |
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| 6SG7M | 0·44 |
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| 7B6 | 0·75 |
| 7B7 | 0·70 |
| 7F8 | 1·00 |
| 7H7 | 0·75 |
| 7R7 | 0·80 |
| 7V7 | 1·00 |
| 7Y4 | 0·65 |
| 7Z4 | 0·80 |
| 9BW6 | 0·65 |
| 9D7 | 0·65 |
| 10C2 | 0·65 |
| 10C14 | 0·38 |
| 10D1 | 0·70 |
| 10DE7 | 0·55 |
| 10F1 | 0·50 |
| 10F9 | 0·65 |
| 10F18 | 0·55 |
| 10L14 | 0·45 |
| 10LD11 | 0·70 |
| 10LD12 | 0·40 |
| 10PL12 | 0·38 |
| 10P13 | 0·70 |
| 10P14 | 2·00 |
| 10P18 | 0·42 |
| 12A6 | 1·00 |
| 12AC6 | 0·45 |
| 12AD6 | 0·65 |
| 12AE6 | 0·65 |
| 12AT6 | 0·38 |
| 12AT7 | 0·34 |
| 12AU6 | 0·45 |
| 12AU7 | 0·28 |

| | |
|---|---|
| 12AV6 | 0·50 |
| 12AX7 | 0·28 |
| 12AY7 | 0·80 |
| 12BA6 | 0·40 |
| 12BE6 | 0·50 |
| 12BH7 | 0·50 |
| 12E1 | 3·00 |
| 12J5GT | 0·33 |
| 12J7GT | 0·55 |
| 12K5 | 1·00 |
| 12K7GT | ·45 |
| 12Q7GT | 0·45 |
| 12SA7GT | ·55 |
| 12SC7 | 0·50 |
| 12SG7 | 0·40 |
| 12SH7 | 0·35 |
| 12SJ7 | 0·44 |
| 12SQ7GT | 0·65 |
| 12SR7 | 0·75 |
| 14H7 | 0·55 |
| 14S7 | 0·80 |
| 18 | 1·00 |
| 19AQ5 | 0·50 |
| 19BG6G | 0·55 |
| 19G6 | 1·40 |
| 19H1 | 2·00 |
| 20D1 | 0·55 |
| 20D4 | 2·00 |
| 20F2 | 0·75 |
| 20L1 | 0·88 |
| 20P1 | 0·55 |
| 20P3 | 0·80 |
| 20P4 | 1·00 |
| 20P5 | 1·30 |
| 25A6G | 0·38 |
| 25L6G | 0·60 |
| 25Y5 | 0·80 |
| 25Y5G | 0·70 |
| 25Z4G | 0·33 |
| 25Z5 | 0·80 |
| 25Z6G | 0·70 |
| 28D7 | 1·00 |
| 30A5 | 0·65 |
| 30C1 | 0·33 |
| 30C15 | 0·75 |
| 30C17 | 0·90 |
| 30C18 | 0·73 |
| 30F5 | 0·80 |
| 30FL1 | 0·75 |
| 30FL2 | 0·75 |
| 30FL12 | 1·00 |
| 30FL14 | 0·70 |
| 30FL13 | 0·55 |
| 30L1 | 0·40 |
| 30L15 | 0·65 |
| 30L17 | 0·70 |
| 30P4MR | |
| 30P12 | 0·80 |
| 30P16 | 0·40 |

| | |
|---|---|
| 30P19/30P4 | 0·75 |
| 30PL1 | 0·66 |
| 30PL12 | 0·35 |
| 30PL13 | 0·75 |
| 30PL14 | 0·80 |
| 30PL15 | 0·90 |
| 35A3 | 0·65 |
| 35A5 | 0·80 |
| 35D5 | 0·75 |
| 35L6GT | ·55 |
| 35W4 | 0·40 |
| 35Z3 | 0·75 |
| 35Z4GT | 0·55 |
| 35Z5GT | 0·75 |
| 43 | 1·00 |
| 50B5 | 0·85 |
| 50C5 | 0·45 |
| 50CD6G | 1·25 |
| 50EH5 | 0·55 |
| 50L6GT | ·65 |
| 72 | 0·33 |
| 77 | 0·53 |
| 85A2 | 0·60 |
| 85A3 | 1·00 |
| 90AG | 3·38 |
| 90CG | 2·40 |
| 90CV | 1·68 |
| 90C1 | 0·75 |
| 150B2 | 0·75 |
| 150C2 | 0·40 |
| 215SG | 0·50 |
| 303 | 0·75 |
| 305 | 0·83 |
| 807 | 0·59 |
| 956 | 0·30 |
| 1821 | 1·00 |
| 4033X | 6.00 |
| 5702 | 0·80 |
| 5763 | 1·00 |
| 6057 | 1·00 |
| 6060 | 1·00 |
| 6067 | 1.00 |
| 7193 | 0·53 |
| 7475 | 1·00 |
| 9002 | 0·50 |
| 9006 | 0·30 |
| A1834 | 1·00 |
| A2134 | 0·98 |
| A3042 | 0·75 |
| AC2PEN | 0·98 |
| AC2PENDD | 0·98 |
| AC6/PEN | 0·60 |
| AC/PEN(7) | 0·98 |
| AC/TH1 | 1·00 |
| AC/TP | 0·98 |
| AL60 | 1·00 |
| ARP3 | 0·35 |

| | |
|---|---|
| ATP4 | 0·40 |
| AZ1 | 0·60 |
| AZ31 | 0·60 |
| AZ41 | 0·65 |
| B319 | 0·40 |
| BL63 | 2·00 |
| CL33 | 1·50 |
| CV6 | 0·53 |
| CV63 | 0·53 |
| CV988 | 0·25 |
| CY1C | 1·00 |
| CY31 | 0·45 |
| D63 | 0·25 |
| DAC32 | 0·55 |
| DAF96 | 0·44 |
| DC90 | 0·60 |
| DD4 | 1·00 |
| DF91 | 0·30 |
| DF96 | 0·44 |
| DH63 | 0·50 |
| DH76 | 0·45 |
| DH77 | 0·38 |
| DH81 | 0·75 |
| DK32 | 0·65 |
| DK40 | 0·70 |
| DK92 | 0·70 |
| DK96 | 0·60 |
| DL92 | 0·35 |
| DL96 | 0·55 |
| DM70 | 0·44 |
| DM71 | 1·00 |
| DW4/350 | 1·00 |
| DY87/6 | 0·30 |
| DY802 | 0·33 |
| E80CC | 1·65 |
| E80F | 1·20 |
| E83F | 1·20 |
| E88CC | 1·00 |
| E92CC | 1·00 |
| E180CC | 0·95 |
| E180F | 1·00 |
| E182CC | 1·00 |
| E1148 | 0·53 |
| EA50 | 0·27 |
| EA76 | 1·00 |
| EABC80 | 0·38 |
| EAC91 | 0·75 |
| EAF42 | 0·60 |
| EAF801 | ·75 |
| EB34 | 0·25 |
| EB91 | 0·15 |
| EBC41 | 0·65 |
| EBC81 | 0·35 |
| EBC90 | 0·38 |
| EBC91 | 0·33 |
| EBF80 | 0·39 |
| EBF83 | 0·43 |
| EBF89 | 0·30 |
| EBL21 | 2·00 |
| EC53 | 1·00 |

| | |
|---|---|
| EC54 | 1·00 |
| EC86 | 0·70 |
| EC88 | 0·70 |
| EC92 | 0·45 |
| ECC32 | 1·50 |
| ECC33 | 1·50 |
| ECC35 | 0·95 |
| ECC40 | 1·00 |
| ECC81 | 0·34 |
| ECC82 | 0·28 |
| ECC83 | 0·28 |
| ECC84 | 0·30 |
| ECC85 | 0·36 |
| ECC86 | 0·85 |
| ECC88 | 0·44 |
| ECC189 | 0·65 |
| ECC804 | 0·80 |
| ECC807 | 1·30 |
| ECF80 | 0·34 |
| ECF82 | 0·38 |
| ECF86 | 0·75 |
| ECF804 | 2·10 |
| ECH21 | 2·00 |
| ECH35 | 1·25 |
| ECH42 | 0·70 |
| ECH81 | 0·30 |
| ECH83 | 0·44 |
| ECH84 | 0·44 |
| ECL80 | 0·40 |
| ECL82 | 0·34 |
| ECL83 | 0·75 |
| ECL84 | 0·60 |
| ECL85 | 0·60 |
| ECL86 | 0·40 |
| EF22 | 1·50 |
| EF40 | 0·75 |
| EF41 | 0·70 |
| EF42 | 0·55 |
| EF73 | 1·50 |
| EF80 | 0·26 |
| EF83 | 0·95 |
| EF85 | 0·34 |
| EF86 | 0·30 |
| EF89 | 0·27 |
| EF91 | 0·37 |
| EF92 | 0·40 |
| EF94 | 0·30 |
| EF97 | 0·80 |
| EF98 | 0·80 |
| EF183 | 0·29 |
| EF184 | 0·32 |
| EF804 | 1·20 |
| EFP60 | 2·00 |
| EH90 | 0·45 |
| EK90 | 0·32 |
| EL32 | 0·50 |
| EL33 | 2·00 |
| EL34 | 0·66 |
| EL35 | 2·50 |
| EL37 | 2·50 |
| EL41 | 0·60 |

| | |
|---|---|
| EL81 | 0·60 |
| EL83 | 0·55 |
| EL84 | 0·31 |
| EL85 | 0·44 |
| EL86 | 0·38 |
| EL91 | 0·40 |
| EL360 | 1·20 |
| EL506 | 0·85 |
| ELL80 | 1·50 |
| EM80 | 0·45 |
| EM81 | 0·65 |
| EM83 | 0·55 |
| EM84 | 0·40 |
| EM85 | 1·00 |
| EM87 | 0·70 |
| EMM803 | 2·00 |
| EY51 | 0·40 |
| EY81 | 0·40 |
| EY83 | 0·54 |
| EY84 | 0·70 |
| EY87/6 | 0·33 |
| EY88 | 0·40 |
| EY91 | 0·58 |
| EZ35 | 0·40 |
| EZ40 | 0·55 |
| EZ41 | 0·75 |
| EZ80 | 0·28 |
| EZ81 | 0·27 |
| EZ90 | 0·40 |
| FW4/500 | 1·00 |
| FW4/800 | 1·00 |
| GY501 | 0·75 |
| GZ30 | 0·35 |
| GZ32 | 0·54 |
| GZ33 | 1·00 |
| GZ34 | 0·65 |
| GZ37 | 0·67 |
| HABC80 | 0·50 |
| HL13C | 0·50 |
| HL23 | 0.60 |
| HL23DD | 0·75 |
| HL41DD | 2·00 |
| HL42DD | 0·70 |
| HN309 | 1·50 |
| HVR2 | 1·00 |
| HVR2A | 1·00 |
| IW3 | 1·00 |
| KT2 | 0·50 |
| KT8 | 2·00 |
| KT41 | 0·98 |
| KT44 | 1·00 |
| KT66 | 2·40 |
| KT81 | 2·00 |
| KTW61 | 1·00 |
| KTW62 | 1·00 |
| KTW63 | 1·00 |
| M8162 | 1·00 |
| MHL4 | 0·75 |
| MHLD6 | 1·00 |
| MKT4 | 0·98 |
| MU12/14 | 1·00 |
| N308 | 1·00 |
| N339 | 2·00 |

| | |
|---|---|
| P61 | 0·50 |
| PABC80 | 0·38 |
| PC86 | 0·60 |
| PC88 | 0·60 |
| PC95 | 0·75 |
| PC97 | 0·38 |
| PC900 | 0·45 |
| PCC84 | 0·40 |
| PCC85 | 0·45 |
| PCC88 | 0·60 |
| PCC89 | 0·50 |
| PCC189 | 0·53 |
| PCF80 | 0·33 |
| PCF82 | 0·35 |
| PCF84 | 0·59 |
| PCF86 | 0·55 |
| PCF87 | 0·90 |
| PCF200 | 0·67 |
| PCF800 | 0·75 |
| PCF801 | 0·48 |
| PCF802 | 0·50 |
| PCF805 | 0·73 |
| PCF806 | 0·55 |
| PCF808 | 0·70 |
| PCH200 | 0·70 |
| PCL82 | 0·35 |
| PCL83 | 0·66 |
| PCL84 | 0·49 |
| PCL86 | 0·47 |
| PCL88 | 0·80 |
| PCL800 | ·75 |
| PCL801 | 0·66 |
| PCL805/PCL85 | 0·55 |
| PEN4DD | 2·00 |
| PEN45 | ·80 |
| PEN45DD | 0·80 |
| PEN46 | 0·50 |
| PEN453DD | 2·00 |
| PENA4 | 0·98 |
| PENDD/4020 | 2·00 |
| PL33 | 0·50 |
| PL36 | 0·55 |
| PL81 | 0·44 |
| PL81A | 0·55 |
| PL82 | 0·40 |
| PL83 | 0·45 |
| PL84 | 0·40 |
| PL302 | 0·75 |
| PL504/500 | 0·67 |
| PL505 | 1·15 |
| PL508 | 0·90 |
| PL509 | 1·15 |
| PL801 | 0·80 |
| PL802 | 0·95 |
| PM84 | 0·60 |
| PY33/2 | ·50 |

| | |
|---|---|
| PY80 | 0·38 |
| PY81 | 0·31 |
| PY82 | 0·30 |
| PY83 | 0·35 |
| PY88 | 0·38 |
| PY301 | 0·70 |
| PY500 | 0·85 |
| PY500A | ·85 |
| PY800 | 0·35 |
| PY801 | 0·35 |
| PZ30 | 0·48 |
| QP21 | 0·50 |
| QQV03/10 | 1·75 |
| QS75/20 | 1·00 |
| QS95/10 | 1·00 |
| QS150/15 | 1·50 |
| QV04/7 | 1·00 |
| R11 | 0·98 |
| R16 | 1·75 |
| R17 | 0·88 |
| R18 | 0·70 |
| R19 | 0·38 |
| R20 | 0·60 |
| R52 | 0·35 |
| RK34 | 1·00 |
| SP13C | 0·63 |
| TH4B | 1·00 |
| TH233 | 0·98 |
| TP2620 | ·98 |
| UABC80 | ·40 |
| UAF42 | 0·60 |
| UBC41 | 0·53 |
| UBC81 | 0·45 |
| UBF80 | 0·38 |
| UBF89 | 0·40 |
| UBL21 | 0·77 |
| UC92 | 0·45 |
| UCC84 | 0·75 |
| UCC85 | 0·45 |
| UCF80 | 0·65 |
| UCH21 | 2·00 |
| UCH42 | 0·70 |
| UCH81 | 0·38 |
| UCL82 | 0·38 |
| UCL83 | 0·55 |
| UF41 | 0·70 |
| UF42 | 0·70 |
| UF80 | 0·35 |
| UF85 | 0·44 |
| UF86 | 1·00 |
| UF89 | 0·38 |
| UL41 | 0·65 |
| UL84 | 0·42 |
| UM80 | 0·44 |
| UR1C | 1·00 |
| UU5 | 1·00 |
| UU9 | 0·55 |
| UU12 | 0·27 |
| UY41 | 0·49 |
| UY85 | 0·38 |

| | |
|---|---|
| U10 | 1·00 |
| U12/14 | 1·00 |
| U16 | 1·00 |
| U17 | 0·80 |
| U18/20 | 1·00 |
| U19 | 1·73 |
| U22 | 0·50 |
| U25 | 0·80 |
| U26 | 0·60 |
| U31 | 0·33 |
| U33 | 1·50 |
| U35 | 1·50 |
| U37 | 1·75 |
| U45 | 0·78 |
| U47 | 0·80 |
| U49 | 0·60 |
| U50 | 0·45 |
| U76 | 0·55 |
| U78 | 0·40 |
| U153 | 0·31 |
| U191 | 0·70 |
| U192 | 0·30 |
| U193 | 0·35 |
| U251 | 0·80 |
| U281 | 0·55 |
| U282 | 0·55 |
| U291 | 0·50 |
| U301 | 0·58 |
| U329 | 0·80 |
| U381 | 0·38 |
| U403 | 0·75 |
| U404 | 0·49 |
| U801 | 0·85 |
| U4020 | 0·55 |
| VP2 | 0·53 |
| VP13C | 0·35 |
| VP23 | 0·75 |
| VP41 | 0·75 |
| VT61A | 0·35 |
| VU111 | 0·80 |
| VU120 | 1·00 |
| VU120A | 1·00 |
| VU133 | 0·80 |
| W76 | 0·45 |
| W81M | 1·00 |
| W107 | 1·00 |
| W729 | 1·00 |
| XE3 | 5·00 |
| XFY12 | 0·48 |
| XH1-5 | 0·48 |
| X41 | 1·00 |
| X61 | 1·25 |
| X65 | 1·25 |
| X66 | 1·25 |
| X101 | 2·00 |
| Z329 | 0·80 |
| Z729 | 0·30 |
| Z749 | 0·80 |
| **Transistors and Diodes** | |
| 1N1124A | ·58 |
| 1N4744A | 0·15 |
| 1N4952 | 0·55 |

| | |
|---|---|
| 2N404 | 0·20 |
| 2N966 | 0·58 |
| 2N1756 | 0·55 |
| 2N2147 | 0·94 |
| 2N2297 | 0·25 |
| 2N2369A | ·15 |
| 2N2613 | 0·43 |
| 2N3053 | 0·36 |
| 2N3121 | 2·75 |
| 2N3703 | 0·21 |
| 2N3709 | 0·22 |
| 2N3866 | 1·10 |
| 2N3988 | 0·55 |
| 2S323 | 0·55 |
| AA119 | 0·17 |
| AA120 | 0·17 |
| AA129 | 0·17 |
| AAZ13 | 0·20 |
| AC107 | 0·17 |
| AC113 | 0·28 |
| AC114 | 0·44 |
| AC126 | 0·14 |
| AC127 | 0·19 |
| AC128 | 0·22 |
| AC132 | 0·22 |
| AC154 | 0·28 |
| AC156 | 0·22 |
| AC157 | 0·28 |
| AC165 | 0·28 |
| AC166 | 0·28 |
| AC167 | 0·66 |
| AC168 | 0·42 |
| AC169 | 0·36 |
| AC176 | 0·61 |
| AC177 | 0·31 |
| ACY17 | 0·28 |
| ACY18 | 0·22 |
| ACY19 | 0·21 |
| ACY20 | 0·20 |
| ACY21 | 0·21 |
| ACY22 | 0·17 |
| ACY28 | 0·20 |
| AD149 | 0·55 |
| AD161 | 0·50 |
| AD162 | 0·50 |
| ADT140 | ·69 |
| AF102 | 0·99 |
| AF106 | 0·55 |
| AF114 | 0·28 |
| AF115 | 0·17 |
| AF117 | 0·21 |
| AF121 | 0·33 |
| AF124 | 0·28 |
| AF125 | 0·19 |
| AF126 | 0·20 |
| AF139 | 0·72 |

| | |
|---|---|
| AF178 | 0·75 |
| AF180 | 0·53 |
| AF186 | 0·61 |
| AF239 | 0·42 |
| ASY27 | 0·47 |
| ASY28 | 0·36 |
| ASY29 | 0·55 |
| BA102 | 0·50 |
| BA115 | 0·15 |
| BA116 | 0·20 |
| BA129 | 0·14 |
| BA130 | 0·11 |
| BA153 | 0·17 |
| BCY10 | 0·50 |
| BCY12 | 0·55 |
| BCY33 | 0·22 |
| BCY34 | 0·25 |
| BCY38 | 0·25 |
| BCY39 | 0·28 |
| BC107 | 0·14 |
| BC108 | 0·14 |
| BC109 | 0·11 |
| BC113 | 0·28 |
| BC115 | 0·17 |
| BC116 | 0·28 |
| BC118 | 0·25 |
| BCZ11 | 0·42 |
| BF154 | 0·28 |
| BF158 | 0·20 |
| BF159 | 0·28 |
| BF163 | 0·22 |
| BF173 | 0·42 |
| BF180 | 0·33 |
| BF181 | 0·44 |
| BF185 | 0·44 |
| BF194 | 0·17 |
| BFY50 | 0·25 |
| BFY51 | 0·21 |
| BFY52 | 0·22 |
| BTX34/400 | 2·20 |
| BY100 | 0·20 |
| BY101 | 0·17 |
| BY105 | 0·20 |
| BY114 | 0·20 |
| BY126 | 0·17 |
| BY127 | 0·20 |
| BYY23 | 1·10 |
| BYZ10 | 0·28 |
| BYZ11 | 0·28 |
| BYZ12 | 0·28 |
| BYZ13 | 0 28 |
| BYZ15 | 1·93 |
| CG12E | 0·22 |
| CG64H | 0·22 |
| FSY11A | ·25 |

| | |
|---|---|
| FSY41A | ·25 |
| GD4 | 0·36 |
| GD5 | 0·31 |
| GD6 | 0·31 |
| GD8 | 0·22 |
| GD9 | 0·22 |
| GD11 | 0·22 |
| GD12 | 0·22 |
| GD14 | 0·55 |
| GD15 | 0·44 |
| GD16 | 0·22 |
| GET113 | ·22 |
| GET116 | ·44 |
| GET118 | ·22 |
| GET119 | ·27 |
| GET573 | ·42 |
| GET587 | ·47 |
| GET8721 | ·05 |
| GET873 | ·17 |
| GET882 | ·55 |
| GET887 | ·25 |
| GET889 | ·25 |
| GET890 | ·25 |
| GET896 | ·25 |
| GET897 | ·25 |
| GET898 | ·25 |
| GEX13 | 0·20 |
| GEX35 | 0·25 |
| GEX36 | 0·55 |
| GEX45 | 0·36 |
| GEX55 | 0·83 |
| GT3 | 0·28 |
| M1 | 0·17 |
| MAT100 | ·43 |
| MAT101 | ·47 |
| MAT120 | ·43 |
| OA5 | 0·31 |
| OA9 | 0·14 |
| OA10 | 0·47 |
| OA47 | 0·11 |
| OA70 | 0·17 |
| OA73 | 0·17 |
| OA79 | 0·10 |
| OA81 | 0·10 |
| OA85 | 0·09 |
| OA86 | 0·22 |
| OA90 | 0·14 |
| OA91 | 0·10 |
| OA95 | 0·10 |
| OA200 | 0·10 |
| OA202 | 0·11 |
| OA210 | 0·53 |
| OA211 | 0·75 |
| OC19 | 1·38 |
| OC22 | 0·42 |

| | |
|---|---|
| OC23 | 0·42 |
| OC24 | 0·42 |
| OC25 | 0·42 |
| OC28 | 0·66 |
| OC29 | 0·69 |
| OC36 | 0·47 |
| OC38 | 0·47 |
| OC41 | 0·55 |
| OC42 | 0·69 |
| OC43 | 1·30 |
| OC44 | 0·11 |
| OC45 | 0·12 |
| OC46 | 0·17 |
| OC65 | 1·24 |
| OC70 | 0·14 |
| OC71 | 0·12 |
| OC72 | 0·12 |
| OC74 | 0·25 |
| OC75 | 0·12 |
| OC76 | 0·17 |
| OC77 | 0·30 |
| OC78 | 0·17 |
| OC78D | 0·17 |
| OC79 | 0·44 |
| OC81 | 0·12 |
| OC81D | 0·12 |
| OC82 | 0·12 |
| OC82D | 0·12 |
| OC83 | 0·22 |
| OC84 | 0·26 |
| OC123 | 0·25 |
| OC139 | 0·25 |
| OC140 | 1·05 |
| OC169 | 0·25 |
| OC172 | 0·39 |
| OC200 | 0·24 |
| OC201 | 0·42 |
| OC202 | 0·47 |
| OC203 | 0·33 |
| OC204 | 0·33 |
| OC205 | 0·47 |
| OC206 | 0·55 |
| OC812 | 0·44 |
| ORP12 | 0·58 |
| S6M1 | 0·28 |
| SM1036 | 0·55 |
| ST1276 | 0·55 |
| SX1/6 | 0·20 |
| U14706 | 0·28 |
| XZ30 | 0·28 |
| Y543 | 0·20 |
| Y728 | 0·20 |
| ZE12V7 | ·10 |

**MATCHED TRANSISTOR SETS**
LP15 (AC113, AC154, AC157, AA120). 58p per pack.
1—OC81D and 2—OC81, 47p.
1—OC44 and 2—OC45. 47p.
1—OC82D and 2—OC82, 53p. Set of 3—OC83 72p.
1 watt Zeners. 2·4v., 2·7v., 3v., 3·6v., 4·3v., 4·7v., 5·1v., 13v., 15v., 16v., 18v., 20v., 24v., 30v., 20p each.

All goods are unused and subject to the manufacturers' guarantee. Business hours Mon.-Fri. 9-5.30 p.m. Closed 1-2 p.m.
Terms of business. Cash or cheque with order. Despatch charges:—Orders below £5 add 10p per order up to three items, then each additional item 3p extra. Orders between £5 and £10 add 25p total. Orders over £10 post free. All orders cleared same day. Any parcel insured against damage in transit for 3p extra per parcel. Conditions of sale available on request. Please enclose S.A.E. for reply to any correspondence. Many others in stock too numerous to list.

# ELECTROVALUE

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P.20 SINGLE linear 100ohms to 2·2megohms ea. **14p**
P.20 SINGLE log. 4·7Kohms to 2·2megohms ea. **14p**
JP.20 DUAL GANG lin. 4·7Kohms to 2·2megohms ea. **48p**
JP.20 DUAL GANG log. 4·7Kohms to 2·2megohms ea. **48p**
JP.20 DUAL GANG Log/antilog 10K, 22K, 47K, 1 megohm only ea. **48p**
JP.20 DUAL GANG antilog 10K only **48p**
2A DP mains switch for any of above **14p** extra.
Decades of 10, 22 and 47 only available in ranges above.
Skeleton Carbon Presets Type PR, horizontal or vertical **6p** each.

### SLIDER
**NEW STEREO SLIDERS**
Matched tracks. Type PG58ST. Lin of log from 47K to 1 meg **60p**
Linear or log. 4·7K to 1 meg. in all popular values ea. **30p**
Escutcheon plates, black, white or light grey ea. **10p**
Control knobs, blk/wht/red/yel/grn/blue/dk. grey/lt grey ea. **7p**

### CAPACITORS
**POLYESTER C.280**

*Radial leads for P.C.B. mounting. Working voltage 250V d.c.*
0·01, 0·015, 0·022, 0·033, 0·047 ea. **3p**
0·068, 0·1, 0·15 ea. **4p**
0·22, **5p**; 0·33, **7p**; 0·47, **8p**; 0·68, **11p**; 1·0, **14p**; 1·5, **21p**; 2·2, **24p**

**TANTALUM BEAD**
0·1, 0·22, 0·47, 1·0 mF/35V, 1·5/20V ea. **14p**
2·2/16V, 2·2/35V, 4·7/16V, 10/6·3V ea. **14p**
4·7/35V, 10/16V, 22/6·3V ea. **18p**
10/25V, 22/16V, 47/6·3V, 100/3V, 6·8/25V, 15/25V ea. **20p**

**POLYCARBONATE**
Type B32540 Working Voltage—250V d.c.
Values in mF: 0·0047; 0·0068; 0·0082; 0·1; 0·012; 0·015 ea. **3p**
0·018; 0·022; 0·027; 0·033; 0·039; 0·047; 0·056; 0·068; 0·082; 0·1 ea. **4p**

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 pFs—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**

**CERAMIC DISC**
1000pF/500, 2000/500, 5000/500, 0·01mF/50, 0·02mF/50, 0·1mF/3—each **2p**; 0·05mF/50V—**3p**

**CERAMIC PLATE**
In a range of 26 values from 22 to 6800pF/50V d.c., each **2p**

**ZENER DIODES**
Full range E24 values: 400mW: 2·7V to 36V, **14p** each; 1W: 6·8V to 82V, **21p** each; 1·5W: 4·7V to 75V, **67p** each. 20W 7·5V to 75V **94p**. Clip to increase 1·5W rating to 3 watts (type 266F), **5p**.
20W 7·5V to 75V **69p** each

**VEROBOARD**
Copper clad 0·1 matrix—2·5 × 3·75 ins. **27p**; 3·75 × 3·75 ins.—**30p**; 2·5 × 5 ins.—**30p**; 3·75 × 5 ins.—**33p**. Copper clad 0·15 in. matrix 2·5 × 3·75 ins.—**20p**; 3·75 × 3·75 ins.—**30p**. 2·5 × 5 ins.—**30p**; 3·75 × 5 ins.—**36p**.
Vero spot face cutter (any matrix) **43p**.
0·040 pins (for 0·1 matrix) per 100—**35p**.
0·052 pins (for 0·15 matrix) per 100—**35p**.

**MINITRON DIGITAL INDICATORS**
**3015F** Seven segment filament, compatible with standard logic modules. 0–9 and decimal point; 9mm characters in 16 lead DIL. **£1·20**
Suitable BCD decoder driver 7447 **£1·15**
**3015G** showing + or − & 1 & dec. pt. **£1·20**

**LEDS** (Light Emitting Diodes) **25p**
Photo Cells, each **40p**

### THE BEST 100 TRANSISTORS
**Taken from our catalogue 7**

| | | | | | |
|---|---|---|---|---|---|
| 2N1307 | **47p** | AF200U | **70p** | BD135 | **37p** |
| 2N2646 | **51p** | AF239 | **60p** | BD136 | **39p** |
| 2N3053 | **26p** | B1906 | **36p** | BDY20 | **83p** |
| 2N3054 | **60p** | BA138 | **31p** | BF194 | **15p** |
| 2N3055 | **60p** | BB103 | **24p** | BFR39 | **23p** |
| 2N3702 | **11p** | BB105 | **34p** | BFR79 | **23p** |
| 2N3703 | **10p** | BB109 | **18p** | BFX29 | **33p** |
| 2N3704 | **11p** | BC107A | **15p** | BFX84 | **27p** |
| 2N3705 | **10p** | BC107B | **15p** | BFY51 | **23p** |
| 2N3794 | **18p** | BC108B | **14p** | BRY39 | **45p** |
| 2N3B19 | **25p** | BC108C | **14p** | BY164 | **51p** |
| 2N4062 | **11p** | BC109B | **18p** | C106B1 | **42p** |
| 2N4443 | **93p** | BC109C | **18p** | C106D1 | **62p** |
| 2N5062 | **42p** | BC147A | **12p** | C1406 | **78p** |
| 2N5163 | **20p** | BC147B | **13p** | MJ481 | **£1·20** |
| 2N5459 | **32p** | BC14BB | **12p** | MJ491 | **£1·35** |
| 40361 | **48p** | BC149C | **14p** | MJ2955 | **80p** |
| 40362 | **44p** | BC158B | **15p** | MJE371 | **89p** |
| 40602 | **46p** | BC159 | **15p** | MJE521 | **81p** |
| 40636 | **£1·36** | BC167B | **13p** | MJE2955 | **£1·12** |
| 40669 | **£1·10** | BC168B | **12p** | MJE3055 | **68p** |
| AC128 | **17p** | BC169B | **12p** | OA91 | **6p** |
| AC151R | **23p** | BC169C | **13p** | SD4 | **8p** |
| AC153 | **27p** | BC179B | **26p** | TIP31A | **70p** |
| AC153K | **37p** | BC182L | **26p** | TIP32A | **80p** |
| AC176 | **24p** | BC184L | **26p** | TIP41A | **80p** |
| AC176K | **38p** | BC212L | **12p** | TIP42A | **£1·00** |
| AC187K | **31p** | BC214L | **14p** | WO2 | **30p** |
| AC188K | **29p** | BC257A | **14p** | ZTX300 | **14p** |
| AD133 | **£1·92** | BC259B | **14p** | ZTX304 | **23p** |
| AD136 | **£1·11** | BC758 | **30p** | ZTX500 | **14p** |
| AD149 | **65p** | BD130 | **90p** | ZTX504 | **45p** |
| AD161 | **42p** | BD131 | **48p** | | |
| AD162 | **40p** | BD132 | **52p** | | |

**HUNDREDS MORE IN CATALOGUE 7**

### RESISTORS

| Code | Watts | Ohms | 1 to 9 | 10 to 99 | 100 up (see note below) |
|---|---|---|---|---|---|
| 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** | **0·97** nett |
| C | 1 | 4·7–10M | **3·2** | **2·5** | **1·92** nett |
| MO | 1/2 | 10–1M | **4** | **3·3** | **2·3** nett |
| WW | 1 | 0·22–3·9Ω | **11** | **10** | **8** |
| WW | 3 | 1–10K | **9** | **8** | **6** |
| WW | 7 | 1–10K | **11** | **10** | **8** |

**Codes:**
C = carbon film, high stability, low noise.
MO = metal oxide, Electrosil TR5, ultra low noise.
WW = wire wound, Plessey.
**Values:** All E12 except C ⅓W, C ¾W, and MO ½W.
E12: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and their decades.
E24: as E12 plus 11, 13, 16, 20, 24, 30, 36, 43, 51, 62, 75, 91 and their decades.
**Tolerances:**
5% except WW 10% ± 0·05Ω below 10Ω and MO ½W 2%.
**Prices are in pence each for quantities of the same ohmic value and power rating. NOT mixed values. (Ignore fractions of one penny on total value of resistor order.) Prices for 100 up in units of 100 only.**

### ELECTROLYTIC CAPACITORS
**Axial Lead**

| qF | 3V | 6·3V | 10V | 16V | 25V | 40V | 63V | 100V |
|---|---|---|---|---|---|---|---|---|
| 0·47 | — | — | — | — | — | — | **11p** | **8p** |
| 1·0 | — | — | — | — | — | **11p** | — | **8p** |
| 2·2 | — | — | — | — | **11p** | — | **8p** | **9p** |
| 4·7 | — | — | — | **11p** | — | **8p** | **9p** | **8p** |
| 10 | — | — | — | — | **8p** | **9p** | **8p** | **8p** |
| 22 | — | — | **8p** | — | **9p** | **8p** | **8p** | **10p** |
| 47 | **8p** | — | **9p** | **8p** | **8p** | **8p** | **10p** | **13p** |
| 100 | **9p** | **8p** | **8p** | **8p** | **9p** | **10p** | **12p** | **19p** |
| 220 | **8p** | **8p** | **9p** | **10p** | **10p** | **11p** | **17p** | **28p** |
| 470 | **9p** | **10p** | **10p** | **11p** | **13p** | **17p** | **24p** | **45p** |
| 1,000 | **11p** | **13p** | **13p** | **17p** | **20p** | **25p** | **41p** | — |
| 2,200 | **15p** | **18p** | **23p** | **26p** | **37p** | **41p** | — | — |
| 4,700 | **26p** | **30p** | **39p** | **44p** | **58p** | — | — | — |
| 10,000 | **42p** | **46p** | — | — | — | — | — | — |

### ALUMINIUM BOXES
**5 sided + lid (or base)**
2¾" × 5¼" × 1½" high, 4" × 4" × 1½" high, 4" × 2¾" × 1½" high, 4" × 2½" × 2" high, each **43p.**
3" × 3" × 1" high **38p**; 4" × 5¼" × 1½" high **48p**;
6" × 4" × 2" high **60p**; 5" × 3½" × 2½" high **52p**

### JACKS AND PLUGS
**SOCKETS**
2 circuit unswitched S1/SS **12p**
2 circuit 2 break contacts S1/BB **15p**
3 circuit unswitched (Not GPO) S3/SSS **17p**
3 circuit with 3 break contacts S3/BBB **20p**
2 circuit with chrome nut and black/white/red/green or grey unswitched S5/SS **16p**
with 2 break contacts S5/BB **20p**
Miniature 3.5mm 2 circuit, (black) 2 break contacts S6/BB **9p**

**PLUGS**
2 circuit screened top entry P1 **24p**
side entry SEP1 **36p**
Line socket mono 231 **40p**
Line socket stereo 244 **45p**
3 circuit unscreened, black/grey/white P4 **46p**
2 circuit, unscreened, black/white/red/black/green/grey P2 **18p**
3 circuit screen top entry P3 **53p**
side entry SEP3 **55p**
Miniature 3·5mm 2 circuit screened P5 **13p**
Miniature 3·5mm 2 circuit unscreened various colours P6 **10p**

### INSULATED SCREW TERMINALS
In moulded polypropylene, with nickel plate on brass. With insulating set, washers, tag and nuts, 15A/250V In black/brown/red/yellow/green/blue/grey/white. Type TP.1 ea. **14p**

### DIN CONNECTORS

| | | |
|---|---|---|
| **2 way loudspeaker** | **Socket 10p** | **Plug 12p** |
| **3 way audio** | **Socket 10p** | **Plug 12p** |
| **5 way audio 180°** | **Socket 12p** | **Plug 15p** |
| **5 way audio 240°** | **Socket 12p** | **Plug 15p** |
| **6 way audio** | **Socket 13p** | **Plug 15p** |

### S-DEC
Unsurpassed for "breadboard work" can be used indefinitely without deterioration. Components just push into plug holes and connect automatically. Slot for control panel. 70 holes **£1·98**

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For more advanced work with 208 contacts in 38 rows. Will take one 16 lead carrier. **£3·63.** (Carriers supplied separately.)

### COVERS & HEATSINKS
Many types including:
**T03** Transistor cover, clip-on **7p**
**HEATSINK**
Type 6WI Extruded aluminium 1° C/W, undrilled **60p**
drilled 2 × T03 **78p**

### ANTEX soldering irons
CN340 **£1·95** Spare bits **32p**
CCN240 **£2·30** Spare bits **40p**

### DESOLDER BRAID
6 ft strip **66p**

### WAVECHANGE SWITCHES
1 pole 12 way; 2 pole 6 way
3 pole 4 way; 4 pole 3 way each **29p**
TAG STRIP 28 way **11p**

### NUTS, SCREWS, ETC.
In lots of 100 each
4BA NUTS **28p**; 6BA NUTS **28p**
½" 4B Screws **28p**; ½" 6BA Screws **24p**
Threaded pillars 6BA, ½" hexagonal **£1·68**
Plain spacers ½" round **£1·12**
Other sizes available

### ENAMEL COPPER WIRE in 2 ounce reels
16, 18, 20, 22 SWG **34p**; 24, 26, 28, 30 SWG **40p**
32, 34 **46p**; 36, 38, 40 **5p**

MAGNETO RESISTORS ● FERRITES ● LIQUID CRYSTAL DISPLAYS ● TOUCH SWITCHES ● SPECIAL I.Cs

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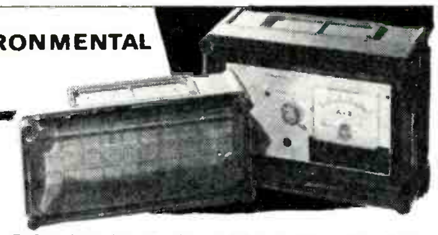
# EnCase ENVIRONMENTAL HOUSING



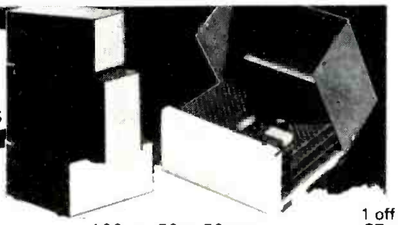
A cleverly designed protected polycarbonate enclosure; weatherproof, hoseproof and damp and dust protecting. Its high impact strength will withstand rough handling. The seven sizes can interconnect and any case will extend vertically or horizontally or both, while maintaining full protection. Send for new catalogue.

EnCase includes chassis, retaining screws, cover, gasket and cover-retaining screws; also includes P. & P. and 8% VAT. Many extras available, incl. hinges, etc.

| | | |
|---|---|---|
| ENA | 7½" × 7½" × 5" | £4.90 |
| ENB | 11" × 7½" × 5" | £6.28 |
| ENC | 15" × 7½" × 5" | £8.39 |
| END | 11" × 11" × 5" | £8.58 |
| ENE | 15" × 11" × 5" | £10.97 |
| ENF | 22" × 11" × 5" | £15.14 |
| ENG | 22" × 15" × 7" | £20.91 |

Prices correct August 1974.

# CONTIL SAMOS miniature cases



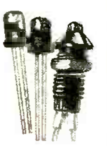
in easy-to-work blue and white PVC/steel. Assemble in the lower half; complete before springing cover into place—four Pozidrives, two to hinge it, two to fasten it. Carries four P.C. boards horizontally, or two vertically; four required for each case (for one vertical board, two each case).

| | | 1 off |
|---|---|---|
| S1 | 100 × 50 × 50mm | 87p |
| S2 | 100 × 100 × 50mm | 99p |
| S3 | 100 × 150 × 50mm | £1.12 |
| S4 | 125 × 50 × 75mm | £1.24 |
| S5 | 125 × 100 × 75mm | £1.42 |
| S6 | 125 × 150 × 75mm | £1.67 |
| S7 | 125 × 200 × 75mm | £1.86 |

much less for quantity. Prices include P. & P, 8% VAT, four feet and four plated screws.
Special feet to carry Printed Circuit Boards sold separately. Price, incl. 8% VAT, 25p for four PC feet.
Prices correct August 1974.

# WH Printed Circuit System

is simple, inexpensive, and fits into low-cost West Hyde cases. The System comprises six cards (two styles, three sizes), connectors and five types of board guide. Connectors are double-sided and all contacts gold-plated. Shown: Mod-301 case with boards 421, guides 311, 21-way connectors. Prices: Mod-301 (including chassis) **£3.95**; Connector 21-way **77p**; Boards 421 & 422 **£1** (up to eight DILs on each board); Card guide pairs 311 **£2.26**. Prices include P. & P. and 8% VAT. Much less for quantities.



**LEDs** with chromium-plated screwed case suitable for 5.5mm. hole or unmounted LEDs 3.2mm. dia.

| 1 off inc. | P & P and 8% VAT | 1 off inc. | P & P and 8% VAT |
|---|---|---|---|
| Cased red | 59p | w/o case | 30p |
| Cased green | 70p | w/o case | 48p |

Much less for quantities. Send for catalogue. Prices correct August 1974.

# 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" | £3.59 | M | 4.5" | 3" | 13" | £4.41 |
| B | 4.5" | 7" | 6.5" | £4.41 | N | 4.5" | 7" | 13" | £5.40 |
| C | 4.5" | 10" | 6.5" | £4.88 | O | 4.5" | 10" | 13" | £6.84 |
| D | 9" | 3" | 6.5" | £4.88 | P | 9" | 3" | 13" | £5.40 |
| E | 9" | 7" | 6.5" | £5.40 | Q | 9" | 7" | 13" | £6.84 |
| F | 9" | 10" | 6.5" | £6.22 | R | 9" | 10" | 13" | £8.74 |
| G | 13" | 3" | 6.5" | £5.40 | S | 13" | 3" | 13" | £6.84 |
| H | 13" | 7" | 6.5" | £6.22 | T | 13" | 7" | 13" | £8.74 |
| I | 13" | 10" | 6.5" | £6.84 | U | 13" | 10" | 13" | £10.13 |
| J | 18" | 3" | 6.5" | £6.22 | V | 18" | 3" | 13" | £8.74 |
| K | 18" | 7" | 6.5" | £8.74 | W | 18" | 7" | 13" | £10.13 |
| L | 18" | 10" | 6.5" | £10.13 | X | 18" | 10" | 13" | £12.09 |

Woodgrain: D @ **£5.40**; E & G @ **£6.22**; H @ **£6.84**

Prices include screws, rubber feet, one or two chassis according to size, P & P and 8% VAT. Prices correct August 1974.

## WEST HYDE

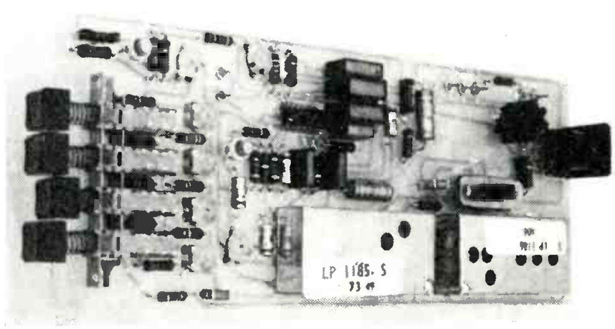
**WEST HYDE DEVELOPMENTS Ltd**, Ryefield Cres., Northwood Hills, Northwood, Middx HA6 1NN.
Tel: Northwood 24941/26732 Telex: 923231

*Write or 'phone for new free catalogue.*

WW—105 FOR FURTHER DETAILS

# 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 1½ in. × 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 1½ 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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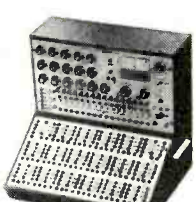

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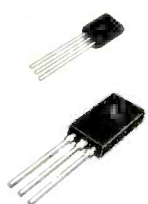

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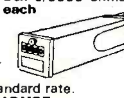

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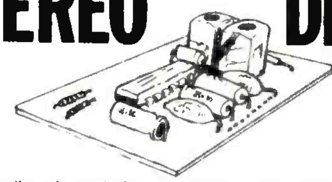

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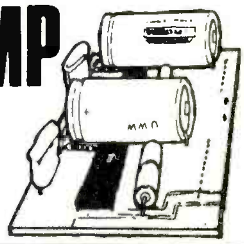

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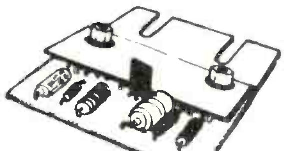

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| 2N492 | 3·99 |
| 2N493 | 4·20 |
| 2N696 | 0·15 |
| 2N697 | 0·15 |
| 2N698 | 0·25 |
| 2N699 | 0·29 |
| 2N706 | 0·16 |
| 2N706A | 0·18 |
| 2N708 | 0·14 |
| 2N709 | 0·38 |
| 2N711 | 0·30 |
| 2N718 | 0·21 |
| 2N718A | 0·49 |
| 2N720 | 0·50 |
| 2N721 | 0·55 |
| 2N914 | 0·22 |
| 2N916 | 0·41 |
| 2N918 | 0·47 |
| 2N929 | 0·30 |
| 2N1302 | 0·19 |
| 2N1303 | 0·19 |
| 2N1304 | 0·24 |
| 2N1305 | 0·24 |
| 2N1306 | 0·31 |
| 2N1307 | 0·22 |
| 2N1308 | 0·25 |
| 2N1309 | 0·36 |
| 2N1671 | 1·44 |
| 2N1671A | 1·54 |
| 2N1671B | 1·72 |
| 2N1671C | 4·32 |
| 2N1711 | 0·45 |
| 2N1907 | 5·50 |
| 2N2102 | 0·50 |
| 2N2147 | 0·70 |
| 2N2148 | 0·94 |
| 2N2160 | 0·60 |
| 2N2192 | 0·40 |
| 2N2192A | 0·40 |
| 2N2913 | 0·40 |
| 2N2193A | 0·61 |
| 2N2194 | 0·73 |
| 2N2194A | 0·30 |
| 2N2218A | 0·60 |
| 2N2219 | 0·45 |
| 2N2219A | 0·60 |
| 2N2220 | 0·45 |
| 2N2221 | 0·41 |
| 2N2221A | 0·40 |
| 2N2222 | 0·40 |
| 2N2222A | 0·50 |
| 2N2368 | 0·31 |
| 2N2369 | 0·20 |
| 2N2369A | 0·22 |
| 2N2646 | 0·77 |
| 2N2647 | 1·12 |
| 2N2904 | 0·55 |
| 2N2904A | 0·70 |
| 2N2905 | 0·48 |
| 2N2905A | 0·50 |
| 2N2906 | 0·31 |

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|---|---|
| 2N2906A | 0·37 |
| 2N2907 | 0·40 |
| 2N2907A | 0·45 |
| 2N2926 | 0·11 |
| 2N3053 | 0·32 |
| 2N3054 | 0·60 |
| 2N3055 | 0·75 |
| 2N3390 | 0·26 |
| 2N3391 | 0·23 |
| 2N3391A | 0·29 |
| 2N3392 | 0·13 |
| 2N3393 | 0·13 |
| 2N3394 | 0·13 |
| 2N3402 | 0·18 |
| 2N3403 | 0·19 |
| 2N3440 | 0·59 |
| 2N3441 | 0·97 |
| 2N3442 | 1·69 |
| 2N3414 | 0·10 |
| 2N3415 | 0·10 |
| 2N3416 | 0·15 |
| 2N3417 | 0·21 |
| 2N3638 | 0·15 |
| 2N3638A | 0·15 |
| 2N3639 | 0·27 |
| 2N3641 | 0·17 |
| 2N3702 | 0·11 |
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| 2N3709 | 0·11 |
| 2N3710 | 0·12 |
| 2N3711 | 0·11 |
| 2N3712 | 0·96 |
| 2N3713 | 1·20 |
| 2N3714 | 1·33 |
| 2N3715 | 1·50 |
| 2N3716 | 1·80 |
| 2N3771 | 2·20 |
| 2N3722 | 1·80 |
| 2N3773 | 2·65 |
| 2N3779 | 3·15 |
| 2N3790 | 2·40 |
| 2N3791 | 2·35 |
| 2N3792 | 2·69 |
| 2N3794 | 0·10 |
| 2N3819 | 0·37 |
| 2N3820 | 0·38 |
| 2N3823 | 1·42 |
| 2N3900 | 0·21 |
| 2N3901 | 0·32 |
| 2N3903 | 0·24 |
| 2N3904 | 0·27 |
| 2N3905 | 0·24 |
| 2N3906 | 0·27 |
| 2N4036 | 0·63 |
| 2N4037 | 0·42 |
| 2N4058 | 0·16 |
| 2N4059 | 0·09 |
| 2N4060 | 0·11 |
| 2N4061 | 0·11 |
| 2N4062 | 0·11 |
| 2N4126 | 0·20 |

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|---|---|
| 2N4289 | 0·34 |
| 2N4919 | 0·84 |
| 2N4920 | 0·99 |
| 2N4921 | 0·73 |
| 2N4922 | 0·84 |
| 2N4923 | 0·83 |
| 2N5172 | 0·12 |
| 2N5174 | 0·22 |
| 2N5175 | 0·26 |
| 2N5176 | 0·32 |
| 2N5190 | 0·92 |
| 2N5191 | 0·95 |
| 2N5192 | 1·24 |
| 2N5195 | 1·46 |
| 2N5245 | 0·43 |
| 2N5457 | 0·49 |
| 2N5458 | 0·45 |
| 2N5459 | 0·49 |
| 40361 | 0·48 |
| 40362 | 0·50 |
| 40363 | 0·61 |
| 40389 | 0·46 |
| 40394 | 0·56 |
| 40395 | 0·65 |
| 40406 | 0·44 |
| 40407 | 0·33 |
| 40408 | 0·50 |
| 40409 | 0·52 |
| 40410 | 0·52 |
| 40411 | 2·25 |
| 40414 | 3·55 |
| 40430 | 0·85 |
| 40583 | 0·23 |
| 40601 | 0·67 |
| 40602 | 0·46 |
| 40603 | 0·53 |
| 40604 | 0·56 |
| 40636 | 1·10 |
| 40669 | 1·00 |
| 40673 | 0·70 |
| AC107 | 0·25 |
| AC113 | 0·16 |
| AC117 | 0·20 |
| AC126 | 0·25 |
| AC127 | 0·25 |
| AC128 | 0·25 |
| AC151V | 0·14 |
| AC152V | 0·17 |
| AC153 | 0·25 |
| AC153K | 0·25 |
| AC154 | 0·20 |
| AC176 | 0·18 |
| AC176K | 0·25 |
| AC187K | 0·23 |
| AC188K | 0·34 |
| ACY18 | 0·24 |
| ACY19 | 0·27 |
| ACY20 | 0·22 |
| ACY21 | 0·26 |
| ACY28 | 0·20 |
| ACY30 | 0·42 |
| AD142 | 0·50 |
| AD143 | 0·45 |
| AD149V | 0·66 |
| AD150 | 0·63 |
| AD161 | 0·45 |

| | |
|---|---|
| AD162 | 0·45 |
| AD161 } | pr |
| AD162 } | 1·05 |
| AF109R | 0·40 |
| AF115 | 0·24 |
| AF116 | 0·25 |
| AF117 | 0·20 |
| AF118 | 0·50 |
| AF124 | 0·30 |
| AF125 | 0·30 |
| AF126 | 0·28 |
| AF127 | 0·28 |
| AF139 | 0·39 |
| AF170 | 0·25 |
| AF172 | 0·25 |
| AF178 | 0·55 |
| AF179 | 0·65 |
| AF180 | 0·50 |
| AF186 | 0·40 |
| AF200 | 0·35 |
| AF239 | 0·51 |
| AF240 | 0·72 |
| AF279 | 0·54 |
| AF280 | 0·54 |
| AL102 | 0·75 |
| AL103 | 0·70 |
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| BC160 | 0·37 |
| BC167B | 0·13 |
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| BC168C | 0·11 |
| BC169B | 0·13 |
| BC169C | 0·13 |
| BC170 | 0·11 |
| BC171 | 0·13 |
| BC172 | 0·11 |
| BC182 | 0·12 |

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|---|---|
| BC182L | 0·12 |
| BC183 | 0·09 |
| BC183L | 0·09 |
| BC184 | 0·11 |
| BC184L | 0·11 |
| BC186 | 0·25 |
| BC187 | 0·27 |
| BC207 | 0·12 |
| BC208 | 0·11 |
| BC212K | 0·10 |
| BC212L | 0·16 |
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| BC239 | 0·09 |
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| BC258 | 0·09 |
| BC259 | 0·13 |
| BC261 | 0·20 |
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| BC263 | 0·23 |
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| BC307 | 0·10 |
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| BC237 | 0·21 |
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| BC337 | 0·19 |
| BC338 | 0·19 |
| BCY30 | 0·43 |
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| BD115 | 0·75 |
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| BD121 | 0·75 |
| BD123 | 0·32 |
| BD124 | 0·67 |
| BD131 | 0·40 |
| BD132 | 0·50 |
| BD135 | 0·43 |
| BD136 | 0·49 |
| BD137 | 0·55 |
| BD138 | 0·63 |

| | |
|---|---|
| BD139 | 0·71 |
| BD140 | 0·87 |
| BDY20 | 1·05 |
| BF115 | 0·25 |
| BF116 | 0·29 |
| BF117 | 0·43 |
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| BF121 | 0·25 |
| BF123 | 0·27 |
| BF125 | 0·25 |
| BF152 | 0·20 |
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| BF161 | 0·42 |
| BF163 | 0·32 |
| BF166 | 0·32 |
| BF167 | 0·21 |
| BF173 | 0·24 |
| BF177 | 0·29 |
| BF178 | 0·35 |
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| BF196 | 0·15 |
| BF197 | 0·15 |
| BF198 | 0·18 |
| BF199 | 0·18 |
| BF200 | 0·40 |
| BF225J | 0·19 |
| BF237 | 0·22 |
| BF238 | 0·22 |
| BF244 | 0·16 |
| BF245 | 0·33 |
| BF246 | 0·43 |
| BF247 | 0·23 |
| BF254 | 0·16 |
| BF255 | 0·17 |
| BF257 | 0·46 |
| BF258 | 0·59 |
| BF259 | 0·55 |
| BFS21A | 2·30 |
| BFS28 | 0·92 |
| BFS61 | 0·27 |
| BFS98 | 0·20 |
| BFX29 | 0·30 |
| BFX30 | 0·25 |
| BFX44 | 0·33 |
| BFX63 | 2·48 |
| BFX68 | 0·30 |
| BFX84 | 0·24 |
| BFX85 | 0·30 |
| BFX87 | 0·28 |
| BFX88 | 0·25 |
| BFX89 | 0·45 |
| BFY18 | 0·35 |
| BFY19 | 0·35 |
| BFY20 | 0·50 |
| BFY29 | 0·40 |
| BFY50 | 0·23 |

| | |
|---|---|
| BFY51 | 0·19 |
| BFY52 | 0·21 |
| BFY53 | 0·16 |
| BFY90 | 0·60 |
| BRY39 | 0·48 |
| BU104 | 1·42 |
| BU105 | 2·25 |
| C106A | 0·46 |
| C106B | 0·55 |
| C106D | 0·65 |
| C106E | 0·43 |
| CA3011 | 0·83 |
| CA3020A | 1·80 |
| CA3029 | 0·52 |
| CA3046 | 0·70 |
| CA3036 | 0·52 |
| CA3043 | 1·57 |
| CA3045 | 1·35 |
| CA3048 | 2·11 |
| CA3049 | 1·96 |
| CA3050 | 1·89 |
| CA3051 | 1·31 |
| CA3052 | 1·62 |
| CA3053 | 0·52 |
| CA3070 | 1·94 |
| CO3086 | 0·40 |
| CA3089E | 1·96 |
| CA30900 | 4·23 |
| CD4000 | 0·51 |
| CD4001 | 0·51 |
| CD4002 | 0·51 |
| CD4009 | 1·07 |
| CD4010 | 1·07 |
| CD4011 | 0·51 |
| CD4015 | 2·66 |
| CD4016 | 1·02 |
| CD4017 | 2·66 |
| CD4020 | 2·96 |
| CD4023 | 0·51 |
| CD4024 | 1·90 |
| CD4027 | 1·56 |
| CD4028 | 2·34 |
| CD4029 | 3·79 |
| CD4041 | 2·11 |
| CD4044 | 2·11 |
| CD4047 | 1·65 |
| CD4049 | 0·90 |
| CD4050 | 0·90 |
| LM301A | 0·48 |
| LM304A | 2·03 |
| LM309K | 1·88 |
| LM702C | 0·75 |
| LM709TO99 | 0·48 |
| 8DIL | 0·38 |
| 14DIL | 0·33 |
| LM723C | 0·75 |
| LM741TO99 | 0·40 |
| 8DIL | 0·46 |
| 14DIL | 0·38 |
| LM747 | 1·00 |
| LM748 8DIL | 0·60 |
| LM7805 | 2·50 |
| 14DIL | 0·73 |
| MC1303P | 1·26 |
| MC1310 | 2·92 |
| MC1458CP1 | 0·79 |
| MJ480 | 0·90 |

| | |
|---|---|
| MJ481 | 1·14 |
| MJ490 | 0·98 |
| MJ491 | 1·38 |
| MJE340 | 0·42 |
| MJE2955 | 1·12 |
| MJE3055 | 0·68 |
| MP8111 | 0·32 |
| MP8112 | 0·40 |
| MP8113 | 0·47 |
| MPF102 | 0·39 |
| MPSA05 | 0·25 |
| MPSA06 | 0·26 |
| MPSA55 | 0·26 |
| MPSA56 | 0·27 |
| NE555V | 0·70 |
| NE560 | 4·48 |
| NE561 | 4·48 |
| NE565A | 4·48 |
| OC23 | 0·56 |
| OC28 | 0·76 |
| OC35 | 0·60 |
| OC42 | 0·35 |
| OC45 | 0·32 |
| OC71 | 0·12 |
| OC72 | 0·13 |
| OC81 | 0·20 |
| OC83 | 0·20 |
| ORP12 | 0·55 |
| R53 | 1·20 |
| RL54 | 0·15 |
| SC35D | 1·68 |
| SC36D | 1·46 |
| SC40D | 1·89 |
| SC41D | 1·32 |
| SC45D | 1·89 |
| SC46D | 1·96 |
| SC50D | 2·60 |
| SC51D | 2·39 |
| SL414A | 1·80 |
| SL623 | 4·59 |
| TAA263 | 1·00 |
| TAA350 | 2·10 |
| TAA621 | 2·03 |
| TAA661B | 1·32 |
| TAD100 | 1·50 |
| Filter | 0·70 |
| TBA271 | 0·64 |
| TBA641B | 2·25 |
| TBA800 | 1·50 |
| TBA810 | 1·50 |
| TIL209 | 0·30 |
| TIP29A | 0·49 |
| TIP30A | 0·58 |
| TIP31A | 0·62 |
| TIP32A | 0·74 |
| TIP33A | 1·01 |
| TIP34A | 1·51 |
| TIP35A | 2·90 |
| TIP36A | 3·70 |
| TIP41A | 0·79 |
| TIP42A | 0·90 |
| TIP2995 | 0·93 |
| TIP3055 | 0·60 |
| ZTX300 | 0·12 |
| ZTX302 | 0·20 |
| ZTX500 | 0·15 |
| ZTX502 | 0·17 |
| ZTX503 | 0·21 |

**Teletennis.** Play on your own TV. SAE for details—as described in *PW*, July, 1974—Special discounts!

**Liquid Crystals**—£13·00 Ex-stock. SAE for details of CMOS battery operated clock kit using LCDs.

**Scorpio Car Ignition Kit**—£11·50 + VAT.

| | | | |
|---|---|---|---|
| BSTB0246 | £1·05 | Transformer | £2·75 |
| 1 1440V | £1·10 | MINITRON | £1·55 |
| DL707 | £2·35 or 4 for £8·00 | | |

**PC Marker Pen** Dalo 33PC Price 87p
Zeners 400MW 11p 1W 17p 3.3V–4V

**Heatsinks**—Redpoint

| | | | |
|---|---|---|---|
| TO5 | 6p | TO18 | 7p |
| 6W1 6" × 4" | undrilled | | £1·00 |
| 4W4 4" × 4" | drilled 2xTO3 | | 80p |
| 2W1 2" × 4" | undrilled | | 45p |
| 4W1 4" × 4" | undrilled | | 70p |

**Resistors** / **Tant Beads**

| W | Tol | Price | Value | |
|---|---|---|---|---|
| ⅛ | 5% | 1p | .1/35 | 14p |
| ¼ | 5% | 1·5p | .22/35 | 14p |
| ½ | 5% | 2p | .47/35 | 14p |
| 1 | 10% | 2·5p | 2.2/35 | 14p |
| 2 | 10% | 6p | 4.7/35 | 18p |
| 2½ | 5% | 7p | 10/16V | 18p |
| 5 | 5% | 9p | 47/6.3V | 20p |
| 10 | 5% | 10p | 100/3V | 20p |

**Veroboard**

| | Copper .1 | Copper 0.15 | Plain 0.1 | Plain 0.15 |
|---|---|---|---|---|
| 2.5 × 3¾ | 28p | 20p | — | 14p |
| 2.5 × 5 | 30p | 30p | — | 14p |
| 3¾ × 3¾ | 30p | 30p | — | — |
| 3¾ × 5 | 34p | 35p | — | 24p |
| 2½ × 17 | £1·21 | 95p | 76p | 69p |
| PINS × 36 | 24p | 24p | | |
| × 200 | 89p | 92p | | |

**Trade and Retail supplied**

## Integrated Circuits TTL

| | |
|---|---|
| SN7400 | 16p |
| SN7401 | 16p |
| SN7401AN | 38p |
| SN7402 | 16p |
| SN7403 | 16p |
| SN7404 | 24p |
| SN7405 | 24p |
| SN7406 | 45p |
| SN7407 | 45p |
| SN7408 | 25p |
| SN7409 | 33p |
| SN7410 | 16p |
| SN7411 | 25p |
| SN7412 | 28p |
| SN7413 | 50p |
| SN7416 | 45p |
| SN7417 | 30p |
| SN7420 | 16p |
| SN7423 | 37p |
| SN7425 | 37p |
| SN7427 | 45p |
| SN7430 | 16p |
| SN7432 | 45p |
| SN7437 | 35p |
| SN7438 | 35p |
| SN7440 | 16p |
| SN7441 | 85p |
| SN7442 | 85p |
| SN7445 | £1·59 |
| SN7446 | £2 |
| SN7447 | £1·30 |
| SN7448 | £1·50 |
| SN7450 | 16p |
| SN7451 | 16p |
| SN7453 | 16p |
| SN7454 | 16p |
| SN7460 | 16p |
| SN7470 | 30p |
| SN7472 | 38p |
| SN7473 | 44p |
| SN7474 | 48p |
| SN7475 | 59p |
| SN7476 | 45p |
| SN7480 | 75p |
| SN7481 | £1·25 |
| SN7482 | 87p |
| SN7483 | £1·20 |
| SN7484 | 95p |
| SN7485 | £1·58 |
| SN7486 | 45p |
| SN7490 | 65p |
| SN7491 | £1·10 |
| SN7492 | 75p |
| SN7493 | 65p |
| SN7494 | 85p |
| SN7495 | 80p |
| SN7496 | £1·00 |
| SN74100 | £2·16 |
| SN74107 | 43p |
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| SN74119 | £1·92 |
| SN74121 | 57p |
| SN74122 | 80p |
| SN74123 | 72p |
| SN74141 | £1·00 |
| SN74145 | £1·44 |
| SN74150 | £1·44 |
| SN74151 | £1·10 |
| SN74153 | £1·09 |
| SN74154 | £1·66 |
| SN74155 | £1·55 |
| SN74157 | £1·09 |
| SN74160 | £1·58 |
| SN74161 | £1·58 |
| SN74162 | £1·58 |
| SN74164 | £2·01 |
| SN74165 | £2·01 |
| SN74167 | £4·10 |
| SN74174 | £1·80 |
| SN74175 | £1·29 |
| SN74176 | £1·74 |
| SN74180 | £1·44 |
| SN74181 | £5·18 |
| SN74190 | £1·95 |
| SN74191 | £1·95 |
| SN74192 | £2·05 |
| SN74193 | £2·30 |
| SN74196 | £1·58 |
| SN74197 | £1·58 |
| SN74198 | £3·16 |
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| | Single | Double |
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| PIV | 50 | 100 | 200 | 400 | 600 | 800 | 1000 |
|---|---|---|---|---|---|---|---|
| 1·5 | 0·08 | 0·09 | 0·10 | 0·11 | 0·12 | 0·15 | 0·20 |
| 3 | 0·15 | 0·17 | 0·20 | 0·22 | 0·25 | 0·27 | 0·20 |
| 10 | — | 0·35 | 0·40 | 0·47 | 0·56 | — | — |
| 35 | 0·84 | 0·92 | 1·18 | 2·15 | 2·52 | 3·65 | 4·20 |

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| IN914 | 0·07 | BA110 | 0·25 | BA154 | 0·12 | BZ10 | 0·35 | OA70 | 0·07½ | OA91 | 0·07 |
| IN916 | 0·07 | BA115 | 0·07 | BY100 | 0·15 | BYZ11 | 0·32 | OA73 | 0·10 | OA95 | 0·07 |
| AA119 | 0·07 | BA141 | 0·17 | BY126 | 0·15 | BYZ12 | 0·30 | OA79 | 0·07 | OA200 | 0·07 |
| AA129 | 0·15 | BA142 | 0·17 | BY127 | 0·17½ | OA9 | 0·10 | OA81 | 0·08 | OA202 | 0·10 |
| BA100 | 0·15 | BA144 | 0·12 | BY140 | 1·00 | OA10 | 0·20 | OA85 | 0·10 | OA210 | 0·27½ |

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|---|---|---|---|---|
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| 100 | 0·36 | 0·37 | 0·70 | 0·75 |
| 200 | 0·30 | 0·41 | 0·75 | 0·80 |
| 400 | 0·36 | 0·45 | 0·85 | 1·10 |
| 600 | 0·40 | 0·52 | 0·95 | 1·25 |

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| | 5A | 15A | 25A | 50A |
|---|---|---|---|---|
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| 100 | 2.24 | 3.60 | 3.60 | 12.36 |
| 200 | 2.82 | 3.78 | 4.32 | 14.40 |
| 400 | 3.72 | 4.20 | 5.40 | 16.38 |

**Construction Kits**

| | | |
|---|---|---|
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# Communications Engineers

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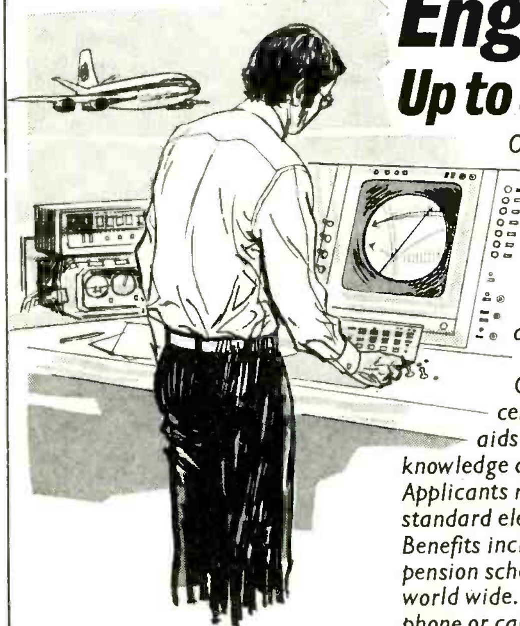

*Opportunities are available following expansion within our FINAL INSPECTION department for engineers of ability with a sound technical and practical understanding of electronics.*

*These are positions of responsibility which involve varied and interesting work associated with a wide range of communications equipment including Air Traffic Control Consoles and monitoring aids for data handling centres, associated hardware and M.F. navigation aids. You will be given full scope for using your knowledge and experience in order to develop your career. Applicants must be able to demonstrate competence in standard electronic test procedures.*

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EMI

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We urgently require

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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.**

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# ELECTRONIC VACANCIES

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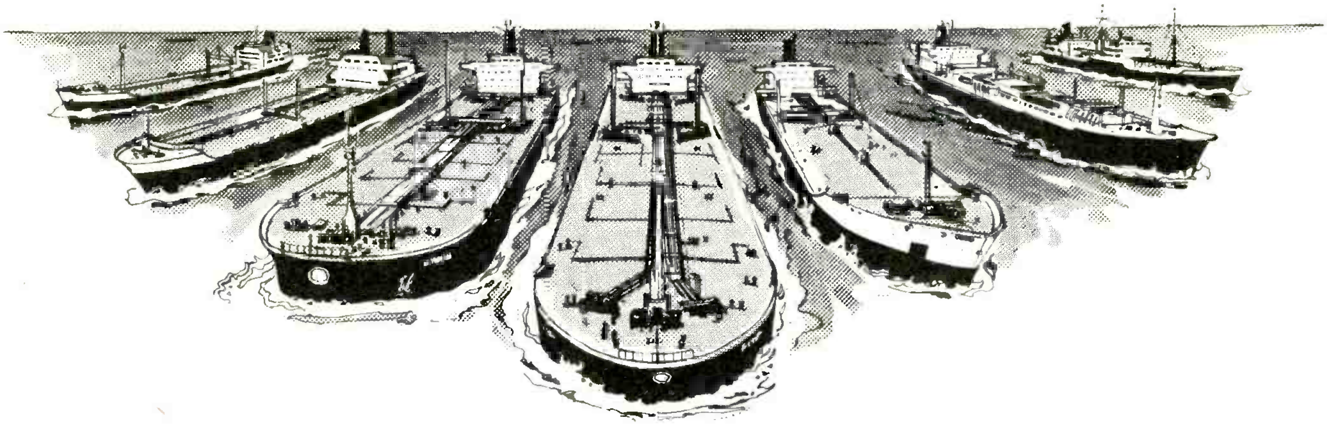

When you're thinking about your career and your family's future, it would be wise to think of Shell. Whether you're in the service now or ashore for the time being, you will already know a lot about us. Our British flag fleet of about 80 ships (with more on the way) is widely diversified, carrying many different cargoes—bitumen, luboils, crude, LNG, chemicals and black and white products. That means that you don't have to be stuck in one particular kind of tanker for long periods. You can move up and move around with equal familiarity. Our large and increasing investment in training underwrites our determination to ensure that we will achieve our intended service periods of 4½ months, and underlines our confidence in the future of the Fleet. When it comes to pay, you'll find our salaries are highly competitive. You can earn between £2,972 (with general certificate and DTI radar certificate) and £6,156 (including MNTB electronics certificate). Your experience and qualifications will determine the point at which you can enter this scale. Leave too is generous—at the rate of 183 days per year served. All officers are members of the company pension scheme and certificated officers can take their wives to sea whenever they wish, which includes two free air fares a year. If you are returning to the service after a spell ashore or already in service, we'll be pleased to tell you all about the extra benefits that Shell can offer you as a Radio/Electronics Officer in our fleet. Write or phone, reversing the charges:

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Shell Centre,
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# Senior Development Engineer Audio Products

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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 RF (AM and VHF stereo reception) and AF (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.

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**Pye Limited**
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Area to include part of Northern England and as far south as Newcastle. Most convenient residence Glasgow-Edinburgh area.

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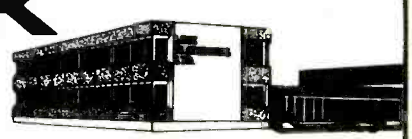

## *ELECTRONIC TEST ENGINEERS*

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Link Electronics is a successful, expanding Company making studio equipment—cameras, Outside Broadcast Units and complete Studio systems—for TV Broadcasting.
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**LINK ELECTRONICS**

**LINK ELECTRONICS LTD.**
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Andover, Hampshire, England

Telephone: Andover 61345

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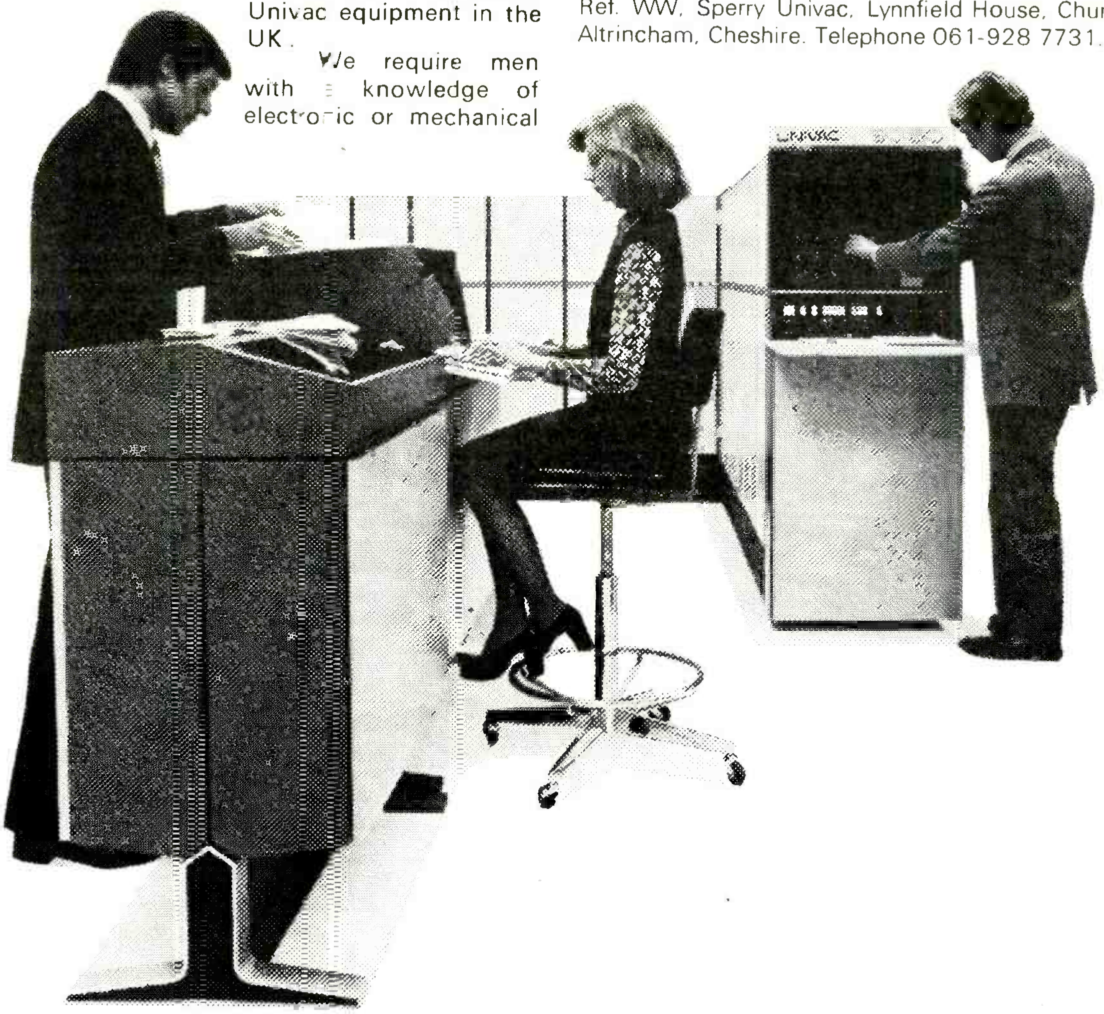
Our Customer Service organisation is, therefore, immensely important to us if we are to maintain the high standards we have set ourselves over the years, during which we have pioneered much of the advanced technology in use today throughout the industry.

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.

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# Engineers for T.V. Design & Development

## *South Africa: £3500-£5000*

Experienced Engineers are invited to accept the challenge of the new T.V. industry in South Africa. Barlows T.V. Ltd., a new subsidiary of Barlow Rand Ltd., one of the largest companies in South Africa, have been chosen by the South African Government to start Television Receiver manufacture this year, in co-operation with Rediffusion. This venture means new career opportunities for experienced engineers to join the design and development team we are setting up.

You will be based at our modern laboratory at New Germany, 12 miles from the attractive coastal resort of Durban, and close to beautiful residential areas. Apart from the climate, South Africa offers: relatively low-cost shopping; low income tax—as little as 8% in some cases; unrivalled outdoor sporting and pleasure facilities.

There are opportunities at senior level for engineers qualified to degree or equivalent standard where experience and proven ability in T.V. Receiver design are of primary importance.

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**BARLOWS T.V. LTD.**

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## ELECTRONIC DESIGN ENGINEER

### (SPECIALISED TEST AND AUTOMATION EQUIPMENT)

**JOB FUNCTION:**
Design of (a) test equipment for use in the production of semi-conductor devices and (b) electronic systems for automated production of devices.

**AGE:**
Not really important, but probably in 25–35 age bracket.

**EXPERIENCE:**
Wide knowledge of present-day electronic techniques including I/Cs, F.E.T. etc.
An awareness of the problems of high current and high voltage measurements would also be advantageous.

**QUALIFICATIONS:**
Are less important than experience—but we anticipate that the ideal man will be educated/experienced to about HNC level.

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**APPLY TO:**
Mr. R. Sutton, Personnel Manager,

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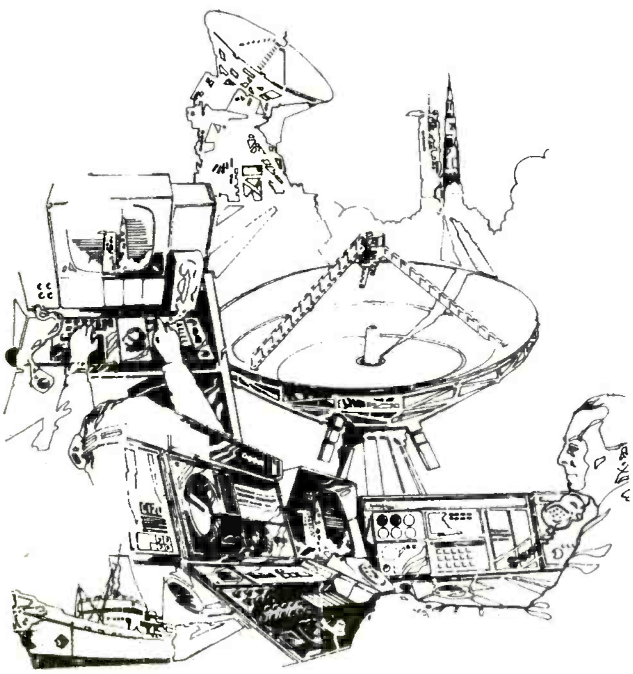
# Telecommunications Engineers



We are world leaders in the vital modern technology field of telecommunications – owning, engineering, and operating a vast network of international Satellite Earth Station, Submarine Cable, Radio, Telephone, Telex and Data Communication systems.
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We offer realistic salaries and excellent conditions of service including generous leave and pension arrangements, sports and social club and other benefits.
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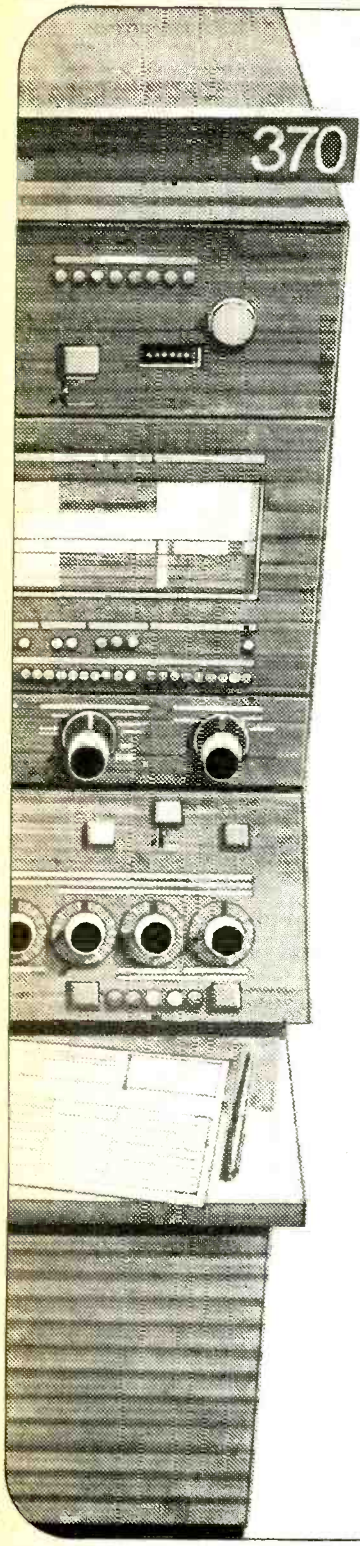


## Customer Engineers

# Even computers need a little understanding

Computers may make life more simple, but they're pretty complex themselves, and sometimes they need the understanding of a trained Customer Engineer to sort out their problems.

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**IBM**

[3926

# SENIOR ENGINEER

Senior Engineer required, 26 plus, to take charge of rapidly growing London-based service/development department. Good academic qualifications required, B.Sc. or H.N.C., but preference given to applicant with proven experience in professional audio equipment, audio or digital tape recording techniques.

Applicants should be free to undertake UK and European travel on service visits, exhibition attendance and technical liaison with manufacturers. An excellent opening for a responsible person looking for a fulfilling position with basic service duties along with some management and general company responsibilities.

Vehicle provided. Salary £2,100 to £2,500 according to age and experience. Please write to:

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**Stanlake Mews**
**London W12 7HA**

[4045

# SERVICE ENGINEER

required for the installation, commissioning and servicing of X-Ray and Cobalt Units and other Radiotherapy equipment both in this country and abroad. X-Ray Unit servicing experience essential. Excellent remuneration and car provided.

Details of training and experience to:

**The Technical Manager,**
**T.E.M. Instruments Limited,**
**Gatwick Road,**
**Crawley,**
**Sussex, RH10 2RG.**

[4015

**CITY OF LONDON POLYTECHNIC**
**Department of Psychology**

# Technician Grade III

A vacancy exists in the above department for a Technician to assist in the Development and construction of apparatus, including electronic circuitry. ment for a Technician to assist in the Development and construction of apparatus, including electronic circuitry.

The successful applicant will be familiar with standard test equipment and its use and should be capable of making a practical representation of ideas presented to him.

Salary in the range £1,650 to £1,920 plus £174 L.W.A. plus Threshold payments.

For further details please telephone 01-283 1030 extension 486.

Written applications should be addressed to:

**Dr I. Balanescu,**
**Department of Psychology,**
**City of London Polytechnic,**
**Central House,**
**Whitechapel High Street,**
**London E1 7PF.**

[4037

**Merton, Sutton and Wandsworth Area Health Authority (Teaching)**
**Wandsworth and East Merton Teaching District**

# AN OPPORTUNITY IN ELECTRONICS

A vacancy exists in the Electronics Section of the Department of Medical Physics. The work involves the design, development and manufacture of a wide variety of medical and research instruments; in particular, the solution of problems arising from the use of cardiac pacemakers. Experience with digital integrated circuits very desirable.

Salary on Technician Scale III £1,845 to £2,337 or Technician Scale II £2,166 to £2,787 (salary under review) depending on age and experience.

**Please apply for application forms to the Hospital Secretary's Office, St. George's Hospital, Hyde Park Corner, SW1.**

[3985

THE POLYTECHNIC
OF NORTH LONDON
Holloway Road N7 8DB

Department of Chemistry

# Laboratory Technician

Grade IV

is required in the Spectroscopy section of the Department. The technician will be mainly responsible for the running and maintenance of a Perkin Elmer R12B NMR and should also be familiar with Spectroscopy instruments. A practical knowledge of electronics would be an advantage.

Candidates should hold C&G/IST Ordinary Certificate or an equivalent qualification and have seven years' experience.

Salary in the range £2,022 to £2,337 inclusive of London Weighting Allowance. In addition, the Threshold Agreement is applicable.
For further details and application forms please apply to:—

**Head of Department of Chemistry
The Polytechnic of North London
Holloway Road
London N7 8DB**

[3999

OXFORD AREA
HEALTH AUTHORITY (TEACHING)
Churchill Hospital, Oxford

# CHIEF or SENIOR ELECTRONICS TECHNICIAN

required for the Electronics Laboratory of the Department of Radiation Physics, for work mainly with radiotherapy and radioisotope counting equipment. The work includes both development and maintenance. Familiarity with pulse circuitry and integrated circuits is essential; experience of logic design is desirable.

The appointment may be as Medical Physics Technician II or Medical Physics Technician III. The qualifications normally expected are:—

Grade III ONC, HNC or appropriate science degree plus 5-6 years experience. Salary £1,719 to £2,211 (under review).

Grade II Normally at least 2 years experience as a Technician III. Salary £2,040 to £2,661 (under review).

Further information can be obtained from Dr. T. R. Munro, Physicist-in-charge, Department of Radiation Physics, Churchill Hospital (Oxford 64841 Ext. 665).

Applications should be sent to him by September 18th, 1974. [3998

THE CITY UNIVERSITY
PHYSICS DEPARTMENT

There are vacancies in the Physics Laboratories for the following positions:

**TECHNICIAN**
experienced in construction and servicing of electronic equipment;

**TECHNICIAN**
experienced in the running of under-graduate physics laboratories;

**JUNIOR TECHNICIAN**
for training in laboratory techniques and organisation. School leavers would be eligible and would be allowed part-time day release to follow an approved course.

Salary scale: Posts 1 and 2: £1,848 to £2,163 per annum plus £228 London Allowance, point of entry dependent on age, qualifications and experience. Post 3: £798 per annum (at age 16) rising to £1,251 per annum plus £228 London Allowance. In addition threshold payments at the appropriate rate are being implemented.

Application forms available from **The Personnel Officer, The City University, St. John Street, London EC1V 4PB, telephone 253 4399 ext. 334. Please quote reference PD/4.**

[4040

# Opportunities for Electronic Engineers

Here's an opportunity for electronic engineers to join the company which invented the world's first electronic calculator. Today we are a leader in our field in Britain and are part of the Rockwell Organisation, world famous for its space and microelectronic technology.

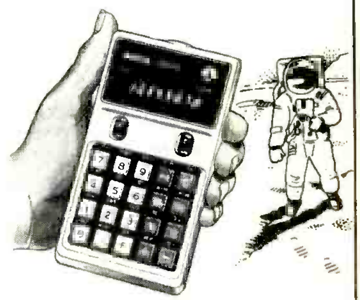
Our continued expansion in calculators and more complex systems now leads to vacancies for electronic engineers.

At our national service centre at Hemel Hempstead our requirements in engineering are nearly as wide as the range of business equipment we produce.

Now we are seeking additional permanent staff ranging from junior technicians (who will be eligible for day-release training where appropriate) to fully qualified and experienced engineers.

The working week is from Monday to Friday and we offer the excellent salary and conditions of employment you would expect from an industry leader.

Write, 'phone or call for full details of these positions and an application form to: Mr. D. D. Davies, Sumlock Anita Ltd., 1 Frogmore Road, Apsley, Hemel Hempstead, Herts. Tel: Hemel Hempstead 61771.



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# ELECTRONICS ENGINEERS

for maintenance on advanced television broadcast equipment including Video Tape Recorders and Telecine machines.

Experience and knowledge of computers and computer controlled systems desirable.

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**GENERAL MANAGER on 01-734 2235.**

[4000

# Opportunities in Communications

Men with a good communications knowledge are required to be responsible for the maintenance of radio, closed circuit television and public address systems on London Transport.

A sound knowledge of some, or all, of the following systems is required:—

**1. V.H.F. radio fixed to mobile, including leaky aerial communication systems.**

**2. Closed Circuit Television.**

**3. Audio playback machines and Public Address.**

The possession of City and Guilds Certificates (or equivalent) in the above subjects would be an added advantage.

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These positions offer free travel for you on London Transport's road and rail services and special facilities on main line trains also travel concessions for your wife and family on London Transport trains and mainline trains, sick pay and pension schemes.

Please apply in writing to:—

**London Transport (Ref. RTVL),**
**Chief Signal Engineer's Department,**
**270 Bollo Lane, Acton, W.3.**

or telephone Mr. Crowder on

**01-748 9564**

**LONDON TRANSPORT**

4008

# Technical Advisers

To deal with problems of a technical nature and advise customers on queries relating to radio television, tape recorders, washing machines and all similar products.

This requires a good working knowledge of these products and the ability to convey technical information by telephone and correspondence. The work is interesting, varied and would provide a workshop engineer with the opportunity to use his technical abilities and further his career in the technical/commercial aspect of customer liaison. We provide, of course, product familiarisation training.

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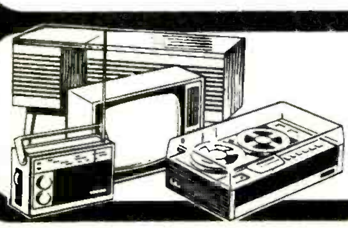
Please write or phone for an application form.

**Personnel Officer,**
**Combined Electronic Services Ltd.,**
**604 Purley Way,**
**Waddon, Croydon CR9 4DR**
**Tel. 686 0505**

4026



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A Television System Design House — London Area — expanding rapidly U.K. and overseas, requires qualified and highly capable installation engineer to head up department.

Position calls for either experienced middle-aged engineer or younger man motivated by enthusiasm and determination. Top grade salary and benefits offered.

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**MERCURY ELECTRONICS**

# BROADCAST SYSTEMS ENGINEERS

Mercury is rapidly expanding its systems engineering services throughout the international broadcast industry, and is looking for more young engineers to complement our staff in Uxbridge and in Westbury, Wiltshire.

You will be responsible for the progressing of projects from initial proposal stage through planning and installation to commissioning, under the direction of a senior project engineer.

You will be required to use considerable initiative and should have a good theoretical and practical knowledge of broadcast television engineering with qualifications to HNC Electronics standard. Overseas travel will be involved.

Generous salary by negotiation.

If you have the ability and drive to make a successful career with us, write or telephone to:—

**Mercury Electronics**
**6 Rockingham Wharf**
**Rockingham Road**
**Uxbridge, Middlesex**
**Tel. Uxbridge 39876**

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**CHELSEA COLLEGE**
**University of London**

# TWO ELECTRONIC TECHNICIANS

**GRADE 2B**

required for the construction and maintenance of equipment and apparatus and to assist in the running of Electronics and Physics Undergraduate Teaching Laboratories, one in the College Main Building at Manresa Road, Chelsea, London SW3 and the other at the Pulton Place Annexe, Fulham SW6.

Day release facilities for approved courses. Salary Scale £1,752 to £2,022 per annum including London Allowance, plus payments under a Threshold Agreement. 37½ hour week, generous holidays.

Application forms and further details from Mr. M. E. Cane (2B ET) WW Chelsea College, Pulton Place, Fulham London SW6 5PR.

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## TELEVISION ENGINEER

A vacancy occurs for an additional TV. Engineer with an expanding Rental and Retail company. Applicant will preferably have some colour experience. Large s/c flat available after trial period. Salary according to experience.

**Hydes of Chertsey Ltd.,**
**56/60 Guildford Street, Chertsey 63243**
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## SERVICE ENGINEER EXTRAORDINARY NEEDED

Experience of digital pulse techniques very valuable. Post relates to field service of advanced pulse height analysis systems. Exciting challenge, good prospects and pay.

*Please reply in confidence to:—*

**Managing Director,**
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**Cottrell House**
**53-56 Wembley Hill Road**
**Wembley, HA9 8BE.**
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**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 ........................................

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**lansdowne Appointments Register**
97

# Telecommunications Engineer

## Harlow

The Electrical Products Division of 3M Company, who are major suppliers of specialised jointing and terminating systems to telecommunications organisations, are seeking a Technical Service Engineer for their laboratory in Harlow.

The Technical Service Group provides an advisory and back-up service to our Marketing groups and customers, and this position will therefore involve both field engineering and laboratory applications work.

Applicants should have a general background in telecommunications techniques, preferably with experience in modern practice in jointing, connecting and terminating cables with a major communications company.

This position will suit a self-motivated man, preferably in the age range 25 to 40 with a degree, HND or HNC in a relevant subject.

An attractive salary and excellent prospects are available for the right man plus, of course, the range of benefits one would expect from a major international company.

Please write giving brief details to:
Howard Miners, Personnel Department,
3M United Kingdom Ltd., 3M House,
Wigmore Street, London W1A 1ET.

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## TENDERS

The Secretary, Department of Electronics, Government of India, Vigyan Shavan Annexe, Maulana Azed Road, NEW DELHI 110011, invites tenders for the following:

**Supply, Installation and Commissioning of a complete Computer System—Jadavpur University, CALCUTTA.**

Due in New Delhi on or before 3.00 pm on 1st OCTOBER, 1974.

Tender documents relating to the above enquiry can be obtained from the Co-ordination Branch, India Supply Mission, India House, Aldwych, LONDON WC2B 4NA, on payment of Rs.100 (£5.26) quoting S.3059/74/ET.

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## AGENTS

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**Box No. WW4018**

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**Royal Holloway College, (University of London) Egham Hill, Egham, Surrey.**

# TECHNICIANS

Experienced Electronics Technician (Grade 4) required in the Physics Department. Salary on the scale £1.848—£2163.

Applications together with the names and addresses of two referees should be sent to the Personnel Officer as soon as possible.

[4056

# ELECTRONIC TEST ENGINEERS

## MARHAM—Norfolk

We require an engineer conversant with complex electronic circuitry—analogue and digital, with at least five years' practical experience of fault-finding on transistorised communication receivers.

Applicants between 25 and 50 years of age who want to further their career by applying their skills to some of the most advanced electronic systems in the world, this could be the opportunity.

We offer a competitive salary £2,000–£2,300 p.a. and excellent career prospects.

Please write for an Application Form, to:

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**Multitone Electric Co. Ltd.**

**10–28 Underwood Street, London N1 7JT.**

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Eastern Gas wish to recruit a Maintenance Technician to be based at their Communications and Instrumentation Workshop at Hertford.

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The salary will be in a range rising to £2,250 per annum, and there are excellent opportunities for promotion to Senior Technician with a salary rising to £2,544 per annum, plus Threshold payment of £2.40 per week. National Salary Scales are currently under review.

Considerable travelling within the Eastern Region of British Gas will be necessary and a current driving licence is therefore essential.

Write for an application form to: H. A. Lloyd, Personnel Officer, Eastern Gas, Star House, Potters Bar, Herts., or telephone him on Potters Bar 51151.

**EASTERN GAS**

3995

**Appointments continued on p.81**

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**TANTALUM BEAD CAPACITORS**—Values available: 0·1, 0·22, 0·47, 1·0, 2·2, 4·7, 6·8μF at 15V/25V or 35V; 10·0μF at 16V/20V or 25V; 22·0μF at 6V/10V or 16V; 33·0μF at 6V or 10V; 47·0μF at 3V or 6V; 100·0μF at 3V. ALL AT 10p EACH; 10 for 95p; 50 for £4·00.

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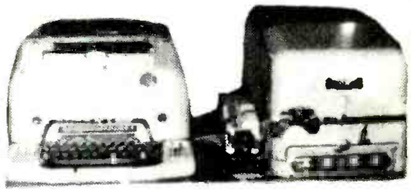

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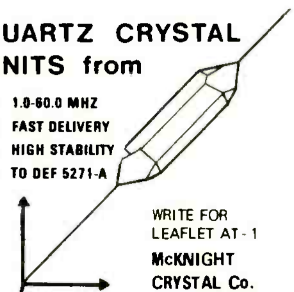

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Classifieds continued on p. 111

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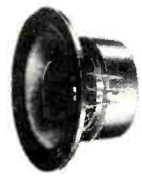

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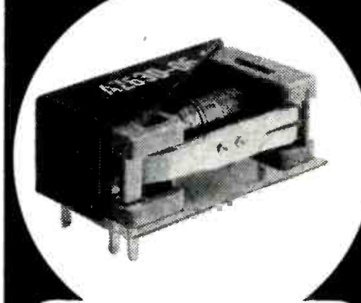

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Contact material:
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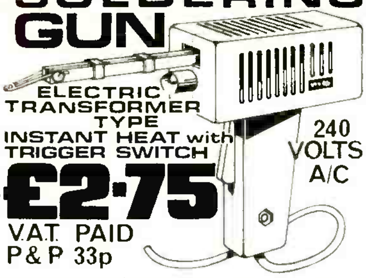

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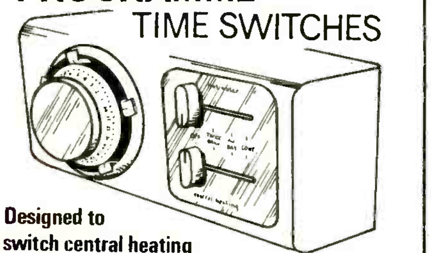

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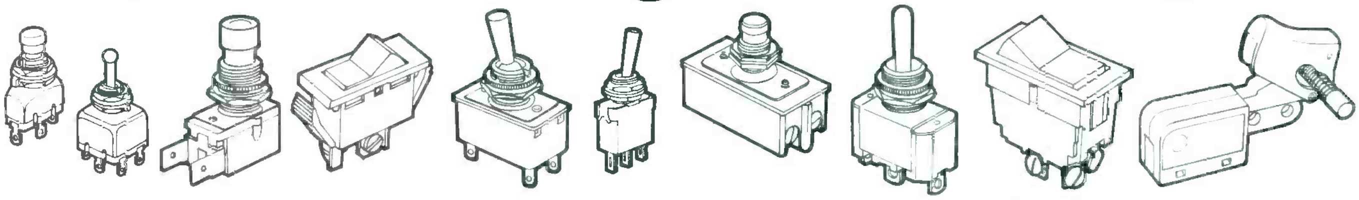

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